Errata

Title & Document Type: 3776A/B PCM Terminal Test Set Service Manual

Manual Part Number: 03776-90013

Revision Date: March 1985

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

Support for Your Product

Agilent no longer sells or supports this product. You will find any other available product information on the Agilent Test & Measurement website:

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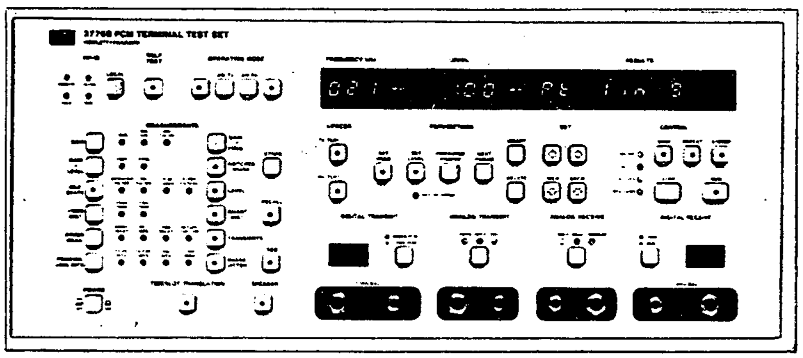
Search for the model number of this product, and the resulting product page will guide you to any available information. Our service centers may be able to perform calibration if no repair parts are needed, but no other support from Agilent is available.

Agilent Technologies

SERVICE MANUAL

3776A/B

PCM TERMINAL TEST SET



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SERVICE MANUAL

3776A/B

PCM TERMINAL TEST SET

(Including Options 001, 002 & 801 for 3776A & B, and Option 004 for 3776B only)

SERIAL NUMBER

This manual applies directly to instruments with serial numbers prefixed 2309U.

For additional important information about serial numbers, see INSTRUMENTS COVERED BY MANUAL in Section I.

Manual Part Number 03776-90013
Microfiche Part Number 03776-90038

Printed: March 1985

WARNING

READ THE FOLLOWING NOTES BEFORE INSTALLING OR SERVICING THE INSTRUMENT.

1. IF THIS INSTRUMENT IS TO BE ENERGIZED VIA AN AUTO-TRANSFORMER MAKE SURE THAT THE COMMON TERMINAL OF THE AUTO-TRANSFORMER IS CONNECTED TO THE NEUTRAL POLE OF THE POWER SOURCE.

2. THE INSTRUMENT MUST ONLY BE USED WITH THE MAINS CABLE PROVIDED. IF THIS IS NOT SUITABLE, CONTACT YOUR NEAREST HP SERVICE OFFICE. THE MAINS PLUG SHALL ONLY BE INSERTED IN A SOCKET OUTLET PROVIDED WITH A PROTECTIVE EARTH CONTACT. THE PROTECTIVE ACTION MUST NOT BE NEGATED BY THE USE OF AN EXTENSION CORD (POWER CABLE) WITHOUT A PROTECTIVE CONDUCTOR (GROUNDING).

3. THE SERVICE INFORMATION FOUND IN THIS MANUAL IS OFTEN USED WITH POWER SUPPLIED TO AND PROTECTIVE COVERS REMOVED FROM THE INSTRUMENT. ENERGY AVAILABLE AT MANY POINTS MAY, IF CONTACTED, RESULT IN PERSONAL INJURY.

4. BEFORE SWITCHING ON THIS INSTRUMENT:

   (a) Make sure the instrument input voltage selector is set to the voltage of the power source.

   (b) Ensure that all devices connected to this instrument are connected to the protective (earth) ground.

   (c) Ensure that the line power (mains) plug is connected to a three-conductor line power outlet that has a protective (earth) ground. (Grounding one conductor of a two-conductor outlet is not sufficient).

   (d) Check that the instrument fuse(s) is of the correct type and rating.

5. SERVICING INFORMATION:

   (a) This manual contains information, cautions, and warnings which must be followed to ensure safe operation and to retain the instrument in safe condition. Service and adjustments should be performed only by qualified service personnel.

   (b) Any adjustment, maintenance, and repair of the opened instrument under voltage should be avoided as much as possible and, when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

   (c) Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

   (d) Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

LIST OF CONTENTS
SECTION I GENERAL INFORMATION

SECTION II INSTALLATION

SECTION III OPERATION

SECTION IV PERFORMANCE TESTS

SECTION V ADJUSTMENTS

SECTION VI REPLACEABLE PARTS

SECTION VII MANUAL CHANGES

SECTION VIII SERVICE

TROUBLESHOOTING - 1. GENERAL SERVICE SHEETS

TROUBLESHOOTING - 2. ASSEMBLY SERVICE SHEETS

Component Layouts and Schematic Diagrams

APPENDICES

General Information

1

Figure 1-1 The 3776 PCM Terminal Test Set with Accessories Supplied

SECTION I
GENERAL INFORMATION

1-1 INTRODUCTION

1-2 This Service Manual contains information required to install, test, adjust and service the Hewlett-Packard Model 3776A and 3776B PCM Terminal Test Sets. A PCM Terminal Test Set together with the power cable and extender board supplied are shown in Figure 1-1. The extender board is housed inside the instrument adjacent to assembly A1.

1-3 Operating instructions for the 3776 are contained in a separate Operating Manual.

1-4 On the title page of this manual is a Microfiche Part Number. This number can be used to order 4 X 6 inch microfilm transparencies of the manual. Each microfiche contains up to 96 photo duplicates of the manual pages.

1-5 SPECIFICATION

1-6 Instrument specifications are listed in Table 1-3. These specifications are the performance standards or limits against which the instrument is tested. Table 1-2 (page 1-5) is a tabular index to facilitate location of individual measurement specifications within Table 1-3.

1-7 SAFETY CONSIDERATION

1-8 This product is a Safety Class 1 instrument (provided with a protective earth terminal). The instrument and manual should be reviewed for safety markings and instructions before operation. Also read the Warning on Page 2.

1-9 INSTRUMENTS COVERED BY MANUAL

1-10 Attached to the instrument is a serial number plate. This serial number is in the form XXXXUXXXXX. It is in two parts; the first four digits and the letter are the serial prefix and the last five are the suffix. The prefix is the same for all identical instruments, it changes only when a change is made to the instrument. The suffix however, is assigned sequentially and is different for each instrument. The contents of this manual apply to instruments with the serial number prefix(es) listed under SERIAL NUMBERS on the title page.

1-11 An instrument manufactured after the printing of this manual may have a serial number prefix that is not listed on the title page. This unlisted serial number prefix indicates the instrument is different from those described in this manual. The manual for this new instrument is accompanied by a Manual Changes supplement. This supplement contains "change information" that explains how to adapt the manual to the newer instrument.

1-12 In addition to change information, the supplement may contain information for correcting errors in the manual. To keep this manual as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes supplement. The supplement for this manual is identified with the manual print data and part number, both of which appear on the manual title page. Complimentary copies of the supplement are available from Hewlett-Packard.

1-13 For information concerning a serial number prefix that is not listed on the title page or in the Manual

Changes supplement, contact your nearest Hewlett-Packard office.

1-14 DESCRIPTION

1-15 The 3776A and 3776B PCM Terminal Test Sets make comprehensive voice and data measurements on 4kHz bandwidth, analog and digital channels. Besides testing PCM multiplexers and channel banks, these instruments also provide powerful facilities for testing transmultiplexers and digital switching systems. Both versions of HP's Terminal Test Set are fully programmable from an external controller via the HP-IB.

1-16 The 3776A fulfils the measurement needs of CEPT/CCITT transmission networks while the 3776B covers North American/Bell and Japanese systems.

Table 1-1 Summary of Measurements Available

Standard Measurements	A-A	A-D	D-A	D-D	AN Tx	DIG Tx	DIG Rx	AN Rx
Gain	*	*	*	*	*	*	*	*
Digital mW gain			*	*		*	*	*
Level (including harmonic distortion)	*	*	*	*	*	*	*	*
Gain v level (using tone)	*	*	*	*	*	*	*	*
Gain v level (using noise - 3776A)	*	*	*	*	*	*	*	*
Gain v level (using sync 2kHz)			*	*		*	*	*
Gain v frequency	*	*	*	*	*	*	*	*
Idle state (choice of filters)	*	*	*	*	*	*	*	*
Coder offset and peak codes		*		*	*	*	*	
Noise with tone	*	*	*	*	*	*	*	*
Quantizing distortion (using tone)	*	*	*	*	*	*	*	*
Quantizing distortion (using noise - 3776A)	*	*	*	*	*	*	*	*
Intermodulation (using two tones)	*	*	*	*	*	*	*	*
Intermodulation (using four tones - 3776B) †	*	*	*	*	*	*	*	*
Digital Tx/Rx				*		*	*	
Return loss 4W (ERL - 3776B)	*	*	*	*	*	*	*	*
Loop timing (selected by using the FRAMING+ SIG BITS key)				*				
Option 001 Measurements								
Group delay distortion (3776A)	*	*	*	*	*	*	*	*
Envelope delay distortion	*	*	*	*				
Absolute delay	*	*	*	*				
Phase jitter (choice of filters)	*	*	*	*	*	*	*	*
Re-modulation	*	*						
Transients:	*	*	*	*	*	*	*	*
Amplitude/gain hits								
Phase hits								
Interruptions/dropouts								
Impulse noise								

† This non-linear distortion technique is licensed under Hekimiam Laboratories Inc., U.S. Patent No. 3,862,380.

1-17 HP's PCM Terminal Test Sets perform the measurements needed for both analog and digital testing on 4kHz channels. They replace the collection of independant analog and digital test equipment previously used in a mixed system environment with one test set. A summary of the measurements available is given in Table 1-1.

1-18 The main features incorporated into the 3776A and 3776B are listed as follows:

Pre-programmed measurement default parameters,
User-modified measurement parameters held in non-volatile memory,
Automatic validity checks carried out on parameter entries,
Measurement sequences can be loaded into non-volatile memory from an external controller,
Once entered, measurement sequences can be run with or without an external controller,
Hard-copy measurement parameters results output via HP-IB without an external controller.

1-19 The 3776A can be used to set and to monitor the PCM stream's framing and signalling bits, ie frame word, non-frame word, TS16 frame 0 and TS16 signalling bits. When control of the frame word is selected, simulated error ratio, frame alignment, AIS and loss of 2.048Mb/s signal parameters can be inserted into the transmitter's output stream for checking alarms in the PCM multiplex.

1-20 The 3776B provides the capability to set and to monitor the PCM stream's F_T, F_S and signalling bits. It can also generate a DS-1 (Extended Framing Format Fe) digital stream containing any framing and signalling bits set by the user. This checks channel bank alignment and alarms. A looped timing check is also available and this indicates whether or not a remote channel bank is loop-timed, in addition to detecting the presence of timing jitter on the line.

1-21 ACCESSORIES SUPPLIED

1-22 Figure 1-1 shows the HP Model 3776 together with the power cable and extender board supplied. The extender board is housed inside the instrument, adjacent to assembly A1.

a) The line power cable is supplied in one of six configurations depending upon the country of destination of the instrument (see INSTALLATION, SECTION II).

b) The following manuals are also supplied with each instrument.

1 Service Manual (combined 3776A/B manual)
2 Operating Manual (separate 3776A and 3776B manual)
3 Operating Booklet (separate 3776A and 3776B booklet)

1-23 EQUIPMENT AVAILABLE

1-24 A Loop Holding Accessory is available for use with either the 3776A or 3776B. There are three Loop Holding Accessories and their model numbers are listed here:

HP 15518A available with 3776A only
HP 15518B available with 3776B only
HP 15518C available with 3776B fitted with Japanese option.

1-25 A Channel Selector, printer, plotter and external controller may also be used with this instrument. A typical example of each is listed here:

HP 3777A	Channel Selector
HP 85	Controller
HP 2631B	80 Column Printer
HP 7470A	HP-GL Plotter

1-26 OPTIONS

1-27 The following options are available and are covered by this manual:

	3776A	3776B
OPTION 001	Adds the following data measurements; group delay distortion, envelope delay distortion, absolute delay, phase jitter, transients of amplitude hits, phase hits, interruptions and 3 level impulse noise. Also adds rear panel MONITOR O/P.	Add the following data measurements; envelope delay distortion, remodulation, absolute delay, phase jitter, transients of gain hits, phase hits, dropouts and 3 level impulse noise. Also adds rear panel MONITOR O/P.
OPTION 002	Replaces front panel BNC connectors with Siemens 75ohms UNBALanced coaxial (1.6mm/5.6mm) connector.	Japanese option requirements same as standard 3776B except for the following: a) Psophometric weighted filter in place of C-message. b) 810Hz default test frequency instead of 1010Hz. c) Front panel connectors replaced by Japanese I-214 type BALanced connector.
OPTION 004		Front panel connectors change to TROMPETER and mounted on rear panel.
OPTION 801	Front cover including foam insert to hold Loop Holding Accessory.	Front cover including foam insert to hold Loop Holding Accessory.

1-28 RECOMMENDED TEST EQUIPMENT

1-29 Equipment required to maintain the PCM Terminal Test Set is listed in Table 1-4. Other equipment may be substituted if it meets or exceeds the critical specification listed in the table.

Table 1-2 Index to Specifications in Table 1-3

A/B/ OPT	MEASUREMENT	SPECIFICATION/PAGE NUMBER							
		A-A	A-D	D-A	D-D	AN Tx	DIG Tx	AN Rx	DIG Rx
A & B	GAIN (Tone)	1-19	1-25	1-32	1-37	1-42	1-46	1-50	1-53
	GAIN (Digital MW)			1-32	1-37		1-46	1-50	1-53
	GAIN (Digital Tx-Rx)				1-37		1-46		1-53
	GAIN V FREQUENCY	1-19	1-25	1-32	1-37	1-42	1-46	1-50	1-53
A	GAIN V LEVEL (Using Noise)	1-19	1-25	1-32	1-38	1-42	1-46	1-50	1-53
A & B	GAIN V LEVEL (Using Tone)	1-19	1-26	1-33	1-38	1-43	1-47	1-50	1-53
	GAIN V LEVEL (Synchronising 2kHz)			1-33	1-39		1-47	1-51	1-54
	NOISE WITH TONE	1-20	1-26	1-34	1-39	1-43	1-47	1-51	1-54
	IDLE STATE					1-43	1-48		
	IDLE STATE (Weighted, Selective, Other Filters)	1-20	1-27	1-34	1-39			1-51	1-54
	IDLE STATE (PCM Codes)		1-27		1-39				1-54
	LEVEL					1-44	1-48		
	LEVEL (Weighted, Other Filters)	1-21	1-27						
	LEVEL (Selective)	1-22	1-28						
	LEVEL (Weighted, Selective, Other Filters)			1-34	1-40			1-51	1-54
	LEVEL (PCM Codes)		1-29		1-40				1-54
A	QUANTISING DISTORTION (Using Noise)	1-22	1-29	1-35	1-40	1-44	1-48	1-51	1-55
A & B	QUANTISING DISTORTION (Using Tone)	1-23	1-30	1-35	1-40	1-44	1-48	1-52	1-55
	INTERMODULATION (2-Tone)	1-23	1-30	1-36	1-41	1-45	1-48	1-52	1-55
B	INTERMODULATION (4-Tone)	1-23	1-31	1-36	1-41	1-45	1-49	1-52	1-56
	RETURN LOSS (ERL)	1-24	1-31	1-36	1-41	1-45	1-49	1-52	1-56
A	GROUP DELAY					1-58	1-60	1-59	1-60
A & B	ABSOLUTE DELAY					1-60	1-61	1-61	1-61
	ENVELOPE DELAY					1-61	1-62	1-62	1-62
B	RE-MODULATION					1-63		1-63	1-63
A & B	PHASE JITTER					1-63	1-64	1-63	1-64
	TRANSIENTS					1-65	1-67	1-65	1-67
	(A) GAIN HITS							1-65	1-67
	(B) PHASE HITS							1-66	1-68
A	(C) INTERRUPTIONS							1-66	1-68
B	(D) DROPOUTS							1-66	1-68
A & B	(E) IMPULSE NOISE							1-66	1-68

ADDITIONAL ITEMS FOR OPT 001 ONLY

Table 1-3 Hardware and Measurement Specifications

Except where otherwise indicated, the following parameters are warranted performance specifications. Parameters described as "typical" or "nominal" are supplemental characteristics which provide a useful indication of typical, but non-warranted, performance characteristics.

HARDWARE SPECIFICATIONS

1. ANALOG TRANSMITTER

SIGNALS

Sinewave

Frequency range: 200 to 3900Hz (50 to 4600Hz for level measurements)
Frequency accuracy: 50ppm
Frequency resolution: 10Hz
Harmonics, spurious signals: >65dB down
(for output levels >-40dBm)

Two Tone

Frequency range f_A and f_B: 200 to 3900Hz
Frequency accuracy: 50ppm
Frequency resolution: 10Hz
Relative amplitude (f_A relative to f_B): +/-0.1dB
Harmonics, spurious signals: >65dB down
(for output levels >-40dBm)

Noise
3776A only

Meets CCITT Rec. 0.131
Amplitude distribution: gaussian nominal
Frequency distribution (3dB points): 375 to 525Hz nominal
Spectral line spacing: 3.9Hz
Crest Factor: 10.5 +/-0.5dB nominal
Repetition rate: 256ms +/-50ppm

Four Tone
3776B only

Meets BSTR Pub. 41009
Lower tones centre frequencies: 860Hz +/-50ppm
Lower tones separation: 6Hz +/-1Hz
Upper tones centre frequencies: 1380Hz +/-50ppm
Upper tones separation: 16Hz +/-1Hz
Relative level of four tones: +/-0.1dB
Harmonic distribution: <-35dB
Spurious signals 1877 to 1923Hz: <-70dB
503 to 537Hz: <-70dB
2223 to 2257Hz: <-70dB

Echo Return Loss (ERL)
3776B only

Meets BSTR pub. 41009

Group Delay
3776A option 001 only

Reference frequency range: 500 to 3000Hz
Measurement frequency range: 200 to 3600Hz
Modulation method and measurement: conforms to CCITT Rec. 0.81

Envelope Delay
(option 001 only)

A Modulation frequency: 41 2/3Hz +/-50ppm
Modulation depth: 0.40 +/-0.05
Carrier frequency range: 300 to 3500Hz

B Meets BSTR Pub. 41009
Modulation frequency: 83 1/3Hz +/-50ppm
Carrier frequency range: 300 to 3500Hz

Absolute Delay
(option 001 only)

Same as envelope delay

LEVEL
Maximum Output Level

sinewave: +10dBm
two tone: +7dBm
noise (3776A only): +2dBm
four tone (3776B only): +4dBm
echo return loss (3776B only): 0dBm
group delay (3776A option 001 only): +5dBm
envelope delay (option 001 only): +5dBm

Minimum Output level

-76.5dBm nominal
Level resolution: 0.1dB nominal
Transmit dBr (TLP) range: -20 to +10dB
Level accuracy: (includes return loss effects)

Nominal Signal Level (dBm)	Accuracy (+/-dB)
>-30	0.09
>-60	0.11
>-76	0.13

Level Flatness

50 to 200Hz: +/-0.3dB
200 to 3900Hz: +/-0.04dB

OUTPUT

Max dc isolation: +/-56V
Impedance: selectable 600ohm/900ohm nominal, balanced/unbalanced
Connectors: 3776A - Siemens 3-pin
3776B - WECO 310 and Bantam jack

2. ANALOG RECEIVER

INPUT

Noise floor: <-100dBmp (<-10dBrnC)
Maximum continuous ac signal level: 9V p-p
Maximum continuous dc signal level: +/-56V
Input flatness (200 to 3900Hz): +/-0.03dB
Receiver dBr (TLP) range: -20 to +10dB
Impedance: selectable 600ohm/900ohm/50kohm, nominal
Connectors: 3776A - Siemens 3-pin
3776B - WECO 310 and Bantam jack

FILTERS

The following filters are provided and are selected as appropriate by the measurement software:

Selective: 85Hz nominal noise bandwidth over frequency range 200 to 3900Hz
3kHz flat: meets BSTR Pub. 41009
Wideband: flat filter with dc rejection
4100Hz high pass: filter used for out-of-band measurements

Filters used in 3776A only:
Quantising distortion reference and measurement: meets CCITT Rec. 0.13
Psophometric*: meets CCITT Rec. P53A
810Hz notch*: meets CCITT Rec. 0.132

*These filters are also used in 3776B Option 002 (Japanese)

Filters used in 3776B only:-
Four-tone intermodulation: meets BSTR Pub. 41009
C-message: meets IEEE P743/D3*
C-message notch: meets IEEE P743/D3*
200Hz high pass: filter used for echo return loss (ERL)

*Not used in 3776B option 002.

Filters used when option 001 is fitted:-
  Impulse noise:
    3776A - selectable three notched band-pass filters to CCITT Rec. 0.71
    3776B - C-notched filter to IEEE P743/D3
  Phase jitter: selectable as
    Fil A - 30 to 300Hz
    Fil B - 4 to 300Hz

3. DIGITAL TRANSMITTER

SIGNALS

As analog transmitter except bandwidth limited to 200 to 3600Hz

LEVEL

Maximum Output Level

sinewave: +3.1dBm0
two tone: 0.0dBm0
noise (3776A only): -5.0dBm0
four tone (3776B only): -3.0dBm0
echo return loss (3776B only): -7.0dBm0
group delay (3776A Option 001 only): -2.0dBm0
envelope delay (Option 001 only): -2.0dBm0

Minimum output level:

-60.0dBm0 nominal
Level resolution: 0.1dBm0 nominal
Level accuracy:

Nominal Signal Level (dBm0)	A-law	u-law
>-40	0.01	0.01
>-55	0.03	0.03
>-60	0.03	0.05

TEST CHANNEL OR TIMESLOT

Insertion of test signals into one selectable timeslot, all timeslots or all timeslots except one in the PCM stream.

FRAMING & SIGNALLING BITS MANIPULATION

Selectable bit patterns of:-
3776A - timeslot 0 in frame 0; timeslot 0 in non-frame 0;
timeslot 16 in frame 0; timeslot 16 signalling bits in all other frames
3776B (FT frame format) - FT bits, FS bits, signalling A & B bits
(FE frame format) - FE bits, signalling ABCD bits

SIMULATION OF TERMINAL ALARMS (3776A only)

Timeslot 0 in frames containing alignment word
Error Ratio - 1×10^{-5}, 5×10^{-5}, 1×10^{-4}, 5×10^{-4}, 1×10^{-3} can be simulated in the frame alignment word
Frame alignment - 1 in 2, 2 in 4, 3 in 4 frame alignment word in error can be simulated in the PCM stream
AIS - an all ones signal can be inserted in PCM stream
OFF - no 2048kb/s PCM stream signal

Timeslot 0 in non-frames containing alignment word
Frame alignment - 1 in 2 or 3 in 4 of bit 3 in error can be simulated in the PCM stream

UNSELECTED AUDIO TIMESLOTS

THRU PCM: as received from digital receiver
SYNTH PCM: background signal
(Two user programmable PCM codes alternating at 1kHz.
The two PCM codes are accessable via the Digital Tx-Rx measurement on the front panel.)

PCM OUTPUT

Frame format:
3776A - conforms to CCITT Rec. G732. Rear panel switch selects 30 or 31 audio channels (timeslot 16 is used as an audio channel)
3776B - rear panel switch selects
FT - standard frame format conforming to BSTR Pub. 43801 (CCITT Rec. G.733)
or FE - extended superframe (ESF) format conforming to AT & T Technical Advisory No. 70

Frame source: Synthesized from internal source or looped through from digital receiver

Compression characteristics: conforms to CCITT Rec. G.711
3776A - A-law with alternate digit inversion (ADI), ideal
3776B - U-law, ideal

Signalling: rear panel switch selects channel associated signalling (CAS) or common channel signalling (CCS)

Coding:

3776A - rear panel switch selects HDB3 or AMI
3776B - rear panel switch selects AMI (AZS) or B8ZS

Impedance:

3776A - 120ohm balanced nominal and 75ohm unbalanced nominal
3776B - 100ohm balanced nominal

Connectors:

3776A - Siemens 3-pin (balanced); BNC (unbalanced)
3776B - WECO 310 and Bantam jack

Amplitude:

	3776A, 3776B balanced outputs	3776A unbalanced output
Mark	+/-3V +/-10%	+/-2.37V +/-10%
Space	+/-0.3V max	+/-0.24V max

Overshoot: <10% amplitude
Width (at 50% amplitude): 50% +/-6%
Transistion times: <30ns

CLOCKS
Internal

Frequency: 3776A - 2048kHz +/-50ppm
3776B - 1544kHz +/-50ppm

External

Frequency: internal bit rate
Level: TTL into 75ohm, nominal
Connector: BNC

4. DIGITAL RECEIVER

TEST CHANNEL

Selected timeslot in the PCM stream

PCM INPUT
Frame format:

3776A - meeting CCITT Rec. G.732
3776B - meeting BSTR Pub. 43801 (CCITT Rec. 733) if FT selected
meeting AT+T Technical Advisory Note No. 70 if FE selected

Expansion characteristics: conforms to CCITT Rec. G.711

3776A - A-law ideal
3776B - u-law ideal

Frame alignment: automatic

Multi-frame alignment: automatic if CAS selected

Signalling: selectable as CAS or CCS

Coding:
3776A - selectable HDB3 or AMI
3776B - selectable AMI (AZS) or B8ZS

Impedance:
3776A - 120ohm balanced nominal; 75ohm unbalanced nominal
3776B - 100ohm balanced nominal

Connector:
3776A - Siemens 3-pin (balanced); BNC (unbalanced)
3776B - WECO 310 and Bantam jack

Maximum input level: +/-8V
Minimum input levels (equivalent cable loss):
3776A - 6dB at 1MHz
3776B - 6dB at 0.75MHz

Modes: selectable as
TERMinated - PCM input terminated by characteristic impedance

MONitor

3776A - provides 30dB gain	PCM input terminated by
3776B - provides 20dB gain	characteristic impedance

LED status indicators:
no signal - >15 consecutive zeros or signal level too low
all ones - >4096 consecutive ones

frame alignment loss
3776A - complies with CCITT Rec. G.732
3776B - 3 out of 7 FT bits in error

multi-frame alignment loss
3776A - complies with CCITT Rec. G.732
3776B - 2 consecutive FS bits in error

FRAMING & SIGNALLING BITS MONITORING

Bit pattern monitoring of
3776A - timeslot 0 in frame 0; timeslot 0 in non-frame 0;
timeslot 16 in frame 0; timeslot 16 signalling bits in all other frames
3776B (FT frame format) - FT bits, FS bits, signalling A&B bits
(FE frame format) - FE bits, CRC bits, signalling ABCD bits

FILTERS

As analog receiver up to channel bandwidth of 3600Hz

CLOCK

Clock recovered from PCM input.
Frequency: 3776A - 2048kHz nominal
3776B - 1544kHz nominal
Max number of consecutive zeros: 15

DIGITAL TTL OUTPUT: (rear panel)

Received PCM bit pattern available as a serial output
Format: Low true
Signal levels: TTL, open collector
Receiver timing outputs: framing synchronisation; multi-frame synchronisation; clock; selected data valid
Connector: Cannon 15 way

TIMESLOT TRANSLATION

3776A - contents of TS (n) and TS (16+n) exchanged
3776B - contents of TS (n) and TS (n+1) exchanged for all timeslots, where n is odd

AUXILIARY ANALOG INPUT: (rear panel)

An external level source can be applied for retransmission from the analog or digital transmitter.

Impedance: 600ohm balanced
Connector: binding posts
Additional parameters:

Analog transmitter only
Additional flatness to internal source: +/-0.2dB nominal over 200 to 3600Hz

Digital transmitter only
Aux input dBr (TLP): -14dB (3776A)
-16dB (3776B)

Aux input flatness (nominal):

Frequency (Hz)	Accuracy (dB)
>200 to <300	+0.15, -2
>300 to <3000	+/-0.2
>3000 to <3300	+0.1, -0.4

ANALOG MONITOR OUTPUT option 001 only: (rear panel)
Analog output of the received analog or digital input after filtering.
Impedance: 600ohm balanced
Connector: binding posts

SPEAKER
Simple amplified loudspeaker output of analog input or selected timeslot decoded to allow channel monitoring/talk over channel.

HP-IB: (rear panel)
Flags: Remote, Listen, Talk, and Service Request
Implementation: (IEEE 488, 1978)
SH1 (complete capability)
AH1 (complete capability)
T5 (basic talker, serial poll, talk only mode, unaddress if MLA)
L4 (basic listener, unaddress if MTA)
SR1 (complete SRQ capability)
RL1 (complete remote-local capability)
DC1 (complete device clear capability)

The IEEE 728 codes and formats capabilities are ...

PM2 (program messages as Fig 24 and 25(b) in IEEE 728)
NRD1 (implicit point numeric data)
NRD2 (fixed point numeric data)
NRD3 (floating point numeric data)
CHDF (character data field)
BDFA (binary block data, length specified, no check)
BDFI (binary block data, length unspecified, no check)
BDFH (hexadecimal data)
, (comma parameter separator)
; (semicolon command separator)
CRLF (CRLF command string terminator)
NL (NL command string terminator)
END (EOI command string terminator)

MM1 (measurement messages as Fig 21(a) and 21(b) in IEEE 728)
NRD1 (implicit point numeric data)
NRD2 (fixed point numeric data)
BDFA (binary block data, length specified, no check)
, (comma data separator)
CRLF (CRLF data list separator)
END (EOI data list terminator)

Modes: selectable as
'addressable' - when an external controller is connected
'talk-only' - when no external controller is connected

Print format: (talk-only mode)
dual in line (DIL) switches select result output string to 'listen only' printer or plotter connected.
binary 2 - print output
binary 8 to 31 - plot option of various configurations

PLOT OPTIONS

Binary Format Number	Scale X Axis	Scale Y Axis	Auto Paper Eject	Plot Title and Axes	Plot CCITT Mask
8				yes	yes
9	yes			yes	yes
10		yes		yes	yes
11	yes	yes		yes	yes
12			yes	yes	yes
13	yes		yes	yes	yes
14		yes	yes	yes	yes
15	yes	yes	yes	yes	yes
16				yes	
17	yes			yes	
18		yes		yes	
19	yes	yes		yes	
20			yes	yes	
21	yes		yes	yes	
22		yes	yes	yes	
23	yes	yes	yes	yes	
24					
25	yes				
26		yes			
27	yes	yes			
28			yes		
29	yes		yes		
30		yes	yes		
31	yes	yes	yes		

Power on SRQ: selectable DIL switch
EOI: sets end or identify (EOI) with serial poll byte in addressable mode only; selectable DIL switch

Connector: Cannon 24 way

5. GENERAL

Supply voltages: 115V ac +10%, -22%
220V ac +10%, -22%

Power consumption: 85W nominal

Dimensions:
55178mm (7in) high
425mm (16.75in) wide
440mm (17.25in) deep

Weight: 15kg (331b) nominal

Temperature range: operating 0degrees to 55degrees centigrade
storage -40degrees to 75degrees centigrade

6. OPTIONS

3776A

Option 001

Adds data measurements of:
group delay distortion
envelope delay distortion
absolute delay
phase jitter
transients* of
ampliture hits
phase hits
interruptions
3-level impulse noise

3776B

Option 001

Adds data measurements of:
envelope delay distortion
remodulation
absolute delay
phase jitter
transients* of
gain hits
phase hits
dropouts
3-level impulse noise

*All four parameters in transients are measured simultaneously.

3776A

Option 002

Replaces front panel BNC connectors with Siemens 75ohm unbalanced coaxial (1.6mm/5.6mm) connectors

3776B

Option 002 - Japanese requirement same as standard instrument with the following exceptions:

a) Psphometric weighting filter in place of C-message
b) 810Hz default test frequency instead of 1010Hz
c) Front panel connectors replaced with Japanese I-214 type balanced connectors

Option 004

Front panel analog & digital interface connectors on std. instrument located on rear panel.
Connector: balanced triaxial trompeter type BJ77

OTHER COMMON OPTIONS

Option 801
Front panel cover

Option 907
Front handle kit

Option 908
Rack flange kit

Option 909
Rack flange & front handle combination kit

Option 910
Extra set of operating and service manuals

MEASUREMENT SPECIFICATIONS

GENERAL

In a PCM Channel, the apparent gain for tones varies with the phase of the signal at the start of the measurement. The size of the variation depends on the number (n) of independent values present in the sampled wave n = fs/h, where h is the highest common factor of the tone frequency (Hz) and fs = Sampling frequency = 8000 or 16000. This governs the choice of test tones; frequencies such as 800 or 1000Hz have few independent samples and large gain variations, while 810 or 1010Hz have n = 800 give stable results.

The standard test frequencies in this instrument have >400 independent samples, and the specifications for A-D and D-A measurements include a corresponding allowance for gain variation with phase. The specifications for A-A measurements do not include this effect, which is present only on PCM Channels. Its magnitude may be formed from the following table:

Level (dBm0)	Gain Variation with Phase (+/-dB)		
	A-law	u-law CCS	u-law CAS
>-40	0.005	0.005	0.01
>-60	0.015	0.01	0.03
>-75	0.03	0.03	0.05

The A-A measurements affected are shown below:

A-A Measurement	Number of error contributions
Gain Quantising distortion (tone) Level	one
Gain v Frequency Gain v Level (tone) Intermodulation (2-tone)	two

ERROR CONTRIBUTIONS

Each measurement accuracy is calculated as the total sum of the worst case values of all the individual component specification that make up the neasurement. Error contributions due to transmission impairments in the system under test (eg QD in Gain vs Level measurement) are not included. Attempting to measure a tone where the frequency is not tied to the 3776 transmitter will result in an error in the following measurements:

Measurement Affected	Maximum additional error (dB)	
	Frequency	Error
Gain (tone) Gain (digital mW) Gain vs Frequency Intermod (2-tone)	200-400Hz >400Hz	0.04dB +0.01dB/Hz 0.02dB +0.01dB/Hz
Level (selective) Idle State (selective)	200-400Hz >400Hz	0.01dB +0.01dB/Hz 0.01dB/Hz

(For <5Hz offset between actual and selected Rx frequencies).

ANALOG-TO-ANALOG (A-A) MEASUREMENTS

GAIN (TONE)

Accuracy: +/-0.05dB (Tx and Rx levels >-30dBm; 200Hz to 3900Hz).

GAIN v FREQUENCY

Accuracy: +/-0.10dB (Tx and Rx levels >-30dBm; 200Hz to 3900Hz).

GAIN v LEVEL (USING NOISE) - 3776A ONLY

Accuracy (+/-dB):

Tx level (dBm)	Rx level (dBm)		
	>-46	>-66	>-76
>-46	0.15		
>-66	0.18	0.20	
>-76		0.22	0.30

Tx and Rx reference level >-36dBm0

GAIN v LEVEL (USING TONE)

Accuracy (+/-dB):

Tx level (dBm)	Rx level (dBm)		
	>-40	>-60	>-76
>-40	0.12		
>-60	0.12	0.16	
>-70		0.18	
>-76		0.22	0.30

Tx and Rx reference level >-40dBm0

NOISE WITH TONE

Transmit signal
Frequency range:
3776A - 810 to 850Hz
3776B - 1010 to 1020Hz

Level accuracy: +/-0.10dB
(for Level >-30dBm)

Accuracy (+/-dB):

S+N/N Ratio (dB)	Accuracy (+/-dB)
<30	0.5
<40	0.6
<45	0.8

Rx noise level >-80dBm

IDLE STATE (WEIGHTED, SELECTIVE OR OTHER FILTERS)

Accuracy (+/-dB):

Filter Type	Rx Level (dBm)	
	>-40	>-80
Psophometric	0.3	0.5
C-message	0.3	0.5
Selective	0.2	0.3
other filters:		
Filter A: 3Hz	0.3	0.5
Filter B: flat	0.3	0.75
Filter C: high pass	0.3	0.75

Rx signal crest factor assumed <12

LEVEL (WEIGHTED, OTHER FILTERS)

Internal Source
Frequency range: 50 to 4600Hz

Accuracy (+/-dB):

Nominal Signal Level (dBm)	Signal Level Accuracy (+/-dB)	
	50-200Hz	200-4600Hz
>-30	0.20	0.09
>-60	-	0.11
>-76	-	0.13

Auxiliary input
Gain between aux input (50kohms nominal) & analog transmit (600ohm balanced): +/-0.5dB (nominal)

Frequency range: 50 to 4600Hz

Receiver
Accuracy (+/-dB):

Filter type	Rx Level (dBm)	
	>-40	>-80
Psophometric	0.3	0.5
C-Message	0.3	0.5
other filters:		
Filter A: 3kHz	0.3	0.5
Filter B: flat	0.3	0.75
Filter C: high pass	0.3	0.75

LEVEL (SELECTIVE)

Internal source: same as LEVEL (weighted)
Auxiliary input: same as LEVEL (weighted)

Receiver
Frequency range: 200 to 3900Hz
Accuracy (+/-dB):

a) Transmit (ref) frequency same as receive (measure) frequency

Receive level (dBm)	Receive Accuracy (+/-dB)
>-40	0.10
>-80	0.14

Rx level >-80dBm

b) Transmit (ref) frequency not the same as receive (measure) frequency

Ref/Meas Ratio (dB)	Receive Accuracy (+/-dB)
<40	0.7
<45	1.1

Rx level >-80dBm

QUANTISING DISTORTION (USING NOISE) - 3776A ONLY

Accuracy (+/-dB):

S/N Ratio (dB)	Rx distortion level (dBm)	
	>-72	>-76
<40	0.5	0.9
<45	1.0	1.2

Rx noise level >-66dBm

QUANTISING DISTORTION (USING TONE)

Transmit signal
Frequency range:

3776A - 810 to 850Hz
3776B - 1010 to 1020Hz

Accuracy (+/-dB):

S+N/N Ratio (dB)	Accuracy (+/-dB)
<30	0.3
<40	0.5
<45	0.8

Rx noise level >-80dBm

INTERMODULATION (2 TONE)

Frequency range of f_A and f_B: 200 to 3900Hz
Intermodulation product, fp ($2f_A - f_B$) frequency range: 200 to 3900Hz
Tones at $|f_A - f_B|$, $|f_p - f_A|$ and $|f_p - f_B|$ >150Hz

Accuracy (+/-dB):

Tone f_A/Tone fp (dB)	Accuracy (+/-dB)
<30	0.1
<40	0.2
<45	0.5

Rx level (tone A) >-36dBm

INTERMODULATION (4 TONE) - 3776B ONLY

Accuracy (+/-dB):

Measured intermodulation (dB)	Accuracy (+/-dB)
<45	0.5
<55	1.0

Rx stimulating signal >-30dBm

RETURN LOSS (ERL) - 3776B ONLY

Tx level accuracy: +/-0.25dB
(Tx levels >-30dBm)
Rx accuracy:

Rx signal level (dBm)	Accuracy (+/-dB)
>-40 >-80	0.3 0.5

ANALOG-TO-DIGITAL (A-D) MEASUREMENTS

GAIN (TONE)

Accuracy (+/-dB):

	Accuracy (+/-dB)
3776A; 3776B (CCS) 3776B (CAS)	0.10 0.11

Tx level >-30dBm; Rx level >-20dBm0
800 independent samples

GAIN v FREQUENCY

Accuracy (+/-dB):

	Accuracy (+/-dB)
3776A; 3776B (CCS) 3776B (CAS)	0.08 0.11

Tx level >-30dBm; Rx level >-20dBm0
800 independent samples

GAIN v LEVEL (USING NOISE) - 3776A ONLY

Accuracy (+/-dB):

Tx level (dBm)	Rx level (dBm0)		
	>-40	>-55	>-60
>-46	0.11	0.12	0.18
>-56	0.12	0.13	0.19
>-66	0.13	0.14	0.20
>-76	0.15	0.16	0.22
>-82	0.18	0.20	0.25

Tx reference level >-30dBm
Rx reference level >-20dBm0

GAIN v LEVEL (USING TONE)

Frequency range: 200 to 3900Hz
Accuracy (+/-dB):
3776A and 3776B (CCS) -

Tx level (dBm)	Rx level (dBm0)		
	>-40	>-50	>-60
>-50	0.11	0.13	-
>-60	0.12	0.15	0.30
>-70	0.14	0.17	0.32
>-76	0.18	0.20	0.35

3776B (CAS) -

Tx level (dBm)	Rx level (dBm0)		
	>-40	>-50	>-60
>-50	0.12	0.15	-
>-60	0.14	0.20	0.35
>-70	0.16	0.22	0.37
>-76	0.20	0.25	0.40

Tx reference level >-30dBm; Rx reference level >-20dBm0

NOISE WITH TONE

Accuracy (+/-dB):

S+N/N Ratio (dB)	Accuracy (+/-dB)
<30	0.2
<40	0.4
<45	0.6

Rx noise level >-60dBm0

Transmit Signal
Frequency range:
3776A: 810 to 850Hz
3776B: 1010 to 1020Hz
Level accuracy: +/-0.10dB
(for level >-30dBm)

IDLE STATE (WEIGHTED, SELECTIVE, OTHER FILTERS)

Accuracy (+/-dB):

Filter type	Rx level (dBm0)	
	>-60	>-75
Psophometric	0.15	0.3
C-message	0.15	0.3
Selective	0.25	0.7
other filters:		
Filter A: 3kHz	0.15	0.7
Filter B: Flat	0.15	0.7

IDLE STATE (PCM CODES)

Transmitter: terminated with characteristic impedance
Receiver: detects average of 800 codes; result expressed as number of compressed code level steps from centre of coding law.

Signal range: bottom two segments of coding law
Resolution: +/-0.5 coded step

LEVEL (WEIGHTED, OTHER FILTERS)

Internal Source
Frequency range: 50 to 4600Hz
Accuracy (+/-dB):

Nominal Signal Level (dBm)	Signal Level Accuracy (+/-dB)	
	50-200Hz	200-4600Hz
>-30	0.2	0.09
>-60	-	0.11
>-76	-	0.13

Auxiliary input

Gain between aux input (50kohms nominal) & analog transmit (600ohms balanced): +/-0.5dB

Frequency range: 50 to 4600Hz

Accuracy (+/-dB):

Nominal Signal Level (dBm)	Signal Level Linearity (+/-dB)
>-30	0.25
>-60	0.28
>-76	0.30

Receiver

Accuracy (+/-dB):

Filter type	Rx Level (dBm0)	
	>-60	>-75
Psophometric	0.3	0.5
C-Message	0.3	0.5
other filters:		
Filter A: 3kHz	0.2	0.7
Filter B: flat	0.2	0.7

LEVEL (SELECTIVE)

Transmitter

Internal source same as LEVEL (weighted)

Auxiliary input

Receiver
Frequency range: 200 to 3900Hz
Accuracy (+/-dB):

a) Transmit (ref) frequency same as receive (measure) frequency

Receive Level (dBm0)	Receive Accuracy (+/-dB)
>-40 >-60	0.1 0.25

b) Transmit (ref) frequency not the same as receive (measure) frequency

Ref/Meas Ratio (dB)	Rx level (dBm0)	
	>-40	>-60
<40 <45	0.12 0.25	0.3 0.4

LEVEL (PCM CODES)

Transmitter
Internal source same as LEVEL (weighted)
Auxiliary input

Receiver
Detection: display the peak positive and peak negative PCM codes in 800 samples. Result expressed in compressed codes.

QUANTISING DISTORTION (USING NOISE) - 3776A ONLY

Accuracy (+/-dB):

S/N Ratio (dB)	Rx distortion level (dBm0) >-60
<40 <45	0.3 0.6

Rx noise level >-60dBm0

QUANTISING DISTORTION (USING TONE)

Transmit signal
Frequency range:
3776A - 810 to 850Hz
3776B - 1010 to 1020Hz

Accuracy (+/-dB):

S+N/N Ratio (dB)	Accuracy (+/-dB)
<30	0.2
<40	0.4
<45	0.6

Rx tone level >-60dBm0

INTERMODULATION (2 TONE)

Frequency range of f_A and f_B: 200 to 3900Hz
Intermodulation product fp ($2f_A - f_B$) frequency range: 200 to 3900Hz
Tones at $|f_A - f_B|$, $|f_p - f_A|$ and $|f_p - f_B|$ >150Hz

Accuracy (+/-dB):

Tone f_A/Tone fp (dB)	Accuracy (+/-dB)
<30	0.2
<40	0.3
<45	0.5

Rx level (tone f_A) >-20dBm0
Rx level (tone fp) >-50dBm0

INTERMODULATION (4 TONE) - 3776B ONLY

Accuracy (+/-dB):

Measured intermodulation (dB)	Accuracy (+/-dB)
<45	0.5
<55	1.0

Rx Stimulating signal >-20dBm0
Intermod Rx level >-50dBm0

RETURN LOSS (ERL) - 3776B ONLY

Tx level accuracy: +/-0.25dB
(Tx levels >-30dBm)
Rx accuracy: +/-0.3dB
(Rx levels >-60dBm)

DIGITAL-TO-ANALOG (D-A) MEASUREMENT

GAIN (TONE)

Frequency range: 200 to 3900Hz
Accuracy (+/-dB):

	Accuracy (+/-dB)
3776A; 3776B (CCS)	0.11
3776B (CAS)	0.12

Tx level >-20dBm0; Rx level >-30dBm

GAIN (DIGITAL mW)

Accuracy (+/-dB): 0.10

GAIN v FREQUENCY

Frequency range: 200 to 3900Hz
Accuracy (+/-dB):

	Accuracy (+/-dB)
3776A; 3776B (CCS)	0.10
3776B (CAS)	0.11

Tx level >-20dBm0; Rx level >-30dBm

GAIN v LEVEL (USING NOISE) - 3776A ONLY

Accuracy (+/-dB):

Tx level (dBm0)	Rx level (dBm)		
	>-46	>-66	>-82
>-40	0.10	0.15	-
>-55	0.12	0.16	-
>-60	-	0.16	0.20

Tx reference level >-20dBm0
Rx reference level >-48dBm

GAIN v LEVEL (USING TONE)

Frequency range: 200 to 3900Hz
Accuracy (+/-dB):
3776A and 3776B (CCS)

Tx Level (dBm0)	Rx Level (dBm)		
	>-40	>-60	>-76
>-40	0.08	0.12	-
>-55	-	0.15	0.20
>-60	-	0.17	0.22

3776B (CAS)

Tx level (dBm0)	Rx Level (dBm)		
	>-40	>-60	>-76
>-40	0.09	0.13	-
>-55	-	0.17	0.22
>-60	-	0.20	0.25

Tx reference level >-20dBm0; Rx reference level >-40dBm

GAIN v LEVEL (SYNCHRONISED 2kHz)

Tx PCM code levels: ideal
Frequency: 2kHz
Accuracy (+/-dB):

	Rx level (dBm)		
	>-40	>-60	>-76
3776A; 3776B (CCS)	0.05	0.10	0.20
3776B (CAS)	0.05	0.10	0.20

Rx reference level >-20dBm

NOISE WITH TONE

Transmit Signal
Frequency range:
3776A - 810 to 850Hz
3776B - 1010 to 1020Hz
Level accuracy: +/-0.01dB
(for levels >-40dBm0)

Accuracy (+/-dB):

S+N/N Ratio (dB)	Accuracy (+/-dB)
<-30	0.5
<-40	0.6
<-45	0.8

Rx noise level >-80dBm

IDLE STATE (WEIGHTED, SELECTIVE, OTHER FILTERS)

Accuracy (+/-dB): same as IDLE STATE (A-A)

LEVEL (WEIGHTED, SELECTIVE, OTHER FILTERS)

Internal Source
Frequency range: 50 to 3900Hz
Accuracy (+/-dB):

Nominal Signal Level (dBm0)	Signal Level Accuracy (+/-dB)
>-40	0.01
>-55	0.03
>-60	0.05

Auxiliary input
Aux input dBr (TLP):
-14dB (3776A)
-16dB (3776B)

Level accuracy: +/-0.5dB
Aux input flatness (nominal):

Frequency (Hz)	Accuracy (dB)
>200 to <300	+0.15, -2
>300 to <3000	+/-0.2
>3000 to <3300	+0.1, 0.4

Receiver
Accuracy (+/-dB): same as LEVEL (weighted) (A-A)

QUANTISING DISTORTION (USING NOISE) - 3776A ONLY

Accuracy (+/-dB):

S/N Ratio (dB)	Rx distortion level (dBm)	
	>-72	>-76
<-40	0.5	0.9
<-45	0.9	1.2

Rx noise levels >-68dBm

QUANTISING DISTORTION (USING TONE)

Transmit signal
Frequency range:
3776A - 810 to 850Hz
3776B - 1010 to 1020Hz

Accuracy (+/-dB):

S+N/N Ratio (dB)	Accuracy (+/-dB)
<-30	0.5
<-40	0.6
<-45	0.8

Rx noise level >-80dBm

INTERMODULATION (2-TONE)

Frequency range of f_A and f_B: 200 to 3900Hz
Intermodulation product, fp ($2f_A-f_B$) frequency range: 200 to 3900Hz
Tones at $|f_A-f_B|$, $|f_p-f_A|$ and $|f_p-f_B|$ >150Hz

Accuracy (+/-dB):

Tone f_A/Tone fp (dB)	Accuracy (+/-dB)
<30	0.1
<40	0.2
<45	0.5

Rx level (tone f_A) >-36dBm

INTERMODULATION (4 TONE) - 3776B ONLY

Accuracy (+/-dB):

Measured intermodulation (dB)	Accuracy (+/-dB)
<45	0.5
<55	1.0

Rx stimulating signal >-36dBm

RETURN LOSS (ERL) - 3776B ONLY

Tx level accuracy: +/-0.01dB
(Tx levels >-20dBm0)
Rx accuracy:

Rx Signal level (dBm)	Accuracy (+/-dB)
>-40	0.3
>-80	0.5

DIGITAL-TO-DIGITAL (D-D) MEAUSREMENTS

GAIN (TONE)

Accuracy (+/-dB):

	Accuracy (+/-dB)
3776A; 3776B (CCS) 3776B (CAS)	0.04 0.05

Tx, Rx levels >-20dBm0
800 indpendent samples

GAIN (DIGITAL mW)

Accuracy (+/-dB):

	Accuracy (+/-dB)
3776A; 3776B (CCS) 3776B (CAS)	0.02 0.03

Rx level >-20dBm0

GAIN (DIGITAL Tx-Rx)

Transmit signal: alternates two 8-bit PCM codes at 1kHz rate.
Receiver: displays the positive peak and negative peak PCM codes.
(3776B CAS signalling bits suppressed)

GAIN v FREQUENCY

Accuracy (+/-dB):

	Accuracy (+/-dB)
3776A; 3776B (CCS) 3776B (CAS)	0.05 0.08

Tx, Rx levels >-20dBm0; 800 independent samples.

GAIN v LEVEL (USING NOISE) - 3776A ONLY

Accuracy (+/-dB):

Tx level (dBm0)	Rx level (dBm0)		
	>-40	>-55	>-60
>-40	0.08	0.10	0.15
>-55	0.10	0.12	0.18
>-60	-	0.12	0.18

GAIN v LEVEL (USING TONE)

Frequency range: 200 to 3900Hz
Accuracy (+/-dB):
3776A and 3776B (CCS)

Tx level (dBm0)	Rx level (dBm0)		
	>-40	>-50	>-60
>-40	0.08	0.10	-
>-50	0.10	0.12	0.25
>-60	-	0.14	0.30

3776B (CAS)

Tx level (dBm0)	Tx level (dBm0)		
	>-40	>-50	>-60
>-40	0.10	0.12	-
>-50	0.14	0.16	0.35
>-60	-	0.18	0.35

Tx, Rx reference levels >-20dBm0

GAIN v LEVEL (SYNCHRONIZED 2kHz)

Tx PCM code levels: ideal
Frequency: 2kHz
Accuracy (+/-dB):

	Rx level (dBm0)		
	>-20	>-40	>-60
3776A; 3776B (CCS)	0.05	0.06	0.08
3776B (CAS)	0.08	0.08	0.10

Rx reference level >-20dBm0

NOISE WITH TONE

Transmit signal
Frequency range:
3776A - 810 to 850Hz
3776B - 1010 to 1020Hz
Level accuracy: +/-0.01dB
(for levels >-40dBm0)

Accuracy (+/-dB):

S+N/N Ratio (dB)	Accuracy (+/-dB)
<-30	0.2
<-40	0.4
<-45	0.6

Rx noise levels >-60dBm0

IDLE STATE (WEIGHTED, SELECTIVE, OTHER FILTERS)

Accuracy (+/-dB): same as IDLE STATE (A-D)

IDLE STATE (PCM CODES)

Transmitter: quiet background
Receiver: detects average of 800 codes; result expressed as number of compressed PCM code level steps from centre of coding law

Signal range: bottom two segments of coding law
Resolution: +/-0.5 coded step

LEVEL (WEIGHTED, SELECTIVE, OTHER FILTERS)

Internal source
Auxiliary input Tx level accuracy same as LEVEL (D-A)

Receiver accuracy (+/-dB): same as LEVEL (A-D)

LEVEL (PCM CODES)

Detects the peak positive and peak negative PCM codes in 800 samples.
Result expressed in compressed codes.

QUANTISING DISTORTION (USING NOISE) - 3776A ONLY

Accuracy (+/-dB):

S/N Ratio (dB)	Rx distortion level (dBm0) >-60
<-40	0.3
<-45	0.6

Rx noise levels >-60dBm0

QUANTISING DISTORTION (USING TONE)

Transmit signal
Frequency range:
3776A - 810 to 850Hz
3776B - 1010 to 1020Hz

Accuracy (+/-dB):

S+N/N Ratio	Accuracy (+/-dB)
<30	0.2
<40	0.4
<45	0.6

Rx tone level >-60dBm0

INTERMODULATION (2 TONE)

Frequency range of f_A and f_B: 200 to 3900Hz
Intermodulation product fp ($2f_A-f_B$) frequency range: 200 to 3900Hz
Tones at $|f_A-f_B|$, $|f_p-f_A|$ and $|f_p-f_B|$ >150Hz

Accuracy (+/-dB):

Tone fA/Tone fp (dB)	Accuracy (+/-dB)
<30	0.2
<40	0.3
<45	0.5

Rx level (tone f_A) >-20dBm0
Rx level (tone fp) >-50dBm0
800 indpendent samples

INTERMODULATION (4-TONE) - 3776B ONLY

Accuracy (+/-dB):

Measured intermodulation (dB)	Accuracy (+/-dB)
<45	0.5
<55	1.0

Rx stimulating signal >-20dBm0
Intermod Rx level >-50dBm0

RETURN LOSS (ERL) - 3776B ONLY

Tx level accuracy: +/-0.01dB
(Tx levels >-20dBm0)
Rx accuracy: +/-0.3dB
(Rx levels >-60dBm0)

ANALOG TRANSMITTER (AN Tx) ONLY

GAIN (TONE)

Frequency range: 200 to 3900Hz
Tx Level accuracy: +/-0.09dB

GAIN v FREQUENCY

Frequency range: 200 to 3900Hz
Tx level accuracy: +/-0.09dB
Tx level flatness: +/-0.04dB
(Tx levels >-30dBm)

GAIN v LEVEL (USING NOISE) - 3776A ONLY

Level accuracy:

Nominal Signal Level (dBm)	Signal Level Accuracy (+/-dB)
>-36	0.09
>-66	0.11
>-82	0.13

Level Linearity:

Nominal Signal Level (dBm)	Signal Level Linearity (+/-dB)
>-46	0.05
>-56	0.06
>-66	0.07
>-76	0.09
>-82	0.12

(Reference levels >-38dBm)

GAIN v LEVEL (USING TONE)

Frequency Range: 200 to 3900Hz
Level accuracy:

Nominal Signal Level (dBm)	Signal Level Accuracy (+/-dB)
>-30	0.09
>-60	0.11
>-76	0.13

Level linearity:

Nominal Signal Level (dBm)	Signal Level Linearity (+/-dB)
>-40	0.05
>-50	0.06
>-60	0.07
>-70	0.09
>-76	0.12

(Reference levels >-30dBm)

NOISE WITH TONE

Tx frequency range:
3776A - 810 to 850Hz
3776B - 1010 to 1020Hz
Tx level accuracy: +/-0.10dB
(Tx levels >-30dBm)

IDLE STATE

Tx: terminated with characteristic impedance
(ie 600ohms/900ohms, balanced/unbalanced)

LEVEL

Frequency range: 50 to 4600Hz
Internal Source:

Nominal Signal Level (dBm)	Signal Level Accuracy (+/-dB)	
	50 to 200Hz	200 to 4600Hz
>-30	0.2	0.09
>-60	-	0.11
>-76	-	0.13

Auxiliary input:
Auxiliary input to analog Tx gain: +/-0.5dB (nominal)

QUANTISING DISTORTION (USING NOISE) - 3776A ONLY

Nominal Signal Level (dBm)	Signal Level Accuracy (+/-dB)
>-36	0.09
>-66	0.11
>-82	0.13

QUANTISING DISTORTION (USING TONE)

Frequency range:
3776A - 810 to 850Hz
3776B - 1010 to 1020Hz
Tx level accuracy: same as Level (internal source) as above

INTERMODULATION (2 TONE)

Tone f_A/Tone f_B level ratio: <0.1dB
Tx level accuracy: +/-0.10dB
Tx spurious level: >65dB down
(Tx levels >-30dBm)

INTERMODULATION (4 TONE) - 3776B ONLY

Tx level accuracy: +/-0.10dB
(Tx levels >-30dBm)

RETURN LOSS (ERL) - 3776B ONLY

Tx level accuracy: +/-0.25dB
(Tx levels >-30dBm)

DIGITAL TRANSMITTER (DIG Tx) ONLY

GAIN (TONE)

Frequency range: 200 to 3900Hz
Tx level accuracy: +/-0.01dB

GAIN (DIGITAL mW)

Transmits fixed sequence of PCM codes as defined in CCITT Rec G711
Tx send level: ideal

GAIN (DIGITAL Tx-Rx)

Transmits two programmable PCM codes alternating at 1kHz rate
Tx send level: ideal

GAIN v FREQUENCY

Frequency range: 200 to 3900Hz
Tx level accuracy: +/-0.01dB
Tx level flatness: ideal
(Tx levels >-40dBm0)

GAIN v LEVEL (USING NOISE) - 3776A ONLY

Level accuracy:

Nominal Signal Level (dBm0)	Signal Level Accuracy (+/-dB)
>-55	0.01
>-60	0.03

Level Linearity:

Nominal Signal Level (dBm0)	Signal Level Linearity (+/-dB)
>-55	0.02
>-60	0.04

(Reference levels >-40dBm0)

GAIN v LEVEL (USING TONE)

Frequency range: 200 to 3900Hz
Level Accuracy:

Nominal Signal Level (dBm0)	Signal Level Accuracy (+/-dB)	
	3776A	3776B
>-40	0.01	0.01
>-55	0.01	0.03
>-60	0.03	0.05

Level linearity:

Nominal Signal Level (dBm0)	Signal Level Linearity (+/-dB)	
	3776A	3776B
>-40	0.02	0.02
>-55	0.02	0.04
>-60	0.04	0.06

(Reference levels >-40dBm0)

GAIN v LEVEL (SYNCHRONISED 2kHz)

Transmits sequence of PCM codes at 2kHz rate; level programmable
Tx send level: ideal

NOISE WITH TONE

Tx Frequency range:
3776A - 810 to 850Hz
3776B - 1010 to 1020Hz
Tx level accuracy: +/-0.01dB
(Tx levels >-40dBm0)

IDLE STATE

Tx code:

3776A - 11010101 [after alternate digit inversion (ADI)]
3776B - alternates 11111111 and 01111111 at 1kHz rate

LEVEL

Frequency range: 200 to 3900Hz
Internal Source:

Nominal Signal Level (dBm0)	Signal Level Accuracy (+/-dB)	
	3776A	3776B
>-40	0.01	0.01
>-55	0.03	0.03
>-60	0.03	0.05

Auxiliary input:
Same as LEVEL (D-A) meausrement.

QUANTISING DISTORTION (USING NOISE) - 3776A ONLY

Nominal Signal Level (dBm0)	Signal Level Accuracy (+/-dB)
>-40	0.01
>-60	0.03

QUANTISING DISTORTION (USING TONE)

Tx frequency range:

3776A - 810 to 850Hz
3776B - 1010 to 1020Hz

Tx level accuracy: same as LEVEL (internal source) as above

INTERMODULATION (2 TONE)

Tone f_A/Tone f_B ratio: ideal (0.0dB)
Tx level accuracy: +/-0.01dB
(Tone f_A and tone f_B >-20dBm0)

INTERMODULATION (4 TONE) - 3776B ONLY

Tx level accuracy: +/-0.01dB
(Tx levels >-20dBm0)

RETURN LOSS (ERL) - 3776B ONLY

Tx level accuracy: +/-0.01dB
(Tx levels >-20dBm0)

ANALOG RECEIVER (AN Rx) ONLY

GAIN (TONE)

Frequency range: 200 to 3900Hz
Accuracy: +/-0.10dB
(Rx level >-30dBm; assume perfect Tx level)

GAIN (DIGITAL mW)

Accuracy: +/-0.10dB
(Rx level >-30dBm; assume perfect Tx level)
As defined in CCITT REC G711

GAIN v FREQUENCY

Frequency range: 200 to 3900Hz
Accuracy: +/-0.08dB
(Rx level >-30dBm; assume perfect Tx level)

GAIN v LEVEL (USING NOISE) - 3776A ONLY

	Rx level (dBm)		
	>-46	>-66	>-82
Accuracy (+/-dB)	0.08	0.12	0.30

(Rx reference level >-28dBm; assume perfect Tx levels)

GAIN v LEVEL (USING TONE)

Frequency range: 200 to 3900Hz

	Rx level (dBm)		
	>-40	>-60	>-76
Accuracy (+/-dB)	0.06	0.10	0.18

(Rx reference level >-20dBm, assume perfect Tx levels)

GAIN v LEVEL (SYNCHRONISED 2kHz)

	Rx level (dBm)		
	>-40	>-60	>-76
Accuracy (+/-dB)	0.05	0.1	0.2

(Rx reference level >-20dBm; assume ideal Tx levels)

NOISE WITH TONE

S+N/N Ratio (dB)	Accuracy (+/-dB)
<30	0.5
<40	0.6
<45	0.8

(Rx noise levels >-80dBm)

IDLE STATE (WEIGHTED, SELECTIVE, OTHER FILTERS)

Rx accuracy: same as IDLE STATE (A-A)

LEVEL (WEIGHTED, SELECTIVE, OTHER FILTERS)

Rx accuracy: same as Level (A-A)

QUANTISING DISTORTION (USING NOISE) - 3776A ONLY

Accuracy (+/-dB):

S/N Ratio (dB)	Rx distortion level (dBm)	
	>-72	>-76
<40	0.5	0.9
<45	0.9	1.2

(Rx noise levels >-68dBm)

QUANTISING DISTORTION (USING TONE)

Accuracy (+/-dB):

S+N/N Ratio (dB)	Accuracy (+/-dB)
<30	0.5
<40	0.6
<45	0.8

(Rx noise levels >-80dBm)

INTERMODULATION (2-TONE)

Tones at $|f_A - f_B|$, $|f_p - f_A|$ and $|f_p - f_B|$ >150Hz
Accuracy (+/-dB):

Tone f_A/Tone fp (dB)	Accuracy (+/-dB)
<30	0.1
<40	0.2
<45	0.5

(Rx level (tone A) <-36dBm)

INTERMODULATION (4 TONE) - 3776B ONLY

Accuracy (+/-dB):

Measured intermodulation (dB)	Accuracy (+/-dB)
<45	0.5
<55	1.0

(Rx stimulating signal >-36dBm)

RETURN LOSS (ERL) - 3776B ONLY

Rx accuracy (+/-dB):

Rx Signal Level (dBm)	Accuracy (+/-dB)
>-40	0.3
>-80	0.5

DIGITAL RECEIVER (DIG Rx) ONLY

GAIN (TONE)
GAIN (DIGITAL mW)

	Accuracy (+/-dB)
3776A; 3776B (CCS) 3776B (CAS)	0.03 0.04

(Rx levels >-20dBm0; assume perfect Tx level; 800 independent samples)

GAIN (DIGITAL Tx-Rx)

Receiver: detects peak positive and peak negative PCM codes

GAIN v FREQUENCY

	Accuracy (+/-dB)
3776A; 3776B (CCS) 3776B (CAS)	0.05 0.07

(Rx levels >-20dBm0; assume perfect Tx level; 800 independent samples)

GAIN v LEVEL (USING NOISE) - 3776A ONLY

Accuracy (+/-dB):

Rx level (dBm0)	Accuracy (+/-dB)
>-40	0.07
>-55	0.08
>-60	0.13

(Rx reference level >-20dBm0; assume perfect Tx level)

GAIN v LEVEL (USING TONE)

Accuracy (+/-dB):

Rx Level (dBm0)	3776A	3776B (CCS)	3776B (CAS)
>-40	0.07	0.06	0.08
>-50	0.08	0.08	0.12
>-60	0.25	0.25	0.30

(Rx reference level >-20dBm0; assume perfect Tx level; 800 independent samples)

GAIN v LEVEL (SYNCHRONISED 2kHz)

Accuracy (+/-dB):

Rx Level (dBm0)	3776A	3776B (CCS)	3776B (CAS)
>-40	0.06	0.05	0.08
>-60	0.08	0.08	0.10

(Rx reference level >-20dBm0; assume ideal Tx level)

NOISE WITH TONE

Accuracy (+/-dB):

S+N/N Ratio (dB)	Accuracy (+/-dB)
<30	0.2
<40	0.4
<45	0.6

(Rx noise levels >-60dBm0)

IDLE STATE (WEIGHTED, SELECTIVE, OTHER FILTERS)

Rx accuracy: same as IDLE STATE (A-D)

IDLE STATE (PCM CODES)

Receiver: detects average of 800 codes; result expressed as number of compressed PCM code level steps from centre of coding law.
Signal range: bottom two segments of coding law
Resolution: +/-0.5 coded step

LEVEL (WEIGHTED, SELECTIVE, OTHER FILTERS)

Rx accuracy: same as LEVEL (A-D)

LEVEL (PCM CODES)

Detects the peak positive and peak negative PCM codes in 800 samples. Result expressed in compressed codes.

QUANTISING DISTORTION (USING NOISE) - 3776A ONLY

Accuracy (+/-dB):

S/N Ratio (dB)	Rx distortion level (dBm0) >-60
<-40	0.3
<-45	0.6

(Rx noise levels >-60dBm0)

QUANTISING DISTORTION (USING TONE)

Accuracy (+/-dB):

S+N/N Ratio (dB)	Accuracy (+/-dB)
<30	0.2
<40	0.4
<45	0.6

(Rx noise levels >-60dBm0)

INTERMODULATION (2 TONE)

Tones at $|f_A - f_B|$, $|f_p - f_A|$ and $|f_p - f_B|$ >150Hz

Accuracy (+/-dB)

Tone f_A/Tone fp (dB)	Accuracy (+/-dB)
<30	0.2
<40	0.3
<45	0.5

[Rx (tone A) >-20dBm0; Rx (tone fp) >-50dBm0; assume perfect Tx levels; assume Tx spurious <-60dB; 800 independent samples]

INTERMODULATION (4 TONE) - 3776B ONLY

Accuracy (+/-dB):

Measured intermodulation (dB)	Accuracy (+/-dB)
45	0.5
55	1.0

(Rx level >-20dBm0; intermod Rx level >-50dBm0)

RETURN LOSS (ERL) - 3776B ONLY

Accuracy: +/-0.3dB
(Rx levels >-60dBm0).

MEASUREMENT SPECIFICATIONS
OPTION 001

The specifications on pages 1-58 to 1-69 apply only to Models 3776A and 3776B fitted with Option 001.

MEASUREMENT SPECIFICATIONS
OPTION 001

The following specifications apply only to the 3776A/B PCM Terminal Test Set with Option 001 fitted. Option 001 provides measurements of:

3776A

Group delay distortion
Envelope delay distortion
Absolute delay
Phase jitter
Transients:
- amplitude hits
- phase hits
- interruptions
- impulse noise (3-level)

3776B

Envelope delay distortion
Remodulation
Absolute delay
Phase jitter
Transients:
- gain hits
- phase hits
- dropouts
- impulse noise (3-level)

The following table shows the various operating modes in which the measurements are valid:

Measurements	A-A	A-D	D-A	D-D	An Tx	Dig Tx	An Rx	Dig Rx
Group delay distortion	*	*	*	*	*	*	*	*
Envelope delay distortion	*	*	*	*	-	-	-	-
Remodulation	*	*	-	-	-	-	-	-
Absolute delay	*	*	*	*	-	-	-	-
Phase jitter	*	*	*	*	*	*	*	*
Transients	*	*	*	*	*	*	*	*

An Tx - Analog Transmit only
Dig Tx - Digital Transmit only
An Rx - Analog Receive only
Dig Tx - Digital Receive only

MEASUREMENTS

1. GROUP DELAY - 3776A ONLY

Analog Transmitter

Frequency range: 200 to 3600Hz
Error introduced by Tx: <+/-10us
Tx signal level: >-40dBm
Tx carrier level accuracy: 0.3dB
Note: 40% modulation adds approximately 0.33dB to signal level.

Analog Receiver
Frequency range: 200 to 3600Hz
Measurement range:
relative delay - 0 to +/-10ms
relative amplitude - 0 to +/-10dB
Signal level range (Ref and Meas): >-40dBm

a) Relative delay measurement
measurement error:

Frequency range (Hz)	Rx error (us)
200 to 400 400 to 600 600 to 3600	+/-35 +/-15 +/-10

(< +/-3dB relative attenuation, REF to MEAS;
100ppm, signal freq to Rx freq)

Typical additional error due to relative levels, REF to MEAS:

REF to MEAS (dB)	Error (us)
< +/-6 < +/-10 < -15	+10 +20 +60

Typical error due to gaussian white noise 26dB below carrier: <20us RMS
Typical error due to single tone 150Hz from carrier, +26dB below carrier: <20us

(NOTE: When the received test signal has passed through a PCM system, the sampling and quantising process of the system under test will cause spreading of results, with deviation of approximately 50 to 60us).

b) Relative amplitude measurement
Rx accuracy: +/-0.2dB nominal

c) Frequency measurement
Accuracy: +/-10Hz nominal

Digital Transmitter

Frequency range: 200 to 3600Hz
Delay error introduced by Tx: nil
Tx signal level: > -20dBm0
Tx carrier level accuracy: 0.3dB
Note: 40% modulation adds approximately 0.33dB to signal level

Digital Receiver

Frequency range: 200 to 3600Hz
Measurement range:
relative delay - 0 to +/-10ms
relative amplitude - 0 to +/-10dB
Signal level range (Ref and Meas): > -30dBm0

a) Relative delay measurement
Rx error: +/-10us
(< +/-3dB relative attenuation, REF to MEAS;
< 100ppm, signal freq to Rx freq)
Typical additional error due to relative levels:

REF to MEAS (dB)	Error (us)
< +/-6	+/-10
< +/-10	+/-20
< -15	+/-60

Typical additional error for 1% f, signal freq to Rx freq: +/-15us
Typical error due to gaussian white noise 26dB below carrier: < 20us RMS
Typical error due to single tone, 150Hz from carrier, +26dB below carrier: < 20us

(NOTE: When the received test signal has passed through a PCM system, the sampling and quantising process of the system under test will cause spreading of results, with deviation of approximately 50 to 60us).

b) Relative amplitude measurement
Accuracy: +/-0.2dB nominal

c) Frequency measurement
Accuracy: +/-10Hz nominal

2. ABSOLUTE DELAY

Analog Transmitter

Signal: modulated fixed frequency carrier
Carrier frequency range: 300 to 3500Hz

Modulation index:
3776A - 0.4 +/-0.05
3776B - 0.5 +/-0.05

Modulation frequency:
3776A - 41 2/3 +/-0.1%
3776B - 83 1/3 +/-0.1%

Analog Receiver

Signal range: >-40dBm
Measurement error: <20us
Measurement range:
3776A - 0 to 24ms
3776B - 0 to 12ms

Digital Transmitter

Signal: modulated, fixed frequency carrier
Carrier frequency range: 300 to 3500Hz
Modulation index:
3776A - 0.4 +/-0.05
3776B - 0.5 +/-0.05

Modulation frequency:
3776A - 41 2/3 +/-0.1%
3776B - 83 1/3 +/-0.1%

Digital Receiver

Signal level: >-20dBm0
Measurement error: <20us
Measurement range:
3776A - 0 to 24ms
3776B - 0 to 12ms

(NOTE: When the received test signal has passed through a PCM system, the sampling & quantising process of the system under test will cause spreading of the results, deviating by a few micro-seconds.)

3. ENVELOPE DELAY

Analog Transmitter

Frequency range: 300 to 3500Hz
Error introduced by Tx: <+/-10us
Tx Signal level: >-40dBm
Tx flatness: <+/-0.2dB

Analog Receiver

Frequency range: 300 to 3500Hz
Measurement range:
relative delay 3776A - +/-12ms
3776B - -3 to +9ms
Signal level range: >-40dBm

a) Relative delay measurement
Measurement error:

Frequency (Hz)	Error (us)
> 300	< +/-20
> 500	< +/-15

(S/N Ratio > 35dB)
Typical additional error (S/N Ratio of 24dB): < +/-10us

(NOTE: When the received test signal has passed through a PCM system, the sampling & quantising process of the system under test will cause spreading of the results, deviating by a few micro-seconds.)

b) Relative amplitude measurement
Rx accuracy: +/-0.2dB nominal

c) Frequency measurement
Accuracy: +/-10Hz nominal

Digital Transmitter

Frequency range: 300 to 3500Hz
Delay error introduced by Tx: nil
Tx signal level: > -20dBm0
Tx flatness: ideal

Digital Receiver

Frequency range: 300 to 3500Hz
Measurement range:
relative delay 3776A - +/-12ms
3776B - -3 +9ms
Signal level range: >-20dBm0

a) Relative delay measurement
Measurement error (S/N ratio > 35dB): +/-5us
Typical additional error (S/N ratio of 24dB): +/-10us

(NOTE: When the received test signal has passed through a PCM system, the sampling & quantising process of the system under test will cause spreading of the results, deviating by a few micro-seconds.)

b) **Relative amplitude measurement**
Rx accuracy: +/-20dB nominal

c) **Frequency measurement**
Accuracy: +/-10Hz nominal

4. RE-MODULATION - 3776B ONLY

Analog Transmitter

Frequency range: 300 to 3500Hz
Error introduced by Tx: <+/-10us
Tx signal level: >-40dBm
Tx flatness: <+/-0.2dB

Analog Receiver

Received frequency measurement accuracy: +/-10Hz
Rx Signal level: >-40dBm
Envelope delay introduced by receiver:
300 to 500Hz - <+/-50us
500 to 3500Hz - <+/-15us

Digital Receiver

Received frequency measurement accuracy: +/-10Hz
Rx signal level: >-40dBm
Envelope delay introduced by receiver: nil

5. PHASE JITTER

Analog Transmitter

Frequency range: 1010 to 1020Hz
Level accuracy: +/-0.10dB
(for levels >-30dBm)

Analog Receiver

Frequency range: 990 to 1030Hz
Carrier level: >-40dBm
Measurement range: 30 degrees p-p
Measurement accuracy: +/-5% +/-0.2 degrees
Spread of readings: <0.7 degrees
Selectable filters
Filter A - 20 to 300Hz
Filter B - 4 to 300Hz
Detection: true peak-to-peak

Settling time: (within 0.7° of final reading)
Filter A - <4 seconds
Filter B - <25 seconds

Typical white noise rejection at S/N ratio 30dB: <4 degrees p-p jitter
Modulation measurement weighting characteristics (two tone method):

Δf using filter A (Hz)	2	5	10	-	-	12	20-240	300	500	700
Δf using filter B (Hz)	0.4	1	2	4	6	-	8-240	300	500	700
Reading (degree p-p)	<1	<3	<8	9.2 to 12.2	10.2 to 12.2	<10	10.8 to 12.2	10 to 12.2	<3	<1

Amplitude modulation to phase modulation conversion:
3776A - < 0.2 degrees over 20 to 300Hz
3776B - < 1 degree p-p over 2 to 900Hz

Averaging time:

Gate frequency	5Hz	1Hz
Display variation	<10%	>40%

Digital Transmitter

Frequency range: 1010 to 1020Hz
Level accuracy: +/-0.01dB
(for levels >-30dBm0)

Digital Receiver

Frequency range: 900 to 1030Hz
Carrier level: >-40dBm0
Measurement range: 30 degrees p-p
Measurement accuracy: +/-5% +/-0.02 degrees
Spread of readings: <0.7 degrees
Selectable filters:
Filter A - 20 to 300Hz
Filter B - 4 to 300Hz
Detection: true peak-to-peak
Settling time:
Filter A - < 4 seconds
Filter B - < 25 seconds

Typical white noise rejection at S/N ratio 30dB: <4 degrees p-p jitter

Modulation measurement weighting characteristics (two tone method):

Δf using filter A (Hz)	2	5	10	-	-	12	20-240	300	500	700
Δf using filter B (Hz)	0.4	1	2	4	6	-	8-240	300	500	700
Reading (degree p-p)	<1	<3	<8	9.2 to 12.2	10.2 to 12.2	<10	10.8 to 12.2	10 to 12.2	<3	<1

Amplitude modulation to phase modulation conversion:
3776A - < 0.2 degrees over 20 to 300Hz
3776B - < 1 degree p-p over 2 to 900Hz

Averaging time:

Gate frequency (Hz)	5	1
Display variation (%)	<10	>40

6. TRANSIENTS

Analog Transmitter

Frequency range: 1010 to 1020Hz
Level accuracy: +/-0.10dB
(for levels >-30dBm)

Analog Receiver

Simultaneous measurements of:
gain hits
phase hits
interruptions (3776A)
dropouts (3776B)
impulse noise (3-levels)

GENERAL
Measurement time: programmable between 1min and 9hr 59min in 1min steps; or continuous
Count capacity: up to 9998 counts for each measurement; 9999 indicates overflow
Carrier Rx frequency range: 995 to 1025Hz

a) GAIN HITS
Carrier level: >-40dBm
Thresholds: selectable 2, 3, 4 or 6dB
Accuracy: +/-0.5dB
Qualification period: 3.5 to 4.5ms

Loop recovery: with a 4dB change in carrier level in time T
- to register 2dB hit: T <200ms
- not to register 2dB hit: T>600ms

Count rate:
slow count - nominal 8 counts/s
fast count (3776B only) - nominal 100 counts/s

Phase to amplitude conversion: nominal 180 degrees phase change in <0.2ms does not count on 2dB threshold

Dead time:
slow - 125ms +/-10% nominal
fast (3776B) - 10ms +/-20% nominal

b) PHASE HITS

Carrier level: >-40dBm

Threshold accuracy on slow count: +/-10% of threshold +/-0.5 degrees

Range: 5 degrees to 40 degrees in 5 degrees steps

Qualification period: 3.5 to 4.5ms

Loop recovery: with a linear phase variation of carrier over 100° in either direction in time T
- for 20° hit to be registered: T <20ms
- for 20° hit not to register: T >50ms

Count rate:
slow - nominal 8 counts/s
fast (3776B) - nominal 100 counts/s

Amplitude to phase modulation conversion: 10dB gain hit in < 0.2ms does not record 10 degrees phase hit.

Dead time:
slow - 125ms +/-10% nominal
fast (3776B) - 10ms +/-20% nominal

c) INTERRUPTIONS (3776A)

Carrier level: >-30dBm at start of measurement

Threshold/ref carrier level at start: -10dB +/-1dB

Qualification period: 2.5 to 4.0ms

Dead time:
slow - 125ms +/-25ms nominal
fast - 3ms +/- 1ms nominal

Lockout: an interruption blocks counting of other transients for duration of interruptions plus 1s +/-10% nominal.

d) DROPOUTS (3776B)

Carrier level: >-28dBm at start of measurement

Threshold/ref carrier level at start of measurement: -12dB +/-1dB

Qualification period: 3.5 to 4.5ms

Count rate:
slow - nominal 1 counts/s
fast - nominal 100 counts/s

Interlock: (a dropout blocks counting of other transients)
slow - duration of dropout plus 1s +/-10%
fast - duration of dropout plus 6ms nominal

e) IMPULSE NOISE

Thresholds: three thresholds; programmable in 1dB steps

Threshold spacing:

3776A - +3dB

3776B - +4dB

Threshold range: (lowest threshold)

3776A - -6 to -40dBm

3776B - -8 to -40dBm

Threshold accuracy (for thresholds >-25dBm): +/-1dB

Carrier rejection: >55dB

Filters:

3776A - Selectable as

Filter A: 200Hz high pass, with 1kHz notch

Filter B: 600 to 3000Hz, with 1kHz notch

Filter C: 300 to 500Hz, with 1kHz notch

3776B - notched C-message

Count rate:

slow - nominal 8 counts/s

fast - nominal 100 counts/s

Dead time:

slow - 125ms +/-10% nominal

fast - 10ms +/-10% nominal

Digital Transmitter

Frequency range: 1010 to 1020Hz

Level accuracy: +/-0.01dB

(for levels > -30dBm0)

Digital Receiver

Simultaneous measurements of:

gain hits

phase hits

interruptions (3776A)

dropouts (3776B)

impulse noise (3-levels)

Measurement time: programmable between 1 min and 9hr 59min in 1min steps; or continuous

Count capacity: up to 9998 counts for each measurement; 9999 indicates over flow

Carrier Rx frequency range: 995 to 1025Hz

a) GAIN HITS

Carrier level: >-30dBm0

Thresholds: selectable 2, 3, 4 or 6dB

Accuracy: +/-0.5dB

Qualification period: 3.5 to 4.5ms

Loop recovery: with a 4dB change in carrier level in time T

- to register 2dB hit: T <200ms
- not to register 2dB hit: T >600ms

Count rate:
slow - nominal 8 counts/s
fast (3776B) - nominal 100 counts/s
Phase to amplitude conversion: nominal 180 degrees phase change in <0.2ms does no count on 2dB threshold
Dead time:
slow - 125ms +/-10% nominal
fast (3776B) - 10ms +/-20% nominal

b) PHASE HITS
Carrier level: >-30dBm0
Threshold accuracy on slow count: +/-10% of threshold +/-0.5 degrees
Range: 5 degrees to 40 degrees in 5 degrees steps
Qualification period: 3.5 to 4.5ms
Loop recovery: with a linear phase variation of carrier level over 100° in either direction in time T
- for 20° hit to be registered: T <20ms
- for 20° hit not to register: T >50ms

Count rate:
slow - nominal 8 counts/s
fast (3776B) - nominal 100 counts/s
Amplitude to phase modulation conversion:
10dB gain hit in < 0.2ms does not record 10 degrees phase hit
Dead time:
slow - 125ms +/-10% nominal
fast (3776B) - 10ms +/-20% nominal

c) INTERRUPTIONS (3776A)
Carrier level: >-30dBm0
Threshold/ref carrier level at start of measurement: -10dB +/-1dB
Qualification period: 2.5 to 3.5ms
Dead time:
slow - 125ms +/-25ms nominal
fast - 3ms +/- 1ms nominal
Lockout: an interruption blocks counting of other transients for duration of interruption plus 1s +/-10% nominally

d) DROPOUTS (3776B)
Carrier level: >-18dBm0 at start of measurement
Threshold/ref carrier level at start of measurement: -12dB +/-1dB
Qualification period: 3.5 to 4.5ms
Count rate:
slow - nominal 1 counts/s
fast - nominal 100 counts/s
Interlock: (a dropout blocks counting of other transients)
slow - duration of dropout plus 1s +/-10% nominal
fast - duration of dropout plus 6ms nominal

e) IMPULSE NOISE

Thresholds: three thresholds; programmable in 1dB steps

Threshold spacing:
3776A - +3dB
3776B - +4dB

Threshold range: (lowest threshold)
3776A - -9 to -40dBm0
3776B - -11 to -40dBm0

Threshold accuracy (for thresholds >-25dBm): +/-1dB

Carrier rejection: >55dB

Filters:
3776A - selectable as
Filter A: 200Hz high pass, with 1kHz notch
Filter B: 600 to 3000Hz, with 1kHz notch
Filter C: 300 to 500Hz, with 1kHz notch
3776B - notched C-message

Count rate:
slow - nominal 8 counts/s
fast - nominal 100 counts/s

Dead time:
slow - 125ms +/-10% nominal
fast - 10ms +/-10% nominal

Table 1-4 Recommended Test Equipment

Instrument	Critical Specifications	Recommended Model	Use*
AC Voltmeter/ DC Voltmeter	MATH % ERROR X-Y/Y X 100 Capability, AC, 1V to 10V ranges accuracy approx +/-0.2% of the input for frequencies in the range 30Hz to 20kHz. DC, 1V to 10V ranges accuracy approx +/-0.1% of the input.	HP 3455A	PATO
AC Calibrator	Output 2 to 3V RMS +/-0.026% 200Hz to 4kHz	Fluke 5200A (The obsolete HP 745A can be used)	PO
Personal Computer	Unique Note: HP 85B Service Tool comprises the following items:- HP 85B Mainframe HP-IB Interface 128k Memory Module ROM Drawer Advanced Programming ROM Plotter/Printer ROM Matrix ROM	HP 85B Service Tool	PTO
3776 Test Program Data Cartridge	Unique	03776-10001	PTO
Pulse Generator	External-Manual capability; pulse width range from 1m sec to 3 sec. Reptition rate range from 0.3 to 10Hz. Rise and fall time variation control from 200ms to 600ms.	HP 8005B	PTO
Two Function Generators	Frequency control of frequencies in the range 300Hz to 1200Hz via external VCO input; internal/external amplitude modulating capability; external frequency modulating input; gated or burst operation; ac voltage output amplitude (sinewave) of 50mV to 1V into 600ohms.	HP 3312A (only one required for troubleshooting and Operational Verification).	PTO

*P=Performance Tests, A=Adjustments, T=T'shooting, O=Operational Verification

Table 1-4 Recommended Test Equipment (continued)

Instrument	Critical Specifications	Recommended Model	Use*
Storage ** Oscilloscope	Capable of monitoring a 0.25Hz complex signal.	HP 1741A	PO
Oscilloscope	0.005V/DIV to 5V/DIV sensitivity in ranges; 0.1us to 0.5s/DIV timebase in ranges; dual trace 20MHz bandwidth external trigger.	HP 180D/1801A/ 1821A	PTO
RMS Voltmeter	True RMS responding; ac coupled input; 100mV to 10V ranges; 10kHz bandwidth; input impedance 10Mohm shunted with |<20pF; accuracy better than +/-0.4% of range.	HP 3403C	PT
Frequency Counter	Frequency measurements in the range 200 to 4kHz.	HP 5328A	PATO
Two Oscillators	600ohm impedance; +10dBm to -80dBm output (into 600ohm); 20Hz to 20kHz frequency range; output attenuator with 90dB range in 10dB steps with an accuracy of +0.1dB at +10dBm and +/-0.2dB at < +10dBm.	HP 651B	PTO
Attenuator	600ohm input/output impedance unbalanced. 0 to 85dB attenuation range; accuracy better than +/-0.1dB at frequencies in the range 20Hz to 20kHz; 0.1dB resolution.	HP 4437A	PTO
Three 200ohm Resistors	Tolerance nominal	HP 0757-0407	PTO
600ohm Resistor	Tolerance +/-0.01%	HP 0811-3502	PO
900ohm Resistor	Tolerance +/-0.01%	HP 0811-3504	PO
75ohm Resistor	Tolerance, nominal	HP 0757-0398	P
100ohm Resistor	Tolerance +/-0.1%	HP 0757-0713 (3776B only)	P
120ohm Resistor	Tolerance +/-0.1%. Two resistors, 110ohm +10ohm combined in series.	HP 0757-0713 HP 0757-0489 (3776A only)	P

**This oscilloscope can be used for all oscilloscope applications. The storage capability is only used for one check in Section IV.

Table 1-4 Recommended Test Equipment (continued)

Instrument	Critical Specifications	Recommended Model	Use*
Matching Pad	50ohm to 75ohm, 1.5MHz to 2.1MHz	HP 11852A	P
75ohm Attenuator	-6dB and -30dB nominal	HP 3750A	P
@@BAL/UNBAL Converter	Z in 600 or 900ohm switchable. Z out <1ohm, gain +/-0.005dB, 200Hz to 4kHz	SA1	P
@@UNBAL/BAL	Z in >10kohm, Z out 600 or 900ohm Switchable, gain +/-0.005dB, 200Hz to 4kHz	SA2	P
Pulse Generator	2 separate channels which can be combined; Trigger input/output; repetition rate range from 4Hz to 4kHz; selectable polarity of pulse output; pulse width range from 0.2ms to 50ms.	HP 8160A Option 020	PTO
@Frame Word Error Detector	Unique	HP 3783A (3776A only)	P
Decode Transformer	Ratio Accuracy +/-25ppm, 200Hz to 4kHz	ESI Dekatran Type DT72A	P
Dual Power Supply	Dual DC Supply capable of supplying 0 to +15V, and 0 to -15V at 100mA.	HP 6205B	P
Spectrum Analyzer	5s/DIV timebase; 100Hz resolution bandwidth; Frequency Span /Div 2kHz.	HP 3580A	P
**Power Splitter	Characteristic impedance; 600ohm attenuation between any two ports; 6.02dB +/-0.05dB, 40Hz to 40kHz.	SA3	P
Test Oscillator	+10dBm into 600ohm Balanced, 200Hz to 4kHz.	HP 654A	P

@ Used for checking the 3776A only.
** Unique Service Accessory for Performance Tests. See Section IV for details.
@@ Service Accessory used for Performance Checks. See Section IV for details.

Table 1-4 Recommended Test Equipment (continued)

Instrument	Critical Specifications	Recommended Model	Use*
Two 75ohm UNBAL to 110ohm BAL Converters	75ohm unbal to 110ohm, 1.5MHz	HP 15508B (3776B only)	P
Two 75ohm UNBAL to 120ohm BAL Converters	75ohm unbal to 120ohm, 2MHz	HP 15508C (3776A only)	
Signature Analyzer	Qualified signature mode; adjustable thresholds.	5005A	T
Digital Multimeter	DC Current; 200uA range; accuracy; 0.4% of input.	HP 3435A	T
DC Power Supply	Adjustable positive and negative output dc voltage in the range 0 to +/-2V, with relatively fine output voltage resolution.	HP 6282A	PT
Synthesizer	600ohm Output,200Hz to 4kHz, +10dBm to -60dBm, 0.1Hz resolution. Frequency accuracy: +/-5 x 10^{-6} of programmed frequency. Frequency stability: +/-5 x 10^{-6}/day.	HP 3336A	P
Adaptor	50ohm N-male to BNC female	HP 1250-1476	P
Adaptor	70ohm N-female to BNC female	HP 1250-1536	P

SECTION II
INSTALLATION

2-1 INTRODUCTION

2-2 This section provides installation instructions for the Hewlett-Packard Models 3776A and 3776B PCM Terminal Test Sets and their accessories. This section also includes information about initial inspection and damage claims, preparation for use, packaging, storage and shipment.

2-3 INITIAL INSPECTION

WARNING
TO AVOID HAZARDOUS ELECTRICAL SHOCK, DO NOT PERFORM ELECTRICAL TESTS WHEN THERE ARE SIGNS OF SHIPPING DAMAGE TO ANY PORTION OF THE OUTER ENCLOSURE (COVERS, PANELS, METERS).

2-4 Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in Figure 1-1; procedures for checking electrical performance are given in Section IV. If the contents are incomplete, if there is mechanical damage or defect or if the instrument does not pass the Performance Tests, notify the nearest Hewlett-Packard office. If the shipping container is damaged or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for the carriers inspection. The HP office will arrange for repair or replacement at HP option without waiting for claim settlement.

2-5 PREPARATION FOR USE

WARNING
TO AVOID THE POSSIBILITY OF INJURY OR DEATH, THE FOLLOWING PRECAUTIONS MUST BE FOLLOWED BEFORE THE INSTRUMENT IS SWITCHED ON.

(A) NOTE THAT THE PROTECTION PROVIDED BY GROUNDING THE INSTRUMENT CABINET MAY BE LOST IF ANY POWER CABLE OTHER THAN THE THREE-PRONGED TYPE SUPPLIED IS USED TO COUPLE THE AC LINE VOLTAGE TO THE INSTRUMENT.

(B) IF THIS INSTRUMENT IS TO BE ENERGIZED VIA AN AUTO-TRANSFORMER TO REDUCE OR INCREASE THE LINE VOLTAGE, MAKE SURE THAT THE COMMON TERMINAL IS CONNECTED TO THE NEUTRAL POLE OF THE POWER SOURCE.

(C) THE POWER CABLE PLUG SHALL ONLY BE INSERTED INTO A SOCKET OUTLET PROVIDED WITH A PROTECTIVE EARTH CONTACT. THE PROTECTIVE ACTION MUST NOT BE NEGATED BY THE USE OF AN EXTENSION CORD WITHOUT A PROTECTIVE CONDUCTOR (GROUNDING).

2-6 Power Requirements

2-7 The instrument requires a power source of 115V or 240V ac, +10% -22%, 48 to 66Hz single phase. The maximum power consumption is 100VA. Refer to Para 2-49 for details of the internal battery associated with Assembly A14 (Memory).

2-8 Line Voltage Selection and Fuse

2-9 The line voltage is selected by the rear panel switch labelled 115V and 230V.

CAUTION
Before connecting the instrument to a power outlet ensure that the line voltage selector is correctly set, and that a fuse of the correct rating is fitted.

2-10 Fuse ratings are given in Table 2-1.

Table 2-1 Fuses

Nominal Line	Fuse Rating	HP Part Number
115V	3AT	2110-0381
230V	2AT	2110-0303

2-11 Power Cable

2-12 This instrument is equipped with a three-wire power cable. When connected to a power outlet, this cable grounds the instrument case. The type of power cable shipped with each instrument depends on the country of destination. Refer to Figure 2-1 for part numbers of the power cable and plug configurations available. The number shown below each plug is the Hewlett-Packard part number of a power cord equipped with that plug. If the appropriate power cord is not included with the instrument, notify the nearest Hewlett-Packard Sales and Service Office and a replacement will be provided.

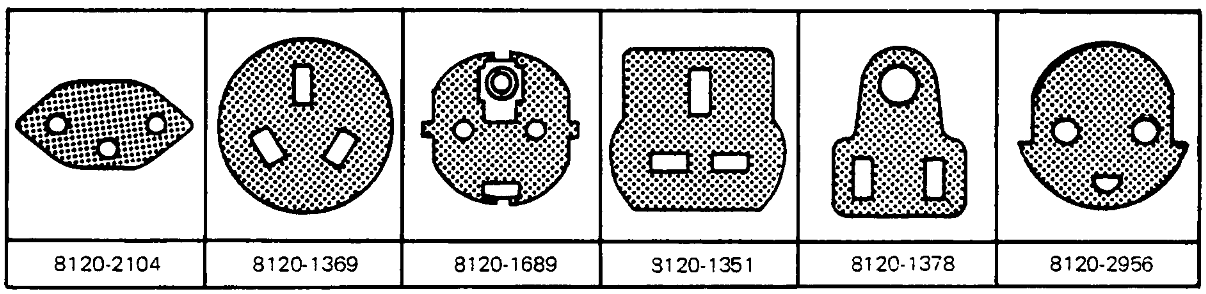


Figure 2-1 Power Receptacles

2-13 The colour code used in each power cable is given below:

```
Line:     Brown                    Ground:  Green/Yellow
Neutral:  Blue
```

2-14 Operating Environment

2-15 Temperature - The instrument may be operated in temperatures from 0 degrees centigrade to +55 degrees centigrade.

2-16 Humidity - The instrument may be operated in environments with humidity up to 95%. However, the instrument should also be protected from temperature extremes which may cause condensation within the instrument.

2-17 Altitude - The instrument may be operated at altitudes up to 4600m (15,000ft).

2-18 Air flow - The air intake to the instrument is via a fan mounted on the rear panel. The air exhaust is via the perforated side panels. To provide adequate cooling, an air gap of approximately 3 inch should be maintained around the instrument.

2-19 MATING CONNECTORS

2-20 The connectors listed in Tables 2-2 and 2-3 mate with the 3776 PCM Terminal Test Set. Details of HP-IB cables are given in Table 2-4 and details of the mains power cables are given in 2-1. Figure 2-2 identifies the front panel connectors.

Table 2-2 Rear Panel Connectors

Reference	Function	HP Part Number	Mating Connector
J1 – J4	SEE NOTE BELOW		
J9	DIG Tx CLOCK	1250-1253	Standard: 50Ω BNC to suit cable diameter. e.g.: Body: 1250-0052 Contact: 1250-0298 Bush/Clamp: 1250-0050
A23J2	HP-IB Connector	1251-4040	1251-0293
A23J3	DIG Rx DATA OUTPUT	1251-5503	1251-0219

Note: J1 – J4 fitted on rear panel on 3776B Option 004 only.
For details and connector configuration refer to Table 2-3 and Figure 2-2 on following page.

Table 2-3 Front Panel Connectors

Function		Ref	3776A/B/ Option		Connector Type	HP Part Number	Mating Conn. Part No.
DIGITAL	Rx	J1*	A	STD, 001, 002	Siemens	1251-5586	5060-4444
			B	STD, 001	WECO 310	1251-3677	1251-0695
				002	1240	1251-8589	Ord. Banana
				004	Trompeter	1250-1639	5955-0331
		J5	A	STD, 001	BNC (75Ω)	1250-0610	1250-1448
				002	Siemens	1250-1077	1250-1078
			B	STD, 001	Bantam	1251-3059	† TT-253
	Tx	J4*	A	STD, 001, 002	Siemens	1251-5586	5060-4444
			B	STD, 001	WECO 310	1251-3677	1251-0695
				002	1240	1251-8589	Ord. Banana
				004	Trompeter	1250-1639	1250-1413
		J6	A	STD, 001	BNC (75Ω)	1250-0610	1250-1448
				002	Siemens	1250-1077	1250-1078
			B	STD, 001	Bantam	1251-3059	† TT-253
ANALOG	Rx	J2*	A	STD, 001, 002	Siemens	1251-5586	5060-4444
			B	STD, 001	WECO 310	1251-3677	1251-0695
				002	1240	1251-8589	Ord. Banana
				004	Trompeter	1250-1639	5955-0331
		J8	B	STD, 001	Bantam	1251-3059	† TT-253
	Tx	J3*	A	STD, 001, 002	Siemens	1251-5586	5060-4444
			B	STD, 001	WECO 310	1251-3677	1251-0695
				002	1240	1251-8589	Ord. Banana
				004	Trompeter	1250-1639	5955-0311
		J7	B	STD, 001	Bantam	1251-3059	† TT-253

* Located on rear panel on 3776B Option 004.
† Manufacturer is Switchcraft Electronics.

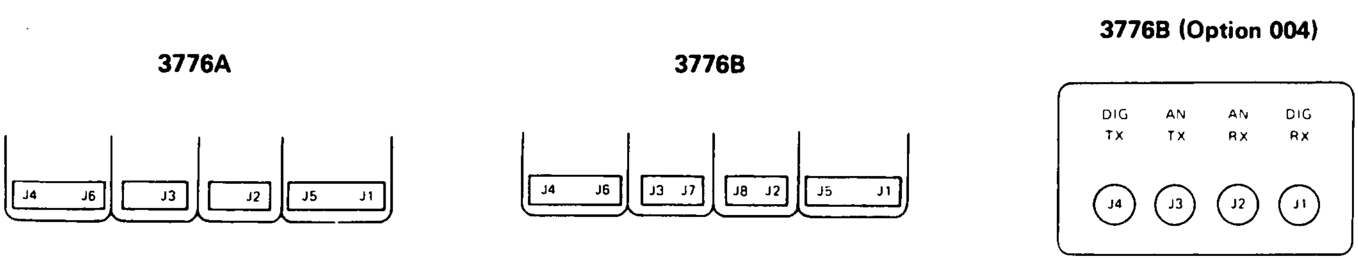


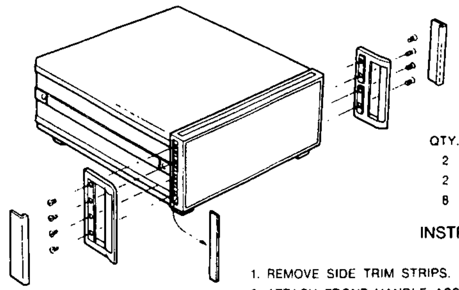
Figure 2-2 Connector Configuration

2-21 RACK MOUNTING

2-22 Illustrated in Figure 2-3 are the three Rack Mount Kits available with the 3776. See Paragraph 2-18 regarding the cooling of rack mounted instruments.

7H FRONT HANDLE KIT
(PRODUCT HT 177.0mm/6.969 in)

HP PART NUMBER 5061-0090 (OPTION 907)



CONTENTS

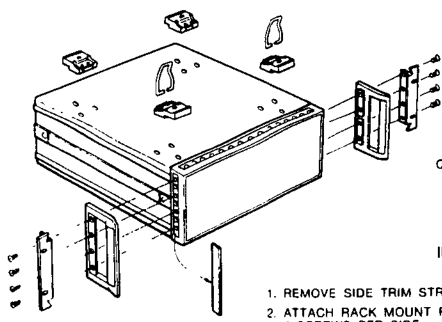
QTY.		PART NO.
2	FRONT HANDLE ASS'Y	5060-9900
2	FRONT HANDLE TRIM	5020-8897
8	#8-32 x 3/8 SCREW	2510-0195

INSTRUCTIONS

1. REMOVE SIDE TRIM STRIPS.
2. ATTACH FRONT HANDLE ASS'Y WITH 4 SCREWS PER SIDE.
3. PRESS FRONT HANDLE TRIM IN PLACE.

7H RACK MOUNT KIT WITH FRONT HANDLES
(PRODUCT HT 177.0mm/6.969 in)

HP PART NUMBER 5061-0084 (OPTION 909)



CONTENTS

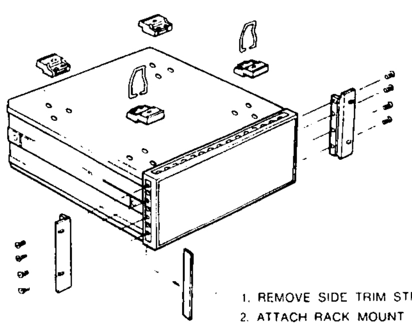
QTY.		PART NO.
2	RACK MOUNT FLANGE	5020-8875
2	FRONT HANDLE ASS'Y	5060-9900
8	#8-32 x 5/8 SCREW	2510-0194

INSTRUCTIONS

1. REMOVE SIDE TRIM STRIPS.
2. ATTACH RACK MOUNT FLANGE AND FRONT HANDLE ASS'Y WITH 4 SCREWS PER SIDE.
3. REMOVE FEET AND TILT STANDS BEFORE RACK MOUNTING.

7H RACK MOUNT KIT WITHOUT FRONT HANDLES
(PRODUCT HT 177.0mm/6.969 in)

HP PART NUMBER 5061-0078 (OPTION 908)



CONTENTS

QTY.		PART NO.
2	RACK MOUNT FLANGE	5020-8863
8	#8-32 x 3/8 SCREW	2510-0193

INSTRUCTIONS

1. REMOVE SIDE TRIM STRIPS.
2. ATTACH RACK MOUNT FLANGE WITH 4 SCREWS PER SIDE.
3. REMOVE FEET AND TILT STANDS BEFORE RACK MOUNTING.

Figure 2-3 Rack Mount Kits

2-23 HEWLETT-PACKARD INTERFACE (HP-IB) BUS INSTALLATION

2-24 This section contains information and instructions on the installation of the 3776A and 3776B PCM Terminal Test Set into a Hewlett-Packard Interface Bus (HP-IB) system.

2-25 The HP-IB is Hewlett-Packard's implementation of the IEEE Standard 488-1978 (Digital Interface for Programmable Instrumentation). This standard defines a physical interface and protocol which enables the remote control of instrumentation systems.

2-26 Connection to the HP-IB

Logic Levels

The HP-IB logic levels are TTL compatible ie the true (1) state is 0V dc to 0.5V dc and the false (0) state is +2.5V to 5V dc.

Mating Connector

HP 1251-0293;
Amphenol 57-302040

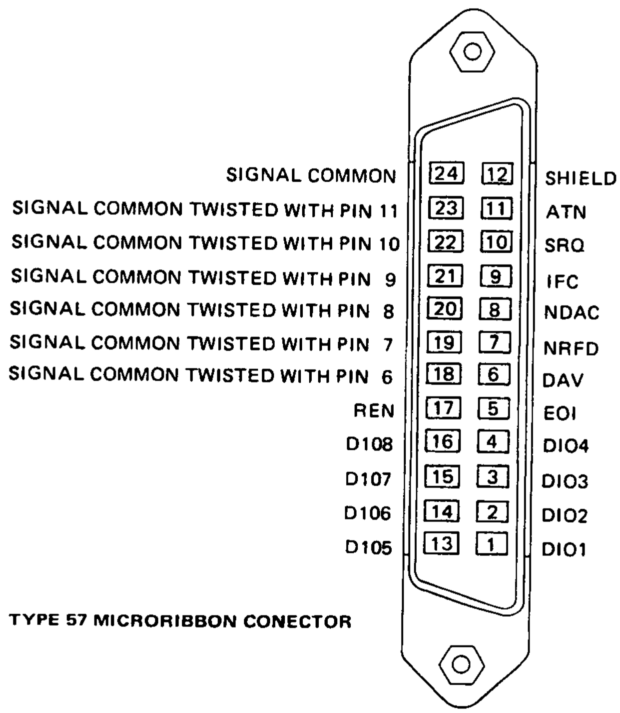


Figure 2-4 HP-IB (rear panel) Connector

2-27 The HP-IB connector on the rear panel of the 3776 provides the physical interface to connect the 3776 into an HP-IB system. Figure 2-4 illustrates the connector pin configuration. Devices in the HP-IB system may be interconnected in any suitable arrangement (star, delta, etc) using the HP-IB cables listed in Table 2-4 provided the restrictions given in Paragraph 2-28 are obeyed.

Table 2-4 HP-IB Interface Cables

HP-IB Part Numbers	Cable Lengths
HP10833A	1m (3.3ft)
HP10833B	2m (6.6ft)
HP10833C	4m (13.2ft)
HP10833D	0.5m (1.6ft)

2-28 To achieve design performance, restrictions are placed on the length of HP-IB system cable as follows:

1 The total length of HP-IB cable used to interconnect devices on the HP-IB must not exceed 2 metres (6 feet) times the number of devices in the system.

2 The total length of HP-IB cable used to interconnect all devices must not exceed 20 metres (65 feet).

2-29 3776 CONFIGURATION

2-30 The 3776 may be configured either in the TALK only mode in an HP-IB system containing a printer/plotter or as a device (addressable) under the remote control of a separate system controller (normally a computer or computing controller).

2-31 3776 in TALK ONLY Mode

2-32 In the talk only mode, an output suitable for a printer or plotter is provided at the rear panel HP-IB connector.

2-33 When the rear panel HP-IB ADDRESSABLE/TALK ONLY switch is set to TALK ONLY, the required output format is selected with the HP-IB ADDRESS/PRINT FORMAT switches (A23S1).

2-34 The output formats available are illustrated in Table 2-5.

2-35 Suitable 80 column printers are: Hewlett Packard HP 2631B, HP 2671A/G and HP 2673A.

2-36 Suitable HP GL plotters are the Hewlett Packard HP 7470A or for programmable paper advance, HP 9872C/D.

2-37 3776 Configured as an Addressable Device

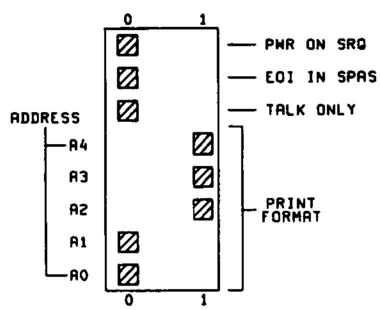
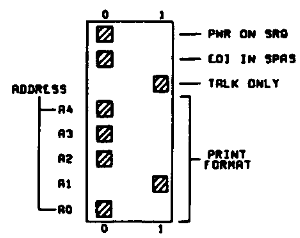
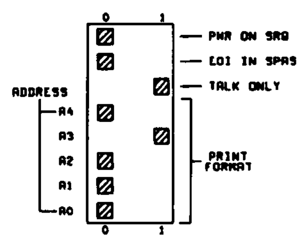


Figure 2-5 HB-IB Switches - 3776 as an Addressable Device

2-38 The setting of the TALK ONLY switch (see Figure 2-5) on the 3776 rear panel to the OFF (0) position configures the 3776 as an HP-IB addressable device under the remote control of a separate HP-IB controller. Each device in the HP-IB system requires a unique address to enable the system controller to differentiate between the devices. The address switches A0 to A4 shown in Figure A2-5 define the 3776 address (addresses range from 0 to 31).

Table 2-5 HP-IB Output Format

Binary value of PRINT FORMAT switches (A0 to A4)	Output format	Typical HP-IB ADDRESS/PRINT FORMAT Switch Setting
0 1	ASCII BINARY	
2	The 80 column printer output format comprises a header which includes the measurement code, operating mode and measurement parameters; and the measurement results output.	 Setting for 80 column printer output.
8 to 31	Plotter outputs HP-GL* A3 or A4 must = 1 A3 and A4=1 not title axes A4=1 no CCITT mask A2=1 auto paper advance A1=1 Y axis scaled A0=1 X axis scaled	 Setting for HP-GL* plotter output. with title and axes with CCIT mask without programmable paper advance with fixed X and Y axes

*HP-GL Hewlett-Packard Graphics Language

2-39 DIG Rx DATA OUTPUT (rear panel) Connector

2-40 PCM bit patterns applied to the 3776 front panel DIG Rx input may be applied to other measuring equipment through a suitable TTL interface via the 3776 rear panel DIG Rx DATA OUTPUT. Figure 2-6 illustrates the pin connections of the DIG Rx DATA OUTPUT. N DATA is the serial TTL data and is formatted low true. The signals shown in Figure 2-6 originate on A11/A111.

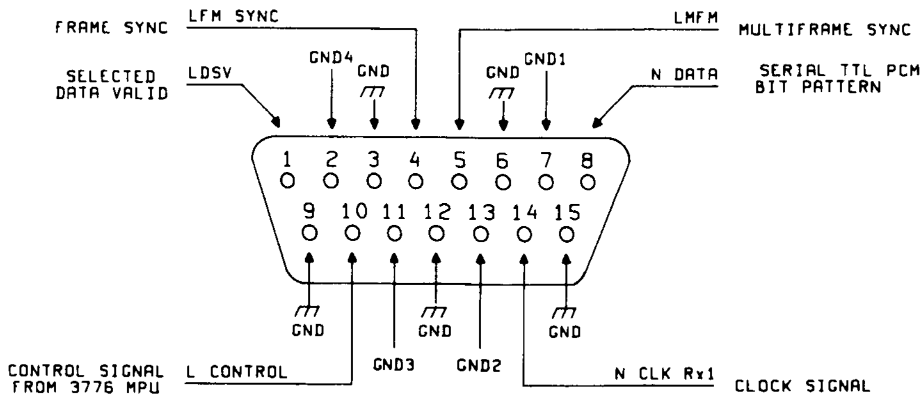


Figure 2-6 DIG Rx DATA OUTPUT Connector

2-41 STORAGE AND SHIPMENT

2-42 Environment

2-43 The instrument may be stored or shipped in environments within the following limits:

Temperature	-40 degrees centigrade to +75 degrees centigrade
Humidity	90%
Altitude	15,300m (50,000ft)

2-44 The instrument should also be protected from temperature extremes which may cause condensation within the instrument.

2-45 Packaging

2-46 Tagging for Service - If the instrument is being returned to Hewlett-Packard for service, please complete one of the blue repair tags located at the front of this manual and attach it to the instrument.

2-47 Original Packaging - Containers and material identical to those used in the factory packaging are available through Hewlett-Packard offices. If the instrument is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service required, return address, model number, and full serial number. Also mark the container "FRAGILE" to ensure careful handling. In any correspondence, refer to the instrument by model number and full serial number.

2-48 Other Packaging - The following general instructions should be used for re-packing with commercially available materials:

(a) Wrap instrument in heavy paper or plastic. (If shipping to Hewlett-Packard office or service centre, attach a tag indicating type of service required, return address, model number and full serial number.)

(b) Use strong shipping container. A double-walled carton of 350-pound test material is adequate.

(c) Use a layer of shock absorbing material 70 to 100mm (3 to 4 inch) thick around all sides of the instrument to provide firm cushioning and prevent movement inside the container. Protect the control panel with cardboard.

(d) Seal shipping container securely.

(e) Mark the shipping container "FRAGILE" to ensure careful handling.

(f) In any correspondence, refer to instrument by model number and full serial number.

2-49 INTERNAL BATTERY

WARNING
DO NOT INCINERATE OR MUTILATE THE BATTERY. IT MIGHT BURST OR RELEASE TOXIC MATERIALS CAUSING PERSONAL INJURY.

2-50 The lithium battery on A14 (used as a power supply to the non-volatile memory) should be checked annually. Life expectancy of the battery is approximately 5 years.

Operation

3

SECTION III
OPERATION

3-1 INTRODUCTION

3-2 Operating instructions are NOT available with this manual, refer to the Operating Manual or the Operators Guide for 3776 operating information.

SECTION IV
PERFORMANCE TESTS

4-1 INTRODUCTION

4-2 This section contains procedures which test the instrument's electrical performance using the specifications listed in Table 1-3 as the performance standards.

4-3 Due to the complex nature of the digital signals, some of the individual A-D, D-D, D-A and Digital Transmitter/Receiver specification parameters cannot be readily and independently verified using normally available commercial test equipment. Since the instrument is, however, effectively a generator-receiver pair, it has been possible to include self-test routines to provide internal verification for most of these parameters. These routines are performed automatically by the POWER ON test sequence and Self-test. In the event of failure, an error code is displayed (see Section VIII).

4-4 The individual parameters referred to above may be checked using a suitable PCM Multiplex terminal; however, due to the wide variety of such equipment, no attempt has been made to detail procedures for such tests - the assumption being made that the user of such standard equipment will be sufficiently familiar with its capability and operation to devise the necessary procedures.

4-5 In the following performance test procedures, the instrument's specification parameters are verified in one of three ways:

(a) independently,
(b) by self-test,
(c) by inference from other tests.

A basic operating knowledge of the 3776A/B is assumed throughout the tests. If no previous operating experience has been obtained refer to the GETTING STARTED paragraphs in the Operating Manual.

4-6 Table 4-2 gives a list of specification parameters and indicates which Performance Checks are required to verify the parameters.

4-7 OPERATIONAL VERIFICATION

4-8 To ensure (with >90% confidence) that the instrument is performing properly without testing all the specifications in Table 1-3, Operational Verification Procedures (summarised in Table 4-1) and an Abbreviated Test Record are provided.
NOTE: It is recommended that only the SELF TEST and TEST PROGRAM Tests be carried out after instrument repair or during routine maintenance.

4-9 CALIBRATION CYCLE

4-10 This instrument requires periodic verification of performance. Depending on the use and environmental conditions, the instrument should be checked, using the Operational Verification Tests, at intervals of approximately one year.

4-11 OPTIONS

4-12 The performance tests apply to all instrument options except where specified in the test procedure. Parameters for option instruments are given as an alternative to Parameters for the standard instrument where appropriate.

4-13 PERFORMANCE TEST LIST

4-14 Table 4-1 below and Table 4-3 (page 4-69) provide lists of Operational Verification Procedures and Performance Tests respectively, together with page references.

4-15 If a complete check of the analog and digital specifications is not required, Operational Verification Procedures are provided which give a better than 90% confidence level that the instrument is meeting its full specification (see Paragraph 4-21).

NOTE: It is recommended that only the SELF TEST and TEST PROGRAM Procedures be carried out after instrument repair or during routine maintenance.

4-16 EQUIPMENT REQUIRED

4-17 Equipment required for the Performance Tests and the Operational Verification Procedures is listed in the Recommended Test Equipment table in Section I. The equipment for individual tests is also listed with the test. Any equipment that satisfies the critical specifications given in the table may be substituted for the recommended model(s).

4-18 Special Service Accessories are required for full performance testing of the instrument. Details of these and the parts required to construct them are given in Appendix A at the end of this section.

4-19 TEST RECORDS

4-20 Results of the performance tests may be recorded on the Test Record at the end of the performance tests, or on the Abbreviated Test Record at the end of the operational verification procedures, as appropriate. The test records list the tested specifications and their acceptable limits. The results recorded at incoming inspection can be used for comparison in periodic maintenance, when troubleshooting, and after repairs or adjustments.

IMPORTANT NOTE
SAVING AND RE-INITIALISING NON-VOLATILE MEMORY

Before performing the Operational Verification Checks, or Performance Tests, the 3776 NVM must be re-initialised. It is recommended that customer pre- programmed measurement sequences and other data held in NVM be saved before re-initialising the NVM. See General Service Sheet G1 Section VIII of this Service Manual for procedures used for saving and re-initialising the NVM.

Table 4-1 Operational Verification Procedures

4-21 OPERATIONAL VERIFICATION PROCEDURES

4-22 INTRODUCTION

4-23 If the Operational Verfification Procedures are succesfully completed, then this gives a greater than 90% confidence level that the instrument will meet specification. Results of the Operational Verification Procedures may be tabulated on the Test Record at the end of the procedures.

4-24 POWER-ON SEQUENCE

DESCRIPTION

The power-on sequence is automatically implemented at switch-on and takes approximately 3 seconds. During this time initialisation and verification of instrument control, memory etc takes place. At the end of the sequence the instrument measurement configuration is set. If the sequence checks fail an error code will be displayed in the RESULTS window. Sequence details are given in paragraph 4-25. Normally this will not need to be read, however, the information may be useful in the event of a fault preventing the completion of the power-on sequence.

PROCEDURE

1. Re-initialise 3776 NVM (see IMPORTANT NOTE on page 4-2).

2. Set the rear panel HP-IB switch to the addressable mode (ADDR).

3. Power-up the 3776 and check that no error codes are displayed in the RESULTS window during the power-up sequence. If an error code is displayed refer to section VIII.

NOTE: The instrument HP-IB address will be displayed for a short time in the RESULTS window.

4. When the sequence is complete, check that the following conditions are set on the front panel:

```
OPERATING MODE  - ANTx, ANRx
FREQUENCY kHz   - 1.01 MEAS (3776B), 0.81 (3776A)
LEVEL           - 0.0dBm0
MEASUREMENTS    - GAIN TONE
```

NOTE: If the instrument was switched off during a TRANSIENT measurement run, then the instrument will power-up in the TRANSIENT mode.

4-25 SEQUENCE DESCRIPTION

1. 68A21 PIA INITIALISATION

Port B of the PIA (connected to the green leds on the processor board) and bits 5 and 6 of port A (connected to test pins TP1 and TP2) are configured as outputs. Bits 0, 4 and bit 7 of port B (connected to the switches and LPWRFAIL line respectively) are configured as inputs. The CB1, CB2 and CA1 pins are configured as interrupts inputs, although their capability is left disabled for the present. Port B of the PIA is then loaded with the hex word OFF to turn off all the leds.

2. 8291A HP-IB CHIP RESET

This initialises the 8291A HP-IB chip and loads the HP-IB address/Talk Only mode as set by the rear panel switches.

3. FRONT PANEL CLEAR

The front panel display ram is cleared and the display enabled. The Self Test and Run leds are then lit to indicate that the power-on self-test sequence is running.

4. PROCESSOR BOARD RAM TEST

This implements an optimal ram test algorithm due to KNAIZUK and HARTMAN (IEEE Transactions on Computers, vol C-26, 11 November 1977). The algorithm detects all combinations of stuck faults in the address decode circuitry or data cells. If this test fails Error 100 is displayed on the front panel. A faulty processor ram is catastrophic and no further progress can be made with the system initialisation.

5. PROVISIONAL HARDWARE INITIALISATION

Once the ram has been verified as working bus timout NMIs (Non Maskable Interrupts) can be enabled by setting bits 0 and 3 in PIA control register B. A hardware initialisation is now implemented to clear possible hardware IRQs and to make sure the A2, A6 and A7 boards have not powered-up in a potentially damaging state.

6. ACTIVATION OF SYSTEM MONITOR AND RESET PROGRAM

The final operation in this part of the power-on sequence is the activation of the multitasking monitor. After constructing the monitor tables and process descriptors and assigning stack area, the RESET program is scheduled and entered via the dispatcher. All subsequent power-on checks and configurations are done by the RESET program. When successfully scheduled the RESET program writes 01000 to the processor board leds.

7. SWITCH SELECTED SELF-TESTS

The switch selected tests are now called if switch S2 5 on the A13 processor board is set to "1" (up). Note that some switch selected tests run in a continuous loop, never returning to the rest of the power-on sequence. See General Service Sheet G1 in Section VIII of the Service Manual.

8. FRONT PANEL DISPLAY TEST

The front panel bus and display ram are now checked. During this test the front panel leds are kept disabled and so no display will be visible. Note: A fault in the front panel is not regarded as catastrophic as the instrument can operate normally under HP-IB control.

9. INSTRUMENT BUS TEST

The instrument bus test checks for jammed data, address and handshake lines. A working A3 board is required as the test uses the read/write coarse attenuator register on this board.

10. INSTRUMENT BUS PORT CHECKS

After the instrument bus has been verified as working, all defined ports on the bus are accessed. This makes sure all boards are loaded and their bus handshake circuitry is working. Note: The option boards are only accessed if the A4 board option link is set.

11. NON-VOLATILE AREA VERIFICATION

The non-volatile ram (A14, U43) is split into the following four logically distinct areas:-

1. The instrument configuration saved at the last power-fail.
2. Measurement parameters saved by the STORE key.
3. Measurement sequence list.
4. Dialling parameters for multifrequency and signalling bit dialling.

Each area is protected by a CRC (Cyclic Redundancy Code) and these are now checked. If a CRC is found to be wrong the corrupt area is initialised to a default state.

12. GROUP DELAY RAM TEST

This runs the ram test routine on the group delay ram (A14, U33).

13. DISPLAY OF HP-IB MODE

The HP-IB mode of operation is now displayed on the front panel result display. If addressable mode is selected, the HP-IB address is displayed as "Addr.=nn". If talk only mode is selected, the print format (as selected by the lower four HP-IB address switches) is displayed.

14. GO/NO GO CHECK

All power-on tests have now been completed. Before the instrument configuration is carried out, a final go/no go check is performed. This makes sure that ROM C, ROM A and ROM 20 on the memory board are loaded. These three roms are the minimum required to configure the 3776 to its stop-idle state. If they are missing or A14 is faulty an error code is displayed and the instrument freezes.

15. INSTRUMENT CONFIGURATION

The instrument configuration sequence is as follows:

a. The default configuration is loaded from ROM and all instrument hardware and measurement software set up according to this configuration.

b. The CRC of non-volatile area 1 is then checked and if in order, the instrument configuration saved at the last power-fail is loaded. A flag in this configuration indicates if the last power-fail was successful. If at the last power-down the processor did not receive a power-fail interrupt, or the processor was previously reset by the A13 reset switch, this flag will be clear and an error will be reported. In this case the configuration loaded will be that of the instrument at the last successful power-down.

c. The newly loaded configuration is then checked to see if a power-fail protected measurement (e.g. Transients) was running at the last power-down. If so the measurement parameters and results are recovered and the measurement re-scheduled. Otherwise a GAIN measurement in A-A mode is selected and the instrument put into the stop state.

d. The four transmitter and receiver programming routines are now called to initialise the measurement software and hardware to the current configuration. Power fail interrupts are enabled by setting the appropriate mask bit in the PIA control register A. The current configuration is now copied back to non-volatile area 1 with the power-fail flag clear.

e. The local control, remote control and idle calibration programs are now scheduled.

f. The initialisation sequence is now complete and the reset program suspends itself, waiting for a device clear from the HP-IB.

4-26 SELF-TEST

PROCEDURE

1. Press SELF TEST - CAL will be displayed.

2. Press RUN and after approximately 18 seconds, check that CAL PASS 0 is displayed. This confirms pts 2 to 11 in the SELF TEST have been checked (see SELF TEST DESCRIPTION below).

3. Press the NEXT PARAM key (pt 2 will be displayed). Continue to press the NEXT PARAM key until pt 12 is displayed.

4. Press RUN and check that no FAILS or ERROR CODES are displayed during or after the run. When the test is complete the LED on the STOP key will be illuminated.

5. Repeat step 4 for pts 13 to 21.

SELF TEST DESCRIPTION

a. Pt 2 TX GAIN

Measures the gain of the analog transmitter (atx) and tests against a predefined limit, returns pass/fail plus the actual result over the HP-IB.

b. Pt 3 RX GAIN

Measures the gain of the analog receiver (arx) and tests against a predefined limit; returns pass/fail plus the actual result over the HP-IB.

c. Pt 4 AUTORANGE GAIN PATHS

Measures the gains of the arx autorange paths and tests them against predefined limits; returns pass/fail for each point plus each actual result over the HP-IB.

d. Pt 5 AUTORANGE GAINS

Combines the autorange paths results to give the gains for all used paths and stores them in the relevant cal figure table; returns pass/fail and gain correction (mB/32) for each path over HP-IB.

e. Pt 6 ATTENUATOR GAIN PATHS

As for autorange gain paths but testing the analog transmitter (atx) attenuator.

f. Pt 7 ATTENUATOR GAINS

As for autorange gains but using attenuator gain path values and cal figure table.

g. Pt 8 ATX 16 FLATNESS

Measures the Gain versus Frequency (G v F) of the atx 16kHz path at a number of points across the band and tests each against a predefined limit; returns pass/fail for each point and each actual result over the HP-IB.

h. Pt 9 ARX FLATNESS

Measures the GvF of the arx at a number of points across the band and tests each against a predefined limit, returns pass/fail for each point and each actual result over the HP-IB.

i. Pt 10 ATX 8 FLATNESS

Measures the GvF of the atx 8kHz path at a number of points across the band and tests each against a predefined limit, returns pass/fail for each point plus each actual result over the HP-IB.

j. Pt 11 TRANSIENTS GAIN

If option 001 is loaded, measures the transients circuits and test against a predefined limit; returns pass/fail plus the actual result over the HP-IB.

k. Pt 12 ARX WEIGHTING CHECK

As ARX FLATNESS but uses a different set of limits that ensure that the combined arx path ripple and the WEIGHTING filter are within the CCITT weighting mask limits.

l. Pt 13 ROM CHECK

Generates the CRC code for each rom and checks that it is correct, returning pass/fail for each rom plus a revision code as the result over the HP-IB.

m. Pt 14 NVRAM CHECK

Verifies correct operation of the non-volatile ram (A14 U43). Then re-initialises and checks the CRC of each of the four non-volatile areas contained in this ram. Returns pass/fail and failure code over the HP-IB.

n. Pt 15 GROUP DELAY RAM CHECK

Verifies correct operation of the A14 U33 ram chip, returns pass/fail and failure code over the HP-IB.

o. Pt 16 INSTRUMENT BUS CHECK

Tests that the Interface Bus will transfer data; returns pass/fail and failure code over the HP-IB.

p. Pt 17 FRONT PANEL CHECK

Tests that data can be transfered to and from the front panel ram, returns pass/fail and failure code over the HP-IB.

q. Pt 18 TX-RX CONTINUITY

Tests that a signal from the synthesizer can be received by the digital filter via the atx and arx with the analog looping relay looped, returns pass/fail over the HP-IB.

r. Pt 19 PCM CONTINUITY

Tests that a signal from the synthesizer can be received by the digital filter via the dtx and drx with the digital looping relay looped; returns pass/fail over the HP-IB.

s. Pt 20 DIGITAL FILTER TEST

Operation of the digital filter is checked by running the following tests:-

Programming test
Interrupt rate arx/drx 16kHz
Digital Filter Bus test arx
Digital Filter Bus test drx
Digital Filter Clear test
Addition test (tests the Carry-Out counter)
Arithmetic and Hardware overflow test
Instruction Set test, (leaves the digital filter in the Signature Analysis state)

t. Pt 21 PCM FUNCTION TEST

Runs a variety of tests for the drx via the internal dtx-drx loop relay:

Checks that drx alignment is okay
Tests that correct codes are sent and received on A11/A111 code port.
Peak Codes tests
Drx to digital filter handshake test

Note: Pt 22 (ie NATTER) is not a Self-Test Check. It allows the user to set up a two way conversation over the currently selected tx and rx MODE. If digital tx or rx are selected then the current channel selection is used.

4-27 ABSOLUTE LEVEL CHECK

SPECIFICATION

Transmitter Output and Receiver Input Level Accuracy at +10dBm: +/-0.09dB

EQUIPMENT

AC Voltmeter	HP 3455A
AC Calibrator	Fluke 5200A
+/-0.01% 600ohm Resistor	HP 0811-3502
+/-0.01% 900ohm Resistor	HP 0811-3504

PROCEDURE

1. Connect the equipment as shown with the 600ohm resistor connected.

2. Set the 3776 to ANTx/ANRx LEVEL, SEL FILTER and 600ohms BAL.

3. Set the 3776 LEVEL to +10dBmO, ensure that the I/FACES Tx and Rx are set to 0.0dB.

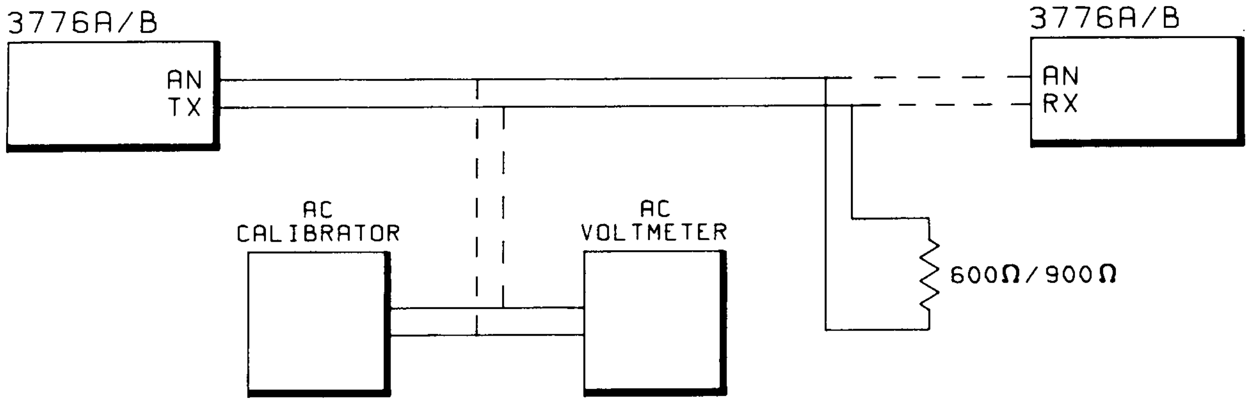


Figure 4-1 Absolute Level Test Set-up

4. Set the 3776 Frequency to 1.01kHz if a 3776B or 0.81kHz if a 3776A.

5. Set the AC Calibrator to 2.44948V/1.01kHz (3776B) or 2.44948V/0.81kHz (3776A).

6. With the AC Calibrator connected to the AC Voltmeter, select AC volts range on the AC Voltmeter and store the reference AC Calibrator voltage as Y.

7. Disconnect the AC Calibrator from the AC Voltmeter and connect the AC Voltmeter across the termination resistor.

8. Press % Error (X-Y/Y x 100) on the AC Voltmeter.

9. Convert the % Error displayed on the AC Voltmeter to a power level as follows:

   AdBmO = 20log (Vin/0.7746)
   where, Vin = 2.44948v (1+ %Error/100)

   Record the computed value AdBmO.

10. Check that AdBmO is +10dBm +/-0.09dB.

11. Disconnect the 600ohm resistor and connect the 3776 AnTx output directly to the 3776 AnRx input.

12. Press RUN and check that the displayed result is within AdBmO +/-0.09dB.

13. Repeat steps 1 to 12 with the 900ohm resistor used in place of the 600ohm resistor and the ANALOG TRANSMIT and RECEIVE impedances set to 900ohm. In Step 5 the AC Calibrator should be set to 3.0000V and in Step 9 the fomulas are:-

   AdBmO = 20log (Vin/0.9487)
   where, Vin = 3.0V (1+ %Error/100)

4-28 TEST PROGRAM

EQUIPMENT

Personal Computer..HP 85B Service Tool
3776 Test Program Data Cartridge........................03776-10001

1. Connect the HP 85 to the 3776 via the HP-IB interface. DON'T TRY STE 9000 FOR 3776A MODELS

2. Connect the 3776 DIGITAL TRANSMIT to the DIGITAL RECEIVE and connect the ANALOG TRANSMIT to the ANALOG RECEIVE.

3. Note the 3776 HP-IB address. This can be checked by switching the power on and checking that Addr = is displayed for approx 2 secs, or by checking the rear panel address switch setting (see SECTION II for ADDRESS SELECTION).

4. Load the 3776 Test Program Data Cartridge into the HP 85 with the power off.

5. Switch the HP 85 power on to run Autost (Auto start).

6. When "Autost" is loaded into the HP 85, enter day, month and year and press ENDLINE.

7. Enter current time Hours: Minutes and press ENDLINE.

8. The "TEST76" program is now automatically loaded into the Controller.

9. When "Enter HP-IB address of 3776?" is displayed, enter the address noted in Step 3 and press ENDLINE.

10. When "Error log (1 = CRT, 2 = PRINTER)?" is displayed, enter 1 and press ENDLINE if displayed error results are required or enter 2 and press ENDLINE if printed error results are required.

11. When "Enter test cycle limit, or 0 for continuous testing?" is displayed, enter the amount of program cycles required. Only 1-cycle is required for Operational Verification, enter 1 and press ENDLINE. This facility is particularily useful if continuous testing is required, i.e. if 0 is entered the program will continually cycle and any intermittant out of limit errors will be printed or displayed. Each program cycle takes about 10 minutes.

12. When "Attempts per measurement point?" is displayed, enter 1 and press ENDLINE. This facility enables individual measurements e.g. A-A Gain-Tone, to be tested a number of times before the test program steps on to the next measurement which again will be tested the same number of times.

13. When "Enable idle cal? 0 = OFF, 1 = ON" is displayed, enter 0 and press ENDLINE. This facility is useful when continuous testing is required, ie. if 1 is entered, the instrument automatically calibrates when the instrument is in the STOP state.

14. When "Enter error limit. After this number of errors the program will be aborted. Enter 0 if no error limit required?" is displayed, enter 0 and press ENDLINE. When running the TEST76 program over a long period (see Step 11), this facility is useful for limiting the number error print-out, in the event of a failure occuring in an unattended instrument.

15. When "Enable Idle cal? 0 = OFF, 1 = ON" is displayed, enter 0 address ENDLINE. The program will now

run and the following heading will be printed or displayed. After running the program proceed to Paragraph 4-30.

```
**** 3776 PERFORMANCE TESTS ****

3776A OPT 001, ADDRESS 2
FIRMWARE REV: 1.3
CYCLE LIMIT: 1
ATTEMPTS PER POINT: 1
NO ERROR LIMIT
IDLE CAL OFF


Cycle 1 12/12/83 06:12
```

A program cycle lasts for approx 10 minutes. Any out-of-limit results will be printed or displayed.

NOTE: The 3776 **FIRMWARE REV** number may change from that printed or displayed.

4-29 TEST PROGRAM DESCRIPTION

INTRODUCTION

The following checks and back-to-back measurements are performed by the TEST 76 program.

NOTE: By performing these measurements, the **HP-IB** Basic Functions (ie Talker, Listener, Serial Poll etc) are exercised.

CALIBRATION ROUTINE (See Para 4-26 Steps a to j)
A-A GAIN/TONE
A-A GAIN v FREQ
A-A GAIN v LEVEL/NOISE (3776A ONLY)
A-A GAIN v LEVEL/TONE
A-A NOISE + TONE
A-A IDLE STATE
A-A LEVEL/SEL FILTER
A-A LEVEL/OTHER FILTERS
A-A QUANT DIST/NOISE (3776A ONLY)
A-A QUANT DIST/TONE
A-A I/MOD DIST/TWO TONE
A-A I/MOD/FOUR TONE (3776B ONLY)
A-A DELAY/GROUP DELAY (3776A ONLY)

A-A OTHER MEAS/ENVEL DELAY (3776B ONLY)
A-A PHASE JITTER
A-A GAIN/TONE (Tx TLP/dBr = -20, Rx TLP/dBr = +10)
D-D GAIN/TONE
D-D GAIN/DIG MW
D-D GAIN/DIG Tx-Rx
D-D GAIN v FREQ
D-D GAIN v LEVEL/NOISE (3776A ONLY)
D-D GAIN v LEVEL/TONE
D-D GAIN v LEVEL/SYNC (2kHz)
D-D NOISE +TONE (3776A) or C-NOTCH NOISE (3776B)
D-D IDLE STATE/PCM CODES (Average Codes)
D-D LEVEL/C-MESS FILTER (3776B) OR PSOPH FILTER (3776A)
D-D LEVEL/SEL FILTER
D-D LEVEL/PCM CODES (Peak Codes)
D-D LEVEL/OTHER FILTERS
D-D LEVEL/SEL FILTER
D-D QUANT DIST/NOISE (3776A ONLY)
D-D QUANT DIST.TONE
D-D GROUP DELAY (3776A ONLY)
D-D LEVEL/PCM CODES (CHANNEL TESTS)

1. **CALIBRATION ROUTINE (see para 4-26 Steps a to j).**

2. **A-A GAIN/TONE.**

(a)

Parameters Selected

FREQUENCY kHz	LEVEL dBm0	TERMINATION	TEST LIMIT dB
0.210	+10.0	600ohm BAL	0 +/-0.05
1.010	+10.0	600ohm BAL	0 +/-0.05
3.890	+10.0	600ohm BAL	0 +/-0.05

(b) As (a) with 600ohm UNBAL selected.

(c) As (a) with 900ohm BAL selected.

(d) As (a) with 900ohm UNBAL selected.

(e) As (a) to (d) but with -30dBmO selected.

(f) As (a) to (d) but with -76dBmO selected and TEST LIMITS set to 0 +/-0.30dB.

Notes:

1. The A-A GAIN/TONE measurements checks the hardware ability to transmit and receive the correct level for several levels, frequencies and impedances.

2. For all other measurements, 600ohm BAL is selected unless otherwise stated.

3. A-A GAIN v FREQ

(a)

Parameters Selected

REF FREQ	MEAS FREQ	LEVEL	TEST LIMITS
1010Hz	210Hz to 3890Hz in 200Hz steps	+10dBm0	0 +/-0.10dB

(b) As (a) but with -30dBm LEVEL selected.

4. A-A GAIN v LEVEL/NOISE (3776A ONLY)

(a)

Parameters Selected

REF LEVEL	MEAS LEVEL	TEST LIMITS
-10dBm	0dBm to -40dBm in 10dB steps	0 +/-0.15dB
-10dBm	-50dBm and -60dBm	0 +/-0.2dB
-10dBm	-75dBm	0 +/-0.3dB

5. A-A GAIN v LEVEL/TONE

(a)

Parameters Selected

REF FREQ	REF LEVEL	MEAS LEVEL	TEST LIMITS
210Hz	-10dBm	-10dBm to -40dBm in 10dB steps	0 +/-0.12dB
210Hz	-10dBm	-50dBm and -60dBm	0 +/-0.16dB
210Hz	-10dBm	-75dBm	0 +/-0.30dB

(b) As (a) but with REF. FREQ of 1010Hz.

(c) As (a) but with REF. FREQ of 3890Hz.

6. A-A NOISE + TONE (Noise Floor Check)

Parameters Selected 3776B

FREQ	LEVEL	LIMITS
1010Hz	+10dBm	<48dBrnC0

Parameters Selected 3776A

FREQ	LEVEL	LIMITS
810Hz	+10dBm	<-42dBm0p

7. **A-A IDLE STATE (Noise Floor Check)**

Parameters Selected

INSTRUMENT	FILTER	LIMITS
3776A 3776B	PSOPH C-MESS	<-100dBm0p <-10dBrnCo

8. **A-A LEVEL/SEL FILTER (Selective Filter Check)**

Parameters Selected

LEVEL	REF FREQ	MEAS FREQ	LIMITS
+10dBm +10dBm	1010Hz 1010Hz	2020Hz 3030Hz	<-55dBm0 <-55dBm0

9. **A-A LEVEL/OTHER FILTERS (Filters Check)**

Parameters Selected

Tx FREQ	Tx LEVEL	FILTER	LIMITS (dBm0) MAX	MIN
3010Hz 3010Hz 4200Hz	+10dBm0 +10dBm0 +10dBm0	A B C	7.0 10.1 10.2	6.6 9.9 9.8

10. A-A QUANT DIST/NOISE (3776A ONLY) (Noise Floor Check)

Parameters Selected

LEVEL (dBm)	LIMIT (dB)	LEVEL (dBm)	LIMIT (dB)
0	>52.00	-35	>51.79
-5	>52.00	-36	>51.74
-10	>52.00	-37	>51.67
-15	>52.00	-38	>51.59
-20	>52.00	-39	>51.49
-25	>51.98	-40	>51.37
-29	>51.95	-41	>51.21
-30	>51.94	-45	>50.24
-31	>51.92	-50	>47.88
-32	>51.90	-55	>44.21
-33	>51.87	-60	>39.74
-34	>51.84	-66	>33.94

11. A-A QUANT DIST/TONE (Noise Floor Check)

Parameters Selected

LEVEL	LIMITS
+10dBm	>52dB
0dBm	>52dB
-20dBm	>52dB
-40dBm	>52dB
-60dBm	>41.5dB

Frequency set to 810Hz in the 3776A and 1010Hz in the 3776B.

12. A-A I/MOD DIST/TWO TONE

With the LEVEL set to 0dBm, Frequency F1 = 320Hz and F2 = 470Hz, third order product i.e. 2F2-F1 = 620Hz is measured at the Receiver. Limit set to <-60dB.

13. A-A I/MOD/FOUR TONE (3776B ONLY)

With Output LEVEL set to -5dBm 2nd and 3rd order product limits set to <-60dB.

14. A-A DELAY/GROUP DELAY (3776A ONLY)

(a)

Parameters Selected

LEVEL	REF FREQ	MEAS FREQ	LIMITS	ATTEN LIMITS
-5dBm	1810Hz	210Hz	0 +/-0.045ms	0 +/-0.2dB
		1010Hz	0 +/-0.020ms	0 +/-0.2dB
		1810Hz	0 +/-0.020ms	0 +/-0.2dB
		1980Hz	0 +/-0.020ms	0 +/-0.2dB
		2590Hz	0 +/-0.020ms	0 +/-0.2dB
		3590Hz	0 +/-0.020ms	0 +/-0.2dB

(b) As (a) but with output level set to -30dBm.

15. A-A OTHER MEAS/ENVEL DELAY (3776B ONLY)

(a)

Parameters Selected

LEVEL	REF FREQ	MEAS FREQ	LIMITS	ATTEN LIMITS
-5dBm	1810Hz	310Hz	0 +/-0.030ms	0 +/-0.2dB
		610Hz	0 +/-0.030ms	0 +/-0.2dB
		1010Hz	0 +/-0.025ms	0 +/-0.2dB
		1510Hz	0 +/-0.025ms	0 +/-0.2dB
		1810Hz	0 +/-0.025ms	0 +/-0.2dB
		2010Hz	0 +/-0.025ms	0 +/-0.2dB
		2510Hz	0 +/-0.025ms	0 +/-0.2dB
		3010Hz	0 +/-0.025ms	0 +/-0.2dB
-5dBm	1810Hz	3490Hz	0 +/-0.025ms	0 +/-0.2dB

(b) As (a) but with LEVEL set to -30dBm.

16. A-A PHASE JITTER

(a) Output LEVEL set to 0dBm, frequency set to 1010Hz and FIL A selected. Limits 0 to 0.7 degrees.

(b) As (a) but with FIL B selected.

17. A-A GAIN/TONE (Tx TLP/dBr =-20, Rx TLP/dBr =+10)

(a) Level set to 0dBmO, frequency to 1010Hz, Tx TLP/dBr =-20, Rx TLP/dBr =+10 and 600ohm terminated and bridged. Limits set to -30 +/-0.05.

(b) As (a) but ANALOG RECEIVE set to 600ohm BRIDGED. Limits set to -24.03 +/-0.05.

18. D-D GAIN/TONE

(a) With the instrument configured as detailed below, LEVEL is set to 0dBmO and FREQUENCY to 1010Hz. Limit set to 0.01 +/-0.04 (3776A) or 0.02 +/-0.04 (3776B).

3776A Configuration	3776B Configuration
DIGITAL TRANSMIT SYNTH PCM	DIGITAL TRANSMIT SYNTH PCM
DIGITAL RECEIVE TERM	DIGITAL RECEIVE TERM
Tx CHANNEL 1	TX TIMESLOT 1
Rx CHANNEL 1	Rx TIMESLOT 1
30 Audio Channels	FT FORMAT
HDB3 CODE	AMI (AZS) CODE
CAS	CCS
INT CLK	INT CLK

(b) As (a) but with LEVEL set to -20dBmO and Limits set to -0.02 +/-0.04 (3776A) or 0.00 +/-0.04 (3776B).

(c) As (a) but with LEVEL set to -40dBmO and Limits set to 0.02 +/-0.04 (3776A) or 0.03 +/-0.04 (3776B).

(d) As (a) but with LEVEL set to -50dBmO and Limits set to 0.09 +/-0.08 (3776A) or 0.04 +/-0.08 (3776B).

(e) As (a) but with LEVEL set to -60dBmO and Limits set to 0.70 +/-0.10 (3776A) or 0.20 +/-0.10 (3776B).

19. D-D GAIN/DIG MW

Runs DIG MW with Limits set to 0 +/-0.02dB.

20. D-D GAIN/DIG Tx-Rx

Codes set to +127, -0 (3776A) or +85, -42 (3776B).
Limits set to +127, -0 (3776A) or +85, -42 (3776B).

21. D-D GAIN v FREQ

Parameters Selected

LEVEL	REF FREQ	MEAS FREQ	LIMITS
-20dBm0	1010Hz	210Hz 1010Hz 3590Hz	0 +/-0.05dB 0 +/-0.05dB 0 +/-0.05dB

22. D-D GAIN v LEVEL/NOISE (3776A ONLY)

Parameters Selected

REF LEVEL	MEAS LEVEL	LIMITS
-20dBm0	-5dBm0 -20dBm0 -40dBm0 -55dBm0 -60dBm0	0 +/-0.08dB 0 +/-0.08dB 0 +/-0.08dB 0.4 +/-0.12dB 0.16 +/-0.18dB

23. D-D GAIN v LEVEL/TONE

Parameters Selected

REF LEVEL	MEAS LEVEL	3776A LIMITS	3776B LIMITS
-20dBm0	+2.1dBm0 0.0dBm0 -20dBm0 -40dBm0 -50dBm0 -60dBm0	0.03 +/-0.08dB 0.03 +/-0.08dB 0.0 +/-0.08dB 0.04 +/-0.08dB 0.09 +/-0.12dB 0.72 +/-0.30dB	0.01 +/-0.08dB 0.02 +/-0.08dB 0.0 +/-0.08dB 0.03 +/-0.08dB 0.04 +/-0.12dB 0.30 +/-0.30dB

24. D-D GAIN v LEVEL/SYNC (2kHz)

Parameters Selected

REF CODE	MEAS CODE	3776A LIMITS	3776B LIMITS
92	127(3776A) or 126 (3776B) to 16	0.0 +/-0.05	0.0 +/-0.05
	15 to 3	0.0 +/-0.06	0.0 +/-0.08

25. D-D NOISE + TONE (3776A) or C-NOTCH NOISE (3776B)

(a) In the 3776A, OdBmO LEVEL/810Hz FREQ is selected and the LIMIT is set at <-35dBmOp.

(b) In the 3776B, OdBmO LEVEL/1010Hz FREQ is selected and the LIMIT is set at <55dBrnCO.

26. D-D IDLE STATE/PCM CODES (Average Codes)

The average of approx 800 timeslots or Quiet Tone codes is measured. The Limit is set at 0 +/-0.01.

27. D-D LEVEL/C-MESS FILTER (3776B) or PSOPH FILTER (3776A)

Parameters Selected

Tx FREQ	Tx LEVEL	LIMITS 3776A	LIMITS 3776B
3010Hz	0dBm0	-5.99 +/-0.3dBm0p	86.5 +/-0.3dBrnC0

28. D-D LEVEL/SEL FILTER

Parameters Selected

Tx FREQ	Tx LEVEL	LIMITS 3776A	LIMITS 3776B
3010Hz	0dBm0	0.01 +/-0.3dBm0	0.02 +/-0.3dBm0

29. D-D LEVEL/PCM CODES (Peak Codes)

Parameters Selected

Tx FREQ	Tx LEVEL	LIMITS
3010Hz	0dBm0	+118 -118

30. D-D LEVEL/OTHER FILTERS

Parameters Selected

Tx FREQ	Tx LEVEL	FILTER	LIMITS 3776A	LIMITS 3776B
3010Hz	0dBm0	A B	-3.2 +/-0.20dBm0 0.0 +/-0.20dBm0	-3.2 +/-0.20dBm0 0.0 +/-0.20dBm0

31. D-D LEVEL/SEL FILTER

Parameters Selected

REF or Tx FREQ	Tx LEVEL	MEAS or Rx FREQ	LIMITS
1010Hz	0dBm0	3030Hz	<-50dBm0

32. D-D QUANT DIST/NOISE (3776A ONLY)

Parameters Selected

LEVEL (dBm0)	LIMITS (dBm0)	LEVEL (dBm0)	LIMITS (dBm0)
-5	-37.4	-19	-37.29
-9	-37.39	-20	-37.26
-10	-37.39	-21	-37.18
-11	-37.38	-25	-36.86
-12	-37.38	-30	-35.86
-13	-37.37	-35	-33.7
-14	-37.36	-40	-20.19
-15	-37.35	-45	-25.79
-16	-37.33	-50	-21
-17	-37.31	-55	-16.07
-18	-37.29	-60	-11.09

33. D-D QUANT DIST/TONE

Parameters Selected

FREQ (3776A)	FREQ (3776B)	LEVEL (dBm0)	LIMITS
810Hz	1010Hz	+3	-35
		-20	-34.84
		-40	-28.03
		-55	-13.97
		-60	-8.99

34. D-D GROUP DELAY (3776A Only)

(a)

Parameters Selected

LEVEL	REF FREQ	MEAS FREQ	DELAY LIMITS	ATTEN LIMITS
-5dBm	1810Hz	210Hz	0 +/-70us	0 +/-0.2dB
		1010Hz	0 +/-70us	0 +/-0.2dB
		1810Hz	0 +/-70us	0 +/-0.2dB
		1980Hz	0 +/-70us	0 +/-0.2dB
		2590Hz	0 +/-70us	0 +/-0.2dB
		3590Hz	0 +/-70us	0 +/-0.2dB

(b) As (a) but with output level set to -30dBm.

35. D-D LEVEL/PCM CODES (CHANNEL TESTS)

Digital Tx Foreground codes are set to +/-118 and Digital Rx Background codes are set to +/-15.

(a) Tx Foreground Timeslot/Channel set to 10 and Rx Timeslots/Channels 1 to 24 (3776B) or 1 to 30 (3776A) are checked. Limit set for Rx Foreground Timeslot/Channel is +/-118 and all other Timeslots/Channels is +/-15.

(b) As (a) but with Tx Foreground Timeslot/Channel 21 selected.

(c) As (a) but with Tx Foreground Timeslot/Channels set to 1..24 (3776B) or 1..30 (3776A).

(d) As (a) but with Tx Timeslot/Channel set to -10.

(e) As (a) but with Tx Timeslot/Channel set to -21.

4-30 INTERRUPTIONS (3776A)/DROPOUTS (3776B) OPTION 001

SPECIFICATION

3776B
Threshold/ref carrier level
at start of measurement: -12dB +/-1dB

Qualification Period: 3.5 to 4.5ms

3776A
Threshold/ref carrier level
at start of measurement: -10dB +/-1dB

Qualification period: 2.5 to 4.0ms

DESCRIPTION

Dropouts or Interruptions are tested by amplitude modulating a sinewave carrier using a pulse. By adjusting the amplitude of the pulse, the depth of level of the dropout or interruption can be varied (see Figure 4-2).

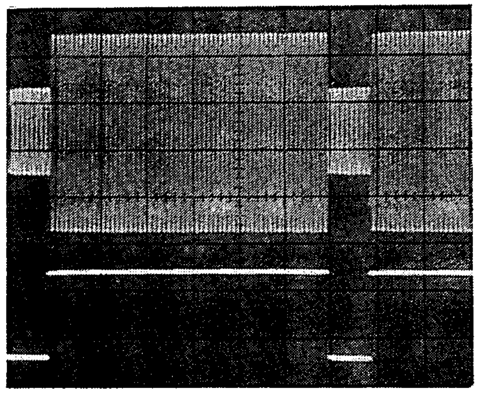


Figure 4-2 Dropout or Interruption Test Waveform

EQUIPMENT

Pulse Generator	HP 8005B
Function Generator	HP 3312A
Oscilloscope Mainframe	HP 180A
Dual Channel Vertical Amplifier Plug-in	HP 1801A
Time Base Plug-in	HP 1821A
AC Voltmeter	HP 3455A
Frequency Counter	HP 5328A

PROCEDURE

Threshold

1. Set the 3776 as follows:

OPERATING MODE	ANRx
MEASUREMENTS	TRANSIENTS
ANALOG RECEIVE	600ohm (Terminated)

2. Using the PARAMETERS and SET keys, set the 3776 for SLO Count; 1.00hr; -12dB d.out (3776B) or -10 Irpt (3776A).

3. Connect the equipment as shown in Figure 4-3.

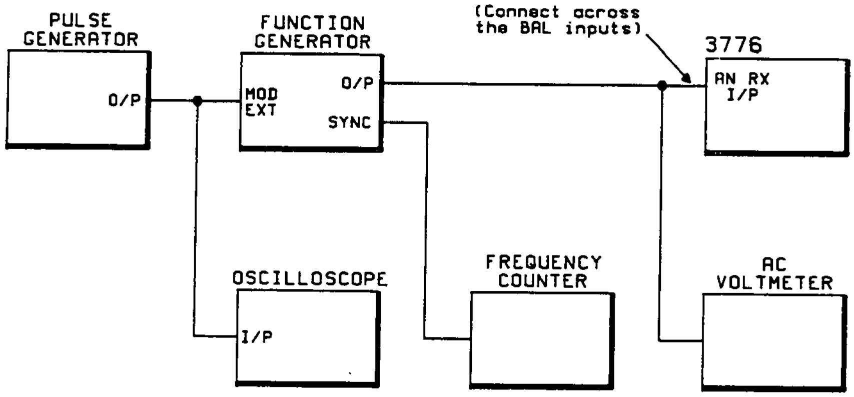


Figure 4-3 Dropouts/Interruptions Test

4. Set the Pulse Generator to provide a 4Hz repetition rate negative pulse of width 10ms as displayed on the Oscilloscope.

5. Set the Pulse Generator operating mode to GATED. The level displayed on the Oscilloscope should be 0V ac.

6. Set the Function Generator to give a sinewave output at 1010Hz +/-10Hz (if using HP 3312A see settings below) as displayed on the Frequency Counter. Adjust the Function Generator amplitude control for a reading of 2.450 +/-0.002V (+10dBm into 600ohm) as displayed on the AC voltmeter.

   3312A settings:

   MODULATION........EXT, AM, % control to mid-range
   FUNCTION........ ~
   TRIGGER PHASE........FREE RUN
   RANGE Hz........ 100Hz
   OFFSET........CAL
   SYM........CAL

7. Set the 3776 CONTROL to RUN and press the NEXT PARAM key to display -12dB d.out (3776B) or -10dB Irpt (3776A).

   Note: The 3776 will use the level measured at the beginning of the run as a reference.

8. Set the Pulse Generator operation to normal and adjust the pulse amplitude to obtain the point where the 3776 just begins to accumulate counts in the results window.

9. Set the Pulse Generator PULSE WIDTH control to its maximum (preferably about 3 secs) and check that the AC Voltmeter reading is between 0.690 and 0.548V (ie between -1dBm and -3dBm) if the instrument is a 3776B or between 0.869 and 0.690 (ie between +1dBm and -1dBm) for the 3776A, during the 3 second pulse periods.

Guard Interval

10. Adjust the Pulse Generator Amplitude to give an AC Voltmeter indication of 0.435V +/-0.002 during the 3 second pulse periods (ie -15dB below the +10dBm reference level) for the 3776B or 0.581V +/-0.002V (ie -12.5dB below the +10dBm reference level) if the instrument is a 3776A.

    Note: These levels will ensure dropouts (interrupts) are counted for the next step.

11. Reduce the Pulse Generator pulse width to obtain the point where the counts just stop accumulating in the 3776 RESULTS window.

12. Check that the output pulse width displayed on the Oscilloscpe is between 3.5 and 4.5ms (3776B) or between 2.5 and 4.0ms (3776A).

4-31 IMPULSE NOISE (3776B Only) OPTION 001

SPECIFICATION

Threshold Range:	Low; Selectable in 1dB steps between -8dBm0 to -40dBm0. Mid; always 4dB above Low (i.e. range between -4dBm0 to -36dBm0). High; always 4dB above Mid (i.e. range between 0dBm0 to -32dBm0).

Threshold Accuracy for threshold >-25dBm : +/- 1dB

DESCRIPTION

The Impulse Noise threshold range and accuracy tests use a 1810Hz sinewave of known amplitudes to test the three thresholds. A 1010Hz sinewave is combined with the 1810Hz sinewave to ensure that impulse counts are not inhibited by other Transient measurements. The 1010Hz holding tone is notched out by the 3776B and therefore does not affect the impulse noise thresholds.

NOTE: Thresholds set correspond to peak values (e.g. a count/no count condition occurs when the threshold is set to 0dBmO and a sinewave used as a source of impulse noise is at a level of -3dBmO).

EQUIPMENT

Test Oscillator	HP 651B
AC Voltmeter	HP 3455A
Frequency Counter	HP 5328A
Attenuator (600ohm)	HP 4437A
Three 200ohm Resistors	HP 0757-0407

PROCEDURE

Threshold Range and Threshold Accuracy

1. Connect up the test circuit as shown in Figure 4-4 with the Attenuator set to 0dB.

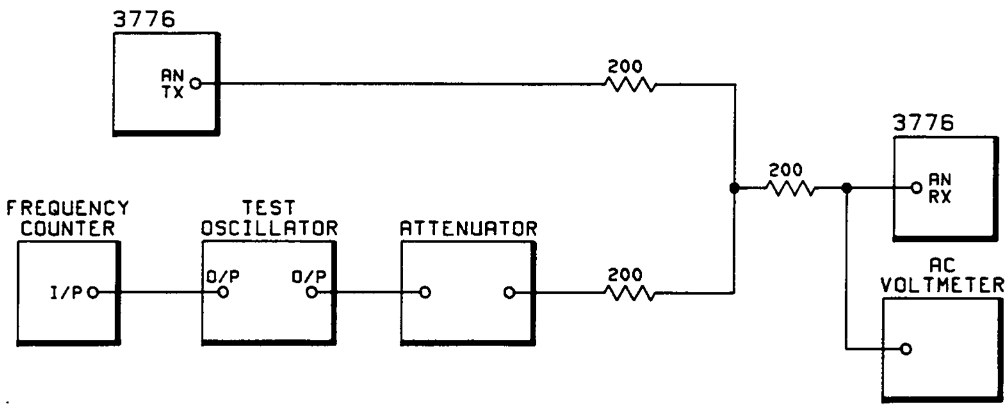


Figure 4-4 3776B Impulse Noise Threshold Range and Threshold Accuracy and Test Set-up

2. Set the Test Oscillator output voltage to its minimum.

3. Set the 3776 to 600ohms UNBAL/A-A TRANSIENTS with the REF Frequency set to 1010Hz and LEVEL set to +6dBm0. Press RUN and check that approximately 0.7745V is displayed on the AC Voltmeter. Press STORE.

4. Press STOP on the 3776.

   Note: If Option 002 is fitted, set the Test Oscillator output level and frequency to give 0.7745V +/-0.0005V displayed on the AC Voltmeter and 1810Hz +/-10Hz displayed on the Frequency Counter then go to Step 7.

5. Set the 3776 to A-A, IDLE STATE, C-MESS FILTER or A-A IDLE STATE, WEIGHTED if Option 002 is fitted.

6. Press RUN/REPEAT on the 3776 and set the Test Oscillator output level and frequency to give 90dBrnC0 displayed on the 3776B RESULTS display and 1810Hz +/-10Hz displayed on the Frequency Counter.

   Note: Setting the 3776 to IDLE STATE, C-MESS FILTER or WEIGHTED FILTER then adjusting the test oscillator output level to give 90dBrnCo on the 3776 display compensates for the loss (approximately 1.5dB) in the C-MESS or WEIGHTED filter at 1810Hz.

7. Press STOP; set the 3776 to A-A TRANSIENTS and press RECALL.

8. Set the 3776 to TRANSIENTS, SLO Count/1.00hr/40 degrees P.hit/-8.0dBm0 I.cnt/Low Threshold and press RUN.

   Note: If option is fitted, select Fil. A on the I.cnt display. Setting the P.hit threshold to 40 degrees ensures that phase hits, which inhibit inpulse counts, are not detected.

9. Set the LOW Threshold as shown in Table 1. At each setting, scroll the appropriate threshold count in turn (i.e. LOW, MID and HIGH) and adjust the Attenuator to give a count/no count condition on the 3776 display. Check when the count/no count condition is reached that the Attenuator setting is within the limits given in Table 1.

Table 1

LOW Threshold Setting (dBm0)	LOW Attenuator Limits		MID Attenuator Limits		HIGH Attenuator Limits	
	Max	Min	Max	Min	Max	Min
-8	12	10	8	6	4	2
-10	14	12	10	8	6	4
-20	24	22	20	18	16	14
-25	29	27	25	23	21	19

4-32 IMPULSE NOISE (3776A Only) OPTION 001

SPECIFICATION

Threshold Range: Low; Selectable in 1dB steps between -6dBm0 to -40dBm0.

Mid; Always 3dB above Low (ie range between -3dBm0 to -37dBm0).

High; Always 3dB above Mid (ie range between 0dBm0 to -34dBm0).

Threshold Accuracy for threshold >-25dBm : +/- 1dB.

Weighting Filters:

Filter A: 200Hz High Pass, with 1kHz Notch.

Filter B: 600Hz to 3000Hz, with 1kHz Notch.

Filter C: 300Hz to 500Hz, with 1kHz Notch.

DESCRIPTION

The Impulse Noise threshold range and accuracy tests use a 1810Hz sinewave to test the threshold when Filter A is selected. A 1010Hz sinewave is combined with the 1810Hz sinewave to ensure that impulse counts are not inhibited by other Transient measurements. The 1010Hz tone is notched out by the 3776A Rx and therefore does not affect the impulse noise thresholds. Filters B and C characteristics are checked by Self Test.

EQUIPMENT

Test Oscillator..HP 651B
Attenuator (600ohm)....................................HP 4437A
Three 200ohm resistors............................HP 0757-0407
AC Voltmeter...HP 3455A

PROCEDURE

Threshold Range and Threshold Accuracy

1. Connect the equipment as shown in Figure 4-5.

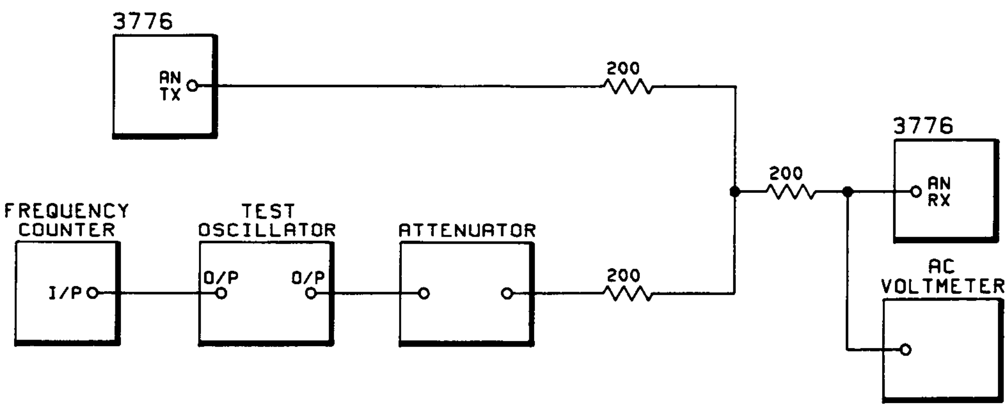


Figure 4-5 3776A Impulse Noise Threshold Range and Threshold Accuracy Test Circuit.

2. Set the Test Oscillator output voltage to its minimum.

3. Set the 3776 to 600ohms UNBAL/A-A TRANSIENTS with REF Frequency set to 1010Hz and the LEVEL set to +6.00dBm0. Press RUN and check that approximately 0.7745V is displayed on the AC Voltmeter.

4. Press STOP and set the 3776 to AnRx only.

5. Set the Attenuator set to 02.0dB, and set the Test Oscillator to give 0.7745V +/-0.0005V displayed on the AC Voltmeter and 1810Hz +/-10Hz displayed on the Frequency Counter.

6. Set the 3776 to A-A TRANSIENTS/SLO Count/1-00hr/40 degrees P.hit/Fil.A, -6dBm0, I.cnt and press RUN. The combined AnTx and Test Oscillator output should now be applied to the 3776 AnRx input.

Note: Setting the P.hit threshold to 40 degrees ensures that the impulse counts are not inhibited by phase hits.

7. Set the LOW I.cnt threshold as shown in Table 1. At each setting, scroll the appropriate threshold count in turn (ie LOW, MID and HIGH) and adjust the Attenuator to give a count/no count condition on the 3776 display. Check that when the count/no count condition is reached the Attenuator setting is within the limits given in Table 1.

Table 1

LOW Threshold Setting (dBm0)	LOW Attenuator Limits (dB)		MID Attenuator Limits (dB)		HIGH Attenuator Limits (dB)	
	Max	Min	Max	Min	Max	Min
-06	9	7	6	4	3	1
-10	13	11	10	8	7	5
-20	23	21	20	18	17	15
-25	28	26	25	23	22	20

4-33 GAIN HITS (OPT 001)

SPECIFICATION

Thresholds: 2, 3, 4 and 6dB

Threshold Accuracy: +/-0.5dB

Guard Interval or
Qualification Period: If the test tone exceeds a threshold by 1dB and returns to its original value within 3.5ms, a Gain Hit should not be counted. If the test tone returns to its original level after 4.5ms, a Gain Hit should be counted.

DESCRIPTION

A Gain-hit is classified as an abrupt change in gain of a received test tone.

EQUIPMENT

Pulse Generator	HP 8005B
Function Generator	HP 3312A
Oscilloscope Mainframe	HP 180A
Vertical Amplifier Plug-in	HP 1801A
Time Base Plug-in	HP 1821A
AC Voltmeter	HP 3455A

PROCEDURE

Threshold Accuracy

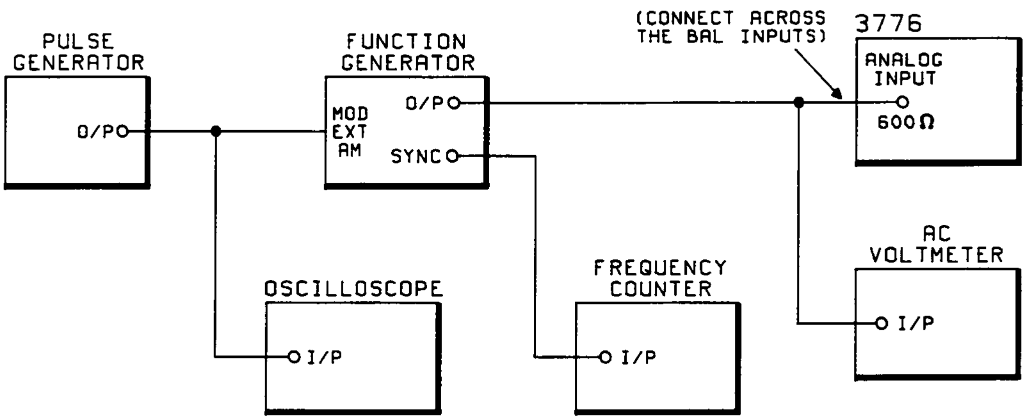


Figure 4-6 Gain Hits Test Set-up

1. Connect the equipment as shown in Figure 4-6.

2. Set the 3776 as follows:

OPERATING MODE	ANRx
MEASUREMENTS	TRANSIENTS
ANALOG RECEIVE	600ohm (Terminated)

3. Using the PARAMETERS and SET keys, set the 3776 for SLO Count; 1.00hr; 2dB G.hit.

4. Set the Pulse Generator to give a positive - going pulse with a pulse width of approx 3 seconds displayed on the Oscilloscope.

   Note: The Pulse Generator transition times should be set to minimum. The DC offset control should be switched off.

5. Set the Pulse Generator to EXT-MAN.

6. The level displayed on the Oscilloscope should be 0V ac.

7. Set the Function Generator to give a sinewave output at 1010Hz +/-10Hz (if using a HP 3312A see settings below) as displayed on the Frequency Counter. Adjust the Function Generator amplitude control for a reading of 1.1590V +/-0.001V (ie 3.5dBm/600ohms) displayed on the AC Voltmeter.

   3312A settings

MODULATION	EXT, AM, % control to mid-range
FUNCTION	~
TRIGGER PHASE	FREE RUN
RANGE Hz	100Hz
OFFSET	CAL
SYM	CAL

8. Set the 3776 CONTROL to RUN and press the NEXT PARAM key to display 2dB G.hit.

9. Continually press the Pulse Generator EXT-MAN pushbutton, and adjust the Pulse Generator amplitude controls to obtain a count/no count condition (Gain-hit threshold) displayed on the 3776 RESULTS display.

   Note: Each time the EXT-MAN pushbutton is depressed, the Pulse Generator produces a 3-second positive-going pulse. If the pulse amplitude is sufficient, two gain-hits will be registered. One gain-hit is registered at the positive-going edge of the pulse and the other at the negative-going edge of the pulse. The following procedure refers to the gain-hit which is registered at the positive-going edge of the 3 second pulse.

10. Check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT MAN pushbutton is pressed, is between 1.3774V and 1.5455V. This corresponds to +2dB hit limits.

11. Adjust the controls of the Pulse Generator to give a negative-going pulse with a pulse width of 3 seconds. This can be achieved by connecting the Function Generator MOD EXT input to the Pulse Generator OUTPUT (-). Using the oscilloscope, check that no DC offset is introduced when the Pulse Generator OUTPUT (-) is selected.

12. Repeat Step 9.

13. Check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT-MAN pushbutton is pressed, is between 0.8691V and 0.9752V. This corresponds to -2dB limits.

14. Press the 3776 STOP key and set the 3776 gain-hit threshold to 3dB. Press the 3776 RUN key.

15. Repeat Step 9.

16. Check that the voltage displayed on the AC Voltemeter during the 3 seconds after the EXT-MAN pushbutton is pressed, is between 0.7746V and 0.8691V. This corresponds to -3dB hit limits.

17. Connect the Function Generator MOD EXT input to the Pulse Generator OUTPUT (+), (ie positive - going 3 second pulse output).

18. Repeat Step 9 and check that the voltage displayed on the AC Voltmeter during the 3 seconds after the

EXT-MAN pushbutton is pressed, is between 1.7341V and 1.5455V. This corresponds to +3dB hit limits.

19. Press the 3776 STOP key and set the 3776 gain-hit threshold to 4dB. Press the 3776 RUN key.

20. Repeat Step 9 and check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT-MAN pushbutton is pressed, is between 1.9457V and 1.7341V. This corresponds to +4dB hit limits.

21. Connect the Function Generator MOD EXT input to the Pulse Generator OUTPUT (-), (ie negative-going 3 second pulse output).

22. Repeat Step 9 and check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT-MAN pushbutton is pressed is between 0.6904V and 0.7746V. This corresponds to -4dB hit limits.

23. Press the 3776 STOP key and set the 3776 gain hit threshold to 6dB. Press the 3776 RUN key.

24. Repeat Step 9 and check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT-MAN pushbutton is pressed, is between 0.5484V and 0.6153V. This corresponds to -6dB limits.

25. Connect the Function Generator MOD EXT input to the Pulse Generator OUTPUT (+), (ie positive-going 3 second pulse output).

26. Repeat Step 9 and check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT-MAN pushbutton is pressed is between 2.4495V and 2.1831V. This corresponds to +6dB hit limits.

Guard Interval or Qualification Period

27. Continually press the Pulse Generator EXT-MAN pushbutton and adjust the Pulse Generator amplitude controls to give 2.5V displayed on the AC Voltmeter. Gain-hits should now be registered every time the EXT-MAN pushbutton is pressed.

28. Adjust the controls of the Pulse Generator to give a positive-going pulse with a pulse width of approx 10ms and a repitition rate of approx 4Hz, displayed on the oscilloscope.

29. Gently reduce the Pulse Generator pulse width control until the point is just reached where no further counts register on the 3776 Gain hits display.

30. Check that the Pulse Generator output pulse width, displayed on the oscilloscope is between 3.5ms and 4.5ms.

4-34 PHASE HITS (OPT 001)

SPECIFICATION

Threshold Accuracy:	+/-10% of the PHASE threshold switch setting +/-0.5 degrees for phase changes occuring in less than 0.2ms
Threshold Range:	5 degrees to 40 degrees in 5 degree steps.

Guard Interval or Qualification Period:

A phase-hit exceeding a threshold by 5 degrees is not counted if the holding tone returns to its original phase at any time within the 3.5ms, and is counted if the tone returns to its original phase any time after 4.5ms.

DESCRIPTION

Phase Hit

A Phase Hit is classified as an abrupt change in phase of a received sinewave.

A sudden phase change (i.e. phase hit) of a sinewave can be generated by changing the sinewave frequency for a brief period. As the frequency is changed, the phase of the sinewave with respect to the original sinewave will increase proportionally with time. The amount of phase change will also be proportional to the amount of frequency change.

This technique is used in the performance tests to generate phase hits. Figure 4-7 illustrates this process.

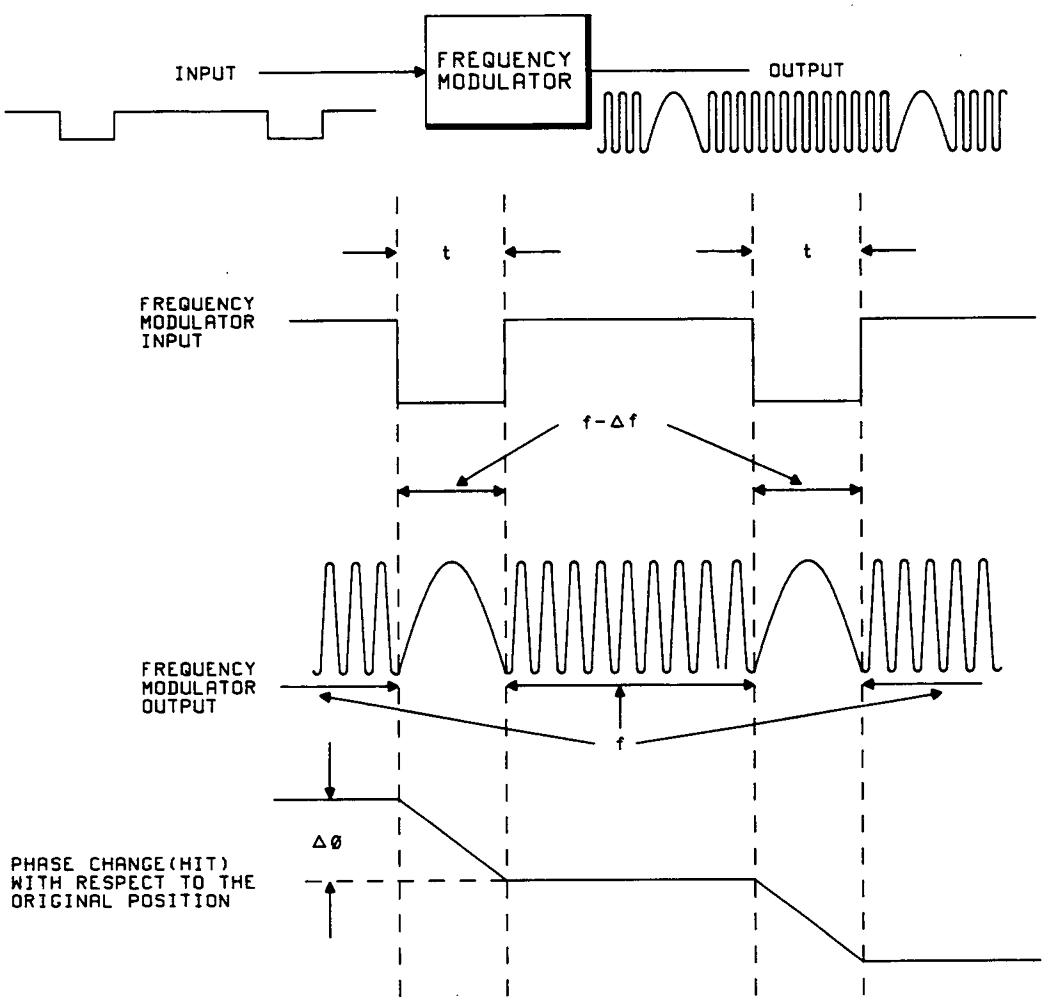


Figure 4-7 Phase Hits Test Signal Generation

The amount of phase change ϕ in degrees is given by:

$$\Delta\phi = 360 \times \Delta f \times t$$

where

Δf = frequency difference between sinewaves (Hz)

t = time at new frequency $f_1 - \Delta f$

Guard Interval or Qualification Period

By applying a negative-going pulse followed by a positive-going pulse into the Frequency Modulator (see Figure 4-8), the sinewave frequency at the output of the Frequency Modulator can be increased and decreased by an amount Δf. This frequency change causes a phase change as previously described for Phase Hits.

The direction of the phase change however is reversed by the dual polarity input signal to the Frequency Modulator. Figure 4-8 illustrates this phase change.

This technique is used in the performance tests to test the Qualification Period.

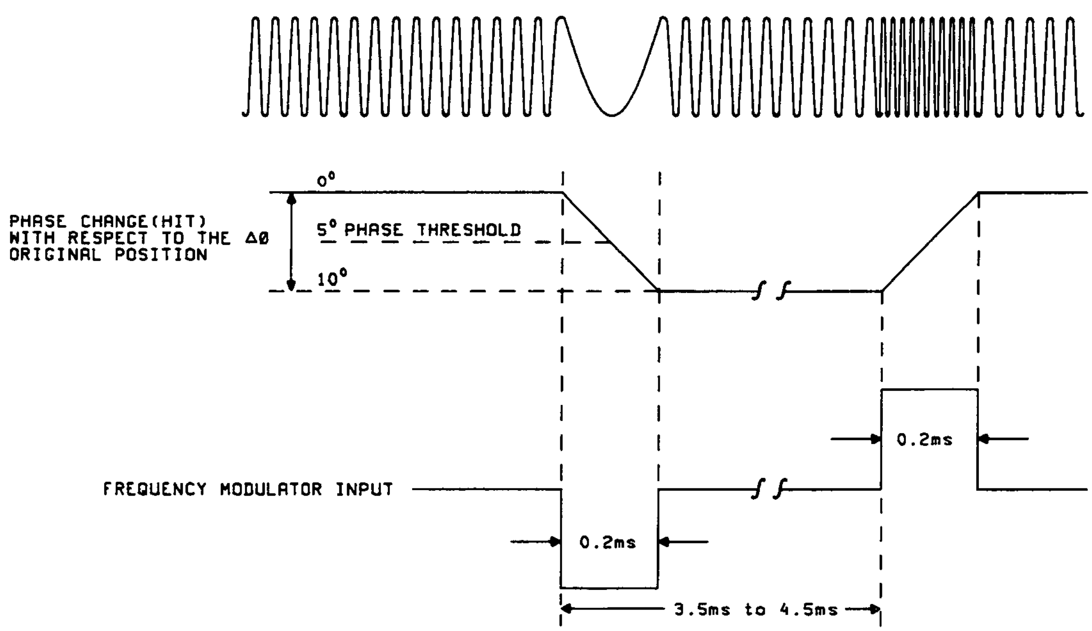


Figure 4-8 Phase Hit Qualification Period Test Signal Generation

EQUIPMENT

Pulse Generator	HP 8160A Option 020
Function Generator	HP 3312A
Oscilloscope Mainframe	HP 180A
Dual Channel Vertical Amplifier Plug-in	HP 1810A
Time Base Plug-in	HP 1821A
Frequency Counters	HP 5328A
AC Voltmeter	HP 3455A

PROCEDURE

Threshold Range and Threshold Accuracy

1. Connect the equipment as shown in Figure 4-9.

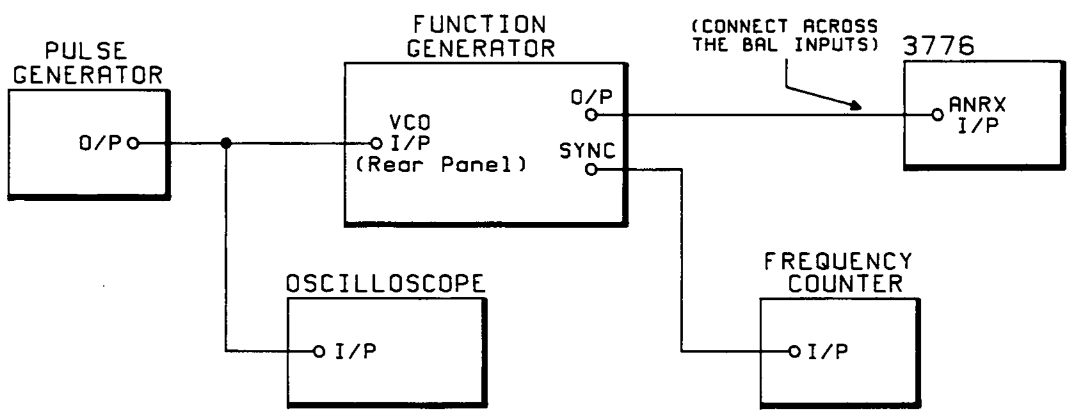


Figure 4-9 Phase Hits Threshold Range and Threshold Accuracy Test Set-up

2. Set the Pulse Generator to give -1V negative-going pulses with a repetition rate of approx 1kHz and a pulse width of exactly 0.2ms. The oscilloscope timebase should be set to 20us/DIV for best resolution.

3. Set the Pulse Generator repetition rate to approx 4Hz.

4. Set the Pulse Generator to the EXT-MAN mode (ie, the level displayed on the oscilloscope should be 0V ac).

5. Adjust the frequency control of the Function Generator to give 1010Hz displayed on the Frequency Counter. When a 3312A Function Generator is used, the front panel controls should be set as follows:

MODULATION ∼ ∧ ⊓	switches all out
FUNCTION ∼	switch depressed
TRIGGER PHASE	FREE RUN
RANGE Hz	100
OFFSET	CAL
SYM	CAL
AMPLITUDE	10

6. Set the 3776 as follows:

OPERATING MODE	ANRx
ANALOG RECEIVE	600ohm (Terminated)
MEASUREMENT	LEVEL-SEL FILTER

7. Press the 3776 NEXT PARAM key, set the MEAS frequency to 1.01kHz and press RUN/REPEAT.

8. Adjust the output amplitude of the Function Generator to give 0dBm +/-0.1dBm displayed on the 3776 RESULTS display.

9. Press the 3776 STOP key.

10. Set the 3776 as follows:

OPERATING MODE	ANRx
ANALOG RECEIVE	600ohm (Terminated)
MEASUREMENT	TRANSIENTS

11. Scroll the transient parameters using the NEXT PARAM key and set as follows:

SLO Count
1-00 hr
5 deg P. hit

12. Press the 3776 RUN key and press the NEXT PARAM key to display 5 deg P. hit.

13. Set the Pulse Generator to normal mode, (ie, 0.2ms, -1V -ve-going pulse at approx 4Hz repetition rate).

14. Adjust the Pulse Generator output amplitude to obtain the condition where the phase hit counts just register on the 3776 P.hit display. This point is the 5 deg phase hit threshold.

15. Set the Pulse Generator repetition rate to 1Hz and pulse width to 0.5 seconds displayed on the oscilloscope.

16. Set the Frequency Counter Function to PERIOD and TIMEBASE to 0.1us. The period displayed on the counter will alternate between the carrier frequency (1010Hz = 990us +/-5us) and the frequency f2 which was inserted during the 0.2ms pulse period.

Note: If an HP 5345A Counter is available, the Pulse Generator output can be used to gate the 5345A input. This enables only the period of interest (ie, f2) to be displayed.

17. Check that the f2 period (see Step 16) displayed on the Frequency Counter is between 1096us and 1064us.

18. Select the 3776 phase hit thresholds shown in Table 1 and using the procedure given in Steps 9 to 17 check that the f2 periods obtained are within the limits given.

Table 1

3776 Phase Hit Threshold Setting (degrees)	f2 Period Limits (us)	
	Max	Min
10	1197	1140
15	1317	1227
20	1465	1329
25	1649	1450
30	1887	1595
35	2206	1771
40	2653	1992

Guard Interval

19. Press the 3776 STOP key.

20. Scroll the transient parameters using the NEXT PARAM key and set the 3776 as follows:

    SLO Count
    1-00 hr
    5 deg P.hit

21. Set the Pulse Generator to Channel A + Channel B mode.

22. Adjust the controls of the Pulse Generator to give a combined Channel A and Channel B signal with 0.2ms negative-going and 0.2ms positive-going pulses as shown (Figure 4-10) and a repetition rate of approx 4Hz. The oscilloscope timebase should be set to 20us/DIV for best resolution when setting the 0.2ms pulse widths.

23. Press the 3776 RUN key and press the NEXT PARAM key to display 5 deg P. hit. Phase Hits should register on the 3776 RESULTS display.

24. Using the Pulse Generator Pulse Delay Control, set the delay between the negative and positive going pulses to 4.5ms as shown (Figure 4-11) and check that counts register on the 3776 Phase display.

25. Set the delay between the negative and positive-going pulses to 3.5ms as shown (Figure 4-12) and check that counts **do not** register on the Phase display.

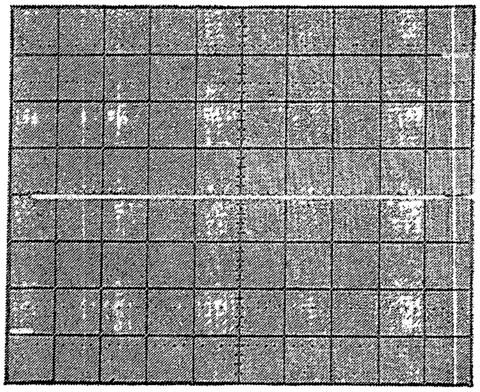


Figure 4-10

0.5ms/DIV 0.1V/DIV

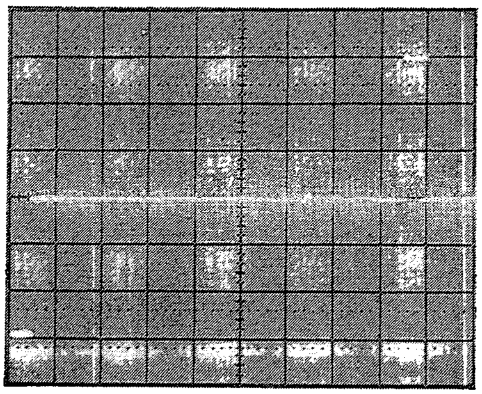


Figure 4-11

0.5ms/DIV 0.1V/DIV

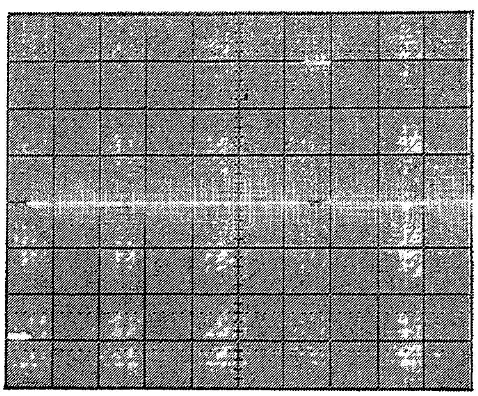


Figure 4-12

0.5ms/DIV 0.1V/DIV

4-35 PHASE JITTER (OPT 001)

SPECIFICATION

Measurement Accuracy: +/-5% +/-0.2 degrees

Measurement Range: 0 degree to 30 degrees peak to peak

DESCRIPTION

Phase Jitter Measurement Technique: A waveform with a known amount of phase jitter can be constructed by adding together two sinewaves of known frequency and amplitude. The voltage amplitude ratio of the two added sinewaves is proportional to the phase jitter. This action is illustrated vectorially in Figure 4-13.

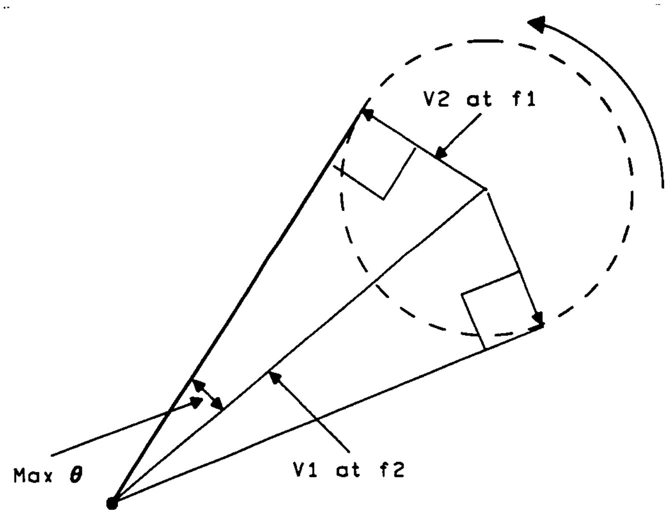


Figure 4-13 Phase Jitter Generation Vector Diagram

$$\text{Max}\theta = \sin^{-1} V2/V1$$

$$\text{Total peak deviation} = 2(\text{Max}\theta)$$

The voltage ratios (V2/V1) versus corresponding peak-to-peak jitter readings are given in Table 1.

Table 1 Voltage Ratios Versus Peak-to-Peak Jitter

Phase Jitter (Degrees pk-pk)	Voltage Ratio	dB Ratio
0.0114	10000	80
0.115	1000	60
0.363	316	50
1 15	100	40
3.63	31.6	30
11 48	10	20
20	5.76	15.20
30	3.86	11.74

EQUIPMENT

Two Test Oscillators (A and B)....HP 651B
Frequency Counter....HP 5328A
A.C. Voltmeter....HP 3455A
Three 200ohm Resistors....HP 0757-0407

PROCEDURE

Measurement Accuracy and Measurement Range

1. Set the 3776 to 600ohm UNBAL.

2. Set the 3776 MEASUREMENT to PHASE JITTER.

3. Connect the equipment as shown in Figure 4-14.

4. Adjust the controls of Oscillator A to give an output frequency of 1010Hz displayed on the Frequency Counter and a voltage of 0.7745V displayed on the AC Voltmeter.

NOTE: To set the output voltage or frequency from either Oscillator accurately and also maintain the circuit impedances, the output voltage from the other Oscillator(s) must be set to their minimum level. (If 651B Oscillators are used, the OUTPUT ATTENUATOR switch should be adjusted to reduce the output voltage to its minimum.)

5. Adjust the output frequency from Oscillator B to give a frequency of 910Hz displayed on the Frequency Counter.

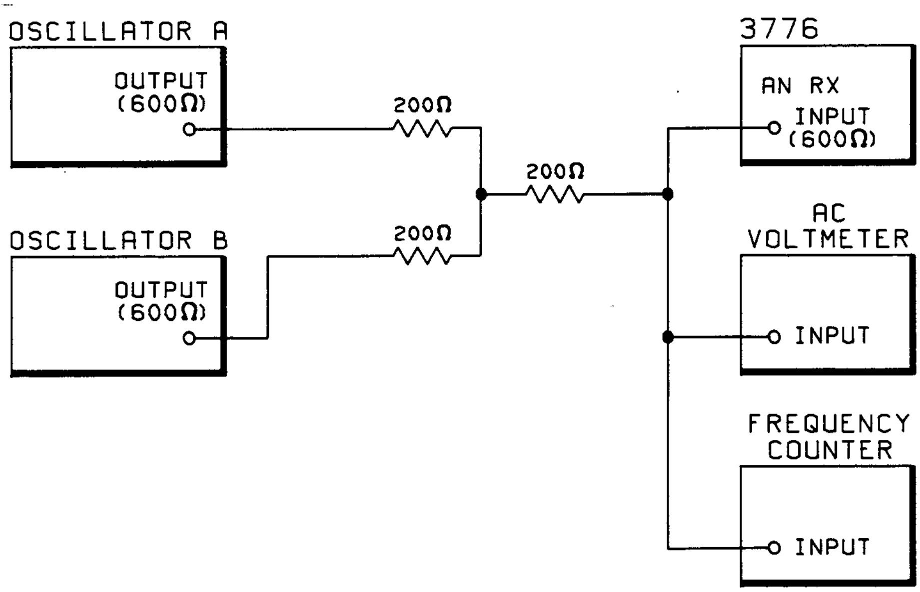


Figure 4-14 Phase Jitter Measurement Accuracy and Measurement Range Set-up

6. Adjust the output voltage from Oscillator B to give the voltage steps given in Table 2(a) displayed on the AC Voltmeter and check that at each voltage step, the Phase Jitter readings are within the limits specified.

NOTE: After adjusting Oscillator B to the voltages specified in Table 2(a), return Oscillator A OUTPUT ATTENUATOR switch to the position set in Step 4 and press RUN/REPEAT on the 3776.

7. With the output voltage from Oscillator B set to 0.0775V, change Oscillator B Attenuation switch to reduce the output level in 10dB steps as given in Table 2(b).

8. Check that at each Attenuator switch setting the Phase Jitter readings are within the limits specified in Table 2(b).

Table 2 Phase Jitter Measurement Range and Accuracy

(a)

Oscillator 'B' Output Voltage (Volts)	Phase Jitter Readings (Degrees)
0.201	28.3 to 31.7
0.134	18.8 to 21.2
0.0775	10.8 to 12.2

Table 2 Phase Jitter Measurement Range and Accuracy

(b)

Oscillator 'B' Additional Attenuation (dB)	Phase Jitter Readings (Degrees)
10	3.2 to 4.0
20	0.9 to 1.3
30	0.16 to 0.56
40	0 to 0.2
50	0 to 0.2

4-36 SEQUENCE TEST

DESCRIPTION

A sequence of up to approximately 240 measurement points can be stored in the 3776. An **HP-IB** controller is required to compile and store the sequence in the 3776 non-volatile memory. The sequence can only be run by pressing the 3776 front panel SEQ key. If the SEQ key is pressed and no sequence is stored, ERROR 20 is displayed.

EQUIPMENT

HP-IB Controller .... HP 85
ROM Drawer .... HP 82936A
Input/Output ROM .... HP 00085-15003
HP 85 Advanced Program ROM .... HP 00085-15005
HP-IB Interface .... HP 82937A

PROCEDURE

CAUTION

This procedure clears all sequence measurements stored in memory.

1. Set the 3776 operating mode to ANTx ANRx and Tx/Rx I/FACES to 0.0dB.

2. Set the 3776 to DIGTx DIGRx and Tx/Rx CHANNELS/T-SLOT to 1.

3. Loop the ANTx to ANRx and DIGTx to DIGRx.

4. Connect a HP 85 controller to the 3776 via HP-IB.

5. Set the 3776 **HP-IB** address to 2. Switch the power on.

6. Type OUTPUT 702; "CS" on the controller and press the controller END LINE key.

7. Press the 3776 LOCAL key, then press the SEQ key.

8. Check that the SEQ key cannot be illuminated and either ERROR 18 or 20 is displayed on the 3776. Error 18 or 20 indicates that the SEQ memory is clear.

9. Select ANTx to ANRx GAIN V FREQ measurement on the 3776.

10. Set the REF Frequency to 1.81kHz, MEAS Frequency to 0.21kHz and LEVEL to 0.0dBm.

11. Type OUTPUT 702; "AS" on the controller and press the controller END LINE key. This action appends the measurement selected in Steps 9 and 10 to the sequence.

12. Press the 3776 LOCAL key.

13. Select DIGTx to DIGRx LEVEL - SEL FILTER measurement, set the REF and MEAS frequencies to 2.81kHz and LEVEL to 0.0dBm.

14. Type OUTPUT 702; "AS" on the controller and press the ENDLINE key. This action appends the measurement selected in Step 13 to the sequence.

15. Press the 3776 LOCAL key.

16. Press the 3776 SEQ key.

17. Check that the SEQ key is illuminated and Pt 1 is displayed on the 3776.

18. Press the 3776 RUN key and check that the measurements appended to the sequence in Steps 9, 10 and 13 are performed.

19. When the 3776 STOP key led comes on, type OUTPUT 702; "RS?" on the controller and press END LINE. This action causes the 3776 to return the total number of measurements in the stored sequence (ie 2).

20. Type ENTER 702; A$ on the controller and press END LINE.

21. Type DISP A$ on the controller and check that RS 2 is displayed on the controller.

4-37 DUAL-TONE MULTI-FREQUENCY (DTMF) SIGNALLING TEST

DESCRIPTION

Multi-Frequency dialling or signalling tones can be loaded into the 3776 using the following command on HP-IB.

MD, on time, off time, level, tone, pair 1,
tone pair 2, etc.

Where tone on/off times are in seconds to a resolution of 0.001 seconds and level is the transmitted level of the two-tone signal.

The default DTMF values conform to the Bell System and are as follows:-

1 On time = 0.4 second
2 Off time= 0.1 second

3 Level = 0.0dBm
4 Tones are as shown in Table 1.

Table 1

FREQUENCY (Hz)	1209	1336	1477	1633
697	digit 1	2	3	13 = A
770	4	5	6	14 = B
852	7	8	9	15 = C
941	11 = *	10 = #	12 = 0	16 = D

Example:
To set the above default Bell System DTMF signalling, send the following to the 3776:
"MD, 0.4, 0.1, 0.0, 697, 1209, 697, 1336, 697, 1477, 770, 1209, 770, 1336, 770, 1477, 852, 1209, 852, 1336, 852, 1477, 941, 1336, 941, 1209, 941, 1477, 697, 1633, 770, 1633, 852, 1633, 941, 1633, CRLF".

These parameters are stored in N.V.M. and are retained when the 3776 is powered down. Once the DTMF parameters have been established, dialling can now be performed by sending the MP2 command followed by the number required.

Example:
"MP 2, 10, 3, 1, 3, 3, 1, 1, 10, 10, 10"
Note: When dialling always use the tone pair number, not the digits dialled. See Table 2.

Table 2

Tone Pairs	Digits Dialled
1 to 9	1 to 9
10	0
11	*
12	#
13	A
14	B
15	C
16	D

EQUIPMENT

HP-IB Controller........HP 85
ROM Drawer........HP 82936A
Input/Ouput ROM........HP 00085-15003
HP-IB Interface........HP 82937A
Storage Oscilloscope........HP 1741A

PROCEDURE

1. Set the 3776 to ANTx and Tx I/FACE to 0.0dB.

2. Connect the ANALOG TRANSMIT output to the ANALOG RECEIVE input and set the ANALOG TRANSMIT output to 600ohm UNBAL.

3. Connect the HP 85 to the 3776 and load the DTMF program listed, into the HP 85 Controller.

```
10 DIM A$[250], B$[250], C$[250]
20 DIM D$[250]
30 D$=", 1,2,3,4,5,6,7,8,9,10,11
  ,12,13,14,15,16,5,5,5,5,5,5,
  5,5,5,5,5,5,5,5,5,5,5,5"
60 A$="0.4,0.1,0.0,697,1209,697
  ,1336,697,1477,770,1209,770,
  1336,770,1477,852,1209,852.1
  336"
70 B$=",852,1477,941,1336,941,1
  209,941,1477,697,1633,770,16
  33,852,1633,941,1633"
80 C$=A$&B$
90 OUTPUT 708 "ST"
100 OUTPUT 708 "CA OFF"
110 OUTPUT 708 "MO4;ME40"
120 OUTPUT 708 "MO";C$
140 OUTPUT 708 "MP2";D$
160 OUTPUT 708 "SS"
170 END
```

4. Connect a storage oscilloscope across the ANALOG TRANSMIT output as shown in Figure 4-15 and run the DTMF program.

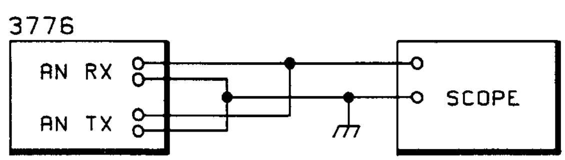
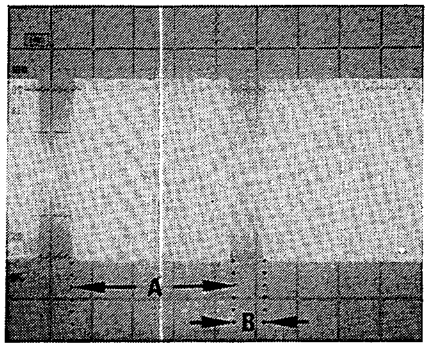


Figure 4-15

5. Check that the following occurs when the program is run:-

(a) 2 MEAS appears in the FREQUENCY display and 1 incrementing to 9 then 0, Star, hash, A, b, C and d. After d, 5 is displayed.

(b) The waveform shown in Figure 4-16 can be obtained. Note, that the waveform is present for only approx 20 seconds. Re-run the DTMF program, if required, until a satisfactory waveform is obtained.



0.2V/DIV (10:1 Probe)
0.1s/DIV

ON TIME(A) : 0.36–0.44s
OFF TIME(B) : 0.09–0.11s

Figure 4-16

4-38 3776B PCM TESTS

SPECIFICATIONS

Frame Format:	Selectable. Standard frame format conforms to BSTR Pub 43801 (CCITT Rec G. 733); Extended Super-Frame (ESF) format conforms to AT & T Technical Advisory No. 70.
Signalling:	Channel Associated Signalling (CAS) or Common Channel Signalling (CCS).
Led Status Indicators:	No signal; loss of frame alignment; all ones; loss of multi-frame alignment.

DESCRIPTION

The following manual checks perform virtually the same tests as running the PCM76B program. The procedure provided therefore serves as a description of the PCM76B program.

Basically, the following tests are performed.

1. DIGTx to DIGRx LEVEL-SEL FILTER, AZS code measurement checked with CAS then CCS selected. Checks that the No SIG, ALL 1s, FA LOSS and MFA LOSS leds are all off.

2. In CCS, Terminal Framing or FA LOSS is checked.

3. In CCS, Signalling Bits Check.

4. In CAS, Signalling Framing Check or MFA LOSS check.

5. CAS Terminal Farming loss causing Signalling Framing Loss.

6. Signalling Bits in Signalling Channels A and B checked. During this test, the NO SIG, ALL 1s, FA LOSS and MFA LOSS leds are checked.

7. Tests 1 to 6 are repeated with the line code set to B8ZS.

8. In CCS, Terminal Framing or FA LOSS is checked with Extended Framing (FE) selected.

9. In FE/CCS mode, the CRC default word checked.

10. In FE/CAS, the A to D signalling bits default value checked.

11. In FE/CAS mode, the CRC default word is checked ? Also NO SIG, ALL 1s, FA LOSS and MFA LOSS checked.

12. In FE/CAS, CRC Default value checked.

13. In FE/CCS mode, Idle codes versus CRC bits are checked.

14. In FE/CAS mode, A to D signalling bits are sequencially checked. Also NO SIG, ALL 1s, FA LOSS and MFA LOSS are checked.

15. Digital Tx to Digital Rx LOOP TIMING check.

EQUIPMENT (No equipment is required if performing manual checks)

Controller	HP 85
HP-IB Interface	HP 82937A
ROM Drawer	HP 82936A
Input/Output ROM	HP 00085-15003
3776 DATA CARTRIDGE	HP 03776-10001

PROCEDURE (using the PCM 76B Program)

1. Connect the Controller to the 3776B via the HP-IB Interface and connect the DIGITAL TRANSMIT output to the DIGITAL RECEIVE input.

2. Load the PCM76B Program into the Controller.

3. Run the PCM 76B Program and check that no error codes are displayed on the HP 85 Controller. Note: only one program cycle is required for performance checking.

PROCEDURE (Manual)

(Perform this procedure only if the PCM76B Program is not available)

DIGTx to DIGRx LEVEL - SEL FILTER Check

1. Connect the 3776B DIGITAL TRANSMIT output to the DIGITAL RECEIVE input.

2. Reset the 3776 to its default values as follows:

WARNING

This procedure requires the removal of the instruments protective covers and should only be performed by Service trained personnel who are aware of the hazards involved.

(a) Remove the top cover and pc assemblies metal retaining cover.

(b) set A13S2 switches to 10010 and press A13S1 reset button.

(c) After approx 5 seconds, set A13S2 switches back to 00000.

3. Set the 3776B as follows:

OPERATING MODE	DIGTx to DIGRx
I/FACES	Tx/Rx T-SLOTS 1/1
GAIN/DIG Tx-Rx	+/-0
	(Press STORE after setting this backgroung code)
MEASUREMENTS	LEVEL SEL FILTER
FREQUENCY kHz	1.01 REF and MEAS
LEVEL	As in Table 1 in Step 4
SYNTH PCM/THRU PCM	SYNTH PCM
TERM/MON	TERM
CAS/CCS	See Procedure
B8ZS/AZS	AZS
FE/FT	FT

4. Set the LEVEL, in turn, to values given in Table 1 and check at each level that the 3776 displayed result (for CAS and CCS) is within the corresponding limits given in the Table.

Table 1

LEVEL (dBm0)	3776 Displayed Result Limits	
	CAS (dBm0)	CCS (dBm0)
+3	2.88 to 3.04	2.88 to 3.04
-19	-18.92 to -19.08	-18.94 to -19.10
-35	-34.89 to -35.05	-34.91 to -35.07
-46	-45.76 to -46.22	-45.77 to -46.23
-60	-59.47 to -59.93	-59.37 to -59.83

5. Check that the CONTROL leds (NO SIG, ALL 1s, FA LOSS and MFA LOSS) are all off.

FT/CCS Mode Terminal Framing Check

6. Set the 3776 to DIGTx only.

7. Set the MEASUREMENT to FRAMING + SIG BITS - FT/FE BITS and check that 101010 is displayed on the 3776 RESULTS display. Check that 101010 is displayed with the CAS/CCS switch set to either CAS or CCS.

8. Set the CAS/CCS switch to the CCS position and press the MEASURMENTS STORE key.

9. Set the 3776 to DIGRx only, press RUN/REPEAT and check that 101010 is displayed on the RESULTS display.

10. Check that the CONTROL leds (NO SIG, ALL 1s, FA LOSS and MFA LOSS) are all off. Press the STOP key.

11. Set the 3776 to DIGTx only, change the FT bits to 001010 (10) and press the STORE key.

12. Set the 3776 to DIGRx only and press the RUN key.

13. Check that the 3776 displays 001010 (10) or 100010 (34) or 101000 (40).

14. Check that the CONTROL leds (NO SIG, ALL 1s, FA LOSS and MFA LOSS) are all off. Press the STOP key.

15. Set the 3776 to DIGTx only and change the FT bits to 011010 (26). Press the STORE key.

16. Set the 3776 to DIGRx only and press RUN/REPEAT.

17. Check that Error 21 is displayed and that the NO SIG, ALL 1s and MFA LOSS leds are off and that the FA LOSS led is on. Press the STOP key.

18. Set the 3776 to DIGTx only, change the FT bits back to 101010 (42) and press the STORE key.

19. Set the 3776 to DIGRx, press RUN/REPEAT and check that 101010 (42) is displayed and that the 4-CONTROL leds are off. Press the STOP key.

CCS mode Signalling Bits Check

20. With the 3776 set to DIGRx only, select FRAMING + SIG BITS - FS/CRC BITS and press the RUN key.

21. Check that 111111 is displayed and press STOP.

22. Set the 3776 to DIGTx only.

23. Change the FS bits to 100110 (38) and press STORE.

24. Set the 3776 to DIGRx only and press the RUN key.

25. Check that 100110 (38) or 101001 (41) or 011010 (36) is displayed. Press the STOP key.

26. Set the 3776 to DIGTx only, change the FS bits back to 111111 (63) and press STORE.

CAS Signalling Framing or MFA LOSS Check

27. Set the Rear Panel CAS/CCS switch to CAS.

28. With the 3776 set to DIGTx, select FRAMING + SIG BITS - FS/CRC BITS and check that the 3776 displays 001110 (14). Press STORE.

29. Set the 3776 to DIGRx only, press RUN/REPEAT and check that 001110 (14) is displayed. Check also

that the 4-Control leds are off. Press STOP.

30. Set the 3776 to DIGTx, change the FS bits to 101110 (46) and press STORE.

31. Set the 3776 to DIGRx and press RUN/REPEAT.

32. Check that 101110 (46) is displayed. Check also that the 4-Control leds are off. Press STOP.

33. Set the 3776 to DIGTx and change the FS bits to 101111 (47). Press STORE.

34. Set the 3776 to DIGRx only and press RUN/REPEAT.

35. Check that 101111 (47) is displayed and the 4-Control leds are off. Press STOP.

36. Set the 3776 to DIGTx only and change the FS bits to 111110 (62). Press STORE.

37. Set the 3776 to DIGRx only and press RUN/REPEAT.

38. Check that ERROR 21 is displayed. Check also that CONTROL led MFA LOSS is on and the other 3-CONTROL leds are off. Press STOP.

39. With the 3776 in the DIGRx mode, select the FT/FE BITS and press RUN/REPEAT.

40. Check that ERROR 21 is displayed. Check also that CONTROL led MFA LOSS is on and the other 3-CONTROL leds are off. Press STOP.

41. Set the 3776 to DIGTx only and select FS/CRC BITS.

42. Change the FS BITS back to 001110 (14) and press STORE.

43. Set the 3776 to DIGRx only, press RUN/REPEAT and check that 001110 (14) is displayed and that all 4-CONTROL leds are off. Press STOP.

CAS Terminal Framing Loss causing Signalling Framing Loss Check

44. Set 3776 to DIGTx only and select FT/FE BITS.

45. Change the FT bits to 001010 (10) and press STORE.

46. Set the 3776 to DIGRx only and press RUN.

47. Check that 001010 (10) is displayed. Check also that the 4-CONTROL leds are off. Press STOP.

48. Set the 3776 to DIGTx only and change the FT bits to 011010 (26). Press STORE.

49. Set the 3776 to DIGRx and press RUN/REPEAT.

50. Check that ERROR 21 is displayed and that FA LOSS and MFA LOSS leds are on and the NO SIG and ALL 1s leds are off. Press STOP.

51. Set the 3776 to DIGTx only and change the FT bits back to 101010 (42). Press STORE.

52. Set the 3776 to DIGRx and press RUN/REPEAT.

53. Check that 101010 (42) is displayed and that all 4-CONTROL leds are off. Press STOP.

Signalling Bits in Signalling Channels A and B Check

54. Set the 3776 to DIGTx.

55. Set the Tx TLP/T-SLOT to 1..24 (ie Barrage Loaded).

56. Select FRAMING + SIG BITS - SIG BITS and check that the 3776 displays A = 0, B = 0.

57. Set the rear panel CAS/CCS to CCS and check that the display blanks. Set the switch back to CAS.

58. Change the SIG BITS in turn as given below and perform the following procedure, for each signalling A and B bit combination.

(a) Change the A and B bits.

(b) Press STORE.

(c) Set the 3776 to DIGRx only.

(d) Press RUN/REPEAT.

(e) Check that the displayed A and B bits correspond to the appropriate combination set below. Check also that the 4-CONTROL leds are off. Press STOP.

(f) Change the OPERATING MODE back to DIGTx only.

A =	B =
1	0
1	1
0	1
0	0

59. Set the Tx TLP/T-SLOT to 1.

B8ZS Checks

60. Set the Rear Panel AMI/B8ZS switch to B8ZS and repeat Steps 1 to 59 of the Manual Procedure.

CCS/FE Terminal Framing or FA LOSS Check

61. Set the Rear Panel FT/FE switch to FE.

62. With the 3776 set to DIGTx only, and Tx and Rx TLP/T-SLOT set to 1, select FRAMING + SIG BITS - FT/FE BITS measurement.

63. Check that 001011 (11) is displayed.

64. Set the CAS/CCS switch to CCS and check that 001011 (11) is displayed. Press STORE.

65. Set the 3776 to DIGRx only and press RUN/REPEAT.

66. Check that 001011 (11) is displayed and that all 4-CONTROL leds are off. Press STOP.

67. Set the 3776 to DIGTx only and change the FT bits to 001000 (8). Press STORE.

68. Set the 3776 to DIGRx only and press RUN/REPEAT.

69. Check that ERROR 21 is displayed. Check also that the FA LOSS led is on and the other 3-CONTROL leds are off. Press STOP.

70. Set the 3776 to DIGTx and change the FT bits back to 001011 (11). Press STORE.

71. Set the 3776 to DIGRx, press RUN/REPEAT and check that 001011 (11) is displayed. Check also that all 4-CONTROL leds are off. Press STOP.

CAS/FE Signalling channels A to D Default value Check

72. With the 3776 set to DIGTx only, change the Rear Panel CAS/CCS switch to CAS.

73. Select FRAMING + SIG BITS - SIG BITS and check that A-d = 0000 is displayed. Press STORE.

CAS/FE CRC Default Value Check

74. Set the 3776 to DIGRx and select FRAMING + SIG BITS - FS/CRC BITS.

75. Press RUN/REPEAT and check that 100111 (39) is displayed. (!Check this word!). Check also that the 4-CONTROL leds are off. Press STOP.

CCS/FE Idle Codes Versus CRC bits Check

76. Set the 3776 to DIGTx only and rear panel CAS/CCS switch to CCS.

77. Select GAIN - DIGTx-Rx measurement and set CODE to 0/0 (ie, remove negative code sign). Press STORE.

78. Set the 3776 to DIGRx only and select FRAMING +SIG BITS - FS/CRC BITS.

79. Press RUN and check that 010011 (19) is displayed. Press STOP.

80. Repeat Steps 76 to 79 using the codes given below and check that the corresponding CRC bits are displayed.

Idle Code Inserted (Step 77)	CRC Bits Displayed (Step 79)
-127/-127	000010 (2)
-112/-112	000011 (3)
-42/-42	001101 (13)
+85/+85	011100 (28)
+15/+15	010010 (18)
+0/-0	100011 (35)

CAS/FE A to D Signalling Bits Check

81. Set the 3776 to DIGTx only and set the rear panel CAS/CCS switch to CAS

82. Set the TxTLP/T-SLOT to 1..24 (Barrage Loaded).

83. Select FRAMING + SIG BITS - SIG BITS and check that A-d = 0000 is displayed.

84. Change the CAS/CCS switch to CCS and check that the display blanks. Set the CAS/CCS switch back to CAS.

85. With the 3776 set to DIGTx and A-d = 0000, press STORE.

86. Set the 3776 to DIG Rx and press RUN/REPEAT.

87. Check that A-d = 0000 is displayed. Check also that the 4-CONTROL leds are off. Press STOP.

88. Repeat Steps 85 to 87, setting the A-d bits as shown below. Check at each setting of the A-d bits that the displayed result (Step 87) corresponds to the A-d bits set (Step 85).

Where A-d = A, b, C, d	A	b	C	d
	0	0	0	1
	0	0	1	0
	0	1	0	1
	1	0	1	0
	1	1	1	1

89. Set the 3776 to DIGTx and A-d = 0000. Press STORE.

DIGTx to DIGRx LOOP TIMING Check

90. Set the 3776 to DIGTx and DIGRx.

91. Select FRAMING + SIGBITS - LOOP TIMING.

92. With the DIGTx looped to the DIGRx, press the RUN/REPEAT key and check that a stationary segment pattern is obtained. Press STOP.

4-39 3776A PCM TESTS

SPECIFICATION

Frame Format:	Conforms to CCITT Rec G.732; 30 or 31 audio channels may be selected.
Signalling:	Channel Associated Signalling (CAS) or Common Channel Signalling (CCS).

Led Status Indicators:	No signal; loss of frame alignment; all ones; loss of multi-frame alignment.
Frame Word Error Rate:	Generates Frame Word Errors over defined periods to give 1×10^{-5}, 5×10^{-5}, 1×10^{-4}, 5×10^{-4} and 1×10^{-3} error rates.

DESCRIPTION

The following manual checks perform virtually the same tests as running the PCM76A program. The procedure provided therefore, serves as a description of the PCM76A program. Basically, the following tests are performed.

1. DIGTx to DIGRx LEVEL-SEL FILTER measurement with HDB3 code selected. Checks that the NO SIG, ALL 1s, FA LOSS and MFA LOSS leds are all off.
2. Non-Frame Word Check.
3. Frame Word Check.
4. Frame Word Loss of Alignment Check (Using the 4-word sequence of good/bad frame words).
5. AIS (Alarm Indication Signal) Check.
6. Signal Loss (NO SIG) Check.
7. Re-Gain Alignment Check.
8. Frame Word in CAS mode check.
9. Multi-frame Alignment (MFA LOSS) Check.
10. Distant Multi-frame Alarm Bit Check.
11. Frame Word Loss of Alignment Check (using a sequence of Frame Word bit errors).
12. Signalling Bits Check.
13. Frame Alignment Word Error Rate. This check is not performed by the PCM76A program.

EQUIPMENT

(Only the Frame Word Error Detector is required if performing manual checks)

Controller	HP 85
HP-IB Interface	HP 82937A
ROM Drawer	HP 82936A
Input/Output ROM	HP 00085-15003
3776 Data Cartridge	HP 03776-10001
Frame Word Error Detector	HP 3783A

PROCEDURE (using the PCM76A Program)

1. Connect the Controller to the 3776A via the HP-IB interface and connect the DIGITAL Tx output to the DIGITAL Rx input.

2. Load the PCM76A Program into the Controller.

3. Run the PCM76A Program and check that no error codes are displayed on the HP 85 Controller.

   Note: only one program cycle is required for performance checking.

4. Perform Steps 70 to 81 of the Manual Procedure.

PROCEDURE (Manual)

(Perform this procedure only if the PCM76A Program is not available)

DIGTx to DIGRx LEVEL-SEL FILTER Check

1. Connect the 3776A DIGITAL TRANSMIT output to the DIGITAL RECEIVE input.

2. Reset the 3776A to its default values as follows:

WARNING

This procedure requires the removal of the instruments protective covers and should only be performed by Service trained personnel who are aware of the hazards involved.

(a) Remove the top cover and pc assemblies retaining cover.

(b) Set A13S2 switches to 10010 and press A13S1 reset button.

(c) After approx 5 seconds, set A13S2 switches back to 00000.

3. Set the 3776A as follows:

OPERATING MODE	DIGTx to DIGRx
I/FACES	Tx/Rx CHAN 1/1
TERM/MON	TERM
CAS/CCS	CCS
HDB3/AMI	HDB3
30 CHAN/31 CHAN	30 CHAN
SYNTH PCM/THRU PCM	SYNTH PCM
GAIN/DIG Tx-Rx	+/-0 (Press STORE after setting this Background code)
LEVEL/SEL FILTER	See Table 1 in Step 4 for LEVEL settings. Set the REF and MEAS Frequency to 0.81kHz.

4. Set the LEVEL in turn, to the values given in Table 1 and check at each level that the 3776 displayed

result is within the corresponding limits given in the Table.

Table 1

Level (dBm0)	3776A Displayed Result Limits (dBm0)
+3	2.99 to 3.03
-20	-19.98 to -20.04
-36	-35.97 to -36.03
-44.7	-44.58 to -44.71
-60	-59.21 to -59.39

Non-Frame Word Check

5. Set the 3776A to DIGTx mode only and select FRAMING + SIG BITS/NON-FM WORD.

6. Check that 11011111 (223) is displayed on the 3776A RESULTS display.

7. Set the 3776A to DIGRx only and press RUN/REPEAT.

8. Check that 11011111 (223) is displayed. Check also that the 4-CONTROL leds NO SIG, ALL 1s, FA LOSS and MFA LOSS are all off. Press STOP.

9. Set the 3776A to DIGTx only and change the NON-FM word to 11111111 (255). Press STORE.

10. Set the 3776A to DIGRx only, press RUN/REPEAT and check that 11111111 (255) is displayed. Check also that the 4-CONTROL leds are off. Press STOP.

11. Set the 3776A to DIGTx only, change the NON-FM WORD back to 11011111 and press STORE.

Frame Word Check

12. With the 3776A in the DIGTx mode only, select FRAMING + SIG BITS/FRAME WORD.

13. Check that 10011011 (155) is displayed. Press STORE.

14. Set the 3776A to DIGRx only, press RUN/REPEAT and check that 10011011 (155) is displayed. Check also that the 4-CONTROL leds are off. Press STOP.

Frame Word Loss of Alignment Check (Using the 4-word sequence of GOOD/BAD Frame Words)

15. Set the 3776A to DIGTx only and press RUN.

16. Press the NEXT PARAM key until "**2 in 4**" is displayed.

17. Check that the 4-CONTROL leds NO SIG, ALL 1s, FA LOSS and MFA LOSS are all off.

18. Press the NEXT PARAM key and check that "**1 in 2**" is displayed. Check also that the 4-CONTROL

leds are off

19. Press the NEXT PARAM key and check that "**3 in 4**" is displayed. Check that the NO SIG, ALL 1s and MFA LOSS leds are off and FA LOSS is on. Note that multiframe alignment is lost but MF LOSS led is off. This is due to the 3776A being set in CCS mode (the status word, returned on HP-IB, indicates MFA LOSS).

AIS (Alarm Indication Signal) Check

20. Press the NEXT PARAM key and check that "**AIS**" is displayed.

21. Check that the NO SIG and MFA LOSS leds are off and the ALL 1s and FA LOSS leds are on. See note in Step 19 regarding MFA LOSS.

Signal Loss (NO SIG) Check

22. Press the NEXT PARAM key and check that "**OFF**" is displayed.

23. Check that the ALL 1s and MFA LOSS leds are off and the NO SIG and FA LOSS leds are on. See note in Step 19 regarding MFA LOSS.

Re-Gain Alignment Check

24. Press the PREVIOUS PARAM key until "**1 in 2**" is displayed.

25. Check that the NO SIG, ALL 1s and MFA LOSS leds are off and the FA LOSS led is on. See Step 19 note regarding MFA LOSS.

26. Press the PREVIOUS PARAM key until "**2 in 4**" is displayed.

27. Check that the 4-CONTROL leds (NO SIG, ALL 1s, FA LOSS and MFA LOSS) are all off. Press STOP.

Frame Word in CAS mode Check

28. Set the rear panel CAS/CCS switch to CAS and set the OPERATING MODE to DIGRx only.

29. Press RUN/REPEAT and check that 10011011 (155) is displayed. Check that the 4-CONTROL leds are off. Press STOP.

Multi-Frame Alignment (MFA LOSS) Check

30. Set the 3776A to DIGTx only and select FRAMING + SIG BITS/TS16 FM0.

31. Check that 00001011 (11) is displayed on the RESULTS display. Press STORE.

32. Set the 3776A to DIGRx only and press RUN/REPEAT.

33. Check that 00001011 (11) is displayed and that the 4-CONTROL leds are off. Press STOP.

34. Set the 3776A to DIGTx only.

35. Change the TS16 FM0 word to 10001011 (139) and press STORE.

36. Set the 3776A to DIGRx only, press RUN/REPEAT and check that ERROR 21 is displayed. Check also that the NO SIG, ALL 1s and FA LOSS leds are off and that the MFA LOSS led is on. Press STOP.

Distant Multi-Frame Alarm Bit Check

37. Set the 3776A to DIGTx only.

38. Change the TS16 FM0 word to 00001111 (15) and press STORE.

39. Set the 3776A to DIGRx only and press RUN/REPEAT.

40. Check that 00001111 (15) is displayed and the 4-CONTROL leds are off. Press STOP.

41. Set the 3776A to DIGTx only and change the TS16 FM0 word back to 00001011 (11). Press STORE.

Frame Word Loss of Alignment Check (Using a sequence of Frame Word bit errors)

42. Select FRAMING + SIG BITS/FRAME WORD and check that 10011011 (155) is displayed. Press STORE.

43. Set the 3776A to DIGRx only and press RUN/REPEAT.

44. Check that 10011011 (155) is displayed. Check also that the 4-CONTROL leds are off. Press STOP.

45. Set the 3776A to DIGTx only and change the FRAME WORD to 11011011 (219). Press STORE.

46. Set the 3776A to DIGRx only and press RUN/REPEAT.

47. Check that ERROR21 is displayed and that the NO SIG and ALL 1s leds are off and the FA LOSS and MFA LOSS leds are on.

48. Set the 3776 to DIGTx only, change the FRAME WORD to 00011011 (27) and press STORE.

49. Set the 3776 to DIGRx only and press RUN/REPEAT.

50. Check that 00011011 (27) is displayed and that the 4-CONTROL leds are all off. Press STOP.

51. Set the 3776A to DIGTx only and change the FRAME WORD back to 10011011. Press STORE.

52. Set the 3776A to DIGRx and press RUN/REPEAT.

53. Check that 10011011 (155) is displayed and that the 4-CONTROL leds are off. Press STOP.

Signalling Bits Check

54. Set the 3776A to DIGTx only and select FRAMING + SIG BITS/TS16 SIG BITS.

55. Check that 0101 (5) is displayed and press STORE.

56. Set the 3776A to DIGRx only and press RUN/REPEAT.

57. Check that 0101 (5) is displayed and the 4-CONTROL leds (NO SIG, ALL 1S, FA LOSS and MEA LOSS)

are off. Press STOP.

58. Set the 3776A to DIGTx only and change the TS16 SIG BITS to 1010 (10). Press STORE.

59. Set the 3776A to DIGRx only and press RUN/REPEAT.

60. Check that 0101 (5) is displayed. Check also that the 4-CONTROL leds are off. Press STOP.

61. Set the Tx CHAN I/FACES to 1..30 (i.e. barrage loaded).

62. Set the 3776 to DIG Tx only and check that 0101 (5) is displayed.

63. Change the TS16 SIG BITS to 1010 (10) and press STORE.

64. Set the 3776A to DIGRx only and press RUN/REPEAT.

65. Check that 1010 (10) is displayed and the 4-CONTROL leds are all off. Press STOP.

66. Set the 3776A to DIGTx and change the TS16 SIG BITS to 0101 (5). Press STORE.

67. Set the Tx CHAN I/FACES back to 1.

68. Set the rear panel CAS/CCS switch to CCS.

69. Check that 11111111 (255) is displayed.

Frame Alignment Word Error Rate

70. Connect the 75ohm UNBAL DIGITAL TRANSMIT output to the HP 3783A SIGNAL INPUT.

71. With the 3776 set as follows, press the NEXT PARAM key to set the 3776 to 1.10E-5.

OPERATING MODE	DIGTx
SYNTH PCM/THROUGH PCM	SYNTH PCM
I/FACES Tx/Rx CHAN	I/I
CAS/CCS	CAS
HDB3/AMI	HDB3
30 CHAN/31 CHAN	30 CHAN

72. Set the HP 3783A as follows:

AUDIO INDICATION	OFF
MODE	FA
DIG SIG	TERM
ALARM	FREERUN/AUTO RESET

73. Press the 3776A RUN key and check after approx 60 seconds that 10^{-5} ERROR RATE is displayed on the 3783A. Check also that the LINE, AIS, FRAME and M-F leds on the 3783A are off and that the ERROR led is on. The ERROR COUNT display on the 3783A should be incrementing at a rate of approx 3 in 10 seconds.

74. Press the 3776A NEXT PARAM key and check that 5. 10E-5 is displayed on the RESULTS display.

75. Press the 3783A RESET key and check that after approx 7 seconds the ERROR RATE exponent displayed on the 3783A is 5. Check also that the 3783A ERROR COUNT increments at an approx rate of 15 in 10 seconds.

76. Press the 3776A NEXT PARAM key and check that 1. 10E-4 is displayed on the 3776A RESULTS display.

77. Press the 3783A RESET key and check that after approx 4 seconds, the ERROR rate exponent displayed on the 3783A is 4. Check also that the 3783A ERROR COUNT increments at an approx rate of 30 in 10 seconds.

78. Press the 3776A NEXT PARAM key and check that 5. 10E-4 is displayed on the 3776A RESULTS display.

79. Press the 3783A RESET key and check that the ERROR rate exponent displayed on the 3783A is 4. Check also that 3783A ERROR COUNT increments at an approx rate of 150in 10 seconds.

80. Press the 3776A NEXT PARAM key and check that 1. 10E-3 is displayed on the 3776A RESULTS display.

81. Press the 3783A RESET key and check that the ERROR rate exponent displayed on the 3783A is 3. Check also that the 3783A ERROR COUNT increments at an approx rate of 300 in 10 seconds.

PERFORMANCE TESTS

The remainder of Section VI contains the Performance Tests.

Table 4-2 and 4-3 enables specification parameter to be checked quickly. Table 4-2 gives a list of specification parameters and indicates which Performance Checks are required to verify the parameters. Table 4-3 lists the Performance Tests and check number together with page references.

Table 4-2 Specification Parameter Verification

3776A ★ BOTH □
3776B ☆

	SPECIFICATION PARAMETER	PERFORMANCE CHECK NUMBER																																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
ANALOG - ANALOG	GAIN T	□	□											□							□	□															
	GAIN V FREQ	□	□					□		□	□										□	□															
	GAIN V LEVEL N	★	★						★												★																
	GAIN V LEVEL T	□	□					□	□												□	□															
	NOISE + TONE	□	□						□			□				□					□																
	IDLE STATE WTD	□	□					□				□									□																
	IDLE STATE SEL	□	□					□													□																
	IDLE STATE OTHER	□	□					□													□																
	LEVEL WTD	□	□					□	□			□				□					□	□															
	LEVEL OTHER	□	□					□	□							□					□	□															
	LEVEL SEL	□	□					□								□				□	□	□															
	QUANT DIST N	★	★												★	★					★																
	QUANT DIST T	□	□						□			□				□					□	□															
	I/MOD 2T	□	□								□					□	□				□	□															
	I/MOD 4T	☆	☆												☆	☆	☆				☆	☆															
ANALOG - DIGITAL	GAIN T	□	□			□	□		□													□			□												
	GAIN V FREQ	□	□			□	□			□												□			□												
	GAIN V LEVEL N	★	★			★	★		★																★												
	GAIN V LEVEL T	□	□			□	□		□													□			□												
	NOISE + TONE	□	□			□	□		□																□												
	IDLE STATE WTD	□	□			□	□																		□												
	IDLE STATE SEL	□	□			□	□																		□												
	IDLE STATE OTHER	□	□			□	□																		□												
	IDLE STATE PCM CODES	□	□			□	□																		□												
	LEVEL WTD	□	□			□	□		□													□			□												

Table 4-2 Specification Parameter Verification (continued)

3776A ★ BOTH □
3776B ☆

	SPECIFICATION PARAMETER	PERFORMANCE CHECK NUMBER																																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
AN - DIG (cont'd)	LEVEL OTHER	□	□			□	□		□													□			□												
	LEVEL SEL	□	□			□	□		□													□			□												
	LEVEL PCM CODES	□	□			□	□																		□												
	QUANT DIST N	★	★			★	★									★									★												
	QUANT DIST T	□	□			□	□		□													□			□												
	I/MOD 2T	□	□			□	□									□						□			□												
	I/MOD 4T	☆	☆			☆	☆									☆						☆			☆												
DIGITAL - ANALOG	GAIN T	□	□			□	□	□													□		□	□													
	GAIN DIG MW	□	□			□	□	□													□		□	□													
	GAIN V FREQ	□	□			□	□	□			□										□		□	□													
	GAIN V LEVEL N	★	★			★	★						★								★		★	★													
	GAIN V LEVEL T	□	□			□	□	□													□		□	□													
	GAIN V LEVEL SYNC	□	□			□	□	□													□		□	□													
	NOISE + TONE	□	□			□	□	□				□									□		□	□													
	IDLE STATE WTD	□	□			□	□	□				□									□		□	□													
	IDLE STATE SEL	□	□			□	□	□													□		□	□													
	IDLE STATE OTHER	□	□			□	□	□													□		□	□													
	LEVEL WTD	□	□			□	□	□				□									□		□	□													
	LEVEL SEL	□	□			□	□	□								□				□	□		□	□													
	LEVEL OTHER	□	□			□	□	□													□		□	□													
	QUANT DIST N	★	★			★	★								★						★		★	★													
	QUANT DIST T	□	□			□	□					□									□		□	□													
	I/MOD 2T	□	□			□	□				□						□				□		□	□													
	I/MOD 4T	☆	☆			☆	☆								☆		☆				☆		☆	☆													
	———																																				

Table 4-2 Specification Parameter Verification (continued)

3776A ★ BOTH □
3776B ☆

	SPECIFICATION PARAMETER	PERFORMANCE CHECK NUMBER																																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
DIGITAL - DIGITAL	GAIN T	□	□			□	□																□	□	□												
	GAIN DIG MW	□	□			□	□																□	□	□												
	GAIN DIG Tx-Rx	□	□			□	□																□	□	□												
	GAIN V FREQ	□	□			□	□																□	□	□												
	GAIN V LEVEL N	★	★			★	★																★	★	★												
	GAIN V LEVEL T	□	□			□	□																□	□	□												
	GAIN V LEVEL SYNC	□	□			□	□																□	□	□												
	NOISE + TONE	□	□			□	□																□	□	□												
	IDLE STATE WTD	□	□			□	□																□	□	□												
	IDLE STATE SEL	□	□			□	□																□	□	□												
	IDLE STATE OTHER	□	□			□	□																□	□	□												
	IDLE STATE PCM CODES	□	□			□	□																□	□	□												
	LEVEL WTD	□	□			□	□																□	□	□												
	LEVEL SEL	□	□			□	□																□	□	□												
	LEVEL OTHER	□	□			□	□																□	□	□												
	LEVEL PCM CODES	□	□			□	□																□	□	□												
	QUANT DIST N	★	★			★	★																★	★	★												
	QUANT DIST T	□	□			□	□																□	□	□												
	I/MOD 2T	□	□			□	□																□	□	□												
	I/MOD 4T	☆	☆			☆	☆																☆	☆	☆												
ANALOG Tx	GAIN T	□	□						□							□						□															
	GAIN V FREQ	□	□						□							□						□															
	GAIN V LEVEL N	★	★						★																												
	GAIN V LEVEL T	□	□						□							□						□															
	NOISE + TONE	□	□						□							□																					

Table 4-2 Specification Parameter Verification (continued)

3776A ★ BOTH □
3776B ☆

	SPECIFICATION PARAMETER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
AN Tx (cont'd)	IDLE STATE	□	□																																		
	LEVEL	□	□						□							□						□															
	QUANT DIST N	★	★						★																												
	QUANT DIST T	□	□						□							□						□															
	I/MOD 2T	□	□						□							□						□															
	I/MOD 4T	☆	☆						☆							☆						☆															
DIGITAL Tx	GAIN T	□	□			□	□																□	□													
	GAIN DIG MW	□	□			□	□																□	□													
	GAIN DIG Tx-Rx	□	□			□	□																□	□													
	GAIN V FREQ	□	□			□	□																□	□													
	GAIN V LEVEL N	★	★			★	★																★	★													
	GAIN V LEVEL T	□	□			□	□																□	□													
	NOISE + TONE	□	□			□	□																□	□													
	IDLE STATE	□	□			□	□																□	□													
	LEVEL	□	□			□	□																□	□													
	QUANT DIST N	★	★			★	★																★	★													
	QUANT DIST T	□	□			□	□																□	□													
	I/MOD 2T	□	□			□	□																□	□													
	I/MOD 4T	☆	☆			☆	☆																☆	☆													
ANALOG Rx	GAIN T	□	□					□													□																
	GAIN DIG MW	□	□					□													□																
	GAIN V FREQ	□	□					□			□										□																
	GAIN V LEVEL N	★	★										★								★																
	GAIN V LEVEL T	□	□					□													□																
	GAIN V LEVEL SYNC	□	□					□													□																

Table 4-2 Specification Parameter Verification (continued)

3776A ★ BOTH □
3776B ☆

SPECIFICATION PARAMETER		PERFORMANCE CHECK NUMBER																																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
ANALOG Rx (cont'd)	NOISE + TONE	□	□					□				□									□																
	IDLE STATE WTD	□	□					□				□									□																
	IDLE STATE SEL	□	□					□													□																
	IDLE STATE OTHER	□	□					□													□																
	LEVEL WTD	□	□					□				□									□																
	LEVEL SEL	□	□					□												□	□																
	LEVEL OTHER	□	□					□													□																
	QUANT DIST N	★	★												★						★																
	QUANT DIST T	□	□					□				□									□																
	I/MOD 2T	□	□								□						□				□																
	I/MOD 4T	☆	☆												☆		☆				☆																
DIGITAL Rx	GAIN T	□	□			□	□																		□												
	GAIN DIG MW	□	□			□	□																		□												
	GAIN DIG Tx-Rx	□	□			□	□																		□												
	GAIN V FREQ	□	□			□	□																		□												
	GAIN V LEVEL N	★	★			★	★																		★												
	GAIN V LEVEL T	□	□			□	□																		□												
	GAIN V LEVEL SYNC	□	□			□	□																		□												
	NOISE + TONE	□	□			□	□																		□												
	IDLE STATE WTD	□	□			□	□																		□												
	IDLE STATE SEL	□	□			□	□																		□												
	IDLE STATE OTHER	□	□			□	□																		□												
	IDLE STATE PCM CODES	□	□			□	□																		□												
	LEVEL WTD	□	□			□	□																		□												
	LEVEL SEL	□	□			□	□																		□												

Table 4-2 Specification Parameter Verification (continued)

3776A ★ BOTH □
3776B ☆

SPECIFICATION PARAMETER		PERFORMANCE CHECK NUMBER																																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
DIG Rx (cont'd)	LEVEL OTHER	□	□			□	□																		□												
DIG Rx (cont'd)	LEVEL PCM CODES	□	□			□	□																		□												
DIG Rx (cont'd)	QUANT DIST N	★	★			★	★																		★												
DIG Rx (cont'd)	QUANT DIST T	□	□			□	□																		□												
DIG Rx (cont'd)	I/MOD 2T	□	□			□	□																		□												
DIG Rx (cont'd)	I/MOD 4T	☆	☆			☆	☆																		☆												
FRAMING & SIG. BITS	FRAME WORD	★	★																																		
FRAMING & SIG. BITS	NON-FM WORD	★	★																																		
FRAMING & SIG. BITS	TS 16 FM 0	★	★																																		
FRAMING & SIG. BITS	TS 16 SIG BITS	★	★																																		
FRAMING & SIG. BITS	FT/FE BITS	☆	☆																																		
FRAMING & SIG. BITS	FS BITS	☆	☆																																		
FRAMING & SIG. BITS	SIG BITS	☆	☆																																		
FRAMING & SIG. BITS	LOOP TIMING	☆	☆																																		
MISCELLANEOUS	HP-IB FUNCTIONS	□	□																																		
MISCELLANEOUS	SEQ TEST			□																																	
MISCELLANEOUS	DT MF				□																																

Table 4-2 Specification Parameter Verification (continued)

ADDITIONAL CHECKS APPLICABLE ONLY TO MODELS 3776A & B EQUIPPED WITH OPTION 001

	SPECIFICATION PARAMETER	PERFORMANCE CHECK NUMBER																																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
3776B	ENVEL DELAY	●	●																													●					
	RE-MOD	●	●																													●					
	ABSOLUTE DELAY	●	●																													●					
	RETURN LOSS (4W)	●	●																																		
3776A	GROUP DELAY	●	●																													●					
	RE-MOD	●	●																													●					
	ABSOLUTE DELAY	●	●																													●					
A & B	TRANSIENTS	●	●																								●	●	●	●	●						
	PHASE JITTER	●	●																							●											

Table 4-3 Performance Tests

No	Title	Para	Page
1	Power-On Sequence	4-24	4-3
2	Self Test	4-26	4-6
3	Sequence Test	4-36	4-44
4	Dual-Tone Multi-Frequency (DTMF) Signalling Test	4-37	4-45
5	3776B PCM Tests	4-38	4-48
6	3776A PCM Tests	4-39	4-55
7	Analog Receiver Levels and Linearity	4-40	4-71
8	Analog Transmitter Levels and Linearity	4-41	4-75
9	Analog Transmitter Flatness	4-42	4-80
10	Analog Receiver Flatness	4-43	4-82
11	Analog Receiver Digital Filter	4-44	4-83
12	Analog Receiver Noise Linearity (3776A ONLY)	4-45	4-86
13	Analog to Analog (A-A) Gain	4-46	4-88
14	Analog Receiver Noise Floor	4-47	4-89
15	Analog Transmitter Spurious	4-48	4-89
16	Analog Receiver Inter-modulation Floor	4-49	4-90
17 18	} Not applicable to this instrument		
19	Analog Receiver Out-of-Band Rejection	4-52	4-91
20	Analog Receiver Anti-Aliasing Filter Flatness	4-53	4-92
21	Analog Transmitter Frequency Accuracy	4-54	4-93
22	Digital Transmitter External Clock Input	4-55	4-95
23	Digital Transmitter PCM Waveforms	4-56	4-96
24	Digital Receiver Sensitivity	4-57	4-97
25	Phase Jitter (OPTION 001)	4-58	4-98
26	Phase Hits (OPTION 001)	4-59	4-109
27	Gain Hits (3776B OPTION 001)/Amplitude Hits (3776A)	4-60	4-119
28	Dropouts (3776B OPT 001)/Interruptions (3776A OPT 001)	4-61	4-123
29	Impulse Noise (3776B OPTION 001 ONLY)	4-62	4-126
30	Impulse Noise (3776A OPTION 001 ONLY)	4-63	4-129
31	Envelope Delay Distortion (3776B OPTION 001) and Group Delay (3776A OPTION 001)	4-64	4-132

4-40 ANALOG RECEIVER LEVELS AND LINEARITY

PARAMETERS TESTED

(a) Linearity of the A7 Analog to Digital Converter.

(b) Imperfections in Self-Cal of the Receiver Gain.

(c) Imperfections in Self-Cal of the Receiver Autoranging.

(d) Gain of the A7 Analog to Digital Converter plus the Analog Receiver Input.

(e) Low-Level check.

SPECIFICATIONS

With reference to the input level;
Analog Receiver displayed Level and Linearity
accuracy (Internal Source):

Table 1 Analog Rx Level and Linearity Limits

Receiver Input Level	Level Limits	Linearity Limits (With reference to -30dBm)
-10dBm	+/-0.09dB	0.06dB
0	+/-0.09dB	0.06dB
-10dBm	+/-0.09dB	0.06dB
-20dBm	+/-0.09dB	0.06dB
-30dBm	+/-0.09dB	-
-40dBm	+/-0.11dB	0.06dB
-50dBm	+/-0.11dB	0.08dB
-60dBm	+/-0.11dB	0.10dB
-70dBm	+/-0.13dB	0.12dB
-76dBm	+/-0.13dB	0.18dB

DESCRIPTION

Analog Receiver Level and Linearity are tested by measuring the Receiver input voltage, converting this to dBm0 and comparing the computed dBm0 value with the displayed value. Displayed results at different input range settings are then compared to the initial displayed value. The Dekatran Attenuator is used to maintain the 3776 Tx output at +10dBm and -30dBm. This eliminates Transmitter linearity errors.

EQUIPMENT

AC Voltmeter........................HP 3455A
AC Calibrator........................FLUKE 5200A
Attenuator........................DEKATRAN

BAL/UNBAL Converter	SA1 (see Appendix D)
UNBAL/BAL Converter	SA2 (see Appendix D)
Dual Power Supply	HP 6205B
+-0.01% 600 ohm Resistor	HP 0811-3502
+-0.01% 900 ohm Resistor	HP 0811-3504
*Frequency Counter	HP 5328A

*Required only if AC Calibrator does not have a Frequency display.

PROCEDURE

1. Connect the equipment as shown in Figure 4-17 with the 600 ohm resistor connected.

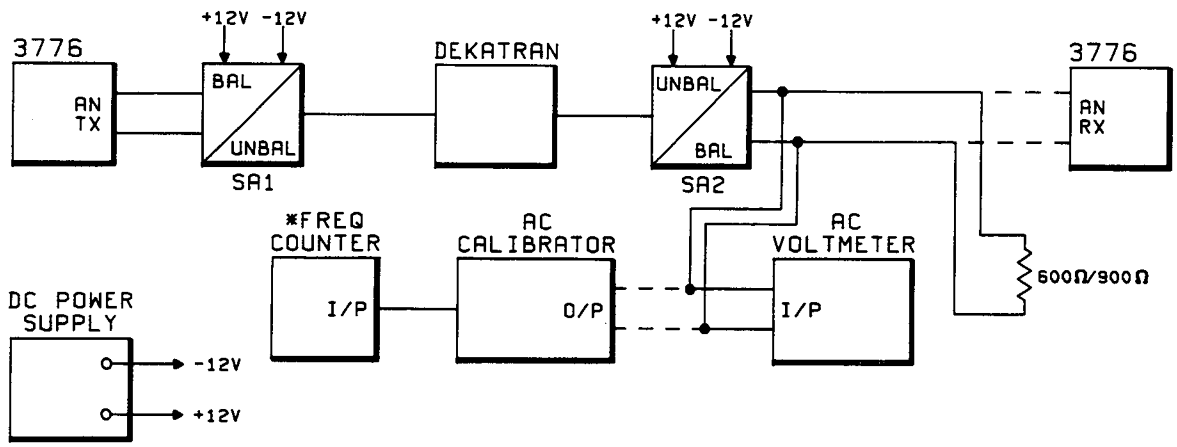


Figure 4-17 Analog Receiver Levels and Linearity Test Set-up

2. Set the 3776A/B to A-A LEVEL-SEL and 600 ohms BAL.

3. Set SA1 and SA2 to 600 ohm.

4. Set the Dekatran to 0.0100000 (-40dB).

5. Ensure that the Tx and Rx channel interface is set to 0dBr, and set the output level to +10dBm0.

6. Set the AC Calibrator to 24.4948mV/0.81kHz (3776A) or 24.4948mV/1.02kHz (3776B) and connect it direct to the HP 3455A AC Voltmeter only.

7. Select AC volts range on the AC Voltmeter and store the reference AC Calibrator voltage as Y.

8. Disconnect the AC Calibrator from the AC Voltmeter and connect the AC Voltmeter as shown in the test circuit, with SA2 driving the 600 ohm load.

9. Set the 3776 to RUN/REPEAT.

10. Press MATH % Error (X-Y/Y x 100) on the AC voltmeter.

11. Convert the % Error displayed on the AC Voltmeter to a power level as follows:

$$AdBm0 = 20 \log (Vin/0.7746)$$

where; $Vin = 24.4948mV (1+\%Error/100)$

Record the computed value AdBm0.

The following HP 85 BASIC program can be used to convert % Error to AdBmO (-30dBm/600ohms)

```
10 DISP "ENTER %ERROR & PRESS ENDLINE"
20 INPUT B
30 V=.024495*(1+B/100)
40 A=20*LGT(V/.7746)
50 PRINT "COMPUTED LEVEL=";A
70 END
 30027
```

12. Disconnect the 600 ohm load and connect the output from SA2 to the 3776 Receiver.

13. Record the reading on the 3776 display, call this BdBm0.

14. Check that BdBm0 is within AdBm0 +/-0.09dB. Record the error (ie AdBm0 - BdBm0).

15. Set the Dekatran as shown in Table 2. At each setting calculate the Linearity and Level Errors and check that they are within the limits given in Table 2.

Notes:
1. Linearity Error = 3776 Displayed value +/-(BdBmO-D) where BdBmO = value recorded in Step 13, and D = difference between Dekatran setting in Step 4 and settings given in Table 2.

2. Level Error or Total Error = Error noted in Step 14 +- Linearity Error.

3. Take several readings at each setting and compute the average Receiver Level.

Table 2 Analog Rx Linearity and Level Limits (+10dBm to -30dBm)

Dekatran Setting (dB Value)	Rx I/P LEVEL	Linearity Error Limits (See Step 15 Note 1)	Level Error Limits (See Step 15 Note 2)	D (See Step 15 Note 1)
0.0316228 (-30)	-20dBm	0.06dB	+/-0.09dB	+10dB
0.1000000 (-20)	-10dBm	0.06dB	+/-0.09dB	+20dB
0.3162277 (-10)	0dBm	0.06dB	+/-0.09dB	+30dB
1.0000000 (0)	+10dBm	0.06dB	+/-0.09dB	+40dB

16. Set the 3776A/B Tx level to -30dBm.

17. Set the Dekatran to 1.0000000 (0dB).

18. Set the AC Calibrator to 24.4948mV (-30dBm/600ohm) and connect it to the HP 3455A AC Voltmeter.

19. Store the AC Calibrator voltage as Y in the AC Voltmeter.

20. Disconnect the AC Calibrator and connect the AC Voltmeter as shown in the test circuit, with SA2 output driving the 600 ohm load.

21. Press % Error (X-Y/Y x 100) on the AC Voltmeter.

22. Convert the % Error displayed on the AC Voltmeter to a power level as follows:

$$CdBm0 = 20 \log (Vin/0.7746)$$

where; $Vin = 24.4948mV\ (1 + \%Error/100)$

Record the computed value CdBm0.

Note: See Step 11 for program to convert % Error to CdBm0.

23. Disconnect the 600 ohm load and connect the output from SA2 to the 3776 Receiver.

24. Record the reading in the 3776 display, call this XdBm0.

25. Check that XdBm0 is within CdBm0 +-0.09dB. Record the error (ie, CdBm0 - XdBm0).

26. Set the Dekatran as shown in Table 3. At each setting calculate the Linearity and Level Errors and check that they are within the limits given in Table 3.

Notes:
1. Linearity Error = 3776 Displayed value +/-(XdBmO-D); where XdBmO = value recorded in Step 24 and D = Difference between the Dekatran Setting in Step 17 and settings given in Table 3.

2. Level Error or Total Error = Error noted in Step 25 +- Linearity Error.

3. Take several readings at each setting and compute the average Receiver level.

Table 3 Analog Rx Linearity and Level Limits (-40dBm to -76dBm)

Dekatran Setting (dB Value)	Rx I/P Level	Linearity Error Limits (See Step 26 Note 1)	Level Error Limits (See Step 26 Note 1)	D (See Step 26 Note 1)
0.3162277 (-10)	-40dBm	0.06	+/-0.11	-10
0.1000000 (-20)	-50dBm	0.08	+/-0.11	-20
0.0316227 (-30)	-60dBm	0.10	+/-0.11	-30
0.0100000 (-40)	-70dBm	0.12	+/-0.13	-40
0.0050118 (-46)	-76dBm	0.18	+/-0.13	-46

27. Repeat Steps 1 to 15 with the Analog Rx set to 600 ohm - BRIDGED. In Step 12 do not disconnect the 600 ohm load when connecting to the Analog Rx.

28. Repeat Steps 1 to 15 with Analog Tx/Rx set to 900 ohm BAL. In Step 6 the AC Calibrator should be set to a level of 30.000mV (ie -30dBm/900 ohm) and the formula used to convert to a power level in Step 11 is:

$$AdBm0 = 20 \log (Vin/0.9487)$$

where; $Vin = 30.000mV (1 + \%Error/100)$

The following HP 85 BASIC program can be used to convert %Error to AdBmO (-30dBm/900ohms).

```
10 DISP "ENTER %ERROR & PRESS ENDLINE
20 INPUT B
30 V=.03*(1+B/100)
40 A=20*LGT(V/.9487)
50 PRINT "COMPUTED LEVEL=";A
70 END
```

Also, remember to use the 900 ohm resistor (HP Part Number 0811- 3504). SA1 and SA2 should be set to 900 Ohm.

29. Repeat Steps 1 to 15 with the Analog Rx set to 900 ohm - BRIDGED. In Step 12 do not disconnect the 900 ohm load when connecting to the Analog Rx.

4-41 ANALOG TRANSMITTER LEVELS AND LINEARITY

PARAMETERS TESTED

(a) Linearity of the A3 D/A Converter.

(b) Imperfections in Self-Cal. of the A3 Analog Attenuator and Analog Transmitter Gain.

(c) Gain of the A7 A/D Converter (used in the Self-Cal of the A3 Analog Attenuator).

(d) Gain of the Analog Transmitter Output.

(e) Low-Level test.

SPECIFICATION

Analog Transmitter Output Level and Linearity Accuracy (Internal Source):

Table 1 Analog Tx Level and Linearity Limits

Transmitter Output Level	Level Limits	Linearity Limits (With reference to -30dB)
+10dBm	+/-0.09dB	0.05dB
0dBm	+/-0.09dB	0.05dB
-10dBm	+/-0.09dB	0.05dB
-20dBm	+/-0.09dB	0.05dB
-30dBm	+/-0.09dB	0.05dB
-40dBm	+/-0.11dB	0.05dB
-50dBm	+/-0.11dB	0.06dB
-60dBm	+/-0.11dB	0.07dB
-70dBm	+/-0.13dB	0.09dB
-76dBm	+/-0.13dB	0.12dB

Table 2 summarises the technique used, assuming no loss in the Dekatran.

Table 2

Check Sequence	Tx O/P	Dek. Set.	Rx Approx Disp Value
2	+10	-40	-30
3	00	-30	-30
4	-10	-20	-30
5	-20	-10	-30
1	-30	00	Ref level and absolute level error computed and recorded. This error used to compute all level errors.
6	-30	-10	Linearity Ref Value for Tx-40
7	-40	00	
8	-30	-20	Linearity Ref Value for Tx-50
9	-50	00	
10	-30	-30	Linearity Ref Value for Tx-60
11	-60	00	
12	-30	-40	Linearity Ref Value for Tx-70
13	-70	00	
14	-30	-46	Linearity Ref Value for Tx-76
15	-76	00	

DESCRIPTION

The absolute Transmitter level is measured at -30dBm using the AC Calibrator, AC Voltmeter and termination load. The 3776 AnTx is then connected via the Dekatran to the AnRx and an initial Receiver reference displayed result recorded. Using the Dekatran to maintain the AnRx at a constant level, the AnTx output is set at different range settings and the AnRx displayed results are compared with the initial reference result.

EQUIPMENT

AC Voltmeter.......................................HP 3455A
AC Calibrator.......................................FLUKE 5200A
Attenuator.......................................DEKATRAN
0.01% 600 Ohm Resistor.......................................HP 0811-3502
BAL/UNBAL Converter.......................................SA1 (See Appendix D)
UNBAL/BAL Converter.......................................SA2 (See Appendix D)
Dual Power Supply.......................................HP 6205B
0.01% 900 Ohm Resistor.......................................HP 0811-3504
*Frequency Counter.......................................HP 5328A

*Required only if AC Calibrator does not have a Frequency display.

PROCEDURE

1. Ensure that the Tx and Rx Channel Interface is set to OdBr.

2. Set the 3776A/B to A-A LEVEL SEL FILTER and 600ohm BAL.

3. Connect the equipment as shown in Figure 4-18, with the Analog Transmitter connected to the 600 Ohm load.

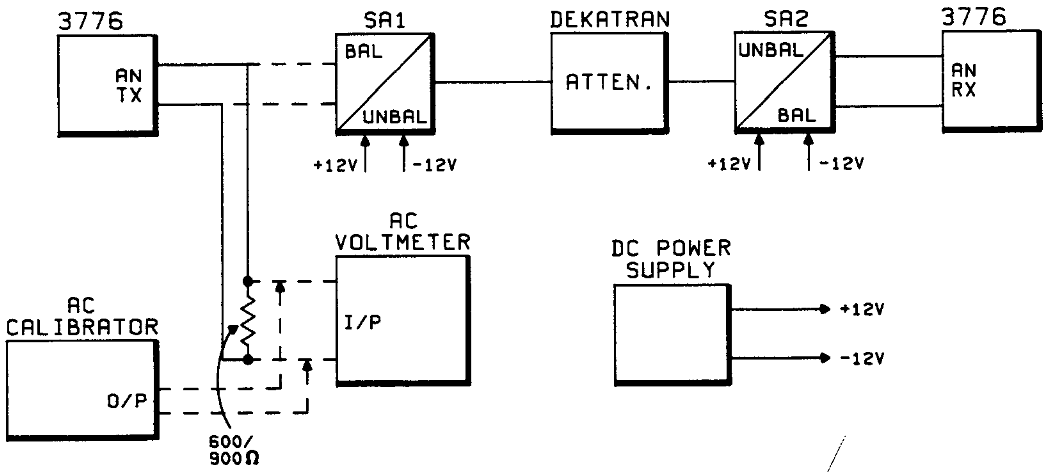


Figure 4-18 Analog Transmitter Levels and Linearity Test Set-up

4. Set the 3776A/B to -30dBm0.

5. Connect the AC Calibrator to the AC Voltmeter and select AC Volts on the AC Voltmeter.

6. Set the AC Calibrator to 24.4948mV/0.81kHz (3776A) or 24.4948mV/1.01kHz (3776B). If a 900ohm resistor is used, set the AC Calibrator to 30.000mV.

7. Store the voltage on the AC Voltmeter as Y.

8. Disconnect the AC Voltmeter from the AC Calibrator and connect the AC Voltmeter across the 600ohm resistor.

9. Press RUN/REPEAT on the 3776.

10. Press % ERROR (x-y/y x 100) on the AC Voltmeter.

11. Check that the % ERROR displayed is within +-1.04% (+-0.09dB = +-1.04% Error). Note the % Error.

12. Convert the % Error to dBm as follows:

    AdBm0 = 20 log (Vout/0.7746)

    where; Vout = 24.4950mv (1 + (% Error/100))

    record the calculated actual transmitted power AdBm0.

The following HP 85 BASIC program can be used to convert % Error to AdBmO (-30dBm/600ohms).

```
10 DISP "ENTER %ERROR & PRESS ENDLINE"
20 INPUT B
30 V=.024495*(1+B/100)
40 A=20*LGT(V/.7746)
50 PRINT "COMPUTED LEVEL=";A
70 END
```

13. Record the output level error ie AdBm0 - -30dBmO.

14. Set the Dekatran to 1.0000000 (0dB).

15. Disconnect the load resistor and AC Voltmeter and connect the 3776 Analog Transmitter output directly to SA1 (see Test Set-up).

16. Press RUN/REPEAT on the 3776 and record the reading on the 3776 display, call this BdBmO, (BdBmO should be approx. -30dBmO).

17. Set the 3776 Tx Output Level and Dekatran as shown in Table 1. At each setting calculate the Linearity and Level errors and check that they are within the limits given in Table 1.

Notes:
1. Linearity Error = BdBm0 - Displayed value, where BdBm0 is the value recorded in step 16.

2. Level Error or Total Error = Error noted in Step 13 +- Linearity Error.

3. Take several readings at each setting and compute the average Receiver Level.

Table 1

3776 Tx Output Level Setting	Dekatran Setting (dB)	Linearity Error Limits (see Step 17 Note 1)	Level Error Limits (see Step 17 Note 2)
+10dBm0	0.0100000 (-40)	0.05	+/-0.09dB
0dBm0	0.0316228 (-30)	0.05	+/-0.09dB
-10dBm0	0.1000000 (-20)	0.05	+/-0.09dB
-20dBm0	0.3162277 (-10)	0.05	+/-0.09dB

18. Set the 3776A/B to -30dBmO.

19. Set the Dekatran to 0.3162277 (-10dB).

20. Press RUN/REPEAT and record the 3776A/B reading; call this reference reading CdBmO.

21. Set the Dekatran to 1.0000000 (0dB).

22. Set the 3776 Tx to -40dBmO and press RUN/REPEAT.

23. Record the 3776A/B reading.

24. Calculate the Linearity and Level errors as follows:

    Linearity Error = CdBmO - value recorded in Step 23

    Level Error = Error recorded in Step 13 +/- Linearity Error

25. Check that the Level error is within +/-0.09dB and the Linearity error is within 0.05dB.

26. Repeat the sequence given in Steps 18 to 25 with the Dekatran (Step 19) and 3776 Tx output (Step 22) set as given in Table 2. Check at each setting that the Level and Linearity is within the limits given in Table 2.

    Notes:
    1. See Table given in the Description summarising the technique used

    2. Take several readings at each setting and compute the average Receiver Level.

Table 2

Dekatran Setting (Step 19)	3776 Tx Output Level Setting (Step 22)	Linearity Limits (See Step 24)	Level Limits (See Step 24)
0.1000000 (-20)	-50	0.06dB	+/-0.11dB
0.0316228 (-30)	-60	0.07dB	+/-0.11dB
0.0100000 (-40)	-70	0.09dB	+/-0.13dB
0.0050119 (-46)	-76	0.12dB	+/-0.13dB

27. Set the 3776 to 900ohm BAL and using the 900ohm load impedance repeat steps 2 to 21.

    Notes:
    1. SA1 and SA2 must be set to 900ohm.

    2. Step 6, AC Calibrator must be set to 30.00mV (ie -30dBm/900ohm).

    3. Step 12, AdBmO = 20 log (Vout/0.94868).

The following HP 85 BASIC program can be used to convert % Error to AdBmO (-30dBm/900ohm) in Step 12.

```
10 DISP "ENTER %ERROR & PRESS ENDLINE"
20 INPUT B
30 V=.03*(1+B/100)
40 A=20*LGT(V/.9487)
50 PRINT "COMPUTED LEVEL=";A
70 END
```

4-42 ANALOG TRANSMITTER FLATNESS

SPECIFICATION

Analog Transmitter Flatness: +/-0.04dB at frequencies of 70Hz, 210Hz, 1.01kHz (3776B), 0.81kHz (3776A) 3.59kHz and 4.59kHz.

DESCRIPTION

The 3776A/B Transmitter output is terminated by a precision load and the output level is compared with the AC Calibrator output at selected frequencies.

EQUIPMENT

*Frequency Counter	HP 5328A
AC Calibrator	Fluke 5200A
AC Voltmeter	HP 3455A
0.01% 600ohm Resistor	HP 0811-3502

*Required only if AC Calibrator does not have a frequency display.

PROCEDURE

1. Connect the equipment as shown in Figure 4-19.

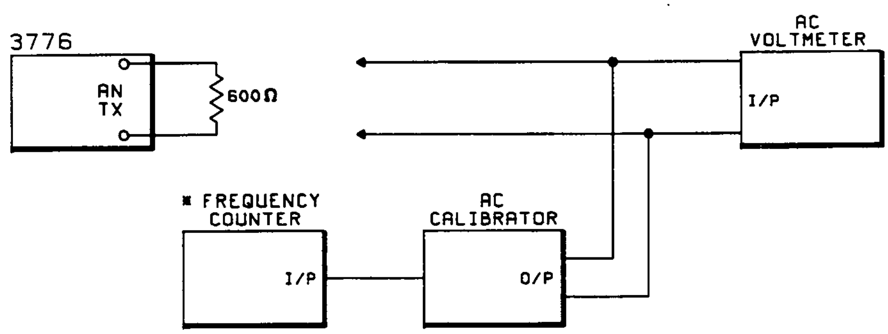


Figure 4-19 Analog Transmitter Flatness Test Set-up

2. Set the 3776 to Analog Transmitter LEVEL SELECTIVE, 600ohm BAL.
3. Set the 3776A/B level to +10dBmO and frequency to 1.01kHz (3776B), 0.81kHz (3776A).
4. Set the AC Calibrator to 1.01kHz if the instrument is a 3776B or 0.81kHz if the instrument is a 3776A.
5. Set the AC Calibrator level to 2.44948V.
6. Connect the AC Calibrator to the AC Voltmeter and store the reference voltage as Y.
7. Disconnect the AC Calibrator from the AC Voltmeter and connect the AC Voltmeter across the 600ohm resistor. Press RUN/REPEAT on the 3776.
8. Press % ERROR on the AC Voltmeter and record the % ERROR displayed.
9. Repeat steps 3 to 8 for 70Hz, 210Hz, 3.59kHz and 4.59kHz set on both the 3776 and the AC Calibrator and check that the % Errors obtained are within +/-0.461% (0.04dB) of the initial % Error at 1.01kHz (3776B) or 0.81kHz (3776A).

4-43 ANALOG RECEIVER FLATNESS

SPECIFICATION

Analog Receiver Flatness: +/-0.03dB

DESCRIPTION

The AC Calibrator output is fed directly to the 3776 Analog Receiver Input. The AC Calibrator voltage is set at 2.44948V (i.e. +10dBm/600ohm) and its frequency set at 210Hz, 1.01kHz (3776B) or 0.81kHz (3776A) and 3.89kHz. At each frequency step, the 3776 displayed level is recorded and the analog receiver flatness computed.

EQUIPMENT

AC Calibrator	Fluke 5200A
*Frequency Counter	HP 5328A
Unbalanced to Balanced Converter	SA2 (See Appendix D)
Dual Power Supply	HP 6205B

*Required only if AC Calibrator does not have a Frequency display.

PROCEDURE

1. Connect the equipment as shown in Figure 4-20.

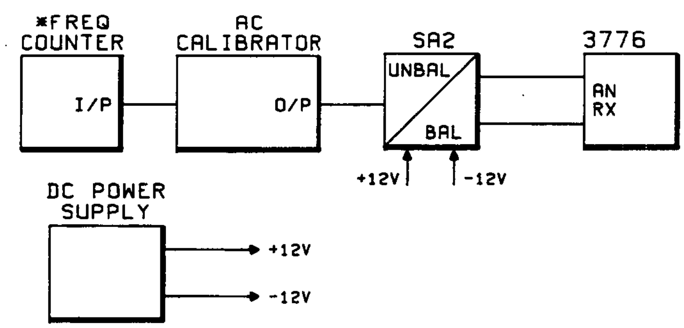


Figure 4-20 Analog Receiver Flatness Test Set-up

2. Set the AC Calibrator level to 2.44948V (+10dBm/600ohm) and frequency to 0.81kHz if 3776A or 1.01kHz 3776B.

3. Set the 3776 to Analog Rx, LEVEL SEL FILTER, 600ohm. Select 1.01kHz MEAS Frequency (3776B). 810Hz MEAS Frequency (3776A). Press RUN/REPEAT on the 3776.

4. Record the 3776 displayed value.

5. Set the AC Calibrator frequency, displayed on the Frequency Counter, to 210Hz and the 3776 MEAS Frequency to 210Hz.

6. Press RUN and record the 3776 displayed value.

7. Set the AC Calibrator frequency and 3776 MEAS frequency to 3.89kHz, press RUN and record the displayed value.

8. Check that the values recorded in steps 6 and 7 are within +/-0.030dB of value recorded in step 4.

4-44 ANALOG RECEIVER DIGITAL FILTER

DESCRIPTION

If the 3776 passes Self-Test (including a self-test of the AnRx filter), it can be assumed that all Digital and Analog Filters function to specification. If further verification is required, the following procedure can be performed. The procedure checks only the mask for the 3776A Psophometric Filter or the 3776B C-Message Filter. Note: the Max and Min mask limits quoted in the spec below have a tolerance of +/-0.073dB.

SPECIFICATION

Psophometric Filter Mask:

FREQ (Hz)	Mask (dB)	
	Max	Min
250	-13.0	-17.0
800	+0.1	-0.1
3000	-4.6	-6.6
4500	-22.0	-28.0

Psophometric Filter Noise Floor: <-100dBm

C-Message Filter Mask:

FREQ (Hz)	Mask (dB)	
	Max	Min
300	-15.5	-17.5
900	+0.4	-1.6
3000	-1.5	-3.5
4500	-18.5	-24.5

C-Message Filter Noise Floor: <-100dBm

EQUIPMENT

AC Voltmeter........HP 3455A
AC Calibrator........FLUKE 5200A

PROCEDURE

1. Connect the 3776 Analog Transmitter to the Analog Receiver.

2. Ensure that the Tx and Rx channel interface is set to 0dBr, (and set the output level to +10dBmO).

3. Set the 3776 to 600ohm UNBAL and A-A LEVEL/SEL FILTER Measurement. Set the REF and MEAS Frequencies to 1.01kHz (3776B) or 810Hz (3776A).

4. Set the AC Calibrator to 1.01kHz (3776B) or 810Hz (3776A) and 2.4495V and connect it to the 3455A AC Voltmeter.

5. Select AC volts range in the AC Voltmeter and store the AC Calibrator voltage as Y.

6. Disconnect the AC Calibrator from the AC Voltmeter and connect the AC Voltmeter across the 3776 Receiver Input.

7. Press % ERROR (x-y/y x 100) on the AC Voltmeter.

8. Convert the % ERROR displayed on the AC Voltmeter to a power level as follows:

$$xdBm0 = 20\log (V_{in} / 0.7746)$$

where $V_{in} = 2.4495(1 + \%ERROR/100)$

NOTE: If the instrument is a 3776B and the C-message filter has been selected, the dBm0 value calculated can be converted to dBrnC0 by adding 90. For Example +10dBm0 = 100dBrnC0.

The following HP 85 BASIC program can be used to convert % Error to XdBmO (+10dBm/600ohms).

```
10 DISP "ENTER %ERROR & PRESS ENDLINE
20 INPUT B
30 V=2.4495*(1+B/100)
40 A=20*LGT(V/.7746)
50 PRINT "COMPUTED LEVEL=";A
70 END
```

9. If a 3776A is used, select the Psophometric Filter, set the 3776 output frequency as shown in Table 1 and at each step check that the 3776A display is within the limits given in Table 1. Ensure that the 3776 is set to +10 dBm0.

   If a 3776B is used, select the C-Message Filter, set the 3776 output frequency as shown in Table 2 and at each step, check that the 3776B display is within the limits given in Table 2.

Table 1 Psophometric Filter

3776 O/P FREQ (Hz)	Psophometric Mask Limits	
	Max	Min
250	(xdBm0 - 12.927)	(xdBm0 - 17.073)
800	(xdBm0 - 0.173)	(xdBm0 - 0.173)
3000	(xdBm0 - 4.527)	(xdBm0 - 6.673)
4500	(xdBm0 - 21.927)	(xdBm0 - 28.073)

Table 2 C-Message Filter

3776 O/P FREQ (Hz)	C-Message Mask Limits	
	Max	Min
300	(xdBrnC0 - 15.427)	(xdBrnC0 - 17.573)
900	(xdBrnC0 + 0.473)	(xdBrnC0 - 1.673)
3000	(xdBrnC0 - 1.427)	(xdBrnC0 - 3.573)
4500	(xdBrnC0 - 18.427)	(xdBrnC0 - 24.573)

4-45 ANALOG RECEIVER NOISE LINEARITY (3776A ONLY)

SPECIFICATION

Analog Receiver Noise Linearity: +-0.08dB for input noise level range between +2dBm to -46dBm.

+-0.12dB for input noise level range between -46dBm and -66dBm.

+-0.30dB for input noise level range between -66dBm and -82dBm.

DESCRIPTION

Similar to Test Procedure para 4-40 (Analog Receiver Linearity), but uses a 350 to 550Hz noise test signal and the Quantizing Distortion Reference Filter.

EQUIPMENT

Decade Transformer........Dekatran
BAL/UNBAL Converter........SA1 (See Appendix D)
UNBAL/BAL Converter........SA2 (See Appendix D)
Dual Power Supply........HP 6205B

PROCEDURE

1. Connect the equipment as shown:

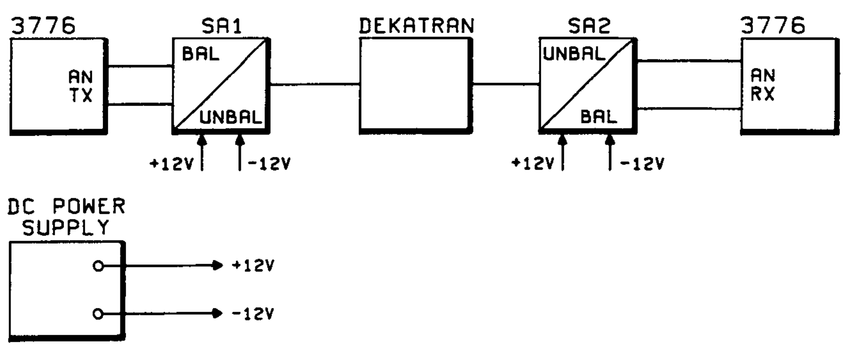


Figure 4-21 3776A Analog Receiver Noise Linearity Test Set-up

2. Set the 3776 to GAIN V LEVEL/NOISE and 600 ohm BAL.

3. Set SA1 and SA2 to 600 ohm.

4. Set the Dekatran to 1.0000000 (0dB).

5. Ensure that the Tx and Rx Channel Interface is set to 0dBr, and set the output level of the REF and all 20 MEAS Points to +2dBmO.

6. Set the Dekatran as shown in Table 1. Use the result displayed in the 3776A with the Dekatran set to 1.0000000 as the initial reference value x. Check at each setting that the 3776A display is within the limits given in Table 1.

NOTE: Because GAIN V LEVEL/NOISE multipoint measurement is made with respect to an initial reference level, the following procedure should be used for checking the Receiver Linearity.

a. With the Dekatran set to 1.0000000 press the 3776 S/STEP button and wait until the initial reference value is displayed (should be approx 0dB).

b. Change the Dekatran to the next setting given in the Table and press S/STEP.

c. Check that the displayed results are within the limits given.

d. Continue to change the Dekatran setting, pressing S/STEP and then checking that the displayed results are within the limits given in the Table.

Table 1

Dekatran Settings	3776A/B Display Limits
1.0000000 (0dB)	x = (initial reference value)
0.3162277 (-10dB)	(x-10) +- 0.08dB
0.1000000 (-20dB)	(x-20) +- 0.08dB
0.0316228 (-30dB)	(x-30) +- 0.08dB
0.0100000 (-40dB)	(x-40) +- 0.08dB
0.0039810 (-46dB)	(x-48) +- 0.06dB

7. Press STOP and set the 3776A Tx level of the REF and all 20 MEAS Points to -40dBmO.

8. Set the Dekatran as shown in Table 2. Use the result displayed on the 3776A with the Dekatran set to 1.0000000 (0dB) as initial reference value Y. Check at each setting that the 3776A display is within the limits given. Use the procedure listed in step 6 to set the 3776.

Table 2

Dekatran Settings	3776A/B Display Limits
1.0000000 (0dB)	y = (initial reference value)
0.3162277 (-10dB)	(y-10) +- 0.12dB
0.1000000 (-20dB)	(y-20) +- 0.12dB
0.0316228 (-30dB)	(y-30) +- 0.30dB
0.0079432 (-42dB)	(y-42) +- 0.30dB

4-46 ANALOG TO ANALOG (A-A) GAIN

SPECIFICATION

Accuracy for Tx, Rx Levels >-30dBm
and any frequency in the Range
200Hz to 3.9kHz: +/-0.05dB

EQUIPMENT

Attenuator	ESI DEKATRAN DT72A
BAL/UNBAL Converter	SA1 (See Appendix D)
UNBAL/BAL Converter	SA2 (See Appendix D)
Dual Power Supply	HP 6205B

PROCEDURE

1. Connect the equipment as shown in Figure 4-22.

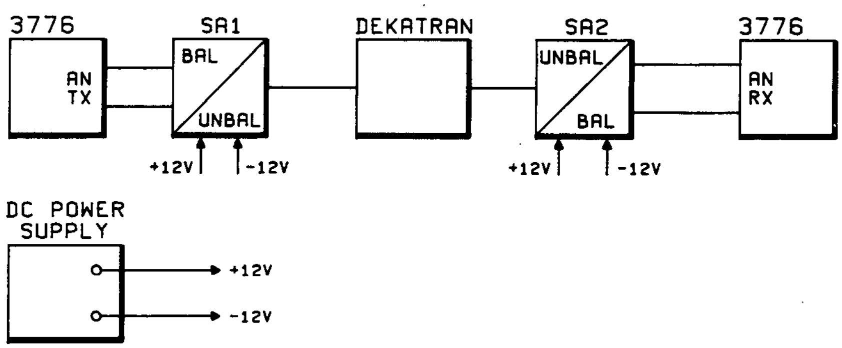


Figure 4-22 Analog to Analog (A-A) Gain Test Set-up

2. Set the Dekatran to 1.0000000 (0dB) and SA1 and SA2 to 600ohm.
3. Set the 3776 to GAIN/TONE and 600ohm Balanced.
4. Set the output level to +10dBmO and frequency to 210Hz.
5. Ensure that Tx and Rx channel interface is set to 0dBr.
6. Press RUN and check for a displayed result of 0dB +/-0.05dB.
7. Repeat measurement at 0.81kHz (3776A) or 1.01kHz (3776B) and 3.89kHz. Results should be 0dB +/-0.05dB.
8. Set the Dekatran to 0.0100000 (-40dB). Repeat steps 4 to 7. Results should be -40dB +/-0.05dB.

9. Change the 3776 Transmitter level to -30dBmO and set Frequency to 210Hz.

10. Set the Dekatran to 1.0000000 (0dB). Repeat steps 5 to 7; displayed result should be 0dB +/-0.05dB.

4-47 ANALOG RECEIVER NOISE FLOOR

SPECIFICATION

	Psophometric Filter	(3776A):	<-100dBm
	C-Message Filter	(3776B):	<-10dBrnC0
	Selective Filter	(3776A/B):	<-110dBm0
Filter A	3kHz Flat Filter	(3776A/B):	<-95dBm0
Filter B	Flat Filter	(3776A/B):	<-90dBm0
Filter C	High Pass	(3776A/B):	<-90dBm0

EQUIPMENT

0.01% 600ohm Resistor..HP 0811-3502

PROCEDURE

1. Connect the 600ohm Resistor across the 3776 Analog Receiver input.

2. Select A-A IDLE STATE/PSOPH or C-MESS.

3. Press RUN and check that the displayed result is less that -100dBm or -10dBrnCO.

   NOTE: When making a measurement, press RUN/REPEAT and take the average of several results.

4. Select IDLE STATE/OTHER FILTERS FIL A(3kHz).

5. Press RUN and check that the displayed result is less than -95dBmO.

6. Select IDLE STATE/OTHER FILTERS FIL B (Flat Filter) by pressing SET FREQ followed by INCR.

7. Press RUN and check that the displayed result is less than -90dBm.

8. Select IDLE STATE/OTHER FILTERS FILC (High Pass) by pressing INCR key.

9. Press RUN and check that the displayed result is less than -90dBmO.

10. Select IDLE STATE/SEL, (810Hz, 3776A or 1010Hz, 3776B).

11. Press RUN and check that the displayed result is less than -110dBmO.

4-48 ANALOG TRANSMITTER SPURIOUS

SPECIFICATION

Transmitter Spurious: >-65dB

DESCRIPTION

The Analog Transmitter generates a 1kHz tone and the Spectrum Analyzer is used to check that other components (spurious or harmonics) are at a level >-65dB below the 1kHz tone level.

EQUIPMENT

Spectrum Analyzer.................HP 3580A OPT 001
Resistor 600ohm +/-0.25%.................HP 0698-6261

PROCEDURE

1. Terminate the 3776 Analog Transmitter Output in 600ohm.

2. Set the 3776 to 600ohm BAL, LEVEL/SEL FILTER, 0dBm0. Set the 3776 MEAS and REF frequencies to 1kHz.

3. Connect the Spectrum Analyzer across one of the balanced outputs and ground.

4. Set the Spectrum Analyzer as follows:

FREQUENCY START.................0
FREQ. SPAN/DIV.................2kHz
RESOLUTION BANDWIDTH.................100Hz
DISPLAY SMOOTHING.................MIN
AMPLITUDE MODE.................10dB LOG
SWEEP TIME/DIV.................5s/DIV
SWEEP MODE.................REP
AMPLITUDE REF LEVEL.................0dBm/600ohm
INPUT SENSITIVITY.................0dB

5. Set the 3776 to RUN/REPEAT.

6. Start the Spectrum Analyzer sweep.

7. Check that all spurious or harmonics are >-65dB below the 1kHz tone level.

4-49 ANALOG RECEIVER INTER-MODULATION FLOOR

SPECIFICATION

Third order product intermodulation
Distortion (i.e. 2F1-F2, 2F2-F1 etc) with
F1 = 320Hz and F2 = 470Hz: >-65dB

EQUIPMENT

Test Oscillator.................HP 654A
Power Splitter.................SA3 (See Appendix D)
Frequency Counter.................HP 5328A

PROCEDURE

1. Connect the equipment as shown in Figure 4-23.

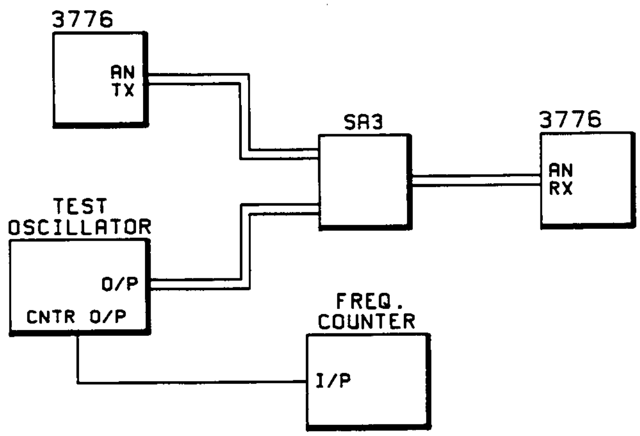


Figure 4-23 Analog Receiver Inter-modulation Floor Test Set-up

2. Set the 3776 to A-A LEVEL/SEL FILTER Measurement.

3. With the Test Oscillator set to <-80dBm and 600ohm BAL, set the 3776 to +10dBm, 320Hz REF/MEAS and 600ohm Balanced. Press RUN and check that +10dBm - XdB (XdB is the loss of the power splitter) is displayed in the results display. Record the value displayed.

4. Set the 3776 to Rx-only LEVEL/SEL FILTER, MEAS frequency set to 470Hz.

5. Set the Test Oscillator output to 470Hz displayed on the Frequency Counter. Press RUN/REPEAT and adjust the Test Oscillator output to give the value recorded in Step 3, displayed on the 3776 RESULTS display. Press STOP.

6. Set the 3776 to A-A with the REF Frequency set to 320Hz and level set to 10dBmO, set the MEAS Frequency to 620Hz (i.e. 2F2-F1).

7. Press RUN/REPEAT and check that the reading on the 3776 RESULTS display is less than -55dBmO.

4-50
4-51 } Not applicable to this instrument

4-52 ANALOG RECEIVER OUT OF BAND REJECTION

SPECIFICATION

Analog Receiver Out-of-Band Rejection,
Out-of-band frequency = 14kHz (i.e. 16kHz - f)
where f = 2kHz: >60dB rejection

DESCRIPTION

An out-of-band signal 16kHz-f is applied to the Analog Receiver and the level measured. The Analog Receiver is then tuned to f and the level is measured. The out-of-band signal rejection must be greater than 60dB.

EQUIPMENT

Test Oscillator..HP654A
Frequency Counter....................................HP5328A

PROCEDURE

1. Connect the equipment as shown in Figure 4-26.

2. Set the 3776 to ANRx only LEVEL/SEL FILTER, 600ohm BAL, MEAS Frequency 2kHz.

3. Set the Test Oscillator to give 2kHz displayed on the Frequency Counter.

4. Press RUN/REPEAT on the 3776.

5. Adjust the Test Oscillator output amplitude to give 0dBmO displayed on the 3776 display.

6. Set the Test Oscillator to give 14kHz displayed on the Frequency Counter.

7. Check that the level displayed on the 3776 is less than -60dBmO.

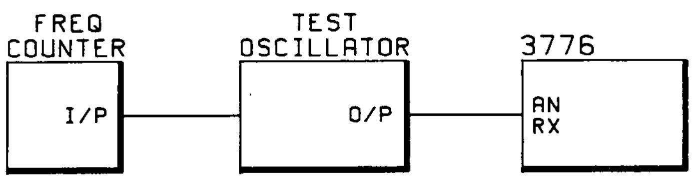


Figure 4-26 Analog Receiver Out of Band Rejection Set-up

4-53 ANALOG RECEIVER ANTI-ALIASING FILTER FLATNESS

SPECIFICATION

Anti-Aliasing Filter Flatness: <0.1dB peak to peak

EQUIPMENT

AC Calibrator..FLUKE 5200A
UNBAL TO BAL CONVERTER....................SA2 (See Appendix D)
*Frequency Counter....................................HP 5328A
DC Power Supply..HP 6205B

*Required only if AC Calibrator does not have a Frequency display.

PROCEDURE

1. Connect the equipment as shown in Figure 4-27.

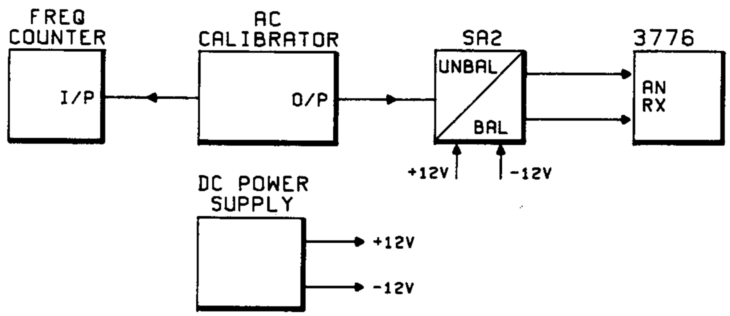


Figure 4-27 Analog Receiver Anti-Aliasing Filter Flatness Test Set-up

2. Set SA2 and the 3776 to 600ohm Balanced.

3. Set the 3776 to ARx LEVEL/OTHER FILTERS (FIL B).

4. Set the AC Calibrator output frequency to 1kHz.

5. Set the Level of the AC Calibrator to 0.7746V.

6. Press RUN/REPEAT on the 3776.

7. Record the value displayed on the 3776 RESULTS display.

8. Set the AC Calibrator frequency to the Frequency steps given and check that the difference between the minimum and maximum readings at selected frequency points is less than 0.1dB.

   Frequency Steps: 210Hz, 3.59kHz, 3.89kHz.

4-54 ANALOG TRANSMITTER FREQUENCY ACCURACY

SPECIFICATION

SINEWAVE

Frequency Range	:	50Hz to 4.6kHz for Level measurements, 200Hz to 3.9kHz for other measurements
Frequency Resolution	:	10Hz
Frequency Accuracy	:	50ppm

2-TONE

Frequency Range : 200Hz to 3.6kHz
Frequency Resolution: 10Hz
Frequency Accuracy : 50ppm

4-TONE - 3776B only : Meets BSTR Pub. 41009

DESCRIPTION

If the 3776 passes self-test it can be assumed that frequencies in the 2-Tone or 4-Tone modes of operation will be constructed to specification. The following procedure checks range, resolution and accuracy for a single sinewave.

EQUIPMENT

Oscilloscope............HP180C/1801A/1812A
Frequency Counter............HP5328A

PROCEDURE

1. Connect the equipment as shown in Figure 4-28.

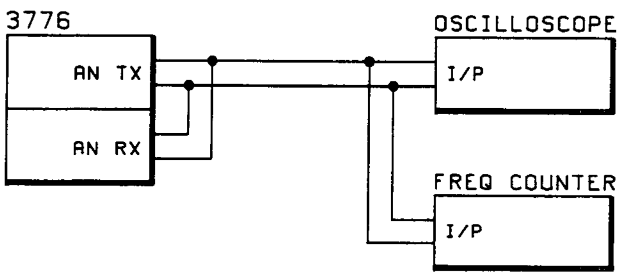


Figure 4-28 Analog Transmitter Frequency Accuracy Set-up

2. Select LEVEL/SEL FILTER measurement. Set the ANALOG TRANSMIT to 600ohm UNBAL.
3. Set the level to 0dBm and REF frequency to 4.6kHz.
4. Press RUN then REPEAT and check that the period displayed on the Frequency Counter is 217.391us +/-0.01us, (i.e. 4.6kHz +/-50ppm).
5. Set the REF frequency to 50Hz.
6. Press RUN then REPEAT and check that the period displayed on the Frequency Counter is 20ms +/-1us.
7. Check that a clean sinewave is displayed on the Oscilloscope.

4-55 DIGITAL TRANSMITTER EXTERNAL CLOCK INPUT

SPECIFICATION

Frequency: 3776A, 2048kHz +/-1%
3776B, 1554kHz +/-1%

Level: TTL levels into 75ohm nominal

EQUIPMENT

Frequency Counter	HP 5328A
Function Generator	HP 3312A
Oscilloscope	HP 180C/1801A/1821A
75/50ohm Matching Pad	Rhode and Schwarz Type DAF BN18084
75ohm Resistor	HP 0757-0398

PROCEDURE

1. Connect the Frequency Counter to the output of the Function Generator. Set the Function Generator FUNCTION to SQUARE and FREQUENCY to 2048kHz +/-20kHz (3776A), or 1544kHz +/-15kHz (3776B). Check the frequency on the Frequency Counter.

2. Disconnect the Frequency Counter from the Function Generator and connect the equipment as shown in Figure 4-29.

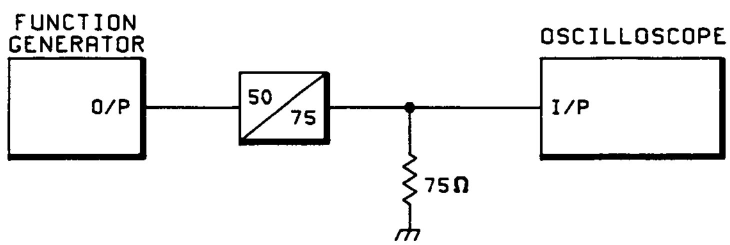


Figure 4-29 Digital Transmitter Ext Clock Input Set-up

3. Adjust the 3310A AMPLITUDE/OFFSET controls to give a squarewave with low level 0.5V and high level 2.5V displayed on the Oscilloscope.

4. Set the 3776 rear panel DIG TX CLOCK to EXT.

5. Connect the 3776 Digital Transmitter output to the Receiver Input.

6. RUN a D-D GAIN measurement and check that Error Code 30 is displayed.

7. Disconnect the 75ohm resistor and the Oscilloscope and connect the output from the Matching Pad to the 3776 rear panel DIG TX CLOCK input.

8. RUN a D-D GAIN measurement and check that a measurement result is obtained (result is irrelevant).

4-56 DIGITAL TRANSMITTER PCM WAVEFORMS

SPECIFICATION

Mark: +/-2.37V +/-10% (UNBAL 3776A Only); +/-3.0V +/-10% (BAL)
Space: +/-0.24V max (UNBAL 3776A Only); +/-0.3V max (BAL)
Overshoot: <10% of amplitude
Width at 50% Amplitude: 50% +/-6%
Transition Times: <30ns

EQUIPMENT

75ohm Resistor	HP 0757-0710
100ohm Resistor	HP 0757-0178
120ohm Resistor	110ohm (HP 0757-0713) +10ohm (HP 0757-0489)
Oscilloscope	HP 180C/1801A/1821A

PROCEDURE

1. Connect the equipment as shown in Figure 4-30.

2. Set the Oscilloscope to channel A-B. Set the Volts/Div to 0.1 using a 10:1 Probe.

3. Check that the levels (with respect to ground) of the positive and negative marks are within +3.3V and +2.7V, and -3.3V and -2.7V respectively.

4. Check that the level of the space is +/-0.30V with respect to ground.

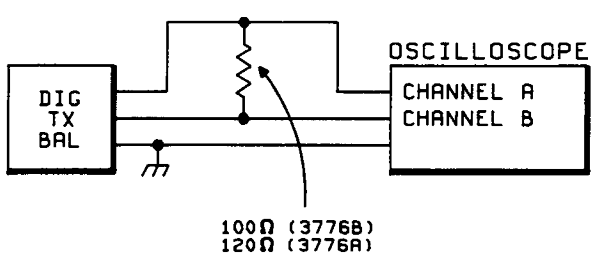
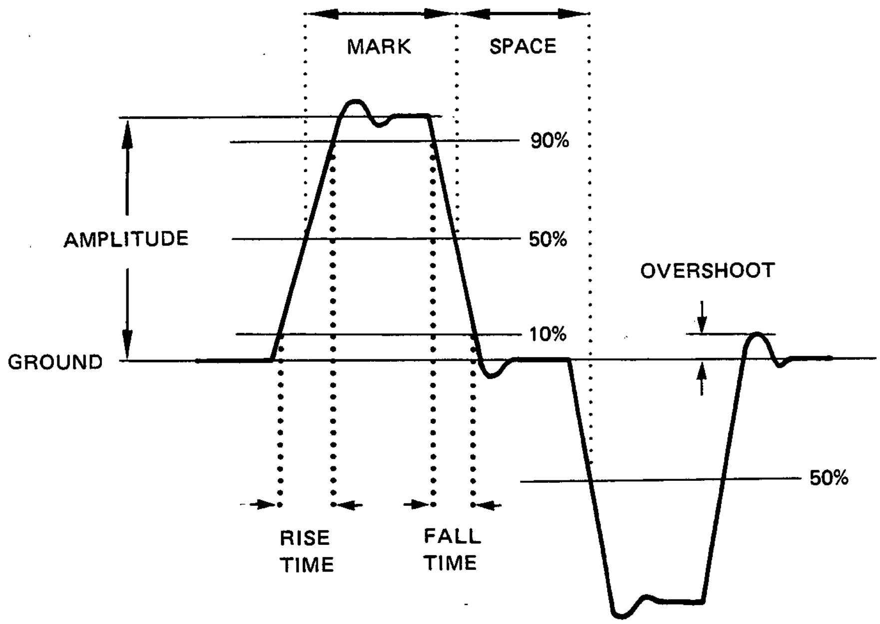


Figure 4-30 Digital Transmitter PCM Waveforms Set-up



5. Check also that the Rise Time and Fall Time are less than 30ns and the Overshoot is less than 10% of the amplitude.

6. Measure the waveform mark period (M) and space period (S) at the 50% positive-going amplitude level.
   Calculate M/(M+S) x 100%
   This should be between 44% and 56%.

7. Repeat step 6 for the negative-going waveform.

3776A Only

8. Connect the Digital Transmitter 75ohm UNBAL Output to an Oscilloscope terminated in 75ohms.

9. Check that the levels (with respect to ground) of the positive and negative marks are within +2.60V and +2.14V, and -2.60V and -2.14V respectively.

10. Check that the level of the space is +/-0.24V with respect to ground.

11. Repeat steps 5, 6 and 7.

4-57 DIGITAL RECEIVER SENSITIVITY

SPECIFICATION

In the Digital Receive TERM mode with the instrument connected back to back and -6dB of attenuation inserted, the receiver must be capable of gaining frame alignment.

In the Digital Receive MON mode with the instrument connected back to back and -30dB (3776A) or -20dB (3776B) of attenution inserted, the receiver must be capable of gaining frame alignment.

EQUIPMENT

2 x 75ohm UNBAL -110ohm BAL Converter (3776B Only)..............HP 15508B
75ohm attenuator...HP 3750A

PROCEDURE

3776B Only

1. Connect the equipment as shown in Figure 4-31.

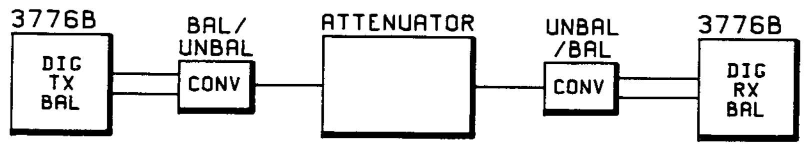


Figure 4-31 Digital Receiver Sensitivity Test Set-up

2. Set the 3776 to D-D, LEVEL/SEL FILTER, DIGITAL RECEIVE TERM and set the REF and MEAS frequencies to 1kHz. Set the LEVEL to 0dBmO.

3. Set the attenuator to -6dB.

4. Press the 3776 RUN button and check that frame alignment is achieved.

5. Set the 3776 to DIGITAL RECEIVE MON.

6. Set the Attenuator to -20dB.

7. Press the 3776 RUN button and check that frame alignment is achieved.

3776A Only

8. Remove the BAL/UNBAL Converters and connect the 3750A Attenuator direct to the 75ohm unbal Input/Outputs.

9. Repeat Steps 2 to 7 except in step 6 of this procedure, set the attenuator to -30dB.

4-58 PHASE JITTER (OPTION 001)

SPECIFICATION

Measurement Accuracy: +/-5% +/-0.2 degrees

Measurement Range: 0 degree to 30 degrees peak to peak

Input Holding Tone Requirements:

The receiver should accept holding tone frequencies between 990Hz and 1030Hz, with levels within the range of +10dBm to -40dBm.

Noise Rejection:

A 3.5kHz band-limited noise signal 30dB down from a 1010Hz sinewave carrier should indicate less than 4 degrees peak-to-peak jitter.

Frequency Weighting:

Frequency Weighted Phase Jitter is tested as follows:

A 0.0dBm 1010Hz tone used as the carrier is combined with a second tone and applied to the Analog input of the 3776. The second tone is 20dB lower in level than the carrier and is used as a source of Phase Jitter. The Phase Jitter produced is a function of the difference frequency between the two tones. The Phase Jitter should be less than that given in Table 1.

Table 1 Frequency Weighted Phase Jitter

FILTER B 4-300Hz Difference Frequency (Hz)	FILTER A 20-300Hz Difference Frequency (Hz)	Phase Jitter (Degrees)
0.4	2	<1
1	5	<3
2	10	<8
4	-	9.2-12.2
6	-	10.2-12.2
-	12	<10
8-240	20-240	10.8-12.2
300	300	10-12.2
500	500	<3
700	700	<1

Level to Phase Conversion:

Using a test set-up as suggested for testing the frequency weighting specification and with the second tone at 1110Hz, attenuation is applied to the combined signal in 10dB steps to 50dB. The spread of Phase Jitter readings should not exceed 0.7 degrees. The Phase Jitter limits given in Table 1 should be met at any of the attenuation settings up to 50dB.

Amplitude Modulation to Phase Conversion:

A 10% amplitude modulated 1010Hz carrier at a level consistent with the Input Holding Tone requirements is applied to the input of the 3776. As the modulating frequency is changed, the resulting Phase Jitter should not exceed the values given in Table 2.

Table 2 Modulating Frequency Phase Jitter

Modulating Frequency (Hz)	Phase Jitter (Degrees)
20 to 300 (3776A) 2 to 900 (3776B)	<0.2 <1

Measurement Averaging Time:

The 3776 Detector and Display circuits response averaging time characteristics are tested as follows:

A gated phase modulated sinewave on a steady 1010Hz carrier is applied to the 3776 input. The modulation signal is gated at a duty cycle of 50%. With the appropriate gating frequency, the Phase Jitter display variation should be within the percentage figure limit given in Table 3.

Table 3 Phase Jitter Measurement Averaging Time

Gating Frequency (Hz)	Phase Jitter Display Variations (Degrees)
FILTER A 20 to 300Hz Range	
5.0	$\frac{2(Max - Min)}{Max + Min}$ <10%
1.0	$\frac{2(Max - Min)}{Max + Min}$ <40%

Time to Display Correct Reading:

The 3776 display should be within +-0.7 degrees of its final value in <4 seconds with Filter A selected or in <25 seconds with Filter B selected.

DESCRIPTION

Phase Jitter Measurement Technique:

A waveform with a known amount of phase jitter can be constructed by adding together two sinewaves of known frequency and amplitude. The voltage amplitude ratio of the two added sinewaves is proportional to the phase jitter. This action is illustrated vectorially in Figure 4-32.

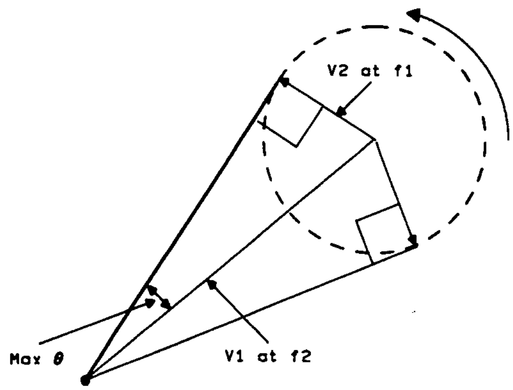


Figure 4-32 Phase Jitter Generation Vector Diagram

$$\text{Max}\Theta = \sin^{-1} V2/V1$$

$$\text{Total peak deviation} = 2(\text{Max}\Theta)$$

The voltage ratios (V2/V1) versus corresponding peak-to-peak jitter readings are given in Table 4.

Table 4 Voltage Ratios Versus Peak-to-Peak Jitter

Phase Jitter (Degrees pk-pk)	Voltage Ratio	dB Ratio
0.0114	10000	80
0.115	1000	60
0.363	316	50
1.15	100	40
3.63	31.6	30
11.48	10	20
20	5.76	15.20
30	3.86	11.74

EQUIPMENT

Signal Synthesiser........HP 3336A
Function Generator A (gated or
burst operation........HP3312A/3310A
Function Generator B (External F M Input)........HP 3312A
Frequency Counter........HP 5245L
A C Voltmeter........HP 3455A
True RMS Voltmeter........HP 3403C
600 Ohm Attenuator........HP 4437A
Four 200 Ohm Resistors........HP 0757-0407

Note: Where Test Circuits show more than one Frequency Counter, use the one Frequency Counter and connect it at the appropriate point in the test circuit when required.

PROCEDURE

Measurement Accuracy and Measurement Range

1. Connect the equipment as shown in Figure 4-33.

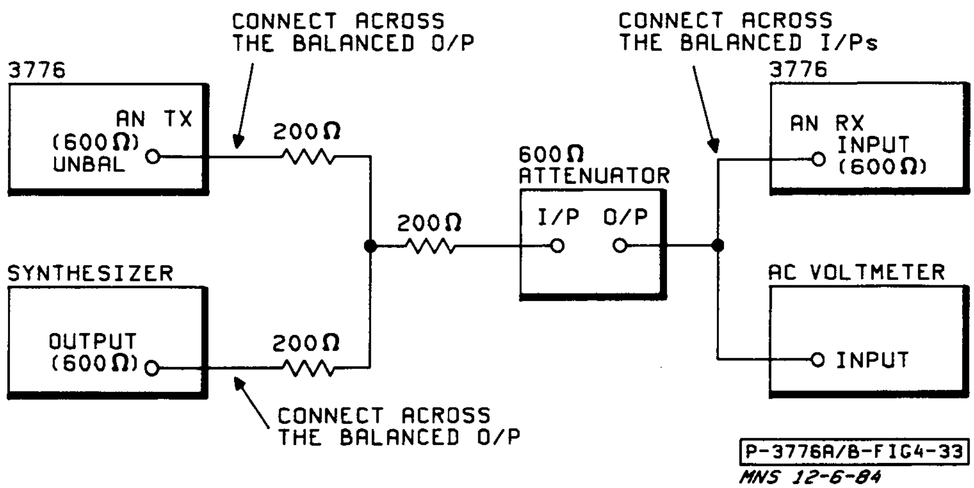


Figure 4-33 Phase Jitter Test Set-up

2. Set the 3776 as follows:

OPERATING MODE	ANTx ANRx
MEASUREMENTS	PHASE JITTER
ANALOG TRANSMIT	600ohms UNBAL
ANALOG RECEIVE	600ohms
I/FACES	Tx dBr (TLP) and Rx dBr (TLP) set to 0.0

3. Set the 3776 Frequency to 1010Hz and Level to +6dBm0. Select FIL A.

4. Set the 600ohms Attenuator to 0.00dB and set the Synthesiser output voltage to a low level (less than -65dBm).

   NOTE: To set the output voltage or frequency from either the 3776 or Synthesiser accurately and also maintain the circuit impedances, the output voltage from the other source must be set to its minimum level.

5. Press RUN/REPEAT on the 3776 and record the voltage displayed on the AC Voltmeter (should be approximately 0.7745V).

6. Press the 3776 STOP key and set the 3776 to ANRx only (this reduces the 3776 ANTx to minimum output level).

7. Set the Synthesizer to give a frequency of 910Hz and adjust the output level for X volts displayed on the AC Voltmeter. X volts can be calculated as follows:

   X volts = Volts recorded in Step 5 X 0.2588

   NOTE: 0.2588 is the voltage ratio required to give 30degrees pk to pk jitter.

   (X volts should be approx 0.200V).

8. Set the 3776 to ANTx ANRx and press RUN/REPEAT.

9. Check that the Phase Jitter reading on the 3776 is between 28.3 to 31.7 degrees.

10. Repeat Steps 6 to 9 setting the Synthesiser output levels in Step 7 as shown in Table 5a and check at each level setting that the Phase Jitter readings are within the Limits specified in Table 5a.

Table 5a Phase Jitter Measurement Range and Accuracy

Synthesiser Output Voltage	Phase Jitter Readings (Degrees)
Voltage recorded in Step 5 X 0.1736	18.2 to 21.2
Voltage recorded in Step 5 X 0.1002	10.8 to 12.2

11. With the Synthesizer set to voltage recorded in Step 5 X 0.1002, change the Synthesizer output level in -10dB Steps as given in Table 5b. Check at each Synthesizer -10dB Step that the Phase Jitter readings are within the limits specified in Table 5b.

    NOTE: After each reading has been taken, always press STOP on the 3776, change to new input level condition, then press RUN/REPEAT.

Table 5b Phase Jitter Measurement and Accuracy

Synthesizer Additional Attenuation (dB)	Phase Jitter Readings (Degrees)
10	3.2 to 4.0
20	0.9 to 1.3
30	0.16 to 0.56
40	0 to 0.2
50	0 to 0.2

Frequency Weighting, Level to Phase Conversion, Input Holding Tone Requirements and Time to Display Correct Reading.

12. Press the 3776 STOP key then set Operating Mode to ANRx only.

13. Set the Synthesizer to give a frequency of 1012Hz and adjust the output level until the reading on the AC voltmeter is 20dB below the voltage reading recorded in Step 5. Multiply the voltage recorded in Step 5 by 0.1 to calculate the voltage reading for a 20dB drop in level.

14. Set the 3776 to ANTx ANRx and press RUN/REPEAT. Both signal sources should now be combined and applied to the 3776 Analog Rx input.

Frequency Weighting and Level to Phase Conversion.

15. Set the Synthesizer frequency to the frequency steps given for Fil A and Fil B in Table 6, select the appropriate filter on the 3776 and check that the corresponding Phase Jitter readings are within the limits specified in Table 6. At each frequency step, insert up to 40dB of attenuation in 10dB steps using the 600ohm Attenuator and check that the Phase Jitter readings remian within the limits specified in Table 6.

NOTE: 1. Allow 4 seconds settling time when Filter A is selected and approximately 25 seconds when Filter B is selected before each reading.

2. After each reading has been taken, always press STOP on the 3776, change new input level condition, then press RUN/REPEAT.

Table 6 Phase Jitter Frequency Weighting and Level to Phase Conversion Limits

Synthesiser B Frequency Steps (Hz)		Phase Jitter Limits (Degrees)
Filter B Range 4-300Hz	Filter A Range 20-300Hz	
1010.4 & 1009.6	1012 & 1008	<1
1011.0 & 1009.0	1015 & 1005	<3
1012.0 & 1008.0	1020 & 1000	<8
1014.0 & 1006.0	-	9.2 to 12.2
1016.0 & 1004.0	-	10.2 to 12.2
-	1022 & 998	<10
1002.0 & 770.0	990 & 770	10.8 to 12.2
1310.0 & 710.0	1310 & 710	10.0 to 12.2
1510.0 & 510.0	1510 & 510	<3
1710.0 & 310.0	1710 & 310	<1

Input Holding Tone Requirements

16. Press the 3776 STOP key and set the 3776 Frequency to 1000Hz.

17. Set the 600ohm Attenuator to 0.0dB.

18. Set the Synthesizer frequency to 890Hz.

19. Set the 3776 to RUN/REPEAT.

20. Check that the Phase Jitter Reading with Filter A and Filter B selected is between 10.8 and 12.2 degrees.

21. Press the 3776 STOP key and set the 3776 Frequency to 1020Hz.

22. Set the Synthesizer Frequency to 1120Hz.

23. Press RUN/REPEAT on the 3776 and check that the 3776 Phase Jitter reading with Fil A and Fil B selected is between 10.8 and 12.8 degrees. Record the Phase Jitter readings for both Fil A and Fil B.

Time to Display Correct Reading

24. Disconnect the signal to the 3776 ANALOG RECEIVE input.

25. Reconnect the signal to the 3776 ANALOG RECEIVE input and check that the display appears within 4 seconds if Fil A is selected and 25 seconds if Fil B is selected. The display readings should be within +/-0.7 degrees of those recorded in Step 23.

Noise Rejection

26. Press the 3776 STOP key and set the 3776 to 1010Hz. Set the 3776 to ANRx only.

27. Set the Synthesizer to give 2000Hz and 24.5mV +/- 0.1mV displayed on the AC Voltmeter (ie. 2kHz -30dBm). Set the 3776 to ANTx ANRx and press RUN/ REPEAT.

28. Select Fil A and Fil B in turn and check that the 3776 Phase Jitter reading in each case is <4 degrees.

Amplitude to Phase Conversion

29. Connect the equipment as shown in Figure 4-36.

30. Adjust the Function Generator Main Generator Output frequency to give a frequency of 1010Hz displayed on Frequency Counter A.

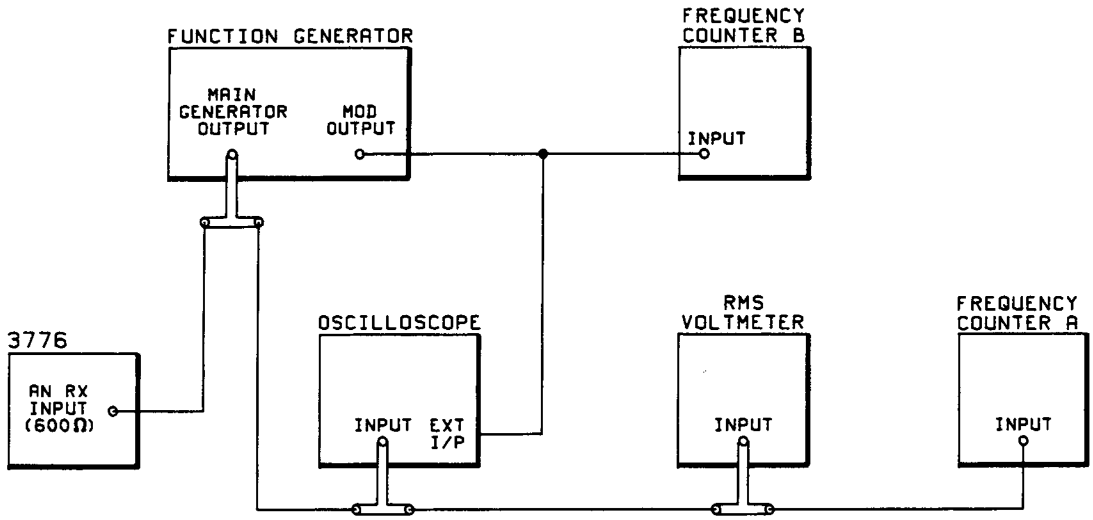


Figure 4-36 Phase Jitter Amplitude to Phase Conversion Test Set-up

31. Adjust the Function Generator Main Generator Output voltage to give a voltage of 0.7745V displayed on the RMS Voltmeter.

32. Set the Function Generator to give an amplitude modulated signal at the MOD Output with a modulating frequency of 30Hz displayed on Frequency Counter B.

33. Adjust the Function Generator A.M. controls to produce a 10% amplitude modulated signal displayed on the Oscilloscope as shown in Figure 4-37.

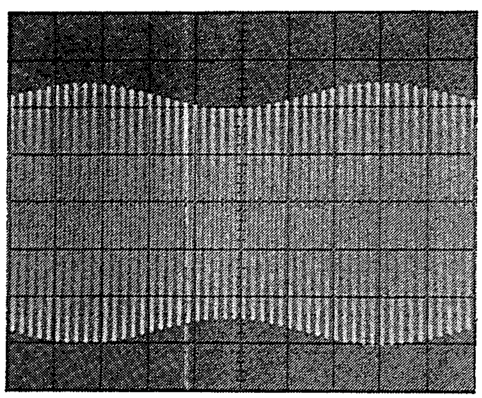


Figure 4-37 Phase Jitter Amplitude to Phase Conversion Waveform Diagram

34. Adjust the Function Generator Main Generator Output voltage with the Amplitude Modulation present to give a voltage of 0.7745V displayed on the RMS Voltmeter.

35. Select Phase Jitter Filter A and B in turn, press RUN/REPEAT and sweep the modulating frequency of the Function Generator between the limits given in Table 7 as displayed on Frequency Counter B and check that the Phase Jitter readings are within the limits specified.

Table 7 Phase Jitter Amplitude to Phase Conversion Limits

Modulating Frequency (Hz)	Phase Jitter Readings (Degrees)
20 to 300 (3776A Only)	<0.2
2 to 900 (3776B Only)	<1.0

Measurement Averaging Time

36. Set the 3776 MEASUREMENT to LEVEL/SEL FILTER and set the MEAS Frequency to 1010Hz.

37. Connect up the equipment as shown in Figure 4-38.

38. Disconnect Function Generator A output from the input of Function Generator B.

39. Adjust Function Generator B output frequency to give a sinewave frequency of 1010Hz, displayed on Frequency Counter C. Function Generator B should be set as follows:-

RANGE	100Hz
FREQUENCY	adjusted for 1010Hz
FUNCTION	∿
OFFSET	CAL
SYM	CAL
MODULATION	FM depressed

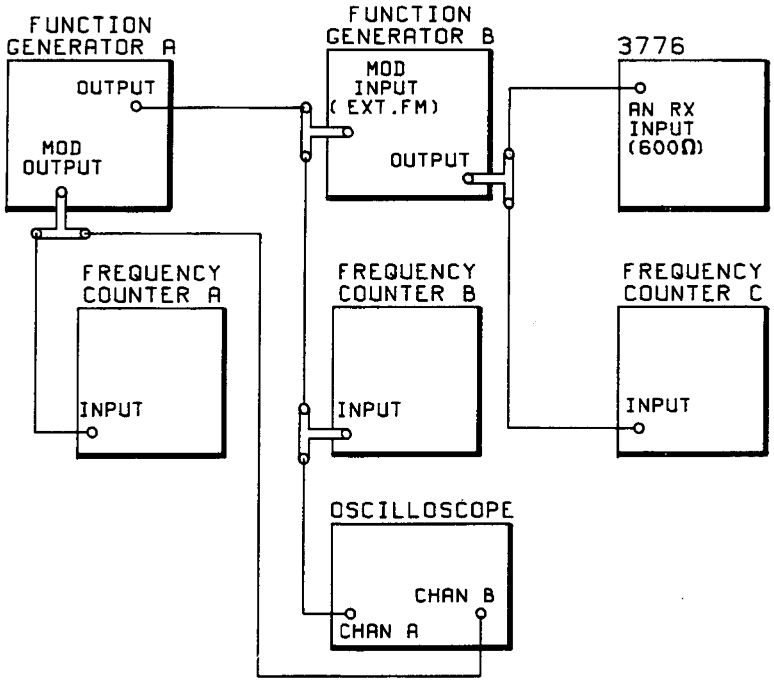


Figure 4-38 Phase Jitter Measurement Averaging Time Test Set-up

40. Repeat RUN/REPEAT on the 3776 then adjust Function Generator B output voltage to give a level of 0dBm0 displayed on the 3776. After adjusting for 0dBm0, press the 3776 STOP key.

41. Set the 3776 MEASUREMENT to PHASE JITTER, FIL A, then press RUN/REPEAT.

42. Connect Function Generator A output to the MOD input (EXT FM) of Function Generator B. Function Generator A should be set as follows:-

RANGE.................................... 100Hz
FREQUENCY.................................... adjusted for 100Hz (Step 43)
FUNCTION.................................... ∿
AMPLITUDE.................................... adjusted to give 11.5 degrees on the 3776 (Step 44)
TRIGGER PHASE.................................... FREE RUN
MODULATION.................................... depressed (Trigger)
SYM.................................... CAL
OFFSET.................................... CAL

43. Adjust the output frequency from Function Generator A to give a sinewave frequency of 100Hz displayed on Frequency Counter B.

44. Adjust Function Generator A amplitude control and/or Function Generator B delta f modulation control to obtain a Phase Jitter reading of 11.5 degrees on the 3776.

45. Adjust the period of the frequency at the MOD output of the Function Generator A displayed on Frequency Counter A, to 200ms (5Hz).

46. Adjust the controls of Function Generator A to give a burst of 100Hz frequency displayed on the Oscilloscope (see Figure 4-39).

NOTE:- Adjust the TRIGGER PHASE to give OV as shown in Figure 4-39. This is best performed by expanding channel A of the oscillscope and adjusting for OV. Use the MODULATION RANGE Hz to adjust for 5Hz gating frequency.

47. Record the maximum (MAX) and minimum (MIN) Phase Jitter readings displayed on the 3776.

48. Check that 2(MAX - MIN)/MAX + MIN is <0.1.

49. Adjust the frequency period at the MOD output of Function Generator A displayed on Frequency Counter A to 1000ms (1Hz).

50. Record the MAX and MIN Phase Jitter readings displayed on the 3776.

51. Check that 2(MAX - MIN)/MAX + MIN is >0.4.

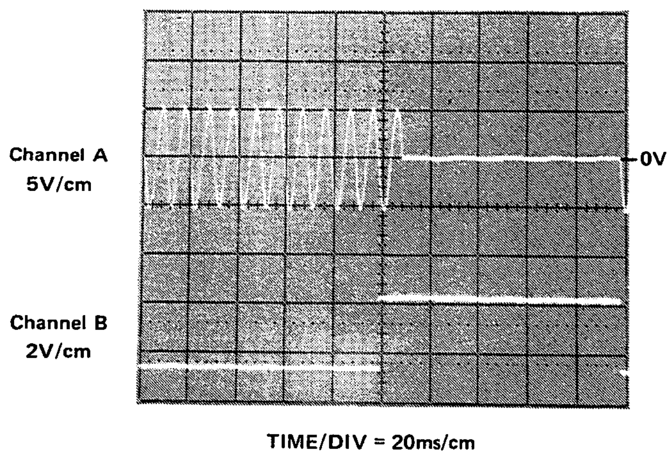


Figure 4-39 Phase Jitter Measurement Averaging Time Waveform Diagram (5Hz Gating Frequency)

4-59 PHASE HITS (OPTION 001)

SPECIFICATION

Threshold Accuracy (Slow Count):

+/-10% of the PHASE threshold setting
+/-0.5degrees for phase changes occurring in less than 0.2ms

Threshold Range:

5 degrees to 40 degrees in 5 degree steps.

Input Holding Tone Requirements:

The receiver should accept test tone frequencies between 995Hz and 1025Hz with levels within the range +10dBm to -40dBm.

Qualification Period or Guard Interval:

A phase-hit exceeding a threshold by 5 degrees is not counted if the holding tone returns to its original phase at any time within 3.5ms, and is counted if the tone returns to its original phase any time after 4.5ms.

Counting Rate:

3776A - The maximum counting rate is 8 counts per second.
3776B - Selectable = 100 counts/sec maximum or 8 counts/sec maximum.

Loop Recovery Time:

With the phase of the test tone varied linearly over 100 degrees during a period defined as the rise time, the following results should be obtained:

1) With a rise time of 20ms and THRESHOLD-PHASE HITS set to 20 degrees, the 3776 should record a phase hit.

2) With a rise time of 50ms and the THRESHOLD-PHASE HITS set to 20 degrees, a phase hit should not be recorded.

Amplitude to Phase Conversion:

With the 3776 THRESHOLD-PHASE HITS switch set to 10 degrees, a 10dB gain hit should not cause a phase hit to be counted.

DESCRIPTION

Phase Hit:

A Phase Hit is classified as an abrupt change in phase of a received sinewave.

A sudden phase change (i.e. phase hit) of a sinewave can be generated by changing the sinewave frequency for a brief period. As the frequency is changed, the phase of the sinewave with respect to the original sinewave will increase proportionally with time. The amount of phase change will also be proportional to the amount of frequency change.

This technique is used in the performance tests to generate phase hits.

Figure 4-40 illustrates this process.

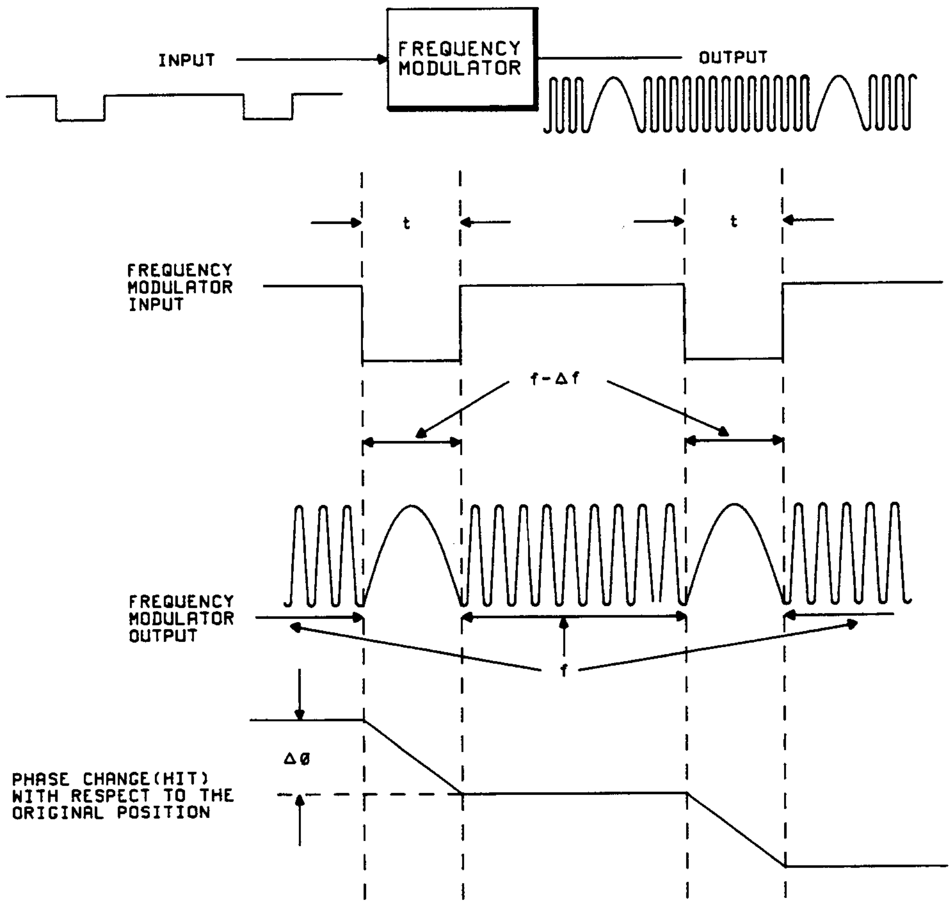


Figure 4-40 Phase Hits Test Signal Generation

The amount of phase change ϕ in degrees is given by:

$$\Delta\phi = 360 \times \Delta f \times t$$

where

Δf = frequency difference between sinewaves (Hz)

t = time at new frequency $f_1 - \Delta f$

Guard Interval:

By applying a negative-going pulse followed by a positive-going pulse into the Frequency Modulator (see Figure 4-41), the sinewave frequency at the output of the Frequency Modulator can be increased and decreased by an amount. This frequency change causes a phase change as previously described for Phase Hits.

The direction of the phase change however is reversed by the dual polarity input signal to the Frequency Modulator. Figure 4-41 illustrates this phase change.

This technique is used in the performance tests to test the guard interval specification.

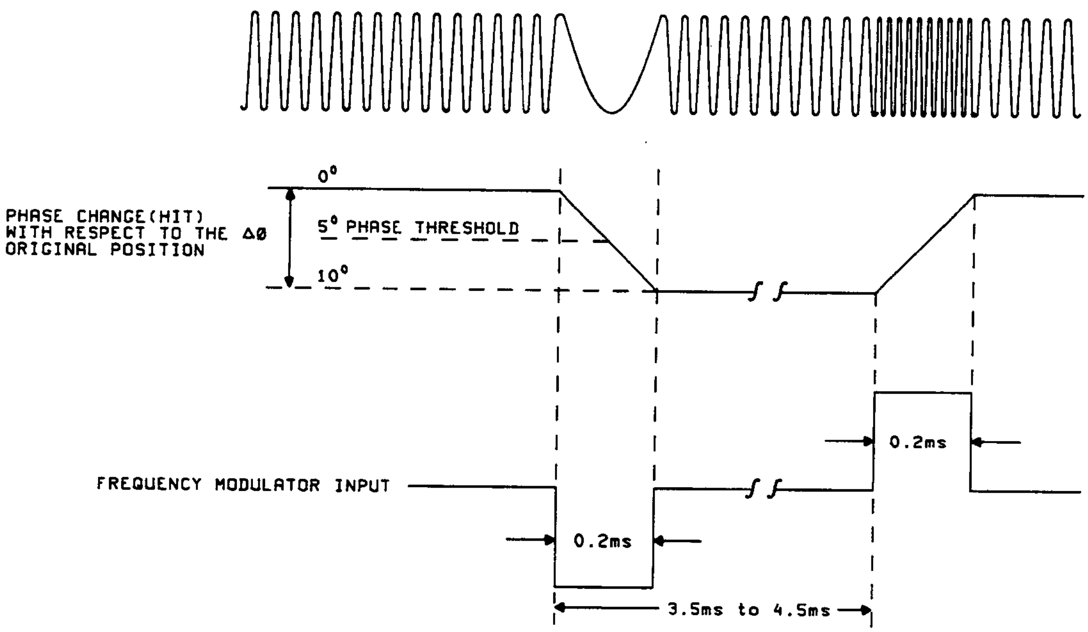


Figure 4-41 Phase Hit Guard Interval Test Signal Generation

EQUIPMENT

Pulse Generator	HP 8160A Option 020
Function Generator	HP 3312A
Oscilloscope Mainframe	HP 180A
Dual Channel Vertical Amplifier Plug-in	HP 1810A
Time Base Plug-in	HP 1821A
Frequency Counter	HP 5328A
AC Voltmeter	HP 3455A

PROCEDURE

Threshold Range and Threshold Accuracy

1. Connect up the equipment as shown in Figure 4-42.

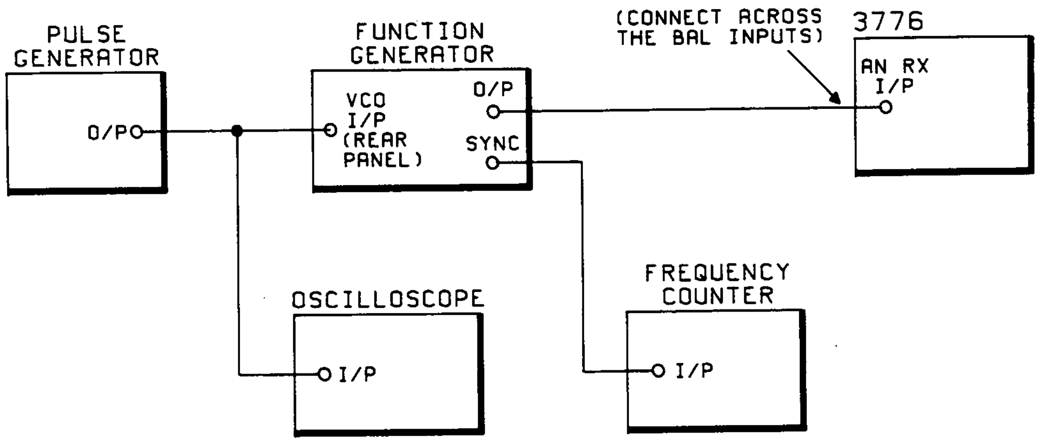


Figure 4-42 Threshold Range and Threshold Accuracy Test Set-up

2. Set the Pulse Generator to give -1V negative-going pulses with a repetition rate of approx 1kHz and a pulse width of exactly 0.2ms. The oscilloscope timebase should be set to 20us/DIV for best resolution.

3. Set the Pulse Generator repetition rate to approx 4Hz.

4. Set the Pulse Generator to the EXT-MAN mode (ie, the level displayed on the oscilloscope should be 0V ac).

5. Adjust the frequency control of the Function Generator to give 995Hz displayed on the Frequency Counter. When a 3312A Function Generator is used, the front panel controls should be set as follows:

MODULATION	~ ∿ ⊓ switches all out
FUNCTION	switch depressed
TRIGGER PHASE	FREE RUN
RANGE Hz	100
OFFSET	CAL
SYM	CAL
AMPLITUDE	10

6. Set the 3776 as follows:

OPERATING MODE	ANRx
ANALOG RECEIVE	600ohm (Terminated)
MEASUREMENT	LEVEL -SEL FILTER

7. Press the 3776 NEXT PARAM key, set the MEAS frequency to 0.99kHz and press RUN/REPEAT.

8. Adjust the output amplitude of the Function Generator to give 0dBm +/-0.1dBm displayed on the 3776 RESULTS display.

9. Press the 3776 STOP key.

10. Set the 3776 follows:

    OPERATING MODE........ANRx
    ANALOG RECEIVE........600ohm (Terminated)
    MEASUREMENT........TRANSIENTS

11. Scroll the transient parameters using the NEXT PARAM and PREVIOUS PARAM keys and set as follows:

    SLO Count
    1-00hr
    5 deg P.hit

12. Press the 3776 RUN key and press the NEXT PARAM key to display 5 deg P. hit.

13. Set the Pulse Generator to normal mode (ie, 0.2ms, -1V negative-going pulse at approx 4Hz repetition rate).

14. Adjust the Pulse Generator output amplitude to obtain the condition where the phase hit counts just register on the 3776 P. hit display. This point is the 5 deg phase hit threshold.

15. Set the Pulse Generator repetition rate to 1Hz and pulse width to 0.5 seconds displayed on the oscilloscope.

16. Set the Frequency Counter Function to PERIOD and TIMEBASE to 0.1us. The period displayed on the Counter will alternate between the carrier frequency f1 (995Hz = 1005us +/-5us) and the frequency f2 which was inserted during the 0.2ms pulse period.

    Note: If an HP 5345A counter is available, the Pulse Generator output can be used to gate the 5345A input. This enables only the period of interest (ie, f2) to be displayed.

17. Check that the f2 period (see Step 16) displayed on the Frequency Counter is between 1096us and 1064us.

18. Select the 3776 phase hit thresholds shown in Table 1 and using the procedure given in Steps 9 to 17 check that the f2 periods obtained are within the limits given.

Table 1

3776 Phase Hit Threshold Setting (degrees)	f2 Period Limits (us)	
	Max	Min
10	1197	1140
15	1317	1227
20	1465	1329
25	1649	1450
30	1887	1595
35	2206	1771
40	2653	1992

Guard Interval

19. Press the 3776 STOP key.

20. Scroll the transient parameters using the NEXT PARAM key and set the 3776 as follows:

    SLO Count
    1-00 hr
    5 deg P. hit

21. Set the Pulse Generator to Channel A + Channel B mode.

22. Adjust the controls of the Pulse Generator to give a combined Channel A and Channel B signal with 0.2ms negative-going and 0.2ms positive-going pulses as shown in Figure 4-43 and a repetition rate of approx 4Hz. The oscilloscope timebase should be set to 20us/DIV for best resolution when setting the 0.2ms pulse widths.

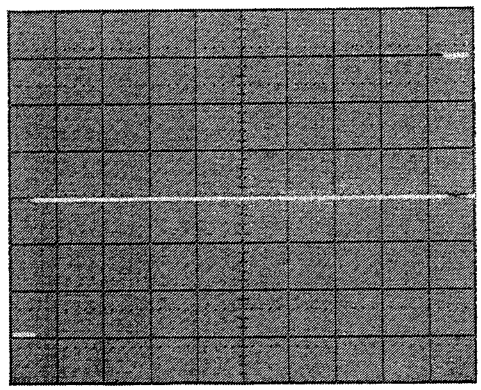


Figure 4-43

23. Press the 3776 RUN key and press the NEXT PARAM key to display 5 deg P. hit. Phase Hits should register on the 3776 RESULTS display.

24. Using the Pulse Generator Pulse Delay Control, set the delay between the negative and positive-going pulses to 4.5ms as shown in Figure 4-44 and check that counts register on the 3776 Phase display.

25. Set the delay between the negative and positive-going pulses to 3.5ms as shown in Figure 4-45 and check that counts **do not** register on the 3776 Phase display.

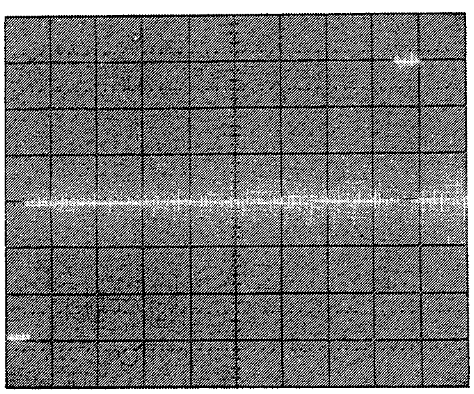


Figure 4-44

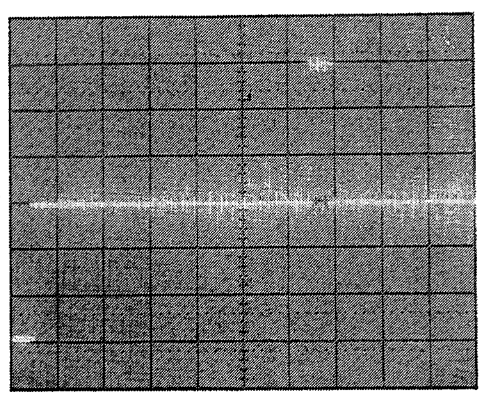


Figure 4-45

Holding Tone

26. Press the 3776 STOP key.

27. Set the 3776 as follows:

    OPERATING MODE..ANRx
    ANALOG RECEIVE..600ohm (Terminated)
    MEASUREMENT..LEVEL SEL FILTER

28. Press the NEXT PARAM key, set the MEAS frequency to 1.02kHz and press RUN/REPEAT.

29. Set the Pulse Generator to EXT-MAN mode.

30. Adjust the frequency control of the Function Generator to give 1025Hz displayed on the Frequency Counter.

31. Adjust the output amplitude of the Function Generator to give +10dBm +/-0.1dBm displayed on the 3776 RESULTS display.

32. Press the 3776 STOP key.

33. Set the 3776 as follows:

    OPERATING MODE..ANRx
    ANALOG RECEIVE..600ohm (Terminated)
    MEASUREMENT..TRANSIENTS

34. Scroll the transient parameters using the NEXT PARAM key and set as follows:

    SLO Count
    1-00 hr
    5 deg P. hit

35. Press the 3776 RUN key and press the NEXT PARAM key to display 5 deg P. hit.

36. Set the Pulse Generator to single channel operation and to give approx -1V negative-going pulses with repetition rates of approx 100Hz and a pulse width of exactly 0.2ms. The oscilloscope timebase should be set to 20us/DIV for best resolution.

37. Set the Pulse Generator repetition rate to approx 4Hz.

38. Adjust the Pulse Generator output amplitude to obtain the condition where the phase hit counts just register on the 3776 P. hit display. This point is the 5 deg phase hit threshold.

39. Set the Pulse Generator repetition rate to 1Hz and pulse width to 0.5 seconds displayed on the oscilloscope.

40. Set the Frequency Counter FUNCTION to PERIOD and TIMEBASE to 0.1us.

41. Check that the f2 period (see step 16) displayed on the Frequency Counter is between 1062us and 1031us.

42. Repeat Steps 26 to 41 setting the output level of the Function Generator in Step 24 to give -40dBm +/-0.1dBm displayed on the 3776 RESULTS display.

Loop Recovery Time

43. Press the 3776 STOP key.

44. Set the Pulse Generator to EXT-MAN mode (ie, the level displayed on the oscilloscope should be 0V ac).

45. Set the 3776 as follows:

OPERATING MODE....................ANRx
ANALOG RECEIVE....................600ohm (Terminated)
MEASUREMENT....................LEVEL -SEL FILTER

46. Press the 3776 NEXT PARAM key and set the MEAS frequency to 0.99kHz.

47. Press RUN/REPEAT and adjust the Function Generator output to give 0dBm +/-0.1dB displayed on the 3776 RESULTS display.

48. Adjust the Function Generator frequency to give 995Hz +/-1Hz displayed on the Frequency Counter (995Hz = 1005us period).

49. Set the Pulse Generator to normal mode with a repetition rate of 1Hz and negative-going pulse width of 0.5 seconds.

50. Set the Frequency Counter to **PERIOD** and TIMEBASE to 0.1us.

51. Adjust the Pulse Generator output level to give an f2 period (see Step 16) of 1019us +/-1us, displayed on the Frequency Counter (ie difference frequency of 14Hz for 20ms causes a 100 deg phase change).

52. Adjust the Pulse Generator to give a 20ms negative-going pulse with a repetition rate of approximately 4Hz.

53. Press the 3776 STOP key and set the 3776 as follows:

OPERATING MODE....................ANRx
ANALOG RECEIVE....................600ohm (Terminated)
MEASUREMENT....................TRANSIENTS

54. Scroll the 3776 Transient parameters using the NEXT PARAM key and set as follows:

SLO Count
1-00 hr
20 deg P. hit

55. Press the 3776 RUN key and press the NEXT PARAM key to display 20 deg P. hit.

56. Check that counts register on the 3776 P. hit display.

57. Repeat Steps 43 to 55 setting the Pulse Generator output level to give an f2 period of 1011us +/-1us displayed on the Frequency Counter in Step 51, and adjust the Pulse Generator to give a 50ms

negative-going pulse in Step 52.

Notes:
1. It may be necessary to insert a 50ohm load (ie set the Oscilloscope to 50ohm) at the Pulse Generator output in order to set the f2 period to 1011us in Step 51.

2. Setting the f2 period to 1011us in Step 51 gives a difference frequency of 6Hz. With the pulse width set to 50ms in Step 52, this causes a 100 deg phase change.

58. Check that counts do not register on the 3776 P.hit display.

Amplitude to Phase Conversion

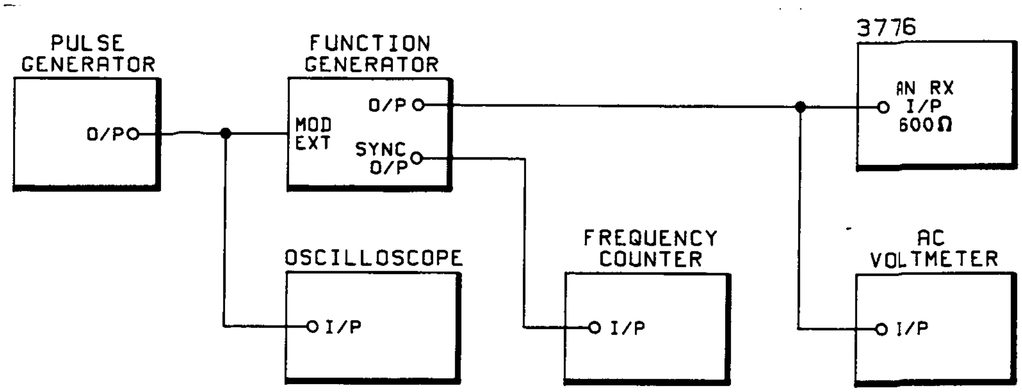


Figure 4-46 Amplitude to Phase Conversion Test Set-up

59. Connect the equipment as shown in Figure 4-46. 60. Set the Pulse Generator to EXT-MAN mode (ie, the level displayed on the oscilloscope should be 0V ac). Ensure that the DC offset control is switched off.

61. Set the Function Generator to give an output sinewave frequency of 1010Hz +/-1Hz (990us +/-1us) displayed on the Frequency Counter and 0.774V +/-0.001V displayed on the AC Voltmeter. When an HP 3312A Function Generator is used, the front panel controls should be set as follows:

MODULATION	EXT, AM, % control to midrange
FUNCTION	switch depressed
TRIGGER PHASE	FREE RUN
OFFSET	CAL
SYM	CAL

62. Set the Pulse Generator to its lowest repetition rate and to give a negative-going pulse set to maximum pulse width.

63. Adjust the Pulse Generator output level to give 0.2449V (ie, -10dB below 0.7745V) displayed on the AC Voltmeter.

64. Set the Pulse Generator to give a negative-going pulse with a pulse width of 10ms and repetition rate of approx 4Hz displayed on the oscilloscope.

65. Set the 3776 as follows:

OPERATING MODE....................ANRx
ANALOG RECEIVE....................600ohm (Terminated)
MEASUREMENT....................TRANSIENTS

66. Scroll the 3776 Transient parameters using the NEXT PARAM key and set as follows:

SLO Count
1-00 hr
10 deg P. hit

67. Press the 3776 RUN key and press the NEXT PARAM key to display 10 deg P. hit.

68. Check that phase hits are not registered.

4-60 GAIN HITS (3776B) or AMPLITUDE HITS (3776A) - OPTION 001

SPECIFICATION

Thresholds:	2, 3, 4 and 6dB
Threshold Accuracy:	+/- 0.5dB
Guard Interval or Qualification Period:	If the test tone exceeds a threshold by 1dB and returns to its original value within 3.6ms, a Gain/Amplitude Hit should not be counted. If the test tone returns to its original level after 4.4ms, a Gain/Amplitude Hit should be counted.
Loop Recovery:	With the amplitude of the test tone varied linearly over 4dB during a period defined as the risetime, the following results should be obtained: (1) With a risetime of 200ms and the Gain/Amplitude Hit threshold set to 2dB, the 3776 should record a gain/amplitude hit. (2) With a risetime of 600ms and the Gain/Amplitude Hit threshold set to 2dB, the 3776 should not record a gain hit.
Counting Rate:	3776A - Maximum count rate is 8 counts/sec 3776B - Selectable: Maximum 8 counts/sec or Maximum 100 counts/sec
Input Holding Tone Requirements:	The 3776 receiver should accept test tone frequencies between 995Hz and 1025Hz, with levels in the range from +10dBm to -40dBm.

DESCRIPTION

A Gain/Amplitude hit is classified as an abrupt change in gain of a received test tone.

EQUIPMENT

Pulse Generator....................HP 8005B
Function Generator....................HP 3312A
Oscilloscope Mainframe....................HP 180A
Vertical Amplifier Plug-in....................HP 1801A
Time Base Plug-in....................HP 1821A
AC Voltmeter....................HP 3455A
Frequency Counter....................HP 5328A

PROCEDURE

Threshold Accuracy

1. Connect up the equipment as shown in Figure 4-47.

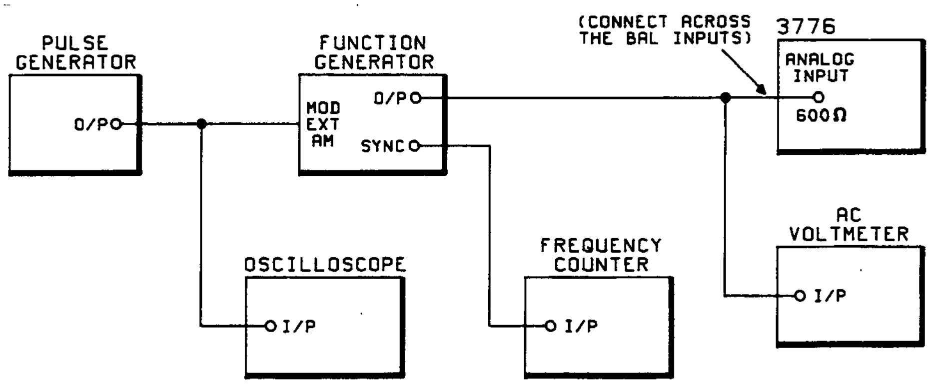


Figure 4-47 Threshold Accuracy Test Set-up

2. Set the 3776 as follows:

OPERATING MODE....................ANRx
MEASUREMENTS....................TRANSIENTS
ANALOG RECEIVE....................600ohm (Terminated)

3. Using the PARAMETERS and SET keys, set the 3776 for SLO Count; 1-00 hr; 2dB G. hit/A. hit.

4. Set the Pulse Generator to give a positive-going pulse with a pulse width of approx 3 seconds displayed on the Oscilloscope.

Note: The Pulse Generator transition times should be set to minimum. The DC offset control should be switched off.

5. Set the Pulse Generator to EXT-MAN.

6. The level displayed on the Oscilloscope should be 0V ac.

7. Set the Function Generator to give a sinewave output at 995Hz +/-2Hz (if using a HP 3312A see

settings below) as displayed on the Frequency Counter. Adjust the Function Generator amplitude control for a reading of 1.1590V +/-0.001V (ie, 3.5dBm/600ohms) displayed on the AC Voltmeter.

3312A Settings:

MODULATION....EXT, AM, % control to mid-range
FUNCTION....
TRIGGER PHASE....FREE RUN
RANGE Hz....100Hz
OFFSET....CAL
SYM....CAL

8. Set the 3776 CONTROL to RUN and press the NEXT PARAM key to display 2dB G. hit/A. hit.

9. Continually press the Pulse Generator EXT-MAN pushbutton, and adjust the Pulse Generator amplitude controls to obtain a count/no count condition (Gain-hit threshold) displayed on the 3776 RESULTS display.

   Note:
   Each time the EXT-MAN pushbutton is depressed, the Pulse Generator produces a 3-second positive-going pulse. If the pulse amplitude is sufficient, two gain-hits will be registered. One gain-hit is registered at the positive-going edge of the pulse and the other at the negative-going edge of the pulse. The following procedure refers to the gain-hit which is registered at the positive-going edge of the 3 second pulse.

10. Check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT MAN pushbutton is pressed, is between 1.3774V and 1.5455V. This corresponds to -2dB hit limits.

11. Adjust the controls of the Pulse Generator to give a negative-going pulse with a pulse width of 3 seconds. This can be achieved by connecting the Function Generator MOD EXT input to the Pulse Generator OUTPUT (-). Using the oscilloscope, check that no DC offset is introduced when the Pulse Generator OUTPUT (-) is selected.

12. Repeat Step 9.

13. Check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT-MAN pushbutton is pressed, is between 0.8691V and 0.9752V. This corresponds to -2dB limits.

14. Press the 3776 STOP key and set the 3776 gain-hit threshold to 3dB. Press the 3776 RUN key.

15. Repeat Step 9.

16. Check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT-MAN pushbutton is pressed, is between 0.7746V and 0.8691V. This corresponds to -3dB hit limits.

17. Connect the Function Generator MOD EXT input to the Pulse Generator OUTPUT (+), (ie, positive-going 3 second pulse output).

18. Repeat Step 9 and check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT-MAN pushbutton is pressed, is between 1.7341V and 1.5455V. This corresponds to +3dB hit limits.

19. Press the 3776 STOP key and set the 3776 gain-hit threshold to 4dB. Press the 3776 RUN key.

20. Repeat Step 9 and check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT-MAN pushbutton is pressed, is between 1.9457V and 1.7341V. This corresponds to +4dB hit limits.

21. Connect the Function Generator MOD EXT input to the Pulse Generator OUTPUT (-), (ie, negative-going 3 second pulse output).

22. Repeat Step 9 and check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT-MAN pushbutton is pressed is between 0.6904V and 0.7746V. This corresponds to -4dB hit limits.

23. Press the 3776 STOP key and set the 3776 gain hit threshold to 6dB. Press the 3776 RUN key.

24. Repeat Step 9 and check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT-MAN pushbutton is pressed, is between 0.5484V and 0.6153V. This corresponds to -6dB limits.

25. Connect the Function Generator MOD EXT input to the Pulse Generator OUPUT (+), (ie, positive-going 3 second pulse output).

26. Repeat Step 9 and check that the voltage displayed on the AC Voltmeter during the 3 seconds after the EXT-MAN pushbutton is pressed is between 2.4495V and 2.1831V. This corresponds to +6dB hit limits.

Guard Interval or Qualification Period

27. Continually press the Pulse Generator EXT-MAN pushbutton and adjust the Pulse Generator amplitude controls to give 2.50V +/-0.05V displayed on the AC Voltmeter. Gain-hits should now be registered every time the EXT-MAN pushbutton is pressed.

28. Adjust the controls of the Pulse Generator to give a positive-going pulse with a pulse width of approx 10ms and a repetition rate of approx 4Hz, displayed on the oscilloscope.

29. Gently reduce the Pulse Generator pulse width control so that no further counts register on the 3776 Gain hits display.

30. Check that the Pulse Generator output pulse width, displayed on the oscilloscope, is between 3.5ms and 4.5ms.

Loop Recovery Time

31. Press the 3776 STOP key.

32. Repeat Step 4.

33. Set the Pulse Generator to EXT-MAN. Ensure that the level displayed on the oscilloscope is 0V ac.

34. Ensure that the Function Generator is set to 995Hz +/-2Hz, displayed on the Frequency Counter and 1.159V +/-0.001V displayed on the AC Voltmeter.

35. Continually press the Pulse Generator EXT-MAN pushbutton, and adjust the Pulse Generator output level to give 1.837V +/-0.001V (ie, 4dB above 1.159V) displayed on the AC Voltmeter.

36. With the Pulse Generator level set as in Step 35, adjust the Pulse Generator controls to obtain the waveform shown in Figure 4-48, displayed on the Oscilloscope.

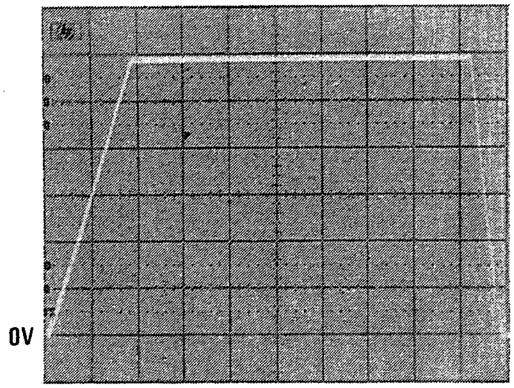


Figure 4-48

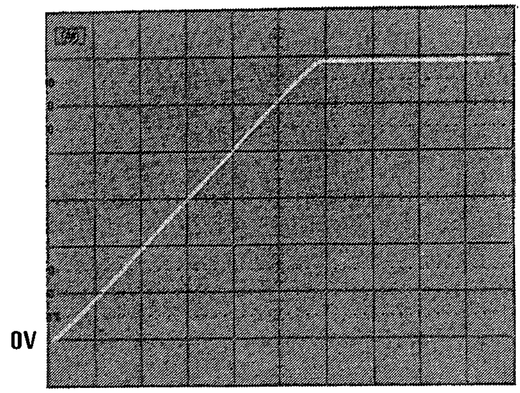


Figure 4-49

37. Set the Pulse Generator pulse width to maximum width (approx 3 seconds).

38. Set the Pulse Generator to EXT-MAN.

39. Set the 3776 as follows:

OPERATING MODE........ANRx
ANALOG RECEIVE........600ohms (Terminated)
MEASUREMENT........TRANSIENTS

40. Scroll the transients parameters using the NEXT PARAM key and set as follows:

SLO Count
1-00 hr
2dB G. hit/A. hit

41. Press the 3776 RUN key and press NEXT PARAM to display 2dB G. hit/A. hit.

42. Press the Pulse Generator EXT-MAN pushbutton and check that the instant the pushbutton is pressed, a hit is registered.

43. With the Pulse Generator level set as in Step 35, adjust the Pulse Generator controls to obtain the waveform shown in Figure 4-49, displayed on the oscilloscope.

44. Set the Pulse Generator to maximum pulse width and EXT-MAN.

45. Press the Pulse Generator EXT-MAN pushbutton and check that the instant the pushbutton is pressed, a hit is **not** registered.

4-61 DROPOUTS (3776B OPTION 001)/INTERRUPTIONS (3776A OPTION 001)

SPECIFICATION

3776B
Threshold Setting: -12dB +/-1dB

Qualification period or Guard Interval: 3.5ms to 4.5ms

3776A
Threshold Setting: -10dB +/-1dB

Qualification period or Guard Interval: 2ms to 3.5ms

3776A and 3776B Input
Holding Tone Requirements: 995Hz to 1025Hz, +10dBm to -40dBm

DESCRIPTION

Dropouts are tested by amplitude modulating a sinewave carrier using a pulse. By adjusting the amplitude of the pulse, the depth of level of the dropout can be varied (see Figure 4-50).

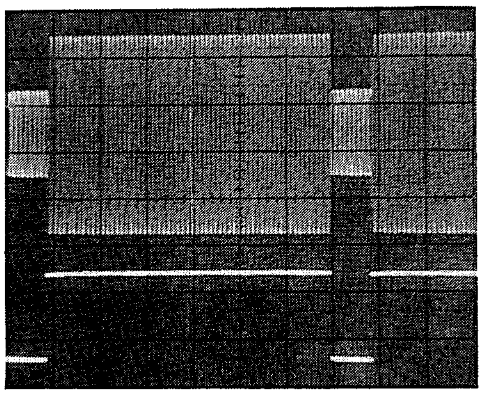


Figure 4-50 Dropout Test Waveform

EQUIPMENT

Pulse Generator	HP 8005A
Function Generator	HP 3312A
Oscilloscope Mainframe	HP 180A
Dual Channel Vertical Amplifier Plug-in	HP 1801A
Time Base Plug-in	HP 1821A
AC Voltmeter	HP 3455A
Frequency Counter	HP 5328A

PROCEDURE

Threshold, Guard Interval and Input Holding Tone

1. Set the 3776 as follows:

OPERATING MODE	ANRx
MEASUREMENTS	TRANSIENTS
ANALOG RECEIVE	600ohms (Terminated)

2. Using the PARAMETERS and SET keys set the 3776 for SLO Count; 1-00 hr; -12dB d. out (3776B) or -10dB I.rpt 83776A).

3. Connect the equipment as shown in Figure 4-51.

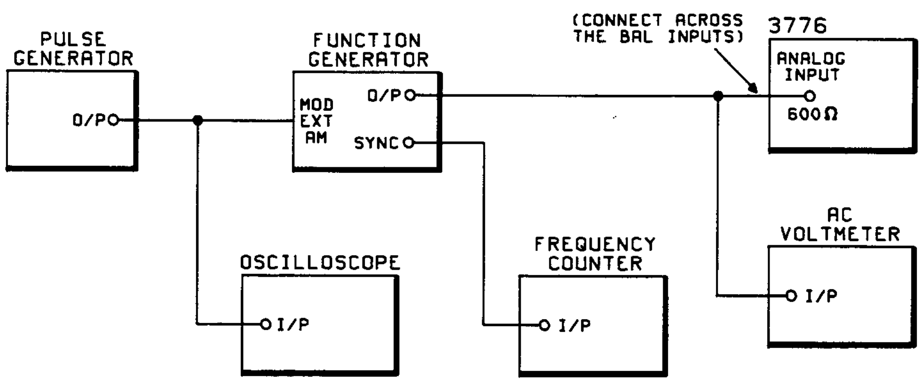


Figure 4-51 Dropouts/Interruptions Test Set-up

4. Set the Pulse Generator to provide a 4Hz repetition rate negative pulse of width 10ms as displayed on the Oscilloscope.

   Note: Pulse Generator transition times should be set to minimum.

5. Set the Pulse Generator operating mode to EXT-MAN. The level displayed on the Oscilloscope should be 0V ac.

6. Set the Function Generator to give a sinewave output at 995Hz +/-2Hz (if using HP 3312A see settings below) as displayed on the Frequency Counter. Adjust the Function Generator amplitude control for a reading of 2.450 +/-0.001V (+10dBm into 600ohms) as displayed on the AC voltmeter.

   3312A settings:

   MODULATION.......EXT, AM, % control to mid-range
   FUNCTION.......~
   TRIGGER PHASE.......FREE RUN
   RANGE Hz.......100Hz
   OFFSET.......CAL
   SYM.......CAL

7. Set the 3776 CONTROL to RUN and press the NEXT PARAM key to display -12dB d. out (3776B) or -10dB I.rpt (3776A).

   Note: The 3776 will use the level measured at the begining of the run as a reference.

8. Set the Pulse Generator operation to normal and adjust the pulse amplitude to obtain the point where the 3776 just begins to accumulate counts in the results window.

9. Set the Pulse Generator PULSE WIDTH control to its maximum (preferably about 3 secs) and check that the AC Voltmeter reading is between 0.690 and 0.548V (ie, between -1dBm and -3dBm) if the instrument is a 3776B or between 0.869 and 0.690 (ie, between +1dBm and -1dBm) for the 3776A, during the 3 second pulse periods.

10. Adjust the Pulse Generator Amplitude to give an AC Voltmeter indication of 0.435V +/-0.002 during the 3 second pulse periods (ie, -15dB below the +10dBm reference level) for the 3776B or 0.581V +/-0.002V (ie, -12.5dB below the +10dBm reference level) if the instrument is a 3776A.

    Note: these levels will ensure dropouts (interrupts) are counted for the next step.

11. Reduce the Pulse Generator pulse width to obtain the point where the counts just stop accumulating in the 3776 RESULTS window.

12. Check that the output pulse width displayed on the Oscilloscope is between 3.5 and 4.5ms (3776B) or between 2 and 3.5ms (3776A).

13. Press the 3776 STOP key.

14. Repeat Steps 4 and 5.

15. Set the Function Generator to give 1025Hz displayed on the Frequency Counter. Adjust the Function Generator amplitude control to give 30.83mV +/-0.01mV (-28dBm/600ohms) displayed on the AC Voltmeter if the instrument is a 3776B or 24.49mV +/-0.01mV (-30dBm/600ohms) displayed on the AC Voltmeter if the instrument is a 3776A.

16. Repeat Steps 7 and 8.

17. Set the Pulse Generator pulse width control to its maximum (approx 3 seconds) and check that the AC Voltmeter reading is between 8.69mV and 6.90mV (ie between -39dBm and -41dBm).

4-62 IMPULSE NOISE (3776B only OPTION 001)

SPECIFICATION

Threshold Range:	Low; Selectable in 1dB steps between -8dBm0 to -40dBm0. Mid; 4dB above Low (i.e. range between -4dBm0 to -36dBm0). High; -4dB above Mid (i.e. range between 0dBm0 to -32dBm0).
Threshold Accuracy for thresholds >-25dBm:	+/- 1dB
Input Holding Tone:	The 3776B should accept holding tone frequencies between 995Hz and 1025Hz with levels within the range from 0dBm to -40dBm.

DESCRIPTION

The Impulse Noise threshold range and accuracy tests use a 1810Hz sinewave of known amplitudes to test the three thresholds (Low, Mid and High). A 995Hz sinewave is combined with the 1810Hz sinewave to ensure that impulse counts are not inhibited by other Transient measurements. The 995Hz holding tone is notched out by the 3776B and therefore does not affect the impulse noise thresholds.

Note: Thresholds set correspond to peak values, (e.g. a count/no count condition occurs when the threshold is set to 0dBmO and a sinewave used as a source of impulse noise is at a level of -3dBmO).

EQUIPMENT

Test Oscillator	HP 651B
AC Voltmeter	HP 3455A
Frequency Counter	HP 5328A
Attenuator (600ohm)	HP 4437A
Three 200ohm Resistors	HP 0757-0407

PROCEDURE

Threshold Range, Threshold Accuracy and Input Holding Tone Requirements

1. Connect up the test circuit as shown in Figure 4-52, with the ATTENUATOR set to 0dB.

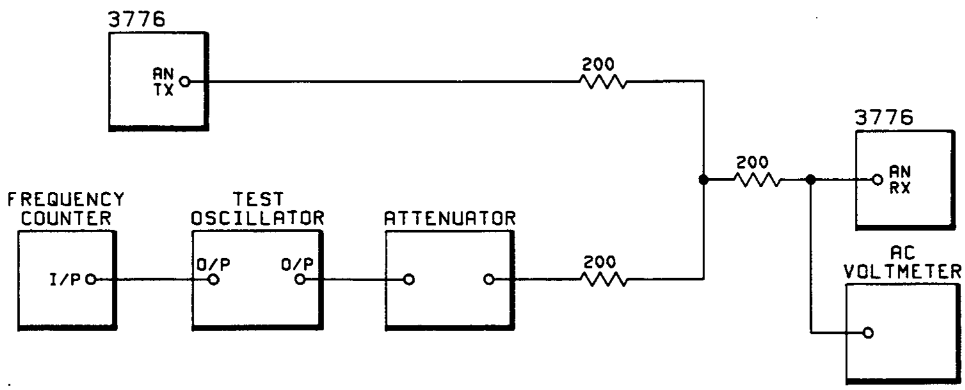


Figure 4-52 3776B Impulse Noise Threshold Range, Threshold Accuracy and Input Holding Tone Requirements Test Circuit

2. Set the Test Oscillator output voltage to its minimum level.

3. Set the 3776 to 600ohm UNBAL A-A TRANSIENTS with the REF Frequency to 0.99kHz. Press RUN/REPEAT and adjust the 3776 output LEVEL to give 0.7745V displayed on the AC Voltmeter. The 3776 LEVEL display should indicate approx +6dBmO. Press STORE.

4. Ensure that the Attenuator is set to 00.0dB. Press STOP on the 3776.

   Note: If Option 002 is fitted, set the Test Oscillator output level and frequency to give 0.7745V ±0.0005V displayed on the AC Voltmeter and 1810Hz ±10Hz displayed on the Frequency Counter, then go to Step 7.

5. Set the 3776 to A-A IDLE STATE C-MESS FILTER.

6. Press RUN/REPEAT on the 3776 and set the Test Oscillator output level and frequency to give 90dBrnCo displayed on the 3776B RESULTS display and 1810Hz displayed on the Frequency Counter.

   Note: Setting the 3776 to IDLE STATE, C-MESS FILTER, then adjusting the test oscillator output level to give 90dBrnCo on the 3776 display, compensates for the loss in the C-MESS filter at 1810Hz.

7. Press STOP and set the 3776 to A-A TRANSIENTS and press RECALL. The combined AnTx and Test Oscillator outputs should now be applied to the 3776 AnRx input.

8. Set the 3776 to TRANSIENTS/SLO Count/1.00hr/40oP.hit/-8.0dBmO I.cnt/ LOW THRESHOLD and press RUN/REPEAT.

   Note:- If option 002 is fitted, select Fil A on the I. cnt display. Setting the Phase Hit Threshold to 40 degrees ensures that Phase Hits, which inhibit inpulse counts, are not detected.

9. Set the LOW Threshold as shown in Table 1. At each setting, scroll the appropriate threshold count in turn (i.e. LOW, MID and HIGH) and adjust the Attenuator to give a count/no count condition on the 3776 display. Check when the count/no count condition is reached that the Attenuator setting is within the limits given in Table 1.

Table 1

LOW Threshold Setting (dBm0)	LOW Attenuator Limits (dB)		MID Attenuator Limits (dB)		HIGH Attenuator Limits (dB)	
	Max	Min	Max	Min	Max	Min
-8	12	10	8	6	4	2
-10	14	12	10	8	6	4
-20	24	22	20	18	16	14
-25	29	27	25	23	21	19

10. Set the Test Oscillator output voltage to a negligible level.

11. Set the 3776 to A-A TRANSIENTS with the REF frequency set to 1.02kHz. Press RUN/REPEAT and adjust the 3776 output LEVEL to give 7.75mV (i.e. -40dBm/600ohm) displayed on the AC Voltmeter. The output level should be set to approx -34dBmO. Press STORE.

12. Repeat steps 4 to 9.

4-63 IMPULSE NOISE (3776A ONLY OPTION 001)

SPECIFICATION

Threshold Range: Low; Selectable in 1dB steps between -6dBm0 to -40dBm0.

Mid; Always 3dB above Low (ie range between -3dBm0 to -37dBm0)

High; Always 3dB above Mid (ie range between 0dBm0 to -34dBm0)

Threshold Accuracy for thresholds >-25dBm: +/-1dB

Weighting Filters:

Filter A: 200Hz High Pass, with 1kHz Notch.
Filter B: 600Hz to 3000Hz, with 1kHz Notch.
Filter C: 300Hz to 500Hz with 1kHz Notch.

Input Holding Tone: The 3776A should accept holding tone frequencies between 995Hz and 1025Hz with levels within the range from 0dBm to -40dBm.

DESCRIPTION

the Impulse Noise threshold range and accuracy tests use a 1810Hz sinewave so test the threshold when Filter A and B are selected. A 400Hz sinewave is used when Filter C is selected. A 1010Hz sinewave is combined with the 1810Hz Or 400Hz sinewave to ensure that impulse counts are not inhibited by other Transient measurements. The 1010Hz tone is notched out by the 3776A Rx and therefore does not affect the impulse noise thresholds.

EQUIPMENT

Test Oscillator........HP 651B
Attenuator (600ohm)........HP 4437A
Three 200ohm resistors........HP 0757-0407
AC Voltmeter........HP 3455A

PROCEDURE

1. Connect up the equipment as shown in Figure 4-53 with the Attenuator set to OdB.

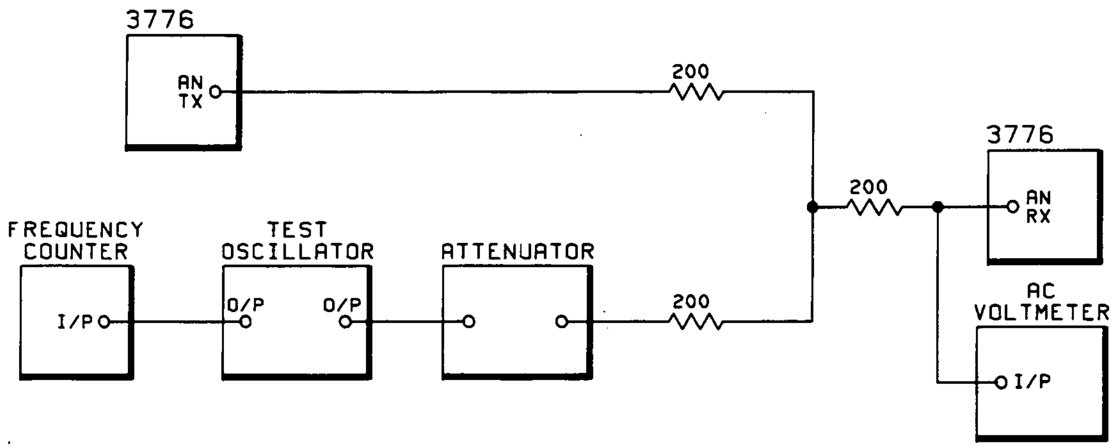


Figure 4-53 3776A Impulse Noise Threshold Range, Threshold Accuracy and Input Holding Tone Requirement Test Circuit.

2. Set the Test Oscillator output voltage to its minimum level.

3. Set the 3776A to A-A TRANSIENT, set frequency to 0.99kHz and adjust the output level to give approx 0.7745V (ie, 0dBm/600ohm) displayed on the AC Voltmeter. The 3776 LEVEL display should read approx +6dBmO. Press STORE.

4. Set the 3776 to AnRx only.

5. Set the Attenuator to 02.0dB and set the Test Oscillator output level to give 0.7745V +/-0.0005V displayed on the AC Voltmeter and 1810Hz +/-5Hz on the Frequency counter.

6. Set the 3776 to A-A TRANSIENTS/SLO Count/1.00 hr/40 degrees P.hit/Fil.A and press RUN/REPEAT. The combined AnTx and Test Oscillator output should now be applied to the 3776 AnRx input.

   Note:- Setting the P.hit threshold to 40 degrees ensures that impulse counts are not inhibited by phase hits.

7. Set the LOW I.cnt threshold as shown in Table 1. At each setting, scroll the appropriate threshold count in turn (ie, LOW, MID and HIGH) and adjust the Attenuator to give a count/no count condition on the 3776 display. Check when the count/no count condition is reached that the Attenuator setting is within the limits given in Table 1.

Table 1

LOW Threshold Setting (dBmO)	LOW Attenuator Limits (dB)		MID Attenuator Limits (dB)		HIGH Attenuator Limits (dB)	
	Max	Min	Max	Min	Max	Min
-6	9	7	6	4	3	1
-10	13	11	10	8	7	5
-20	23	21	20	18	17	15
-25	28	26	25	23	22	20

8. Set the 3776 to A-A TRANSIENTS/SLO Count/1.00hr/Fil. B, -6dBmO, I.cnt and press RUN/REPEAT.

9. Repeat Step 7.

10. Set the 3776 to AnRx only.

11. With the Attenuator set to 02.0dB, set the Test Oscillator output frequency to 400Hz, displayed on the Frequency Counter and output level of 0.7745V +/-0.0005V displayed on the AC Voltmeter.

12. Set the 3776 to A-A TRANSIENTS/SLO Count/1.00hr/Fil. C, -6dBmO, I.cnt and press RUN/REPEAT.

13. Repeat Step 7.

14. Set the Test Oscillator to its minimum level.

15. Set the 3776A to A-A TRANSIENTS with the REF frequency set to 1.02kHz. Press RUN/REPEAT and adjust the 3776 output level to give 7.75mV (ie -40dBm/600ohm) displayed on the AC Voltmeter. The output level should be set to approx -34dBmO. Press STORE.

16. Repeat Steps 4 to 7.

Note: It is only necessary to check the -6dBmO Low Threshold setting in Step 7.

4-64 ENVELOPE DELAY (3776B OPTION 001)/GROUP DELAY (3776A OPTION 001) AND ATTENUATION DISTORTION

SPECIFICATION

Frequency Range:	(3776A) 200Hz to 3600Hz (3776B) 300Hz to 3500Hz
Level Range:	+5dBm to -40dBm
Attenuation Distortion Accuracy:	+/-0.2dB
Attenuation Distortion Range:	0 to +/-10dB
3776A Group Delay Measurement Range:	0 to +/-10ms
3776A Group Delay Accuracy:	200Hz to 400Hz +/-40us 400Hz to 600Hz +/-25us 600Hz to 3600Hz +/-20us
3776B Envelope Delay Measurement Range:	-3ms to +9ms
3776B Envelope Delay Accuracy with a Signal to Noise Ratio >35dB:	>300Hz, < +/-30us >500Hz, < +/-15us

DESCRIPTION

Relative Delay and Attenuation Distortion are checked by connecting the 3776 back-to-back in the ANTx to ANRx operating mode, inserting an accurate known amount of delay (-6ms) and attenuation (+3dB) at the transmitter and measuring the delay and attenuation at the receiver. Tables 1 and 2 give the frequency steps and limits used for testing the 3776A and 3776B respectively. Note: The Reference frequency is set to 1810Hz and Transmitter level set to +5dBmO.

EQUIPMENT

HP-IB Controller	HP 85
HP-IB Interface	HP 82937A
Input/Output ROM	HP 00085-15003
Advanced Programming Rom	HP 00085-15005
ROM Drawer	HP 82936A
3776 Test Program Data Cartridge	HP 03776-10001

PROCEDURE

1. Connect the ANALOG TRANSMIT output to the ANALOG RECEIVE input.
2. Connect the HP-IB Controller via the HP-IB Interface to the 3776.
3. Insert the 3776 Test Program Data Cartridge into the HP-IB Controller.
4. Load the "DELAY" program.
5. RUN the "DELAY" program and check that no errors are displayed in the HP-IB Controller or the 3776.

Table 1 3776A Program Limits

MEAS FREQ (Hz)	Atten Dist Limits (dB)		Group Delay Limits (secs)	
	Max	Min	Max	Min
200	+3.20	+2.80	-0.006040	-0.005960
410	+3.20	+2.80	-0.006025	-0.005975
810	+3.20	+2.80	-0.006020	-0.005980
1010	+3.20	+2.80	-0.006020	-0.005980
1210	+3.20	+2.80	-0.006020	-0.005980
1410	+3.20	+2.80	-0.006020	-0.005980
1610	+3.20	+2.80	-0.006020	-0.005980
1810	+3.20	+2.80	-0.006020	-0.005980
2010	+3.20	+2.80	-0.006020	-0.005980
2210	+3.20	+2.80	-0.006020	-0.005980
2410	+3.20	+2.80	-0.006020	-0.005980
2590	+3.20	+2.80	-0.006020	-0.005980
3600	+3.20	+2.80	-0.006020	-0.005980

Table 2 3776B Program Limits

MEAS FREQ (Hz)	Atten Dist Limits (dB)		Envelope Delay Limits (secs)	
	Max	Min	Max	Min
300	+3.20	+2.80	-0.006030	-0.005970
410	+3.20	+2.80	-0.006015	-0.005985
810	+3.20	+2.80	-0.006015	-0.005985
1010	+3.20	+2.80	-0.006015	-0.005985
1210	+3.20	+2.80	-0.006015	-0.005985
1410	+3.20	+2.80	-0.006015	-0.005985
1610	+3.20	+2.80	-0.006015	-0.005985
1810	+3.20	+2.80	-0.006015	-0.005985
2010	+3.20	+2.80	-0.006015	-0.005985
2210	+3.20	+2.80	-0.006015	-0.005985
2410	+3.20	+2.80	-0.006015	-0.005985
2590	+3.20	+2.80	-0.006015	-0.005985
3600	+3.20	+2.80	-0.006015	-0.005985

Table 4-4 Operational Verification Test Record

Hewlett-Packard

Tested by . . . .

Date . . . .

Serial No. . . . .

Para No.	Test Description	Result Min.	Result Actual	Result Max.
4-24	**POWER ON SEQUENCE**			
(2)	No error codes displayed (√)		. . . .	
(3)	Front Panel conditions:			
	(√) Operating Mode — ANTx, ANRx		. . . .	
	(√) Frequency kHz — 1.01MEAS (3776B)		. . . .	
	—0.81 (3776A)		. . . .	
	(√) Level —0.0dBm0		. . . .	
	(√) Measurements — GAIN TONE		. . . .	
4-26	**SELF TEST**			
(1)	CAL Displayed (√)		. . . .	
(2)	CAL PASS 1 Displayed (√)		. . . .	
(4) (5)	No FAIL or ERROR CODES Displayed (√) (Points 12 to 22)		. . . .	
4-27	**ABSOLUTE LEVEL CHECK**			
(10)	600Ω BAL AdBm0	9.91dBm	. . . .	10.09dBm
(12)	Displayed Level	(A—0.09) dBm0	. . . .	(A +0.09)dBm0
(13)	900Ω AdBm0	9.91dBm	. . . .	10.09dBm
	Displayed Level	(A—0.09)dBm0	. . . .	(A +0.09) dBm0
4-28	**TEST PROGRAM**			
	Test runs with no out-of-limit results (√)		. . . .	
4-30	**INTERRUPTIONS (3776A)/DROPOUTS (3776B)**			
(9)	Threshold —12dB (3776B) } AC Voltmeter Reading	0.548V	. . . .	0.690V
	Threshold —10dB (3776A) } AC Voltmeter Reading	0.690V	. . . .	0.869V
(12)	Qualification period 3776B	3.5ms	. . . .	4.5ms
	3776A	2.5ms	. . . .	4.0ms
4-31	**IMPULSE NOISE (3776B)**			
(9)	Low Threshold Setting (dBm0) —8 LOW	10dB	. . . .	12dB

Table 4-4 Operational Verification Test Record (continued)

Para No.	Test Description		Result Min.	Actual	Max.
		MID	6dB	....	8dB
		HIGH	2dB	....	4dB
	−10	LOW	12dB	....	14dB
		MID	8dB	....	10dB
		HIGH	4dB	....	6dB
	−20	LOW	22dB	....	24dB
		MID	18dB	....	20dB
		HIGH	14dB	....	16dB
	−25	LOW	27dB	....	29dB
		MID	23dB	....	25dB
		HIGH	19dB	....	21dB
4-32	**IMPULSE NOISE (3776A)**				
(7)	Low Threshold Setting (dBm0)				
	−6	LOW	7dB	....	9dB
		MID	4dB	....	6dB
		HIGH	1dB	....	3dB
	−10	LOW	11dB	....	13dB
		MID	8dB	....	10dB
		HIGH	5dB	....	7dB
	−20	LOW	21dB	....	23dB
		MID	18dB	....	20dB
		HIGH	15dB	....	17dB
	−25	LOW	26dB	....	28dB
		MID	23dB	....	25dB
		HIGH	20dB	....	22dB
4-33	**GAIN HITS**				
	Threshold Accuracy				
(10)	+2dB Hit Limit	AC Voltmeter Reading	1.3774V	....	1.5455V
(13)	−2dB Hit Limit	AC Voltmeter Reading	0.8691V	....	0.9752V
(16)	−3dB Hit Limit	AC Voltmeter Reading	0.7446V	....	0.8691V
(18)	+3dB Hit Limit	AC Voltmeter Reading	1.5455V	....	1.7341V
(20)	+4dB Hit Limit	AC Voltmeter Reading	1.7341V	....	1.9457V

Table 4-4 Operational Verification Test Record (continued)

Para No.	Test Description	Result		
		Min.	Actual	Max.
(22)	−4dB Hit Limit — AC Voltmeter Reading	0.6904V	. . . .	0.7446V
(24)	−6dB Hit Limit — AC Voltmeter Reading	0.5484V	. . . .	0.6153V
(26)	+6dB Hit Limit — AC Voltmeter Reading	2.1831V	. . . .	2.4495V
	Guard Internal or Qualification Period.			
	Pulse Width	3.5ms	. . . .	4.5ms
4-34	**PHASE HITS (OPT 001)**			
	Threshold Range and Accuracy			
(18)	Threshold Setting (°)			
	5 — f_2 period limits	1064μs	. . . .	1096μs
	10	1140μs	. . . .	1197μs
	15	1227μs	. . . .	1317μs
	20	1329μs	. . . .	1465μs
	25	1450μs	. . . .	1649μs
	30	1595μs	. . . .	1887μs
	35	1771μs	. . . .	2206μs
	40	1992μs	. . . .	2653μs
(23)	Phase hits register on RESULTS display (√)		. . . .	
(24)	Phase hits register with 4.5ms delay (√)		. . . .	
(25)	No Phase hits with 3.5ms delay (√)		. . . .	
4-35	**PHASE JITTER (OPT 001)**			
(6)	Phase Jitter Readings for Oscillator 'B' Output voltage			
	0.201V	28.3°	. . . .	31.7°
	0.134V	18.8°	. . . .	21.2°
	0.075V	10.8°	. . . .	12.2°
(7)	Phase Jitter Readings with additional attenuation			
	10dB	3.2°	. . . .	4.0°
	20dB	0.9°	. . . .	1.3°
	30dB	0.16°	. . . .	0.56°
	40dB	0°	. . . .	0.2°
	50dB	0°	. . . .	0.2°
4-36	**SEQUENCE TEST**			
(8)	Error 18 or 20 Displayed (√)		. . . .	
(17)	SEQ Key illuminated (√)		. . . .	

Table 4-4 Operational Verification Test Record (continued)

Para No.	Test Description	Result		
		Min.	Actual	Max.
(18)	Appended measurements performed (√)		. . . .	
(21)	RS2 displayed on controller (√)		. . . .	
4-37	**DUAL-TONE MULTI FREQUENCY (DTMF) SIGNALLING TEST**			
(5) (2)	2 MEAS appears in the FREQUENCY display and 1 incrementing to 9 then 0, star, hash, A, b, C and d. After d, 5 is displayed (√)		. . . .	
(6)	Waveform obtained (√)		. . . .	
4-38	**3776B PCM TESTS**			
(3)	No error codes displayed on HP85 (√)		. . . .	
4-39	**3776A PCM TESTS**			
(3)	No error codes displayed HP85 (√)		. . . .	

Table 4-5 Performance Tests Test Record

Hewlett-Packard — **Tested by** ....

Date ....

Model 3776A/B PCM Terminal Test Set — **Serial No.** ....

Para No.	Test Description	Result Min.	Result Actual	Result Max.
4-24	**POWER ON SEQUENCE**			
(2)	No error codes displayed (√)		....	
(3)	Front Panel conditions:			
	(√) Operating Mode – ANTx, ANRx		....	
	(√) Frequency kHz – 1.01MEAS (3776B)		....	
	–0.81 (3776A)		....	
	(√) Level –0.0dBm0		....	
	(√) Measurements – GAIN TONE		....	
4-26	**SELF TEST**			
(1)	CAL Displayed (√)		....	
(2)	CAL PASS 1 Displayed (√)		....	
(4)(5)	NO FAIL or ERROR CODES Displayed (√) (Points 12 to 22)		....	
4-36	**SEQUENCE TEST**			
(8)	ERROR 18 or 20 Displayed (√)		....	
(17)	SEQ key illuminated (√)		....	
(18)	Appended measurements performed (√)		....	
(21)	RS2 displayed on controller (√)		....	
4-37	**DUAL-TONE MULTI-FREQUENCY (DTMF) SIGNALLING-TEST**			
(5)(a)	2 MEAS appears in the FREQUENCY display and 1 incrementing to 9 then 0, star, hash, A, b, C and d. After d, 5 is displayed (√)		....	
(b)	Waveform obtained (√)		....	

Table 4-5 Performance Tests Test Record (continued)

Para No.	Test Description	Result		
		Min.	Actual	Max.
4-38	**3776B PCM TESTS**			
	TEST PROGRAM			
(3)	No error codes displayed on HP85 (√)		. . . .	
4-39	**3776A PCM TESTS**			
	TEST PROGRAM			
(3)	No error codes displayed on HP85 (√)		. . . .	
4-40	**ANALOG RECEIVER LEVELS AND LINEARITY**			
	600Ω BAL			
(14)	AdBm0 – BdBm0	–0.09dB	. . . .	0.09dB
(15)	Linearity Error Limits			
	Dekatron Setting (dB value)			
	–30		. . . .	0.06dB
	–20		. . . .	0.06dB
	–10		. . . .	0.06dB
	0		. . . .	0.06dB
	Level Error Limits			
	Dekatron Setting (dB value)			
	–30	–0.09dB	. . . .	0.09dB
	–20	–0.09dB	. . . .	0.09dB
	–10	–0.09dB	. . . .	0.09dB
	0	–0.09dB	. . . .	0.09dB
(25)	CdBm0 – XdBm0	–0.09dB	. . . .	0.09dB
(26)	Linearity Error Limits			
	Dekatron Setting (dB value)			
	–10		. . . .	0.06dB
	–20		. . . .	0.08dB
	–30		. . . .	0.10dB
	–40		. . . .	0.12dB
	–46		. . . .	0.18dB
4-40	**Level Error Limits**			
(26)	Dekatron Setting (dB value)			
	–10	–0.11dB	. . . .	0.11dB
	–20	–0.11dB	. . . .	0.11dB
	–30	–0.11dB	. . . .	0.11dB
	–40	–0.13dB	. . . .	0.13dB
	–46	–0.13dB	. . . .	0.13dB
(27)	600Ω BRIDGED			
(14)	AdBm0 – BdBm0	–0.09dB	. . . .	0.09dB

Table 4-5 Performance Tests Test Record (continued)

Para No.	Test Description	Result		
		Min.	Actual	Max.
(15)	Linearity Error Limits Dekatron Setting (dB value)			
	−30		....	0.06dB
	−20		....	0.06dB
	−10		....	0.06dB
	0		....	0.06dB
	Level Error Limits Dekatron Setting (dB value)			
	−30	−0.09dB	....	0.00dB
	−20	−0.09dB	....	0.09dB
	−10	−0.09dB	....	0.09dB
	0	−0.09dB	....	0.09dB
(28)	900Ω BAL			
(14)	AdBm0 – BdBm0	−0.09dB	....	0.09dB
(15)	Linearity Error Limits Dekatron Setting (dB value)			
	−30		....	0.06dB
	−20		....	0.06dB
	−10		....	0.06dB
	0		....	0.06dB
	Level Error Limits Dekatron Setting (dB value)			
	−30	−0.09dB	....	0.09dB
	−20	−0.09dB	....	0.09dB
	−10	−0.09dB	....	0.09dB
	0	−0.09dB	....	0.09dB
4-41	**ANALOG TRANSMITTER LEVELS AND LINEARITY**			
	600Ω BAL			
(17)	Linearity Error Limits Dekatron Setting (dB value)			
	−40		....	0.05dB
	−30		....	0.05dB
	−20		....	0.05dB
	−10		....	0.05dB
	Level Error Limits Dekatron setting (dB value)			
	−40	−0.09dB	....	0.09dB
	−30	−0.09dB	....	0.09dB
	−20	−0.09dB	....	0.09dB
	−10	−0.09dB	....	0.09dB

Table 4-5 Performance Tests Test Record (continued)

Para No.	Test Description	Result Min.	Actual	Max.
(26)	Linearity Error Limits Dekatron Setting (dB value)			
	−20		....	0.06dB
	−30		....	0.07dB
	−40		....	0.09dB
	−46		....	0.12dB
	Level Error Limits Dekatron Setting (dB value)			
	−20	−0.11dB	....	0.11dB
	−30	−0.11dB	....	0.11dB
	−40	−0.13dB	....	0.13dB
	−46	−0.13dB	....	0.13dB
	900Ω BAL			
(27)	Repeat steps 2 to 26 i.e.			
(17)	Linearity Error Limits Dekatron Setting (dB value)			
	−40		....	0.05dB
	−30		....	0.05dB
	−20		....	0.05dB
	−10		....	0.05dB
	Level Error Limits Dekatron Setting (dB value)			
	−40	−0.09dB	....	0.09dB
	−30	−0.09dB	....	0.09dB
	−20	−0.09dB	....	0.09dB
	−10	−0.09dB	....	0.09dB
(26)	Linearity Error Limits Dekatron Setting (dB value)			
	−20		....	0.06dB
	−30		....	0.07dB
	−40		....	0.09dB
	−46		....	0.12dB
	Level Error Limits Dekatron Setting (dB value)			
	−20	−0.11dB	....	0.11dB
	−30	−0.11dB	....	0.11dB
	−40	−0.13dB	....	0.13dB
	−46	−0.13dB	....	0.13dB
4-42	**ANALOG TRANSMITTER FLATNESS** Referenced to 1.01kHz (3776B) or 0.81kHz (3776A)			
(9)	0.461% = 0.04dB { 70Hz	−0.461%	....	0.461%
	210Hz	−0.461%	....	0.461%
	3.59kHz	−0.461%	....	0.461%
	4.59kHz	−0.461%	....	0.461%

Table 4-5 Performance Tests Test Record (continued)

Para No.	Test Description	Result Min.	Result Actual	Result Max.
4-43	**ANALOG RECEIVER FLATNESS** Referenced to 1.01kHz (3776B) or 0.81kHz (3776A)			
(8)	210Hz	−0.03dB	....	0.03dB
	3.89kHz	−0.03dB	....	0.03dB
4-44	**ANALOG RECEIVER DIGITAL FILTER** Referenced to 1.01kHz (3776B) or 0.81kHz (3776A)			
(9)	3776A Psophometric			
	250Hz	XdBm0 −17.073	....	XdBm0 −12.927
	800Hz	XdBm0 −0.173	....	XdBm0 +0.173
	3000Hz	XdBm0 −6.673	....	XdBm0 −4.527
	4500Hz	XdBm0 −28.073	....	XdBm0 −21.927
	3776B C-Message			
	300Hz	XdBm0 −17.573	....	XdBm0 −15.427
	900Hz	XdBm0 − 1.673	....	XdBm0 +0.473
	3000Hz	XdBm0 −3.573	....	XdBm0 −1.427
	4500Hz	XdBm0 −24.573	....	XdBm0 −18.427
4-45	**ANALOG RECEIVER NOISE LINEARITY**			
(6)	Dekatron Settings (dB)			
	Initial Reference Value = X 0dB		X =	
	−10dB	(X−10) −0.8dB	....	(X−10) +0.8dB
	−20dB	(X−20) −0.8dB	....	(X−20) +0.8dB
	−30dB	(X−30) −0.8dB	....	(X−30) +0.8dB
	−40dB	(X−40) −0.8dB	....	(X−40) +0.8dB
	−48dB	(X−46) −0.8dB	....	(X−46) +0.8dB
(8)	Dekatron Settings (dB)			
	Initial Reference Value = y 0dB		Y=	
	−10dB	(Y−10)−0.12dB	....	(Y−10)+0.12dB
	−20dB	(Y−20)−0.12dB	....	(Y−20)+0.12dB
	−30dB	(Y−30)−0.30dB	....	(Y−30)+0.30dB
	−42dB	(Y−42)−0.30dB	....	(Y−42)+0.30dB
4-46	**ANALOG TO ANALOG (A-A) GAIN**			
(6)(7)	(+10dBm0) 210Hz	−0.05dB	....	0.05dB
	3776A 810Hz	−0.05dB	....	0.05dB
	3776B 1010Hz	−0.05dB	....	0.05dB
	3.89kHz	−0.05dB	....	0.05dB
(8)	(−40dB) 210Hz	−40.05dB	....	40.05dB
	3776A 810Hz	−40.05dB	....	40.05dB
	3776B 1010Hz	−40.05dB	....	40.05dB
	3.89kHz	−40.05dB	....	40.05dB
(10)	(−30dBm0) 210Hz	−0.05dB	....	0.05dB
	3776A 810Hz	−0.05dB	....	0.05dB
	3776B 1010Hz	−0.05dB	....	0.05dB

Table 4-5 Performance Tests Test Record (continued)

Para No.	Test Description	Result Min.	Result Actual	Result Max.
4-46	**ANALOG RECEIVER NOISE FLOOR**			
(3)	PSOPH 3776A		....	−100dBm
	C-MESS 3776B		....	−10dBrnC0
(5)	FIL A (3kHz)		....	−95dBm0
(7)	FIL B (FLAT)		....	−90dBm
(9)	FIL C (HIGH PASS)		....	−90dBm0
(11)	SELECTIVE		....	−110dBm0
4-48	**ANALOG TRANSMITTER SPURIOUS**			
(7)	Harmonics & spurious		....	−65dB
4-49	**ANALOG RECEIVER INTER-MODULATION FLOOR**			
(7)	Third Order Product		....	−55dBm0
4-50	NOT APPLICABLE TO THIS INSTRUMENT			
4-51	NOT APPLICABLE TO THIS INSTRUMENT			

Table 4-5 Performance Tests Test Record (continued)

Para No.	Test Description		Result Min.	Actual	Max.
4-52	**ANALOG RECEIVER OUT OF BAND REJECTION**				
(7)				. . . .	–60dB
4-53	**ANALOG RECEIVER ANTI-ALIASING FILTER FLATNESS**				
(8)		Max difference at selected frequencies		. . . .	0.1dB
4-54	**ANALOG TRANSMITTER FREQUENCY ACCURACY**				
(4)		4.6kHz – period	217.381µs	. . . .	217.401µs
		50Hz – period	19.999ms	. . . .	20.001ms
4-55	**DIGITAL TRANSMITTER EXTERNAL CLOCK INPUT**				
(8)	D-D GAIN measurement works (√)			. . . .	
4-56	**DIGITAL TRANSMITTER PCM WAVEFORMS**				
(3)		+ve mark	2.7V	. . . .	3.3V
		–ve mark	–2.7V	. . . .	–3.3V
(4)		space – with respect to ground	–0.3V	. . . .	0.3V
(5)		Rise-time		. . . .	30ns
		Fall time		. . . .	30ns
		Overshoot		. . . .	10% Amplitude
(6)	Width at 50% (+ve going)		44%	. . . .	56%
(7)	Width at 50% (–ve going)		44%	. . . .	56%
	3776A Only (UNBAL)				
(9)		+ve mark	2.14V	. . . .	2.60V
		–ve mark	–2.14V	. . . .	–2.60V
(10)		Space – with respect to ground	–0.24V	. . . .	0.24V
(11) (5)		Rise time		. . . .	30ns
		Fall time		. . . .	30ns
		Overshoot		. . . .	10% Amplitude
(6)	Width at 50% (+ve going)		44%	. . . .	56%
(7)	Width at 50% (–ve going)		44%	. . . .	56%

Table 4-5 Performance Tests Test Record (continued)

Para No.	Test Description	Result: Min.	Result: Actual	Result: Max.
4-57	**DIGITAL RECEIVER SENSITIVITY**			
	3776B only			
(4)	Frame Alignment (√)		....	
(7)	Frame Alignment (√)		....	
	3776A only			
(9)(4)	Frame Alignment (√)		....	
(9)(7)	Frame Alignment (√)		....	
4-58	**PHASE JITTER (OPT 001)**			
(9) (10)	Phase Jitter Readings for Synthesizer voltage			
	≏0.201V	28.3°	....	31.7°
	≏0.134V	18.8°	....	21.2°
	≏0.075V	10.8°	....	12.2°
(11)	Phase Jitter Readings with additional attenuation			
	10dB	3.2°	....	4.0°
	20dB	0.9°	....	1.3°
	30dB	0.16°	....	0.56°
	40dB	0°	....	0.2°
	50dB	0°	....	0.2°
(15)	Phase Jitter readings for FILTER B			
	Synthesizer Freq. 1010.4Hz			1°
	1009.6Hz		....	1°
	1011.0Hz		....	3°
	1009.0Hz		....	3°
	1012.0Hz		....	8°
	1008.0Hz		....	8°
	1014.0Hz	9.2°	....	12.2°
	1006.0Hz	9.2°	....	12.2°
	1016Hz	10.2°	....	12.2°
	1004.0Hz	10.2°	....	12.2°
	1002.0Hz	10.8°	....	12.2°
	770.0Hz	10.8°	....	12.2°
	1310.0Hz	10.0°	....	12.2°
	710.0Hz	10.0°	....	12.2°
	1510.0Hz		....	3°
	510.0Hz		....	3°
	1710.0Hz		....	1°
	310.0Hz			1°
	Phase Jitter readings for FILTER A			
	Synthesizer Freq. 1012Hz		....	1°
	1008Hz		....	1°

Table 4-5 Performance Tests Test Record (continued)

Para No.	Test Description	Result		
		Min.	Actual	Max.
	1015Hz		....	3°
	1005Hz		....	3°
	1020Hz		....	8°
	1000Hz		....	8°
	1022Hz		....	10°
	998Hz		....	10°
	990Hz	10.8°	....	12.2°
	770Hz	10.8°	....	12.2°
	1310Hz	10°	....	12.2°
	710Hz	10°	....	12.2°
	1510Hz		....	3°
	510Hz		....	3°
	1710Hz		....	1°
	310Hz		....	1°
(20)	Phase Jitter Filter A	10.8°	....	12.2°
	Phase Jitter Filter B	10.8°	....	12.2°
(23)	Phase Jitter Filter A	10.8°	X =	12.8°
	Phase Jitter Filter B	10.8°	X =	12.8°
(25)	FILTER A – Time for correct reading		....	4 sec
	–Phase Jitter reading	$(X-0.7)^\circ$	....	$(X+0.7)^\circ$
	FILTER B – Time for correct reading		....	25 sec
	– Phase Jitter reading	$(X-0.7)^\circ$	....	$(X+0.7)^\circ$
(28)	Noise Rejection			
	Filter A		....	4°
	Filter B		....	4°
(35)	3776A Phase Jitter for modulating Frequencies 20 to 300Hz			
	Filter A		....	0.2°
	Filter B		....	0.2°
	3776B Phase Jitter for modulating Frequencies 2 to 900Hz			
	Filter A		....	1.0°
	Filter B		....	1.0°
(48)	2 (MAX – MIN)/MAX + MIN		....	0.1
(51)	2 (MAX – MIN)/MAX + MIN	0.4	....	

Table 4-5 Performance Tests Test Record (continued)

Para No.	Test Description	Result: Min.	Result: Actual	Result: Max.
4-59	**PHASE HITS (OPTION 001)**			
	Threshold Range and Accuracy			
(12)	Threshold Setting (°)			
	5 — f_2 period limits	1064µs	....	1096µs
	10 — f_2 period limits	1140µs	....	1197µs
	15 — f_2 period limits	1227µs	....	1317µs
	20 — f_2 period limits	1329µs	....	1465µs
	25 — f_2 period limits	1450µs	....	1649µs
	30 — f_2 period limits	1595µs	....	1887µs
	35 — f_2 period limits	1771µs	....	2206µs
	40 — f_2 period limits	1992µs	....	2653µs
	Guard Interval			
(23)	Phase hits register on RESULTS display (√)		....	
(24)	Phase hits register with 4.5ms delay (√)		....	
(25)	No Phase hits with 3.5ms delay (√)		....	
	Holding Time			
(41)	+10dBm f_2 period	1031µs	....	1062µs
(42)	−40dBm f_2 period	1031µs	....	1062µs
	Loop Recovery Time			
(56)	Counts register on P. hit display (√)		....	
(58)	Counts do not register (√)		....	
	Amplitude to Phase Conversion			
(68)	Counts do not register (√)		....	
4-60	**GAIN HITS (3776B)/AMPLITUDE HITS (3776A)**			
	Threshold Accuracy			
(10)	+2dB Hit Limit — AC Voltmeter Reading	1.3774V	....	1.5455V
(13)	−2dB Hit Limit — AC Voltmeter Reading	0.8691V	....	0.9752V
(16)	−3dB Hit Limit — AC Voltmeter Reading	0.7446V	....	0.8691V

Table 4-5 Performance Tests Test Record (continued)

Para No.	Test Description	Result		
		Min.	Actual	Max.
(18)	+3dB Hit Limit — AC Voltmeter Reading	1.5455V	....	1.7341V
(20)	+4dB Hit Limit — AC Voltmeter Reading	1.7341V	....	1.9457V
(22)	−4dB Hit Limit — AC Voltmeter Reading	0.6904V	....	0.7446V
(24)	−6dB Hit Limit — AC Voltmeter Reading	0.5484V	....	0.6153V
(26)	+6dB Hit Limit — AC Voltmeter Reading	2.1831V	....	2.4495V
	Guard Interval or Qualification Period			
(30)	Pulse Width	3.5ms	....	4.5ms
	Loop Recovery Time			
(42)	Hit Registered (√)		....	
(45)	No Hit Registered (√)		....	
4-61	**DROPOUTS (3776B)/INTERRUPTIONS (3776A)**			
(9)	Threshold −12dB (3776B) — AC Voltmeter Reading	0.548V	....	0.690V
	Threshold −10dB (3776A) — AC Voltmeter Reading	0.690V	....	0.869V
(12)	Qualification period			
	3776B	3.5ms	....	4.5ns
	3776A	2.0ms	....	3.5ms
	Input Holding Tone −40dBm	6.90mV	....	8.69mV
4-62	**IMPULSE NOISE (3776B)**			
(9)	Low Threshold Setting (dBm0)			
	−8 LOW	10dB	....	12dB
	MID	6dB	....	8dB
	HIGH	2dB	....	4dB
	−10 LOW	12dB	....	14dB
	MID	8dB	....	10dB
	HIGH	4dB	....	6dB
	−20 LOW	22dB	....	24dB
	MID	18dB	....	20dB
	HIGH	14dB	....	16dB

Table 4-5 Performance Tests Test Record (continued)

Para No.	Test Description	Result Min.	Actual	Max.
	−25 LOW	27dB	....	29dB
	MID	23dB	....	25dB
	HIGH	19dB	....	21dB
(12)	Holding tone at −40dBm			
	Low Threshold Setting (dBm0)			
	−8 LOW	10dB	....	12dB
	MID	6dB	....	8dB
	HIGH	2dB	....	4dB
	−10 LOW	12dB	....	14dB
	MID	8dB	....	10dB
	HIGH	4dB	....	6dB
	−20 LOW	22dB	....	24dB
	MID	18dB	....	20dB
	HIGH	14dB	....	16dB
	−25 LOW	27dB	....	29dB
	MID	23dB	....	25dB
	HIGH	19dB	....	21dB
4-63	**IMPULSE NOISE 3776A**			
(7)	Low Threshold Setting (dBm0)			
	−6 LOW	7dB	....	9dB
	MID	4dB	....	6dB
	HIGH	1dB	....	3dB
	−10 LOW	11dB	....	13dB
	MID	8dB	....	10dB
	HIGH	5dB	....	7dB
	−20 LOW	21dB	....	23dB
	MID	18dB	....	20dB
	HIGH	15dB	....	17dB
	−25 LOW	26dB	....	28dB
	MID	23dB	....	25dB
	HIGH	20dB	....	22dB

Table 4-5 Performance Tests Test Record (continued)

Para No.	Test Description	Result Min.	Result Actual	Result Max.
(9)	FILTER B Low Threshold Setting (dBm0)			
	−6 LOW	7dB	....	9dB
	MID	4dB	....	6dB
	HIGH	1dB	....	3dB
	−10 LOW	11dB	....	13dB
	MID	8dB	....	10dB
	HIGH	5dB	....	7dB
	−20 LOW	21dB	....	23dB
	MID	18dB	....	20dB
	HIGH	15dB	....	17dB
	−25 LOW	26dB	....	28dB
	MID	23dB	....	25dB
	HIGH	20dB	....	22dB
(12)	FILTER C Low Threshold Setting (dBm0)			
	−6 LOW	7dB	....	9dB
	MID	4dB	....	6dB
	HIGH	1dB	....	3dB
	−10 LOW	11dB	....	13dB
	MID	8dB	....	10dB
	HIGH	5dB	....	7dB
	−20 LOW	21dB	....	23dB
	MID	18dB	....	20dB
	HIGH	15dB	....	17dB
	−25 LOW	26dB	....	28dB
	MID	23dB	....	25dB
	HIGH	20dB	....	22dB

Table 4-5 Performance Tests Test Record (continued)

Para No.	Test Description	Result		
		Min.	Actual	Max.
(16)	Holding Tone at −40dBm Low Threshold Setting (dBm0)			
	−6 LOW	7dB	. . . .	9dB
	MID	4dB	. . . .	6dB
	HIGH	1dB	. . . .	3dB
4-64	**ENVELOPE DELAY (3776B)/GROUP DELAY (3776A) AND ATTENUATION DISTORTION**			
	'Delay' programme runs with no errors (√)		. . . .	

Adjustments 5

SECTION V
ADJUSTMENTS

5-1 INTRODUCTION

5-2 This section describes the adjustment procedure required to enable the Hewlett-Packard Models 3776A and 3776B PCM Terminal Test Sets to meet the specifications listed in Table 1-2 of this manual.

5-3 Table 5-1 is a list of the adjustable components with related information.

Table 5-1 Adjustable Components

Adjustment Name	Reference Designator	Adjustments Paragraph	Description
+5V Power Supply	A15R1	5-16	Sets +5V rail
+15V Power Supply	A16R11	5-17	Sets +15V rail
-15V Power Supply	A16R12	5-18	Sets -15V rail
Processor Clock	A13C1	5-19	Clock frequency set to 2.048MHz (3776A) or 2.316MHz (3776B)
Clock Extraction	A12C1	5-20	Centre clock extractor frequency on 1.544MHz (3776B) or 2.048MHz (3776A).
Codec Gain	A2R6	5-21	Set AUX I/P Interface Level

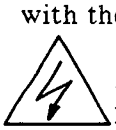
5-4 SAFETY CONSIDERATIONS

5-5 In the interest of safety, it is recommended that page 2 of this manual be consulted before operating this instrument with its covers removed.

5-6 This section contains warnings that must be followed for your protection.

5-7 Safety Symbols

5-8 The 3776 PCM Terminal Test Set is a Safety Class 1 instrument (ie it is provided with a protective earth terminal). Before you operate it, or even connect its ac power cord, you should familiarize yourself with the safety labels on the chassis and the safety instructions in this manual.


High Voltage. This symbol indicates that potentially hazardous voltages are present beneath the protective shield. Extreme caution must be used if it is necessary to remove the protective shield.

WARNING

THE "WARNING" SIGN DENOTES A HAZARD TO PERSONNEL. IT CALLS ATTENTION TO A PROCEDURE, PRACTICE, OR THE LIKE, WHICH, IF NOT CORRECTLY PERFORMED OR ADHERED TO, COULD RESULT IN INJURY OR LOSS OF LIFE. DO NOT PROCEED BEYOND A "WARNING" SIGN UNTIL THE INDICATED CONDITIONS ARE FULLY UNDERSTOOD AND MET.

5-9 EQUIPMENT REQUIRED

5-10 A complete list of all the equipment required for adjustment of this instrument is given in Table 1-4 of this manual. The equipment required to make an individual adjustment is listed with each adjustment procedure. Any equipment which satisfies the critical specifications given in Table 1-4 may be substitued for the recommended equipment.

5-11 One extender board is located within the 3776, access to this board is obtained by removing the top cover and the printed circuit (pc) assemblies retaining metal cover (MP17).

5-12 ADJUSTMENT LOCATION

5-13 The locations of the adjustable components are shown in the component location diagrams given at the end of this Section. The appropriate diagram is referred to at the beginning of each adjustment procedure.

5-14 Related Adjustments

5-15 The +5V Power Supply adjustment set by A15R1 must be performed before adjusting the +15V or -15V Power Supplies. The +5V adjustment affects all low voltage d.c. supplies.

5-16 +5V POWER SUPPLY ADJUSTMENT

WARNING

THIS ADJUSTMENT REQUIRES THE REMOVAL OF THE TOP COVER. ALTHOUGH ADJUSTMENT IS PERFORMED WITH A PROTECTIVE SHIELD COVERING ASSEMBLIES A15 AND A16, ON WHICH APPROXIMATELY 340V DC IS PRESENT, THE ADJUSTMENT PROCEDURE SHOULD BE PERFORMED ONLY BY SERVICE-TRAINED PERSONNEL WHO ARE AWARE OF THE HAZARDS INVOLVED (FOR EXAMPLE FIRE AND ELECTRIC SHOCK).

REFERENCE

Figure 5-2 A15 Component Location

DESCRIPTION

Output of +5V supply set by adjustment of A15R1. This adjustment effects all other voltage d.c. supplies.

EQUIPMENT

DC Voltmeter..HP 3455A

PROCEDURE

1. Switch off the instrument.
2. Remove the Top Cover.
3. Connect the DC Voltmeter to the +5V test point. The +5V test point is indicated on the protective shield covering A15. Do not remove this shield.
4. Switch on the HP 3776.
5. Adjust A15R1 to give +5.10V +/-0.05V displayed on the DC Voltmeter. A15R1 +5V adjustment is indicated on the protective shield covering A15. Do not remove this shield.
6. Switch the HP 3776 off.
7. Replace the Top Cover.

5-17 +15V POWER SUPPLY ADJUSTMENT

WARNING

THIS ADJUSTMENT REQUIRES THE REMOVAL OF THE TOP COVER. ALTHOUGH ADJUSTMENT IS PERFORMED WITH A PROTECTIVE SHIELD COVERING ASSEMBLIES A15 AND A16, ON WHICH APPROXIMATELY 340V DC IS PRESENT, THE ADJUSTMENT PROCEDURE SHOULD BE PERFORMED ONLY BY SERVICE-TRAINED PERSONNEL WHO ARE AWARE OF THE HAZARDS INVOLVED (FOR EXAMPLE FIRE AND ELECTRIC SHOCK).

REFERENCE

Figure 5-3 A16 Component Location

DESCRIPTION

The +15V A16R11 adjustment is affected by the A15R1 +5V adjustment. The +5V adjustment must therefore be performed first.

EQUIPMENT

DC Voltmeter..HP 3455A

PROCEDURE

1. Switch off the instrument.

2. Remove the Top Cover.

3. Connect the DC Voltmeter to the +15V test point. The +15V test point is indicated on the protective shield covering A16. Do not remove this shield.

4. Switch on the 3776.

5. Adjust A16R11 to give +15.00V +/-0.1V displayed on the DC Voltmeter. A16R11 +15V adjustment is indicated on the protective shield covering A16. Do not remove this shield.

6. Switch the 3776 off.

7. Replace the Top Cover.

5-18 -15V POWER SUPPLY ADJUSTMENT

WARNING

THIS ADJUSTMENT REQUIRES THE REMOVAL OF THE TOP COVER. ALTHOUGH ADJUSTMENT IS PERFORMED WITH A PROTECTIVE SHIELD COVERING ASSEMBLIES A15 AND A16, ON WHICH APPROXIMATELY 340V DC IS PRESENT, THE ADJUSTMENT PROCEDURE SHOULD BE PERFORMED ONLY BY SERVICE-TRAINED PERSONNEL WHO ARE AWARE OF THE HAZARDS INVOLVED (FOR EXAMPLE FIRE AND ELECTRIC SHOCK).

REFERENCES

Figure 5-3 A16 Component Location

DESCRIPTION

The -15V A16R12 adjustment is affected by the A15R1 +5V adjustment. The +5V adjustment must therefore be performed first.

EQUIPMENT

DC Voltmeter.......... HP 3455A

PROCEDURE

1. Switch off the instrument.

2. Remove the Top Cover.

3. Connect the DC Voltmeter to the -15V test point. The -15V test point is indicated on the protective shield covering A16. Do not remove this shield.

4. Switch on the HP 3776.

5. Adjust A16R12 to give -15.00V +/-0.1V displayed on the DC Voltmeter. A16R12 -15V adjustment is indicated on the protective shield covering A16. Do not remove this shield.

6. Switch the HP 3776 off.

7. Replace the Top Cover.

5-19 PROCESSOR CLOCK ADJUSTMENT

REFERENCE

Figures 5-4 A13 Component Location

DESCRIPTION

Adjustment A13C1 sets the 68B00 clock rate.

EQUIPMENT

Frequency Counter...HP 5328A

PROCEDURE

1. Switch the 3776 power off.
2. Remove the Top Cover.
3. Remove the pc assemblies metal retaining cover. Do not remove A15/A16 protective shield.
4. Connect the Frequency Counter to A13 test point 2f0.
5. Switch the 3776 power on.
6. Adjust A13C1 to give 2.048000MHz +/-1kHz (3776A) or 2.316000MHz +/-1kHz (3776B) displayed on the Frequency Counter.
7. Switch the 3776 power off.
8. Replace the pc assemblies metal retaining cover and the instrument Top Cover.

5-20 CLOCK EXTRACTION ADJUSTMENT

REFERENCE

Figure 5-5 A12 Component Location

DESCRIPTION

With no clock input, the natural frequency of the clock extractor circuit is centred on 1.544MHz (3776B) or 2.048MHz (3776A) by the adjustment of A12C1.

EQUIPMENT

Frequency Counter.......................................HP 5328A

PROCEDURE

1. Switch the 3776 power off.

2. Remove the 3776 Top Cover.

3. Remove the pc assemblies metal retaining cover. Do not remove A15/A16 protective shield.

4. Connect the Frequency Counter to A12 test point CLK RX.

5. Check that the DIGITAL RECEIVE Input is not connected. Switch the power on and check that the DIGITAL TRANSMIT is in the SYNTH PCM mode (this ensures that the clock extract circuit will not lock onto the Digital Transmit Clock).

6. Adjust A12C1 to give 2.048MHz +/-1kHz (3776A) or 1.544MHz +/-1kHz (3776B) displayed on the Frequency Counter.

7. Switch off the instrument.

8. Replace the pc assemblies metal retaining cover and the instrument Top Cover.

5-21 CODEC GAIN ADJUSTMENT

REFERENCE

Figure 5-6 A2 Component Location
Figure 5-7 A102 Component Location

DESCRIPTION

The codec interface gain is adjusted to give +14dB (3776A) or +16dB (3776B) (ie similar to -14dBr or -16TLP input). A Test Oscillator is connected to the AUX I/P, the 3776 connected back-to-back and the gain of codec adjusted for +14dB/+16dB gain displayed on the 3776 Receiver.

EQUIPMENT

Test Oscillator.......................................HP 654A
AC Voltmeter.......................................HP 3455A
Frequency Counter.......................................HP 5328A

PROCEDURE

1. Remove the instrument Top Cover and pc assemblies metal retaining cover.

2. Connect the DIGITAL TRANSMIT input to the DIGITAL RECEIVE input.

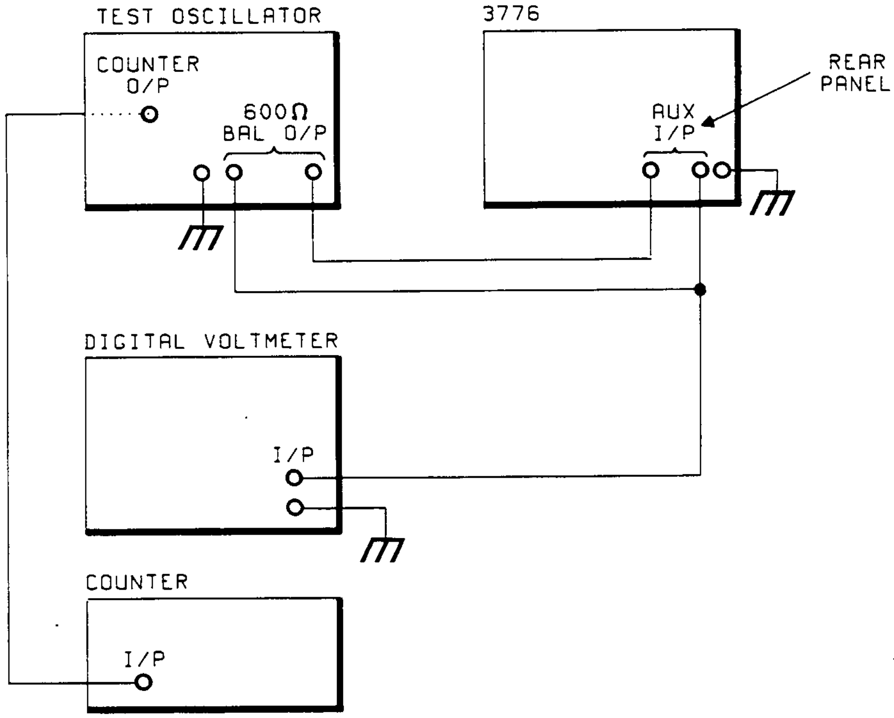


Figure 5-1 Codec Test Setup

3. Connect the test equipment as shown in Figure 5-1.

4. Set the 3776 operating mode to DIG Tx to DIG Rx.

5. Set the 3776 DIGITAL TRANSMIT CHAN to 1..30 (3776A) or TIMESLOT to 1..24 (3776B). Set the DIGITAL RECEIVE CHAN/TIMESLOT to 1.

6. Adjust the Test Oscillator Frequency to give 1.01kHz displayed on the Frequency Counter and 0.1228V (-16dBm/600ohm) if the instrument is a 3776B or 0.1545V (-14dBm/600ohm) if the instrument is a 3776A.

7. Ensure DIGITAL TRANSMIT CHAN/TIMESLOT is in SYNTH PCM mode (LED lit).

8. Set the measurement mode to LEVEL/SEL FILTER.

9. Set the MEAS Frequency on the 3776 to 1.01kHz.

10. Press the 3776 DELETE button (this selects AUX I/P).

11. Press RUN/REPEAT and adjust A2R6 to give 0.00dBmO displayed on the 3776 RESULTS display.

12. Replace the pc assemblies metal retaining cover and the instrument Top Cover.

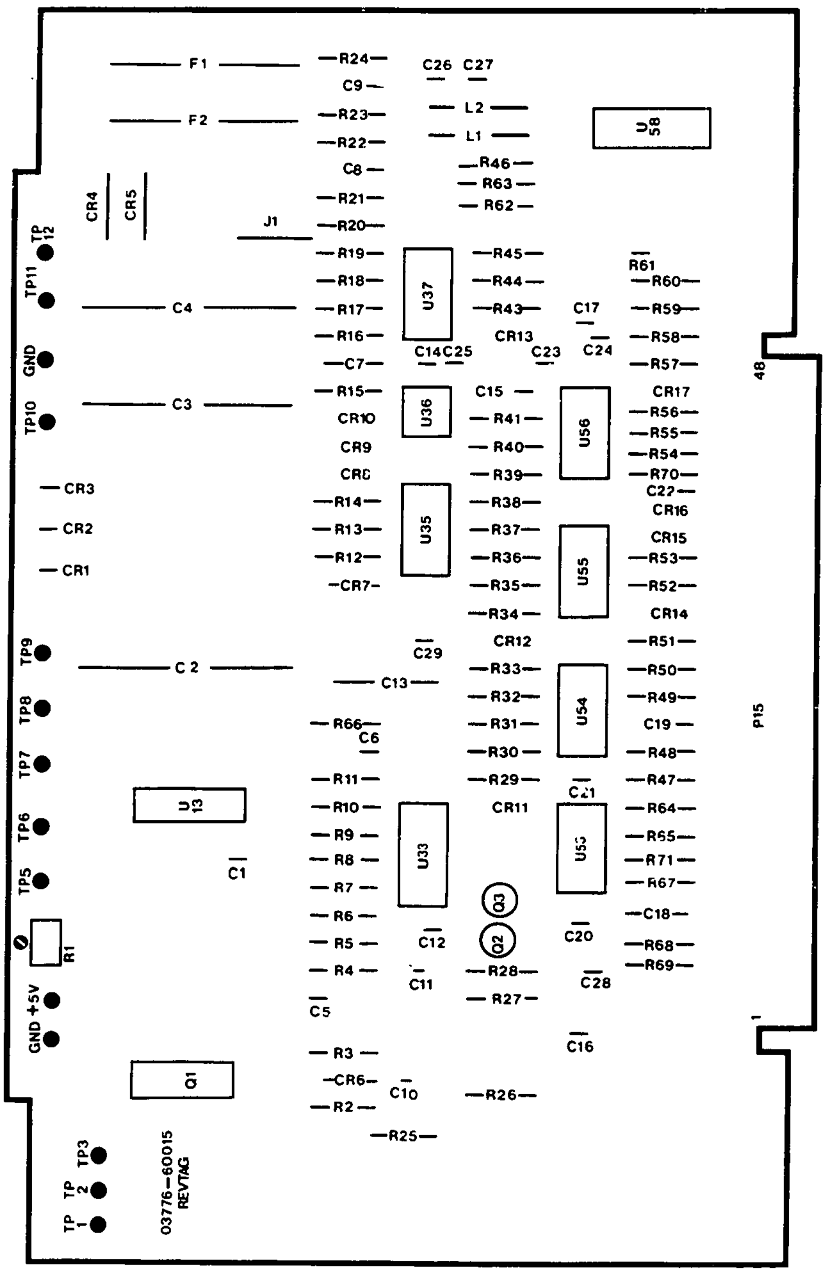


Figure 5-2 A15 Component Location

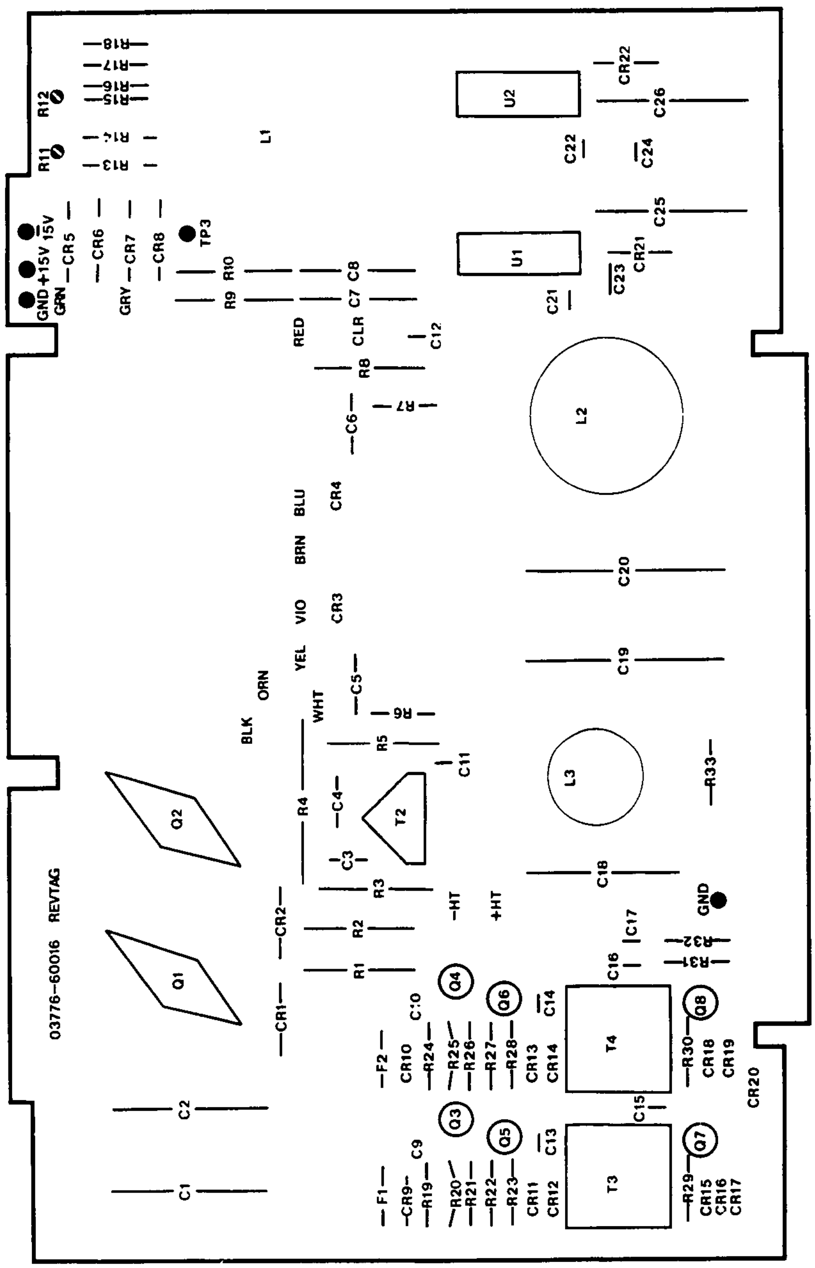


Figure 5-3 A16 Component Location

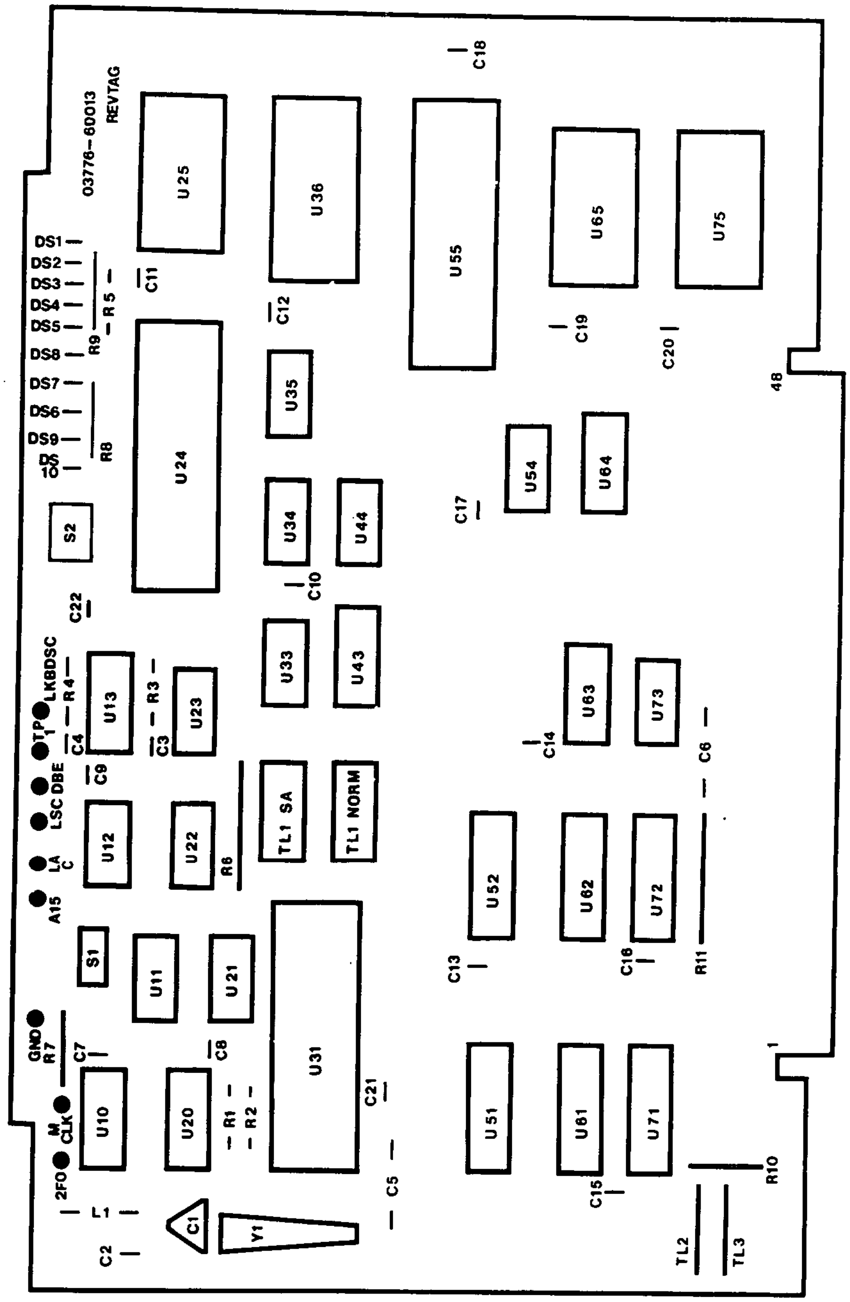
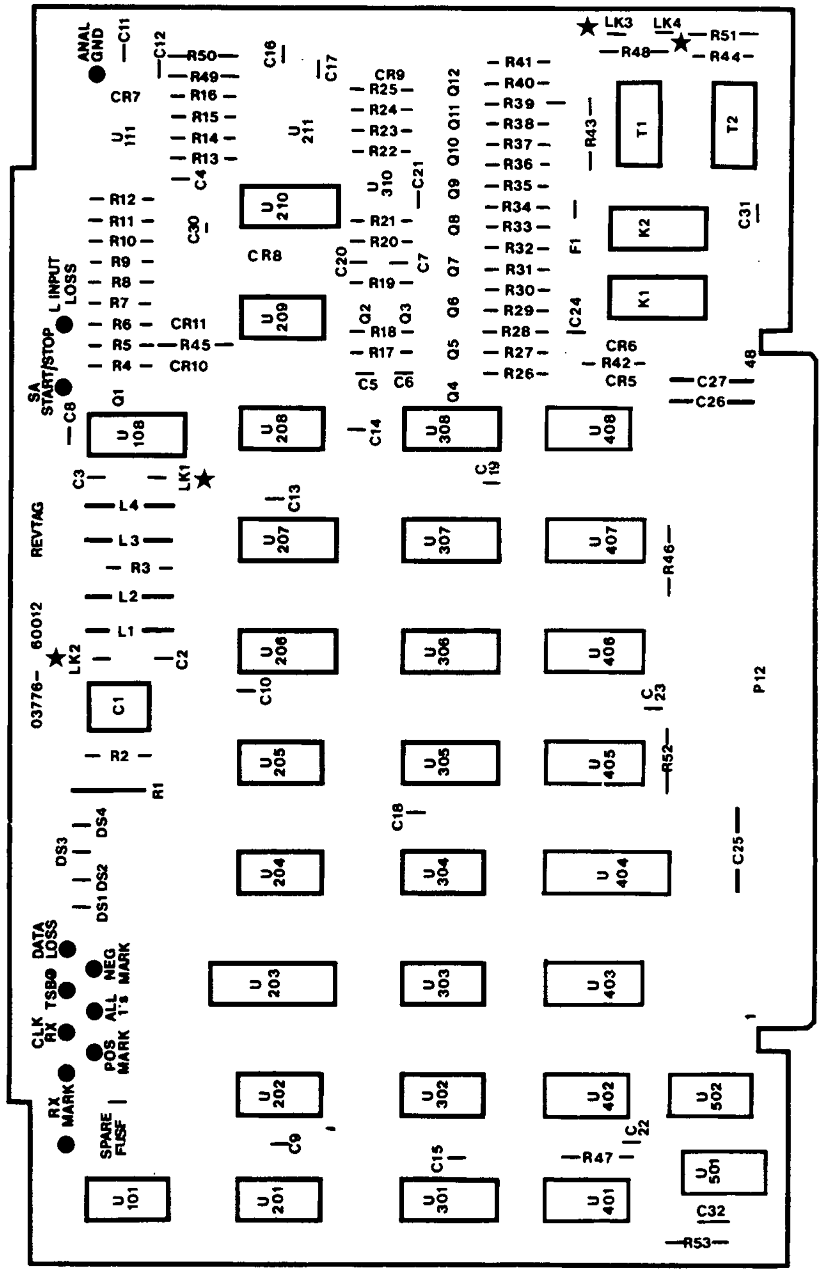


Figure 5-4 A13 Component Location



★ASSEMBLIES A12 & A112 ARE IDENTICAL EXCEPT FOR LINKING LK1, LK2, LK3 & LK4. REFER TO TABLE ON SHEMATIC FOR DETAILS (A12 : 3776A/A112 : 3776B).

Figure 5-5 A12 Component Location

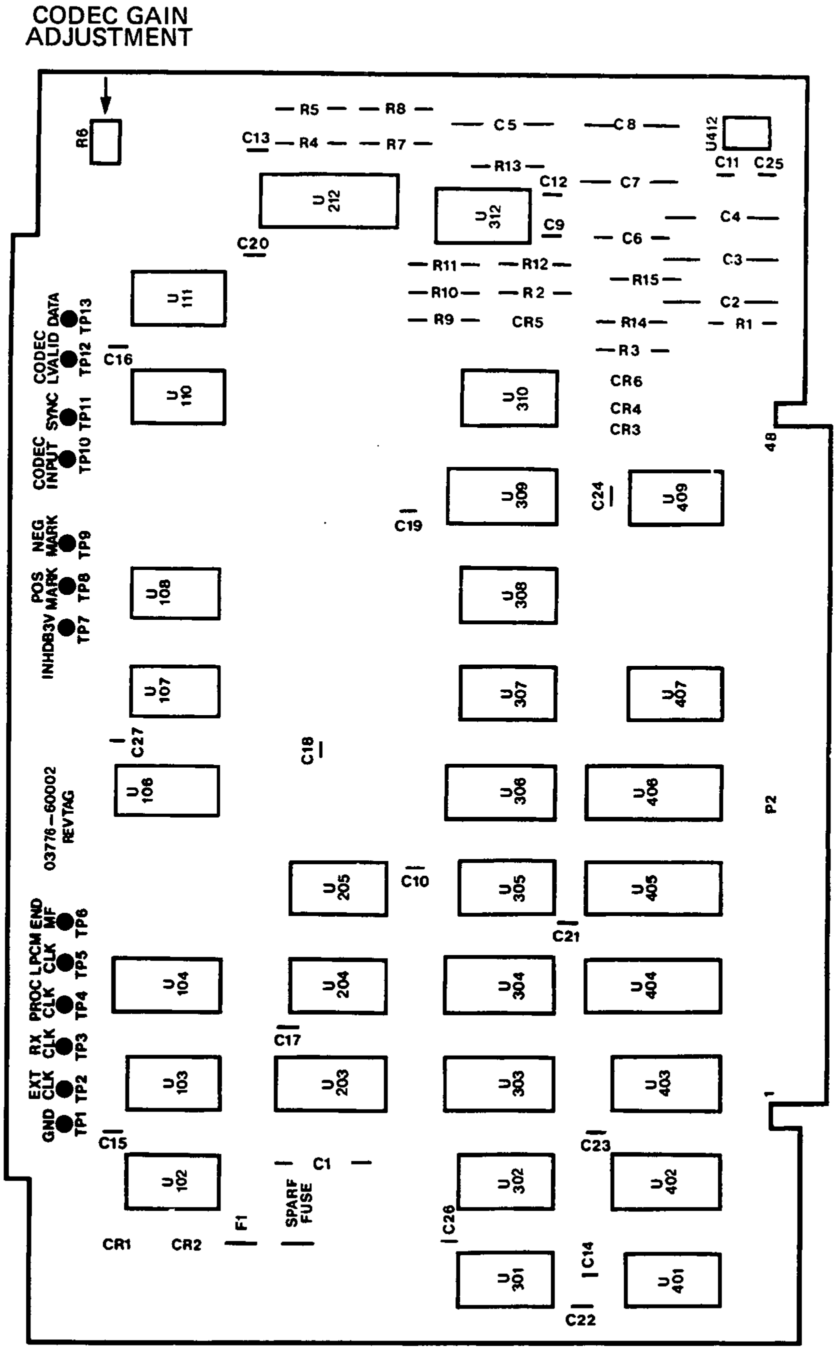


Figure 5-6 A2 Component Location

CODEC GAIN
ADJUSTMENT

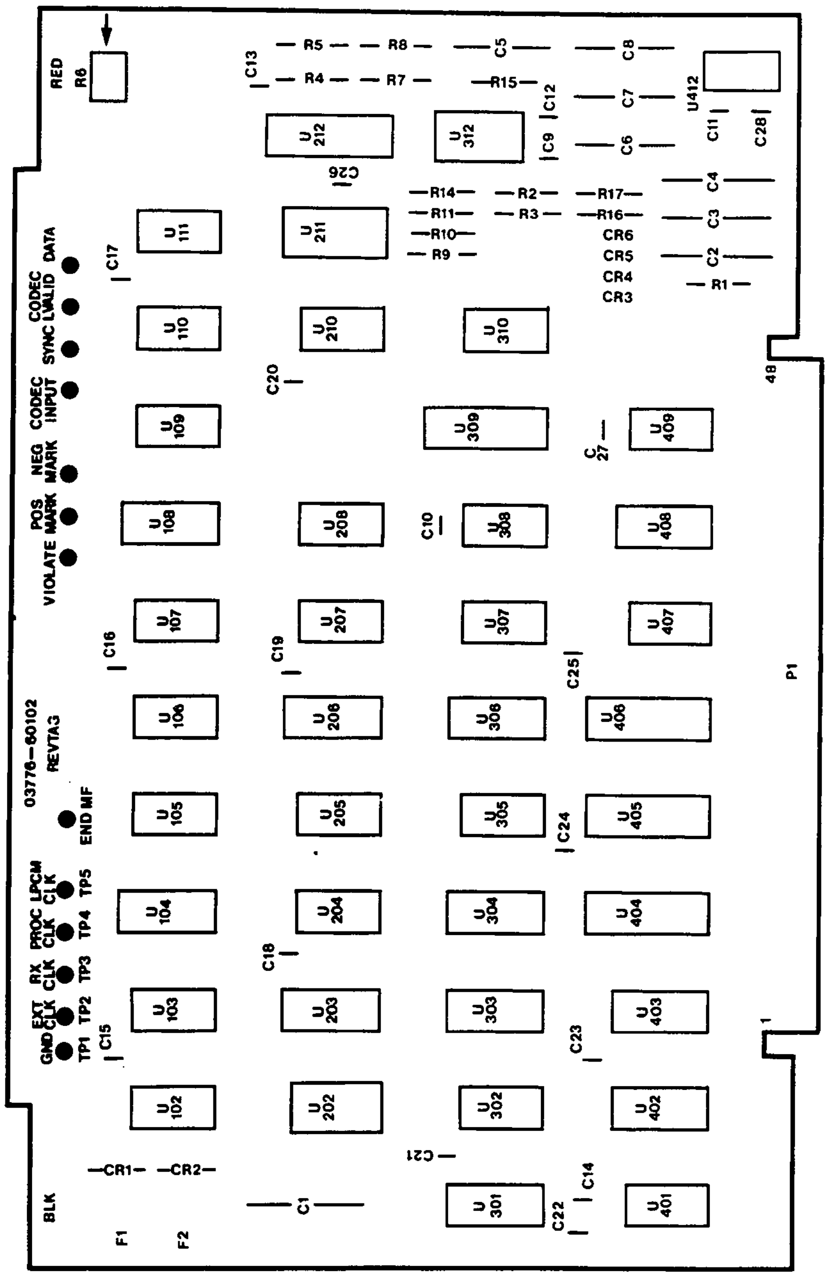


Figure 5-7 A102 Component Location

Replaceable Parts

6

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering parts. Table 6-1 lists the board assemblies unique to the 3776A and 3776B respectively. Table 6-2 lists the abbreviations used in the parts list and throughout the manual. Table 6-3 lists all replaceable parts in reference designator order and Table 6-4 lists the names and addresses that correspond to the manufacturers' code number used in the parts list.

6-3 ABBREVIATIONS

6-4 Table 6-2 lists all the abbreviations used in the parts list, the schematics and throughout the manual. In some cases, two forms of an abbreviation are given, one all capital letters, the other partial or no capital letters. This occurs because the abbreviations used in the parts list are always all capitals; however, in other parts of the manual abbreviations are used with both upper and lower case letters.

6-5 REPLACEABLE PARTS LIST

6-6 Table 6-3 is a combined 3776A/B replaceable parts list. Board assemblies which are unique to the 3776A and to the 3776B (see Table 6-1) are highlighted in the A/B/OPTION column of Table 6-3.

Table 6-1 Unique Board Assemblies

3776A		3776B		DESCRIPTION
Assy No	Page No	Assy No	Page No	
A1	6-5	A101	6-7	Digital Synthesizer/PCM Generator
A2	6-9	A102	6-11	Digital PCM Transmitter
A7	6-29	A107	6-32	SAR, A/D Converter & Digital O/P
A11	6-38	A111	6-40	A & U-Law Alignment
A12	6-42	A112*	6-42	Digital Receiver*
A13	6-45	A113	6-47	Processor
A14	6-49	A114	6-50	Memory
A21	6-57	A121	6-60	Keyboard

*A112 identical to A12 except for arrangement of on-board links.

6-7 The optional assemblies which are covered by the replaceable parts list are as follows:

OPTION 001: A204 Analog Monitor Assembly (03776-60204)
A5 Transients Assembly (03776-60005)
A8 GD Timing, Imp. Noise Freq. Detector Assembly (03776-60008)

OPTION 002: A214 Memory Assembly (03776-60214)
(3776B Japanese Option)

6-8 Table 6-3 is organised as follows:

(a) Electrical assemblies and their components in alpha-numeric order by reference designation.
(b) Chassis-mounted parts in alpha-numeric order by reference designation.
(c) Miscellaneous parts.
(d) Illustrated parts breakdown.

The information given for each part consists of the following:

(a) The Hewlett-Packard part number.
(b) Part number check digit (CD).
(c) The total quantity (QTY) in the instrument.
(d) The description of the part.
(e) A typical manufacturer of the part in a five-digit code.
(f) The manufacturers number for that part.
(g) Highlights the instrument (A/B/Option) in which unique board assemblies are used.

The total quantity for each part is given only once - at the first appearance of the part in the list.

6-9 ORDERING INFORMATION

6-10 To order a part listed in the replaceable parts table, quote the Hewlett-Packard part number (with the check digit), indicate the quantity required, and address the order to the nearest Hewlett-Packard office. The check digit will ensure accurate and timely processing of your order.

6-11 To order a part that is not listed in the replaceable parts table, include the instrument model number, instrument serial number, the description and function of the part, and the number of parts required. Address the order to the nearest Hewlett-Packard Office.

6-12 DIRECT MAIL ORDER SYSTEM

6-13 Within the USA, Hewlett-Packard can supply parts through a direct mail order system. Advantages of using the system are as follows:

(a) Direct ordering and shipment from the HP Parts Centre in Mountain View, California.

(b) No maximum or minimum on any mail order (there is a minimum order amount for parts ordered through a local HP office when the orders require billing and invoicing).

(c) Prepaid transportation (there is a small handling charge for each order).

(d) No invoices - to provide these advantages, a cheque or money order must accompany each order.

6-14 Mail Order forms and specific ordering information are available through your local HP office. Addresses and phone numbers are located at the back of this manual.

Table 6-2 Reference Designations and Abbreviations

REFERENCE DESIGNATIONS

A . . . . assembly
AT . . attenuator; isolator; termination
B . . . . fan; motor
BT . . . . battery
C . . . . capacitor
CP . . . . coupler
CR . . . . diode; diode thyristor; varactor
DC . . . directional coupler
DL . . . . delay line
DS . . . . annunciator; signaling device (audible or visual); lamp; LED
E . . . . miscellaneous electrical part
F . . . . fuse
FL . . . . filter
H . . . . hardware
HY . . . . circulator
J . . . electrical connector (stationary portion); jack
K . . . . relay
L . . . . coil; inductor
M . . . . meter
MP . . . . miscellaneous mechanical part
P . . . electrical connector (movable portion); plug
Q . . . . . . transistor: SCR; triode thyristor
R . . . . resistor
RT . . . . thermistor
S . . . . switch
T . . . . transformer
TB . . . . . . terminal board
TC . . . . . . thermocouple
TP . . . . test point
U . . . . . integrated circuit; microcircuit
V . . . . electron tube
VR . . . . voltage regulator; breakdown diode
W . . . . cable; transmission path; wire
X . . . . socket
Y . . . . crystal unit (piezo-electric or quartz)
Z . . . . tuned cavity; tuned circuit

ABBREVIATIONS

A . . . . ampere
ac . . . . alternating current
ACCESS . . . . . accessory
ADJ . . . . adjustment
A/D . . . . analog-to-digital
AF . . . . . audio frequency
AFC . . . . automatic frequency control
AGC . . . . . automatic gain control
AL . . . . aluminum
ALC . . . . . automatic level control
AM . . . amplitude modulation
AMPL . . . . amplifier
APC . . . . automatic phase control
ASSY . . . . assembly
AUX . . . . auxiliary
avg . . . . average
AWG . . . . American wire gauge
BAL . . . . balance
BCD . . . . . . binary coded decimal
BD . . . . board
BE CU . . . . . . beryllium copper
BFO . . . . . beat frequency oscillator
BH . . . . binder head
BKDN . . . . . . breakdown
BP . . . . bandpass
BPF . . . . . bandpass filter
BRS . . . . brass
BWO . . . . . backward-wave oscillator
CAL . . . . calibrate
ccw . . counter-clockwise
CER . . . . ceramic
CHAN . . . . channel
cm . . . . centimeter
CMO . . cabinet mount only
COAX . . . . coaxial
COEF . . . . coefficient
COM . . . . common
COMP . . . . . composition
COMPL . . . . complete
CONN . . . . connector
CP . . . . . . cadmium plate
CRT . . . cathode-ray tube
CTL . . . . complementary transistor logic
CW . . . . . continuous wave
cw . . . . clockwise
cm . . . . centimeter
D/A . . . . digital-to-analog
dB . . . . decibel
dBm . . . . decibel referred to 1 mW
dc . . . . direct current
deg . . degree (temperature interval or difference)
° . . . . degree (plane angle)
°C . . . . . . degree Celsius (centigrade)
°F . . . . degree Fahrenheit
°K . . . . degree Kelvin
DEPC . . deposited carbon
DET . . . . detector
diam . . . . diameter
DIA . . . diameter (used in parts list)
DIFF AMPL . . differential amplifier
div . . . . division
DPDT . . . . . double-pole, double-throw
DR . . . . drive
DSB . . . . double sideband
DTL . . . . diode transistor logic
DVM . . . digital voltmeter
ECL . . . . emitter coupled logic
EMF . . electromotive force
EDP . . . . . electronic data processing
ELECT . . . . . electrolytic
ENCAP . . . . encapsulated
EXT . . . . external
F . . . . farad
FET . . . . field-effect transistor
F/F . . . . flip-flop
FH . . . . flat head
FIL H . . . . . fillister head
FM . . frequency modulation
FP . . . . front panel
FREQ . . . . frequency
FXD . . . . fixed
g . . . . gram
GE . . . . germanium
GHz . . . . gigahertz
GL . . . . glass
GRD . . . . ground(ed)
H . . . . henry
h . . . . hour
HET . . . . heterodyne
HEX . . . . hexagonal
HD . . . . head
HDW . . . . hardware
HF . . . . . . high frequency
HG . . . . mercury
HI . . . . high
HP . . . . . Hewlett-Packard
HPF . . . . . high pass filter
HR . . . . hour (used in parts list)
HV . . . . high voltage
Hz . . . . Hertz
IC . . . . integrated circuit
ID . . . . . . inside diameter
IF . . . . intermediate frequency
IMPG . . . . . impregnated
in . . . . inch
INCD . . . . . incandescent
INCL . . . . include(s)
INP . . . . input
INS . . . . insulation
INT . . . . internal
kg . . . . kilogram
kHz . . . . kilohertz
kΩ . . . . kilohm
kV . . . . kilovolt
lb . . . . pound
LC . . . . inductance-capacitance
LED . . light-emitting diode
LF . . . . . . low frequency
LG . . . . long
LH . . . . left hand
LIM . . . . limit
LIN . . . linear taper (used in parts list)
lin . . . . linear
LK WASH . . . lock washer
LO . . . low; local oscillator
LOG . . . . logarithmic taper (used in parts list)
log . . . . logrithm(ic)
LPF . . . . . low pass filter
LV . . . . low voltage
m . . . . . . meter (distance)
mA . . . . milliampere
MAX . . . . maximum
MΩ . . . . megohm
MEG . . . . meg (10^6) (used in parts list)
MET FLM . . . . metal film
MET OX . . metallic oxide
MF . . . medium frequency; microfarad (used in parts list)
MFR . . . . . . manufacturer
mg . . . . milligram
MHz . . . . megahertz
mH . . . . millihenry
mho . . . . mho
MIN . . . . minimum
min . . . . . minute (time)
...' . . . . . minute (plane angle)
MINAT . . . . miniature
mm . . . . millimeter
MOD . . . . modulator
MOM . . . . momentary
MOS . . . . metal-oxide semiconductor
ms . . . . millisecond
MTG . . . . mounting
MTR . . . meter (indicating device)
mV . . . . millivolt
mVac . . . . . . millivolt, ac
mVdc . . . . . . millivolt, dc
mVpk . . . . millivolt, peak

NOTE

All abbreviations in the parts list will be in upper-case.

Table 6-2 Reference Designations and Abbreviations (continued)

mVp-p . . . millivolt, peak-to-peak
mVrms . . . . millivolt, rms
mW . . . . milliwatt
MUX . . . . multiplex
MY . . . . mylar
μA . . . . microampere
μF . . . . microfarad
μH . . . . microhenry
μmho . . . . micromho
μs . . . . microsecond
μV . . . . microvolt
μVac . . . . . . microvolt, ac
μVdc . . . . . microvolt, dc
μVpk . . . microvolt, peak
μVp-p . . . microvolt, peak-to-peak
μVrms . . . . microvolt, rms
μW . . . . microwatt
nA . . . . nanoampere
NC . . . . . . no connection
N/C . . . . normally closed
NE . . . . neon
NEG . . . . negative
nF . . . . nanofarad
NI PL . . . . . . nickel plate
N/O . . . . . normally open
NOM . . . . nominal
NORM . . . . normal
NPN . . . negative-positive-negative
NPO . . . . negative-positive zero (zero temperature coefficient)
NRFR . . not recommended for field replacement
NSR . . . . . not separately replaceable
ns . . . . nanosecond
nW . . . . nanowatt
OBD . . . order by description
OD . . . . . outside diameter
OH . . . . oval head
OP AMPL . . . operational amplifier
OPT . . . . option
OSC . . . . oscillator
OX . . . . oxide
oz . . . . ounce
Ω . . . . ohm

P . . . . peak (used in parts list)
PAM . . . . pulse-amplitude modulation
PC . . . . . . printed circuit
PCM . . pulse-code modulation; pulse-count modulation
PDM . . . . . pulse-duration modulation
pF . . . . picofarad
PH BRZ phosphor bronze
PHL . . . . Phillips
PIN . . . positive-intrinsic-negative
PIV . . . . peak inverse voltage
pk . . . . peak
PL . . . . phase lock
PLO . . . . phase lock oscillator
PM . . . . phase modulation
PNP . . . positive-negative-positive
P/O . . . . part of
POLY . . . . . . polystyrene
PORC . . . . porcelain
POS . . positive; position(s) (used in parts list)
POSN . . . . position
POT . . . . . potentiometer
p-p . . . . peak-to-peak
PP . . . peak-to-peak (used in parts list)
PPM . . . . . pulse-position modulation
PREAMPL . . . preamplifier
PRF . . . . pulse-repetition frequency
PRR . . . . pulse repetition rate
ps . . . . picosecond
PT . . . . point
PTM . . . . pulse-time modulation
PWM . . . . pulse-width modulation
PWV . . . . . . peak working voltage
RC . . . . resistance-capacitance
RECT . . . . rectifier

REF . . . . reference
REG . . . . regulated
REPL . . . . . . replaceable
RF . . . . . radio frequency
RFI . . . . radio frequency interference
RH . . . . round head; right hand
RLC . . . . resistance-inductance-capacitance
RMO . . . rack mount only
rms . . . . root-mean-square
RND . . . . round
ROM . . read-only memory
R&P . . . . . rack and panel
RWV . . . reverse working voltage
S . . . scattering parameter
s . . . . second (time)
. . ." . second (plane angle)
S-B . . . . . slow-blow (fuse) (used in parts list)
SCR . . . silicon controlled rectifier; screw
SE . . . . selenium
SECT . . . . sections
SEMICON . . . . . semiconductor
SHF . . . . . . superhigh frequency
SI . . . . silicon
SIL . . . . silver
SL . . . . slide
SNR . . signal-to-noise ratio
SPDT . . . . . . single-pole, double-throw
SPG . . . . spring
SR . . . . split ring
SPST . . . . . . single-pole, single-throw
SSB . . . . . single sideband
SST . . . . . . stainless steel
STL . . . . steel
SQ . . . . square
SWR . . standing-wave ratio
SYNC . . . . . . synchronize
T . . timed (slow-blow fuse)
TA . . . . tantalum
TC . . . . temperature compensating
TD . . . . time delay

TERM . . . . terminal
TFT . . thin-film transistor
TGL . . . . toggle
THD . . . . thread
THRU . . . . through
TI . . . . titanium
TOL . . . . tolerance
TRIM . . . . trimmer
TSTR . . . . transistor
TTL . . transistor-transistor logic
TV . . . . television
TVI television interference
TWT . . traveling wave tube
U . . . . . micro (10^{-6}) (used in parts list)
UF . . . microfarad (used in parts list)
UHF . . ultrahigh frequency
UNREG . . . . unregulated
V . . . . volt
VA . . . . voltampere
Vac . . . . volts, ac
VAR . . . . variable
VCO . . . voltage-controlled oscillator
Vdc . . . . volts, dc
VDCW . . volts, dc, working (used in parts list)
V(F) . . . . . . volts, filtered
VFO . . variable-frequency oscillator
VHF . . . . . . very-high frequency
Vpk . . . . volts, peak
Vp-p . . volts, peak-to-peak
Vrms . . . . volts, rms
VSWR . . . voltage standing wave ratio
VTO . . . . . . voltage-tuned oscillator
VTVM . . . . vacuum-tube voltmeter
V(X) . . . . . volts, switched
W . . . . watt
W/ . . . . with
WIV . . . . working inverse voltage
WW . . . . wirewound
W/O . . . . without
YIG . . yttrium-iron-garnet
Z_o . . . . characteristic impedance

NOTE

All abbreviations in the parts list will be in upper-case.

MULTIPLIERS

Abbreviation	Prefix	Multiple
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
da	deka	10
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}
f	femto	10^{-15}
a	atto	10^{-18}

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A1	03776-60001	6	1	DIGITAL SYNTHESIZER/PCM GENERATOR ASSY	28480	03776-60001	
A1C1	0180-0155	8	1	CAPACITOR-FXD 2.2UF+-20% 20VDC TA	56289	150D225X0020A2	
A1C2	0160-0576	5	17	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C3	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C4	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C5	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C6	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A1CR1	1901-0044	5	1	DIODE-SWITCHING 50V 50MA 6NS	28480	1901-0044	
A1R1	0757-0280	3	2	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A1R2	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A1TL1	1258-0124	7	2	PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	
A1TL2	1258-0124	7		PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	
A1U101	1820-1432	5	3	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A1U102	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A1U103	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A1U104	03776-80038	1	1	PROM	28480	03776-80038	
	03779-20305	2	8	HEAT SINK	28480	03779-20305	
A1U105	03776-80039	2	1	PROM	28480	03776-80039	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A1U106	03776-80040	5	1	PROM	28480	03776-80040	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A1U107	03776-80041	6	1	PROM	28480	03776-80041	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A1U108	03776-80042	7	1	PROM	28480	03776-80042	
	03779-20305	2		HEAT SINK	28480	03779-20305	A
A1U109	03776-80043	8	1	PROM	28480	03776-80043	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A1U110	1820-1217	4	2	IC MUXR/DATA-SEL TTL LS 8-TO-1-LINE	01295	SN74LS151N	
A1U201	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A1U202	1820-1217	4		IC MUXR/DATA-SEL TTL LS 8-TO-1-LINE	01295	SN74LS151N	
A1U203	1820-1196	8	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N	
A1U301	1820-1195	7	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N	
A1U302	1818-1718	5	2	IC NMOS 16384 (16K) STAT RAM 120-NS 3-S	50088	MK4802N-1	
A1U303	1820-2795	5	3	IC DRVR TTL F LINE DRVR OCTL	28480	1820-2795	
A1U304	03776-80052	9	1	PROM	28480	03776-80052	
A1U305	1820-2700	2	2	IC LCH TTL F D-TYPE OCTL	07263	74F373PC	
A1U306	1820-2667	0	4	BIT-SLICE PROCESSOR	28480	1820-2667	
	1205-0428	3	4	HEAT SINK SGL DIP	28480	1205-0428	
A1U401	1820-1112	8	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A1U405	1820-1997	7	6	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A1U406	1820-2667	0		BIT-SLICE PROCESSOR	28480	1820-2667	
	1205-0428	3		HEAT SINK SGL DIP	28480	1205-0428	
A1U501	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A1U502	1818-1718	5		IC NMOS 16384 (16K) STAT RAM 120-NS 3-S	50088	MK4802N-1	
A1U503	1820-2795	5		IC DRVR TTL F LINE DRVR OCTL	28480	1820-2795	
A1U504	03776-80053	0	1	PROM	28480	03776-80053	
A1U505	1820-2700	2		IC LCH TTL F D-TYPE OCTL	07263	74F373PC	
A1U506	1820-2667	0		BIT-SLICE PROCESSOR	28480	1820-2667	
	1205-0428	3		HEAT SINK SGL DIP	28480	1205-0428	
A1U601	03776-80050	7	1	PROM	28480	03776-80050	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A1U605	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A1U606	1820-2667	0		BIT-SLICE PROCESSOR	28480	1820-2667	
	1205-0428	3		HEAT SINK SGL DIP	28480	1205-0428	
A1U701	1820-1200	5	1	IC INV TTL LS HEX	01295	SN74LS05N	
A1U702	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A1U703	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A1U801	03776-80051	8	1	PROM	28480	03776-80051	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A1U802	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A1U803	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A1U804	1820-1987	5	1	IC SHF-RGTR TTL LS COM CLEAR STOR 8-BIT	01295	SN74LS299N	
A1U805	1820-2670	9	1	IC GATE TTL F OR QUAD 2-INP	07263	74F32PC	
A1U806	1820-2795	5		IC DRVR TTL F LINE DRVR OCTL	28480	1820-2795	
A1U807	1820-2955	9	1	IC GEN TTL F LOOK-AHD-CRY 4-BIT	28480	1820-2955	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	A
MSC	4040-0748	3	1	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748	
MSC	4040-0749	4	1	EXTR-PC BD BRN POLYC .062-BD-THKNS	28480	4040-0749	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A101	03776-60101	7	1	DIGITAL SYNTHESIZER/PCM GENERATOR ASSY	28480	03776-60101	
A101C1	0180-0155	8	1	CAPACITOR-FXD 2.2UF+-20% 20VDC TA	56289	150D225X0020A2	
A101C2	0160-0576	5	17	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C3	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C4	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C5	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C6	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A101CR1	1901-0044	5	1	DIODE-SWITCHING 50V 50MA 6NS	28480	1901-0044	
A101R1	0757-0280	3	2	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A101R2	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A101TL1	1258-0124	7	2	PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	
A101TL2	1258-0124	7		PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	
A101U101	1820-1432	5	3	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A101U102	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A101U103	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A101U104	03776-80044	9	1	PROM	28480	03776-80044	
	03779-20305	2	8	HEAT SINK	28480	03779-20305	
A101U105	03776-80045	0	1	PROM	28480	03776-80045	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A101U106	03776-80046	1	1	PROM	28480	03776-80046	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A101U107	03776-80047	2	1	PROM	28480	03776-80047	
	03779-20305	2		HEAT SINK	28480	03779-20305	B
A101U108	03776-80048	3	1	PROM	28480	03776-80048	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A101U109	03776-80049	4	1	PROM	28480	03776-80049	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A101U110	1820-1217	4	2	IC MUXR/DATA-SEL TTL LS 8-TO-1-LINE	01295	SN74LS151N	
A101U201	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A101U202	1820-1217	4		IC MUXR/DATA-SEL TTL LS 8-TO-1-LINE	01295	SN74LS151N	
A101U203	1820-1196	8	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N	
A101U301	1820-1195	7	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N	
A101U302	1818-1718	5	2	IC NMOS 16384 (16K) STAT RAM 120-NS 3-S	50088	MK4802N-1	
A101U303	1820-2795	5	3	IC DRVR TTL F LINE DRVR OCTL	28480	1820-2795	
A101U304	03776-80052	9	1	PROM	28480	03776-80052	
A101U305	1820-2700	2	2	IC LCH TTL F D-TYPE OCTL	07263	74F373PC	
A101U306	1820-2667	0	4	BIT-SLICE PROCESSOR	28480	1820-2667	
	1205-0428	3	4	HEAT SINK SGL DIP	28480	1205-0428	
A101U401	1820-1112	8	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A101U405	1820-1997	7	6	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A101U406	1820-2667	0		BIT-SLICE PROCESSOR	28480	1820-2667	
	1205-0428	3		HEAT SINK SGL DIP	28480	1205-0428	
A101U501	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A101U502	1818-1718	5		IC NMOS 16384 (16K) STAT RAM 120-NS 3-S	50088	MK4802N-1	
A101U503	1820-2795	5		IC DRVR TTL F LINE DRVR OCTL	28480	1820-2795	
A101U504	03776-80053	0	1	PROM	28480	03776-80053	
A101U505	1820-2700	2		IC LCH TTL F D-TYPE OCTL	07263	74F373PC	
A101U506	1820-2667	0		BIT-SLICE PROCESSOR	28480	1820-2667	
	1205-0428	3		HEAT SINK SGL DIP	28480	1205-0428	
A101U601	03776-80050	7	1	PROM	28480	03776-80050	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A101U605	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A101U606	1820-2667	0		BIT-SLICE PROCESSOR	28480	1820-2667	
	1205-0428	3		HEAT SINK SGL DIP	28480	1205-0428	
A101U701	1820-1200	5	1	IC INV TTL LS HEX	01295	SN74LS05N	
A101U702	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A101U703	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A101U801	03776-80051	8	1	PROM	28480	03776-80051	
	03779-20305	2		HEAT SINK	28480	03779-20305	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A101U802	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A101U803	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A101U804	1820-1987	5	1	IC SHF-RGTR TTL LS COM CLEAR STOR 8-BIT	01295	SN74LS299N	
A101U805	1820-2690	9	1	IC GATE TTL F OR QUAD 2-INP	07263	74F32PC	B
A101U806	1820-2795	5		IC DRVR TTL F LINE DRVR OCTL	28480	1820-2795	
A101U807	1820-2955	9	1	IC GEN TTL F LOOK-AHD-CRY 4-BIT	28480	1820-2955	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0748	3	1	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748	
MSC	4040-0749	4	1	EXTR-PC BD BRN POLYC .062-BD-THKNS	28480	4040-0749	

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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A2	03776-60002	7	1	DIGITAL PCM TRANSMITTER ASSY	28480	03776-60002	
A2C1	0180-1846	6	4	CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A2C2	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A2C3	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A2C4	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A2C5	0160-0685	7	4	CAPACITOR-FXD 0.1UF 1% 63VDC	28480	0160-0685	
A2C6	0160-0685	7		CAPACITOR-FXD 0.1UF 1% 63VDC	28480	0160-0685	
A2C7	0160-0685	7		CAPACITOR-FXD 0.1UF 1% 63VDC	28480	0160-0685	
A2C8	0160-0685	7		CAPACITOR-FXD 0.1UF 1% 63VDC	28480	0160-0685	
A2C9	0160-0576	5	19	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C19	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C20	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C21	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C22	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C23	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C24	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C25	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C26	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2C27	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A2CR1	1901-0539	3	2	DIODE-SM SIG SCHOTTKY	28480	1901-0539	
A2CR2	1901-0539	3		DIODE-SM SIG SCHOTTKY	28480	1901-0539	
A2CR3	1901-1098	1	4	DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A2CR4	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A2CR5	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A2CR6	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A2F1	2110-0218	9	2	FUSE .1A 250V .25X.27	28480	2110-0218	A
A2F2	2110-0218	9		FUSE .1A 250V .25X.27	28480	2110-0218	
A2R1	0757-0458	7	2	RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F	
A2R2	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A2R3	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A2R4	0757-0458	7		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F	
A2R5	0757-0279	0	1	RESISTOR 3.16K 1% .125W F TC = 0+-100	24546	C4-1/8-TO-3161-F	
A2R6	2100-3353	8	1	RESISTOR-TRMR 20K 10% C SIDE-ADJ 1-TRN	28480	2100-3353	
A2R7	0698-8827	4	4	RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A2R8	0698-0084	9	1	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A2R9	0698-6360	6	4	RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A2R10	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A2R11	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A2R12	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A2R13	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A2R14	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A2R15	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A2U49	1826-0220	9	1	IC V RGLTR TO-39	27014	LM320H-05	
A2U102	1820-1416	5	3	IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N	
A2U103	1820-1416	5		IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N	
A2U104	1820-1217	4	1	IC MUXR/DATA-SEL TTL LS 8-TO-1-LINE	01295	SN74LS151N	
A2U106	1820-1196	8	4	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N	
A2U107	1820-2096	9	1	IC CNTR TTL LS BIN DUAL 4-BIT	01295	SN74LS393N	
A2U108	1820-1201	6	1	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A2U110	1820-1208	3	3	IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A2U111	1820-1112	8	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A2U203	1820-1432	5	1	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A2U204	1820-2506	6	1	IC INV TTL F HEX	07263	74F04PC	
A2U205	1820-1211	8	1	IC GATE TTL LS EXCL-OR QUAD 2-INP	01295	SN74LS86N	
A2U212	1826-1030	1	1	ICD 2913 C20	28480	1826-1030	
A2U301	1820-1416	5		IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N	
A2U302	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A2U303	1820-1281	2	1	IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS139N	
A2U304	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N	
A2U305	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A2U306	1820-1922	8	1	IC SHF-RGTR TTL LS PRL-IN SERIAL-OUT	01295	SN74LS166N	
A2U307	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	

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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A2U308	1820-1144	6	1	IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N	
A2U309	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N	
A2U310	1820-1905	7	1	IC GATE TTL LS NOR DUAL 5-INP	07263	74LS260PC	
A2U312	1826-0410	9	1	IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A2U401	1820-1422	3	1	IC MV TTL LS MONOSTBL RETRIG	01295	SN74LS122N	
A2U402	1820-1491	6	1	IC BFR TTL LS NON-INV HEX 1-INP	01295	SN74LS367AN	
A2U403	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N	
A2U404	1820-1997	7	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A2U405	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	A
A2U406	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A2U407	1820-1433	6	1	IC SHF-RGTR TTL LS R-S SERIAL-IN PRL-OUT	01295	SN74LS164N	
A2U409	1820-1205	0	1	IC GATE TTL LS AND DUAL 4-INP	01295	SN74LS21N	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0748	3	1	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748	
MSC	4040-0750	7	1	EXTR-PC BD RED POLYC .062-BD-THKNS	28480	4040-0750	

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*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A102	03776-60102	8	1	DIGITAL PCM TRANSMITTER ASSY	28480	03776-60102	
A102C1	0180-1846	6	4	CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A102C2	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A102C3	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A102C4	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A102C5	0160-0685	7	4	CAPACITOR-FXD 0.1UF 1% 63VDC	28480	0160-0685	
A102C6	0160-0685	7		CAPACITOR-FXD 0.1UF 1% 63VDC	28480	0160-0685	
A102C7	0160-0685	7		CAPACITOR-FXD 0.1UF 1% 63VDC	28480	0160-0685	
A102C8	0160-0685	7		CAPACITOR-FXD 0.1UF 1% 63VDC	28480	0160-0685	
A102C9	0160-0576	5	20	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C19	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C20	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C21	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C22	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C23	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C24	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C25	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C26	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C27	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102C28	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A102CR1	1901-0539	3	2	DIODE-SM SIG SCHOTTKY	28480	1901-0539	
A102CR2	1901-0539	3		DIODE-SM SIG SCHOTTKY	28480	1901-0539	
A102CR3	1901-1098	1	4	DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A102CR4	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A102CR5	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A102CR6	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A102F1	2110-0218	9	2	FUSE .1A 250V .25X.27	28480	2110-0218	B
A102F2	2110-0218	9		FUSE .1A 250V .25X.27	28480	2110-0218	
A102R1	0757-0458	7	2	RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F	
A102R2	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A102R3	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A102R4	0757-0458	7		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F	
A102R5	0757-0279	0	1	RESISTOR 3.16K 1% .125W F TC =0+-100	24546	C4-1/8-TO-3161-F	
A102R6	2100-3353	8	1	RESISTOR-TRMR 20K 10% C SIDE-ADJ 1-TRN	28480	2100-3353	
A102R7	0698-8827	4	4	RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A102R8	0698-0084	9	1	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A102R9	0698-6360	6	4	RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A102R10	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A102R11	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A102R14	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A102R15	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A102R16	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A102R17	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A102U102	1820-1416	5	3	IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N	
A102U103	1820-1416	5		IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N	
A102U104	1820-1217	4	1	IC MUXR/DATA-SEL TTL LS 8-TO-1-LINE	01295	SN74LS151N	
A102U105	1820-1197	9	2	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A102U106	1820-1208	3	5	IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A102U107	1820-1211	8	2	IC GATE TTL LS EXCL-OR QUAD 2-INP	01295	SN74LS86N	
A102U108	1820-1922	8	3	IC SHF-RGTR TTL LS PRL-IN SERIAL-OUT	01295	SN74LS166N	
A102U109	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A102U110	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A102U111	1820-1112	8	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A102U202	1820-1201	6	1	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A102U203	1820-1432	5	1	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A102U204	1820-2506	6	1	IC INV TTL F HEX	07263	74F04PC	
A102U205	1820-2692	1	1	IC GATE TTL F EXCL-OR QUAD 2-INP	07263	74F86PC	
A102U206	1820-1922	8		IC SHF-RGTR TTL LS PRL-IN SERIAL-OUT	01295	SN74LS166N	
A102U207	1820-1433	6	2	IC SHF-RGTR TTL LS R-S SERIAL-IN PRL-OUT	01295	SN74LS164N	
A102U208	1820-1211	8		IC GATE TTL LS EXCL-OR QUAD 2-INP	01295	SN74LS86N	
A102U210	1820-2096	9	1	IC CNTR TTL LS BIN DUAL 4-BIT	01295	SN74LS393N	
A102U211	1820-1195	7	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N	
A102U212	1826-1030	1	1	ICD 2913 C20	28480	1826-1030	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A102U301	1820-1416	5		IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N	
A102U302	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A102U303	1820-1281	2	1	IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS139N	
A102U304	1820-1196	8	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N	
A102U305	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A102U306	1820-1922	8		IC SHF-RGTR TTL LS PRL-IN SERIAL-OUT	01295	SN74LS166N	
A102U307	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A102U308	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A102U309	1820-1997	7	4	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A102U310	1820-1905	7	1	IC GATE TTL LS NOR DUAL 5-INP	07263	74LS260PC	
A102U312	1826-0410	9	1	IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A102U401	1820-1422	3	1	IC MV TTL LS MONOSTBL RETRIG	01295	SN74LS122N	
A102U402	1820-1491	6	1	IC BFR TTL LS NON-INV HEX 1-INP	01295	SN74LS367AN	B
A102U403	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N	
A102U404	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A102U405	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A102U406	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A102U407	1820-1433	6		IC SHF-RGTR TTL LS R-S SERIAL-IN PRL-OUT	01295	SN74LS164N	
A102U408	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N	
A102U409	1820-1205	0	1	IC GATE TTL LS AND DUAL 4-INP	01295	SN74LS21N	
A102U412	1826-0220	9	1	IC V RGLTR TO-39	27014	LM320H-05	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0748	3	1	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748	
MSC	4040-0750	7	1	EXTR-PC BD RED POLYC .062-BD-THKNS	28480	4040-0750	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A3	03776-60003	8	1	ANALOG TRANSMITTER ASSEMBLY	28480	03776-60003	
A3C1	0160-4389	6	1	CAPACITOR-FXD 100PF +-5PF 200VDC CER	28480	0160-4389	
A3C2	0160-4426	2	10	CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A3C3	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A3C4	0160-4387	4	7	CAPACITOR-FXD 47PF +-5% 200VDC CER 0+-30	28480	0160-4387	
A3C5	0160-4387	4		CAPACITOR-FXD 47PF +-5% 200VDC CER 0+-30	28480	0160-4387	
A3C6	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A3C7	0160-2387	0	4	CAPACITOR-FXD 1000PF +-1% 500VDC MICA	28480	0160-2387	
A3C8	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A3C9	0160-2387	0		CAPACITOR-FXD 1000PF +-1% 500VDC MICA	28480	0160-2387	
A3C10	0160-2387	0		CAPACITOR-FXD 1000PF +-1% 500VDC MICA	28480	0160-2387	
A3C11	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A3C12	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A3C13	0160-0576	5	18	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C19	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C20	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C21	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A3C22	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A3C23	0180-2818	4	4	CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A3C24	0160-3879	7	2	CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879	
A3C25	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879	
A3C26	0160-4387	4		CAPACITOR-FXD 47PF +-5% 200VDC CER 0+-30	28480	0160-4387	
A3C27	0160-4387	4		CAPACITOR-FXD 47PF +-5% 200VDC CER 0+-30	28480	0160-4387	
A3C28	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A3C29	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A3C30	0160-2387	0		CAPACITOR-FXD 1000PF +-1% 500VDC MICA	28480	0160-2387	
A3C31	0160-4387	4		CAPACITOR-FXD 47PF +-5% 200VDC CER 0+-30	28480	0160-4387	
A3C32	0160-4387	4		CAPACITOR-FXD 47PF +-5% 200VDC CER 0+-30	28480	0160-4387	
A3C33	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C34	0180-2662	6	2	CAPACITOR-FXD 10UF+-10% 10VDC TA	25088	D4R7GS1A10K	
A3C35	0180-2662	6		CAPACITOR-FXD 10UF+-10% 10VDC TA	25088	D4R7GS1A10K	
A3C36	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C37	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C38	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C39	0160-4387	4		CAPACITOR-FXD 47PF +-5% 200VDC CER 0+-30	28480	0160-4387	
A3C40	0160-4365	8	1	CAPACITOR-FXD 470PF +-5% 100VDC CER	28480	0160-4365	
A3C41	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C42	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C43	0180-2818	4		CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A3C44	0180-2818	4		CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A3C45	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C46	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C47	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C48	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A3C49	0180-3115	6	4	CAPACITOR-FXD 330UF+50-10% 63VDC AL	28480	0180-3115	
A3C50	0180-3115	6		CAPACITOR-FXD 330UF+50-10% 63VDC AL	28480	0180-3115	
A3C51	0180-3115	6		CAPACITOR-FXD 330UF+50-10% 63VDC AL	28480	0180-3115	
A3C52	0180-3115	6		CAPACITOR-FXD 330UF+50-10% 63VDC AL	28480	0180-3115	
A3C53	0180-2818	4		CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A3C54	0180-2821	9	1	CAPACITOR-FXD 22UF+-20% 35VDC TA	28480	0180-2821	
A3CR1	1990-0450	4	19	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR2	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR3	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR4	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR5	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR6	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR7	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR8	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR9	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR10	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR11	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR12	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR13	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR14	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR15	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR16	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR17	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR18	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR19	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A3CR20	1901-1098	1	9	DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A3CR21	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A3CR22	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A3CR23	1902-0945	7	1	DIODE-ZNR 3V 5% DO-35 PD=.4W TC=-.043%	28480	1902-0945	
A3CR24	1902-0958	2	2	DIODE-ZNR 10V 5% DO-35 PD=.4W TC=+.075%	28480	1902-0958	
A3CR25	1902-0958	2		DIODE-ZNR 10V 5% DO-35 PD=.4W TC=+.075%	28480	1902-0958	
A3CR26	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A3CR27	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A3CR28	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A3CR29	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A3CR30	1901-0033	2	4	DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033	
A3CR31	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033	
A3CR32	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033	
A3CR33	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033	
A3CR34	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A3CR35	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A3K1	0490-1262	7	4	RELAY 2C 12VDC-COIL 2A 120VAC	28480	0490-1262	
A3K2	0490-1262	7		RELAY 2C 12VDC-COIL 2A 120VAC	28480	0490-1262	
A3K3	0490-1262	7		RELAY 2C 12VDC-COIL 2A 120VAC	28480	0490-1262	
A3K4	0490-1262	7		RELAY 2C 12VDC-COIL 2A 120VAC	28480	0490-1262	
A3Q1	1853-0066	8	6	TRANSISTOR PNP SI TO-92 PD=625MW	28480	1853-0066	
A3Q2	1853-0066	8		TRANSISTOR PNP SI TO-92 PD=625MW	28480	1853-0066	
A3Q3	1853-0066	8		TRANSISTOR PNP SI TO-92 PD=625MW	28480	1853-0066	
A3Q4	1853-0066	8		TRANSISTOR PNP SI TO-92 PD=625MW	28480	1853-0066	
A3Q5	1853-0066	8		TRANSISTOR PNP SI TO-92 PD=625MW	28480	1853-0066	
A3Q6	1853-0066	8		TRANSISTOR PNP SI TO-92 PD=625MW	28480	1853-0066	
A3Q7	1854-0492	6	8	TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	MPS3643	
A3Q8	1854-0492	6		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	MPS3643	
A3Q9	1854-0492	6		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	MPS3643	
A3Q10	1854-0492	6		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	MPS3643	
A3Q11	1854-0492	6		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	MPS3643	
A3Q12	1854-0492	6		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	MPS3643	
A3Q13	1854-0492	6		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	MPS3643	
A3Q14	1854-0492	6		TRANSISTOR NPN SI PD=350MW FT=250MHZ	04713	MPS3643	
A3Q15	1855-0386	9	17	TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q16	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q17	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q18	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q19	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q20	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q21	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q22	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q23	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q24	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q25	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q26	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q27	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q28	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q29	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q30	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q31	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A3Q32	1854-0215	1	2	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904	
A3Q33	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904	
A3R1	1810-0204	6	3	NETWORK-RES 8-SIP1.0K OHM X 7	01121	208A102	
A3R2	1810-0204	6		NETWORK-RES 8-SIP1.0K OHM X 7	01121	208A102	
A3R3	1810-0037	3	1	NETWORK-RES 16-DIP1.0K OHM X 8	11236	761-3-R1K	
A3R4	1810-0204	6		NETWORK-RES 8-SIP1.0K OHM X 7	01121	208A102	
A3R5	0757-0448	5	2	RESISTOR 18.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1822-F	
A3R6	0698-3449	6	2	RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A3R7	0757-0200	7	2	RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F	
A3R8	0698-3226	7	2	RESISTOR 6.49K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6491-F	
A3R9	0757-0288	1	3	RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F	
A3R10	0757-0448	5		RESISTOR 18.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1822-F	
A3R11	0698-3243	8	1	RESISTOR 178K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1783-F	
A3R12	0757-0200	7		RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F	
A3R13	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A3R14	0698-0083	8	3	RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F	
A3R15	0757-0442	9	7	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A3R16	0757-0443	0	1	RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1102-F	
A3R17	0757-0470	3	1	RESISTOR 162K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1623-F	
A3R18	0698-3157	3	1	RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F	
A3R19	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A3R20	0757-0438	3	3	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A3R21	0698-3457	6	1	RESISTOR 316K 1% .125W F TC=0+-100	28480	0698-3457	
A3R22	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F	
A3R23	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A3R24	0698-4435	2	1	RESISTOR 2.49K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2491-F	
A3R25	0698-3155	1	1	RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A3R26	0698-3153	9	1	RESISTOR 3.83K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3831-F	
A3R27	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F	
A3R28	0698-3453	2	3	RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F	
A3R29	0698-3453	2		RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F	
A3R30	0699-0144	4	2	RESISTOR 10K .01% .1W F TC=0+-5	28480	0699-0144	
A3R31	0699-0144	4		RESISTOR 10K .01% .1W F TC=0+-5	28480	0699-0144	
A3R32	0698-4485	2	2	RESISTOR 23.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2322-F	
A3R33	0698-4488	5	2	RESISTOR 26.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2672-F	
A3R34	0698-3162	0	2	RESISTOR 46.4K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4642-F	
A3R35	0698-3550	0	2	RESISTOR 127K 1% .125W F TC=0+-25	28480	0698-3550	
A3R36	0698-4475	0	2	RESISTOR 9.76K 1% .125W F TC=0+-100	03888	PME55-1/8-T0-9761-F	
A3R37	0757-0280	3	4	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A3R38	0757-0288	1		RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F	
A3R39	0698-3226	7		RESISTOR 6.49K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6491-F	
A3R40	0698-8827	4	6	RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A3R41	1810-0206	8	1	NETWORK-RES 8-SIP10.0K OHM X 7	01121	208A103	
A3R42	1810-0316	1	2	NETWORK-RES 16-DIP10.0K OHM X 8	01121	316B103	
A3R43	0699-0753	1	4	RESISTOR 2.74K .1% .125W F TC=0+-25	28480	0699-0753	
A3R44	0699-0753	1		RESISTOR 2.74K .1% .125W F TC=0+-25	28480	0699-0753	
A3R45	0699-0753	1		RESISTOR 2.74K .1% .125W F TC=0+-25	28480	0699-0753	
A3R46	0699-0753	1		RESISTOR 2.74K .1% .125W F TC=0+-25	28480	0699-0753	
A3R47	0699-0154	6	1	RESISTOR 7.2K .1% .125W F TC=0+-25	28480	0699-0154	
A3R48	1810-0319	4	2	NETWORK-RES 16-DIP100.0K OHM X 8	01121	316B104	
A3R49	1810-0319	4		NETWORK-RES 16-DIP100.0K OHM X 8	01121	316B104	
A3R50	0698-3550	0		RESISTOR 127K 1% .125W F TC=0+-25	28480	0698-3550	
A3R51	0698-4475	0		RESISTOR 9.76K 1% .125W F TC=0+-100	03888	PME55-1/8-T0-9761-F	
A3R52	0698-4488	5		RESISTOR 26.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2672-F	
A3R53	0698-3162	0		RESISTOR 46.4K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4642-F	
A3R54	0698-4485	2		RESISTOR 23.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2322-F	
A3R55	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A3R56	0698-3154	0	3	RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F	
A3R57	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F	
A3R58	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A3R59	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A3R60	0698-3160	8	4	RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F	
A3R61	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F	
A3R62	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F	
A3R63	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F	
A3R64	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A3R65	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A3R66	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A3R67	0757-0398	4	1	RESISTOR 75 1% .125W F TC=0+-100	24546	C4-1/8-T0-75R0-F	
A3R68	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F	
A3R69	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A3R70	0698-3158	4	1	RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2372-F	
A3R71	1810-0316	1		NETWORK-RES 16-DIP10.0K OHM X 8	01121	316B103	
A3R72	0757-0288	1		RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F	
A3R73	0698-3156	2	1	RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F	
A3R74	0699-0073	8	4	RESISTOR 10M 1% .125W F TC=0+-150	28480	0699-0073	
A3R75	0699-0073	8		RESISTOR 10M 1% .125W F TC=0+-150	28480	0699-0073	
A3R76	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A3R77	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A3R78	0698-3132	4	1	RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A3R79	0698-3453	2		RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F	
A3R80	0698-3755	7	1	RESISTOR 900 .5% .25W F TC=0+-100	24546	C5-1/4-T0-900R-D	
A3R81	0757-1022	3	1	RESISTOR 1.78K 1% .25W F TC=0+-100	24546	C5-1/4-T0-1781-F	
A3R82	0699-1017	2	3	RESISTOR 150 .01% .125W F TC=0+-10	28480	0699-1017	
A3R83	0699-1017	2		RESISTOR 150 .01% .125W F TC=0+-10	28480	0699-1017	
A3R84	0699-1017	2		RESISTOR 150 .01% .125W F TC=0+-10	28480	0699-1017	
A3R85	0699-1016	1	3	RESISTOR 300 .01% .125W F TC=0+-10	28480	0699-1016	
A3R86	0699-1016	1		RESISTOR 300 .01% .125W F TC=0+-10	28480	0699-1016	
A3R87	0699-1016	1		RESISTOR 300 .01% .125W F TC=0+-10	28480	0699-1016	
A3R88	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A3R89	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A3R90	0698-3260	9	1	RESISTOR 464K 1% .125W F TC=0+-100	28480	0698-3260	
A3R93	0698-3456	5	1	RESISTOR 287K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2873-F	
A3R94	0699-0073	8		RESISTOR 10M 1% .125W F TC=0+-150	28480	0699-0073	
A3R95	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A3R96	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A3R97	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A3R98	0699-0073	8		RESISTOR 10M 1% .125W F TC=0+-150	28480	0699-0073	
A3TL1	1258-0124	7	4	PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	
A3TL2	1258-0124	7		PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	
A3TL3	1258-0124	7		PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	
A3TL4	1258-0124	7		PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A3U10	1826-0410	9	5	IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A3U11	1826-0138	8	4	IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A3U12	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A3U13	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A3U14	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A3U20	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A3U21	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A3U22	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A3U23	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A3U30	1820-1858	9	5	IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N	
A3U31	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N	
A3U32	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N	
A3U33	1826-0726	0	1	IC CONV 12-B D/A 24-DIP-P PKG	24355	AD565JN/BIN	
A3U34	1826-0413	2	1	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	34371	HA2-2605-5	
A3U40	1820-1207	2	1	IC GATE TTL LS NAND 8-INP	01295	SN74LS30N	
A3U41	1820-1198	0	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS03N	
A3U42	1820-2024	3	1	IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N	
A3U43	1820-1430	3	1	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS161AN	
A3U44	1858-0047	5	1	TRANSISTOR ARRAY 16-PIN PLSTC DIP	13606	ULN-2003A	
A3U50	1820-1216	3	2	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A3U51	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A3U52	1820-1416	5	1	IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N	
A3U53	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N	
A3U54	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N	
A3U55	1826-0539	3	1	IC 317 V RGLTR TO-39	27014	LM317H	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0748	3	1	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748	
MSC	4040-0751	8	1	EXTR-PC BD ORN POLYC .062-BD-THKNS	28480	4040-0751	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A4	03776-60004	7	1	ANALOG MONITOR ASSEMBLY	28480	03776-60004	
A4C3	0160-2230	2	1	CAPACITOR-FXD 3300PF +-5% 300VDC MICA	28480	0160-2230	
A4C5	0160-3879	7	1	CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879	
A4C13	0160-0576	5	12	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A4C14	0180-0562	1	1	CAPACITOR-FXD 33UF+-20% 10VDC TA	56289	196D336X0010KA1	
A4C15	0160-0570	9	1	CAPACITOR-FXD 220PF +-20% 100VDC CER	20932	5024EM100RD221M	
A4C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A4C19	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A4C20	0180-2818	4	3	CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A4C21	0180-2818	4		CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A4C22	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A4C23	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A4C26	0180-2818	4		CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A4C27	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A4C28	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A4C29	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A4C33	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A4C34	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A4C35	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A4C36	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A4CR1	1990-0450	4	3	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A4CR6	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A4CR7	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A4Q1	1855-0386	9	2	TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A4Q2	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A4Q3	1854-0215	1	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904	
A4Q4	1853-0036	2	1	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A4R3	0698-3155	1	4	RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A4R18	0757-0200	7	1	RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F	
A4R19	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A4R20	0757-0440	7	1	RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F	
A4R21	0698-0084	9	1	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A4R22	0757-0290	5	1	RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F	
A4R34	1810-0319	4	1	NETWORK-RES 16-DIP100.0K OHM X 8	01121	316B104	
A4R35	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A4R36	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A4R37	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A4R46	1810-0204	6	1	NETWORK-RES 8-SIP1.0K OHM X 7	01121	208A102	
A4U10	1820-1278	7	1	IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS191N	
A4U16	1820-1112	8	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A4U21	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A4U25	1820-1211	8	1	IC GATE TTL LS EXCL-OR QUAD 2-INP	01295	SN74LS86N	
A4U26	1820-1416	5	1	IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N	
A4U28	1826-0410	9	1	IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A4U31	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A4U35	1820-1300	6	3	IC SHF-RGTR TTL LS R-S PRL-IN PRL-OUT	01295	SN74LS195AN	
A4U36	1820-1201	6	1	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A4U37	1826-0188	8	1	IC CONV 8-B-D/A 16-DIP-C PKG	04713	MC1408L-8	
A4U38	1826-0138	8	1	IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A4U40	1820-1208	3	1	IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A4U41	1820-1246	9	1	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS09N	
A4U45	1820-1300	6		IC SHF-RGTR TTL LS R-S PRL-IN PRL-OUT	01295	SN74LS195AN	
A4U46	1820-2056	1	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS378N	
A4U50	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A4U51	1820-1492	7	1	IC BFR TTL LS INV HEX 1-INP	01295	SN74LS368AN	
A4U53	1820-2056	1		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS378N	
A4U55	1820-1300	6		IC SHF-RGTR TTL LS R-S PRL-IN PRL-OUT	01295	SN74LS195AN	
A4U56	1820-2056	1		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS378N	
MSC	1258-0124	7	1	PIN-PROGRAMING JUMPER .30 CONTACT	71506	8136-475G1	
MSC	4040-0748	3	1	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748	
MSC	4040-0752	9	1	EXTR-PC BD YEL POLYC .062-BD-THKNS	28480	4040-0752	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A204	03776-60204	1	1	ANALOG MONITOR ASSEMBLY OPT 001	28480	03776-60204	
A204C1	0160-4115	6	1	CAPACITOR-FXD .22UF +-1% 63VDC MET-POLYC	K7723	TPA220NF63	
A204C2	0160-2387	0	3	CAPACITOR-FXD 1000PF +-1% 500VDC MICA	28480	0160-2387	
A204C3	0160-2387	0		CAPACITOR-FXD 1000PF +-1% 500VDC MICA	28480	0160-2387	
A204C4	0160-4426	2	5	CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A204C5	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A204C6	0160-2387	0		CAPACITOR-FXD 1000PF +-1% 500VDC MICA	28480	0160-2387	
A204C7	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A204C8	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A204C9	0160-4512	7	1	CAPACITOR-FXD 120PF +-5% 200VDC CER	28480	0160-4512	
A204C10	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A204C11	0160-4031	5	1	CAPACITOR-FXD 330PF +-5% 100VDC CER	28480	0160-4031	
A204C12	0160-4307	4	1	CAPACITOR-FXD 47PF +-5% 200VDC CER 0+-30	28480	0160-4387	
A204C13	0160-0576	5	19	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C14	0180-0562	1	1	CAPACITOR-FXD 33UF+-20% 10VDC TA	56289	196D336X0010KA1	
A204C16	0160-3077	5	1	CAPACITOR-FXD 100PF +-20% 200VDC CER	28480	0160-3877	
A204C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C19	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C20	0180-2818	4	3	CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A204C21	0180-2818	4		CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A204C22	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C23	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C24	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C25	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C26	0180-2818	4		CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A204C27	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C28	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C29	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C30	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C31	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C32	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C33	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C34	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C35	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C36	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204C37	0160-4566	1	1	CAPACITOR-FXD 2200PF +-1% 50VDC CER	51642	200-50-NP0-222F	001
A204C38	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A204CR1	1990-0450	4	7	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A204CR2	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A204CR3	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A204CR4	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A204CR5	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A204CR6	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A204CR7	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A204CR8	1901-1098	1	4	DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A204CR9	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A204CR10	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A204CR11	1901-1098	1		DIODE-SWITCHING 1N4150 50V 200MA 4NS	9N171	1N4150	
A204CR12	1902-0958	2	2	DIODE-ZNR 10V 5% DO-35 PD=.4W TC=+.075%	28480	1902-0958	
A204CR13	1902-0958	2		DIODE-ZNR 10V 5% DO-35 PD=.4W TC=+.075%	28480	1902-0958	
A204LK1	1460-1336	4	2	WIREFORM CU BRT-TIN	28480	1460-1336	
A204LK2	1460-1336	4		WIREFORM CU BRT-TIN	28480	1460-1336	
A204Q1	1855-0386	9	7	TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A204Q2	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A204Q3	1854-0215	1	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904	
A204Q4	1853-0036	2	1	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A204Q5	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A204Q6	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A204Q7	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A204Q8	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A204Q9	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A204R1	0698-3155	1	5	RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A204R2	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A204R3	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A204R4	0698-6322	0	5	RESISTOR 4K .1% .125W F TC=0+-25	28480	0698-6322	
A204R5	0698-4339	5	2	RESISTOR 11.111K .1% .125W F TC=0+-50	28480	0698-4339	
A204R6	0698-6322	0		RESISTOR 4K .1% .125W F TC=0+-25	28480	0698-6322	
A204R7	0698-6514	2	2	RESISTOR 10.65K .25% .125W F TC=0+-25	28480	0698-6514	
A204R8	0698-7375	5	2	RESISTOR 28.64K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-28641-B	
A204R9	0698-6624	5	2	RESISTOR 2K .1% .125W F TC=0+-25	28480	0698-6624	
A204R10	0698-8721	7	2	RESISTOR 13.95K .1% .125W F TC=0+-25	28480	0698-8721	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A204R11	0698-6360	6	4	RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A204R12	0698-7329	9	1	RESISTOR 3.266K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-3266R-B	
A204R13	0698-6624	5		RESISTOR 2K .1% .125W F TC=0+-25	28480	0698-6624	
A204R14	0757-0464	5	1	RESISTOR 90.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-9092-F	
A204R15	0698-6322	0		RESISTOR 4K .1% .125W F TC=0+-25	28480	0698-6322	
A204R16	0698-6514	2		RESISTOR 10.65K .25% .125W F TC=0+-25	28480	0698-6514	
A204R17	0698-4339	5		RESISTOR 11.111K .1% .125W F TC=0+-50	28480	0698-4339	
A204R18	0698-6322	0		RESISTOR 4K .1% .125W F TC=0+-25	28480	0698-6322	
A204R19	0698-7375	5		RESISTOR 28.64K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-28641-B	
A204R21	0698-0084	9	2	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A204R22	0757-0290	5	2	RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F	
A204R23	0757-0290	5		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F	
A204R24	0698-6614	3	1	RESISTOR 7.5K .1% .125W F TC=0+-25	28480	0698-6614	
A204R25	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A204R26	0698-8457	8	1	RESISTOR 2.567K .25% .125W F TC=0+-25	28480	0698-8459	
A204R27	0757-0280	3	4	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A204R28	0698-6322	0		RESISTOR 4K .1% .125W F TC=0+-25	28480	0698-6322	
A204R29	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A204R30	0698-7360	8	1	RESISTOR 398.5K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-39852-B	
A204R31	0698-4523	9	1	RESISTOR 169K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1693-F	
A204R32	0757-0476	9	1	RESISTOR 301K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3013-F	
A204R33	0698-6117	1	1	RESISTOR 182.3K .1% .125W F TC=0+-50	28480	0698-6117	
A204R34	1810-0319	4	2	NETWORK-RES 16-DIP100.0K OHM X 8	01121	316B104	
A204R35	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A204R36	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A204R37	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A204R38	1810-0319	4		NETWORK-RES 16-DIP100.0K OHM X 8	01121	316B104	
A204R39	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A204R40	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A204R41	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A204R42	0811-1001	4	2	RESISTOR 300 .1% 3W PW TC=0+-20	28480	0811-1001	
A204R43	0811-1001	4		RESISTOR 300 .1% 3W PW TC=0+-20	28480	0811-1001	
A204R44	0698-8721	7		RESISTOR 13.95K .1% .125W F TC=0+-25	28480	0698-8721	
A204R45	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A204R46	1810-0204	6	1	NETWORK-RES 8-SIP1.0K OHM X 7	01121	208A102	
A204R47	0757-0401	0	1	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F	
A204U10	1820-1278	7	11	IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS191N	
A204U11	1820-1112	8	8	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	001
A204U12	1820-1278	7		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS191N	
A204U13	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A204U14	1820-1144	6	1	IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N	
A204U15	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A204U16	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A204U20	1820-1278	7		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS191N	
A204U21	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A204U22	1820-1278	7		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS191N	
A204U23	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A204U24	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A204U25	1820-1211	8	1	IC GATE TTL LS EXCL-OR QUAD 2-INP	01295	SN74LS86N	
A204U26	1820-1416	5	1	IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N	
A204U27	1826-0410	9	3	IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A204U28	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A204U30	1820-1278	7		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS191N	
A204U31	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A204U32	1820-1278	7		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS191N	
A204U33	1820-2024	3	2	IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N	
A204U34	1820-1278	7		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS191N	
A204U35	1820-1300	6	3	IC SHF-RGTR TTL LS R-S PRL-IN PRL-OUT	01295	SN74LS195AN	
A204U36	1820-1201	6	1	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A204U38	1826-0138	8	2	IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A204U40	1820-1208	3	1	IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A204U41	1820-1246	9	1	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS09N	
A204U42	1820-1278	7		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS191N	
A204U43	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N	
A204U44	1820-1278	7		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS191N	
A204U45	1820-1300	6		IC SHF-RGTR TTL LS R-S PRL-IN PRL-OUT	01295	SN74LS195AN	
A204U46	1820-2056	1	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS378N	
A204U47	1826-0726	0	1	IC CONV 12-B-D/A 24-DIP-P PKG	24355	AD565JN/BIN	
A204U48	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A204U50	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A204U51	1820-1492	7	1	IC BFR TTL LS INV HEX 1-INP	01295	SN74LS368AN	
A204U52	1820-1278	7		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS191N	
A204U53	1820-2056	1		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS378N	
A204U54	1820-1278	7		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS191N	
A204U55	1820-1300	6		IC SHF-RGTR TTL LS R-S PRL-IN PRL-OUT	01295	SN74LS195AN	
A204U56	1820-2056	1		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS378N	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A204U57	1826-0413	2	1	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	34371	HA2-2605-5	
A204U58	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
MSC	1258-0124	7	3	PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	001
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0748	3	1	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748	
MSC	4040-0752	9	1	EXTR-PC BD YEL POLYC .062-BD-THKNS	28480	4040-0752	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A5	03776-60005	0	1	TRANSIENTS ASSEMBLY OPTION 001	28480	03776-60005	
A5C1	0160-4564	9	3	CAPACITOR-FXD 5600PF +-1% 100VDC CER	51642	300-100-NPO-562F	
A5C2	0160-4040	6	1	CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040	
A5C3	0160-5118	1	2	CAPACITOR-FXD .22UF +-5% 63VDC MET-POLYC	28480	0160-5118	
A5C4	0160-5118	1		CAPACITOR-FXD .22UF +-5% 63VDC MET-POLYC	28480	0160-5118	
A5C5	0160-0576	5	27	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C6	0160-4441	1	1	CAPACITOR-FXD .47UF +-10% 50VDC CER	28480	0160-4441	
A5C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C8	0160-4426	2	28	CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C9	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC	28480	0160-4426	
A5C10	0160-4586	5	11	CAPACITOR-FXD .033UF +-1% 100VDC CER	28480	0160-4586	
A5C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C14	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C15	0160-3849	1	1	CAPACITOR-FXD .15UF +-5% 63VDC MET-POLYC	28480	0160-3849	
A5C16	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C17	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C18	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C19	0160-4586	5		CAPACITOR-FXD .033UF +-1% 100VDC CER	28480	0160-4586	
A5C20	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C21	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C23	0160-5378	5	3	CAPACITOR-FXD .1UF +-1% 50VDC CER 0+-30	28480	0160-5378	
A5C24	0160-5378*	5		CAPACITOR-FXD .1UF +-1% 50VDC CER 0+-30	28480	0160-5378	
A5C25	0160-5378	5		CAPACITOR-FXD .1UF +-1% 50VDC CER 0+-30	28480	0160-5378	
A5C26	0160-4586	5		CAPACITOR-FXD .033UF +-1% 100VDC CER	28480	0160-4586	
A5C27	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C28	0160-3874	2	2	CAPACITOR-FXD 10PF +-5% 200VDC CER	28480	0160-3874	
A5C29	0180-2697	7	6	CAPACITOR-FXD 10UF+-10% 25VDC TA	28480	0180-2697	
A5C30	0180-2697	7		CAPACITOR-FXD 10UF+-10% 25VDC TA	28480	0180-2697	
A5C31	0180-2697	7		CAPACITOR-FXD 10UF+-10% 25VDC TA	28480	0180-2697	
A5C32	0180-2697	7		CAPACITOR-FXD 10UF+-10% 25VDC TA	28480	0180-2697	
A5C33	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C34	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C35	0160-0627	7	1	CAPACITOR-FXD 1UF +-5%	28480	0160-0627	
A5C36	0160-4586	5		CAPACITOR-FXD .033UF +-1% 100VDC CER	28480	0160-4586	
A5C37	0160-4535	4	4	CAPACITOR-FXD 1UF +-10% 50VDC CER	28480	0160-4535	001
A5C38	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C39	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C40	0160-4535	4		CAPACITOR-FXD 1UF +-10% 50VDC CER	28480	0160-4535	
A5C41	0160-4587	6	3	CAPACITOR-FXD 2700PF +-1% 100VDC CER	51642	300-100-NPO-272F	
A5C42	0160-4586	5		CAPACITOR-FXD .033UF +-1% 100VDC CER	28480	0160-4586	
A5C43	0160-4587	6		CAPACITOR-FXD 2700PF +-1% 100VDC CER	51642	300-100-NPO-272F	
A5C44	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C45	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C46	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C47	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C49	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C50	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C51	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C52	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C53	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C54	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C55	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C56	0160-4535	4		CAPACITOR-FXD 1UF +-10% 50VDC CER	28480	0160-4535	
A5C57	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C58	0160-4567	2	1	CAPACITOR-FXD 3900PF +-1% 100VDC CER	28480	0160-4567	
A5C59	0160-0576	5		CAPACITOR-FXD .1U +-20% 50VDC	28480	0160-0576	
A5C60	0160-4564	9		CAPACITOR-FXD 5600PF +-1% 100VDC CER	51642	300-100-NPO-562F	
A5C61	0160-4586	5		CAPACITOR-FXD .033UF +-1% 100VDC CER	28480	0160-4586	
A5C62	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C63	0160-4586	5		CAPACITOR-FXD .033UF +-1% 100VDC CER	28480	0160-4586	
A5C64	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C65	0160-4586	5		CAPACITOR-FXD .033UF +-1% 100VDC CER	28480	0160-4586	
A5C66	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C67	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C68	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C69	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C70	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C71	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C73	0160-4835	7	8	CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835	
A5C74	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A5C75	0160-4586	5		CAPACITOR-FXD .033UF +-1% 100VDC CER	28480	0160-4586	
A5C76	0160-4564	9		CAPACITOR-FXD 5600PF +-1% 100VDC CER	51642	300-100-NP0-562F	
A5C77	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C78	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C79	0160-4586	5		CAPACITOR-FXD .033UF +-1% 100VDC CER	28480	0160-4586	
A5C80	0160-4587	6		CAPACITOR-FXD 2700PF +-1% 100VDC CER	51642	300-100-NP0-272F	
A5C81	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C82	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C83	0160-4389	6	1	CAPACITOR-FXD 100PF +-5PF 200VDC CER	28480	0160-4389	
A5C84	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835	
A5C85	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835	
A5C86	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C87	0180-2697	7		CAPACITOR-FXD 10UF+-10% 25VDC TA	28480	0180-2697	
A5C88	0180-2697	7		CAPACITOR-FXD 10UF+-10% 25VDC TA	28480	0180-2697	
A5C89	0160-4535	4		CAPACITOR-FXD 1UF +-10% 50VDC CER	28480	0160-4535	
A5C90	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C91	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835	
A5C92	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835	
A5C93	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835	
A5C94	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835	
A5C95	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C96	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C97	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C98	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C99	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C100	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A5C101	0160-4586	5		CAPACITOR-FXD .033UF +-1% 100VDC CER	28480	0160-4586	
A5C102	0160-3872	0	1	CAPACITOR-FXD 2.2PF +-.25PF 200VDC CER	28480	0160-3872	
A5C103	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C104	0160-3875	3	2	CAPACITOR-FXD 22PF +-5% 200VDC CER 0+-30	28480	0160-3875	
A5C105	0160-3874	2		CAPACITOR-FXD 10PF +-5% 200VDC CER	28480	0160-3874	
A5C106	0160-3875	3		CAPACITOR-FXD 22PF +-5% 200VDC CER 0+-30	28480	0160-3875	
A5C107	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C108	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5C109	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A5CR1	1901-0040	1	25	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	001
A5CR2	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR3	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR4	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR5	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR6	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR7	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR8	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR9	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR10	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR11	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR12	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR13	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR14	1901-0535	9	1	DIODE-SM SIG SCHOTTKY	28480	1901-0535	
A5CR15	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR16	1901-0846	5	2	DIODE-CUR RGLTR 1N5284 100V DO-7	04713	1N5284	
A5CR17	1901-0846	5		DIODE-CUR RGLTR 1N5284 100V DO-7	04713	1N5284	
A5CR18	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR19	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR20	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR21	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR22	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR23	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR24	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR25	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR26	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR27	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5CR28	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A5R1	0698-8826	3	2	RESISTOR 825K 1% .125W F TC=0+-100	28480	0698-8826	
A5R2	0698-8826	3		RESISTOR 825K 1% .125W F TC=0+-100	28480	0698-8826	
A5R3	0757-0279	0	2	RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F	
A5R4	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F	
A5R5	0698-3161	9	4	RESISTOR 38.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3832-F	
A5R6	0698-3161	9		RESISTOR 38.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3832-F	
A5R7	0757-0448	5	1	RESISTOR 18.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1822-F	
A5R8	0698-3456	5	1	RESISTOR 287K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2873-F	
A5R9	0698-3454	3	2	RESISTOR 215K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2153-F	
A5R10	0698-3454	3		RESISTOR 215K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2153-F	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A5R11	0698-6353	7	6	RESISTOR 50K .1% .125W F TC=0+-25	28480	0698-6353	
A5R12	0698-6353	7		RESISTOR 50K .1% .125W F TC=0+-25	28480	0698-6353	
A5R13	0698-3162	0	1	RESISTOR 46.4K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4642-F	
A5R14	0757-0438	3	6	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A5R15	0757-0401	0	3	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F	
A5R16	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F	
A5R17	0757-0458	7	3	RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F	
A5R18	0698-8827	4	3	RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A5R19	0757-0978	6	2	RESISTOR 95.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-9532-F	
A5R20	0698-8534	0	1	RESISTOR 15.6K .25% .125W F TC=0+-100	28480	0698-8534	
A5R21	0698-4509	1	1	RESISTOR 80.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8062-F	
A5R22	0698-4474	9	1	RESISTOR 8.45K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8451-F	
A5R23	0757-0473	6	1	RESISTOR 221K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2213-F	
A5R24	0698-8960	6	1	RESISTOR 750K 1% .125W F TC=0+-100	28480	0698-8960	
A5R25	0757-0453	2	1	RESISTOR 30.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3012-F	
A5R26	0698-3159	5	3	RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F	
A5R27	0698-3453	2	6	RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F	
A5R28	0698-3457	6	3	RESISTOR 316K 1% .125W F TC=0+-100	28480	0698-3457	
A5R29	0698-3457	6		RESISTOR 316K 1% .125W F TC=0+-100	28480	0698-3457	
A5R30	0698-6353	7		RESISTOR 50K .1% .125W F TC=0+-25	28480	0698-6353	
A5R31	0698-6353	7		RESISTOR 50K .1% .125W F TC=0+-25	28480	0698-6353	
A5R32	1810-0224	0	5	NETWORK-RES 8-SIP33.0K OHM X 4	01121	208B333	
A5R33	1810-0224	0		NETWORK-RES 8-SIP33.0K OHM X 4	01121	208B333	
A5R34	1810-0224	0		NETWORK-RES 8-SIP33.0K OHM X 4	01121	208B333	
A5R35	1810-0224	0		NETWORK-RES 8-SIP33.0K OHM X 4	01121	208B333	
A5R36	0698-3450	9	1	RESISTOR 42.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4222-F	
A5R37	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A5R38	0698-3453	2		RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F	
A5R39	0757-0284	7	2	RESISTOR 150 1% .125W F TC=0+-100	24546	C4-1/8-T0-151-F	
A5R40	0698-3453	2		RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F	
A5R41	0698-3453	2		RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F	
A5R42	0698-3161	9		RESISTOR 38.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3832-F	
A5R43	0698-3161	9		RESISTOR 38.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3832-F	
A5R44	0698-3451	0	1	RESISTOR 133K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1333-F	
A5R44	0699-0369	5	1	RESISTOR 110.5K .1% .125W F TC=0+-25	28480	0699-0369	
A5R45	0698-6360	6	6	RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A5R46	0698-6631	4	3	RESISTOR 2.5K 1% .125W F TC = 0+-25	28480	0698-6631	001
A5R47	0698-4339	5	1	RESISTOR 11.111K .1% .125W F TC=0+-50	28480	0698-4339	
A5R48	0698-8784	2	1	RESISTOR 19.6K .1% .125W F TC=0+-25	28480	0698-8784	
A5R49	0698-8459	8	1	RESISTOR 2.567K .25% .125W F TC=0+-25	28480	0678-8459	
A5R50	0698-3179	9	1	RESISTOR 2.55K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2551	
A5R51	0698-3960	6	3	RESISTOR 1.1M 1% .125W F TC=0+-100	28480	0698-3960	
A5R52	0698-3960	6		RESISTOR 1.1M 1% .125W F TC=0+-100	28480	0698-3960	
A5R53	0698-8961	7	1	RESISTOR 909K 1% .125W F TC=0+-100	28480	0698-8961	
A5R54	0698-3960	6		RESISTOR 1.1M 1% .125W F TC=0+-100	28480	0698-3960	
A5R55	0698-3243	8	1	RESISTOR 178K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1783-F	
A5R56	0698-3453	2		RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F	
A5R57	0698-3271	2	2	RESISTOR 115K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1153-F	
A5R58	0698-3271	2		RESISTOR 115K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1153-F	
A5R59	0698-6353	7		RESISTOR 50K .1% .125W F TC=0+-25	28480	0698-6353	
A5R60	0698-6353	7		RESISTOR 50K .1% .125W F TC=0+-25	28480	0698-6353	
A5R61	1810-0224	0		NETWORK-RES 8-SIP33.0K OHM X 4	01121	208B333	
A5R62	0757-0465	6	1	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F	
A5R63	0757-0280	3	3	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A5R64	0698-3136	8	2	RESISTOR 17.8K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1782-F	
A5R65	0698-3453	2		RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F	
A5R66	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F	
A5R67	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A5R68	0698-6320	8	2	RESISTOR 5K .1% .125W F TC=0+-25	03888	PME55-1/8-T9-5001-B	
A5R69	0698-4211	2	1	RESISTOR 158K 1% .125W F TC = 0+-100	24546	C4-1/8-TO-1583F	
A5R70	0757-0284	7		RESISTOR 150 1% .125W F TC=0+-100	24546	C4-1/8-T0-151-F	
A5R71	0757-0447	4	1	RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F	
A5R72	0698-6117	1	1	RESISTOR 182.3K .1% .125W F TC=0+-50	28480	0698-6117	
A5R73	0757-0467	8	1	RESISTOR 121K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1213-F	
A5R74	0698-4486	3	1	RESISTOR 24.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2492-F	
A5R75	0698-4497	6	1	RESISTOR 48.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4872-F	
A5R76	0698-6627	8	1	RESISTOR 25K .1% .125W F TC=0+-25	28480	0698-6627	
A5R77	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A5R78	0698-7929	5	1	RESISTOR 9.09K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-9091-B	
A5R79	0698-8283	6	1	RESISTOR 25.84K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-25841-B	
A5R80	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A5R81	0757-0442	9	4	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A5R82	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A5R83	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A5R84	0757-0978	6		RESISTOR 95.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-9532-F	
A5R85	0757-0441	8	3	RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F	
A5R86	0698-3157	3	2	RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F	
A5R87	0757-0441	8		RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F	
A5R88	0757-0441	8		RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F	
A5R89	0698-3226	7	1	RESISTOR 6.49K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6491-F	
A5R90	0698-3157	3		RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F	
A5R91	0698-4499	8	1	RESISTOR 54.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5492-F	
A5R92	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A5R93	0757-0458	7		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F	
A5R94	0698-3457	6		RESISTOR 316K 1% .125W F TC=0+-100	28480	0698-3457	
A5R95	0698-8958	2	1	RESISTOR 511K 1% .125W F TC=0+-100	28480	0698-8958	
A5R96	0757-0450	9	1	RESISTOR 22.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2212-F	
A5R97	0698-7360	8	1	RESISTOR 398.5K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-39852-B	
A5R98	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A5R99	0699-0750	8	1	RESISTOR 16.783K .1% .125W F TC=0+-25	28480	0699-0750	
A5R100	0698-8640	9	1	RESISTOR 4.734K .1% .125W F TC=0+-25	28480	0698-8640	
A5R101	0698-7934	2	2	RESISTOR 12.1K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-1212-B	
A5R102	0698-7934	2		RESISTOR 12.1K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-1212-B	
A5R103	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A5R104	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A5R105	0698-3159	5		RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F	
A5R106	0698-3159	5		RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F	
A5R107	0698-4121	3	1	RESISTOR 11.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1132-F	
A5R108	0698-8179	9	3	RESISTOR 288K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-2883-B	
A5R109	0698-6358	2	3	RESISTOR 100K .1% .125W F TC=0+-25	28480	0698-6358	
A5R110	0698-8179	9		RESISTOR 288K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-2883-B	
A5R111	0698-6361	7		RESISTOR 8K .1% .125W F TC=0+-25	28480	0698-6361	
A5R112	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A5R113	0757-0416	7	1	RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A5R114	0757-0199	3	4	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F	
A5R115	0757-0199	3		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F	
A5R116	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A5R117	0698-4307	7	1	RESISTOR 14.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1432-F	
A5R118	0698-4520	6	1	RESISTOR 143K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1433-F	
A5R119	0757-0458	7		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F	001
A5R120	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A5R121	0698-6358	2		RESISTOR 100K .1% .125W F TC=0+-25	28480	0698-6358	
A5R122	0699-0115	9	1	RESISTOR 14.23K .1% .125W F TC=0+-50	28480	0699-0115	
A5R123	0698-6631	4		RESISTOR 2.5K .1% .125W F TC=0+-25	28480	0698-6631	
A5R124	0698-6631	4		RESISTOR 2.5K .1% .125W F TC=0+-25	28480	0698-6631	
A5R125	0698-6517	5	2	RESISTOR 34.85K .25% .125W F TC=0+-25	28480	0698-6517	
A5R126	0698-6517	5		RESISTOR 34.85K .25% .125W F TC=0+-25	28480	0698-6517	
A5R127	0698-4470	5	1	RESISTOR 6.98K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6981-F	
A5R128	0698-3572	6	1	RESISTOR 60.4K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6042-F	
A5R129	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A5R130	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A5R131	0757-0199	3		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F	
A5R132	0757-0199	3		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F	
A5R133	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A5R134	0698-6358	2		RESISTOR 100K .1% .125W F TC=0+-25	28480	0698-6358	
A5R135	0698-8179	9		RESISTOR 288K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-2883-B	
A5R136	0699-0808	7	1	RESISTOR 18.4K .1% .125W F TC=0+-25	28480	0699-0808	
A5R137	1810-0374	1	1	NETWORK-RES 8-SIP1.0K OHM X 4	01121	208B102	
A5R138	1810-0316	1	1	NETWORK-RES 16-DIP10.0K OHM X 8	01121	316B103	
A5R139	1810-0365	0	2	NETWORK-RES 6-SIP2.2K OHM X 5	01121	206A222	
A5R140	1810-0365	0		NETWORK-RES 6-SIP2.2K OHM X 5	01121	206A222	
A5R141	1810-0406	0	4	NETWORK-RES 8-SIP10.0K OHM X 4	01121	208B103	
A5R142	0698-6320	8		RESISTOR 5K .1% .125W F TC=0+-25	03888	PME55-1/8-T9-5001-B	
A5R143	1810-0406	0		NETWORK-RES 8-SIP10.0K OHM X 4	01121	208B103	
A5R144	1810-0406	0		NETWORK-RES 8-SIP10.0K OHM X 4	01121	208B103	
A5R145	1810-0406	0		NETWORK-RES 8-SIP10.0K OHM X 4	01121	208B103	
A5R146	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A5R147	0757-0454	3	2	RESISTOR 33.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3322-F	
A5R148	0757-0454	3		RESISTOR 33.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3322-F	
A5R149	0757-0462	3	1	RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F	
A5R150	0698-3136	8		RESISTOR 17.8K 1% .125W F TC = 0+-100	24546	C4-1/8-TO-1782-F	
A5R151	0698-3260	9	1	RESISTOR 464K 1% .125W F TC = 0+-100	28480	0698-3260	
A5R152	0698-0083	8	2	RESISTOR 1.96K 1% .125W F TC = 0+-100	24546	C4-1/8-TO-1961-F	
A5R153	0698-0083	8		RESISTOR 1.96K 1% .125W F TC = 0+-100	24546	C4-1/8-TO-1961-F	
A5R154	0698-3452	1	1	RESISTOR 147K 1% .125W F TC = 0+-100	24546	C4-1/8-TO-1473-F	
A5S1	3101-1841	8	1	SWITCH-SL 4-1A DIP-SLIDE-ASSY .1A 50VDC	28480	3101-1841	
A5S2	3101-2135	5	1	SWITCH-RKR DIP-RKR-ASSY DPDT .05A 30VDC	28480	3101-2135	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A5TP1	1251-0600	0	8	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A5TP2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A5TP3	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A5TP4	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A5TP5	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A5TP6	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A5TP7	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A5TP8	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A5U11	1826-0417	6	4	IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13333D	
A5U12	1826-0417	6		IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13333D	
A5U21	1820-1971	7	1	IC SWITCH ANLG QUAD 16-DIP-P PKG	17856	DG201CJ	
A5U22	1858-0045	3	4	TRANSISTOR ARRAY 12-LEAD TO-101	3L585	CA3018A	
A5U23	1826-0753	3	10	IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-C	04713	MC34004BL	
A5U24	1826-0741	9	6	IC OP AMP LOW-BIAS-H-IMPD DUAL TO-99 PKG	04713	MC34002AG	
A5U25	1826-0753	3		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-C	04713	MC34004BL	
A5U31	1826-0138	8	4	IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A5U32	1858-0045	3		TRANSISTOR ARRAY 12-LEAD TO-101	3L585	CA3018A	
A5U33	1826-0753	3		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-C	04713	MC34004BL	
A5U34	1826-0741	9		IC OP AMP LOW-BIAS-H-IMPD DUAL TO-99 PKG	04713	MC34002AG	
A5U35	1826-0753	3		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-C	04713	MC34004BL	
A5U36	1826-0753	3		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-C	04713	MC34004BL	
A5U41	1826-0412	1	2	IC COMPARATOR PRCN DUAL 8-DIP-P PKG	27014	LM393N	
A5U42	1858-0045	3		TRANSISTOR ARRAY 12-LEAD TO-101	3L585	CA3018A	
A5U43	1826-0753	3		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-C	04713	MC34004BL	
A5U44	1826-0741	9		IC OP AMP LOW-BIAS-H-IMPD DUAL TO-99 PKG	04713	MC34002AG	
A5U45	1826-0741	9		IC OP AMP LOW-BIAS-H-IMPD DUAL TO-99 PKG	04713	MC34002AG	
A5U51	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A5U52	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A5U53	1826-0065	0	2	IC COMPARATOR PRCN 8-DIP-P PKG	S0545	UPC311C	
A5U54	1826-0753	3		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-C	04713	MC34004BL	
A5U55	1826-0503	1	2	IC SMPL/HOLD TO-99 PKG	27014	LF398H	
A5U56	1826-0065	0		IC COMPARATOR PRCN 8-DIP-P PKG	S0545	UPC311C	
A5U57	1826-0417	6		IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13333D	001
A5U61	1820-1440	5	1	IC LCH TTL LS QUAD	01295	SN74LS279N	
A5U62	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A5U63	1826-0597	3	1	IC CONV 10-B-A/D 18-DIP-C PKG	28480	1826-0597	
A5U64	1826-0590	6	1	IC MULTIPLXR 4-CHAN-ANLG DUAL 16-DIP-C	27014	LF13509D	
A5U65	1200-0185	9	1	INSULATOR-XSTR NYLON	28480	1200-0185	
A5U65	1826-0414	3	1	V REF TO-5	27014	LH0070-2H	
A5U66	1826-0417	6		IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13333D	
A5U67	1826-0412	1		IC COMPARATOR PRCN DUAL 8-DIP-P PKG	27014	LM393N	
A5U68	1826-0753	3		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-C	04713	MC34004BL	
A5U71	1820-1212	9	1	IC FF TTL LS J-K NEG-EDGE-TRIG	01295	SN74LS112AN	
A5U72	1820-1491	6	1	IC BFR TTL LS NON-INV HEX 1-INP	01295	SN74LS367AN	
A5U73	1820-2024	3	1	IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N	
A5U75	1826-0741	9		IC OP AMP LOW-BIAS-H-IMPD DUAL TO-99 PKG	04713	MC34002AG	
A5U76	1826-0503	1		IC SMPL/HOLD TO-99 PKG	27014	LF398H	
A5U81	1820-1112	8	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A5U82	1820-1246	9	1	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS09N	
A5U83	1820-1997	7	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A5U84	1826-0581	5	1	IC SWITCH ANLG 16-DIP-C PKG	27014	LF13508D	
A5U85	1826-0753	3		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-C	04713	MC34004BL	
A5U86	1826-0753	3		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-C	04713	MC34004BL	
A5U87	1858-0045	3		TRANSISTOR ARRAY 12-LEAD TO-101	3L585	CA3018A	
A5U91	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A5U92	1820-1197	9	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A5U93	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A5U94	1820-1934	2	1	IC CONV 8-B-D/A 16-DIP-C PKG	06665	DAC-08EQ	
A5U95	1826-0471	2	1	IC OP AMP LOW-DRIFT TO-99 PKG	28480	1826-0471	
A5U96	1826-0741	9		IC OP AMP LOW-BIAS-H-IMPD DUAL TO-99 PKG	04713	MC34002AG	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0748	3	1	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748	
MSC	4040-0753	0	1	EXTR-PC BD GRN POLYC .062-BD-THKNS	28480	4040-0753	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A6	03776-60006	1	1	ANALOG RECEIVER ASSEMBLY	28480	03776-60006	
A6C1	0160-0576	5	19	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C2	0180-2818	4	2	CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A6C3	0180-2818	4		CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A6C4	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C5	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C6	0160-4387	4	3	CAPACITOR-FXD 47PF +-5% 200VDC CER 0+-30	28480	0160-4387	
A6C7	0160-4387	4		CAPACITOR-FXD 47PF +-5% 200VDC CER 0+-30	28480	0160-4387	
A6C8	0160-3874	2	1	CAPACITOR-FXD 10PF +-.5PF 200VDC CER	28480	0160-3874	
A6C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C14	0180-0374	3	2	CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2	
A6C15	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2	
A6C16	0160-0685	7	4	CAPACITOR-FXD 0.1UF 1% 63VDC	28480	0160-0685	
A6C17	0160-0685	7		CAPACITOR-FXD 0.1UF 1% 63VDC	28480	0160-0685	
A6C18	0160-0685	7		CAPACITOR-FXD 0.1UF 1% 63VDC	28480	0160-0685	
A6C19	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C20	0160-4426	2	7	CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A6C21	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A6C22	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A6C23	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A6C24	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A6C25	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A6C26	0160-4566	1	1	CAPACITOR-FXD 2200PF +-1% 50VDC CER	51642	200-50-NP0-222F	
A6C27	0180-2211	1	2	CAPACITOR-FXD 5UF+50-10% 150VDC AL	56289	30D505F150CC2	
A6C28	0180-2211	1		CAPACITOR-FXD 5UF+50-10% 150VDC AL	56289	30D505F150CC2	
A6C29	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C30	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C31	0160-4426	2		CAPACITOR-FXD .01UF +-1% 100VDC CER	28480	0160-4426	
A6C32	0180-3115	6	2	CAPACITOR-FXD 330UF+50-10% 63VDC AL	28480	0180-3115	
A6C33	0180-3115	6		CAPACITOR-FXD 330UF+50-10% 63VDC AL	28480	0180-3115	
A6C34	0180-0197	8	3	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A6C35	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A6C36	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A6C37	0180-1846	6	2	CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A6C38	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A6C39	0160-4387	4		CAPACITOR-FXD 47PF +-5% 200VDC CER 0+-30	28480	0160-4387	
A6C40	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C41	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C42	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C43	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C44	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C45	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C46	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C47	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C48	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C49	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C50	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A6C51	0160-0685	7		CAPACITOR-FXD 0.1UF 1% 63VDC	28480	0160-0685	
A6CR1	1902-0943	5	1	DIODE-ZNR 2.4V 5% DO-35 PD=.4W TC=-.037%	28480	1902-0943	
A6CR2	1902-0951	5	1	DIODE-ZNR 5.1V 5% DO-35 PD=.4W TC=+.035%	28480	1902-0951	
A6CR3	1901-0376	6	4	DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376	
A6CR4	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376	
A6CR5	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376	
A6CR6	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376	
A6CR7	1901-0731	7	4	DIODE-PWR RECT 400V 1A	28480	1901-0731	
A6CR8	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731	
A6CR9	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731	
A6CR10	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731	
A6DS1	1990-0450	4	8	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A6DS2	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A6DS3	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A6DS4	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A6DS5	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A6DS6	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A6DS7	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A6DS8	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A6K1	0490-1262	7	3	RELAY 2C 12VDC-COIL 2A 120VAC	28480	0490-1262	
A6K2	0490-1262	7		RELAY 2C 12VDC-COIL 2A 120VAC	28480	0490-1262	
A6K3	0490-1262	7		RELAY 2C 12VDC-COIL 2A 120VAC	28480	0490-1262	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A6L1	9100-1641	0	2	INDUCTOR RF-CH-MLD 240UH 5% .166DX.385LG	28480	9100-1641	
A6L2	9100-1641	0		INDUCTOR RF-CH-MLD 240UH 5% .166DX.385LG	28480	9100-1641	
A6Q1	1855-0386	9	7	TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A6Q2	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A6Q3	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A6Q4	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A6Q5	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A6Q6	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A6Q7	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A6R1	1810-0273	9	1	NETWORK-RES 10-SIP470.0 OHM X 9	01121	210A471	
A6R2	0757-0346	2	3	RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F	
A6R3	0757-0346	2		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F	
A6R4	0757-0346	2		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F	
A6R5	0757-0280	3	3	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A6R6	0698-0085	0	1	RESISTOR 2.61K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2611-F	
A6R7	0757-0438	3	2	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A6R8	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A6R9	0698-3154	0	2	RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F	
A6R10	0698-3161	9	1	RESISTOR 38.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3832-F	
A6R11	0698-3449	6	6	RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A6R12	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F	
A6R13	0757-0288	1	3	RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F	
A6R14	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A6R15	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A6R16	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A6R17	0757-0442	9	5	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A6R18	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A6R19	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A6R20	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A6R21	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A6R22	0757-0416	7	2	RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A6R23	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A6R24	0757-0465	6	2	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F	
A6R25	0699-0144	4	4	RESISTOR 10K .01% .1W F TC=0+-5	28480	0699-0144	
A6R26	0699-0144	4		RESISTOR 10K .01% .1W F TC=0+-5	28480	0699-0144	
A6R27	0699-0144	4		RESISTOR 10K .01% .1W F TC=0+-5	28480	0699-0144	
A6R28	0699-0144	4		RESISTOR 10K .01% .1W F TC=0+-5	28480	0699-0144	
A6R29	0757-0289	2	1	RESISTOR 13.3K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-1332-F	
A6R30	0698-0083	8	1	RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F	
A6R31	0757-0419	0	1	RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F	
A6R32	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A6R33	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A6R34	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A6R35	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A6R36	0698-7682	7	1	RESISTOR 52.98K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-52981-B	
A6R37	0698-7398	2	2	RESISTOR 6.124K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-6124R-B	
A6R38	0698-6977	1	1	RESISTOR 30K .1% .125W F TC=0+-25	28480	0698-6977	
A6R39	0698-3700	2	1	RESISTOR 715 1% .125W F TC=0+-100	24546	C4-1/8-T0-715R-F	
A6R40	0698-3444	1	3	RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F	
A6R41	0757-0317	7	1	RESISTOR 1.33K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1331-F	
A6R42	0698-6360	6	4	RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A6R43	0811-3608	1	3	RESISTOR 300 .01% 3W PW TC=0+-20	28480	0811-3608	
A6R44	0699-0244	5	1	RESISTOR 3.26K .1% .125W F TC=0+-50	28480	0699-0244	
A6R45	0698-6362	8	4	RESISTOR 1K .1% .125W F TC=0+-25	28480	0698-6362	
A6R46	0698-6519	7	2	RESISTOR 26.7K .1% .125W F TC=0+-25	28480	0698-6519	
A6R47	0757-0428	1	2	RESISTOR 1.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1621-F	
A6R48	0698-6362	8		RESISTOR 1K .1% .125W F TC=0+-25	28480	0698-6362	
A6R49	0698-6362	8		RESISTOR 1K .1% .125W F TC=0+-25	28480	0698-6362	
A6R50	0757-0424	7	1	RESISTOR 1.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1101-F	
A6R51	0757-0428	1		RESISTOR 1.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1621-F	
A6R52	0698-3502	0	1	RESISTOR 41.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4122-F	
A6R53	0698-8179	9	1	RESISTOR 288K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-2883-B	
A6R54	0698-6519	7		RESISTOR 26.7K .1% .125W F TC=0+-25	28480	0698-6519	
A6R55	0698-7678	1	1	RESISTOR 79.81K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-79811-B	
A6R56	0698-5498	9	2	RESISTOR 1.5M .1% .5W F TC=0+-50	28480	0698-5498	
A6R57	0698-5498	9		RESISTOR 1.5M .1% .5W F TC=0+-50	28480	0698-5498	
A6R58	0757-0340	6	2	RESISTOR 10K 1% .25W F TC=0+-100	24546	C5-1/4-T0-1002-F	
A6R59	0757-0340	6		RESISTOR 10K 1% .25W F TC=0+-100	24546	C5-1/4-T0-1002-F	
A6R60	0698-6515	3	1	RESISTOR 43.5K .1% .125W F TC=0+-25	28480	0698-6515	
A6R61	0757-0288	1		RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F	
A6R62	0698-8799	9	1	RESISTOR 21.5K .1% .125W F TC=0+-25	28480	0698-8799	
A6R63	0698-8863	8	1	RESISTOR 5.2K .1% .125W F TC=0+-25	28480	0698-8863	
A6R64	0698-3444	1		RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F	
A6R65	0698-6624	5	1	RESISTOR 2K .1% .125W F TC=0+-25	28480	0698-6624	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A6R66	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A6R67	0698-7398	2		RESISTOR 6.124K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-6124R-B	
A6R68	0698-3444	1		RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F	
A6R69	0699-1016	1	1	RESISTOR 300 .01% .125W F TC=0+-10	28480	0699-1016	
A6R70	0811-3608	1		RESISTOR 300 .01% 3W PW TC=0+-20	28480	0811-3608	
A6R71	0811-3608	1		RESISTOR 300 .01% 3W PW TC=0+-20	28480	0811-3608	
A6R72	0811-3607	0	1	RESISTOR 600 .01% 3W PW TC=0+-20	28480	0811-3607	
A6R73	0698-6353	7	2	RESISTOR 50K .1% .125W F TC=0+-25	28480	0698-6353	
A6R74	0698-6353	7		RESISTOR 50K .1% .125W F TC=0+-25	28480	0698-6353	
A6R75	0698-0082	7	1	RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F	
A6R76	0698-4405	6	2	RESISTOR 107 1% .125W F TC=0+-100	24546	C4-1/8-T0-107R-F	
A6R77	0698-4428	3	1	RESISTOR 1.69K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1691-F	
A6R78	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A6R79	0698-6360	6		RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360	
A6R80	0757-0288	1		RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F	
A6R81	0698-4405	6		RESISTOR 107 1% .125W F TC=0+-100	24546	C4-1/8-T0-107R-F	
A6R82	0698-6362	8		RESISTOR 1K .1% .125W F TC=0+-25	28480	0698-6362	
A6R83	0698-8167	5	1	RESISTOR 18K .1% .125W F TC=0+-25	19701	MF4C1/8-T9-1802-B	
A6R84	0698-3548	6	1	RESISTOR 732 1% .125W F TC=0+-100	24546	C4-1/8-T0-732R-F	
A6R85	0698-4454	5	3	RESISTOR 523 1% .125W F TC=0+-100	24546	C4-1/8-T0-523R-F	
A6R86	0698-7329	9	3	RESISTOR 3.266K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-3266R-B	
A6R87	0698-4454	5		RESISTOR 523 1% .125W F TC=0+-100	24546	C4-1/8-T0-523R-F	
A6R88	0757-0403	2	1	RESISTOR 121 1% .125W F TC=0+-100	24546	C4-1/8-T0-121R-F	
A6R89	0698-7929	5	1	RESISTOR 9.09K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-9091-B	
A6R90	0698-7329	9		RESISTOR 3.266K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-3266R-B	
A6R91	0698-4454	5		RESISTOR 523 1% .125W F TC=0+-100	24546	C4-1/8-T0-523R-F	
A6R92	0699-0750	8	1	RESISTOR 16.783K .1% .125W F TC=0+-25	28480	0699-0750	
A6R93	0698-3488	3	1	RESISTOR 442 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F	
A6R94	0698-7329	9		RESISTOR 3.266K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-3266R-B	
A6R95	0698-3454	3	1	RESISTOR 215K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2153-F	
A6R96	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F	
A6U17	1826-0410	9	4	IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A6U21	1820-1440	5	1	IC LCH TTL LS QUAD	01295	SN74LS279N	
A6U22	1826-0360	8	1	IC COMPARATOR GP QUAD 16-DIP-P PKG	04713	MC3431P	
A6U31	1820-1200	5	1	IC INV TTL LS HEX	01295	SN74LS05N	
A6U32	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A6U51	1820-1144	6	1	IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N	
A6U52	1858-0047	5	1	TRANSISTOR ARRAY 16-PIN PLSTC DIP	13606	ULN-2003A	
A6U54	1826-0138	8	2	IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A6U55	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A6U61	1820-1199	1	1	IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A6U62	1820-2056	1	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS378N	
A6U64	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A6U65	1826-0532	6	2	IC OP AMP GP QUAD 14-DIP-C PKG	34371	HA1-4605-5	
A6U71	1820-1197	9	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A6U72	1820-2056	1		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS378N	
A6U75	1826-0532	6		IC OP AMP GP QUAD 14-DIP-C PKG	34371	HA1-4605-5	
A6U77	1826-0178	6	1	IC V RGLTR TO-39	27014	LM320H-12	
A6U78	1826-0438	1	1	IC V RGLTR TO-39	27014	LM340LAH-12	
A6U81	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A6U82	1820-1997	7	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A6U85	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
MSC	1258-0124	7	4	PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0748	3	1	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748	
MSC	4040-0754	1	1	EXTR-PC BD BLU POLYC .062-BD-THKNS	28480	4040-0754	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A7	03776-60007	2	1	SAR, A/D CONVERTER & DIGITAL O/P ASSY	28480	03776-60007	
A7C1	0160-0576	5	29	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C2	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C3	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C4	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C5	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C6	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C19	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C20	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C21	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C22	0180-0374	3	2	CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2	
A7C23	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2	
A7C24	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C25	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C26	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C27	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C28	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C29	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C34	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C35	0160-4992	7	1	CAPACITOR-FXD 330PF 1% 63VDC	28480	0160-4992	
A7C38	0180-0197	8	2	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A7C39	0180-1846	6	5	CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A7C40	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A7C41	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	A
A7C42	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A7C43	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A7C44	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A7C45	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A7CR11	1901-0539	3	4	DIODE-SM SIG SCHOTTKY	28480	1901-0539	
A7CR12	1901-0539	3		DIODE-SM SIG SCHOTTKY	28480	1901-0539	
A7CR13	1901-0539	3		DIODE-SM SIG SCHOTTKY	28480	1901-0539	
A7CR14	1901-0539	3		DIODE-SM SIG SCHOTTKY	28480	1901-0539	
A7CR15	1902-1374	8	1	DIODE-ZNR 5.1V 1% DO-35 PD=.5W	28480	1902-1374	
A7CR17	1902-0943	5	1	DIODE-ZNR 2.4V 5% DO-35 PD=.4W TC=-.037%	28480	1902-0943	
A7CR18	1902-0953	7	2	DIODE-ZNR 6.2V 5% DO-35 PD=.4W TC=+.053%	28480	1902-0953	
A7CR19	1902-0953	7		DIODE-ZNR 6.2V 5% DO-35 PD=.4W TC=+.053%	28480	1902-0953	
A7CR20	1901-0040	1	1	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A7DS1	1990-0450	4	10	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A7DS2	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A7DS3	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A7DS4	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A7DS5	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A7DS6	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A7DS7	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A7DS8	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A7DS9	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A7DS10	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A7F1	2110-0218	9	2	FUSE .1A 250V .25X.27	28480	2110-0218	
A7F2	2110-0218	9		FUSE .1A 250V .25X.27	28480	2110-0218	
A7K1	0490-1262	7	1	RELAY 2C 12VDC-COIL 2A 120VAC	28480	0490-1262	
A7L1	9100-1641	0	2	INDUCTOR RF-CH-MLD 240UH 5% .166DX.385LG	28480	9100-1641	
A7L2	9100-1641	0		INDUCTOR RF-CH-MLD 240UH 5% .166DX.385LG	28480	9100-1641	
A7LK1	1460-1336	4	1	WIREFORM CU BRT-TIN	28480	1460-1336	
A7Q1	1855-0386	9	11	TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A7Q2	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A7Q3	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A7Q4	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A7Q5	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A7Q6	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A7Q7	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A7Q8	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A7Q9	1853-0271	7	6	TRANSISTOR PNP 2N4403 SI TO-92 PD=310MW	04713	2N4403	
A7Q10	1853-0271	7		TRANSISTOR PNP 2N4403 SI TO-92 PD=310MW	04713	2N4403	
A7Q11	1853-0271	7		TRANSISTOR PNP 2N4403 SI TO-92 PD=310MW	04713	2N4403	
A7Q12	1854-0467	5	7	TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A7Q13	1854-0467	5		TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A7Q14	1854-0467	5		TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A7Q15	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A7Q16	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A7Q17	1853-0036	2	1	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A7Q18	1854-0215	1	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904	
A7Q19	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A7Q20	1854-0467	5		TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A7Q21	1853-0271	7		TRANSISTOR PNP 2N4403 SI TO-92 PD=310MW	04713	2N4403	
A7Q22	1853-0271	7		TRANSISTOR PNP 2N4403 SI TO-92 PD=310MW	04713	2N4403	
A7Q23	1853-0271	7		TRANSISTOR PNP 2N4403 SI TO-92 PD=310MW	04713	2N4403	
A7Q24	1854-0467	5		TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A7Q25	1854-0467	5		TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A7Q26	1854-0467	5		TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A7R1	0698-3449	6	8	RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A7R2	0757-0280	3	7	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A7R3	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A7R4	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A7R5	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A7R6	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A7R7	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A7R8	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A7R9	1810-0317	2	1	NETWORK-RES 14-DIP510.0 OHM X 7	01121	314B511	
A7R10	1810-0572	1	1	NETWORK-RES 14-DIP1.2K OHM X 7	28480	1810-0572	
A7R11	0698-4107	5	2	RESISTOR 23.7 1% .25W F TC=0+-100	24546	C5-1/4-T0-23R7-F	
A7R12	0698-4107	5		RESISTOR 23.7 1% .25W F TC=0+-100	24546	C5-1/4-T0-23R7-F	
A7R13	0698-3332	6	2	RESISTOR 80.6 1% .5W F TC=0+-100	28480	0698-3332	
A7R14	0698-3332	6		RESISTOR 80.6 1% .5W F TC=0+-100	28480	0698-3332	
A7R15	0698-3404	3	1	RESISTOR 383 1% .5W F TC=0+-100	28480	0698-3404	
A7R16	0698-5334	2	2	RESISTOR 603 .5% .5W F TC=0+-100	28480	0698-5334	
A7R17	0698-5334	2		RESISTOR 603 .5% .5W F TC=0+-100	28480	0698-5334	A
A7R18	0757-0442	9	5	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A7R19	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A7R20	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A7R21	0757-0410	1	2	RESISTOR 301 1% .125W F TC=0+-100	24546	C4-1/8-T0-301R-F	
A7R22	0757-0410	1		RESISTOR 301 1% .125W F TC=0+-100	24546	C4-1/8-T0-301R-F	
A7R23	0698-3154	0	2	RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F	
A7R24	0757-0288	1	1	RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F	
A7R25	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A7R26	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A7R27	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A7R28	0698-3437	2	1	RESISTOR 133 1% .125W F TC=0+-100	24546	C4-1/8-T0-133R-F	
A7R29	0698-6364	0	2	RESISTOR 50 .1% .125W F TC=0+-25	28480	0698-6364	
A7R30	0698-6364	0		RESISTOR 50 .1% .125W F TC=0+-25	28480	0698-6364	
A7R31	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A7R32	1810-0573	2	1	NETWORK-RES 14-DIP100.0 OHM X 7	28480	1810-0573	
A7R33	0757-0710	4	2	RESISTOR 75 1% .25W F TC=0+-100	24546	C5-1/4-T0-75R0-F	
A7R34	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F	
A7R35	0698-3451	0	1	RESISTOR 133K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1333-F	
A7R36	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A7R37	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A7R38	0757-0200	7	1	RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F	
A7R39	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A7R40	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A7R41	0757-0440	7	1	RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F	
A7R42	0757-0278	9	1	RESISTOR 1.78K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1781-F	
A7R43	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A7R45	0757-0420	3	1	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F	
A7R46	0757-0710	4		RESISTOR 75 1% .25W F TC=0+-100	24546	C5-1/4-T0-75R0-F	
A7R47	1810-0364	9	1	NETWORK-RES 6-SIP470.0 OHM X 5	01121	206A471	
A7R49	0757-1094	9	1	RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F	
A7R76	0757-0465	6	1	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F	
A7T2	15506-80001	7	1	TRANSFORMER ASSEMBLY	28480	15506-80001	
A7U11	1820-2244	9	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS379N	
A7U12	1820-1199	1	3	IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A7U21	1820-1432	5	3	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A7U22	1820-1112	8	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A7U24	1826-0410	9	4	IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL384CN	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A7U25	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A7U31	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A7U32	1820-1197	9	3	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A7U34	1826-0138	8	2	IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A7U41	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A7U42	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A7U45	1826-0503	1	1	IC SMPL/HOLD TO-99 PKG	27014	LF398H	
A7U47	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A7U51	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A7U52	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A7U61	1820-1203	8	1	IC GATE TTL LS AND TPL 3-INP	01295	SN74LS11N	
A7U62	1820-1200	5	1	IC INV TTL LS HEX	01295	SN74LS05N	
A7U64	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A7U65	1813-0257	5	1	A/D 12-BIT 28-CBRZ/SDR BPLR	28480	1813-0257	
A7U67	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N	A
A7U71	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A7U72	1820-2056	1	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS378N	
A7U74	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A7U75	1820-2102	8	2	IC LCH TTL LS D-TYPE OCTL	01295	SN74LS373N	
A7U77	1826-0178	6	1	IC V RGLTR TO-39	27014	LM320H-12	
A7U81	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A7U82	1820-2056	1		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS378N	
A7U83	1820-1416	5	1	IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N	
A7U85	1820-2102	8		IC LCH TTL LS D-TYPE OCTL	01295	SN74LS373N	
A7U87	1826-0438	1	1	IC V RGLTR TO-39	27014	LM340LAH-12	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0748	3	1	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748	
MSC	4040-0755	2	1	EXTR-PC BD VIO POLYC .062-BD-THKNS	28480	4040-0755	

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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A107	03776-60107	3	1	SAR,A/D CONVERTER & DIGITAL O/P ASSY	28480	03776-60107	
A107C1	0160-0576	5	29	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C2	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C3	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C4	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C5	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C6	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C19	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C20	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C21	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C22	0180-0374	3	2	CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2	
A107C23	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2	
A107C24	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C25	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C26	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C27	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C28	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C29	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C34	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C35	0160-4992	7	1	CAPACITOR-FXD 330PF 1% 63VDC	28480	0160-4992	
A107C36	0160-5026	0	1	CAPACITOR-FXD 8200PF 1% 63VDC	28480	0160-5026	
A107C38	0180-0197	8	2	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A107C39	0180-1846	6	5	CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A107C40	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	B
A107C41	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A107C42	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A107C43	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A107C44	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A107C45	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A107CR11	1901-0539	3	4	DIODE-SM SIG SCHOTTKY	28480	1901-0539	
A107CR12	1901-0539	3		DIODE-SM SIG SCHOTTKY	28480	1901-0539	
A107CR13	1901-0539	3		DIODE-SM SIG SCHOTTKY	28480	1901-0539	
A107CR14	1901-0539	3		DIODE-SM SIG SCHOTTKY	28480	1901-0539	
A107CR15	1902-1374	8	2	DIODE-ZNR 5.1V 1% DO-35 PD=.5W	28480	1902-1374	
A107CR16	1902-1374	8		DIODE-ZNR 5.1V 1% DO-35 PD=.5W	28480	1902-1374	
A107CR17	1902-0943	5	1	DIODE-ZNR 2.4V 5% DO-35 PD=.4W TC=-.037%	28480	1902-0943	
A107CR18	1902-0953	7	2	DIODE-ZNR 6.2V 5% DO-35 PD=.4W TC=+.053%	28480	1902-0953	
A107CR19	1902-0953	7		DIODE-ZNR 6.2V 5% DO-35 PD=.4W TC=+.053%	28480	1902-0953	
A107CR20	1901-0040	1	1	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A107DS1	1990-0450	4	10	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A107DS2	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A107DS3	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A107DS4	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A107DS5	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A107DS6	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A107DS7	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A107DS8	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A107DS9	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A107DS10	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A107F1	2110-0218	9	2	FUSE .1A 250V .25X.27	28480	2110-0218	
A107F2	2110-0218	9		FUSE .1A 250V .25X.27	28480	2110-0218	
A107K1	0490-1262	7	1	RELAY 2C 12VDC-COIL 2A 120VAC	28480	0490-1262	
A107L1	9100-1641	0	2	INDUCTOR RF-CH-MLD 240UH 5% .166DX.385LG	28480	9100-1641	
A107L2	9100-1641	0		INDUCTOR RF-CH-MLD 240UH 5% .166DX.385LG	28480	9100-1641	
A107Q1	1855-0386	9	11	TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A107Q2	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A107Q3	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A107Q4	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A107Q5	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A107Q6	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A107Q7	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A107Q8	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A107Q9	1853-0271	7	6	TRANSISTOR PNP 2N4403 SI TO-92 PD=310MW	04713	2N4403	
A107Q10	1853-0271	7		TRANSISTOR PNP 2N4403 SI TO-92 PD=310MW	04713	2N4403	
A107Q11	1853-0271	7		TRANSISTOR PNP 2N4403 SI TO-92 PD=310MW	04713	2N4403	
A107Q12	1854-0467	5	7	TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A107Q13	1854-0467	5		TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A107Q14	1854-0467	5		TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A107Q15	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A107Q16	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A107Q17	1853-0036	2	1	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A107Q18	1854-0215	1	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904	
A107Q19	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392	
A107Q20	1854-0467	5		TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A107Q21	1853-0271	7		TRANSISTOR PNP 2N4403 SI TO-92 PD=310MW	04713	2N4403	
A107Q22	1853-0271	7		TRANSISTOR PNP 2N4403 SI TO-92 PD=310MW	04713	2N4403	
A107Q23	1853-0271	7		TRANSISTOR PNP 2N4403 SI TO-92 PD=310MW	04713	2N4403	
A107Q24	1854-0467	5		TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A107Q25	1854-0467	5		TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A107Q26	1854-0467	5		TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	03508	2N4401	
A107R1	0698-3449	6	8	RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A107R2	0757-0280	3	7	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A107R3	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A107R4	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A107R5	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A107R6	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A107R7	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A107R8	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A107R9	1810-0317	2	1	NETWORK-RES 14-DIP510.0 OHM X 7	01121	314B511	
A107R10	1810-0572	1	1	NETWORK-RES 14-DIP1.2K OHM X 7	28480	1810-0572	
A107R11	0698-4107	5	2	RESISTOR 23.7 1% .25W F TC=0+-100	24546	C5-1/4-T0-23R7-F	
A107R12	0698-4107	5		RESISTOR 23.7 1% .25W F TC=0+-100	24546	C5-1/4-T0-23R7-F	
A107R13	0757-1002	9	2	RESISTOR 61.9 1% .5W F TC=0+-100	28480	0757-1002	
A107R14	0757-1002	9		RESISTOR 61.9 1% .5W F TC=0+-100	28480	0757-1002	
A107R15	0698-3404	3	1	RESISTOR 383 1% .5W F TC=0+-100	28480	0698-3404	
A107R16	0698-5334	2	2	RESISTOR 603 .5% .5W F TC=0+-100	28480	0698-5334	
A107R17	0698-5334	2		RESISTOR 603 .5% .5W F TC=0+-100	28480	0698-5334	
A107R18	0757-0442	9	5	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	B
A107R19	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A107R20	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A107R21	0757-0410	1	2	RESISTOR 301 1% .125W F TC=0+-100	24546	C4-1/8-T0-301R-F	
A107R22	0757-0410	1		RESISTOR 301 1% .125W F TC=0+-100	24546	C4-1/8-T0-301R-F	
A107R23	0698-3154	0	2	RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F	
A107R24	0757-0288	1	1	RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F	
A107R25	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A107R26	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A107R27	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A107R28	0698-3437	2	1	RESISTOR 133 1% .125W F TC=0+-100	24546	C4-1/8-T0-133R-F	
A107R29	0698-6364	0	2	RESISTOR 50 .1% .125W F TC=0+-25	28480	0698-6364	
A107R30	0698-6364	0		RESISTOR 50 .1% .125W F TC=0+-25	28480	0698-6364	
A107R31	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A107R32	1810-0573	2	1	NETWORK-RES 14-DIP100.0 OHM X 7	28480	1810-0573	
A107R33	0757-0710	4	1	RESISTOR 75 1% .25W F TC=0+-100	24546	C5-1/4-T0-75R0-F	
A107R34	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F	
A107R35	0698-3451	0	1	RESISTOR 133K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1333-F	
A107R36	0698-3449	6		RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F	
A107R37	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A107R38	0757-0200	7	1	RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F	
A107R39	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A107R40	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A107R41	0757-0440	7	1	RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F	
A107R42	0698-3150	6	1	RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F	
A107R43	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A107R44	0698-4144	0	1	RESISTOR 21.5 1% .25W F TC=0+-100	28480	0698-4144	
A107R45	0757-0420	3	1	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F	
A107R46	0698-8244	9	1	RESISTOR 64.3 1% .25W F TC=0+-100	19701	MF52C1/4-T0-64R3-F	
A107R47	1810-0364	9	2	NETWORK-RES 6-SIP470.0 OHM X 5	01121	206A471	
A107R48	1810-0364	9		NETWORK-RES 6-SIP470.0 OHM X 5	01121	206A471	
A107R49	0757-1094	9	1	RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F	
A107R96	0757-0465	6	1	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F	
A107T1	15506-80001	7	1	TRANSFORMER ASSEMBLY	28480	15506-80001	
A107U11	1820-2244	9	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS379N	
A107U12	1820-1199	1	3	IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A107U21	1820-1432	5	3	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A107U22	1820-1112	8	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A107U24	1826-0410	9	4	IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A107U25	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A107U31	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A107U32	1820-1197	9	3	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A107U34	1826-0138	8	2	IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A107U41	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A107U42	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A107U45	1826-0503	1	1	IC SMPL/HOLD TO-99 PKG	27014	LF398H	
A107U47	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A107U51	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A107U52	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A107U61	1820-1203	8	1	IC GATE TTL LS AND TPL 3-INP	01295	SN74LS11N	
A107U62	1820-1200	5	1	IC INV TTL LS HEX	01295	SN74LS05N	
A107U64	1826-0410	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL084CN	
A107U65	1813-0257	5	1	A/D 12-BIT 28-CBRZ/SDR BPLR	28480	1813-0257	B
A107U67	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A107U71	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A107U72	1820-2056	1	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS378N	
A107U74	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A107U75	1820-2102	8	2	IC LCH TTL LS D-TYPE OCTL	01295	SN74LS373N	
A107U77	1826-0178	6	1	IC V RGLTR TO-39	27014	LM320H-12	
A107U81	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A107U82	1820-2056	1		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS378N	
A107U83	1820-1416	5	1	IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N	
A107U85	1820-2102	8		IC LCH TTL LS D-TYPE OCTL	01295	SN74LS373N	
A107U87	1826-0438	1	1	IC V RGLTR TO-39	27014	LM340LAH-12	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0748	3	1	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748	
MSC	4040-0755	2	1	EXTR-PC BD VIO POLYC .062-BD-THKNS	28480	4040-0755	

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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A8	03776-60008	3	1	GD, TIMING IMP. NOISE & FREQ DETECT ASSY	28480	03776-60008	
A8C1	0180-0155	8	1	CAPACITOR-FXD 2.2UF+-20% 20VDC TA	56289	150D225X0020A2	
A8C2	0160-0576	5	15	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C3	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C4	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C5	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C6	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A8CR1	1990-0450	4	1	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A8R1	0698-0084	9	5	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A8R2	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A8R3	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A8R4	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A8R5	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A8R6	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A8U11	1820-1195	7	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N	
A8U12	1820-1197	9	3	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A8U13	1820-1432	5	4	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A8U14	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A8U15	1820-1144	6	1	IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N	
A8U16	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A8U21	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A8U22	1820-1216	3	2	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	001
A8U23	1820-1851	2	2	IC ENCDR TTL LS	01295	SN74LS148N	
A8U24	1820-1440	5	2	IC LCH TTL LS QUAD	01295	SN74LS279N	
A8U25	1820-1440	5		IC LCH TTL LS QUAD	01295	SN74LS279N	
A8U26	1820-1208	3	2	IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A8U31	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A8U32	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A8U33	1820-1991	1	3	IC CNTR TTL LS DECD DUAL 4-BIT	01295	SN74LS390N	
A8U34	1820-1991	1		IC CNTR TTL LS DECD DUAL 4-BIT	01295	SN74LS390N	
A8U35	1820-1991	1		IC CNTR TTL LS DECD DUAL 4-BIT	01295	SN74LS390N	
A8U36	1820-1199	1	1	IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A8U41	1820-1112	8	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A8U42	1820-1246	9	1	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS09N	
A8U43	1820-1470	1	1	IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS157N	
A8U44	1820-1210	7	1	IC GATE TTL LS AND-OR-INV DUAL 2-INP	01295	SN74LS51N	
A8U45	1820-2096	9	4	IC CNTR TTL LS BIN DUAL 4-BIT	01295	SN74LS393N	
A8U46	1820-2096	9		IC CNTR TTL LS BIN DUAL 4-BIT	01295	SN74LS393N	
A8U51	1820-1851	2		IC ENCDR TTL LS	01295	SN74LS148N	
A8U52	1820-1201	6	1	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A8U53	1820-2096	9		IC CNTR TTL LS BIN DUAL 4-BIT	01295	SN74LS393N	
A8U54	1820-2096	9		IC CNTR TTL LS BIN DUAL 4-BIT	01295	SN74LS393N	
A8U55	1820-1211	8	1	IC GATE TTL LS EXCL-OR QUAD 2-INP	01295	SN74LS86N	
A8U56	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A8U61	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A8U62	1820-1195	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N	
A8U63	1820-1917	1	3	IC BFR TTL LS LINE DRVR OCTL	01295	SN74LS240N	
A8U64	1820-1917	1		IC BFR TTL LS LINE DRVR OCTL	01295	SN74LS240N	
A8U65	1820-1917	1		IC BFR TTL LS LINE DRVR OCTL	01295	SN74LS240N	
A8U66	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
MSC	1258-0124	7	1	PIN-PROGRAMING JUMPER .30 CONTACT	71506	8136-475G1	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0747	2	1	EXTR-PC BD GRA POLYC .062-BD-THKNS	28480	4040-0747	
MSC	4040-0748	3	1	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A9	03776-60009	4	1	DIGITAL FILTER ASSEMBLY	28480	03776-60009	
A9C1	0160-0576	5	20	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C2	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C3	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C4	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C5	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C6	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C13	0180-1846	6	3	CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A9C14	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A9C15	0180-1846	6		CAPACITOR-FXD 2.2UF+-10% 35VDC TA	56289	150D225X9035B2	
A9C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C19	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C20	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C21	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C22	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9C23	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A9CR1	1990-0450	4	2	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A9CR2	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A9R1	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A9R2	0698-0082	7	2	RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F	
A9R3	0698-0082	7		RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F	
A9R4	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A9R5	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A9R6	0698-8606	7	1	RESISTOR 450 .1% .125W F TC=0+-25	28480	0698-8606	
A9R7	0757-0431	6	1	RESISTOR 2.43K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2431-F	
A9R8	0757-0407	6	1	RESISTOR 200 1% .125W F TC=0+-100	24546	C4-1/8-T0-201-F	
A9R9	0757-0426	9	1	RESISTOR 1.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1301-F	
A9R10	0698-0084	9	1	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A9TL1	1258-0124	7	1	PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	
A9U11	1820-2506	6	2	IC INV TTL F HEX	07263	74F04PC	
A9U12	1820-1198	0	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS03N	
A9U13	1820-2096	9	1	IC CNTR TTL LS BIN DUAL 4-BIT	01295	SN74LS393N	
A9U14	1820-1112	8	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A9U15	1820-1144	6	3	IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N	
A9U16	1820-1144	6		IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N	
A9U21	1820-1196	8	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N	
A9U22	1820-1997	7	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A9U23	1820-2075	4	1	IC MISC TTL LS	01295	SN74LS245N	
A9U24	1820-1216	3	3	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A9U25	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N	
A9U26	1820-1197	9	3	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A9U31	1820-1244	7	1	IC MUXR/DATA-SEL TTL LS 4-TO-1-LINE DUAL	01295	SN74LS153N	
A9U32	1820-1987	5	3	IC SHF-RGTR TTL LS COM CLEAR STOR 8-BIT	01295	SN74LS299N	
A9U33	1820-1432	5	4	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A9U34	1818-1614	0	1	IC NMOS 8192 (8K) STAT RAM 90-NS	50088	MK4801AN-90	
	1200-0541	1	1	SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541	
A9U36	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A9U41	1820-1144	6		IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N	
A9U42	1820-1987	5		IC SHF-RGTR TTL LS COM CLEAR STOR 8-BIT	01295	SN74LS299N	
A9U43	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A9U44	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A9U46	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A9U51	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A9U52	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A9U53	1820-1987	5		IC SHF-RGTR TTL LS COM CLEAR STOR 8-BIT	01295	SN74LS299N	
A9U54	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A9U56	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A9U61	1820-1206	1	1	IC GATE TTL LS NOR TPL 3-INP	01295	SN74LS27N	
A9U62	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A9U63	1820-2506	6		IC INV TTL F HEX	07263	74F04PC	
A9U64	1826-0539	3	1	IC 317 V RGLTR TO-39	27014	LM317H	
A9U65	1SC5-0035	1	1	ICD 1SC5-0035C40	28480	1SC5-0035	
	1200-0654	7	1	SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0748	3	1	EXTR-PC BD BLK POLYC .062-BD-THKNS	28480	4040-0748	
MSC	4040-0756	3	1	EXTR-PC BD WHT POLYC .062-BD-THKNS	28480	4040-0756	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A11	03776-60011	8	1	A-LAW ALIGNMENT ASSEMBLY	28480	03776-60011	
A11C1	0180-0197	8	1	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A11C2	0160-0576	5	14	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11C3	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11C4	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11C5	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11C6	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A11CR1	1990-0450	4	2	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A11CR2	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A11CR3	1901-0731	7	4	DIODE-PWR RECT 400V 1A	28480	1901-0731	
A11CR4	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731	
A11CR5	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731	
A11CR6	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731	
A11R1	0757-0280	3	2	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A11R2	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A11R3	1810-0204	6	1	NETWORK-RES 8-SIP1.0K OHM X 7	01121	208A102	
A11R4	1810-0318	3	1	NETWORK-RES 6-SIP1.0K OHM X 5	01121	206A102	
A11U101	1820-1208	3	2	IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A11U102	1820-1212	9	1	IC FF TTL LS J-K NEG-EDGE-TRIG	01295	SN74LS112AN	
A11U103	1820-1244	7	1	IC MUXR/DATA-SEL TTL LS 4-TO-1-LINE DUAL	01295	SN74LS153N	
A11U104	1820-1419	8	3	IC COMPTR TTL LS MAGTD 4-BIT	01295	SN74LS85N	
A11U105	1820-1470	1	2	IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS157N	
A11U106	1820-1444	9	5	IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS298N	
A11U107	1820-1199	1	2	IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A11U108	03776-80031	4	1	PROM	28480	03776-80031	
	03779-20305	2	5	HEAT SINK	28480	03779-20305	
A11U109	1820-1444	9		IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS298N	A
A11U110	1820-1432	5	3	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A11U111	1820-1206	1	2	IC GATE TTL LS NOR TPL 3-INP	01295	SN74LS27N	
A11U112	1820-1201	6	2	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A11U201	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A11U202	1820-1112	8	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A11U203	1820-1217	4	1	IC MUXR/DATA-SEL TTL LS 8-TO-1-LINE	01295	SN74LS151N	
A11U204	1820-2244	9	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS379N	
A11U205	03776-80037	0	2	PROM	28480	03776-80037	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A11U206	1820-1444	9		IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS298N	
A11U207	1820-1201	6		IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A11U208	03776-80037	0		PROM	28480	03776-80037	
A11U208	1820-1470	1		IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS157N	
A11U209	1820-1444	9		IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS298N	
A11U210	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A11U211	1820-1203	8	2	IC GATE TTL LS AND TPL 3-INP	01295	SN74LS11N	
A11U212	1820-1144	6	1	IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N	
A11U301	1820-1200	5	2	IC INV TTL LS HEX	01295	SN74LS05N	
A11U302	1820-1203	8		IC GATE TTL LS AND TPL 3-INP	01295	SN74LS11N	
A11U303	1820-1419	8		IC COMPTR TTL LS MAGTD 4-BIT	01295	SN74LS85N	
A11U304	1820-1419	8		IC COMPTR TTL LS MAGTD 4-BIT	01295	SN74LS85N	
A11U305	1820-1444	9		IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS298N	
A11U306	1820-1200	5		IC INV TTL LS HEX	01295	SN74LS05N	
A11U307	1820-2244	9		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS379N	
A11U308	03776-80032	5	1	PROM	28480	03776-80032	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A11U309	1820-2384	8	1	IC RGTR TTL LS D-TYPE 2-INP 4-BIT	01295	SN74LS399N	
A11U310	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A11U311	1820-1206	1		IC GATE TTL LS NOR TPL 3-INP	01295	SN74LS27N	
A11U312	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A11U401	1820-2024	3	1	IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N	
A11U402	1820-1858	9	3	IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N	
A11U403	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N	
A11U404	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N	
A11U405	1820-1987	5	3	IC SHF-RGTR TTL LS COM CLEAR STOR 8-BIT	01295	SN74LS299N	
A11U406	1820-1987	5		IC SHF-RGTR TTL LS COM CLEAR STOR 8-BIT	01295	SN74LS299N	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A11U407	1820-1997	7	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	A
A11U408	03776-80033	6	1	PROM	28480	03776-80033	A
	03779-20305	2		HEAT SINK	28480	03779-20305	A
A11U409	03776-80034	7	1	PROM	28480	03776-80034	A
	03779-20305	2		HEAT SINK	28480	03779-20305	A
A11U410	1820-1987	5		IC SHF-RGTR TTL LS COM CLEAR STOR 8-BIT	01295	SN74LS299N	A
A11U411	1820-0538	0	2	IC GATE TTL NOR DUAL 4-INP	01295	SN7423N	A
A11U412	1820-1297	0	1	IC GATE TTL LS EXCL-NOR QUAD 2-INP	01295	SN74LS266N	A
A11U501	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	A
A11U511	1820-0538	0		IC GATE TTL NOR DUAL 4-INP	01295	SN7423N	A
A11U512	1820-1204	9	1	IC GATE TTL LS NAND DUAL 4-INP	01295	SN74LS20N	A
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	A
MSC	4040-0749	4	2	EXTR-PC BD BRN POLYC .062-BD-THKNS	28480	4040-0749	A

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A111	03776-60111	9	1	U-LAW ALIGNMENT ASSEMBLY	28480	03776-60111	
A111C1	0180-2818	4	1	CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A111C2	0160-0576	5	28	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C3	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C4	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C5	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C6	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C19	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C20	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C21	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C22	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C23	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C24	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C25	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C26	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C27	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C28	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111C29	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A111CR1	1990-0450	4	3	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A111CR2	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A111CR3	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A111CR4	1901-0731	7	3	DIODE-PWR RECT 400V 1A	28480	1901-0731	
A111CR5	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731	
A111CR6	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731	B
A111R1	0757-0280	3	3	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A111R2	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A111R3	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A111R4	1810-0204	6	1	NETWORK-RES 8-SIP1.0K OHM X 7	01121	208A102	
A111U101	1820-1470	1	2	IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS157N	
A111U102	1820-2384	8	1	IC RGTR TTL LS D-TYPE 2-INP 4-BIT	01295	SN74LS399N	
A111U103	03776-80032	5	1	PROM	28480	03776-80032	
	03779-20305	2	6	HEAT SINK	28480	03779-20305	
A111U104	1820-2244	9	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS379N	
A111U105	1820-1201	6	5	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A111U106	1820-1112	8	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A111U107	1820-1217	4	2	IC MUXR/DATA-SEL TTL LS 8-TO-1-LINE	01295	SN74LS151N	
A111U108	1820-1144	6	1	IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N	
A111U109	1820-1201	6		IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A111U110	1820-1444	9	5	IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS298N	
A111U111	1820-1201	6		IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A111U112	1820-1199	1	2	IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A111U113	1820-1206	1	1	IC GATE TTL LS NOR TPL 3-INP	01295	SN74LS27N	
A111U201	1820-1201	6		IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A111U202	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A111U204	1820-2244	9		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS379N	
A111U205	1820-1419	8	3	IC COMPTR TTL LS MAGTD 4-BIT	01295	SN74LS85N	
A111U206	1820-1282	3	1	IC FF TTL LS J-K BAR POS-EDGE-TRIG	01295	SN74LS109AN	
A111U207	1820-1208	3	2	IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A111U208	1820-1201	6		IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A111U209	1820-1444	9		IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS298N	
A111U210	03776-80065	4	1	PROM	28480	03776-80065	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A111U211	1820-1444	9		IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS298N	
A111U212	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A111U213	1820-1203	8	1	IC GATE TTL LS AND TPL 3-INP	01295	SN74LS11N	
A111U301	1820-1444	9		IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS298N	
A111U302	1820-1444	9		IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS298N	
A111U303	03776-80031	4	1	PROM	28480	03776-80031	
	03779-20305	2		HEAT SINK	28480	03779-20305	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A111U304	1820-1200	5	1	IC INV TTL LS HEX	01295	SN74LS05N	
A111U305	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A111U306	1820-1419	8		IC COMPTR TTL LS MAGTD 4-BIT	01295	SN74LS85N	
A111U307	1820-1419	8		IC COMPTR TTL LS MAGTD 4-BIT	01295	SN74LS85N	
A111U308	1820-1211	8	1	IC GATE TTL LS EXCL-OR QUAD 2-INP	01295	SN74LS86N	
A111U309	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A111U310	1820-1432	5	4	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A111U311	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A111U312	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A111U313	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A111U314	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A111U401	1820-2024	3	1	IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N	
A111U402	1820-1858	9	3	IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N	
A111U403	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N	
A111U404	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N	
A111U405	1820-1987	5	3	IC SHF-RGTR TTL LS COM CLEAR STOR 8-BIT	01295	SN74LS299N	B
A111U406	1820-1987	5		IC SHF-RGTR TTL LS COM CLEAR STOR 8-BIT	01295	SN74LS299N	
A111U407	1820-1997	7	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A111U408	03776-80035	8	1	PROM	28480	03776-80035	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A111U409	03776-80036	9	1	PROM	28480	03776-80036	
A111U409B	03779-20305	2		HEAT SINK	28480	03779-20305	
A111U410	1820-1987	5		IC SHF-RGTR TTL LS COM CLEAR STOR 8-BIT	01295	SN74LS299N	
A111U411	1820-1470	1		IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS157N	
A111U412	03776-80066	5	1	PROM	28480	03776-80066	
	03779-20305	2		HEAT SINK	28480	03779-20305	
A111U413	1820-1217	4		IC MUXR/DATA-SEL TTL LS 8-TO-1-LINE	01295	SN74LS151N	
A111U414	1820-0471	0	1	IC INV TTL HEX 1-INP	01295	SN7406N	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0749	4	2	EXTR-PC BD BRN POLYC .062-BD-THKNS	28480	4040-0749	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A12	03776-60012	9	1	DIGITAL RECEIVER ASSEMBLY	28480	03776-60012	
A12C1	0121-0436	4	1	CAPACITOR-V TRMR-AIR 2.6-23.5PF 350V	74970	189-0509-125	
A12C2	0160-4492	2	2	CAPACITOR-FXD 18PF +-5% 200VDC CER 0+-30	28480	0160-4492	
A12C3	0160-4492	2		CAPACITOR-FXD 18PF +-5% 200VDC CER 0+-30	28480	0160-4492	
A12C4	0160-0576	5	20	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C5	0160-3486	2	3	CAPACITOR-FXD .47UF +80-20% 50VDC CER	28480	0160-3486	
A12C6	0160-3486	2		CAPACITOR-FXD .47UF +80-20% 50VDC CER	28480	0160-3486	
A12C7	0160-3486	2		CAPACITOR-FXD .47UF +80-20% 50VDC CER	28480	0160-3486	
A12C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C19	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C20	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C21	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C22	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C23	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C24	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C25	0180-0197	8	3	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A12C26	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A12C27	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A12C30	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C31	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A12C32	0160-3508	9	1	CAPACITOR-FXD 1UF +80-20% 50VDC CER	28480	0160-3508	
A12CR1	1990-0450	4	4	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A12CR2	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A12CR3	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A12CR4	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A12CR5	1901-0033	2	2	DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033	
A12CR6	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033	A
A12CR7	1901-0731	7	1	DIODE-PWR RECT 400V 1A	28480	1901-0731	
A12CR8	1902-0579	3	2	DIODE-ZNR 5.1V 5% PD=1W IR=10UA	28480	1902-0579	
A12CR9	1902-0579	3		DIODE-ZNR 5.1V 5% PD=1W IR=10UA	28480	1902-0579	
A12CR10	1901-0040	1	2	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A12CR11	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A12F1	2110-0218	9	2	FUSE .1A 250V .25X.27	28480	2110-0218	
A12F2	2110-0218	9		FUSE .1A 250V .25X.27	28480	2110-0218	
A12K1	0490-1262	7	2	RELAY 2C 12VDC-COIL 2A 120VAC	28480	0490-1262	
A12K2	0490-1262	7		RELAY 2C 12VDC-COIL 2A 120VAC	28480	0490-1262	
A12L1	9100-1639	6	2	INDUCTOR RF-CH-MLD 150UH 5% .166DX.385LG	28480	9100-1639	
A12L2	9140-0138	2	2	INDUCTOR RF-CH-MLD 180UH 5% .166DX.385LG	28480	9140-0138	
A12L3	9140-0138	2		INDUCTOR RF-CH-MLD 180UH 5% .166DX.385LG	28480	9140-0138	
A12L4	9100-1639	6		INDUCTOR RF-CH-MLD 150UH 5% .166DX.385LG	28480	9100-1639	
A12Q1	1853-0036	2	3	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A12Q2	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A12Q3	1854-0215	1	4	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904	
A12Q4	1854-0477	7	4	TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A	
A12Q5	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A	
A12Q6	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A	
A12Q7	1855-0020	8	1	TRANSISTOR J-FET N-CHAN D-MODE TO-18 SI	28480	1855-0020	
A12Q8	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A	
A12Q9	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904	
A12Q10	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A12Q11	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904	
A12Q12	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904	
A12R1	1810-0318	3	1	NETWORK-RES 6-SIP1.0K OHM X 5	01121	206A102	
A12R2	0698-3150	6	5	RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F	
A12R3	0698-3150	6		RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F	
A12R4	0698-3150	6		RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F	
A12R5	0757-0403	2	3	RESISTOR 121 1% .125W F TC=0+-100	24546	C4-1/8-T0-121R-F	
A12R6	0698-8812	7	1	RESISTOR 1 1% .125W F TC=0+-100	28480	0698-8812	
A12R7	0698-3444	1	2	RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F	
A12R8	0698-3444	1		RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F	
A12R9	0757-0419	0	2	RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F	
A12R10	0757-0419	0		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A12R11	0757-0279	0	2	RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F	
A12R12	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F	
A12R14	0698-3155	1	1	RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A12R15	0757-0416	7	7	RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A12R16	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A12R17	0757-0442	9	4	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A12R18	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A12R19	0698-0085	0	1	RESISTOR 2.61K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2611-F	
A12R21	0757-0280	3	8	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A12R22	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A12R23	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A12R24	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A12R25	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A12R26	0698-3150	6		RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F	
A12R27	0698-3150	6		RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F	
A12R28	0698-3446	3	2	RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F	
A12R29	0698-3446	3		RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F	
A12R30	0757-0420	3	2	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F	
A12R31	0757-0420	3		RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F	
A12R32	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A12R32	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A12R33	0757-0465	6	2	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F	
A12R34	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A12R35	0698-0084	9	3	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A12R36	0757-0449	6	1	RESISTOR 20K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2002-F	
A12R37	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A12R38	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A12R39	0757-0728	4	1	RESISTOR 619 1% .25W F TC=0+-100	24546	C5-1/4-T0-619R-F	
A12R40	0757-0403	2		RESISTOR 121 1% .125W F TC=0+-100	24546	C4-1/8-T0-121R-F	
A12R41	0757-0403	2		RESISTOR 121 1% .125W F TC=0+-100	24546	C4-1/8-T0-121R-F	
A12R42	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A12R43	0757-0402	1	1	RESISTOR 110 1% .125W F TC=0+-100	24546	C4-1/8-T0-111-F	
A12R44	0757-0276	7	1	RESISTOR 61.9 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F	
A12R45	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A12R46	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A12R47	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A12R48	0757-0394	0	1	RESISTOR 51.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-51R1-F	
A12R49	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	A
A12R50	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A12R51	0757-0379	1	1	RESISTOR 12.1 1% .125W F TC=0+-100	19701	MF4C1/8-T0-12R1-F	
A12R52	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A12R53	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F	
A12T1	15506-80001	7	1	TRANSFORMER ASSEMBLY	28480	15506-80001	
A12T2	03779-80059	5	1	TRANSFORMER ASSEMBLY	28480	03779-80089	
A12U101	1820-1211	8	1	IC GATE TTL LS EXCL-OR QUAD 2-INP	01295	SN74LS86N	
A12U108	1820-0803	2	1	IC GATE ECL OR-NOR TPL	04713	MC10105P	
A12U111	1820-0475	4	3	IC COMPARATOR HS TO-99 PKG	27014	LM306H	
A12U201	1820-1112	8	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A12U202	1820-1197	9	2	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A12U203	03776-80030	3	1	PROM	28480	03776-80030	
A12U203B	1200-0639	8	1	SOCKET-IC 20-CONT DIP DIP-SLDR	28480	1200-0639	
A12U204	1820-1208	3	1	IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A12U205	1820-1201	6	1	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A12U206	1820-1300	6	2	IC SHF-RGTR TTL LS R-S PRL-IN PRL-OUT	01295	SN74LS195AN	
A12U207	1820-1300	6		IC SHF-RGTR TTL LS R-S PRL-IN PRL-OUT	01295	SN74LS195AN	
A12U208	1820-1433	6	2	IC SHF-RGTR TTL LS R-S SERIAL-IN PRL-OUT	01295	SN74LS164N	
A12U209	1820-1053	6	1	IC SCHMITT-TRIG TTL INV HEX	01295	SN7414N	
A12U210	1820-1282	3	2	IC FF TTL LS J-K BAR POS-EDGE-TRIG	01295	SN74LS109AN	
A12U211	1820-0475	4		IC COMPARATOR HS TO-99 PKG	27014	LM306H	
A12U301	1820-1282	3		IC FF TTL LS J-K BAR POS-EDGE-TRIG	01295	SN74LS109AN	
A12U302	1820-1199	1	1	IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A12U303	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A12U304	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A12U305	1820-1432	5	3	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A12U306	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A12U307	1820-1432	5		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS163AN	
A12U308	1820-1244	7	1	IC MUXR/DATA-SEL TTL LS 4-TO-1-LINE DUAL	01295	SN74LS153N	
A12U310	1820-0475	4		IC COMPARATOR HS TO-99 PKG	27014	LM306H	
A12U401	1820-0513	1	1	IC GATE TTL AND QUAD 2-INP	01295	SN7409N	
A12U402	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A12U403	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A12U404	1820-1858	9	1	IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N	
A12U405	1820-2384	8	3	IC RGTR TTL LS D-TYPE 2-INP 4-BIT	01295	SN74LS399N	
A12U406	1820-2384	8		IC RGTR TTL LS D-TYPE 2-INP 4-BIT	01295	SN74LS399N	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A12U407	1820-2384	8		IC RGTR TTL LS D-TYPE 2-INP 4-BIT	01295	SN74LS399N	
A12U408	1820-1433	6		IC SHF-RGTR TTL LS R-S SERIAL-IN PRL-OUT	01295	SN74LS164N	
A12U501	1820-1422	3	1	IC MV TTL LS MONOSTBL RETRIG	01295	SN74LS122N	
A12U502	1820-1203	8	1	IC GATE TTL LS AND TPL 3-INP	01295	SN74LS11N	A
MSC	1480-0116	8	2	PIN-GRV .062-IN DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0749	4	1	EXTR-PC BD BRN POLYC .062-BD-THKNS	28480	4040-0749	
MSC	4040-0750	7	1	EXTR-PC BD RED POLYC .062-BD-THKNS	28480	4040-0750	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A13	03776-60013	0	1	PROCESSOR ASSEMBLY	28480	03776-60013	
A13C1	0121-0036	0	1	CAPACITOR-V TRMR-CER 5.5-18PF 350V	52763	304324 5.5/18PF NPO	
A13C2	0160-4492	2	1	CAPACITOR-FXD 18PF +-5% 200VDC CER 0+-30	28480	0160-4492	
A13C3	0180-2818	4	1	CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A13C4	0160-4031	5	1	CAPACITOR-FXD 330PF +-5% 100VDC CER	28480	0160-4031	
A13C5	0180-0197	8	2	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A13C6	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A13C7	0160-0576	5	15	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C19	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C20	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C21	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A13C22	0160-4385	2	1	CAPACITOR-FXD 15PF +-5% 200VDC CER 0+-30	28480	0160-4385	
A13CR1	1990-0485	5	5	LED-LAMP LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984	
A13CR2	1990-0485	5		LED-LAMP LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984	
A13CR3	1990-0485	5		LED-LAMP LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984	
A13CR4	1990-0485	5		LED-LAMP LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984	
A13CR5	1990-0485	5		LED-LAMP LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984	
A13CR6	1990-0450	4	5	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A13CR7	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A13CR8	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A13CR9	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A13CR10	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A13R1	0698-3429	2	2	RESISTOR 19.6 1% .125W F TC=0+-100	03888	PME55-1/8-T0-19R6-F	
A13R2	0698-3429	2		RESISTOR 19.6 1% .125W F TC=0+-100	03888	PME55-1/8-T0-19R6-F	A
A13R3	0757-0462	3	2	RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F	
A13R4	0757-0462	3		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F	
A13R5	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A13R6	1810-0280	8	2	NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103	
A13R7	1810-0365	0	2	NETWORK-RES 6-SIP2.2K OHM X 5	01121	206A222	
A13R8	1810-0364	9	2	NETWORK-RES 6-SIP470.0 OHM X 5	01121	206A471	
A13R9	1810-0364	9		NETWORK-RES 6-SIP470.0 OHM X 5	01121	206A471	
A13R10	1810-0365	0		NETWORK-RES 6-SIP2.2K OHM X 5	01121	206A222	
A13R11	1810-0280	8		NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103	
A13S1	3101-2288	9	1	SWITCH-PB SPDT MOM .25A 115VAC RED BTN	28480	3101-2288	
A13S2	3101-2340	4	1	SWITCH-RKR DIP-RKR-ASSY 5-1A .05A 30VDC	28480	3101-2340	
A13TL1	1258-0177	0	1	SHUNT-PROGRAM	28480	1258-0177	
	1200-0607	0	1	SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0607	
A13TL2	1258-0124	7	2	PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	
A13TL3	1258-0124	7		PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	
A13U10	1820-2592	0	1	IC OSC TTL LS	01295	SN74LS320N	
A13U11	1820-1200	5	1	IC INV TTL LS HEX	01295	SN74LS05N	
A13U12	1820-1425	6	1	IC SCHMITT-TRIG TTL LS NAND QUAD 2-INP	01295	SN74LS132N	
A13U13	1820-1782	8	1	IC MV TTL S MONOSTBL RETRIG/RESET DUAL	34335	AM26S02PC	
A13U20	1820-2036	7	1	IC DRVR NMOS CLOCK DRVR	04713	MC6875L	
A13U21	1820-1199	1	2	IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A13U22	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A13U23	1820-1211	8	1	IC GATE TTL LS EXCL-OR QUAD 2-INP	01295	SN74LS86N	
A13U24	1820-2081	2	1	IC NMOS	04713	MC68A21P	
A13U25	1818-1611	7	1	IC CMOS 16384 (16K) STAT RAM 150-NS 3-S	S4013	HM6116P-3	
A13U31	1820-2293	8	1	IC-MPU; CLK FREQ=2MHZ	28480	1820-2293	
A13U31B	1200-0654	7	1	SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654	
A13U33	1820-1202	7	1	IC GATE TTL LS NAND TPL 3 INP	01295	SN74LS10N	
A13U34	1820-1203	8	1	IC GATE TTL LS AND TPL 3-INP	01295	SN74LS11N	
A13U35	1820-1208	3	1	IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A13U36	03776-80054	1	1	PROM	28480	03776-80054	
	1200-0567	1	1	SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A13U43	1820-1440	5	1	IC LCH TTL LS QUAD	01295	SN74LS279N	
A13U44	1820-1210	7	1	IC GATE TTL LS AND-OR-INV DUAL 2-INP	01295	SN74LS51N	
A13U51	1820-2024	3	3	IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N	

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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A13U52	1820-2075	4	3	IC MISC TTL LS	01295	SN74LS245N	
A13U54	1820-1273	2	1	IC BFR TTL LS NOR QUAD 2-INP	01295	SN74LS28N	
A13U55	1820-2748	8	1	IC-GPIB TALKER/LISTENER (E-VERSION)	28480	1820-2748	
A13U61	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N	
A13U62	1820-2075	4		IC MISC TTL LS	01295	SN74LS245N	
A13U63	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A13U64	1820-1281	2	1	IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS139N	
A13U65	1820-2424	7	2	IC MISC TTL OCTL	04713	MC3447P	
A13U71	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N	
A13U72	1820-2075	4		IC MISC TTL LS	01295	SN74LS245N	A
A13U73	1820-1207	2	1	IC GATE TTL LS NAND 8-INP	01295	SN74LS30N	
A13U75	1820-2424	7		IC MISC TTL OCTL	04713	MC3447P	
A13Y1	0410-0555	1	1	CRYSTAL-QUARTZ 8.192 MHZ	28480	0410-0555	
	1200-0950	6	1	SOCKET-XTAL 2-CONT PC	28480	1200-0950	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0749	4	1	EXTR-PC BD BRN POLYC .062-BD-THKNS	28480	4040-0749	
MSC	4040-0751	8	1	EXTR-PC BD ORN POLYC .062-BD-THKNS	28480	4040-0751	

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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A113	03776-60113	1	1	PROCESSOR ASSEMBLY	28480	03776-60113	
A113C1	0121-0036	0	1	CAPACITOR-V TRMR-CER 5.5-18PF 350V	52763	304324 5.5/18PF NPO	
A113C2	0160-4492	2	1	CAPACITOR-FXD 18PF +-5% 200VDC CER 0+-30	28480	0160-4492	
A113C3	0180-2818	4	1	CAPACITOR-FXD 2.2UF+-20% 35VDC TA	28480	0180-2818	
A113C4	0160-4031	5	1	CAPACITOR-FXD 330PF +-5% 100VDC CER	28480	0160-4031	
A113C5	0180-0197	8	2	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A113C6	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A113C7	0160-0576	5	15	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C18	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C19	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C20	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C21	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A113C22	0160-4385	2	1	CAPACITOR-FXD 15PF +-5% 200VDC CER 0+-30	28480	0160-4385	
A113CR1	1990-0485	5	5	LED-LAMP LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984	
A113CR2	1990-0485	5		LED-LAMP LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984	
A113CR3	1990-0485	5		LED-LAMP LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984	
A113CR4	1990-0485	5		LED-LAMP LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984	
A113CR5	1990-0485	5		LED-LAMP LUM-INT=800UCD IF=30MA-MAX	28480	5082-4984	
A113CR6	1990-0450	4	5	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A113CR7	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A113CR8	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A113CR9	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A113CR10	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A113R1	0698-3429	2	2	RESISTOR 19.6 1% .125W F TC=0+-100	03888	PME55-1/8-T0-19R6-F	
A113R2	0698-3429	2		RESISTOR 19.6 1% .125W F TC=0+-100	03888	PME55-1/8-T0-19R6-F	
A113R3	0757-0462	3	2	RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F	B
A113R4	0757-0462	3		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F	
A113R5	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A113R6	1810-0280	8	2	NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103	
A113R7	1810-0365	0	2	NETWORK-RES 6-SIP2.2K OHM X 5	01121	206A222	
A113R8	1810-0364	9	2	NETWORK-RES 6-SIP470.0 OHM X 5	01121	206A471	
A113R9	1810-0364	9		NETWORK-RES 6-SIP470.0 OHM X 5	01121	206A471	
A113R10	1810-0365	0		NETWORK-RES 6-SIP2.2K OHM X 5	01121	206A222	
A113R11	1810-0280	8		NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103	
A113S1	3101-2288	9	1	SWITCH-PB SPDT MOM .25A 115VAC RED BTN	28480	3101-2288	
A113S2	3101-2340	4	1	SWITCH-RKR DIP-RKR-ASSY 5-1A .05A 30VDC	28480	3101-2340	
A113TL1	1258-0177	0	1	SHUNT-PROGRAM	28480	1258-0177	
	1200-0607	0	1	SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0607	
A113TL2	1258-0124	7	2	PIN-PROGRAMING DUMPER .30 CONTACT	71506	8136-475G1	
A113TL3	1258-0124	7		PIN-PROGRAMING DUMPER .30 CONTACT	71506	8136-475G1	
A113U10	1820-2592	0	1	IC OSC TTL LS	01295	SN74LS320N	
A113U11	1820-1200	5	1	IC INV TTL LS HEX	01295	SN74LS05N	
A113U12	1820-1425	6	1	IC SCHMITT-TRIG TTL LS NAND QUAD 2-INP	01295	SN74LS132N	
A113U13	1820-1792	8	1	IC MV TTL S MONOSTBL RETRIG/RESET DUAL	34335	AM26S02PC	
A113U20	1820-2036	7	1	IC DRVR NMOS CLOCK DRVR	04713	MC6875L	
A113U21	1820-1199	1	2	IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A113U22	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N	
A113U23	1820-1211	8	1	IC GATE TTL LS EXCL-OR QUAD 2-INP	01295	SN74LS86N	
A113U24	1820-2081	2	1	IC NMOS	04713	MC68A21P	
A113U25	1818-1611	7	1	IC CMOS 16384 (16K) STAT RAM 150-NS 3-S	54013	HM6116P-3	
A113U31	1820-2293	8	1	IC-MPU; CLK FREQ=2MHZ	28480	1820-2293	
	1200-0654	7	1	SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654	
A113U33	1820-1202	7	1	IC GATE TTL LS NAND TPL 3-INP	01295	SN74LS10N	
A113U34	1820-1203	8	1	IC GATE TTL LS AND TPL 3-INP	01295	SN74LS11N	
A113U35	1820-1208	3	1	IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A113U36	03776-80054	1	1	PROM	28480	03776-80054	
	1200-0567	1	1	SOCKET-IC 20-CONT DIP DIP-SLDR	28480	1200-0567	
A113U43	1820-1440	5	1	IC LCH TTL LS QUAD	01295	SN74LS279N	
A113U44	1820-1210	7	1	IC GATE TTL LS AND-OR-INV DUAL 2-INP	01295	SN74LS51N	
A113U51	1820-2024	3	3	IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A113U52	1820-2075	4	3	IC MISC TTL LS	01295	SN74LS245N	
A113U54	1820-1273	2	1	IC BFR TTL LS NOR QUAD 2-INP	01295	SN74LS28N	
A113U55	1820-2748	8	1	IC GPIB TALKER/LISTENER (E VERSION)	28480	1820-2748	
A113U61	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N	
A113U62	1820-2075	4		IC MISC TTL LS	01295	SN74LS245N	
A113U63	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A113U64	1820-1281	2	1	IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS139N	
A113U65	1820-2424	7	2	IC MISC TTL OCTL	04713	MC3447P	
A113U71	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N	
A113U72	1820-2075	4		IC MISC TTL LS	01295	SN74LS245N	B
A113U73	1820-1207	2	1	IC GATE TTL LS NAND 8-INP	01295	SN74LS30N	
A113U75	1820-2424	7		IC MISC TTL OCTL	04713	MC3447P	
A113Y1	0410-1406	3	1	CRYSTAL QUARTZ 9.2640MHz	28480	0410-1406	
	1200-0950	6	1	SOCKET-XTAL 2-CONT PC	28480	1200-0950	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0749	4	1	EXTR-PC BD BRN POLYC .062-BD-THKNS	28480	4040-0749	
MSC	4040-0751	8	1	EXTR-PC BD ORN POLYC .062-BD-THKNS	28480	4040-0751	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A14	03776-60014	1	1	MEMORY ASSEMBLY	28480	03776-60014	
A14BT1	03776-60014	4	1	BATTERY 2.8V .85A-HR LI/S-DIOX PIN	28480	1420-0275	
A14C1	0180-0197	8	1	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A14C2	0180-0291	3	1	CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2	
A14C3	0160-3878	6	1	CAPACITOR-FXD 1000PF +-20% 100VDC CER	28480	0160-3878	
A14C4	0160-0576	5	13	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A14C5	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A14C6	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A14C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A14C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A14C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A14C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A14C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A14C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A14C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A14C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A14C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A14C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A14CR1	1902-0948	0	1	DIODE-ZNR 3.9V 5% DO-35 PD=.4W TC=-.012%	28480	1902-0948	
A14CR2	1901-0518	8	1	DIODE-SM SIG SCHOTTKY	28480	1901-0518	
A14Q1	1854-0215	1	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904	
A14Q2	1853-0036	2	1	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A14R1	0757-0401	0	1	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F	
A14R2	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A14R3	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A14R4	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A14R5	0698-3970	8	1	RESISTOR 2.61M 1% .125W F TC=0+-100	28480	0698-3970	
A14TL1	1258-0124	7	1	PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	A
A14U12	03776-80056	3	1	PROM	28480	03776-80056	
	1200-0567	1	10	SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A14U13	03776-80055	2	1	PROM	28480	03776-80055	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A14U21	03776-80062	1	1	PROM	28480	03776-80062	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A14U22	03776-80058	5	1	PROM	28480	03776-80058	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A14U23	03776-80067	6	1	PROM	28480	03776-80067	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A14U31	03776-80063	2	1	PROM	28480	03776-80063	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A14U32	03776-80059	6	1	PROM	28480	03776-80059	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A14U33	1818-1611	7	1	IC CMOS 16384 (16K) STAT RAM 150-NS 3-S	S4013	HM6116P-3	
A14U34	1820-1197	9	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A14U35	1820-1216	3	3	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A14U41	03776-80064	3	1	PROM	28480	03776-80064	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A14U42	03776-80060	9	1	PROM	28480	03776-80060	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A14U43	1818-1981	4	1	IC-RAM 5516 APL	28480	1818-1981	
A14U45	1820-1195	7	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N	
A14U54	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A14U55	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
MSC	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0749	4	1	EXTR-PC BD BRN POLYC .062-BD-THKNS	28480	4040-0749	
MSC	4040-0752	9	1	EXTR-PC BD YEL POLYC .062-BD-THKNS	28480	4040-0752	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A114	03776-60114	2	1	MEMORY ASSEMBLY	28480	03776-60114	
A114BT1	03776-60014	4	1	BATTERY 2.8V .85A-HR LI/S-DIOX PIN	28480	1420-0275	
A114C1	0180-0197	8	1	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A114C2	0180-0291	3	1	CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2	
A114C3	0160-3878	6	1	CAPACITOR-FXD 1000PF +-20% 100VDC CER	28480	0160-3878	
A114C4	0160-0576	5	13	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A114C5	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A114C6	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A114C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A114C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A114C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A114C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A114C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A114C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A114C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A114C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A114C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A114C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A114CR1	1902-0948	0	1	DIODE-ZNR 3.9V 5% DO-35 PD=.4W TC=-.012%	28480	1902-0948	
A114CR2	1901-0518	8	1	DIODE-SM SIG SCHOTTKY	28480	1901-0518	
A114Q1	1854-0215	1	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904	
A114Q2	1853-0036	2	1	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A114R1	0757-0401	0	1	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F	
A114R2	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A114R3	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A114R4	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A114R5	0698-3970	8	1	RESISTOR 2.61M 1% .125W F TC=0+-100	28480	0698-3970	
A114TL1	1258-0124	7	1	PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	B
A114U12	03776-80057	4	1	PROM	28480	03776-80057	
	1200-0567	1	10	SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A114U13	03776-80055	2	1	PROM	28480	03776-80055	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A114U21	03776-80062	1	1	PROM	28480	03776-80062	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A114U22	03776-80058	5	1	PROM	28480	03776-80058	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A114U23	03776-80067	6	1	PROM	28480	03776-80067	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A114U31	03776-80063	2	1	PROM	28480	03776-80063	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A114U32	03776-80059	6	1	PROM	28480	03776-80059	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A114U33	1818-1611	7	1	IC CMOS 16384 (16K) STAT RAM 150-NS 3-S	S4013	HM6116P-3	
A114U34	1820-1197	9	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A114U35	1820-1216	3	3	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A114U41	03776-80064	3	1	PROM	28480	03776-80064	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A114U42	03776-80060	9	1	PROM	28480	03776-80060	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A114U43	1818-1981	4	1	IC-RAM 5516 APL	28480	1818-1981	
A114U45	1820-1195	7	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N	
A114U54	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A114U55	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
MSC	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0749	4	1	EXTR-PC BD BRN POLYC .062-BD-THKNS	28480	4040-0749	
MSC	4040-0752	9	1	EXTR-PC BD YEL POLYC .062-BD-THKNS	28480	4040-0752	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A214	03776-60214	3	1	MEMORY ASSEMBLY OPT 002(JAPANESE OPTION)	28480	03776-60214	002 (B)
A214BT1	03776-60014	4	1	BATTERY 2.8V .85A-HR LI/S-DIOX PIN	28480	1420-0275	
A214C1	0180-0197	8	1	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A214C2	0180-0291	3	1	CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2	
A214C3	0160-3878	6	1	CAPACITOR-FXD 1000PF +-20% 100VDC CER	28480	0160-3878	
A214C4	0160-0576	5	13	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A214C5	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A214C6	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A214C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A214C8	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A214C9	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A214C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A214C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A214C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A214C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A214C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A214C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A214C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A214CR1	1902-0948	0	1	DIODE-ZNR 3.9V 5% DO-35 PD=.4W TC=-.012%	28480	1902-0948	
A214CR2	1901-0518	8	1	DIODE-SM SIG SCHOTTKY	28480	1901-0518	
A214Q1	1854-0215	1	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904	
A214Q2	1853-0036	2	1	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A214R1	0757-0401	0	1	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F	
A214R2	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A214R3	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A214R4	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A214R5	0698-3970	8	1	RESISTOR 2.61M 1% .125W F TC=0+-100	28480	0698-3970	
A214TL1	1258-0124	7	1	PIN-PROGRAMING DUMPER .30 CONTACT	91506	8136-475G1	
A214U12	03776-80068	7	1	PROM	28480	03776-80068	
	1200-0567	1	10	SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A214U13	03776-80055	2	1	PROM	28480	03776-80055	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A214U21	03776-80062	1	1	PROM	28480	03776-80062	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A214U22	03776-80058	5	1	PROM	28480	03776-80058	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A214U23	03776-80067	6	1	PROM	28480	03776-80067	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A214U31	03776-80063	2	1	PROM	28480	03776-80063	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A214U32	03776-80059	6	1	PROM	28480	03776-80059	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A214U33	1818-1611	7	1	IC CMOS 16384 (16K) STAT RAM 150-NS 3 S	34313	HM6116P-3	
A214U34	1820-1197	9	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A214U35	1820-1216	3	3	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A214U41	03776-80064	3	1	PROM	28480	03776-80064	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A214U42	03776-80060	9	1	PROM	28480	03776-80060	
	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
A214U43	1818-1981	4	1	IC-RAM 5516 APL	28480	1818-1981	
A214U45	1820-1195	7	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N	
A214U54	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A214U55	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
MSC	1200-0567	1		SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0749	4	1	EXTR-PC BD BRN POLYC .062-BD-THKNS	28480	4040-0749	
MSC	4040-0752	9	1	EXTR-PC BD YEL POLYC .062-BD-THKNS	28480	4040-0752	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A15	03776-60015	2	1	POWER SUPPLY CONTROLLER ASSEMBLY	28480	03776-60015	
A15C1	0180-2698	8	2	CAPACITOR-FXD 4.7UF+-10% 35VDC TA	28480	0180-2698	
A15C2	0180-2500	1	3	CAPACITOR-FXD 1500UF+50-10% 16VDC AL	37942	TT152U016G1C3P	
A15C3	0180-2500	1		CAPACITOR-FXD 1500UF+50-10% 16VDC AL	37942	TT152U016G1C3P	
A15C4	0180-2500	1		CAPACITOR-FXD 1500UF+50-10% 16VDC AL	37942	TT152U016G1C3P	
A15C5	0180-2662	6	2	CAPACITOR-FXD 10UF+-10% 10VDC TA	25088	D4R7GS1A10K	
A15C6	0160-0574	3	1	CAPACITOR-FXD .022UF +-20% 100VDC CER	28480	0160-0574	
A15C7	0160-3740	1	2	CAPACITOR-FXD .22UF +-5% 63VDC MET-POLYC	28480	0160-3740	
A15C8	0160-0576	5	13	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A15C9	0180-0474	4	1	CAPACITOR-FXD 15UF+-10% 20VDC TA	28480	0180-0474	
A15C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A15C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A15C12	0160-0571	0	2	CAPACITOR-FXD 470PF +-20% 100VDC CER	28480	0160-0571	
A15C13	0160-0207	9	1	CAPACITOR-FXD .01UF +-5% 200VDC POLYE	28480	0160-0207	
A15C14	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A15C15	0160-3508	9	1	CAPACITOR-FXD 1UF +80-20% 50VDC CER	28480	0160-3508	
A15C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A15C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A15C18	0160-3740	1		CAPACITOR-FXD .22UF +-5% 63VDC MET-POLYC	28480	0160-3740	
A15C19	0180-2662	6		CAPACITOR-FXD 10UF+-10% 10VDC TA	25088	D4R7GS1A10K	
A15C20	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A15C21	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A15C22	0160-0571	0		CAPACITOR-FXD 470PF +-20% 100VDC CER	28480	0160-0571	
A15C23	0160-3877	5	1	CAPACITOR-FXD 100PF +-20% 200VDC CER	28480	0160-3877	
A15C24	0180-2698	8		CAPACITOR-FXD 4.7UF+-10% 35VDC TA	28480	0180-2698	
A15C25	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A15C26	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A15C27	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A15C28	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A15C29	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A15CR1	1990-0450	4	3	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A15CR2	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A15CR3	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A15CR4	1906-0096	7	2	DIODE-FW BRDG 200V 2A	04713	MDA202	
A15CR5	1906-0096	7		DIODE-FW BRDG 200V 2A	04713	MDA202	
A15CR6	1902-0957	1	1	DIODE-ZNR 9.1V 5% DO-35 PD=.4W TC=+.069%	28480	1902-0957	
A15CR7	1901-0040	1	7	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A15CR8	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A15CR9	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A15CR10	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A15CR11	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A15CR12	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A15CR13	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A15CR14	1902-0950	4	1	DIODE-ZNR 4.7V 5% DO-35 PD=.4W TC=+.025%	28480	1902-0950	
A15CR15	1902-0970	8	1	DIODE-ZNR 33V 5% DO-35 PD=.4W TC=+.097%	28480	1902-0970	
A15CR16	1902-0963	9	1	DIODE-ZNR 16V 5% DO-35 PD=.4W TC=+.088%	28480	1902-0963	
A15CR17	1902-0964	0	1	DIODE-ZNR 18V 5% DO-35 PD=.4W TC=+.07%	28480	1902-0964	
A15F1	2110-0007	4	1	FUSE 1A 250V TD 1.25X.25 UL	75915	313001	
A15L1	9100-3560	6	2	INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	28480	9100-3560	
A15L2	9100-3560	6		INDUCTOR RF-CH-MLD 5.6UH 5% .166DX.385LG	28480	9100-3560	
A15Q1	1854-0634	8	1	TRANSISTOR NPN SI PD=1W FT=50MHZ	04713	MPS-U01	
A15Q2	1854-0477	7	2	TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A	
A15Q3	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A	
A15R2	0757-0280	3	15	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R3	0698-3441	8	2	RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F	
A15R4	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F	
A15R5	0698-3444	1	2	RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F	
A15R6	0757-0442	9	11	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A15R7	0698-3154	0	2	RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F	
A15R8	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F	
A15R9	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A15R10	0757-0438	3	2	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A15R11	0698-3159	5	1	RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F	
A15R12	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R13	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R14	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R15	0698-3155	1	14	RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R16	0757-0462	3	1	RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F	
A15R17	0698-3260	9	2	RESISTOR 464K 1% .125W F TC=0+-100	28480	0698-3260	
A15R18	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R19	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R20	0757-0461	2	1	RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F	
A15R21	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A15R22	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A15R23	0757-0428	1	3	RESISTOR 1.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1621-F	
A15R24	0698-3444	1		RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F	
A15R25	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R26	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R27	0757-0428	1		RESISTOR 1.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1621-F	
A15R28	0757-0428	1		RESISTOR 1.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1621-F	
A15R29	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R30	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R31	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R32	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R33	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R34	0698-3150	6	1	RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F	
A15R35	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A15R36	0757-0465	6	3	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F	
A15R37	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R38	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R39	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F	
A15R40	0698-8827	4	1	RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827	
A15R41	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A15R43	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R44	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R45	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A15R46	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R47	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R48	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R49	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A15R50	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R51	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R52	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A15R53	0757-0394	0	1	RESISTOR 51.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-51R1-F	
A15R54	0698-0084	9	1	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A15R55	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A15R56	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R57	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A15R58	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F	
A15R59	0757-0317	7	1	RESISTOR 1.33K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1331-F	
A15R60	0698-3136	8	1	RESISTOR 17.8K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1782-F	
A15R61	0837-0121	1	1	THERMISTOR BEAD 10K-OHM TC=-4.27%/C-DEG	28480	0837-0121	
A15R62	0698-3446	3	1	RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F	
A15R63	0698-3492	9	1	RESISTOR 2.67K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2671-F	
A15R64	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R65	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R66	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R67	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F	
A15R68	0698-3260	9		RESISTOR 464K 1% .125W F TC=0+-100	28480	0698-3260	
A15R69	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A15R70	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A15R71	0698-3266	5	1	RESISTOR 237K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2373-F	
A15RV1	2100-3351	6	1	RESISTOR-TRMR 500 10% C SIDE-ADJ 1-TRN	28480	2100-3351	
A15U1	1251-4352	7	1	CONNECTOR 4-PIN M POST TYPE	28480	1251-4352	
A15U13	1826-0122	0	1	IC 7805 V RGLTR TO-220	07263	7805UC	
A15U33	1826-0428	9	1	IC 3524 MODULATOR 16-DIP-C	01295	SG3524J	
A15U35	1820-1112	8	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A15U36	1826-0180	0	1	IC TIMER TTL MONO/ASTBL	01295	NE555P	
A15U37	1826-0138	8	3	IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A15U53	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A15U54	1820-1198	0	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS03N	
A15U55	1820-1416	5	1	IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N	
A15U56	1826-0138	8		IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N	
A15U58	1826-0393	7	1	IC V RGLTR TO-220	27014	LM317T	
	1205-0331	7	1	HEAT SINK SGL TO-220-CS	28480	1205-0331	
MSC	1480-0116	8	2	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	2110-0269	0	4	FUSEHOLDER-CLIP TYPE.250-FUSE	28480	2110-0269	
MSC	4040-0749	4	1	EXTR-PC BD BRN POLYC .062-BD-THKNS	28480	4040-0749	
MSC	4040-0753	0	1	EXTR-PC BD GRN POLYC .062-BD-THKNS	28480	4040-0753	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A16	03776-60016	3	1	POWER SUPPLY CONVERTER ASSEMBLY	28480	03776-60016	
A16C1	0160-5051	1	2	CAPACITOR-FXD 2.2UF +-10% 250VDC	28480	0160-5051	
A16C2	0160-5051	1		CAPACITOR-FXD 2.2UF +-10% 250VDC	28480	0160-5051	
A16C3	0160-2142	5	1	CAPACITOR-FXD 1500PF +100-0% 500VDC CER	28480	0160-2142	
A16C4	0160-3800	4	1	CAPACITOR-FXD 5000PF +-20% 3KVDC CER	28480	0160-3800	
A16C5	0160-2144	7	2	CAPACITOR-FXD 3300PF +80-20% 1KVDC CER	28480	0160-2144	
A16C6	0160-2144	7		CAPACITOR-FXD 3300PF +80-20% 1KVDC CER	28480	0160-2144	
A16C7	0160-0160	3	2	CAPACITOR-FXD 8200PF +-10% 200VDC POLYE	28480	0160-0160	
A16C8	0160-0160	3		CAPACITOR-FXD 8200PF +-10% 200VDC POLYE	28480	0160-0160	
A16C9	0160-3486	2	2	CAPACITOR-FXD .47UF +80-20% 50VDC CER	28480	0160-3486	
A16C10	0160-3486	2		CAPACITOR-FXD .47UF +80-20% 50VDC CER	28480	0160-3486	
A16C11	0160-0576	5	4	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A16C12	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A16C13	0180-2662	6	2	CAPACITOR-FXD 10UF+-10% 10VDC TA	25088	D4R7GS1A10K	
A16C14	0180-2662	6		CAPACITOR-FXD 10UF+-10% 10VDC TA	25088	D4R7GS1A10K	
A16C15	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A16C16	0180-0418	6	1	CAPACITOR-FXD 1UF+-20% 35VDC TA	28480	0180-0418	
A16C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A16C18	0180-2208	6	1	CAPACITOR-FXD 220UF+-10% 10VDC TA	56289	150D227X9010S2	
A16C19	0180-0643	9	2	CAPACITOR-FXD 2200UF+50-10% 10VDC AL	80795	EN12.12	
A16C20	0180-0643	9		CAPACITOR-FXD 2200UF+50-10% 10VDC AL	80795	EN12.12	
A16C21	0180-2698	8	2	CAPACITOR-FXD 4.7UF+-10% 35VDC TA	28480	0180-2698	
A16C22	0180-2698	8		CAPACITOR-FXD 4.7UF+-10% 35VDC TA	28480	0180-2698	
A16C23	0180-2811	7	2	CAPACITOR-FXD 10UF+-20% 35VDC TA	28480	0180-2811	
A16C24	0180-2811	7		CAPACITOR-FXD 10UF+-20% 35VDC TA	28480	0180-2811	
A16C25	0180-0097	7	2	CAPACITOR-FXD 47UF+-10% 35VDC TA	56289	150D476X9035S2	
A16C26	0180-0097	7		CAPACITOR-FXD 47UF+-10% 35VDC TA	56289	150D476X9035S2	
A16CR1	1901-0732	8	2	DIODE-PWR RECT 1KV 1A	28480	1901-0732	
A16CR2	1901-0732	8		DIODE-PWR RECT 1KV 1A	28480	1901-0732	
A16CR3	1901-1095	8	2	DIODE-PWR RECT 40V 15A DO-4	04713	MBR1540	
A16CR3B	1200-0080	3	2	INSULATOR-DIO ALUMINUM HD-ANDZ	28480	1200-0080	
A16CR3C	2190-0860	5	2	WASHER-FL NM NO. 10 .188-IN-ID	28480	2190-0860	
A16CR4	1901-1095	8		DIODE-PWR RECT 40V 15A DO-4	04713	MBR1540	
A16CR4B	1200-0080	3		INSULATOR-DIO ALUMINUM HD-ANDZ	28480	1200-0080	
A16CR4C	2190-0860	5		WASHER-FL NM NO. 10 .188-IN-ID	28480	2190-0860	
A16CR5	1901-0692	9	4	DIODE-PWR RECT 200V 3A 200NS	04713	MR852	
A16CR6	1901-0692	9		DIODE-PWR RECT 200V 3A 200NS	04713	MR852	
A16CR7	1901-0692	9		DIODE-PWR RECT 200V 3A 200NS	04713	MR852	
A16CR8	1901-0692	9		DIODE-PWR RECT 200V 3A 200NS	04713	MR852	
A16CR9	1902-0943	5	2	DIODE-ZNR 2.4V 5% DO-35 PD=.4W TC=-.037%	28480	1902-0943	
A16CR10	1902-0943	5		DIODE-ZNR 2.4V 5% DO-35 PD=.4W TC=-.037%	28480	1902-0943	
A16CR11	1901-0050	3	6	DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050	
A16CR12	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050	
A16CR13	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050	
A16CR14	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050	
A16CR15	1901-0347	1	2	DIODE-SM SIG SCHOTTKY	28480	1901-0347	
A16CR16	1902-0951	5	2	DIODE-ZNR 5.1V 5% DO-35 PD=.4W TC=+.035%	28480	1902-0951	
A16CR17	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050	
A16CR18	1901-0347	1		DIODE-SM SIG SCHOTTKY	28480	1901-0347	
A16CR19	1902-0951	5		DIODE-ZNR 5.1V 5% DO-35 PD=.4W TC=+.035%	28480	1902-0951	
A16CR20	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050	
A16CR21	1901-0731	7	2	DIODE-PWR RECT 400V 1A	28480	1901-0731	
A16CR22	1901-0731	7		DIODE-PWR RECT 400V 1A	28480	1901-0731	
A16F1	2110-0321	5	2	FUSE 1A 125V .281X.093	28480	2110-0321	
A16F2	2110-0321	5		FUSE 1A 125V .281X.093	28480	2110-0321	
A16J1	1251-4352	7	1	CONNECTOR 4-PIN M POST TYPE	28480	1251-4352	
A16L1	03770-70088	4	1	INDUCTOR	28480	03770-70088	
A16L2	03763-80101	4	1	COIL TOROID	28480	03763-80101	
A16L3	03763-80100	3	1	TOROID ASSEMBLY	28480	03763-80100	
A16MP1	03763-00041	3	1	CLAMP	28480	03763-00041	
A16MP2	03762-00036	5	1	BRACKET	28480	03762-00036	
A16MP3	03762-00035	4	1	HEATSINK	28480	03762-00035	
A16MP4	03780-20012	1	1	PCB BLANK	28480	03780-20012	
A16Q1	1854-0624	6	2	TRANSISTOR NPN 2N6308 SI TO-3 PD=125W	04713	2N6308	
	0340-0503	0	2	INSULATOR-XSTR POLYE	28480	0340-0503	
A16Q2	1854-0624	6		TRANSISTOR NPN 2N6308 SI TO-3 PD=125W	04713	2N6308	
	0340-0503	0		INSULATOR-XSTR POLYE	28480	0340-0503	
A16Q2C	0340-0782	7	1	INSULATOR-XSTR KAPTON	28480	0340-0782	

See introduction to this section for ordering information
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Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A16Q3	1853-0020	4	2	TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020	
A16Q4	1853-0020	4		TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020	
A16Q5	1854-0477	7	4	TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A	
A16Q6	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A	
A16Q7	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A	
A16Q8	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A	
A16R1	0757-0367	7	2	RESISTOR 100K 1% .5W F TC=0+-100	28480	0757-0367	
A16R2	0757-0367	7		RESISTOR 100K 1% .5W F TC=0+-100	28480	0757-0367	
A16R3	0811-3382	8	1	RESISTOR .5 5% 3W PW TC=0+-70	28480	0811-3382	
A16R4	0811-1204	9	1	RESISTOR 200 5% 5W PW TC=0+-20	28480	0811-1204	
A16R5	0812-0015	0	2	RESISTOR 8 3% 3W PW TC=0+-50	28480	0812-0015	
A16R6	0683-0275	9	4	RESISTOR 2.7 5% .25W FC TC=-400/+500	01121	CB27G5	
A16R7	0683-0275	9		RESISTOR 2.7 5% .25W FC TC=-400/+500	01121	CB27G5	
A16R8	0812-0015	0		RESISTOR 8 3% 3W PW TC=0+-50	28480	0812-0015	
A16R9	0813-0050	5	2	RESISTOR 100 5% 3W PW TC=0+-20	91637	CW2B1-3W-T2-101-J	
A16R10	0813-0050	5		RESISTOR 100 5% 3W PW TC=0+-20	91637	CW2B1-3W-T2-101-J	
A16R11	2100-0552	3	2	RESISTOR-TRMR 50 10% C SIDE-ADJ 1-TRN	28480	2100-0552	
A16R12	2100-0552	3		RESISTOR-TRMR 50 10% C SIDE-ADJ 1-TRN	28480	2100-0552	
A16R13	0757-0280	3	3	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A16R14	0757-0410	1	2	RESISTOR 301 1% .125W F TC=0+-100	24546	C4-1/8-T0-301R-F	
A16R15	0698-3152	8	2	RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F	
A16R16	0698-3152	8		RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F	
A16R17	0757-0410	1		RESISTOR 301 1% .125W F TC=0+-100	24546	C4-1/8-T0-301R-F	
A16R18	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A16R19	0757-0401	0	3	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F	
A16R20	0683-0275	9		RESISTOR 2.7 5% .25W FC TC=-400/+500	01121	CB27G5	
A16R21	0683-0475	1	2	RESISTOR 4.7 5% .25W FC TC=-400/+500	01121	CB47G5	
A16R22	0698-3446	3	2	RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F	
A16R23	0757-0420	3	2	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F	
A16R24	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F	
A16R25	0683-0275	9		RESISTOR 2.7 5% .25W FC TC=-400/+500	01121	CB27G5	
A16R26	0683-0475	1		RESISTOR 4.7 5% .25W FC TC=-400/+500	01121	CB47G5	
A16R27	0698-3446	3		RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F	
A16R28	0757-0420	3		RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F	
A16R29	0698-3155	1	2	RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A16R30	0698-3155	1		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F	
A16R31	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F	
A16R32	0757-0346	2	1	RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F	
A16R33	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A16T1	03776-80002	9	1	SWITCHING XFMR	28480	03776-80002	
A16T2	03780-60049	8	1	TRANSFORMER ASSEMBLY	28480	03780-60049	
A16T3	03776-80003	0	2	TRANSFORMER ASSEMBLY	28480	03776-80003	
A16T4	03776-80003	0		TRANSFORMER ASSEMBLY	28480	03776-80003	
A16U1	1826-0393	7	1	IC V RGLTR TO-220	27014	LM317T	
	1205-0331	7	1	HEAT SINK SGL TO-220-CS	28480	1205-0331	
A16U2	1826-0527	9	1	IC 337 V RGLTR TO-220	27014	LM337T	
	1250-0331	2	1	HEAT SINK	28480	1250-0331	
MSC	0360-0007	1	2	TERMINAL-SLDR LUG PL-MTG FOR-#10-SCR	28480	0360-0007	
MSC	1480-0116	8	1	PIN-GRV .062-IN-DIA .25-IN-LG STL	28480	1480-0116	
MSC	4040-0749	4	1	EXTR-PC BD BRN POLYC .062-BD-THKNS	28480	4040-0749	
MSC	4040-0754	1	1	EXTR-PC BD BLU POLYC .062-BD-THKNS	28480	4040-0754	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3 Replaceable Parts (continued)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A20	03776-60020	9	1	MOTHERBOARD ASSEMBLY	28480	03776-60020	
A20C1	0160-4371	6	1	CAPACITOR-FXD 680PF +-5% 100VDC CER	28480	0160-4371	
A20C2	0160-3622	8	1	CAPACITOR-FXD .1UF +80-20% 100VDC CER	26654	2130Y5V100R104Z	
A20J1	1251-5722	7	2	CONNECTOR 50-PIN M POST TYPE	28480	1251-5722	
A20J2	1251-6080	2	1	CONNECTOR 6-PIN M METRIC POST TYPE	28480	1251-6080	
A20J3	1251-5722	7		CONNECTOR 50-PIN M POST TYPE	28480	1251-5722	
A20J4	1251-0600	0	15	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J5	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J6	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J7	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J8	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J9	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J10	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J11	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J12	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J13	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J14	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J15	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J16	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J17	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20J18	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A20L1	9100-3913	3	1	INDUCTOR RF-CH-MLD 3.3UH 5% .166DX.385LG	28480	9100-3913	
A20R1	0757-0710	4	1	RESISTOR 75 1% .25W F TC=0+-100	24546	C5-1/4-T0-75R0-F	
A20R2	0698-3441	8	1	RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F	
A20R3	0757-0399	5	1	RESISTOR 82.5 1% .125W F TC=0+-100	24546	C4-1/8-T0-82R5-F	
A20T1	03779-80089	5	4	TRANSFORMER ASSEMBLY	28480	03779-80089	
A20T2	03779-80089	5		TRANSFORMER ASSEMBLY	28480	03779-80089	
A20T3	03779-80089	5		TRANSFORMER ASSEMBLY	28480	03779-80089	
A20T4	03779-80089	5		TRANSFORMER ASSEMBLY	28480	03779-80089	
A20XA1	1251-5408	6	16	CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA2	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA3	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA4	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA5	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA6	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA7	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA8	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA9	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA10	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA11	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA12	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA13	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA14	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA15	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	
A20XA16	1251-5408	6		CONNECTOR-PC EDGE 48-CONT/ROW 2-ROWS	28480	1251-5408	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A21	03776-60021	0	1	KEYBOARD ASSEMBLY	28480	03776-60021	
A21C1	0180-2214	4	1	CAPACITOR-FXD 90UF+75-10% 16VDC AL	56289	30D906G016CC2	
A21C2	0160-0576	5	2	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A21C3	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A21CR1	1990-0487	7	4	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4584	
A21CR2	1990-0487	7		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4584	
A21CR3	1990-0487	7		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4584	
A21CR4	1990-0487	7		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4584	
A21CR6	1990-0450	4	31	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR7	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR8	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR9	1990-0665	3	27	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR10	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR11	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR12	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR13	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR14	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR15	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR16	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR17	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR18	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR19	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR20	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR21	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR22	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR23	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR24	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR25	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR26	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR27	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR28	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR29	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR30	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR31	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR32	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	A
A21CR33	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR34	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR35	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR38	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR39	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR40	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR41	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR42	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR43	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR44	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR45	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR46	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR47	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR48	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR49	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR50	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR51	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR52	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR53	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR54	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR55	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR56	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR57	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR58	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR59	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR60	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR61	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A21CR62	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR63	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR64	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21CR65	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A21DS1	1990-0619	7	15	DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS2	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS3	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS4	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS5	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A21DS6	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS7	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS8	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS9	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS10	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS11	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS12	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS13	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS14	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS15	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A21DS16	1990-0588	9	2	DISPLAY-NUM-SEG 4-CHAR .11-H	28480	5082-7414	
A21DS17	1990-0588	9		DISPLAY-NUM-SEG 4-CHAR .11-H	28480	5082-7414	
A21DS18	1990-0759	6	4	LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620	
A21DS19	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620	
A21DS20	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620	
A21DS21	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620	
A21J1	1251-3090	8	1	CONNECTOR 50-PIN M RECTANGULAR	28480	1251-3090	
A21Q1	1853-0036	2	16	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q2	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q3	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q4	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q5	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q6	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q7	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q8	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q9	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q10	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q11	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q12	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q13	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q14	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q15	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21Q16	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A21R1	0698-3132	4	8	RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A21R2	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A21R3	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	A
A21R4	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A21R5	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A21R6	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A21R7	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A21R8	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A21R9	0757-0274	5	16	RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R10	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R11	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R12	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R13	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R14	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R15	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R16	0757-0416	7	16	RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R17	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R18	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R19	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R20	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R21	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R22	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R23	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R24	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R31	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R32	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R33	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R34	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R35	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R36	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R37	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R38	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A21R39	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R40	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R41	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R42	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R43	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R44	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R45	0698-3438	3	2	RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-T0-147R-F	
A21R46	0698-3438	3		RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-T0-147R-F	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A21R47	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R48	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A21R49	0698-0084	9	2	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A21R50	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A21RN1	1810-0325	2	1	NETWORK-RES 16-DIP150.0 OHM X 8	01121	316B151	
A21RN2	1810-0283	1	1	NETWORK-RES 16-DIP270.0 OHM X 8	28480	1810-0283	
A21RN3	1810-0338	7	1	NETWORK-RES 16-DIP100.0 OHM X 8	11236	761-3-R100	
A21RN4	1810-0277	3	3	NETWORK-RES 10-SIP2.2K OHM X 9	01121	210A222	
A21RN5	1810-0277	3		NETWORK-RES 10-SIP2.2K OHM X 9	01121	210A222	
A21RN6	1810-0277	3		NETWORK-RES 10-SIP2.2K OHM X 9	01121	210A222	
A21U1	1820-1216	3	2	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A21U2	1820-1917	1	2	IC BFR TTL LS LINE DRVR OCTL	01295	SN74LS240N	
A21U3	1820-1740	8	2	IC DRVR TTL DSPL DRVR	27014	DS8863N	A
A21U4	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A21U5	1820-1917	1		IC BFR TTL LS LINE DRVR OCTL	01295	SN74LS240N	
A21U6	1820-1740	8		IC DRVR TTL DSPL DRVR	27014	DS8863N	
MSC	1200-0607	0	4	SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0607	
MSC	1200-0638	7	15	SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638	
MSC	1200-0768	4	2	SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0768	
MSC	5041-0276	5	12	KEY CAP PRL GRAY	28480	5041-0276	
MSC	5041-0285	6	25	KEY CAP-QUARTER, LT PIPE	28480	5041-0285	
MSC	5041-0286	7	2	KEY CAP LT PIPE	28480	5041-0286	
MSC	5041-0474	5	1	QTR-BSC	28480	5041-0474	
MSC	5041-0922	8	4	KEY CAP QUARTER-EBY-PRL	28480	5041-0922	
MSC	5060-9436	7	44	PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A121	03776-60121	1	1	KEYBOARD ASSEMBLY	28480	03776-60121	
A121C1	0180-2214	4	1	CAPACITOR-FXD 90UF+75-10% 16VDC AL	56289	30D906G016CC2	
A121C2	0160-0576	5	2	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A121C3	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A121CR1	1990-0487	7	4	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4584	
A121CR2	1990-0487	7		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4584	
A121CR3	1990-0487	7		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4584	
A121CR4	1990-0487	7		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4584	
A121CR6	1990-0450	4	30	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR7	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR8	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR9	1990-0665	3	27	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR10	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR11	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR13	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR14	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR15	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR16	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR17	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR18	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR19	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR20	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR21	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR22	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR23	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR24	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR25	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR26	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR27	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR28	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR29	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR30	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR31	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR32	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR33	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	B
A121CR34	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR35	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR38	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR39	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR40	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR41	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR42	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR43	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR44	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR45	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR46	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR47	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR48	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR49	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR50	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR51	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR52	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR53	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR54	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR55	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR56	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR57	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR58	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR59	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR60	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR61	1990-0665	3		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665	
A121CR62	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR63	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR64	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121CR65	1990-0450	4		LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A121DS1	1990-0619	7	15	DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS2	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS3	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS4	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS5	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A121DS6	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS7	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS8	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS9	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS10	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS11	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS12	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS13	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS14	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS15	1990-0619	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	5082-7613	
A121DS16	1990-0588	9	2	DISPLAY-NUM-SEG 4-CHAR .11-H	28480	5082-7414	
A121DS17	1990-0588	9		DISPLAY-NUM-SEG 4-CHAR .11-H	28480	5082-7414	
A121DS18	1990-0759	6	4	LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620	
A121DS19	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620	
A121DS20	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620	
A121DS21	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620	
A121J1	1251-3090	8	1	CONNECTOR 50-PIN M RECTANGULAR	28480	1251-3090	
A121Q1	1853-0036	2	16	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q2	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q3	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q4	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q5	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q6	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q7	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q8	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q9	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q10	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q11	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q12	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q13	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q14	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q15	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121Q16	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036	
A121R1	0698-3132	4	8	RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A121R2	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A121R3	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	B
A121R4	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A121R5	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A121R6	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A121R7	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A121R8	0698-3132	4		RESISTOR 261 1% .125W F TC=0+-100	24546	C4-1/8-T0-2610-F	
A121R9	0757-0274	5	16	RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R10	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R11	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R12	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R13	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R14	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R15	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R16	0757-0416	7	16	RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R17	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R18	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R19	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R20	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R21	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R22	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R23	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R24	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R31	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R32	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R33	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R34	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R35	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R36	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R37	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R38	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F	
A121R39	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R40	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R41	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R42	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R43	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R44	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R45	0698-3438	3	2	RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-T0-147R-F	
A121R46	0698-3438	3		RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-T0-147R-F	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A121R47	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R48	0757-0416	7		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F	
A121R49	0698-0084	9	2	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A121R50	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A121RN1	1810-0325	2	1	NETWORK-RES 16-DIP150.0 OHM X 8	01121	316B151	
A121RN2	1810-0283	1	1	NETWORK-RES 16-DIP270.0 OHM X 8	28480	1810-0283	
A121RN3	1810-0338	7	1	NETWORK-RES 16-DIP100.0 OHM X 8	11236	761-3-R100	
A121RN4	1810-0277	3	3	NETWORK-RES 10-SIP2.2K OHM X 9	01121	210A222	
A121RN5	1810-0277	3		NETWORK-RES 10-SIP2.2K OHM X 9	01121	210A222	
A121RN6	1810-0277	3		NETWORK-RES 10-SIP2.2K OHM X 9	01121	210A222	
A121U1	1820-1216	3	2	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A121U2	1820-1917	1	2	IC BFR TTL LS LINE DRVR OCTL	01295	SN74LS240N	
A121U3	1820-1740	8	2	IC DRVR TTL DSPL DRVR	27014	DS8863N	B
A121U4	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A121U5	1820-1917	1		IC BFR TTL LS LINE DRVR OCTL	01295	SN74LS240N	
A121U6	1820-1740	8		IC DRVR TTL DSPL DRVR	27014	DS8863N	
MSC	1200-0607	0	4	SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0607	
MSC	1200-0638	7	15	SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638	
MSC	1200-0768	4	2	SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0768	
MSC	5041-0276	5	12	KEY CAP PRL GRAY	28480	5041-0276	
MSC	5041-0285	6	25	KEY CAP-QUARTER, LT PIPE	28480	5041-0285	
MSC	5041-0286	7	2	KEY CAP LT PIPE	28480	5041-0286	
MSC	5041-0474	5	1	QTR-BSC	28480	5041-0474	
MSC	5041-0922	8	4	KEY CAP QUARTER-EBY-PRL	28480	5041-0922	
MSC	5060-9436	7	44	PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A22	03776-60022	1	1	KEYBOARD CONTROLLER ASSEMBLY	28480	03776-60022	
A22C1	0180-0197	8	1	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A22C2	0160-0570	9	5	CAPACITOR-FXD 220PF +-20% 100VDC CER	20932	5024EM100RD221M	
A22C3	0180-1735	2	2	CAPACITOR-FXD .22UF+-10% 35VDC TA	56289	150D224X9035A2	
A22C4	0160-0570	9		CAPACITOR-FXD 220PF +-20% 100VDC CER	20932	5024EM100RD221M	
A22C5	0160-0576	5	23	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C6	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C7	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C8	0160-0570	9		CAPACITOR-FXD 220PF +-20% 100VDC CER	20932	5024EM100RD221M	
A22C9	0180-0228	6	3	CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2	
A22C10	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C11	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C12	0180-1735	2		CAPACITOR-FXD .22UF+-10% 35VDC TA	56289	150D224X9035A2	
A22C13	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C14	0180-0228	6		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2	
A22C15	0160-0570	9		CAPACITOR-FXD 220PF +-20% 100VDC CER	20932	5024EM100RD221M	
A22C16	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C17	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C18	0160-0570	9		CAPACITOR-FXD 220PF +-20% 100VDC CER	20932	5024EM100RD221M	
A22C19	0180-0228	6		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2	
A22C20	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C21	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C22	0140-0197	4	2	CAPACITOR-FXD 180PF +-5% 300VDC MICA	72136	DM15F181J0300WV1CR	
A22C23	0140-0197	4		CAPACITOR-FXD 180PF +-5% 300VDC MICA	72136	DM15F181J0300WV1CR	
A22C24	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C25	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C26	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C27	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C28	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C29	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C30	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C31	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C32	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C33	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C34	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C35	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22C36	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A22CR1	1901-0040	1	1	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040	
A22DS1	1990-0450	4	1	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A22J1	1251-3090	8	2	CONNECTOR 50-PIN M RECTANGULAR	28480	1251-3090	
A22J2	1251-3090	8		CONNECTOR 50-PIN M RECTANGULAR	28480	1251-3090	
A22LS1	9160-0242	1	1	LOUDSPEAKER	28480	9160-0242	
A22R1	1810-0277	3	1	NETWORK-RES 10-SIP2.2K OHM X 9	01121	210A222	
A22R2	0757-0462	3	1	RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F	
A22R3	0698-3159	5	1	RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F	
A22R4	0757-0458	7	1	RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F	
A22R5	0757-0280	3	2	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A22R6	0757-0465	6	1	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F	
A22R7	0698-3162	0	2	RESISTOR 46.4K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4642-F	
A22R8	0698-3162	0		RESISTOR 46.4K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4642-F	
A22R9	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A22R10	0757-0438	3	2	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A22R11	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F	
A22R12	0698-0084	9	2	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A22R13	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F	
A22U10	1820-1423	4	3	IC MV TTL LS MONOSTBL RETRIG DUAL	01295	SN74LS123N	
A22U11	1820-1422	3	1	IC MV TTL LS MONOSTBL RETRIG	01295	SN74LS122N	
A22U12	1820-1112	8	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A22U13	1820-0668	7	3	IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N	
A22U14	1820-0668	7		IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N	
A22U15	1820-0668	7		IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N	
A22U16	1816-1089	9	4	IC TTL LS 64-BIT STAT RAM 80-NS 3-S	27014	DM74LS189N	
A22U17	1816-1089	9		IC TTL LS 64-BIT STAT RAM 80-NS 3-S	27014	DM74LS189N	
A22U18	1820-1208	3	5	IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A22U19	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A22U20	1820-1430	3	1	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS161AN	
A22U21	1820-1216	3	3	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A22U22	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A22U26	1816-1089	9		IC TTL LS 64-BIT STAT RAM 80-NS 3-S	27014	DM74LS189N	
A22U27	1816-1089	9		IC TTL LS 64-BIT STAT RAM 80-NS 3-S	27014	DM74LS189N	

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A22U28	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A22U29	1820-1423	4		IC MV TTL LS MONOSTBL RETRIG DUAL	01295	SN74LS123N	
A22U30	1820-1201	6	2	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A22U31	1820-1195	7	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N	
A22U32	1820-1197	9	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N	
A22U33	1820-1278	7	1	IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS191N	
A22U34	1820-1851	2	1	IC ENCDR TTL LS	01295	SN74LS148N	
A22U36	1820-1917	1	2	IC BFR TTL LS LINE DRVR OCTL	01295	SN74LS240N	
A22U37	1820-1917	1		IC BFR TTL LS LINE DRVR OCTL	01295	SN74LS240N	
A22U38	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A22U39	1820-1144	6	2	IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N	
A22U40	1820-1423	4		IC MV TTL LS MONOSTBL RETRIG DUAL	01295	SN74LS123N	
A22U41	1820-1201	6		IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N	
A22U42	1820-2096	9	1	IC CNTR TTL LS BIN DUAL 4-BIT	01295	SN74LS393N	
A22U43	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A22U46	1820-1997	7	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N	
A22U47	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N	
A22U50	1820-1297	0	1	IC GATE TTL LS EXCL-NOR QUAD 2-INP	01295	SN74LS266N	
A22U51	1820-1730	6	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS273N	
A22U52	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A22U54	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A22U55	1820-1144	6		IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N	
A22U56	1820-1175	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS175N	
A22U57	1820-1200	5	1	IC INV TTL LS HEX	01295	SN74LS05N	
MSC	0380-0958	3	11	SPACER-RVT-ON 1-IN-LG .15-IN-ID	00000	ORDER BY DESCRIPTION	
MSC	03745-27031	5	2	CLIP (LOUDSPEAKER)	28480	03745-27031	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A23	03776-60023	2	1	REAR PANEL CONTROL ASSEMBLY	28480	03776-60023	
A23C1	0180-0418	6	1	CAPACITOR-FXD 1UF+-20% 35VDC TA	28480	0180-0418	
A23C2	0180-0197	8	1	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2	
A23C3	0160-0576	5	2	CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A23C4	0160-0576	5		CAPACITOR-FXD .1UF +-20% 50VDC CER	28480	0160-0576	
A23C5	0160-4389	6	1	CAPACITOR-FXD 100PF +-5PF 200VDC CER	28480	0160-4389	
A23C6	0160-3458	8	4	CAPACITOR-FXD 5000PF +-10% 250VDC CER	28480	0160-3458	
A23C7	0160-3458	8		CAPACITOR-FXD 5000PF +-10% 250VDC CER	28480	0160-3458	
A23C8	0160-3458	8		CAPACITOR-FXD 5000PF +-10% 250VDC CER	28480	0160-3458	
A23C9	0160-3458	8		CAPACITOR-FXD 5000PF +-10% 250VDC CER	28480	0160-3458	
A23CR1	1990-0450	4	1	LED-LAMP LUM-INT=800UCD IF=50MA-MAX	28480	5082-4484	
A23CR2	0837-0257	4	4	VOLTAGE SUPPRESSOR AXIAL LEAD	28480	0837-0257	
A23CR3	0837-0257	4		VOLTAGE SUPPRESSOR AXIAL LEAD	28480	0837-0257	
A23CR4	0837-0257	4		VOLTAGE SUPPRESSOR AXIAL LEAD	28480	0837-0257	
A23CR5	0837-0257	4		VOLTAGE SUPPRESSOR AXIAL LEAD	28480	0837-0257	
A23J1	1251-5722	7	1	CONNECTOR 50-PIN M POST TYPE	28480	1251-5722	
A23J2	1251-4040	0	1	CONNECTOR 24-PIN F MICRO RIBBON	28480	1251-4040	
A23J3	1251-5503	2	1	CONNECTOR 15-PIN M D SUBMINIATURE	28480	1251-5503	
A23R1	1810-0277	3	2	NETWORK-RES 10-SIP2.2K OHM X 9	01121	210A222	
A23R2	0757-0280	3	2	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A23R3	0757-0465	6	1	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F	
A23R4	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F	
A23R5	0757-0199	3	1	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F	
A23R6	1810-0277	3		NETWORK-RES 10-SIP2.2K OHM X 9	01121	210A222	
A23S1	3101-1856	5	1	SWITCH-SL 8-1A DIP-SLIDE-ASSY .1A 50VDC	28480	3101-1856	
A23S2	3101-2631	6	4	SWITCH-SL DPDT SUBMIN .3A 125VAC PC	28480	3101-2631	
A23S3	3101-2631	6		SWITCH-SL DPDT SUBMIN .3A 125VAC PC	28480	3101-2631	
A23S4	3101-2631	6		SWITCH-SL DPDT SUBMIN .3A 125VAC PC	28480	3101-2631	
A23S5	3101-2631	6		SWITCH-SL DPDT SUBMIN .3A 125VAC PC	28480	3101-2631	
A23TP1	1251-0600	0	1	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600	
A23U1	1820-1859	0	2	IC GEN TTL LS PAR GEN 9-BIT	01295	SN74LS280N	
A23U2	1820-1112	8	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN	
A23U3	1820-1423	4	1	IC MV TTL LS MONOSTBL RETRIG DUAL	01295	SN74LS123N	
A23U4	1820-1917	1	2	IC BFR TTL LS LINE DRVR OCTL	01295	SN74LS240N	
A23U5	1820-1917	1		IC BFR TTL LS LINE DRVR OCTL	01295	SN74LS240N	
A23U6	1820-1859	0		IC GEN TTL LS PAR GEN 9-BIT	01295	SN74LS280N	
A23U7	1820-1216	3	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N	
A23U8	1820-1144	6	1	IC GATE TTL LS NOR QUAD 2-INP	01295	SN74LS02N	
A23U9	1820-1215	2	1	IC GATE TTL LS EXCL-OR QUAD 2-INP	01295	SN74LS136N	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3 Replaceable Parts (continued)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
A24	03776-60024	3	1	MAINS INPUT ASSEMBLY	28480	03776-60024	
A24C1	0180-0688	2	4	CAPACITOR-FXD 200UF+50-10% 250VDC AL	28480	0180-0688	
A24C2	0180-0688	2		CAPACITOR-FXD 200UF+50-10% 250VDC AL	28480	0180-0688	
A24C3	0180-0688	2		CAPACITOR-FXD 200UF+50-10% 250VDC AL	28480	0180-0688	
A24C4	0180-0688	2		CAPACITOR-FXD 200UF+50-10% 250VDC AL	28480	0180-0688	
A24C5	0160-4355	6	2	CAPACITOR-FXD .01UF +-10% 250VAC(RMS)	28480	0160-4355	
A24C6	0160-4355	6		CAPACITOR-FXD .01UF +-10% 250VAC(RMS)	28480	0160-4355	
A24C7	0180-0116	1	1	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2	
A24CR1	1901-0759	9	4	DIODE-PWR RECT 1N5406 600V 3A DO-27	14936	1N5406	
A24CR2	1901-0759	9		DIODE-PWR RECT 1N5406 600V 3A DO-27	14936	1N5406	
A24CR3	1901-0759	9		DIODE-PWR RECT 1N5406 600V 3A DO-27	14936	1N5406	
A24CR4	1901-0759	9		DIODE-PWR RECT 1N5406 600V 3A DO-27	14936	1N5406	
A24CR5	1902-0668	1	1	DIODE-ZNR 200V 5% DO-15 PD=1W TC=+.088%	28480	1902-0668	
A24CR6	1901-0732	8	1	DIODE-PWR RECT 1KV 1A	28480	1901-0732	
A24CR7	1884-0268	7	1	THYRISTOR-SCR 2N6508 TO-220AB VRRM=600	04713	2N6508	
A24F2	2110-0044	9	1	FUSE .3A 250V TD 1.25X.25 UL	75915	313.300	
A24F3	2110-0320	4	1	FUSE .15A 250V TD 1.25X.25 UL	75915	313.150	
A24R1	0812-0037	6	2	RESISTOR 20K 3% 5W PW TC=0+-20	28480	0812-0037	
A24R2	0812-0037	6		RESISTOR 20K 3% 5W PW TC=0+-20	28480	0812-0037	
A24R3	0837-0178	8	1	THERMISTOR DISC 15-OHM	KC004	2322 644 90005 TYPE VA1104	
A24T1	03779-80017	9	1	TRANSFORMER ASSEMBLY	28480	03779-80017	
A24XB1	1251-4348	1	2	CONNECTOR 6-PIN M POST TYPE	28480	1251-4348	
A24XB2	1251-4350	5	1	CONNECTOR 7-PIN M POST TYPE	28480	1251-4350	
A24XB3	1251-4348	1		CONNECTOR 6-PIN M POST TYPE	28480	1251-4348	
MSC	2110-0269	0	4	FUSEHOLDER-CLIP TYPE.25D-FUSE	28480	2110-0269	

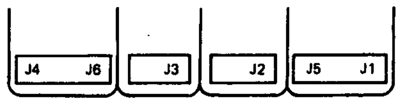
See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3 Replaceable Parts (continued)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
				3776A MAIN LIST			
B1	3160-0380	2	1	FAN-TBAX 74-CFM 100/125V 50/60-HZ	28480	3160-0380	
	03763-60040	8	1	FAN COVER ASSEMBLY	28480	03763-60040	
C1	0160-4616	2	1	CAPACITOR-FXD 560PF +-5% 200VDC CER	28480	0160-4616	
C3	0160-4389	6	2	CAPACITOR-FXD 100PF +-5PF 200VDC CER	28480	0160-4389	
C4	0160-4389	6		CAPACITOR-FXD 100PF +-5PF 200VDC CER	28480	0160-4389	
C5	0160-4040	6	2	CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040	
C6	0160-4040	6		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4040	
E1	9100-3910	0	1	FILTER-LINE CEE 22-TERMS	28480	9100-3910	
E2	03776-60050	5	1	MAINS FILTER ASSEMBLY	28480	03776-60050	
	9135-0042	6	1	FILTER-LINE WIRE LEAD-TERMS	28480	9135-0042	
	1251-2505	8	1	CONNECTOR 2-PIN F UTILITY	28480	1251-2505	
F1	2110-0303	3	1	FUSE 2A 250V TD 1.25X.25 UL	28480	2110-0303	
	2110-0564	8	1	FUSEHOLDER BODY 12A MAX FOR UL	H9027	031.1657	
	2110-0565	9	1	FUSEHOLDER CAP 12A MAX FOR UL	28480	2110-0565	
	2110-0569	3	1	FUSEHOLDER COMPONENT NUT; THREAD M12.7	28480	2110-0569	
MP1	5060-9834	9	1	TOP COVER	28480	5060-9834	
MP2	5060-9846	3	1	BOTTOM COVER	28480	5060-9846	
MP3	5060-9941	9	2	COVER PERF SIDE	28480	5060-9941	
MP4	5040-7202	9	1	TRIM, TOP	28480	5040-7202	
MP5	5041-0201	6	1	KEY CAP WHITE	28480	5041-0201	
MP6	5060-9803	2	2	STRAP HANDLE	28480	5060-9803	
MP7	5040-7220	1	2	STRAP, HANDLE, CAP-REAR	28480	5040-7220	
MP8	5040-7219	8	2	STRAP, HANDLE, CAP-FRONT	28480	5040-7219	
MP9	5004-0440	7	2	TRIM SIDE	28480	5004-0440	
MP10	5020-8805	8	1	FRONT FRAME	28480	5020-8805	
MP11	5020-8806	9	1	REAR FRAME	28480	5020-8806	
MP12	5020-8881	0	4	CRNR STRT TAPPED	28480	5020-8881	
MP13	1460-1345	5	2	TILT STAND SST	28480	1460-1345	
MP14	5040-7201	8	4	FOOT(STANDARD)	28480	5040-7201	
MP15	03776-00001	0	1	MAIN DECK	28480	03776-00001	
MP16	03776-00002	1	3	SCREEN	28480	03776-00002	
MP17	03776-00011	2	1	COVER (A1 TO A14)	28480	03776-00011	
MP18	03776-00016	7	3	INSULATOR	28480	03776-00016	
MP19	03776-00014	5	1	COVER P.S.U. (A15/A16)	28480	03776-00014	
MP20	0403-0187	0	5	BUMPER FOOT-SCR	28480	0403-0187	
MP21	03776-00010	1	1	REAR PANEL	28480	03776-00010	A
MP22	03776-00009	8	1	COVER (A24 ASSEMBLY)	28480	03776-00009	
MP23	1510-0087	7	5	BINDING POST SGL THD STUD JGK BLK	28480	1510-0087	
MP24	0340-0732	7	10	INSULATOR-BDG POST POLYC	28480	0340-0732	
MP24	03776-00003	2	1	FRONT PANEL (DRESS)	28480	03776-00003	
MP25	03776-00004	3	1	DUMMY PANEL	28480	03776-00004	
MP26	03776-20032	9	1	WINDOW (FREQ, LEVEL, RESULTS)	28480	03776-20032	
	03776-00006	5	1	CLAMP	28480	03776-00006	
MP27	03776-20031	8	2	WINDOW (DIGITAL TX/RX)	28480	03776-20031	
	03776-00005	4	2	CLAMP	28480	03776-00005	
MP28	03776-60030	5	1	EXTENDER BOARD ASSEMBLY	28480	03776-60030	
MP29	03776-00025	8	1	PANEL (A23)	28480	03776-00025	
MP30	03776-00017	8	2	CONN PANEL (DRESS)	28480	03776-00017	
MP31	03776-00019	0	2	CONN PANEL DUMMY	28480	03776-00019	
MP32	03776-00074	7	1	BLANKING PLATE (REAR PANEL)	28480	03776-00074	
S1	3101-2216	3	1	SWITCH-PB DPDT ALTNG 4A 250VAC	28480	3101-2216	
	03776-00027	0	1	BRACKET	28480	03776-00027	
S2	03776-60040	3	1	VOLT/SEL (230/115V) ASSEMBLY	28480	03776-60040	
	3101-2614	5	1	SWITCH-SL DPDT STD 5A 250VAC SLDR-LUG	28480	3101-2614	
	1251-4358	3	1	CONNECTOR 7-PIN F POST TYPE	28480	1251-4358	
T1	03776-80001	8	1	TRANSFORMER	28480	03776-80001	
	5001-0256	7	1	XFMR END BELL	28480	5001-0256	
MSC	0360-0243	7	4	TERMINAL-SLDR LUG PL-MTG FOR-#2-SCR	28480	0360-0243	
MSC	0360-1857	1	1	BARRIER BLOCK 6-TERM SINGLE SCREW	28480	0360-1857	
MSC	1400-0611	0	1	CLAMP-FL-CA 1-WD	06915	CFCC-8	
MSC	5040-3070	1	12	PCB GUIDE	28480	5040-3070	
MSC	5040-3071	2	9	PCB GUIDE	28480	5040-3071	
MSC	5040-3072	3	2	PCB GUIDE	28480	5040-3072	
MSC	5040-3073	4	2	PCB GUIDE	28480	5040-3073	
MSC	5040-3074	5	2	PCB GUIDE	28480	5040-3074	
MSC	5040-3075	6	2	PCB GUIDE	28480	5040-3075	
MSC	5040-3076	7	2	PCB GUIDE	28480	5040-3076	
MSC	5040-3077	8	1	PCB GUIDE	28480	5040-3077	
MSC	5040-3078	9	1	PCB GUIDE	28480	5040-3078	
MSC	5040-3079	0	1	PCB GUIDE	28480	5040-3079	
MSC	5040-7221	2	4	FOOT, REAR	28480	5040-7221	
MSC	03776-40003	6	2	GUIDE	28480	03776-40003	

See introduction to this section for ordering information
*Indicates factory selected value

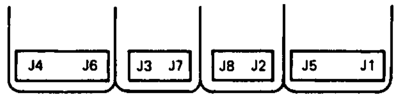
Table 6-3 Replaceable Parts (continued)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
MSC	0360-0042	4	6	TERMINAL-SLDR LUG PL-MTG FOR-#6-SCR	28480	0360-0042	
MSC	0360-1859	3	2	TERMINAL-SLDR LUG PL-MTG FOR-#5-SCR	28480	0360-1859	
MSC	0360-0042	4		TERMINAL-SLDR LUG PL-MTG FOR-#6-SCR	28480	0360-0042	
MSC	0360-1158	5	1	TERMINAL-SLDR LUG PL-MTG FOR-#1/2-SCR	86928	5413-21	
				Front Panel Connectors			
							
J1	1251-5586	1	4	JACK-BNA TRIPLE BLK SLDR-LUG-TERM	28480	1251-5586	
J2	1251-5586	1		JACK-BNA TRIPLE BLK SLDR-LUG-TERM	28480	1251-5586	
J3	1251-5586	1		JACK-BNA TRIPLE BLK SLDR-LUG-TERM	28480	1251-5586	
J4	1251-5586	1		JACK-BNA TRIPLE BLK SLDR-LUG-TERM	28480	1251-5586	
J5	1250-0610	0	2	COMPONENT-RF CONNECTOR BULKHEAD JACK-BNC	28480	1250-0610	
J6	1250-0610	0		COMPONENT-RF CONNECTOR BULKHEAD JACK-BNC	28480	1250-0610	
				Rear Panel Connector			
J9	1250-1253	9	1	CONNECTOR-RF BNC FEM SGL-HOLE-RR 50-OHM	28480	1250-1253	
				Cable Assemblies			
W1	03776-60046	9	1	POWER CABLE ASSEMBLY	28480	03776-60046	
	1251-2510	5	1	CONNECTOR 2-PIN M UTILITY	28480	1251-2510	
	1251-2993	8	1	CONNECTOR 6-PIN F POST TYPE	28480	1251-2993	
W2	03776-60045	8	2	RIBBON CABLE ASSEMBLY (A20/A22)	28480	03776-60045	
W3	03776-60049	2	1	RIBBON CABLE ASSEMBLY (A21/A22)	28480	03776-60049	
W4	03776-60075	4	1	DIGITAL TX 120Ω BAL CABLE ASSEMBLY	28480	03776-60075	
W5	03776-60076	5	1	ANALOG TX CABLE ASSEMBLY	28480	03776-60076	
W6	03776-60073	2	1	DIGITAL TX 75Ω UNBAL CABLE ASSEMBLY	28480	03776-60073	
	1250-0610	0	1	COMPONENT-RF CONNECTOR BULKHEAD JACK-BNC	28480	1250-0610	
W7	03776-60077	6	1	ANALOG RX CABLE ASSEMBLY	28480	03776-60077	
W8	03776-60074	3	1	DIGITAL RX 75Ω UNBAL CABLE ASSEMBLY	28480	03776-60074	
	1250-0610	0	1	COMPONENT-RF CONNECTOR BULKHEAD JACK-BNC	28480	1250-0610	
W9	03776-60078	7	1	DIGITAL RX 120Ω BAL CABLE ASSEMBLY	28480	03776-60078	
W10	03776-60045	8		RIBBON CABLE (A20/A23)	28480	03776-60045	
W11	03776-60079	8	1	CABLE ASSEMBLY (A16/A24)	28480	03776-60079	A
	1251-3167	0	1	CONNECTOR 4-PIN F POST TYPE	28480	1251-3167	
W12	03776-60041	4	1	REAR PANEL CABLE ASSEMBLY	28480	03776-60041	
	1251-5859	1	1	CONNECTOR 6-PIN F METRIC POST TYPE	28480	1251-5859	
3776A OPTIONS ▶				**● Option 001**			
				As standard 3776A, except:-			
				DELETE:			
A4	03776-60004	9	1	ANALOG MONITOR ASSEMBLY	28480	03776-60004	
				ADD:			
A204	03776-60204	1	1	ANALOG MONITOR ASSEMBLY	28480	03776-60204	
A5	03776-60005	0	1	TRANSIENTS ASSEMBLY	28480	03776-60005	
A8	03776-60008	3	1	GD, TIMING IMP, NOISE & FREQ DETECT ASSEMBLY	28480	03776-60008	
				● Option 002			
				As standard 3776A, except:-			
				DELETE:			
MP30	03776-00017	8		CONNECTOR PANEL DRESS	28480	03776-00017	
MP31	03776-00019	0	1	DUMMY PANEL	28480	03776-00019	
	1250-0610	0	2	COMPONENT-RF CONNECTOR BULKHEAD JACK-BNC (P/O W6, W8)	28480	1250-0610	
W6	03776-60073	2	1	DIGITAL TX 75Ω UNBAL CABLE ASSEMBLY	28480	03776-60073	
W8	03776-60074	3	1	DIGITAL RX 75Ω UNBAL CABLE ASSEMBLY	28480	03776-60074	
				ADD:			
MP30	03776-00018	9	1	CONNECTOR PANEL (DRESS)	28480	03776-00018	
MP31	03776-00020	3	1	DUMMY PANEL	28480	03776-00020	
				FRONT PANEL CONNECTOR			
	1250-1077	5	1	COMPONENT-RF CONNECTOR CONN-RF, REAR (P/O W6, W8)	28480	1250-1077	
W6	03776-60072	1	1	DIGITAL TX 75Ω UNBAL CABLE ASSEMBLY	28480	03776-60072	
	1250-1077	5		COMPONENT-RF CONNECTOR CONN-RF, REAR	28480	1250-1077	
W8	03776-60071	0	1	DIGITAL RX 75Ω UNBAL CABLE ASSEMBLY	28480	03776-60071	
	1250-1077	5		COMPONENT-RF CONNECTOR CONN-RF, REAR	28480	1250-1077	
				● Option 801 (Front Cover)			
				ADD:-			
MP32	5001-4980	2	1	FRONT COVER	28480	5001-4980	
	5040-3802	7	2	SUPPORT	28480	5040-3802	
MSC	5001-4981	3	1	LID	28480	5001-4981	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3 Replaceable Parts (continued)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
				3776B MAIN LIST			
				The 3776B Main List is the same as the 3776A Main List except for the following amendments, additions and deletions.			
				AMEND:			
F1	2110-0381	7	1	FUSE 3A 250V TD 1.25X.25	28480	2110-0381	
MP24	03776-00007	6	1	FRONT PANEL (DRESS)	28480	03776-00007	
MP26	03776-20033	0	1	WINDOW (FREQ, LEVEL, RESULTS)	28480	03776-20033	
MP29	03776-00026	9	1	PANEL (A23)	28480	03776-00026	
MP30	03776-00021	4	1	CONNECTOR PANEL (DRESS)	28480	03776-00021	
MP31	03776-00023	6	1	DUMMY PANEL	28480	03776-00023	
				Front Panel Connectors			



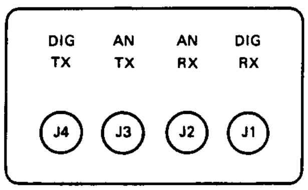
Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
J1-2	1251-3059	9	4	CONNECTOR-TEL JACK 3-CKT .173-SHK-DIA	28480	1251-3059	
J3	1251-3059	9		CONNECTOR-TEL JACK 3-CKT .173-SHK-DIA	28480	1251-3059	
J4	1251-3059	9		CONNECTOR-TEL JACK 3-CKT .173-SHK-DIA	28480	1251-3059	
J5	1251-3677	7	4	CONNECTOR-TEL JACK 2-CKT .25-SHK-DIA	28480	1251-3677	
J6	1251-3677	7		CONNECTOR-TEL JACK 2-CKT .25-SHK-DIA	28480	1251-3677	
J7	1251-3677	7		CONNECTOR-TEL JACK 2-CKT .25-SHK-DIA	28480	1251-3677	
J8	1251-3677	7		CONNECTOR-TEL JACK 2-CKT .25-SHK-DIA	28480	1251-3677	
				Cable Assemblies			
				ADD:			
W13	03776-60075	4	1	DIGITAL TX 120Ω BAL CABLE ASSEMBLY	28480	03776-60075	
W14	03776-60076	5	1	ANALOG TX CABLE ASSEMBLY	28480	03776-60076	
W15	03776-60077	6	1	ANALOG RX CABLE ASSEMBLY	28480	03776-60077	
W16	03776-60078	7	1	DIGITAL RX 120Ω BAL CABLE ASSEMBLY	28480	03776-60078	
				DELETE:			
W6	03776-60073	2	1	DIGITAL TX 75Ω UNBAL CABLE ASSEMBLY	28480	03776-60073	
W8	03776-60074	3	1	DIGITAL RX 75Ω UNBAL CABLE ASSEMBLY	28480	03776-60074	B
3776B OPTIONS ▶				● **Option 001**			
				As standard 3776B, except:-			
				DELETE:			
A4	03776-60004	9	1	ANALOG MONITOR ASSEMBLY	28480	03776-60004	
				ADD:			
A204	03776-60204	1	1	ANALOG MONITOR ASSEMBLY	28480	03776-60204	
A5	03776-60005	0	1	TRANSIENTS ASSEMBLY	28480	03776-60005	
A8	03776-60008	3	1	GD, TIMING IMP, NOISE & FREQ DETECT ASSEMBLY	28480	03776-60008	
				● **Option 002 (Japanese)**			
				As standard 3776B, except:-			
				AMEND:			
MP26	03776-20032	9	1	WINDOW (FREQ, LEVEL, RESULTS)	28480	03776-60032	
MP30	03776-00072	5	1	CONNECTOR PANEL (DRESS)	28480	03776-00072	
MP31	03776-00073	6	1	DUMMY PANEL	28480	03776-00073	
				FRONT PANEL CONNECTORS			
J1	1251-8589	0	12	CONNECTOR 4MM	28480	1251-8589	
J2	1251-8589	0		CONNECTOR 4MM	28480	1251-8589	
J3	1251-8589	0		CONNECTOR 4MM	28480	1251-8589	
J4	1251-8589	0		CONNECTOR 4MM	28480	1251-8589	
				DELETE:			
W13	03776-60075	4	1	DIGITAL TX 120Ω BAL CABLE ASSEMBLY	28480	03776-60075	
W14	03776-60076	5	1	ANALOG TX CABLE ASSEMBLY	28480	03776-60076	
W15	03776-60077	6	1	ANALOG RX CABLE ASSEMBLY	28480	03776-60077	
W16	03776-60078	7	1	DIGITAL RX 120Ω BAL CABLE ASSEMBLY	28480	03776-60078	
J5,6,7,8	1251-3677	7	4	CONNECTOR-TEL JACK (BANTAM)	28480	1251-3677	
A114	03776-60114	2	1	MEMORY ASSEMBLY	28480	03776-60114	
				ADD:			
A214	03776-60214	3	1	MEMORY ASSEMBLY	28480	03776-60214	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3 Replaceable Parts (continued)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
				● **Option 004**			
				As standard 3776B, except:-			
				AMEND:			
MP30	03776-00075	8	1	BLANKING PANEL	28480	03776-00075	
MP32	03776-00076	9	1	REAR CONNECTOR PANEL	28480	03776-00076	
J1, 2, 3, 4	1250-1639	5	4	CONNECTOR-TEL JACK (TROMPETER)	28480	1250-1639	
				DELETE:			
W4	03776-60075	4	2	DIGITAL TX 120Ω BAL CABLE ASSEMBLY	28480	03776-60075	
W5	03776-60076	5	2	ANALOG TX CABLE ASSEMBLY	28480	03776-60076	
W7	03776-60077	6	2	ANALOG RX CABLE ASSEMBLY	28480	03776-60077	
W9	03776-60078	7	2	DIGITAL RX 120Ω BAL CABLE ASSEMBLY	28480	03776-60078	
W13	03776-60075	4		DIGITAL TX 120Ω BAL CABLE ASSEMBLY	28480	03776-60075	
W14	03776-60076	5		ANALOG TX CABLE ASSEMBLY	28480	03776-60076	
W15	03776-60077	6		ANALOG RX CABLE ASSEMBLY	28480	03776-60077	
W16	03776-60078	7		DIGITAL RX 120Ω BAL CABLE ASSEMBLY	28480	03776-60078	
J5, 6, 7, 8	1251-3677	7	4	CONNECTOR-TEL JACK (BANTAM)	28480	1251-3677	
				ADD:			
W17	03776-60080	1	1	REAR PANEL DIG TX 120Ω BAL CABLE ASSEMBLY	28480	03776-60080	
W18	03776-60081	2	1	REAR PANEL ANALOG TX CABLE ASSEMBLY	28480	03776-60081	
W19	03776-60082	3	1	REAR PANEL ANALOG RX CABLE ASSEMBLY	28480	03776-60082	B
W20	03776-60083	4	1	REAR PANEL DIG RX 120Ω BAL CABLE ASSEMBLY	28480	03776-60083	

Rear Panel Connectors (Option 004)



Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number	A/B/ Option
				● **Option 801 (Front Cover)**			
				ADD:			
MP33	5001-4980	2	1	FRONT COVER	28480	5001-4980	
MSC	5040-3802	7	2	SUPPORT	28480	5040-3802	
MSC	5001-4981	3	1	LID	28480	5001-4981	

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-4 Manufacturers Code List

MFR NO.	MANUFACTURER NAME	ADDRESS		ZIP CODE
H9027	SCHURTER A G H	LUZERN	SW	
K0004	MULLARD LTD		EG	
K7723	MFD CAPACITORS LTD	WRERHAM CLWYD	WL	
S0545	NIPPON ELECTRIC CO	TOKYO	JP	
S4013	HITACHI	TOKYO	JP	
00000	ANY SATISFACTORY SUPPLIER			
01121	ALLEN-BRADLEY CO	MILWAUKEE	WI	53204
01295	TEXAS INSTR INC SEMICOND CMPNT DIV	DALLAS	TX	75222
03508	GE CO SEMICONDUCTOR PROD DEPT	AUBURN	NY	13201
03888	K D I PYROFILM CORP	WHIPPANY	NJ	07981
04713	MOTOROLA SEMICONDUCTOR PRODUCTS	PHOENIX	AZ	85008
06665	PRECISION MONOLITHICS INC	SANTA CLARA	CA	95050
06915	RICHCO PLASTIC CO	CHICAGO	IL	60646
07263	FAIRCHILD SEMICONDUCTOR DIV	MOUNTAIN VIEW	CA	94042
11236	CTS OF BERNE INC	BERNE	IN	46711
13606	SPRAGUE ELECT CO SEMICONDUCTOR DIV	CONCORD	NH	03301
14936	GENERAL INSTR CORP SEMICON PROD GP	HICKSVILLE	NY	11802
17856	SILICONIX INC	SANTA CLARA	CA	95054
19701	MEPCO/ELECTRA CORP	MINERAL WELLS	TX	76067
20932	EMCON DIV ITW	SAN DIEGO	CA	92129
24355	ANALOG DEVICES INC	NORWOOD	MA	02062
24546	CORNING GLASS WORKS (BRADFORD)	BRADFORD	PA	16701
25088	SIEMENS CORP	ISELIN	NJ	08830
26654	VARADYNE INC	SANTA MONICA	CA	90404
27014	NATIONAL SEMICONDUCTOR CORP	SANTA CLARA	CA	95051
28480	HEWLETT-PACKARD CO CORPORATE HQ	PALO ALTO	CA	94304
3L585	RCA CORP SOLID STATE DIV	SOMERVILLE	NJ	
34335	ADVANCED MICRO DEVICES INC	SUNNYVALE	CA	94086
34371	HARRIS SEMICON DIV HARRIS-INTERTYPE	MELBOURNE	FL	32901
37942	MALLORY P R AND CO INC	INDIANAPOLIS	IN	46206
50088	MOSTEK CORP	CARROLLTON	TX	75006
51642	CENTRE ENGINEERING INC	STATE COLLEGE	PA	16801
52763	STETTNER ELECTRONICS INC	CHATTANOOGA	TN	13035
56289	SPRAGUE ELECTRIC CO	NORTH ADAMS	MA	01247
72136	ELECTRO MOTIVE CORP	FLORENCE	SC	06226
74970	JOHNSON E F CO	WASECA	MN	56093
75915	LITTELFUSE INC	DES PLAINES	IL	60016
80795	ITT CORP COMPONENTS DIV	NEW YORK	NY	10022
86928	SEASTROM MFG CO	GLENDALE	CA	91201
9N171	UNITRODE COMPUTER PRODUCTS CORP	METHUEN	MA	
91506	AUGAT INC	ATTLEBORO	MA	02703
91637	DALE ELECTRONICS INC	COLUMBUS	NE	68601

Manual Changes

7

SECTION VII
MANUAL CHANGES

7-1 INTRODUCTION

7-2 This section normally contains information for adapting this manual to instruments for which the content does not apply directly. Since this manual does apply directly to instruments having the serial number listed on the title page, no change information is given here. Refer to INSTRUMENTS COVERED BY MANUAL in Section I for additional important information about serial number coverage.

Service

8

SECTION VIII
SERVICE

8-1 INTRODUCTION

8-2 This section assists technicians in the troubleshooting and repair of the Hewlett-Packard Models 3776A and 3776B PCM Terminal Test Sets. The main items contained in this section are listed below.

1 A list of the main assemblies and their location within the instrument (see Figure 8-1).

2 Theory of operation of the instrument accompanied by an overall block diagram (located in envelope at the rear of the manual) and simplified block diagram Figure 8-4 on page 8-15.

3 Troubleshooting Section (General Service Sheets G1 to G9).

4 Assembly Service Sheets covering each of the assemblies illustrated in Figure 8-1.

8-3 SAFETY CONSIDERATIONS

8-4 Before applying power to the instrument or removing any of the covers, review the following warnings and cautions.

WARNING

THESE SERVICING INSTRUCTIONS ARE FOR USE BY TRAINED SERVICE PERSONNEL ONLY. TO AVOID ELECTRICAL SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

WARNING

TO PROTECT OPERATING PERSONNEL, THE INSTRUMENT CHASSIS AND CABINET MUST BE GROUNDED. THE INSTRUMENT IS EQUIPPED WITH A THREE-WIRE POWER CORD WHICH, WHEN PLUGGED INTO AN APPROPRIATE RECEPTACLE, GROUNDS THE INSTRUMENT. THE OFFSET PIN ON THE POWER PLUG IS THE GROUND CONNECTION. TO PRESERVE THIS PROTECTION FEATURE, THE POWER PLUG SHALL ONLY BE INSERTED IN A THREE-TERMINAL RECEPTACLE HAVING A PROTECTIVE EARTH GROUND CONTACT. THE PROTECTIVE ACTION MUST NOT BE NEGATED BY THE USE OF AN EXTENSION CORD OR ADAPTER THAT DOES NOT HAVE THE REQUIRED EARTH GROUND CONNECTION. GROUNDING ONE CONDUCTOR OF A TWO-CONDUCTOR OUTLET IS NOT SUFFICIENT PROTECTION.

CAUTION

1 To prevent damage to the instrument power supply circuits, verify that the line voltage select switch located on the instrument rear panel is set to the correct line voltage. (Refer to Table 2-1 in Section II for correct line fuse sizes).

2 The HP 3776A and 3776B contain static sensitive devices which may be damaged as a result of static discharge.

3 To prevent equipment damage, do not remove circuit boards when the POWER switch is ON.

8-5 ASSEMBLY SERVICE SHEETS

8-6 These service sheets enable fault finding to component level. They contain general and detailed circuit descriptions (where applicable), together with troubleshooting information, component layouts, circuit schematics and block diagrams. The location of each assembly covered by a Service Sheet is illustrated in Figure 8-1. Table 8-1 highlights the differences between the 3776A and 3776B instruments.

Table 8-1 3776A and 3776B Assembly Identification

3776A	A1	A2					A7			A11	A12	A13	A14			A21			
3776B	A101	A102					A107			A111	A112*	A113	A114*			A121			
BOTH			A3	A4*	A5*	A6		A8*	A9					A15	A16		A22	A23	A24

* A4 REPLACED BY A204 IN OPTION 001
A5 OPTION 001 ONLY
A8 OPTION 001 ONLY
A12 BECOMES A112 BY CUTTING LINKS
A114 REPLACED BY A214 IN 3776B OPTION 002(JAPANESE)

8-7 RECOMMENDED TEST EQUIPMENT

8-8 Test equipment required to maintain the 3776A and 3776B is listed in Table 1-4 in Section I. Any other equipment which meets or exceeds the critical specification may be used.

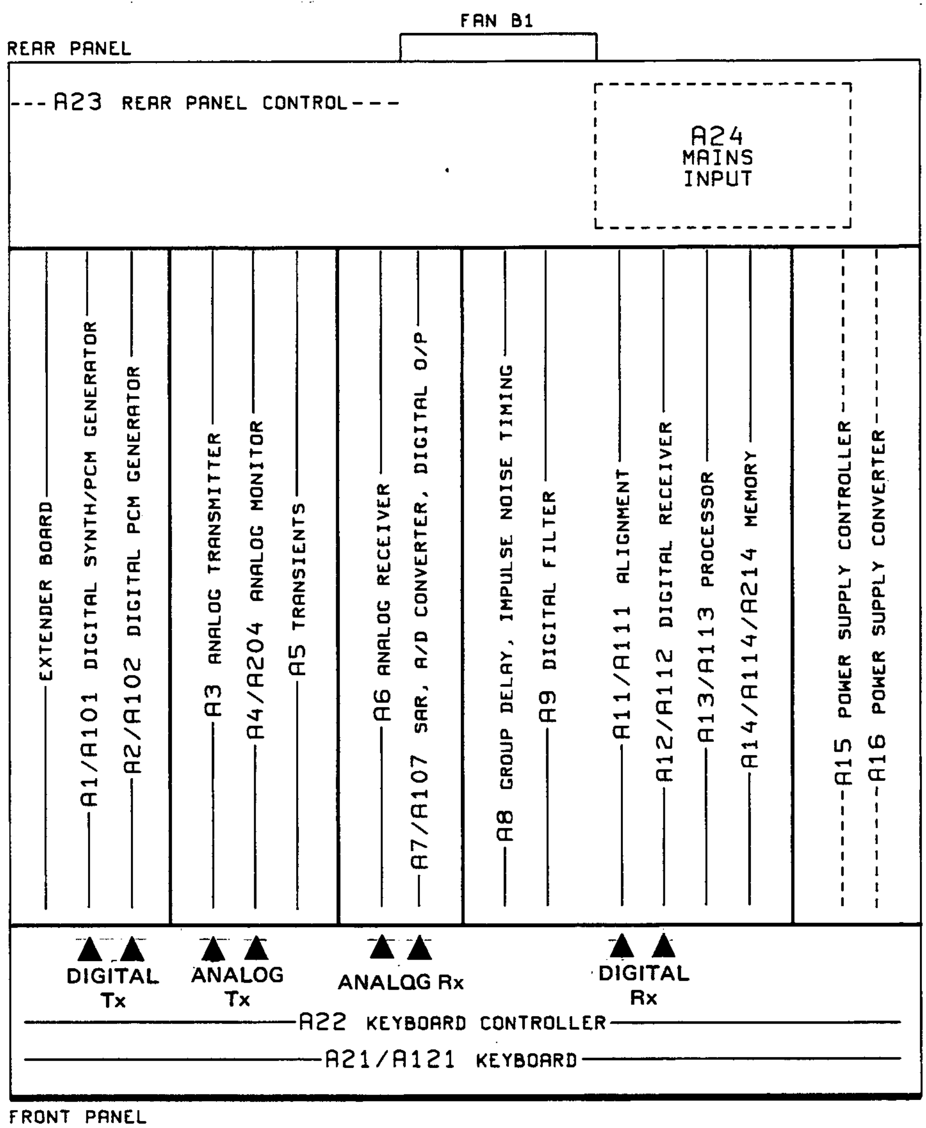


Figure 8-1 Assembly Location

8-9 TROUBLESHOOTING

8-10 The troubleshooting information provided enables technicians to diagnose faults to component level. It is recommended that all troubleshooting should start from GENERAL SERVICE SHEET G1. Service Sheet G1 contains general troubleshooting which guides the technician to the fault via the more specialised General Service Sheets G2 to G9. Figure 8-2 illustrates the troubleshooting layout for the instrument.

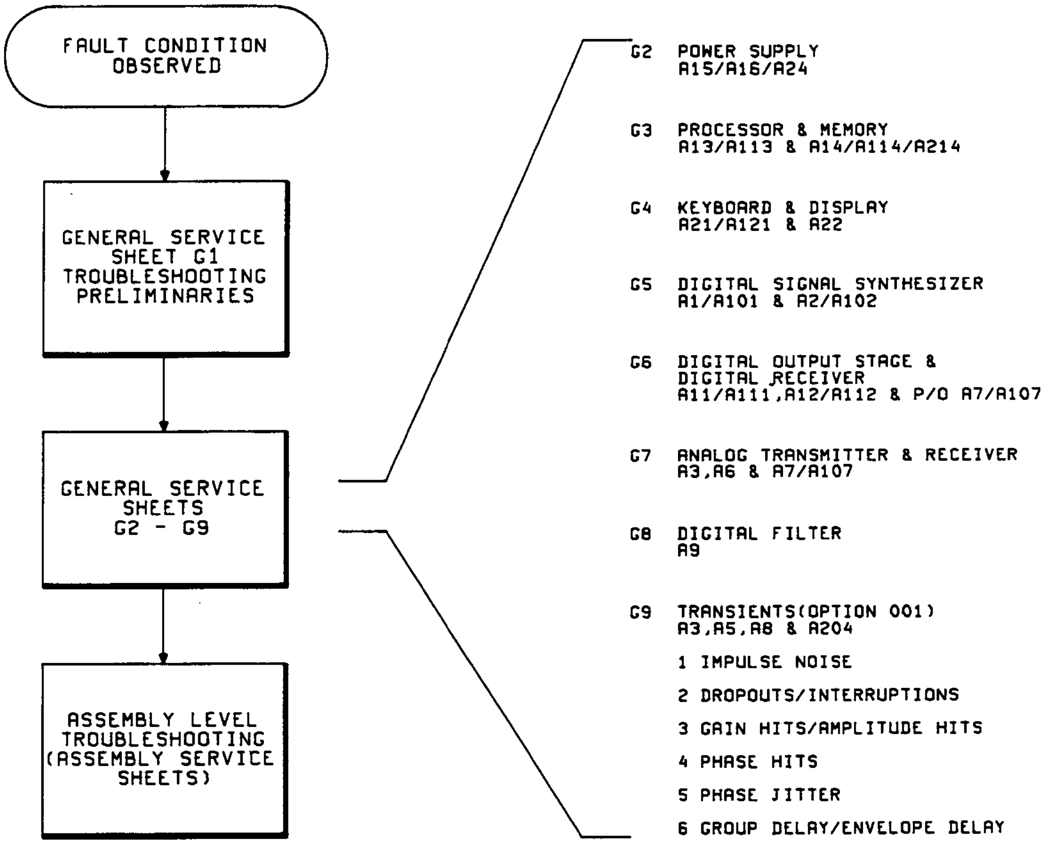


Figure 8-2 Troubleshooting Layout

8-11 REPAIR

8-12 When replacing an ic which has an adhesive fixed heat sink; ensure that the heat sink is fixed to the new ic with an adhesive with the correct thermal conductivity (such as Eccobond 286 by Emerson & Cuming, California, US; HP Part Number 0470-0647).

8-13 After Service Product Safety Checks

8-14 Visually inspect interior of instrument for any signs of abnormal internally generated heat, such as discoloured printed circuit boards or components, damaged insulation, or evidence of arcing. Determine and remedy cause of any such condition.

8-15 Using a suitable ohmmeter, check resistance from instrument enclosure to ground pin on power cord plug. The reading must be less that one ohm. Flex the power cord while making this measurement to determine whether intermittent discontinuities exist.

8-16 Check any indicated front or rear panel ground terminals marked, using the above procedures.

8-17 Check resistance from instrument enclosure to line and neutral (tied together) with the power switch on and the power source disconnected. The minimum acceptable resistance is two megohms. Replace any component which results in a failure.

8-18 Check line fuse(s) to verify that a correctly rated fuse is installed.

8-19 SCHEMATIC DIAGRAMS

8-20 Schematic diagram drawing information is listed in Table 8-2.

Table 8-2 Schematic Diagram Notes

Units		Resistance in ohms, capacitance in picofarads, inductance in millihenries unless otherwise noted.
Factory-selected parts	*	Asterisk denotes a factory-selected value. Value shown is typical. Part may be omitted.
Panel labels		Encloses front-panel designation.
		Encloses rear-panel designation.
Outlines		Circuit assembly borderline.
		Other assembly borderline. Also used to indicate mechanical interconnection (ganging).
Common components		Resistor; Capacitor; Inductor; Transistor (NPN)
Test points		Numbered Test point. Measurement aid provided.
Wire colours	( )	Encloses wire colour code. Code used is the same as the resistor colour code. First number identifies the base colour, second number identifies the wider stripe, third number identifies the narrower stripe. E.G. *(947)* denotes white base, yellow wide stripe, violet narrow stripe.
Grounds and commons		A direct conducting connection to the earth, or a conducting connection to a structure that has a similar function (e.g. the frame of an air, sea, or land vehicle).
		A conducting connection to a chassis or frame.
	A	ANALOG GND. All like-designated points are connected.

8-21 LOGIC SYMBOLS

8-22 The logic symbols used in this manual are based on the American National Standard ANSI Y32.14-1973, "Graphic symbols for Logic Diagrams (Two-State Devices)".

8-23 Qualifiers

8-24 Qualifiers are that portion of a logic symbol that denotes its logic function. The following qualifiers are used in this manual:

& - AND.

<-> - Bilateral Switch: A binary controlled circuit which acts as an on/off switch to analog or binary signals flowing in both directions.

X-Y - Coder: Input code (X) is converted to output code (Y) per weighted values.

mCNTR - COUNTER with modules m.

RAM - RANDOM ACCESS MEMORY.

ROM - READ ONLY MEMORY.

+m - COUNT UP INPUT (m is replaced with a number indicating number of shifts or counts).

MUX - MULTIPLEXER

3-ST - THREE STATE OUTPUT: 3 state label is used with F notation to symbolize devices that have an output disconnect ability.

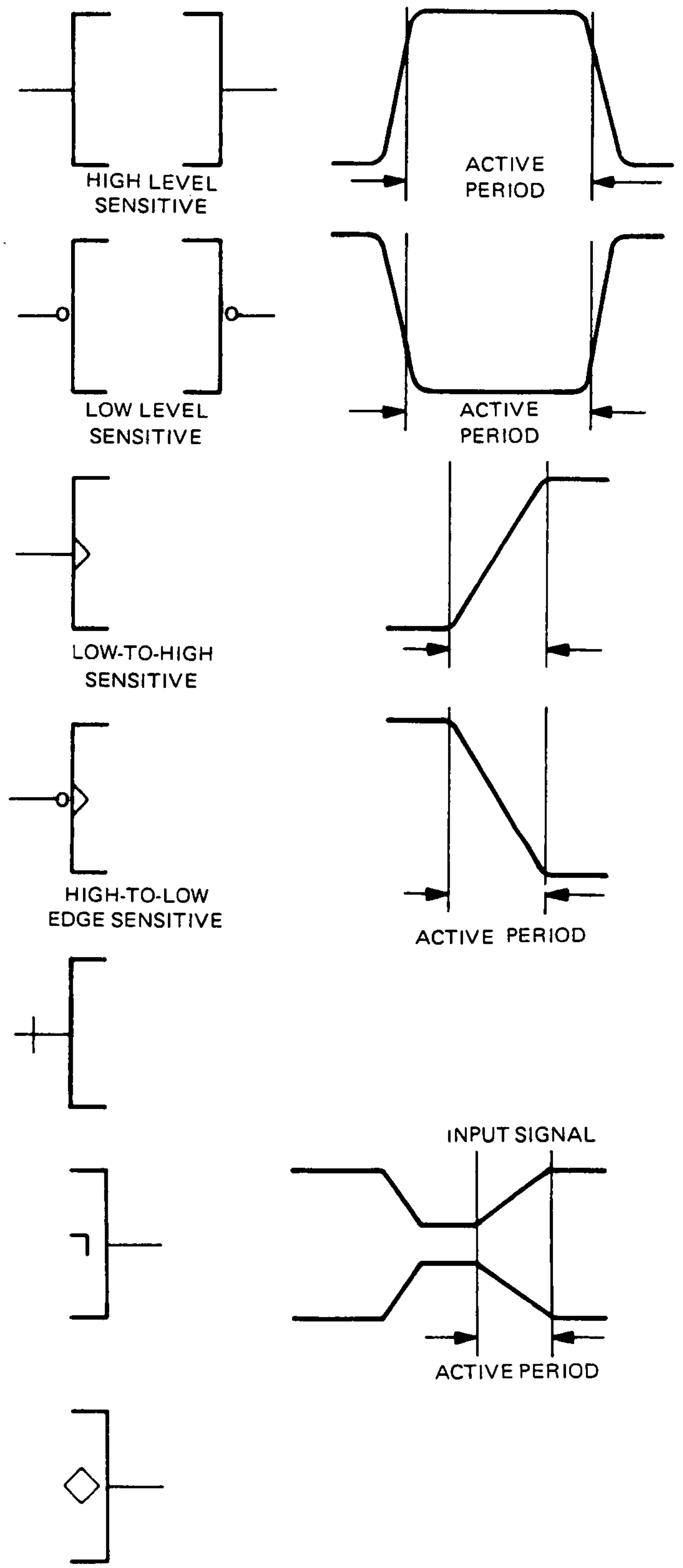
T - Toggle Input.

X/Y - Signal Level Converter: Input levels are different from output levels.

⎎ - Indicates that hysteresis exists in the device.

8-25 Indicator Symbols

Indicator Symbols identify the active state or level of a symbol's input or output (see Figure 8-3).



ACTIVE HIGH inputs and outputs are indicated by the absence of the negation indicator symbol (O).

ACTIVE LOW inputs and outputs are indicated by the presence of the negation indicator symbol (O).

EDGE SENSITIVE (Dynamic) inputs are indicated by the presence of the dynamic indicator symbol (▷).

INHIBIT input (+) used when active input inhibits (blocks) the active state outputs of the logic function.

OUTPUT DELAY indicator symbol (⌝) shows that an output becomes effective when the signal that initiated that change returns to its opposite state.

OPEN COLLECTOR OUTPUT. Output that forms part of a distributed connection.

Figure 8-3 Indicator Symbols

8-26 Dependency Notation

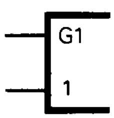
8-27 Dependency notation is the technique for defining input/output and input/input relationships without showing all the elements and interconnections involved. Logic relationships between inputs and outputs are shown in this manual by using the following notation:

mAm - Address Dependency: The m prefix should be replaced with a number that differentiates between several address inputs, indicates dependency or indicated demultiplexing and multiplexing of address inputs/ouputs. The "m" suffix indicates the number of cells that can be addressed.

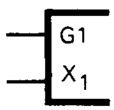
Gm - Gate (AND) Dependency: The G input gates those inputs or outputs labelled with the same identifier m. The m is replaced with a number.

Cm - Control Dependency: This is used only with D type Flip-Flops and indicates that the basic function of the Flip-Flop is controlled by inputs with the same identifier. The m is replaced with a number.

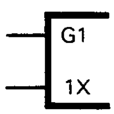
Fm - Free Dependency: This is an input that acts as a connect switch when active and a disconnect when inactive. Used for 3-state.



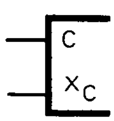
The input that controls or gates other inputs is labelled with a "C" or a "G", followed by an identifying number. The controlled or gated input or output is labelled with the same number. In this example, "1" is controlled by "G1".



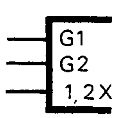
OR



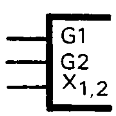
When the controlled or gated input or output already has a functional label (X is used here), that level will be prefixed or subscripted by the identifying number.



If a particular device has only one gating or control input then the identifying number may be eliminated and the relationship shown with a subscript.



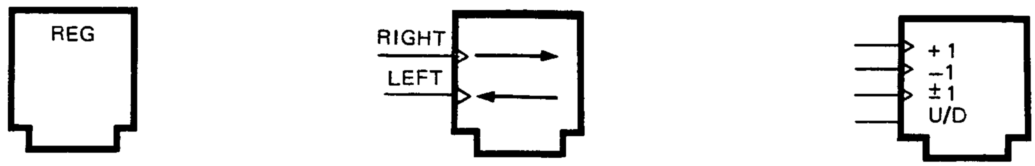
OR



If the input or output is affected by more than one gate or control input, then the identifying numbers of each gate or control input will appear in the prefix or subscript separated by commas. In this example "X" is controlled by "G1" and "G2".

8-28 Control Blocks

8-29 Control Blocks are used with complex logic to show when common control signals are applied to a group of functionally separate units. Typical examples of control blocks follow.



(A) REGISTER CONTROL (B) SHIFT REGISTER CONTROL (C) COUNTER CONTROL

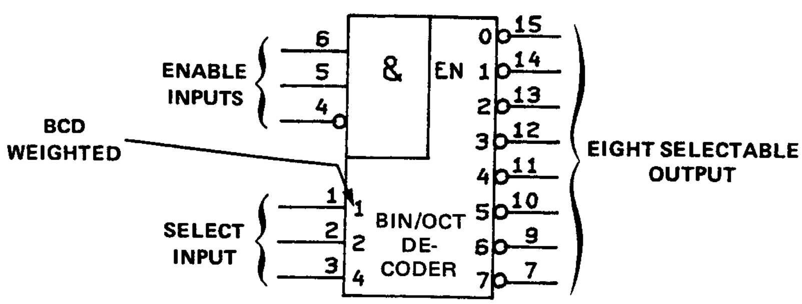
(A) - Register Control Block: This symbol is used with an associated array of flip-flop symbols to provide a point of placement for common function lines, such as a common clear.

(B) - Shift Register Control Block: This symbol is used with an array of flip-flop symbols to form a shift register. An active transition at the inputs causes left or right shifting as indicated.

(C) - Counter Control Block: This symbol is used with an array of flip-flops or other circuits serving as a binary or decade counter. An active transition at the +1 or -1 inputs causes the counter to increment one count upward or downward, respectivly. An active transition at the +/-1 input causes the counter to increment one count upward or downward depending on the input at an up/down control.

8-30 Examples of Logic Devices

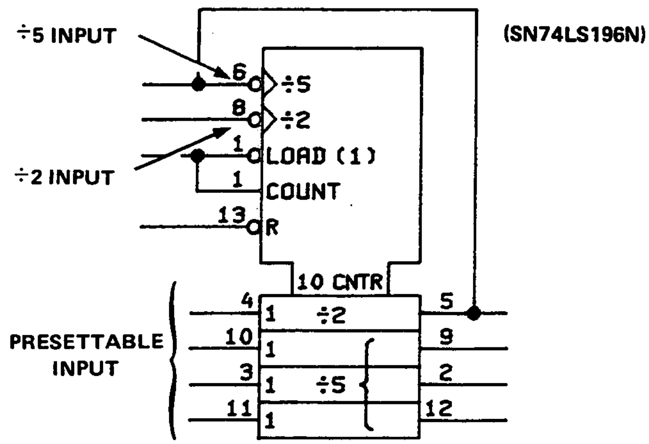
DECODER (SN74LS138N)



DECIMAL WEIGHTED

8-31 This device decodes one of eight lines (0 to 7) depending on the conditions at the three select inputs and the three enable inputs, ie output "5" is selected and set low when the select inputs are 101 and the enable inputs are 110.

PRESETTABLE DECADE COUNTER (÷2, ÷5 OPTION)



8-32 This counter has a divide by 2 or a divide by 5 function. Both the divide by 2 and divide by 5 operations are enabled by positive to negative transition of signals at the respective divide by 2 and divide by 5 inputs.

8-33 The presettable inputs marked "1" are activated when the LOAD (1) input is set low.

8-34 A low on the R input resets all outputs regardless of the other inputs.

THEORY OF OPERATION

8-35 THEORY OF OPERATION

8-36 INTRODUCTION

8-37 The 3776 is a microprocessor controlled transmitter and receiver which performs a wide variety of measurements on PRIMARY MULTIPLEX systems. Test signals are transmitted/received in either the PCM or analog domains. A simplified block diagram of the instrument, illustrated in Figure 8-4, shows the 3776 to be made up of three main sections:-

1 TRANSMITTER
2 RECEIVER
3 PROCESSOR and KEYBOARD/DISPLAYS

The following overall 3776 description should be read along with Figure 8-4 (page 8-15) and the 3776 Overall Block Diagram contained in the envelope at the rear of the Manual.

8-38 TRANSMITTER

8-39 The instrument's TRANSMITTER section is made up of the following four sub-sections:

1 Digital Synthesizer and PCM Generator
2 Digital Transmitter
3 Analog Transmitter
4 Monitor Output

8-40 Digital Synthesizer and PCM Generator assembly A1/A101, generates 7 different types of test signals (see Assembly Service Sheet A1/A101) for 3776 measurements. These signals digitally synthesized on A1/A101 are applied to A3 for A to A and A to D measurements. For D to D and D to A measurements the digitally synthesized signals are inserted into a PCM frame structure prior to being digitally transmitted. The wide range of test signals generated by A1/A101 is due to the A1/A101 software stored in ROM and RAM, and to the bit slice processor. The A1/A101 software program is linearly incremented by the Program Counter and repeats every 125us under the control of the 3776 main operating program.

8-41 Digital Transmitter assembly A2/A102, has data applied to it from A1 or the AUX I/P when performing D to D or D to A measurements, or from A12 when the 3776 is in the THRU MODE and performing an A to A measurement on a 2-WIRE system.

8-42 Digital test signals are inserted into timeslots (selected via the front panel) of a PCM frame structure by the A1/A101 software. This is implemented on A2/A102 by loading the measurement test data D OUT 0 to D OUT 7 into the Foreground Latch at the appropriate times, all other timeslots are loaded with a PCM Background test signal via the Background Latch. The parallel outputs of the Latches are converted to a serial form, then line encoded, HDB3/AMI (3776A) or B8ZS/AMI (AZS) (3776B). The 2,048kb/s (3776A) or 1,544kb/s (3776B) PCM data stream at the output of A2 is fed via the output buffers on A7/A107 to the DIGITAL TRANSMIT outputs.

8-43 An external analog source (connecting a microphone to the AUX I/P) may be inserted into a timeslot and transmitted in the PCM data stream. The analog input from the AUX I/P is converted to digital form on A1 and inserted into a timeslot as in the previous paragraph.

8-44 Analog Transmitter assembly A3, uses a DAC to convert a 12 bit binary word D OUT 0 to D OUT 11 (representing the keyed in frequency) from A1/A101 to an analog form prior to transmission. The signal level information (also keyed in via the front panel) is decoded on A13 and implemented by the gain and attenuator stages on A3. Signal purity is maintained by the de-glitch and anti-aliasing filter circuits. The amplifiers at the ANALOG TRANSMIT output are protected against improper application of RINGING TONE signals.

8-45 The remodulation circuit is used when the 3776 is operating in the THRU mode (see Assembly Service Sheet A3).

8-46 Monitor assembly A4/A204, may be used in the DIGITAL or ANALOG TRANSMIT modes. The binary output data of A1/A101 is applied to A4 via A3 where it is converted to analog form. The analog signal may be applied to a speaker or to the MONITOR OUTPUT for further analysis. Assembly A204 is used in the ENVELOPE DELAY DISTORTION mode (see RECEIVER section).

8-47 RECEIVER

8-48 The RECEIVER section of the instrument is made up of the following seven sub-sections:-

1 Digital Receiver and Alignment
2 Analog Receiver and Autoranging
3 Digital Filtering
4 Impulse Noise
5 Group Delay Distortion
6 Envelope Delay Distortion
7 Transients

8-49 Digital Receiver and Alignment circuits are contained on assemblies A12 and A11/A111 respectively. The received PCM data stream is applied to the 3776 via a BALanced or UNBALanced input port. On A12, this data is converted from a ternary signal to a TTL binary signal prior to having the line code HDB3/AMI (3776A) or B8ZS/AMI (AZS) (3776B) removed, which produces TTL DATA at the output of the Line Code Decoder. Clock signals which drive the A11/A111 and A12 circuits are extracted from the PCM data stream on A12. PCM data is also monitored for alarm conditions (ALL 1s and signal loss).

8-50 PCM data is organised in formal structures (timeslots, frames and multiframes), the commonly used structures are illustrated in Appendix A. The A11/A111 accesses data within the timeslots and applies it to A9. However, before the received PCM data can be analysed by the 3776, the instrument must be in alignment with the formal PCM structures. Searching for and maintaining alignment is a function of the A11/A111 Assembly. Alignment must be achieved before TTL DATA is applied to A9 for processing.

8-51 Alignment information is contained in all PCM structures, the Frame and Multiframe Alignment Detector and Timing Generator on A11/A111 interrogate TTL DATA looking for the alignment information. When a bit/pattern matching the alignment bit/pattern is detected the Timing Generator is enabled and increments through to the next alignment bit/pattern. The Frame and Multiframe Alignment Detector rechecks TTL DATA for each alignment bit/pattern. If the alignment bit/pattern remains good the Timing Generator continues counting and the next alignment bit/pattern is rechecked. This action is repeated and when the frame and multiframe alignment criteria are satisfied alignment is considered to be achieved. When this occurs the Frame and Multiframe Alignment Detector flags the Test Timeslot Selector.

8-52 If however, the frame and multiframe criteria are NOT met the Timing Generator is reset and held in its reset state until an alignment bit/pattern is detected. It should be noted that it may take many attempts before alignment is achieved.

8-53 Once alignment is achieved the Frame and Multiframe Alignment Detector monitors TTL DATA for violations in the alignment criteria and informs the Status Condition Detector accordingly.

8-54 Alignment achieved, data can be accessed within the timeslots by the Timeslot Selector. The Test Timeslot Selector compares the receiver timing data (RX TSC, RX FC) from the Timing Generator with the control pattern for the test timeslot (TEST WORD). When both bit patterns are the same TTL DATA is the data contained in the test timeslot. RX SELTS then flags that the required data is available and ready for processing. The timeslot under test is keyed in via the front panel and stored in A13 and applied to A11/A111 as TEST WORD (see Figure A11-1).

8-55 The data stored in the Test Timeslot Register is either A-Law (3776A) or U-LAW (3776B) encoded, the Expander decodes the data prior to it being processed by the A9 Assembly.

8-56 When the received data is ready for processing the Digital Filter Handshake Control interfaces with A9. Level information is applied to the A13 Assembly via the Peak Codes Detector.

8-57 Analog Receiver and Autoranging circuits are contained on assemblies A6 and A7/A107 respectively. The 3776 uses digital circuits on A9 and A13 to process analog input signals. The circuits on A6 and A7/A107 convert these analog signals to a digital form for processing. Autoranging and calibration routines contained in the 3776 main operating program control the analog receiver circuits and ensure that the sequence of 16 bit binary words obtained at the output of A7/A107 accurately represent the incoming analog signal.

8-58 The autoranging circuits contained on both A6 and A7/A107 are designated Primary Autoranging (PAR) and Secondary Autoranging (SAR) respectively. The level of the incoming signal is monitored by the Level Detector on A6 which instructs the processor to initiate the appropriate PAR routine. After the PAR routine is completed the SAR routine goes into action. In SAR the peak level of the signal is monitored directly by A13 and A9 via the A/D Converter at the output of A7/A107. The processor instructs the SAR circuits to insert the appropriate amount of gain.

8-59 The anti-aliasing filter on A6 ensures that out-of-band signals do not corrupt the in band voice channel with aliasing signals (see APPENDIX B).

8-60 A calibration routine contained in the software of A13 ensures that the various gain stages of the PAR and SAR circuits and the anti-aliasing filter response are accurately checked after every analog measurement.

8-61 Digital Filtering of either analog or digital received data is performed on assembly A9. Fundamental to this operation is the Digital Filter Chip and the loading of the Digital Filter program from the processor on A13 to the Filter Program RAM.

8-62 When the 3776 front panel RUN key is pressed, the processor on A13 assembles the filter coefficients (see Assembly Service Sheet A9) and down loads these into the Filter Program RAM. Once programmed, digital filtering commences. The output of the Digital Filter Chip is applied to A13, A8 and A4/A204 for further processing.

8-63 Impulse Noise is measured on assembly A8 by comparing the input noise against the threshold levels Lo, MID and Hi. The Lo level is keyed in via the front panel while the other two levels are derived from the 3776 main operating program (see Assembly Service Sheet A8).

8-64 Impulse Noise information is applied serially along H THRESHOLD from A9 and converted to a parallel form by the Threshold Detector. The L Lo, L MID and L Hi lines are then monitored by the Latch Self-blocking Timers. When an impluse noise threshold level is exceeded the appropriate input to the Lo/MID/Hi Encoder goes low. The encoder then converts from 3 to 2 lines which are then applied to the processor on A13 for processing.

8-65 Assembly A8 also contains the Group Delay Timing circuits (see Group Delay Distortion) and a frequency counter which measure the carrier frequencies during Group Delay and Envelope Delay Distortion measurements.

8-66 Group Delay Distortion is measured in the PCM and analog domains by the 3776, using the recommended CCITT (0.81) method. A typical analog waveform is illustrated in Assembly Service Sheet A8. The 41 2/3Hz and 166 2/3Hz modulation envelopes of the waveform are used by the 3776 to measure group delay.

8-67 The phase of the 41 2/3Hz modulation envelope is measured alternately in the Reference and Measurement carrier periods by the 3776 (applied to the processor on A13 from the output of A9). Differences in phase define the Group Delay.

8-68 The 166 2/3Hz modulation envelope is a synchronising marker and indicates the start/finish of the Measurement/Reference carrier. This marker detected on A9 (H THRESHOLD) flags the Timing Chain on A8 which generates the group delay timing signals for A13.

8-69 Envelope Delay Distortion

8-70 An Envelope Delay Distortion (EDD) measurement is described in Assembly Service sheet A4/A204. Two measurement steps are necessary in computing EDD. First 55 cycles of the 83 1/3Hz modulated 1.01kHz reference signal IP PH-REF is applied around the loop of Figure A4-3b and the phase of the 83 1/3Hz envelope compared against an absolute reference R PH-ABS (a reference signal produced in the 3776). The result is stored in the processor. The next step is to apply 55 cycles of 83 1/3Hz modulated measurement carrier IP PH-MEAS (in the range 200 to 3.6kHz) around the loop as described in paragraph A4-7. Both the reference and measurement phases are averaged over 55 cycles to overcome any jitter in the carrier frequencies. The IP PH-MEAS of the 83 1/3Hz envelope of these carriers is compared against the absolute reference R PH-ABS. The Envelope Delay Distortion (EDD) is computed as illustrated in Figure A4-4.

8-71 Transients and phase jitter measurements are performed on A5. Five main circuit elements are contained on A5, namely;

*1 Temperature Compensated Log converter
*2 Dropouts (3776B)/Interruptions (3776A)
*3 Gain Hits
*4 Phase Hits
5 Phase Jitter

*Transient Measurements

The transients and phase jitter measurements are described in detail in Assembly Service Sheet A5.

8-72 PROCESSOR and KEYBOARD/DISPLAYS

8-73 Processing and Memory functions of the 3776 are provided by the A13 and A14 Assemblies respectively. The microprocessor contained on A13 communicates with all the other assemblies by means of the following bus systems:

1 Instrument Bus....To/From A1 thru A12
2 Memory Bus....To/From A14
3 Keyboard Bus....To/From A21/A22
4 HP-IB Bus....To/From external controller
5 Address Bus....To A1 thru A12 and A22

The main 3776 operating program stored on A13/A14 allows the instrument to perform a wide variety of measurement.

8-74 Interrupt requests (LIRQ) to the microprocessor can be issued by the following six sources:

HP-IB
front panel keys
rear panel switches
Digital Receiver (A11/A12)
Impulse Noise & Frequency Detector (A8)
Transients (A5)

All these interrupts are maskable and can be enabled or disabled by the processor. There are also non-maskable interrupts (LNMI) which are serviced immediately by the microprocessor and these occur during power failure or time-out conditions (see Assembly Service Sheet A13).

8-75 The transfer of data between A13 and the other assemblies along the bus systems requires a hand-shake protocol. This is described in Assembly Service Sheet A13.

8-76 The main memory store is contained on A14 in RAM and ROM. The A14 Assembly contains a non-volatile memory (NVM) RAM which is used to store set-up and default parameters. It is also used when there is a power failure to store the data being processed.

8-78 Keyboard and Displays, contained on A21 enables the operator to manually control the 3776. The front panel keyboard is arranged in the form of a grid. When a key at the point of intersection is pressed a connection is made between a pair of X and Y lines (see Figure A22-3 in Assembly Service Sheet A22). The X lines strobed at 16kHz are decoded by the processor on A13. The Y lines inform the processor that a key has been pressed, by generating an interrupt request flag LIRQ.

8-79 Assembly A22 interacts with A13 to control the flow of KEYBOARD and DISPLAY DATA (see Figure A22-2). All front panel 7 segment and LED information, DISPLAY DATA, is produced on A13 and stored in RAM in the Display Control Logic on A22. This circuit when instructed by the processor on A13 provides the drive for the 7 segment displays and LEDs.

Figure 8-4 Simplified Block Diagram ▶

ied Block Diag

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Figure 8-4 Simplified Block Diagram ▶

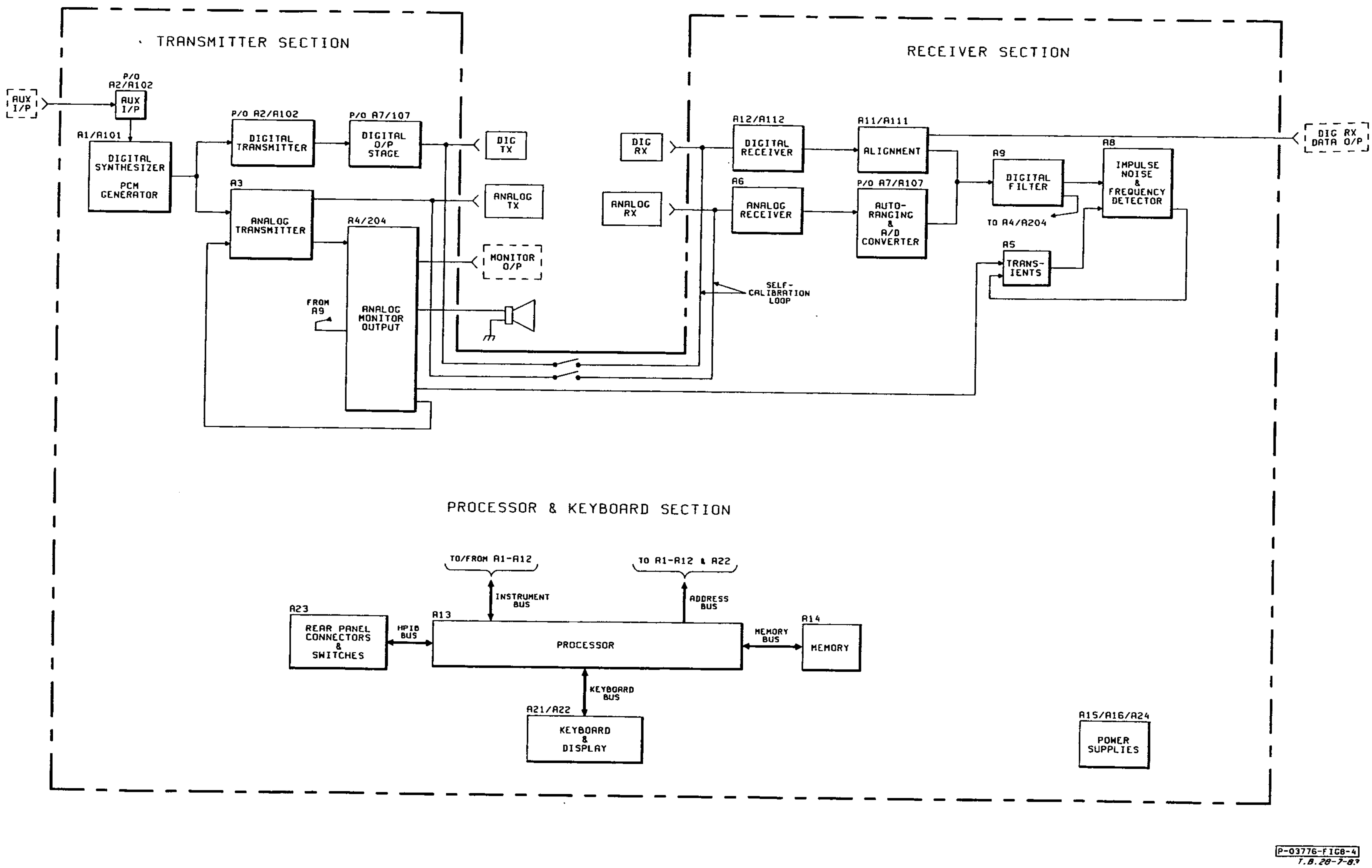


Figure 8-4 Simplified Block Diagram

GENERAL SERVICE SHEET G1
TROUBLESHOOTING PRELIMINARIES

GENERAL SERVICE SHEET G1
TROUBLESHOOTING PRELIMINARIES

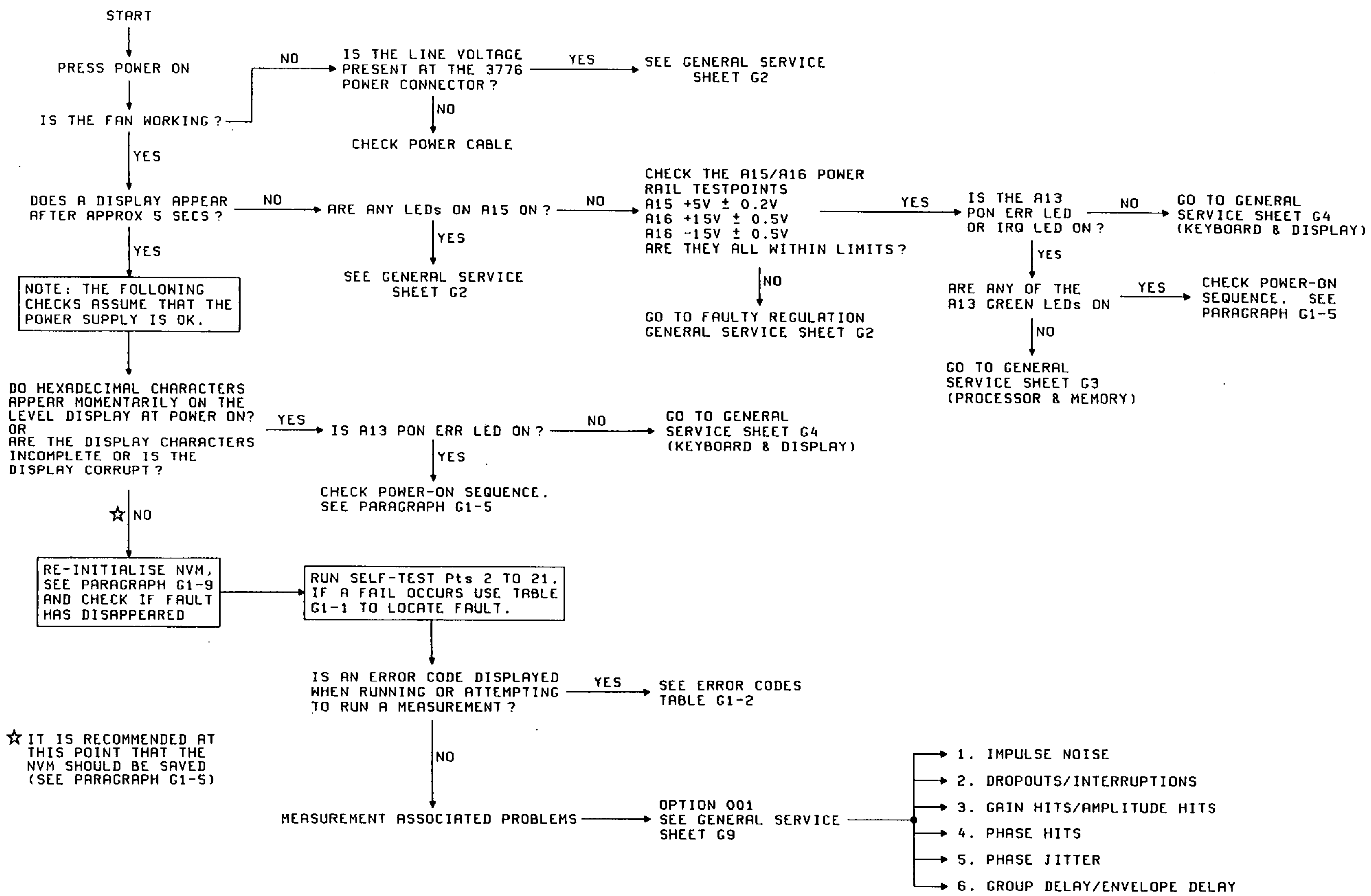
G1-1 INTRODUCTION

G1-2 The 3776 Troubleshooting information is contained in General Service Sheets G1 to G9. All troubleshooting starts from the preliminary troubleshooting in G1.

G1-3 Figure G1-1 is the start point for all fault conditions. By following this chart the detailed information on G2 to G9 is quickly accessed.

G1-4 General Service Sheet G1 also contains other useful troubleshooting information which is listed here.

1. Power-On Sequence
2. Re-initialising NVM (non-volatile memory)
3. Self-Test
4. Error Codes
5. Instrument Bus Access using the utilities
6. Instrument Bus Access using HP-IB
7. Instrument Identification
8. Switch Selected Self Tests
9. Protective Fusing
10. Balanced Lines and Connectors



G1-1 Troubleshooting Entry Chart

G1-5 SAVING CONTENTS OF THE NVM

G1-6 The following procedures should be used to save the NVM data on tape or load saved NVM data from tape into the 3776.

Equipment Required

Controller..HP85B Service Tool
3776 Test Programs
Data Cartridge..HP 03776-10001

Procedure for Saving Contents of 3776 NVM

1. Connect the HP85B controller to the 3776 via the HP-IB interface.
2. Load the "NVMCOP" program into the HP85B and press the HP85B RUN key.
3. Enter the 3776 HP-IB address and press END LINE.
4. Press R to read the 3776 NVM into the HP85B then press END LINE.
5. Ensure that a Data Cartridge set to record is inserted in the HP85B. Enter your file name (eg NEM76) and press END LINE. Ensure that your file name does not correspond to file names already used. The 3776 NVM is now loaded into the HP85B, this takes approximately 6 minutes.

Procedure for Loading Saved NVM back into the 3776

1. Connect the HP85B Controller to the 3776 via the HP-IB interface.
2. Load the "NVMCOP" program into the HP85B and press the HP85B RUN key.
3. Enter the 3776 HP-IB address and press END LINE.
4. Press W to Write the NVM data on tape to the 3776 then press END LINE.
5. Insert the Data Cartridge with the saved NVM into the HP85B.
6. Enter your file name (eg NEM76) then press END LINE. The saved NVM is now transferred from tape into the 3776. This takes approximately 3 minutes.
7. When the program stops, switch the 3776 power off, then on, to verify the NVM checksums. Error 120 should be displayed momentarily at power on. The NVM has now been successfully loaded.

G1-7 POWER-ON SEQUENCE

G1-8 The power on sequence is automatically implemented at switch on. A full description of the checks performed is given in Section IV of the Service Manual.

G1-9 Each item in the power-on sequence has an associated code indicated by the green leds on A13. The led codes and associated items are as follows:

Sequence Step No	Green LED Codes 54321	Description
1	00000	68A21 PIA initialisation
2	00000	8291A HP-IB chip initialisation
3	00000	Front panel display RAM clear
4	00001	Processor board RAM test
5	00010	Provisional hardware initialisation
6	00100	Activation of system monitor
7	01001	Switch selected Self-Test (if required)
8	01010	Front panel and display RAM test
9	01011	Instrument bus operation check
10	01100	Instrument bus ports check
11	01101	Non-volatile area verification (A14 U43)
12	01110	Group delay RAM check (A14 U33)
13	01111	Show HP-IB address/talk only format
14	01111	Check ROM C, ROM A and ROM 20 on A14 are loaded
15	10000	Instrument configuration

G1-10 When a Self-Test Result (Table G1-1) or Error Code (Table G1-2) CANNOT be displayed (ie Processor failure or Keyboard/Display failure), then the above led codes are used in determining the error condition. If any of the power-on sequence steps fail, the PON ERR led on A13 comes on. If the failure is catastrophic, (ie a faulty processor RAM is catastrophic since no further progress can be made) then the appropriate green led code indicates the failed step. In most cases, troublehooting can be performed using General Service Sheet G3 Processor and Memory. If step 9 fails (ie Front Panel and Display RAM) then General Service Sheet G4 Keyboard and Display may be used for troubleshooting.

G1-11 RE-INITIALIZE NVM (Non-Volatile Memory)

G1-12 Introduction

G1-13 The NVM RAM A14U43 can be reset to its factory preset condition by either running the "NVMCLR" program via HP-IB or manually using the A13S2 Utility switches.

G1-14 Manual Procedure for Re-initializing NVM.

G1-15 This check runs a RAM test on the NVM RAM A14U43. After the test, the four non-volatile areas within this memory are reset to the factory preset default condition. The configuration saved at the last power-fail, and the dialling tables, are replaced by default values taken from RAM The measurement parameter store and the sequence store are cleared.

1. Remove the 3776 top cover and assemblies screen.
2. Set the A13S2 switches to 10010.
3. Press the A13S1 reset button.
4. Set the A13S2 switches to 00000.
5. Replace the assemblies screen and top cover.
6. Check and see if the fault has disappeared.

G1-16 HP-IB Procedure for Re-initializing the NVM

G1-17 The following program resets the NVM to its factory preset default condition.

Equipment Required

Controller	HP85B Service Tool
3776 "NVMCLR" Program	HP3776 Test Programs Data Cartridge 03776-10001

Procedure

1. Connect the HP85 to the 3776 via HP-IB.
2. Insert HP3776 Test Programs Data Cartridge 03776-10001 into the HP85.
3. Load program "NVM CLR" and RUN.
4. After running the program check and see if the fault has disappeared.

G1-18 SELF TEST

G1-19 Introduction

G1-20 Self-Test can be either run manually or automatically via HP-IB. A list of all Self-Test points with corresponding description and fault locations are given in Table G1-1.

G1-21 Manual Procedure for Running Self-Test

1. Press the 3776 SELF-TEST key-CAL will be displayed.
2. Press the NEXT PARAM key - Pt2 will be displayed.

3. Press RUN and check that Pt2 PASS 0 is displayed. If FAIL is displayed refer to Table G1-1.

4. Repeat Steps 2 and 3 for Pts 3 to 21.

G1-22 Automatic Procedure for Running Self-Test

Equipment Required

Controller	HP85B Service Tool
3776 "STEST" Program	HP3776 Test Programs Data Cartridge 03776-10001

Procedure

1. Connect the HP85 to the 3776 via HP-IB.

2. Insert HP3776 Test Programs Data Cartridge 03776-10001 into the HP85.

3. Load program "STEST" and RUN.

4. Any Self-Test Pts that FAIL will be printed. Any Error Codes generated are also printed. If a FAIL is printed refer to Table G1-1 for Troubleshooting. See Error Codes Paragraph G1-23 if an Error Code is printed.

Table G1-1 Self-Test Checks

Test No	Description	Fault Location
	Note: Run Test No.13 (A13/A14 ROM check) first before running other Self Test Nos. Other Self Test Nos. should be run in sequence and appropriate troubleshooting performed in sequence given unless otherwise stated.	If any of the Self-Tests 2 to 10 fail, manually run Self-Test 20 to ascertain that the Digital Filter is okay. If Self-Test 20 fails then use GENERAL SERVICE SHEET G8 to locate the fault. If Self-Test 20 passes and any of Self-Test 2 to 10 fail then go to GENERAL SERVICE SHEET G7 for A3, A6, A7 and A107 troubleshooting.
2 to 10	Instrument Calibration Routine	
11	Transient Gain	Check A5 A/D Converter path. Go to GENERAL SERVICE SHEET G9.
12	AN Rx Weighting	Use GENERAL SERVICE SHEET G7 to locate fault.
13	A13/A14 ROM check. Generates the CRC code for each ROM and checks that it is correct. Returns PASS/FAIL for each ROM. The Revision code for each ROM can be obtained over the HP-IB (see G1-46).	The ROM locations are as follows: Pt13 - 0 A13U36 Pt13 - 1 A14U13 Pt13 - 2 A14U12 Pt13 - 3 A14U22 Pt13 - 4 A14U32

		Pt13 - 5 A14U42 Pt13 - 6 A14U41 Pt13 - 7 A14U31 Pt13 - 8 A14U21 Pt13 - 9 A14U23 ● If any of the ROM CRC checks FAIL then replace the appropriate ROM.
14	NVM check. Verifies correct operation of the A14U43 RAM chip. Pt14-0 checks overall operation of the chip. Pt14-1 to Pt14-4 checks the CRC of each of the four non-volatile areas contained in A14U43.	If Pt14-0 FAILS then replace A14U43. If Pt14-1, 14-2, 14-3 or 14-4 FAILS and Pt14-0 PASSES then re-run Self-Test 14 and re-check. If either 14-1, 14-2, 14-3 and 14-4 FAILS after re-running Self-Test 14 then go to GENERAL SERVICE SHEET G3.
15	Group Delay RAM Check. Verifies correct operation of the A14U33 RAM chip.	If Pt15 FAILS then replace A14U33.
16	Instrument Bus Check. Tests that the Interface Bus will transfer data.	Sends data to A3 I/O Buffer and reads data back. Power-on sequence should fail if this check FAILS. Use the utilities (see GENERAL SERVICE SHEET G1 Paragraph G1-25) to continually write to the I/O Buffer checking the I/O Buffer/Processor Handshake.
17	Front Panel Keyboard Controller Assembly A22 RAM check. Checks that data can be transferred to and from A22 Display RAMS A22U16, A22U17, A22U26 and A22U27.	Possible A22U16, A22U17, A22U26 or A22U27 Display RAM fault. See GENERAL SERVICE SHEET G4 Keyboard and Display.
18	AN Tx to AN Rx Internal Loop Continuity Check. **Note: The ANALOG RECEIVE termination must not be set to BRIDGED before setting SELF-TEST and running Pt18.**	If Self-Test Pts 2 to 10 PASS (ie Calibration Routine) then fault is in A3 Output Amplifier Stage or the CAL 1B and CAL 1A lines between A3 and A6.
19	PCM Continuity Check. Checks that the signal from the A1/101 Synthesizer assembly can be received by the digital filter via the DIG Tx and DIG Rx.	Use GENERAL SERVICE SHEETS G6, G5 or G8 to locate fault. Check DIG Rx Troubleshooting G6 first before checking G5. **Note: If S/Test 20 fails then use GENERAL SERVICE SHEET G8 to locate fault.**
20	Digital Filter Test. Operation of the Digital Filter is checked by running the following tests: 20-0: Programming Test 20-1: Interrupt rate AN Rx/DIG Rx 20-2: Digital Filter Bus Test AN Rx 20-3: Digital Filter Bus Test DIG Rx 20-4: Digital Filter Clear RAM Test 20-5: Addition Test (tests the Carry-out Counter) 20-6: Arithmetic and Hardware Overflow test 20-7: Instruction Set Test, (leaves the digital filter in the Signature Analysis mode).	Use GENERAL SERVICE SHEET G8 to locate the fault.

21	PCM Function Test. Runs the following tests for the DIG Rx via the internal DIG Tx to DIG Rx loop. 21-0: Checks that DIG Rx alignment is okay 21-1: Tests that correct codes are sent and received on A11/ A111 code port. 21-2: Positive Peak Codes test 21-3: Negative Peak Codes test 21-4: DIG Rx to digital filter handshake test	Use GENERAL SERVICE SHEET G6 to locate the fault.
22	Pt22 (ie NATTER) is not a SELF-TEST check. It allows the user to set up a two way conversation (see the Operating Manual).	

G1-23 ERROR CODES

G1-24 Normally the SELF-TEST results will indicate the faulty area for troubleshooting, however, when the SELF-TEST procedure (see Paragraph G1-18) passes and a fault condition still exists, the ERROR CODES must be used to indicate the faulty area. It should be noted that this is not the normal function of the Error Codes and particular care should be exercised in interpreting them in this way. The following table is therefore provided as a GUIDE ONLY and should only be used to attempt to locate the faulty areas if SELF-TEST passes.

Table G1-2 Error Codes

Code	Description	Possible fault location/Notes (see Paragraph G1-24)
	Operator/programming errors	
1	HP-IB command string syntax incorrect	
2	HP-IB command string too long	
3	Unrecognised HP-IB command	
4	HP-IB command parameter is out of range	
5	Command parameter missing	
6	Too many command parameters	
7	Unsupported block data format	
8	Zero or negative byte count in BDFA data list	
9	Byte count in BDFA data list is greater than the number of subsequent bytes	
10	Odd number of bytes in binary format data list	
11	Command ignored .. instrument under local control	
12	Key (or command) out of context in current state	
13	Measurement not defined for this instrument	
14	Measurement not available in current mode	

15	Option hardware not present for this measurement	
16	Framing / signalling measurement not applicable with current PCM format	
17	(3776A only) channel 31 requested with 30 channel pcm format	
18	Append to sequence fails - measurement cannot be sequenced or mode not end-end	
19	Append to sequence fails - not enough room left in NVAREA 3	
20	RECALL from sequence failed - no sequence present or beyond end of sequence	
21	RECALL measurement parameters failed - none stored for this measuremet	
22	Format parameter in "OH", "OR" or "OT" command is undefined	
23	HP-IB interface error - addressed to talk but no listeners present	
24	Rear panel switch changed when running	
25	Parameter out of range during run time	
26	Requested pre-distortion of transmit Group Delay/EDD signal is not possible	
27	-- undefined --	
28	Invalid transients / phase jitter test signal requested	
29	-- undefined --	
	Measurement Errors	
30	No clock for digital transmitter - check external clock i/p	Check A2F1
31	Loss of DIG Rx alignment/signal	
32	Loss of DIG Rx alignment / signal when in THRU PCM mode	Suspect synthesizer clock
33	Analogue input level too high	
34	Signal too small to measure	
35	Signal too unstable for autorange	
36	Analogue receiver overloaded following autorange	Signal too unstable
37	Digital filter overload	Signal level too high or unstable
38	Receive level too low to measure in reference section of measurement	
39	No modulation envelope present for delay measurement	
40	Group Delay carrier changeover irrecoverable	Group delay signal not present
41	Digital filter overload during settling	Group delay signal not stable
42	Group Delay sync loss	Reference level too low or no 166Hz burst
43	Meas section of Group Delay waveform is too small	
44	Coder offset too great (outside bottom 2 segments), or >3276 expanded code steps	
45	Power fail recovery for transients, remod etc..	
46	Impulse threshold out of range because of received signal level	
47	Group Delay level too low; peak sample returned by secondary autorange to filter	
48	DC signal offset measured during Group Delay out of range	
49	-- undefined --	

	Measurement Software Faults	
50	Invalid parameters for synthesiser programming routine (formerly AGB conceptual)	
51	Divide by zero	
52	Digital transmit level too high	
53	Digital transmit level too low	
54	DIG Rx mode requested not compatable with PCM format	
55	Both AN Rx and DIG Rx selected to feed digital filter	
56	Invalid mode, filter, or detector passed to the digital filter downloader	
57	Invalid filter number passed to the digital filter programming routine	
58	-- undefined --	
59	Digital filter program too long	
60	Dig filter coefft C1 or C2 not in [-16384 .. 16383] when shifts = -1	
61	Digital filter coefficient C0 not in [-1..6]	
62	Group Delay DFT power squared too high, result may be suspect. Point repeated	
63	Group Delay DFT power squared too low, result may be suspect. Point repeated	
64	Attempt to set run-time abort stack <0.	
65	Too many run-time abort levels.	
66	Overflow in ADD LEVELS routine.	
67	Routine called that is not yet written.	
68	-- undefined --	
69	-- undefined --	
	Calibration Errors	
70	AN Tx calibration not possible - no synthesizer clock	A1/A101, A3, A4, A6, A7/A107. See GENERAL SERVICE SHEETS G5, 7 and 9
71	AN Tx calibration figure not valid	A3, A4, A6, A7/A107. See GENERAL SERVICE SHEET G7 and G9
72	Attempt to use a calibration figure that cannot be calibrated	A3, A4, A6, A7/A107. See GENERAL SERVICE SHEET G7 and G9
73	Transient carrier Level ADC calibration failed	A5. See GENERAL SERVICE SHEET G9
74	Frequency for calibration is out of range	A1/A101. See GENERAL SERVICE SHEET G5
75	- - undefined - -	
76	- - undefined - -	
77	- - undefined - -	
78	- - undefined - -	
79	- - undefined - -	

	Measurement Hardware Fault	
80	Primary Autoranging (PAR) fault	
81	Secondary Autoranging (SAR) timeout	
82	SAR analog input level to high	Fault on A6 or A7/A107 see GENERAL SERVICE SHEET G7
83	SAR hardware fault	
84	SAR analog input level to low	
85	Sync loss between analog receiver and digital filter	Fault on A6 or A7/A107 or A9. See GENERAL SERVICE SHEETS G7 or G8.
86	Sync loss between digital receiver and digital filter	Fault on A11/A111,A12 or A9. See GENERAL SERVICE SHEETS G6 or G8
87	No digital filter handshake	Fault on A9 or A13. See GENERAL SERVICE SHEET G3 or G8
88	Digital filter - 28 bit hardware overflow	Fault on A9, A6, A7/A107, A11/A111 or A12. See GENERAL SERVICE SHEETS G6, G7 or G8.
89	Option 001 - group delay frequency counter failure	Fault on A8. See GENERAL SERVICE SHEET G9.
90	Option 001 - A/D Converter failure	Fault on A5. See GENERAL SERVICE SHEET G9.
91	Digital receiver sample never available	Fault on A9 or A11/A111. See GENERAL SERVICE SHEET G8 or G6.
92	Digital filter programming incorrect	Fault on A9. See GENERAL SERVICE SHEET G8.
93	Digital receiver clock failure	If the digital receiver clock stops then the processor cannot read the digital receiver status. This may occur when the 3776 is connected back to back (DIG Tx to DIG Rx) and in the THRU or MONITOR Mode
94	undefined	
95	HP-IB chip failure - (mislaid SRQ)	Fault on A13. See GENERAL SERVICE SHEET G3.
96	Spurious or untraceable interrupt	Fault on A11/A111, A12 or A5. See GENERAL SERVICE SHEETS G6 or G9

97	Display bus timeout	Fault on A21/A121 or A22 See GENERAL SERVICE SHEET G4
98	Instrument bus timeout	See GENERAL SERVICE SHEET G1, Paragraph G1-39
99	Transient power-failure detected	Fault on A15, A16 or A13 see GENERAL SERVICE SHEETS G2 or G3
	Power-On Self-Test Faults	
100	A13 RAM faulty	See GENERAL SERVICE SHEET G3
101	ROM not loaded	Fault on A14. See GENERAL SERVICE SHEET G3
102	ROM CRC failure	
103	A13 PIA fault	See GENERAL SERVICE SHEET G3
104	Multiple interrupts (LIRQ) from keyboard	Fault on A21/A22. See GENERAL SERVICE SHEET G4
105	Display bus time-out during Self-Test	
106	Display RAM Self-Test failure	
107	Instrument bus timeout during Self-Test	See GENERAL SERVICE SHEET G1, Paragraph G1-18
108	Instrument bus read/ write error	Fault on A4/A204. See GENERAL SERVICE SHEET G9
109	Instrument bus write port faulty	Fault on A13 See GENERAL SERVICE SHEET G3
110	Instrument bus timeout detection faulty	
111	Non-volatile memory - NVM (power-on default parameter) Cyclic Redundancy Check (CRC) failure	Fault on A14 See GENERAL SERVICE SHEET G3
112	NVM (stored masks) CRC failure	
113	NVM (measurement sequence) CRC failure	

114	NVM (dual tone multi frequency - DTMF table) CRC failure	
115	3776A NVM fitted to 3776B or visa versa	Wrong A14 board
116	NVM RAM Self-Test failure	Fault on A14. See GENERAL SERVICE SHEET G3.
117	ROM mapping facility failure	Fault on A14. See GENERAL SERVICE SHEET G3
118	A14 Option RAM faulty	
119	Memory board faulty	Fault on A14. See GENERAL SERVICE SHEET G3
120	Configuration not saved at last power-down, i.e. missing PWR FAIL interrupt	Fault on A15, A16 or A13. (Pressing reset button - A13S1 also causes ERROR CODE 120). See GENERAL SERVICE SHEET G2 or G3.
121	Cannot restart power-fail protected measurement	Fault on A13, A14 or A23. See GENERAL SERVICE SHEET G3.
	Digital Filter Test Error Codes	
130	Error in down Loading program	
131	L DATA READY (status sign bit) at incorrect rate	
132	Digital filter input has error	
133	Unable to clear data RAM	Fault on A9. See GENERAL SERVICE SHEET G8
134	Digital filter failed to increment carry out counter DF STATUS (D3 to D0)	
135	Digital filter unable to set or clear OVR24 in DF STATUS	
136	Digital filter unable to set or clear OVR28 in DF STATUS	
137	Digital filter test program gives incorrect result	
	System Software Errors	
200 to 214	Repeat the operation to confirm the error. These codes are provided for factory service purposes.	

G1-25 INSTRUMENT BUS ACCESS USING THE UTILITIES

G1-26 The utilities are called up at power-on if the A13S2 switches are set to 10001. To exit the utilities and continue the power-on sequence the SELF TEST button should be pressed. To exit utilities, set A13S2 to 00000 then press the reset button A13S1.

The utilities can also be called up at any time during the normal operation of the 3776 by means of the front panel SELF TEST key. If A13S2 #1 is set (up), the SELF TEST key does not select the standard self test items, but causes the utilities to be entered. While in the utilities the normal operation of the instrument is frozen (with interrupts off). Pressing SELF TEST again will toggle out of the utilities and normal operation will resume.

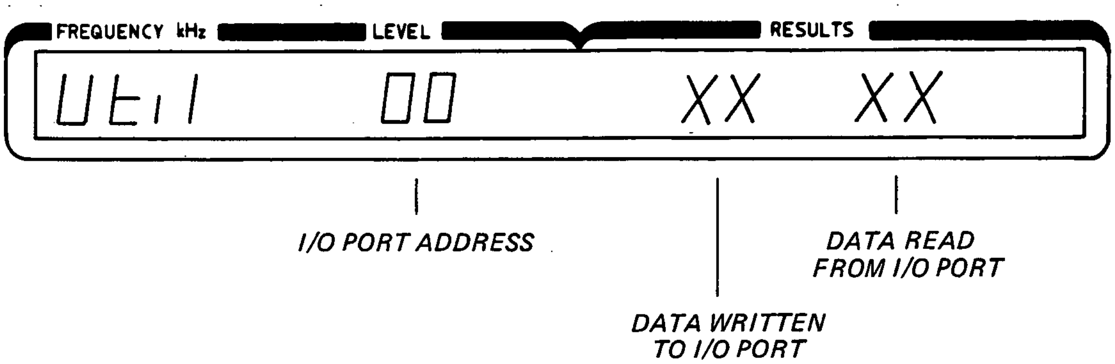
G1-27 On initial entry into the utilities, the Processor Register access utility is automatically selected. The contents of the program counter (PC) just prior to the interrupt into the utilities is displayed.

G1-28 Instrument Bus Access Selection

G1-29 When the utility mode has been called up, Instrument Bus Access is selected by pressing the 3776 AN Tx front panel key.

G1-30 Instrument Bus Access

G1-31 The instrument Bus Access Utility is used to read from or write to the instrument bus ports. The port address number (in hexadecimal) should be entered into the LEVEL display and, if required, the data to be written, entered in the left hand half of the RESULTS display. Tables G1-3 and G1-4 contain the addresses of the Instrument bus read/write ports. To read/write to the instrument bus port, the RUN and REPEAT keys may be used.

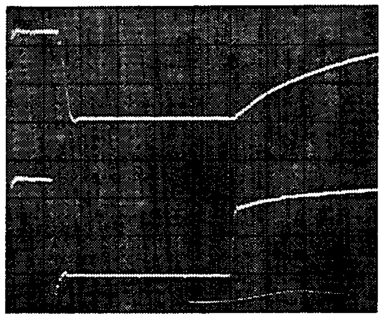


G1-32 If the RUN key is pressed when the SET LEVEL led is lit, a port read is done. The contents of the selected port are displayed in the right hand half of the RESULTS display. If RUN is pressed when the SET FREQ led is lit, a port write is performed. The data displayed on the left hand half of the RESULTS display is written to the selected port. A check read from this port is then done and the data displayed in the right hand half of the RESULTS display.

G1-33 The REPEAT key is used to continually read or write a port. Note: press REPEAT only, not RUN then REPEAT. When this key is pressed the REPEAT led will light and the selected port will be continually read or written (about once every 40us). This enables port handshake timing to be observed on a scope (see handshake waveform). To stop this bus activity, the STOP key should be pressed. Any bus timeouts will be displayed via an error code in the RESULTS display.

Acknowledge (LAC) from Input/Output Port

Start Control (LSC) from A13 Processor



Timebase = 0.2µs/DIV
0.2V/DIV (10:1 PROBE)

Processor & I/O Port Handshake Waveform

G1-34 Hexadecimal Data

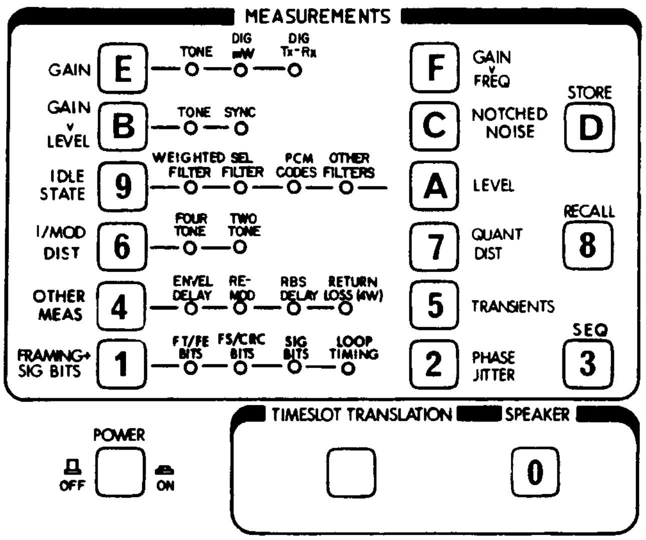
G1-35 Address Data Written or Data Read information is inserted or displayed in Hexadecimal. Instrument bus data is represented in Hex as follows:

Data Bus:	D7	D6	D5	D4	D3	D2	D1	D0
Binary Weighting:	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0
Example:	1	0	1	1	0	1	1	1
Hexadecimal:		B				7		

Note: Hexadecimal Instrument Bus Port Addresses are given in Tables G1-3 and G1-4.

G1-36 Utility Parameters

G1-37 The Instrument Bus Access Utility requires several numeric parameters to set up a read/write sequence. This is done by using the SET LEVEL and SET FREQ keys and the measurement keys. Parameters are entered as hexadecimal numbers. While in the utilities the measurement keys are redefined to be hexadecimal key pad as follows:



decimal	Hexa decimal
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	A
11	B*
12	C
13	D*
14	E
15	F

G1-38 Where a "utility" requires only one parameter, this is always entered into the LEVEL display. If two parameters are required the SET LEVEL and SET FREQ keys are used to select the appropriate parameter. The SET LEVEL key selects the parameter displayed in the LEVEL display and the SET FREQ selects the parameter displayed in the left hand half of the RESULTS display. The INCR/DECR keys may also be used. These add or subtract one from the currently selected parameter. The left and right keys are not active.

G1-39 The following list can be used to determine the faulty assembly when the Power-On Sequence Step Number 10 (Instrument bus ports check) fails.

For example: If, during Power-On Sequence Test, "08 Error 107" is displayed, check the assembly associated with port address 08. In this case port or buffer address 08 is located on assembly A4. Use the REPEAT key to continually read port 08 to locate the fault, see Paragraph G1-35. Note: Press the REPEAT key only, do not press RUN then REPEAT.

* B and D appear as b and d on display.

G1-40 The following tables list the Instrument Bus Read/Write Ports.

Table G1-3 Instrument Bus Read Ports

Port Address	Assembly	Description
00	A23	Rear panel HP-IB address switches
01	A23	Rear panel PCM format switches
02	A9	Digital filter output (ms byte)
03	A9	Digital filter output (middle byte)
04	A9	Digital filter output (ls byte)
05	A9	Digital filter status
06	A9	decoded by A9, but not used
07	A9	Digital filter program read back
08	A4	EDD result (ms byte)
09	A4	EDD result (ls byte)
0A	A4	EDD status and option present flag
0B		-- not used --
0C	A8	Impulse Noise Threshold status
0D	A8	Group delay and impulse count status
0E	A8	Frequency counter (ms byte)
0F	A8	Frequency counter (ls byte)
10	A11/A12	Digital receiver status
11	A11/A12	Digital receiver peak negative code
12	A11/A12	Digital receiver peak positive code
13	A11/A12	Digital receiver code from selected timeslot
14		-- not used --
15	A3	Data Test Buffer
16	A6	Analogue receiver threshold detector outputs
17		-- not used --
18	A1/A2	Digital transmitter status (Address Decoder on A3)
19		-- not used --
1A		-- not used --
1B		-- not used --
1C		-- not used --
1D		-- not used --
1E	A5	Phase jitter results
1F	A5	Transients status

Note: ls = least significant; ms = most significant

Table G1-4 Instrument Bus Write Ports

Port Address	Assembly	Description
20	A9	Digital filter reset
21	A9	Digital filter control register
22	A9	Digital filter threshold register (ms byte)
23	A9	Digital filter threshold register (ls byte)
24	A9	decoded by A9, but not used
25	A9	Digital filter program counter (ms byte)
26	A9	Digital filter program counter (ls byte)
27	A9	Digital filter instruction load port
28	A4	Digital filter output DAC control
29	A3	Analogue transmitter output control
2A	A3	Analogue transmitter coarse attenuator
2B	A3	Analogue transmitter signal path control
2C	A8	Group delay and impulse count reset
2D	A8	Group delay and impulse count control
2E	A8	Frequency counter clear
2F	A8	decoded by A8, but not used
30	A11/A12	Digital receiver control byte #2
31	A11/A12	Digital receiver timeslot selection
32	A11/A12	Digital receiver frame selection
33	A11/A12	Digital receiver control byte #1
34	A6	Analogue receiver impedance and cal path
35	A6	Analogue receiver PAR and anti-alias filter
36	A6/A7	Analogue receiver SAR
37	A6/A7	Analogue receiver SAR path
38	A1/A2	Digital transmitter data load (ls byte)
39	A1/A2	Digital transmitter data load (ms byte)
3A	A1/A2	Digital transmitter address load (ls byte)
3B	A1/A2	Digital transmitter address load (ms byte)
3C	A1/A2	Digital transmitter write enable
3D	A1/A2	Digital transmitter control word
3E	A5	Dropouts/Interruptions threshold
3F	A5	Transients mode

Note: ls = least significant; ms = most significant

G1-41 INSTRUMENT BUS ACCESS USING HP-IB

G1-42 The following commands allow the controller to read or write to any port or buffer on the 3776 instrument bus. See Tables G1-3 and G1-4 for port addresses and descriptions.

G1-43 HP-IB Commands

IO <PORT ADDRESS>, <DATA>
IO? <PORT ADDRESS>

IO <PORT ADDRESS>, <DATA>. This command writes <DATA> to <PORT ADDRESS>. For example, "IO#H28, #H2F" will write 2F (hex) to port address 28 (hex). #H means hexadecimal number.

IO? <PORT ADDRESS>. This command reads the contents of <PORT ADDRESS> and outputs the data to the Controller. The string returned has the same syntax as the write form of the "IO" command. For example, the command "IO?#28" reads port 28 (hex) and returns: "IO 40, 47CRLF".

G1-44 Example using HP85 basic and hex values:

```
10 OUTPUT702; "CA OFF"
20 OUTPUT702; "IO#H28, #H2F"
30 OUTPUT702; "IO?#H28"
40 ENTER702;A$
50 DISPA$
  IO 40, 47
```

Note: The address and data of the returned string is in decimal.

G1-45 Example using HP85 basic and decimal values:

```
10 OUTPUT702; "CA OFF"
20 OUTPUT702; "IO40, 16"
30 OUTPUT702; IO?40"
40 ENTER702;B$
50 DISPB$
  IO 40, 16
```

Note: To avoid the I/O Port data being changed by the instrument calibration routine, always set the calibration off ("CA OFF") before setting the I/O Port data.

G1-46 INSTRUMENT IDENTIFICATION

G1-47 Instrument, options fitted, firmware revision and list of all ROM revisions can be obtained using the following:

1. "OI" HP-IB command. On receipt of this command the 3776 responds with the five character string "3776A CRLF" or "3776B CRLF" as appropriate.

2. "ID" HP-IB command. On receipt of this command the 3776 will respond with the following string-----"HP3776(x), OPT (Opt 1), (Opt 2), (Opt 3), REV (datecode) CRLF".

(x): "A" or "B"

(Opt 1): Set to 1 if optional delay and transients measurements present, otherwise 0.

(Opt 2): Set to 2 if 3776B Opt 002 (Japanese filters), otherwise set to 0.

(Opt 3): For future options. This is always returned as zero at present.

(datecode): Firmware date-code in the HP standard format of (Year - 1960) (Week number). For example 2328 is 1983, week 28.

Example:

```
10 DIM A$[100]
20 DISP "ENTER HP-IB ADDRESS"
30 DISP "AND PRESS ENDLINE"
40 INPUT A
50 A = 700 + A
60 OUTPUT A; "IO?"
70 ENTER A; A$
80 DISP A$
90 END
ENTER HP-IB ADDRESS
AND PRESS ENDLINE
?
8
3776 response ---- HP3776B, OPT 1, 0, 0,REV 2345
```

Note: The REV number returned (i.e. 2329) is the highest date code of all firmware ROMS in asemblies A13 or A14.

3. ROM Revisions. The revisions on datecodes of all ROMS can be obtained as follows.

a. Connect an 80 column printer to the 3776 HP-IB connector (use an HP2671A, HP2671G or HP2673A. The HP82905A is not compatible).

b. Set the 3776 to TALK ONLY and set the Address switches to 00010 (i.e. 2 is the Print mode).

c. Press Self-Test then continually press the NEXT PARAM key until Pt13 is displayed in the LEVEL display.

d. Press the 3776 RUN key. The following ROM datecodes should be printed.

HP 3776A ROM CRC CHECK

Section: 0 PASS 2331
Section: 1 PASS 2344
Section: 2 PASS 2337
Section: 3 PASS 2338
Section: 4 PASS 2343
Section: 5 PASS 2338
Section: 6 PASS 2331
Section: 7 PASS 2328
Section: 8 PASS 2333
Section: 9 PASS 2345

where:

Section 0 = A13U36(E)
Section 1 = A14U13(C)
Section 2 = A14U12(A)
Section 3 = A14U22(8)
Section 4 = A14U32(6)
Section 5 = A14U42(4)
Section 6 = A14U41(20)
Section 7 = A14U31(21)
Section 8 = A14U21(22)
Section 9 = A14U23(1)

Note: 1. The values given in brackets are sometimes used for ROM identification. They correspond to the start address of the appropriate ROM.

2. A14U12 ROM (Section 2) is different for the 3776A and 3776B.

G1-48 SWITCH SELECTED SELF TESTS

G1-49 Introduction

G1-50 The switch selected Self Tests within the 3776 are a set of routines that may be of use in tracing hardware faults. These tests are activated at the beginning of the power-on sequence if switch A13S2#5 is set (up). This is the only time they can be called; they are not accessable via the front panel SELF TEST key or from the HP-IB. Most of the switch selected Self-Tests are referred to in the General Service Sheets. Given that switch #5 is set, switches #1 through #4 select one of the following tests:

A13S2 Switch Code 54321	Description
10000	No operation - return to power-on sequence
10001	Enter utilities
10010	Test and re-initialise the non-volatile RAM
10011	Check ROM CRCs then return to power-on sequence
10100	-- undefined --
10101	Front panel display test
10110	Keyboard test (interrupt driven)
10111	Keyboard test (loop read).
11000	Signature Analysis - PIA stimulus.
11001	Signature Analysis - HP-IB stimlus.
11010	Signature Analysis - Instrument/Display bus
11011	Signature Analysis - A14 assembly stimulus
11100	Processor bus exerciser
11101	Display bus exerciser
11110	Instrument bus exerciser
11111	A13 led check

1. Utilities (10001)

This item calls up the 3776 utilities. This allows access to memory, I/O ports etc. before the majority of the power-on tests and instrument configuration occurs. The utility package is described in detail in Paragraph G1-25. On exiting the utilities (via the SELF-TEST key) the power-on sequence continues normally.

2. Non-Volatile RAM Test (10010)

This runs a RAM test on the non-volatile RAM (A14 U43). After the test the four non-volatile areas within this memory are reset to a default condition. The configuration saved at the last power-fail and the dialling tables are replaced by default values taken from ROM. The measurement parameter store and the sequence store are cleared.

3. ROM CRC Check (10011)

This item checks the existence and CRC of all processor ROMs. As each ROM is checked an identifier is displayed in the LEVEL display. If any ROM is missing or corrupt, an error is displayed along with the ROM identifier.

ROM	DISPLAYED ID	LOCATION
ROM E	E	A13U36
ROM C	C	A14U13
ROM A	A	A14U12
ROM 8	8	A14U22
ROM 6	6	A14U32
ROM 4	4	A14U42
ROM 20	2.0	A14U41
ROM 21	2.1	A14U31
ROM 22	2.2	A14U21
ROM 23	2.3	A14U11
ROM 1	1	A14U23

Note: if the current rev of software does not use ROM 23, this will be faulted as missing.

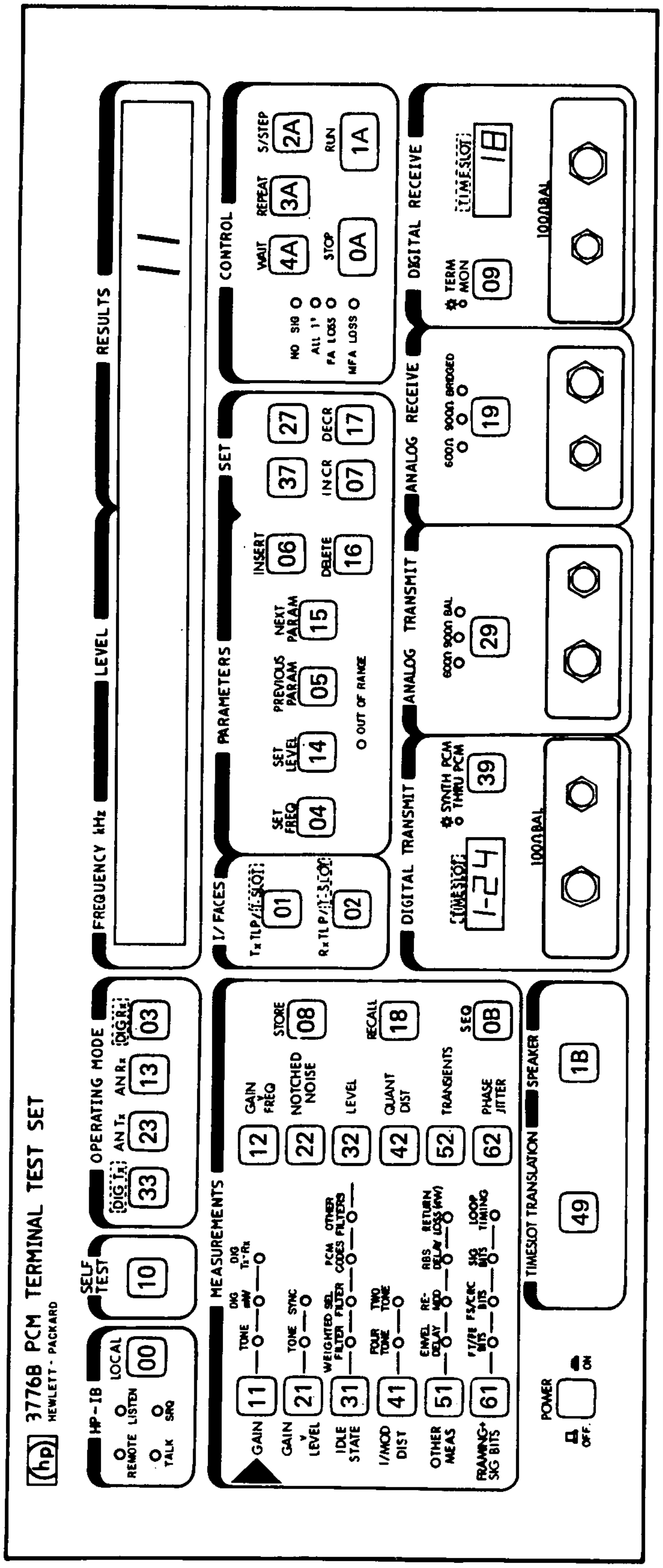
4. Front Panel Display Test (10101)

This lights up all the front panel leds. The display bright-up feature is also tested by "walking" a bright digit along the large seven segment displays. This test never terminates. To reset the instrument to normal operation all A13 switches should be cleared (down) and the A13 reset switch pressed or the power cycled.

5. Keyboard Test (10110/10111)

The keyboard test has two modes of operation selected by the A13S2#1 switch. If this switch is set to "1" the keyboard port is continually read and the key code displayed in the front panel RESULT display. The key codes are listed below. This test should be used when fault finding the front panel keyboard circuitry and display bus. Any display bus time-out error will be reported.

If A13S2 #1 switch is set to "0" the keycode is read and displayed only when a keyboard interrupt occurs. A decimal point in the RESULT display is flashed to indicate interrupts. This test will report key bounce errors (two interrupts within 50ms of each other) but not display bus time-out errors. Like the display test, the keyboard tests never terminate. Key codes (in hexadecimal) are shown with their keys in the following figure, ie 11 is displayed in the RESULT display when GAIN is pressed.



Hexadecimal Key Codes

Note: Hexadecimal "B" and "D" appear in lower case ("b") and ("d") on display.

6. Signature Analysis for the 6821 PIA (11000)

This item runs a signature analysis stimulus program for testing the PIA. Note that this test assumes port A of the PIA is working so that the switches can be read See General Service Sheet G3 Processor and Memory.

7. Signature Analysis for the 8291A HP-IB CHIP (11001)

This item runs a signature analysis stimulus program for testing the 8291A HP-IB interface chip and bus transceivers. See General Service Sheet G3 Processor and Memory.

8. Signature Analysis for the Instrument/Display Bus (11010)

This item runs a signature analysis stimulus program for testing the instrument and display data buses. See General Service Sheet G3 Processor and Memory.

9. Signature Analysis for the A14 Assembly (11011)

This item runs a signature analysis stimulus program for testing the A14 Memory board. See General Service Sheet G3 Processor and Memory.

10. Processor Bus Exerciser (11100)

This drives the address and data lines of the processor with the data patterns listed below. This is useful for examining the bus switching waveforms and ROM and RAM timing on an oscilloscope. Before entering the following 23 cycle loop, the A register is loaded with 055H and the B register with 0AAH.

CYCLE	Instruction	VMA	LWRITE	Address	Data
1	STAA 05555H	1	1	????	0B7H
2		1	1	????	055H
3		1	1	????	055H
5		0	1	05555H	tri-state
6		1	0	05555H	055H
7	STAB 0AAAAH	1	1	????	0F7H
8		1	1	????	0AAH
9		1	1	????	0AAH
11		0	1	0AAAAH	tri-state
12		1	0	0AAAAH	0AAH
13	CLR 00000H	1	1	????	07FH
14		1	1	????	000H
15		1	1	????	000H
16		1	1	00000H	000H
17		0	1	00000H	tri-state
18		1	0	00000H	000H
20	BRA $-009H	1	1	????	020H
21		1	1	????	0F5H
22		0	1	????	????
23		0	1	????	????

Address and data bus contents marked ???? depend on the absolute location of the code. This will vary with software revision, but is somewhere in the range 0E000H . . OFFFFH.

11. Display Bus Exerciser (11101)

This is similar to the processor bus exerciser but applies to the display bus. This enables display bus and handshake switching to be observed on an ocilloscope.

The code executed in this test is . .

```
        CLR     00F90H    turn display off
        LDAA    #055H
Loop    LDAB    00F80H    read keyboard port
        STAA    00FAAH    write 055H to display RAM
        LDAB    00FAAH    check read display RAM
        COMA
        STAA    00FAAH    write OAAH to display RAM
        LDAB    00FAAH    check read display RAM
        BRA     Loop
```

12. Instrument Bus Exerciser (11110)

As above, but for the instrument bus. This uses the bus Self Test ports on A3, so this board must be loaded and preferably working.

The code executed in this test is . .

```
        LDAA    #055H
Loop    STAA    00FEAH    write 055H to port 2A
        LDAB    00FD5H    check read from port 15
        COMA
        STAA    00FEAH    write 0AAH to port 2A
        LDAB    00FD5H    check read from port 15
        BRA     Loop
```

13. A13 Led Check (11111)

This test checks the leds on the A13 board work correctly. On entry to the test all the leds are cleared. After a one second pause the nine leds CR1 thru CR5, IT0, DT0, PON ERR and IRQ are lit in turn, each for half a second. Finally all the leds are lit together (including the HALT led).

G1-51 PROTECTIVE FUSING

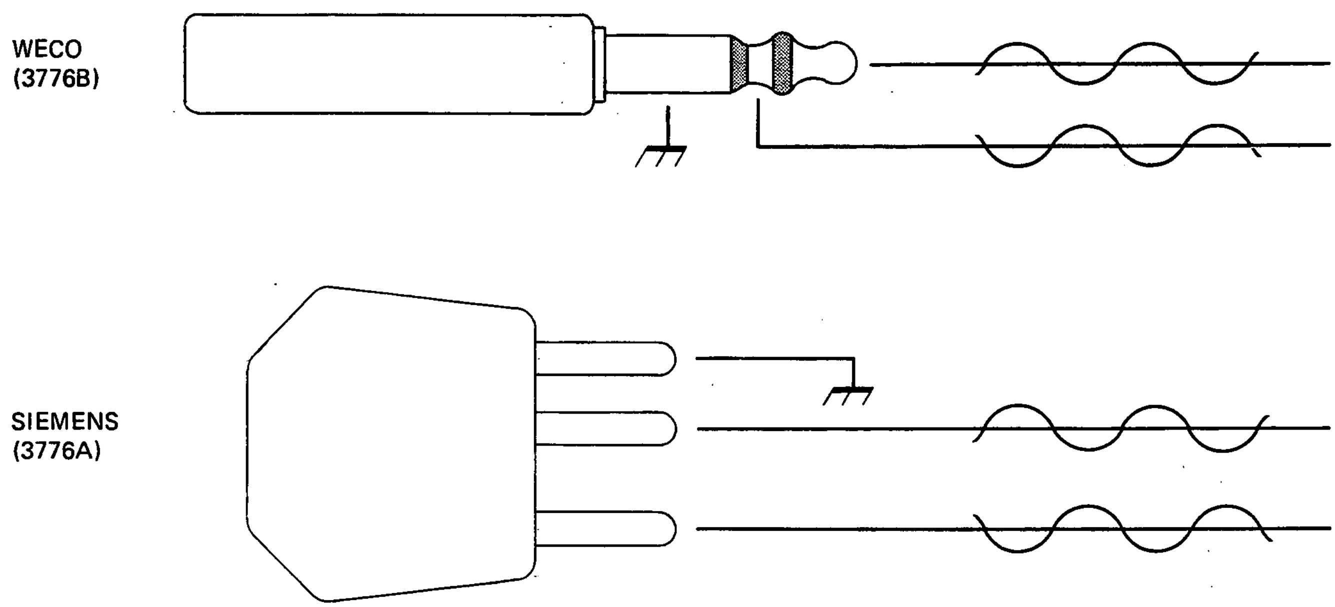
G1-52 Apart from the MAINS POWER FUSE located on the 3776 rear panel, protective fusing is provided on the following assemblies:

Assembly	Fuse Ref	Description	Spare Fuse Ref
A2 (3776A)	F1	Ext. Clock I/P	F2
A102 (3776B)	F1	Ext. Clock I/P	F2
A7 (3776A)	F2	Dig Tx O/P	F1
A107 (3776B)	F2	Dig Tx O/P	F1
A12	F1	Dig Rx I/P	F2
A15	F1	AUX PWR Supply	-
A16	F1&F2	PWR Supply Drivers	-
A24	F2&F3	AUX Transformer Primary	-

G1-53 BALANCED LINES AND CONNECTORS

G1-54 Balanced lines are used extensively where wire pairs are run in a noisy environment. The signal is impressed on two wires such that the signal on each wire is 180 degrees out of phase with respect to the other wire. Since most noise is coupled into each line equally, it can easily be separated from the signal. The unwanted noise is referred to as the common mode signal. Common mode rejection in a balanced line is sometimes referred to as Longitudinal Balance.

G1-55 The balanced output/input connectors used in the 3776 are the Siemens Type connector (3776A Only) and the Weco Type connector (3776B Only). Note: when connecting an UNBAL line to a BAL Input, always connect the UNBAL ground to one of the BAL signal connections and the UNBAL signal to the other BAL signal connection.



GENERAL SERVICE SHEET G2
POWER SUPPLY

GENERAL SERVICE SHEET G2
POWER SUPPLY

G2-1 INTRODUCTION

G2-2 This service sheet covers troubleshooting of the mains input wiring and assemblies A24, A15 and A16. The main sections are:

a. Mains Fuse Blown

b. A15 LED Illuminated

c. Faulty Regulation

d. Switching Power Supply Troubleshooting

G2-3 MAINS FUSE BLOWN

CAUTION

If fuse F1 is blown, adhere to the procedure given below. Missing out a step could result in damage to components.

<table>
<tr><th>Procedure</th><th>Troubleshooting</th></tr>
<tr><td>1. If F1 is blown, switch off the instrument. Replace mains fuse F1 and check the following resistances:

Line to Earth: open circuit
Neutral to Earth: open circuit
Chassis to Earth: <1.0 ohm</td><td>If incorrect, check the wiring between mains socket and Assembly A24 (see Assembly Service Sheet A24).</td></tr>
<tr><td>2. With the instrument POWER switch still on, check the resistance between line and neutral:

<table><tr><th>Position of Voltage Selector</th><th>Correct Resistance</th></tr><tr><td>230V
115V</td><td>80Ω ±10
35Ω ±10</td></tr></table></td><td>If incorrect, remove assemblies A16 and A15 and recheck. If still incorrect fault is on Assembly A24 (see Assembly Service Sheet A24). Suspect Mains Overvoltage Protection on A24. If correct with A15 and A16 removed, proceed to Switching Power Supply Troubleshooting.</td></tr>
</table>

G2-4 A15 LED ILLUMINATED

G2-5 Over-Temperature Detector

G2-6 The OVER TEMP led is most likely to be illuminated when the instrument cooling is defective. Check fan operation.

G2-7 Over-Current Detector

G2-8 This led indicates an overload in one of the low voltage outputs. To determine which low voltage supply is affected, switch off the instrument and check for a short circuit between each supply line and ground. Remove boards one at a time to locate the fault. Maximum current drawn from the low voltage supplies is as follows:

+5V = 10A max
+15V = 1A max
-15V = 0.5A max

Note: It is likely that only the +5V line will bring on the Over-Current led.

G2-9 Over-Voltage Detector

G2-10 The over-voltage led can be illuminated when over-voltage occurs in either the UNREG +15V or the +15V and -15V regulated lines. The over-voltage supply can be determined using a DC Voltmeter.

G2-11 FAULTY REGULATION

G2-12 Faulty regulation occurs when the low voltage lines (i.e. +5V, +15V and -15V) are completely down or when the voltage is out of specification. The following flow chart shows the procedure to be adopted in each case.

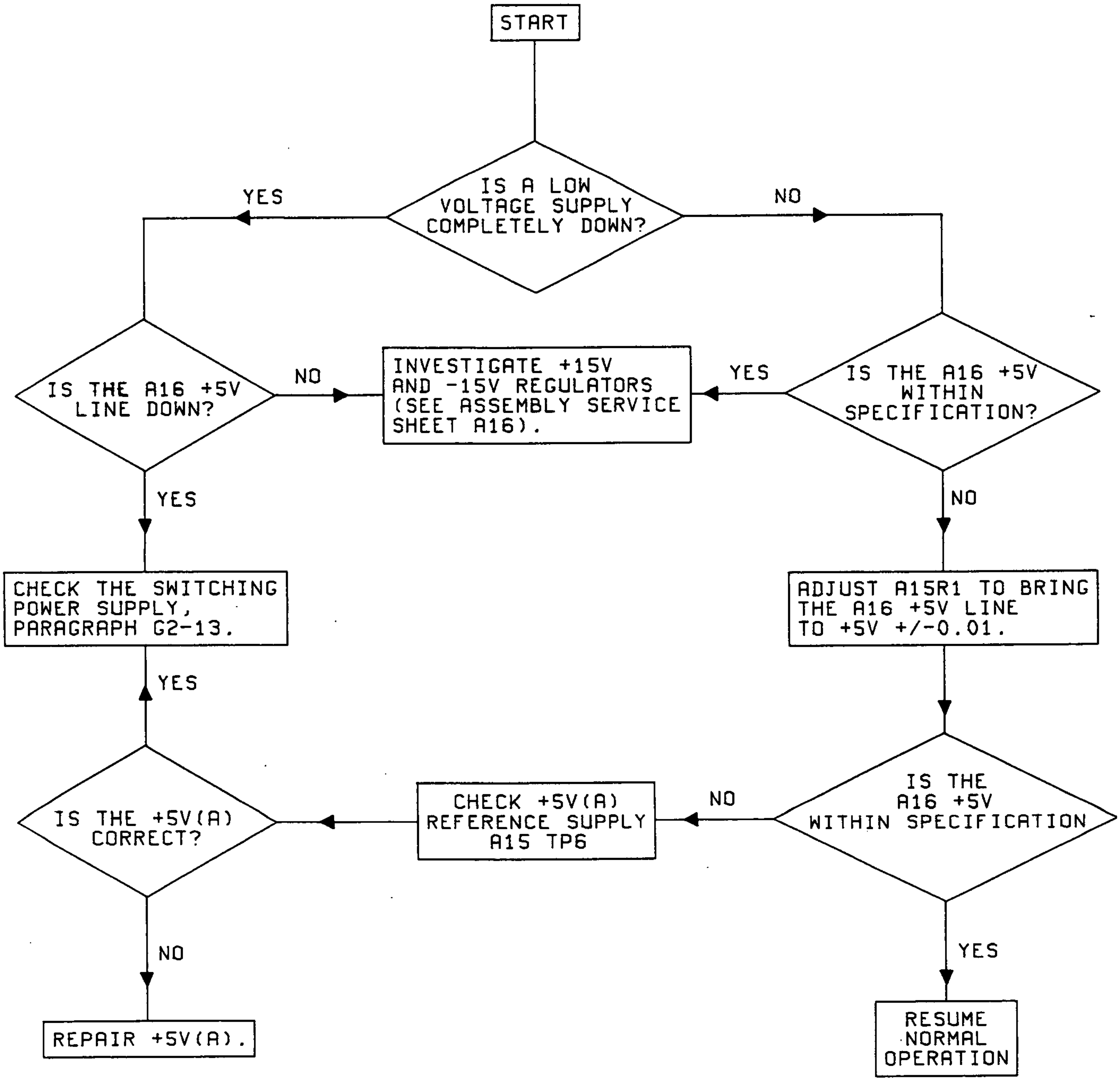


Figure G2-1 Faulty Regulation

G2-13 THE SWITCHING POWER SUPPLY A15/A16 TROUBLESHOOTING

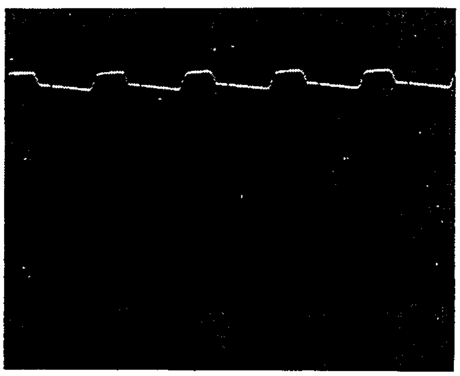
G2-14 A15 Power Supply Controller

G2-15 Check assembly A15 using the following procedure.

Procedure	Troubleshooting
1. Switch the 3776 power off.	
2. Remove assembly A16 and place A15 on the extender board.	
3. Switch the 3776 power on.	
Auxiliary Power Supply	
4. Check that approximately 12VDC is present across bridge rectifier CR4. Waveform should correspond as shown.	If incorrect, check Auxiliary Transformer T1 (see A24 Schematic). Also check bridge rectifier CR4. Check regulators Q1/CR6 and U13.

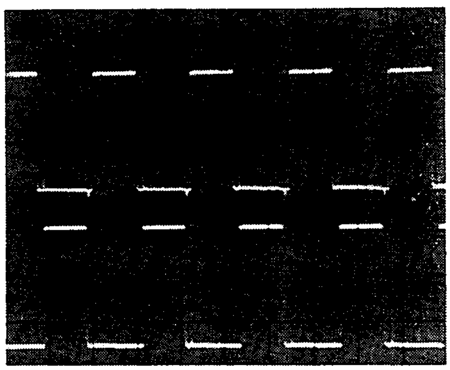
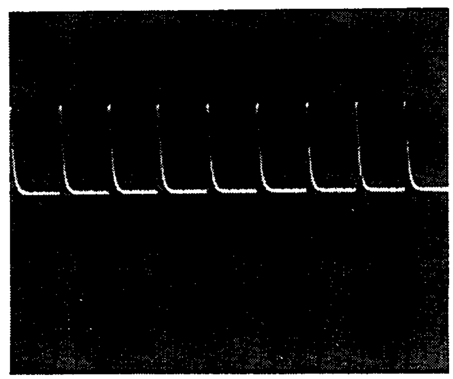
A15CR4+

0V



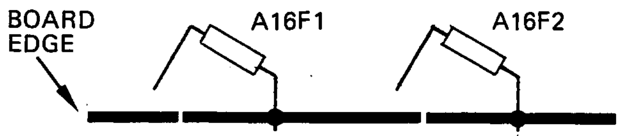
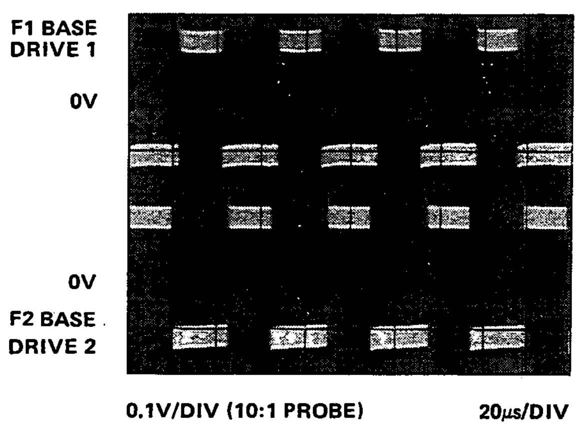
0.5V/DIV (10:1 PROBE) 5ms/DIV

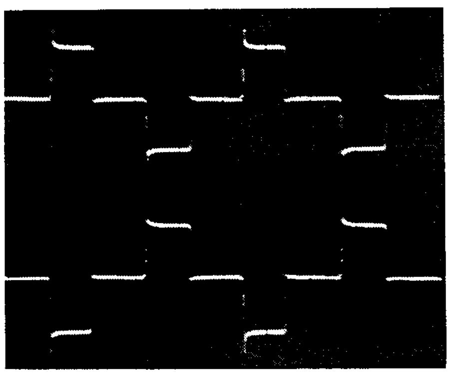
Procedure	Troubleshooting
5. Check that V_{BD} is 8.5V ± 0.5V, +5V(A) is +5V ±0.1V, and $+V_{AUX}$ is +13V ±0.5V. Note: V_{BD}: A15TP7 +5V(A): A15TP6 $+V_{AUX}$: A15U13(1)	

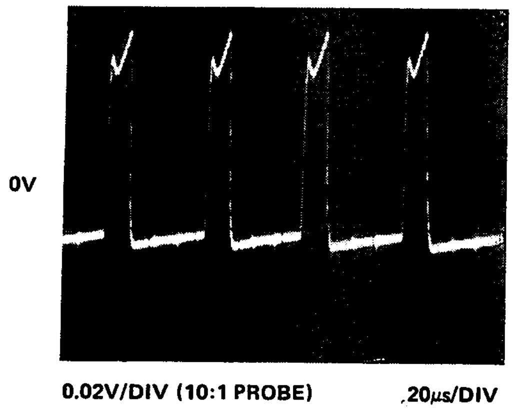
Procedure	Troubleshooting
Mains Power Detector	
6. Check that A15TP2 is high (ie Not L POWER FAIL). **Note: Power failure can be simulated by shorting U37(14) to GND. Check continuity of the LPWR FAIL signal to A13. Remember to remove link.**	Check the operation of CR5, U37A, U55 and U54.
7. Check that U37B(13) is high.	If U37B is not high and none of the leds are illuminated, fault must be in U37B. Check that V_B at U37B(10) is approximately 1.5V.
Overload Protection and Reset Control	
8. Check that U37C(1) is high and U37D(2) is low.	Check the operation of U37C and U37D. Check that V_B is approximately 1.5V.
Variable Pulse Generator	
9. Check that Base Drive 1, A15TP5, and Base Drive 2, A15TP8 correspond to the waveforms shown.	Check the operation of U33 and Q3/Q2. U33 internal oscillator clock at A15TP9 should correspond to the waveform shown.
A15TP5 0V A15TP8 0V  0.05V/DIV (10:1 PROBE) 20μs/DIV	A15TP9 0V  0.2V/DIV (10:1 PROBE) 20μs/DIV

G2-16 A16 Power Supply Converter

G2-17 Check assembly A16 using the following procedures.

<table>
<tr><th>Procedure</th><th>Troubleshooting</th></tr>
<tr><td>1. Switch the 3776 power off and remove power cable.</td><td></td></tr>
<tr><td>2. Remove fuse A15F1 and insert in the A15 F2 position.</td><td></td></tr>
<tr><td>3. Connect a DC Power Supply to A15TP11.</td><td></td></tr>
<tr><td>A16 Inverter Drivers</td><td></td></tr>
<tr><td>4. Unsolder fuses A16F1 and A16F2 as shown below.

</td><td></td></tr>
<tr><td>5. Mount A16 on the extender board</td><td></td></tr>
<tr><td>6. Adjust the DC Power Supply output to give +12V ±1V.</td><td></td></tr>
<tr><td>7. With the mains power switched off, check that Inverter Drive outputs correspond to the waveforms shown. Connect oscillocope probes to A16F1 and A16F2.

</td><td>Check the operation of inverter drivers Q7, T3, Q3, Q5 and Q8, T4, Q4, Q6.</td></tr>
</table>

Procedure	Troubleshooting
A16 Transformer Switching Circuit	
8. Check the fuses A16F1 and A16F2 and replace into A16.	
9. Connect the 3776 mains power cord to a mains auto-transformer, set for 0V.	
10. Switch the 3776 power on.	
WARNING	
Potentially hazardous voltages are now present on A16.	
11. Slowly run up the auto-transformer towards mains voltage, checking for excessive current.	
12. Check the that the following waveforms are present at the anodes of A16CR3 and A16CR4.	Check operation of switching transistors A16Q1 and A16Q2 and transformer A16T1.
CR3 0V CR4 0V  1V/DIV (10:1 PROBE) 10μs/DIV	
13. Check that the +5V UNSMOOTHED voltage is present at A16C20.	Check the operation of +5V Rectifier.
14. Check that the following waveform is present at A16 edge connector 39, 87.	If pulses are not present, check A16R3 and A16T2.

Procedure	Troubleshooting
	
15. Switch the DC Power Supply and Auto-transformer off.	
16. Disconnect the DC Power Supply and Auto-transformer.	
17. Replace A15 fuse into the A15F1 position.	
18. Remove the extender board and replace A16.	

GENERAL SERVICE SHEET G3
PROCESSOR AND MEMORY

GENERAL SERVICE SHEET G3
PROCESSOR AND MEMORY

G3-1 INTRODUCTION

G3-2 This service sheet covers troubleshooting for assemblies A13 (03776-60013) and A14 (03776-60014): 3776A; A114 (03776-60114): 3776B; A214 (03776-60214): 3776B Japanese Option.

G3-3 Signature analysis (SA) is used extensively in the troubleshooting of A13 and A14. When using SA, thresholds should be set as follows:

DATA (TTL): high = 2.00V, low = 0.80V
CLOCK (TTL): 2.00V
ST-SP (TTL): 2.00V

Note that the clock and Start/Stop thresholds are non-standard. This is to increase noise immunity when connected to the NMOS components (68B00 processor and 6875 clock chip).

G3-4 Troubleshooting must be carried out in the following sequence:

1. A13 Processor Clocks and Reset Circuitry
2. A13 Processor, Address Buffers/Bus and Address Decoder
3. A13 Keyboard Bus and Instrument Handshake Control
4. Instrument Address Bus Interface
5. Bus Handshake Timeout
6. A13 Data Bus and U36 ROM Verification
7. A13 PIA U24
8. A13 HP-IB Interface Adapter U55 and Drivers/Receivers U65/U75
9. A13 Instrument Data Bus Interface U62/Instrument Data Bus
10. A13 Keyboard Data Bus Interface U52/Keyboard Data Bus
11. A13 LED Check
12. A14 ROM Address Decoder
13. A14 Non-Volatile RAM Power Supply
14. A14 Non-Volatile RAM
15. A14 ROM CRC

G3-5 A13 PROCESSOR CLOCKS AND RESET CIRCUITRY

1. Using an oscilloscope and frequency counter check that the following clocks are present.

   Note: If any of the clocks cannot be obtained, remove the processor chip U31 and re-check. Remember to replace U31 after performing this check.

   PCLK (U10 pin 10) = Squarewave; 8.192MHz (3776A)
   9.264MHz (3776B)

   2F0 (U20 pin 5) = Squarewave; 2.048MHz (3776A)
   2.316MHz (3776B)

   Note: 2F0 is a quarter the frequency of PCLK.

   MCLK (U20 pin 9) = Squarewave; 1.024MHz (3776A)
   1.158MHz (3776B)

   Note: MCLK is an eighth the frequency of PCLK

   DBE (U35 pin 8) = As MCLK, but 3:1 mark-to-space ratio.

2. Check that when Reset switch A13S1 is pressed, U43(9) goes high and U22(4) goes low. Ensure that L PWR ON is not stuck at 0V.

3. Check the continuity of LPWR FAIL from A15TP2 to A13U24(40). This can be checked by momentarily shorting A15TP2 to GND.

G3-6 A13 PROCESSOR, ADDRESS BUFFERS/BUS AND ADDRESS DECODER

1. Set the MD0 to MD7 bus link TL1 in the SA socket. This sets the processor in the "free run" mode and causes it to cycle through all the memory locations. Set links TL2 and TL3 to the TEST position. This enables the LAC and L KBD SC signals to be looped back.

2. With the power switched off, remove assembly A14.

3. Set the HP5005A function to NORM and connect as follows:

   GROUND to GND
   CLK to A13 2F0 test point. Polarity; positive edge
   START to A13 15 test point. Polarity; negative edge
   STOP to A13 15 test point. Polarity; negative edge

   Note: see Paragraph G3-3 for threshold settings.

4. Switch the power on and check the following signatures.

Assembly	Logic Function	Signature
A13	U31 Processor	U31 pin 2 P757 always logic 1 U31 pin 3 2U52 U31 pin 5 P757 always logic 1 U31 pin 6 P757 always logic 1 U31 pin 7 0000 always logic 0 U31 pin 9 67P9 U31 pin 10 58P3 U31 pin 11 548F U31 pin 12 404U U31 pin 13 UUP5 U31 pin 14 24A8 U31 pin 15 272H U31 pin 16 U038 U31 pin 17 P95A U31 pin 18 8619 U31 pin 19 29C9 U31 pin 20 FU8A U31 pin 22 69F8 U31 pin 23 P064 U31 pin 24 0005 U31 pin 25 0003 U31 pin 34 P757 always logic 1 U31 pin 36 F085 F805 (3776A) U31 pin 37 F085 F805 (3776A)
A13	Address Buffers	U51 pin 3 - MA1 58P3 U51 pin 5 - MA3 404U U51 pin 7 - MA5 24A8 U51 pin 9 - MA7 U038 U51 pin 12 - MA6 272H U51 pin 14 - MA4 UUP5 U51 pin 16 - MA2 548F U51 pin 18 - MA0 67P9 U61 pin 3 - MA8 P95A U61 pin 5 - MA9 8619 U61 pin 7 - MA10 29C9 U61 pin 9 - MA11 FU8A U61 pin 12 - MA12 69F8 U61 pin 14 - MA13 P064 U61 pin 16 - MA14 0005 U61 pin 18 - MA15 0003

Assembly	Logic Function	Signature	
A13	Address Decoder	U12 pin 11 - LNVEN	FH2P
		U21 pin 2	26HU
		U22 pin 6	PC9P
		U22 pin 8	755U
		U22 pin 10	*264U
		U23 pin 11	*24A8
		U33 pin 6 - LROMADDR	9208
		U33 pin 8	0C2H
		U33 pin 12 - LROME	3462
		U35 pin 3 - LBUSEN	F7F3
		U35 pin 6 - LADDROF	PC61
		U35 pin 11	898H
		U44 pin 8 - LRAM	31P8
		U63 pin 14	F118
		U63 pin 15 - LADDRO	F188
		U64 pin 4 - LPIA	78AA
		U64 pin 5 - LHP-IB	3H8P
		U64 pin 6 - LKBDEN	2737
		U64 pin 7	0FF9
		U73 pin 8	8U08

Note: *Set SA CLOCK to negative edge for these signatures.

G3-7 A13 KEYBOARD BUS AND INSTRUMENT HANDSHAKE CONTROL

1. With TL1 in the SA socket and TL2 and TL3 set to TEST, set the HP5005A as shown and check the following signatures.

   GROUND to GND Test Point.
   CLOCK to 2F0 Test Point. Polarity; negative edge.
   START to A15 Test Point. Polarity; negative edge.
   STOP to A15 Test Point. Polarity; negative edge.

Note: see **Paragraph G3-3 for Threshold settings.**

Assembly	Logic Function	Signature
A13	Keyboard Bus and Instrument Bus Handshake Control	U54 pin 1 2094 U54 pin 4 F060 U34 pin 6 7913 U12 pin 6 P757 U12 pin 3 P757 U43 pin 13 2094 U43 pin 7 F060 U44 pin 6 07A3 U13 pin 9 99P7 U54 pin 13 F7F3 U54 pin 10 2737 U34 pin 8 0000 always logic 0 U34 pin 12 0000 always logic 0

G3-8 INSTRUMENT ADDRESS BUS INTERFACE

1. With TL1 in the SA socket and TL2 and TL3 set to TEST, set the HP5005A as shown and check the following signatures.

FUNCTION TO QUAL
GROUND to GND Test Point
CLOCK to 2F0 Test Point. Polarity; negative edge
ST-SP to A15 Test Point. START; negative edge. STOP, negative edge
QUAL to LKBDSC Test Point. Polarity; 0

Note: see Paragraph G3-3 for Threshold settings.

Assembly	Logic Function	Signature	
A13	Data Bus Interface (Address)	U71 pin 9 - A0 U71 pin 12 - A1 U71 pin 7 - A2 U71 pin 14 - A3 U71 pin 5 - A4 U71 pin 16 - A5 U71 pin 3 - LKBDRW	P5PH 5CP0 7P25 85PA 77F7 6PCP CC34

G3-9 BUS HANDSHAKE TIMEOUT

1. This makes use of the HP5005A timing function to check the delay of the timeout monostable U13. Test link TL1 should remain in the SA position for free run mode. Test links TL2 and TL3 should be removed completely so as to cause a timeout when an instrument bus or display bus address is referenced. Set the HP5005A function to ms and connect leads as follows:

   START to LSC Test Point. Polarity; negative edge
   STOP to LSC Test Point. Polarity; positive edge

2. Check that the time displayed is between 9.8ms and 8.8ms. Time variations are due to the tolerance of the timing capacitor C4 and quantising by the processor clock.

Note: 9.8ms equals 0.0098 displayed on the SA. This might be confusing as the range specified on the 5005A is in ms.

G3-10 A13 DATA BUS AND U36 ROM VERIFICATION

1. Ensure that Assembly A14 is removed.
2. Test links A13TL2 and A13TL3 should be in the NORM position.
3. Set A13TL1 to the SA socket and switch the power on.
4. Set the HP5005A function to NORM and connect leads as follows:

   GROUND to GND test point
   CLOCK to MCLK test point. Polarity; negative edge
   START to A15 test point. Polarity; positive edge
   STOP to A15 test point. Polarity; negative edge

Note: See Paragraph G3-3 for Threshold settings.

5. Check that the following signatures can be obtained.

Note: These signatures depend on the software revision. If signatures are incorrect, check if a new revision of software has been installed. This will be covered in the Service Manual Change Sheet. The signatures given here are derived from ROM U36 date code 2338 (HP 03776-80054). See Instrument Identification procedure given in General Service Sheet G1 for ROM date code retrieval.

Assembly	Signatures	Logic Function
A13	U36 ROM	U36 pin 11 - MD0 H7H0 U36 pin 12 - MD1 8672 U36 pin 13 - MD2 73P0 U36 pin 15 - MD3 U2F4 U36 pin 16 - MD4 9PC8 U36 pin 17 - MD5 096F U36 pin 18 - MD6 HP95 U36 pin 19 - MD7 A634

G3-11 A13 PIA U24

1. Switch the power off and replace assembly A14.
2. Set A13 TL1 and TL3 to the NORM positions. Set TL2 to the TEST position. This enables LSC to be used as an SA START/STOP signal. Set the HP5005A function to NORM and connect the leads as follows:

   GROUND to GND test point
   CLOCK to MCLK test point. Polarity; negative edge
   START to LSC test point. Polarity; negative edge
   STOP to LSC test point. Polarity; negative edge

   Note: See Paragraph G3-3 for threshold settings.

3. Switch the power on. Set A13S2 to 11000 and press reset button A13S1.
4. When the A13 green leds stop at 01001, set the A13S2 switches to 00000 (i.e. all open). All the leds on the A13 board except HALT should then come on at half brightness.
5. Check the following signatures:

   Note: When the PIA signature analysis has been completed set A13TL2 to the NORM position.

Assembly	Logic Function	Signatures	
A13	Peripheral Interface Adapter (PIA) U24	U24 pin 40 - LPFAIL	0AU0
		U24 pin 39	8122
		U24 pin 2	18A2
		U24 pin 3	7A4H
		U24 pin 4	F61F
		U24 pin 5	033U
		U24 pin 6	CA40
		U24 pin 7	84CP
		U24 pin 8	8HF8
		U24 pin 9 - 6441 (3776B)	0AU0 (3776A)
		U24 pin 10	U862
		U24 pin 11	FHP9
		U24 pin 12	3U18
		U24 pin 13	P00F
		U24 pin 14	0AP9
		U24 pin 15	C612
		U24 pin 16	3637
		U24 pin 17	802C

CAUTION

At the end of this test, with A13S2 set to 00000, press the A13S1 reset button or power off then on. The PIA chip U24 could be damaged if this is not done.

If the PIA is faulty the chances are that this test cannot be selected (the switches are read via the PIA). If there is difficulty in selecting this test, and all the signatures are correct in the processor free run mode then the PIA is faulty.

G3-12 A13 HP-IB INTERFACE ADAPTER U55 AND DRIVERS/ RECEIVERS U65/U75

1. The HP-IB check tests most of the HP-IB Interface and transceiver signals. The Interface chip U55 is configured as a talk only and listen only device which allows data bytes to be written and read from the bus.

CAUTION

Remove any connections to the rear panel HP-IB connector before performing these checks. The HP-IB Drivers/Receivers could be damaged if this is not done.

2. Set the HP5005A function to NORM and connect the leads as follows:

GROUND to GND Test Point
CLOCK to MCLK Test Point. Polarity; negative edge
START to TP1 Test Point. Polarity; negative edge
STOP to TP1 Test Point. Polarity; negative edge

Note: See Paragraph G3-3 for threshold settings.

3. Set the A13S2 switches to 11001 and press the A13S1 reset button. When the green leds stop at 01001, check the following signatures.

Assembly	Logic Function	Signature	
A13	HP-IB Interface Adapter	U55 pin 1 - TR1	8U41
		U55 pin 2 - TR2	8U41
		U55 pin 8	FHC4
		U55 pin 9	5FU3
		U55 pin 10	2UAF
		U55 pin 11	2799
		U55 pin 12 - MD0	52P4
		U55 pin 13 - MD1	
		U55 pin 14 - MD2	738U
		U55 pin 15 - MD3	91UA
		U55 pin 16 - MD4	C192
		U55 pin 17 - MD5	PC6C
		U55 pin 18 - MD6	P3U7
		U55 pin 19 - MD7	FF8A
		U55 pin 21 - MA0	57P8
		U55 pin 22 - MA1	**U204
		U55 pin 23 - MA2	**46U4
		U55 pin 27 C625	
		U55 pin 28 320A	
		U55 pin 29 U44P	
		U55 pin 30 66AC	
		U55 pin 31 AUPF	
		U55 pin 32 HUC7	
		U55 pin 33 5172	
		U55 pin 34 6169	
		U55 pin 35 9PC0	
		U55 pin 36 735U - probe tip flashes	
		U55 pin 37 735U - logic 1	
		U55 pin 39 02UC	
A13	Drivers/Receivers	U65 pin 16 - E01 02UC	
		U65 pin 18 - NDAC 8U41	
		U65 pin 19 - DI05 HUC7	
		U65 pin 20 - DI06 5172	
		U65 pin 21 - DI07 6169	

Assembly	Logic Function	Signature
		U65 pin 22 - DI08 9PC0 U65 pin 23 - DAV 735U ensure that the probe tip flashes U75 pin 18 - NRFD 735U always logic 1 U75 pin 19 DI01 320A U75 pin 20 - DI02 U44P U75 pin 21 - DI03 66AC U75 pin 22 - DI04 AUPF U75 pin 23 - SRQ C625

****Note: The signatures given were derived from A13U36 ROM datecode 2338 (HP Part Number 03776-80054). See Instrument Identification procedure given in General Service Sheet G1 for ROM datecode retrieval.**

G3-13 INSTRUMENT DATA BUS INTERFACE U62/INSTRUMENT BUS

1. This check tests the Instrument Data Bus Interface. If the signatures are correct, then we can assume that the Instrument Data Bus is NOT faulty.

2. Set the HP 5005A FUNCTION to QUAL and connect the leads as follows:

   GROUND to GND test point
   CLOCK to MCLK test point. Polarity; negative edge
   ST/SP to TP1 test point. START; negative edge. STOP; negative edge
   QUAL to LSC test point. Polarity; 0

Note: See paragraph G3-3 for threshold settings.

3. Set the A13S2 switches to 11010 and press the A13S1 reset button. Check that the following signatures can be obtained.

Assembly	Logic Function	Signature
A13	Data Bus Interface (keyboard)	U62 pin 9 - D0 96PF U62 pin 8 - D1 725C U62 pin 7 - D2 P5PH U62 pin 6 - D3 5CP0 U62 pin 5 - D4 7P25 U62 pin 4 - D5 85PA U62 pin 3 - D6 77F7 U62 pin 2 - D7 6PCP

G3-14 A13 KEYBOARD DATABUS INTERFACE U52/KEYBOARD DATA BUS

1. Set the HP5005A FUNCTION to QUAL.

2. Connect the HP5005A as follows:

   GROUND to GND Test Point
   GLOCK to MCLK Test Point. Polarity; negative edge
   ST-SP to A13 TP1 Test Point. Polarity; START; negative edge
   STOP; negative edge
   QUAL to LKBDSC Test Point. Polarity; 0

Note: See paragraph G3-3 for Threshold settings.

3. Set the A13S2 switches to 11010 and press the A13S1 reset button.

4. Check that the following signatures can be obtained.

Assembly	Logic Function	Signature
A13	Data Bus Interface (Keyboard)	U52 pin 9 - KBD0 96PF U52 pin 8 - KBD1 725C U52 pin 7 - KBD2 P5PH U52 pin 6 - KBD3 5CP0 U52 pin 5 - KBD4 7P25 U52 pin 4 - KBD5 85PA U52 pin 3 - KBD6 77F7 U52 pin 2 - KBD7 6PCP U71 pin 3 - LKBDRW 0000 clock

G3-15 A13 LED CHECK

1. This check tests that the leds on A13 work correctly.

2. Set the A13S2 switches to 11111 and press the reset button A13S1.

3. Check that all leds are cleared, then after aproximately a one second pause the nine leds CR1 to CR5, IT0, DT0, PONERR and IRQ are lit in turn (each for half a second). Finally all the leds are lit together (including the HALT led).

G3-16 A14 ROM ADDRESS DECODER

1. Ensure A13TL1, TL2 and TL3 are set to the NORM position.

2. Switch the power off. Mount A14 on the extender board and with the HP5005A set to NORM connect up as follows:

   GROUND to GND Test Point
   CLOCK to A13 2F0 Test Point. Polarity; positive edge
   START to A13TP1 Test Point. Polarity; negative edge
   STOP to A13TP1 Test Point. Polarity; negative edge

   Note: See Paragraph G3-3 for Threshold settings.

3. Switch the power on. Set the A13S2 switches to 11011 and press the A13S1 reset button.

4. Check the following signatures:

   Note: Some of these signatures depend on the software revision of A13U36. If signatures are incorrect, check if a new revision of software has been installed. This will be covered in the Service Manual Change Sheet. The signatures given here are derived from ROM U36 datecode 2338 (HP03776-80054). See Instrument Identification procedure given in General Service Sheet G1 for ROM datecode retrieval.

Assembly	Logic Function	Signature
A14	A13/A14 Interface *3776B only. These signatures may be unstable. If unstable set the threshold of the signature analyzer data probe from 2.00V to 1.8V and recheck. If still unstable then check that MD0 to MD7 toggle. Note: the 3776 power on sequence tests the A14 assembly and returns error 119 if faulty.	Edge con 44 - MA0 1358 Edge con 43 - MA1 FFA6 Edge con 42 - MA2 HFC6 Edge con 41 - MA3 3U83 Edge con 40 - MA4 34A0 Edge con 39 - MA5 7A96 Edge con 38 - MA6 A7UA Edge con 37 - MA7 1958 Edge con 36 - MA8 U1AC Edge con 35 - MA9 7533 Edge con 34 - MA10 7533 Edge con 33 - MA11 P8U3 Edge con 32 - MA12 72FH Edge con 31 - MA13 C775 Edge con 30 - MA14 9671 Edge con 29 - MA15 394H@ Edge con 26 - LNVEN 03FH Edge con 25 - VMA U36C Edge con 24 - LDBE AH0F Edge con 22 - MCLK 5686 Edge con 18 - MD0 C7C1* Edge con 17 - MD1 5609* Edge con 16 - MD2 9882* Edge con 15 - MD3 U33C* Edge con 14 - MD4 3UU4* Edge con 13 - MD5 C394* Edge con 12 - MD6 HP10* Edge con 11 - MD7 8F66* Edge con 5 - LWRITE C0F7 Edge con 4 - LREAD 4C4H
A14	ROM Address Decoder	U54 pin 15 H3UH U54 pin 14 32A1 U54 pin 13 55PU U54 pin 12 6H4F U54 pin 11 P3HF U54 pin 10 A3P2 U54 pin 9 5C60

Note: @ Set SA CLOCK to negative edge

Assembly	Logic Function	Signature
		U55 pin 9 53C7 U45 pin 2 9F61 U45 pin 7 F0C8 U45 pin 10 3C81 U45 pin 14 - ROM1 HALF 2H2A U35 pin 15 A206 U35 pin 14 867P U35 pin 13 574F U35 pin 12 U31F U35 pin 7 - LGDRAM EN 5P64 U34 pin 3 U847 U34 pin 6 53C7 U34 pin 11 - LRAM 2877 U34 pin 8 6CU8

G3-17 A14 NON-VOLATILE RAM POWER SUPPLY

The following checks test the battery back-up circuitry for the Non-Volatile RAM (NVM). These checks should be implemented if the NVM is corrupted during power down.

WARNING

In the event of battery replacement, the old battery should not be incinerated or mutilated. It might burst or release toxic materials, causing personal injury.

1. Remove the processor card A13.

2. Remove test link TL1 from A14.

3. Without power applied to the board, measure the battery voltage with a high impedance multimeter (e.g. HP 3435A). Black lead to GND, Red lead to BATT VOLTS test pin. This should read in the range 2.75 to 2.82 volts. If less, make sure the board is **CLEAN** and **DRY**. The battery has a very high internal impedance and any moisture will tend to reduce its voltage.

4. Move the black lead from GND to the BATT CURRENT test pin and change the meter range to 200uA. The cmos RAM U43 is now connected to the battery via the meter. The current taken by the RAM should be typically unmeasureable. If greater than 1uA suspect (i) wet or dirty board, (ii) leaky C1, C2, Q1 or Q2, (iii) out-of-spec cmos RAM U43.

5. Apply power to the board with the meter still connected as above. The battery will now be trickle charging from the +5V rail. The meter reading should be approximately -0.7uA.

6. Remove the power and disconnect the meter. Replace test link TL1. Set the meter range to 20V DC and connect the black lead to GND, red lead to RAM volts. This measures the standby voltage at the RAM chip. This should be >2.5V.

7. With the meter still connected as in step 6, apply power to the board. The RAM voltage should be >4.8V. If not, check the +5V within specification. (See Section 5 Adjustments). If +5V rail is okay, suspect Q2. This should not drop by more than 0.15V.

8. Replace Assembly A13.

G3-18 A14 NON-VOLATILE RAM

This check runs the RAM rest on the NVM RAM A14U43. An error is displayed if this check fails.

> **Note: After this check, the four NVM areas within the memory are reset to a default condition. The configuration saved at the last power-fail and the dialling tables are replaced by default values taken from ROM. The measurement parameter store and the sequence are cleared.**

1. Set the A13S2 switches to 10010.

2. Press A13S1 reset button and check that no errors are displayed.

3. If an error is displayed (assuming previous checks have been performed successfully) then A14U43 is faulty.

G3-19 A14 ROM CRC

This check tests the existence and CRC of all processor ROMS. As each ROM is checked an identifier is displayed in the LEVEL display. If any ROM is missing or corrupt an error is displayed opposite the ROM identifier.

> **Note: The current revision of software does not use ROM 23 and this should be faulted as missing.**

1. Set the A13S2 switches to 10011 and press the A13S1 reset button.

2. Check that the following identifiers are displayed:

ROM	DISPLAYED ID	LOCATION
ROM E	"E"	A13U36
ROM C	"C"	A14U22
ROM A	"A"	A14U12
ROM 8	"8"	A14U22
ROM 6	"6"	A14U32
ROM 4	"4"	A14U42
ROM 20	"2.0"	A14U41
ROM 21	"2.1"	A14U31
ROM 22	"2.2"	A14U21
ROM 23	"2.3"	A14U11
ROM 1	"1"	A14U23

Note: The Group Delay RAM A14U33 is checked during Power-on sequence. See General Service Sheet G1. Also ROM23 (A14U11) is not used at firmware revision 2338 and will return Error 101.

GENERAL SERVICE SHEET G4
KEYBOARD AND DISPLAY

GENERAL SERVICE SHEET G4
KEYBOARD AND DISPLAY

G4-1 INTRODUCTION

G4-2 This service sheet covers troubleshooting for the Keyboard and Display Assembly A21 (03776-60021), and the Keyboard Controller Assembly A22 (03776-60022).

G4-3 Troubleshooting is split into two sections:

1. Front Panel Display

2. Keyboard

G4-4 REFERENCES

G4-5 Figures A21-2 and A22-9,10 (Schematics), and A21-1 and A22-8 (Component Location).

G4-6 FRONT PANEL DISPLAY

G4-7 The Front Panel Display troubleshooting sequence is outlined in Figure G4-1.

G4-8 FRONT PANEL DISPLAY TROUBLESHOOTING PROCEDURE

WARNING

MAINTENANCE DESCRIBED HEREIN IS PERFORMED WITH POWER SUPPLIED TO THE INSTRUMENT, AND PROTECTIVE COVERS REMOVED. SUCH MAINTENANCE SHOULD BE PERFORMED ONLY BY SERVICE-TRAINED PERSONNEL WHO ARE AWARE OF THE HAZARDS INVOLVED (FOR EXAMPLE, FIRE AND ELECTRIC SHOCK).

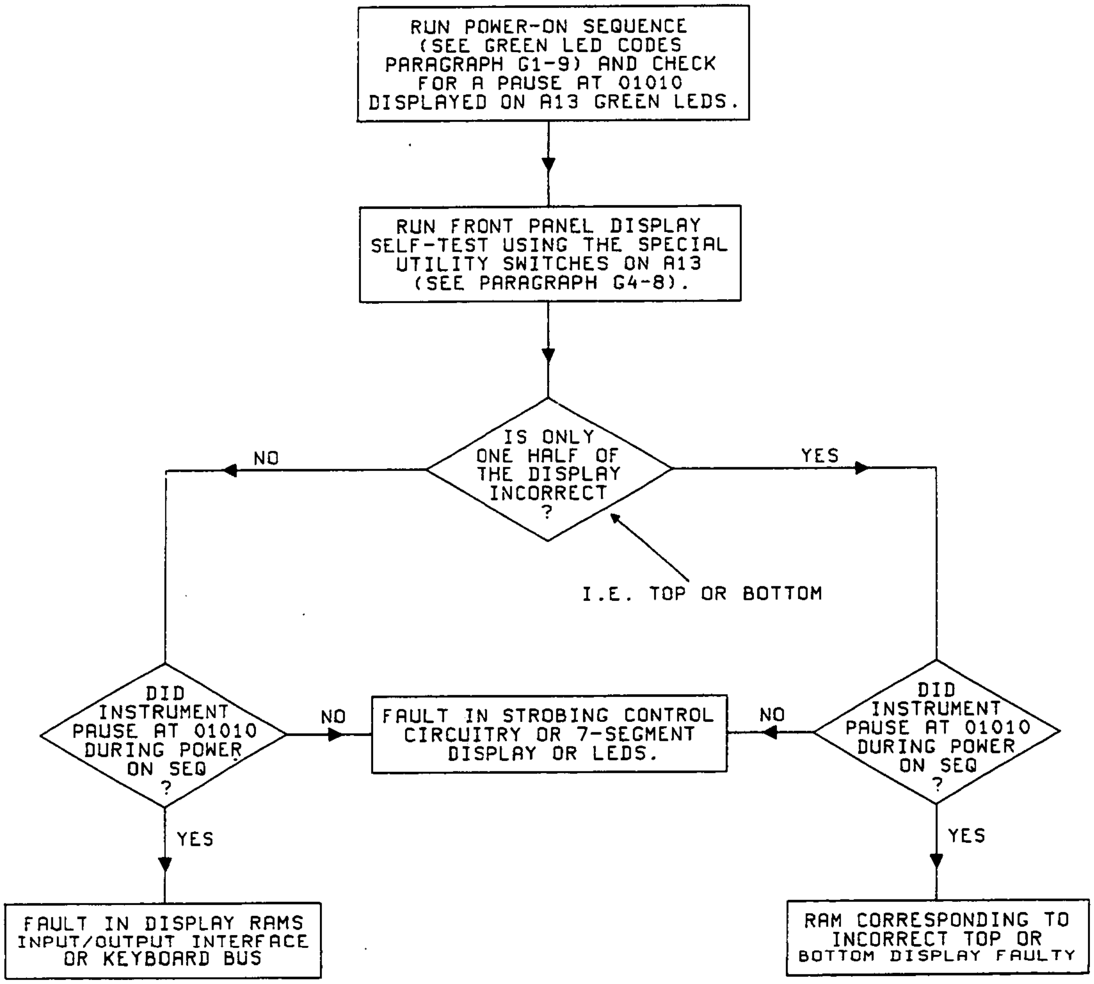


Figure G4-1 Front Panel Display Troubleshooting Sequence

1. Switch the instrument off and remove the top cover and p.c. assemblies retaining cover.

2. Switch the power on and monitor the A13 green leds. If the led sequence pauses for approximately 2 seconds at 01010 a fault is present on the Keyboard bus or the A22 Display RAMS and associated Input/Output Interfaces. Continue with the procedure.

3. Set the A13S2 switches to 10101 and press the A13S1 reset button. This sets the 3776 into the front panel display Self-Test mode. Check that all front panel displays and leds are illuminated. The bright-up facility scans along the FREQUENCY, LEVEL and RESULTS display (bright-up on each 7-segment lasts approximately 1.5 seconds) and the SET FREQ/SET LEVEL/OUT OF RANGE leds flash at approximately a 2Hz rate. Note the DIGITAL RECEIVE CHANNEL display illuminates only two digits.

4. In the Self-Test Display mode, the front panel display and led data is loaded from A13 into the Display "A" RAM and Display "B" RAM on A22, see the A22 Schematic. Display "A" RAM applies data to the top half of the front panel display and Display "B" RAM applies data to the bottom half of the display, see the A21 schematic.

5. If the green leds in A13 pause at 01010 during the power on sequence and only one half of the display is incorrect, then the RAM corresponding to the incorrect top or bottom display is faulty, (see the A22 and A21 schematics).

6. If the green leds on A13 paused at 01010, and both halves of the front panel display are incorrect, then the fault is likely to be in the Keyboard bus or the Display RAMs Input/Output Interfaces. Proceed to Step 8.

7. If the power-on sequence in Step 2 passed and the display is incorrect, then fault must be in the A21 Character Strobe Generator, the display bus buffers or the 7-segment displays or leds.
Proceed to step 8.

8. Switch the 3776 power off and remove the top and bottom front panel trims.

9. Unscrew the front panel retaining screws (3 on top,4 on the bottom).

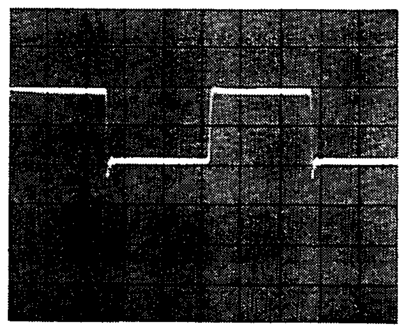
10. Gently pull forward the front panel from the instrument.

11. Set the A13S2 switches to 10101 and switch the power on.

12. Check that the following clocks are present:

DISPLAY CLK A22 TP11

0V



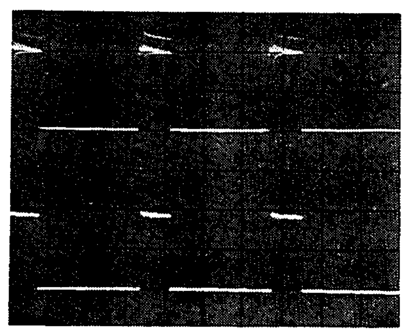
0.2V/DIV (10:1 PROBE) 0.2μs/DIV

H BLANK A22 (J1, pin15)

0V

SCAN CLK A22 TP10

0V



0.2V/DIV (10:1 PROBE) 5μs/DIV

13. If any of these clocks are not present, check the A22 Clock Generator.

14. Using a logic probe check that the following signals are present. Note that all of these signals repeat approximately every 1.5 seconds.

LKBDSC	-ve pulse	A22U54(4)
LKBDAC	-ve pulse	A22U57(10)
HOLD RAM	+ve pulse	A22U56(15)
L HOLD RAM	-ve pulse	A22U56(14)
U54 ENABLE	-ve pulse	A22U56(3)
L SET DISP STATUS	-ve pulse	A22U54(14)
"A" RAM ENABLE	-ve pulse	A22U46(6)
"B" RAM ENABLE	-ve pulse	A22U47(8)

15. If any of the above signals are incorrect, fault must be in the A22 Display ROMS Read/Write Control and Keyboard Read Control or the Display ROMS Hold Control and Write Pulse Generator and Handshake.

16. Check that the following waveforms can be obtained.

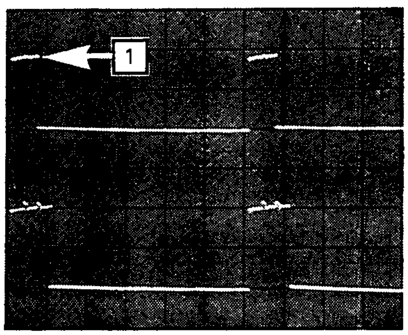
Note: The SCAN HOLD pulses shift right in approximately 10us steps in relation to RAM ADDR 15 TP8. This scanning is repetitive. At the start of each scan the RAM ADDR 15 pulses increase (see waveform (a)).

A22 U33(4) SCAN HOLD

0V

TP8 RAM ADDR 15

0V



(a)

1 SCAN HOLD START POINT

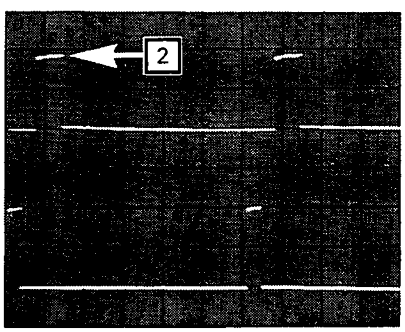
2 AFTER ONE 10μs STEP

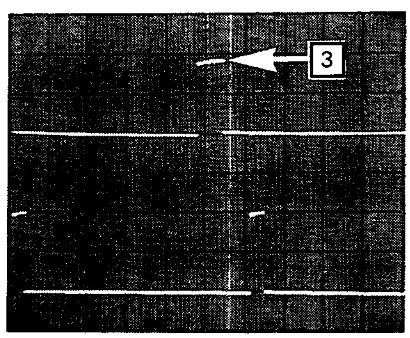
3 AFTER TWELVE 10μs STEPS

0.2V/DIV (10:1 PROBE)

0.05ms/DIV

(b)





(c)

17. If RAM ADDR 15 is not present, check the operation of the Bright-Up Comparator U50 and the Keyboard Data Input Buffer U51.

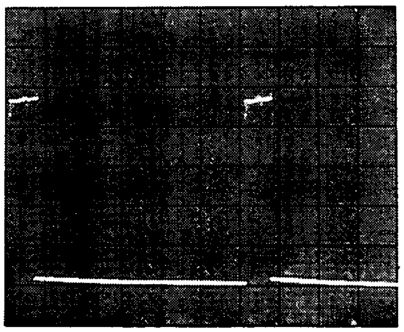
18. Check that a 2Hz squarewave is present at A22TP7. This may be approximately 1.5Hz.

19. If all steps have been completed successfully at this point and the Power-on sequence check (step 2) still pauses at 01010, then the fault must be in Display RAM "A" Read Buffer U36 or Display RAM "B" Read Buffer U37.

20. At this point in the procedure it is assumed that the Power-on sequence does NOT pause at 01010 (see Step 2). With the instrument running as in Step 3, check that the following display bus waveforms can be obtained.

(a)

A22 U14(2)
A22 U14(4)
A22 U13(4)
A22 U13(12)
0V

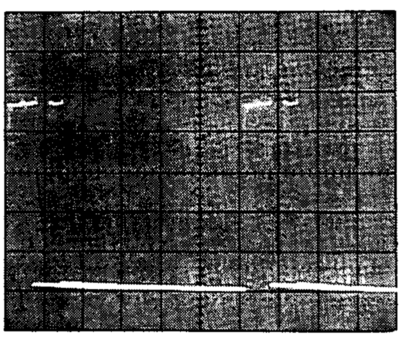


0.2V/DIV (10:1 PROBE) 0.05ms/DIV

(a) STEADY WAVEFORM
(b) CHANGING WAVEFORM
(c) SEE NOTE BELOW

(b)

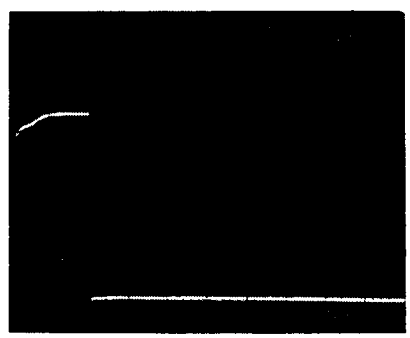
A22 U14(12)
A22 U13(6)
A22 U13(8)
A22 U13(10)
0V



0.2V/DIV (10:1 PROBE) 0.05ms/DIV

(c)

A22 U15(2)
A22 U15(4)
A22 U15(6)
A22 U15(10)
A22 U15(12)
A22 U14(6)
A22 U14(8)
A22 U14(10)
0V



0.2V/DIV (10:1 PROBE) 0.5μs/DIV

Note: Use a scope viewing hood to see waveform (c) as the repetiton rate is approximately 1.5Hz. A logic probe can also be used to check this signal.

21. If any of the display bus waveforms CANNOT be obtained, then the fault is in the Bright-Up Control Logic or buffers U15 or U14 (see A22 schematic).

22. Switch the power off.

23. Unscrew the eleven screws securing assemblies A22 and A21 from the front panel and carefully separate the A21 Assembly from the front panel.

24. Check that the A21 strobe signals can be obtained. Waveforms a, b and c show typical strobing outputs relative to A22 RAM ADDR 15 (A22 TP8). Waveform (a) corresponds to character 0 and waveform (c) corresponds to character 15.

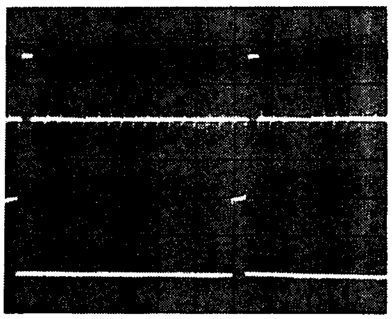
(a)

A21 U2(16)

0V

A22 TP8

0V



0.2V/DIV (10:1 PROBE)

0.05ms/DIV

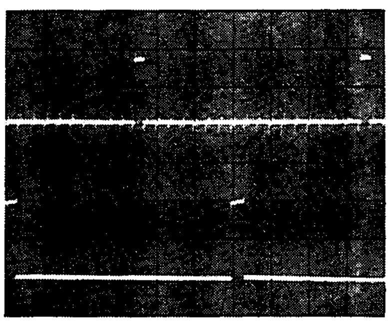
(b)

A21 U2(18)

0V

A22 TP8

0V



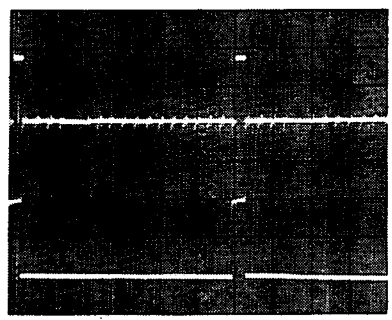
(c)

A21 U5(18)

0V

A22 TP8

0V



Note: **At the start of each bright-up scan (see Step 10) pulse widths increase.**

25. If any of the strobing outputs are not obtained, then the fault is in the corresponding Binary to Octal Decoder or Buffer.

26. Use the waveforms obtained in Step 20 (ie display bus signals) and Step 24 (Strobe signals) to find the faulty displays or leds.

G4-9 KEYBOARD TROUBLESHOOTING

G4-10 Introduction

G4-11 Troubleshooting is performed using the Keyboard Special Utility program selected by the A13S2 switches. The program causes A13 to either continually read the Keyboard Buffer without the Keyboard IRQ being generated, or read the Keyboard Read Buffer only when a Keyboard IRQ is generated. In both modes, the code of the key pressed is displayed on the 3776 RESULTS display.

G4-12 Procedure

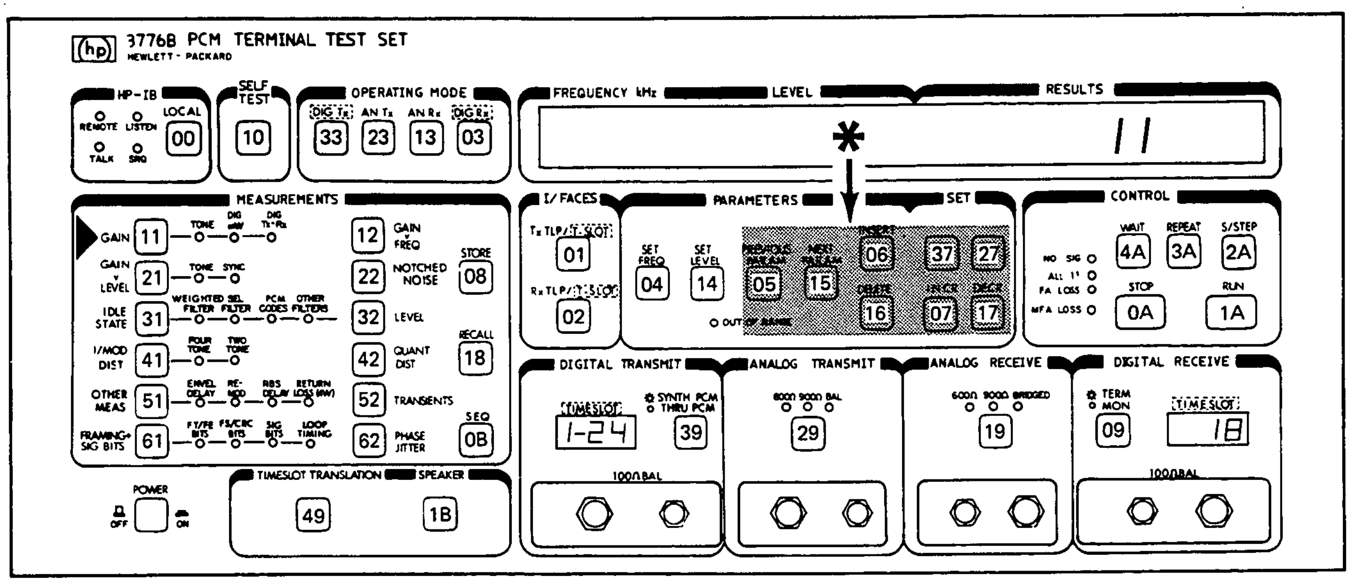
1. Set the A13S2 switches to 10111 and press the A13S1 reset button. The A22 Keyboard Buffer is now continually read without keyboard IRQ being generated and the keycode read from the Buffer is displayed on the 3776 RESULTS Display.

2. Check the following when a key is pressed:

(a) A hexadecimal code corresponding to the apropriate key (see codes in figure given) is displayed on the RESULTS display, ie when GAIN is pressed, 11 is displayed in RESULTS window.

(b) A decimal point appears momentarily in front of the code displayed. This indicates that an IRQ is present on D7 of the word read from the Keyboard Read Buffer.

(c) The decimal point flashes continually when keys indicated with an asterisk below are pressed and held.



Note: See step 3(f) regarding keys marked *

3. Troubleshooting points:

(a) **All keys dead:** Suspect a fault in A22 Scan Counter, Keyboard Scanner or Y-Decoder. Check that L KEY INT is applied to the Scan Counter when a key is pressed. Check also that connector J1 is not loose.

(b) **Group of Keys dead:** If a group of keys are dead on the same X or Y line, press any key on suspect scan line, and track signal through from the Scan Counter to the Y-Decoder.

(c) **Only one key dead:** When key is pressed the code displayed is that of the previous key pressed. Suspect faulty key switch.

(d) **Wrong code obtained after key pressed:** Suspect wrong data being latched into A22 Keyboard Read Buffer. Keep key pressed and check that the X and Y codes output from the Scan Counter respectively correspond to the co-ordinate of the key being pressed.

(e) **Decimal Point does not appear:** Keyboard IRQ not being applied to D7 of the Keyboard bus. Fault in the A22 IRQ Generator or A22 U39B or U57B. Set the A13 S2 switches to 10110, press A13 S1 reset switch and check that the IRQ led on A13 is illuminated momentarily when a key is pressed. If A13 IRQ led illuminates when key is pressed but decimal point does not appear, then fault must be in the Output Buffer U57B. If A13 led does not illuminate then fault is in the A22 IRQ Generator, probably A22 U12A.

(f) **Decimal Point does not flash continuously when key indicated with an asterisk is pressed and held:** Assuming that keyboard IRQs being generated, fault is in the X-Even Coder Repeat Enable Control Logic.

GENERAL SERVICE SHEET G5
DIGITAL SIGNAL SYNTHESIZER

GENERAL SERVICE SHEET G5
DIGITAL SIGNAL SYNTHESIZER

G5-1 INTRODUCTION

G5-2 This service sheet covers troubleshooting for the following assemblies:

3776A: A1 Digital Synthesizer & PCM Generator (03776-60001)

A2 Digital PCM Transmitter (03776-60002)

3776B: A101 Digital Synthesizer & PCM Generator (03776-60101)

A102 Digital PCM Transmitter (03776-60102)

G5-3 The troubleshooting is arranged as follows:

A101 Troubleshooting Procedure (3776B only)
A1 Troubleshooting Procedure (3776A only)
A2/A102 Codec Troubleshooting (combined 3776A/B)
A2 HDB3/AMI Encoder Troubleshooting (3776A only)
A102 B8ZS/AMI (AZS) Encoder Troubleshooting (3776B only)
A2 Clock Selection (3776A only)
A102 Clock Selection (3776B only)
A2/A102 Loop Timing (combined 3776A/B)

NOTES

1. The A1/A101 troubleshooting is performed using the SA programs available on the 3776A/B Test Program Data Cartridge (HP 03776-10001).

2. Some of the signatures depend on the software version. If signatures are incorrect, check if a new version of software has been installed. This will be covered in the Service Manual Change Sheet. The signatures given in paragraphs G5-4 and G5-5 are derived from instrument REV 2345. See Instrument Identification procedure given in General Service Sheet G1 for ROM REVcode retrieval.

G5-4 A101 TROUBLESHOOTING PROCEDURE (3776B only)

1. Connect the HP85 to the 3776B. Remove the top cover and mount assembly A101 on the extender board, and ensure the A13S2 processor switches are set to 00000.
2. Insert the 3776A/B Test Programs Data Cartridge (HP03776-10001) into the HP85.
3. Load the "A1B" program into the HP85 and press the HP85 RUN button.

   Note: After the RUN button is pressed, the HP85 CRT display blanks for approximately 10 seconds.

4. When prompted, enter the 3776B HP-IB address and press END LINE.
5. Check that the following is displayed.

   ***NOTE: The commands given at the bottom of the display (or print out) are actioned by pressing the special function keys (K1 to K8) that aligns with the command. In the example given K1 or K4 action CONTINUE**

```
 3776B A1 TEST ROUTINES
SET PROCESSOR SWITCHES TO
    5 4 3 2 1
    X     X
      X X   X

AND PRESS A13S1 RESET BUTTON
NOW SET PROCESSOR SWITCHES TO

        X   X
    X X   X

AND PRESS A13S1 RESET BUTTON
--------------------------------
CONTINUE                CONTINUE
```

K5 K1	K6 K2	K7 K3	K8 K4

SPECIAL FUNCTION KEYS

6. Set the A13S2 Processor switches as instructed.

7. Press the HP85 special function key K1 to CONTINUE. The following logic circuitry can now be selected by pressing the appropriate special function key. It is recommended that the circuitry be checked in the order given.

   a. CLOCK..K1

   b. I/FACE..K2

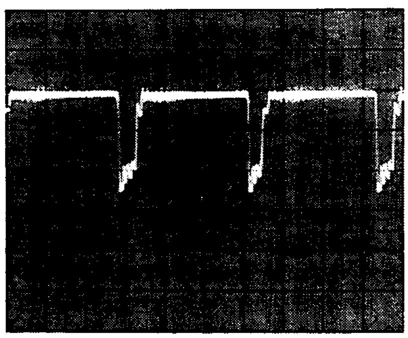
   c. u CODE..K3

   d. DATA..K4

CLOCK

8. Press special function key K1 and check the A1 clock as instructed. The clock waveform should be as shown.

A101 CLK



0.2V/DIV (10:1 PROBE)

0.1μs/DIV

9. Press K1 to continue.

I/FACE

10. Press the HP85 special function key K2 to select I/FACE troubleshooting. The I/FACE troubleshooting makes use of the "utilities" (See Instrument Bus Access Using the Utilities, General Service Sheet G1) to continually write HEX data 55 to I/O Port or Buffer addresses 38, 39, 3A, 3b, 3C and 3d in turn.

> **Note: On some instruments, when writing data 55 to address 3C, error 98 may be displayed. If this occurs, ignore the waveform at address 3C and continue to address 3d.**

11. After each I/O Port check press special function key K1 to continue to the next step.

u CODE

12. Press the HP85 special function key K3 to select the u CODE troubleshooting. Check through the signatures as instructed.

> **Note: Only signatures preceded by an asterisk need be checked to verify IC operation.**

13. When signatures on all ICs have been checked press K7 to END TEST.

DATA

14. Press the special function key K4 to select the DATA troubleshooting. It is recommended that the circuitry be checked in the order given.

    a. CONST

    b. RAM TEST

    c. SINE ROM

    d. BIT SLICE

15. Use the HP85 special function keys to select the appropriate circuitry and check through the signatures as instructed.

> **Note: Only signatures preceded by an asterisk need be checked to verify IC operation.**

G5-5 A1 TROUBLESHOOTING PROCEDURE (3776A only)

1. Connect the HP85 to the 3776A. Remove the top cover and mount assembly A1 on the extender board.

2. Insert the 3776A/B Test Programs Data Cartridge (HP03776-10001) into the HP85.

3. Load the "A1 A" program into the HP85 and press the HP85 RUN button.

> **Note: After the RUN button is pressed, the HP85 CRT display blanks for approximately 10 seconds.**

4. When prompted, enter the 3776A HP-IB address and press END LINE.

5. Check that the following is displayed.

> **Note: The commands given at the bottom of the display (or print out) are actioned by pressing the special function key (K1 to K8) that aligns with the command. In the example given K1 or K4 action CONTINUE.**

```
 3776A A1 TEST ROUTINES
SET PROCESSOR SWITCHES TO
    5 4 3 2 1
    X     X
      X X   X

AND PRESS A1S1 RESET BUTTON
NOW SET PROCESSOR SWITCHES TO

        X   X
    X X   X

AND PRESS A13S1 RESET BUTTON
--------------------------------
CONTINUE                CONTINUE
```

K5 K1	K6 K2	K7 K3	K8 K4

SPECIAL FUNCTION KEYS

6. Set the A13S2 Processor switches as instructed.

7. Press the HP85 special function key K1 to continue. The following logic circuitry can now be selected by pressing the appropriate special function key. It is recommended that the circuitry be checked in the order given.

   a. CLOCK.....................................K1

   b. I/FACE.....................................K2

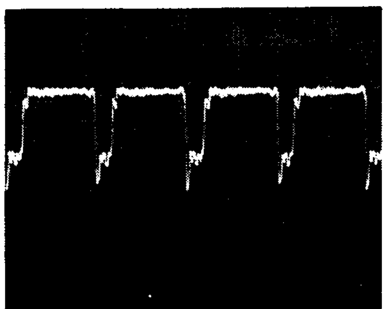
   c. u CODE.....................................K3

   d. DATA.......................................K4

CLOCK

8. Press special function key K1 and check the A1 clock as instructed. The clock waveform should be as shown.

A1 CLK



0.2V/DIV (10:1 PROBE)

$0.1\mu s$/DIV

9. Press K1 to continue.

I/FACE

10. Press the HP85 special function key K2 to select I/FACE troubleshooting. The I/FACE troubleshooting makes use of the Utilities (See Instrument Bus Access Using the Utilities, General Service Sheet G1) to continually write HEX data 55 to I/O Port on Buffer addresses 38, 39, 3A, 3b, 3C and 3d in turn.

11. After each I/O Port check press special function key K1 to continue to the next step.

u CODE

12. Press the HP85 special function key K3 to select u CODE troubleshooting. Check through the signatures as instructed.

Note: Only signatures preceded by an asterisk need be checked to verify IC operation.

13. When signatures on all ICs have been checked, press K7 to END TEST.

DATA

14. Press the special function key K4 to select DATA troubleshooting. It is recommended that the circuitry be checked in the order given.

    a. CONST

    b. RAM TEST

    c. SINE ROM

    d. BIT SLICE

15. Use the HP85 special function keys to select the appropriate circuitry and check through the signatures as instructed.

Note: Only signatures preceded by an asterisk need be checked to verify IC operation.

G5-6 A2/A102 CODEC TROUBLESHOOTING (combined 3776A/B)

Equipment Required

Test Oscillator	HP654A
AC Voltmeter	HP3455A
Frequency Counter	HP5328A

Procedure

1. Remove the instrument top cover and printed circuit assemblies metal retaining cover.
2. Connect the DIGITAL TRANSMIT output to the DIGITAL RECEIVE input.
3. Connect the test equipment as shown in Figure G5-1.
4. Set the 3776 operating mode to DIG Tx to DIG Rx.
5. Set the 3776 DIGITAL TRANSMIT CHAN to 1.30 (3776A) or TIMESLOT to 1.24 (3776B). Set the DIGITAL RECEIVE CHAN/TIMESLOT to 1.

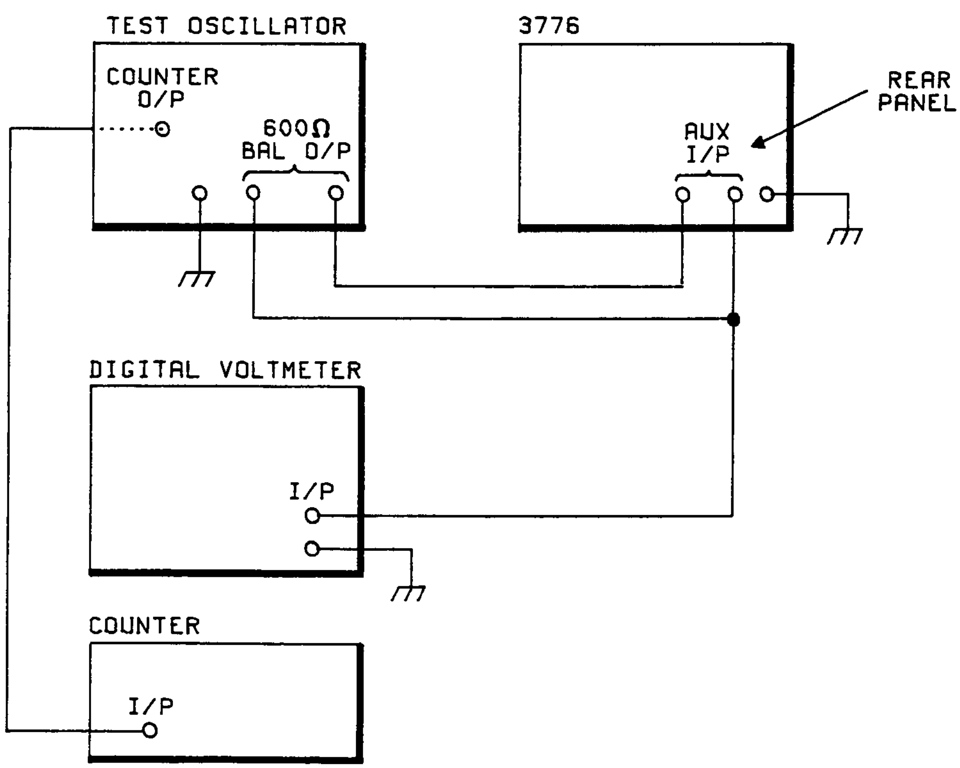


Figure G5-1 Codec Test Setup

6. Adjust the Test Oscillator Frequency to display 1.01kHz on the Frequency Counter and 0.1228V (-16dBm/600Ω) if the instrument is a 3776B or 0.[illegible]45V (-14dBm/600Ω) if the instrument is a 3776A displayed on the AC Voltmeter.

7. Ensure DIGITAL TRANSMIT CHAN/TIMESLOT is in SYNTH PCM mode (led lit).

8. Set the measurement mode to LEVEL/SEL FILTER.

9. Set the MEAS Frequency on the 3776 to 1.01kHz.

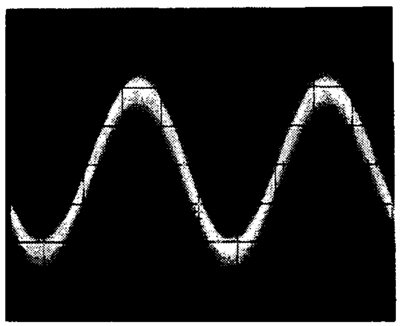
10. Press the 3776 DELETE button (this selects AUX I/P).

11. Press RUN/REPEAT.

12. At this point, if the codec circuitry is not faulty, 0.00 dBm0 will be displayed in the 3776 RESULTS display. If the 3776 display is approximately 0.00 dBm0, then adjust A2R6 to give 0.00dBm0 on the RESULTS display. If the display cannot be adjusted, then continue with the procedure.

13. Check that the following waveform can be obtained. Note that noise pick-up is high on the signal, this is normal. If the waveform cannot be obtained, check the A2 Auxiliary Input Stage.

A2 CODEC INPUT Test Point



0.02V/DIV (10:1 PROBE)

0.2ms/DIV

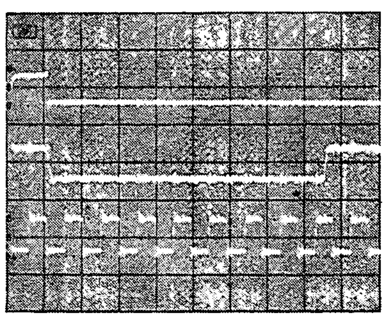
14. Check that the following waveforms can be obtained (trigger the scope from the positive-going edge of the CODEC SYNC waveform).

Note: The following waveforms were obtained from a 3776A. As the 3776B clock rate is slower (ie 1.544MHz) the LCODEC VALID signal should be approximately 5.15us wide and each Codec Data bit approximately 0.65us wide. The oscilloscope setting of 0.5us/Div for the 3776A waveforms will be different for the 3776B waveforms.

A2 CODEC SYNC (8kHz)

A2 LCODEC

*** L PCM CLK**



0.5V/DIV (10:1 PROBE)

0.5µs/DIV

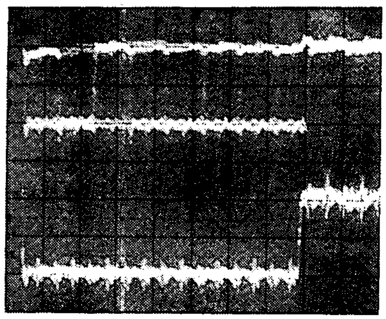
* 3776A : 2.048MHz , 3776B : 1.544MHz

15. If the waveforms cannot be obtained, check the operation of the A2 Codec Timing Logic and the Clock Selection Logic.

16. Check that the following Codec waveform can be obtained.

A2 CODEC DATA (8-bit word)

A2 LCODEC VALID

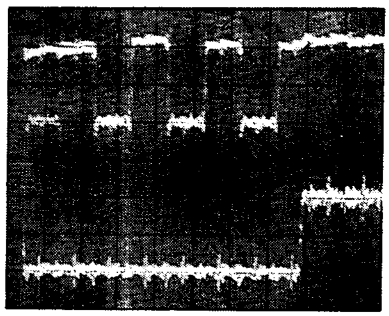


0.2V/DIV (10:1 PROBE)
0.5μs/DIV

17. The Codec Data 8-bit word should be able to be changed by setting the Test Oscillator to a negligible output level or a maximum output level. Typical waveforms obtained are as follows:

A2 CODEC DATA (8-bit word)

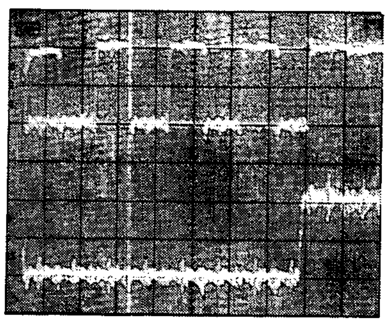
WITH TEST OSCILLATOR SET TO NEGLIGIBLE OUTPUT LEVEL



AS ABOVE

A2 CODEC DATA (8-bit word)

WITH TEST OSCILLATOR SET TO MAXIMUM OUTPUT LEVEL



AS ABOVE

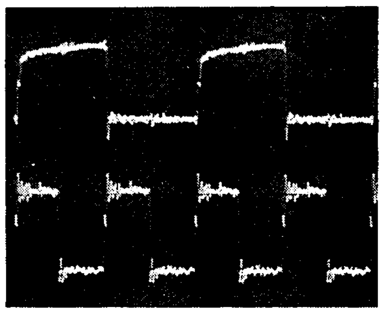
18. If the waveforms cannot be obtained then Codec U212 is faulty.

G5-7 A2 HDB3/AMI ENCODER TROUBLESHOOTING (3776A only)

1. Set the 3776A operating mode to DIG Tx only.
2. Select FRAME WORD then continually press NEXT PARAM to select AIS.
3. Press RUN.
4. Check that the output of U307(6) is held high.
5. The outputs of D-type flip-flops U309(10), U309(5), U309(2) should all be set high and U309(12) should be low.
6. Check that U309(15) output is as shown.

U309 (15) (AIS selected)

LPCM CLK



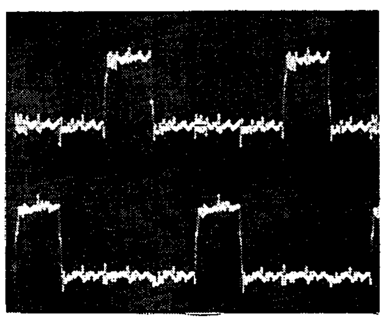
0.2V/DIV (10:1 PROBE)

0.2μs/DIV

7. Check that the POS MARK and NEG MARK signals are as shown.

A2 POS MARK (AIS selected)

A2 NEG MARK (AIS selected)



0.2V/DIV (10:1 PROBE)

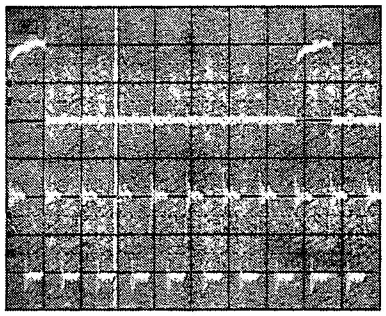
0.2μs/DIV

8. Press STOP and check that the output of D-type flip-flops U309(10), U309(5), U309(2) and U309(12) toggle.

9. Connect the DIGITAL TRANSMIT output to DIGITAL RECEIVE input and ensure that the rear panel HDB3/AMI switch is set to HDB3.

10. Set the 3776A Tx CHAN to 1. . 30 and Rx CHAN to 1. Set D-D GAIN/TONE measurement and press RUN/REPEAT.

11. Check that the following waveform can be obtained.



12. If the INHDB3V signal cannot be obtained, check the operation of U310B. Also check that U310B(11) L CODE is set low and when the rear panel HDB3/AMI switch is set to AMI that LCODE goes high.

G5-8 A102 B8ZS/AMI ENCODER (3776B only)

1. Connect DIGITAL TRANSMIT output to DIGITAL RECEIVE input.

2. Mount assembly A102 on the extender board.

3. Set the A13S2 switches to 10001 then press the A13S1 reset button. This selects "utilities" (see General Service Sheet G1).

4. Press AN Tx.

5. Write OC to address 3d as follows:

   a. Press SEQ then STORE, 3d should be displayed on the LEVEL display.

   b. Press SET FREQ, 00 should be displayed on the RESULTS display.

   c. Press SPEAKER then NOTCHED NOISE, OC should now be displayed on the RESULTS display.

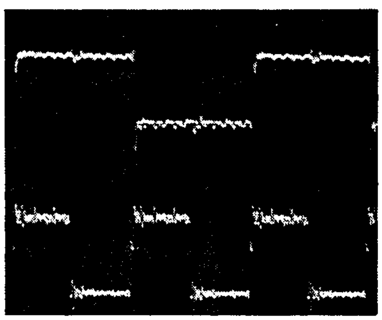
   d. Press REPEAT. This selects AIS (all ones) in the digital transmitter.

6. Check that the outputs of D-type flip-flops U309(2), U309(5), U309(6), U309(9), U309(12), U309(15) and U309(16) are held high. Check also that the outputs of D-type flipflops U408(2), U408(5), U408(7), U408(10) and U408(12) are held low.

7. Check that the following waveform can be obtained.

A102 U309 (19) (AIS selected)

LPCM CLK



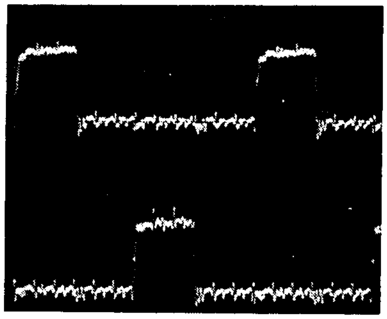
0.2V/DIV (10:1 PROBE)

0.2μs/DIV

8. Check that the POS MARK and NEG MARK signals are as shown.

A102 POS MARK

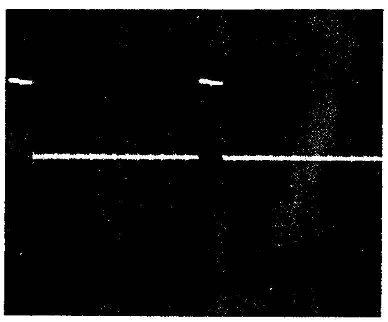
A102 NEG MARK



0.2V/DIV (10:1 PROBE)
2μs/DIV

9. Set the A13S2 switches to 00000 and press the A13S1 reset button.
10. Set the 3776B operating mode, DIG Tx to DIG Rx and GAIN/DIG Tx - Rx. Set the rear panel B8ZS/AMI switch to B8ZS.
11. Set the I/FACES Tx T-SLOT to 1..24.
12. Set the displayed CODE to -127 and press RUN/REPEAT.
13. Check that the following waveform can be obtained.

A102 TP7 VIOLATE



0.2V/DIV (10:1 PROBE)
1μs/DIV

14. If the VIOLATE signal cannot be obtained, check the operation of gates U202(11), U310(6) and U310(5). Check that LB8ZS is low. Also check that the D-Type flip-flops U309A to U309G are toggling.
15. Check that the VIOLATE waveform given in Step 13 can be obtained at the outputs of D-type flip-flops U408A to U408E.

G5-9 A2 CLOCK SELECTION (3776A only)

Introduction

The 3776A 2.048MHz internal or PCM CLK can be derived from three sources, they are:

a. P CLK (A13 Processor Clock); 8.192MHz divided down to give 2.048MHz.

b. DIG Tx EXT CLK; 2.048MHz provided by the external equipment.

c. N CLK Rx (3776 Receiver Clock); 2.048MHz clock recovered by the 3776 Receiver. Selected when the 3776 is in the THROUGH mode.

Procedure

1. Mount assembly A2 on the extender board.

2. Check that Processor clock (test point PROC CLK) is 8.192MHz ±kHz and that the output of the divide-by-four stage U203(13) is 2.048MHz ±1kHz.

3. Connect a Function Generator to the 3776 rear panel DIG Tx CLOCK.

4. Set the Function Generator to give a 2.048MHz ±1kHz squarewave with TTL levels (nominal), ie 0V low, +5V high.

5. Check that the Function Generator clock is present on A2 EXT CLK test point. If the clock cannot be obtained, check fuse A2F1. A spare fuse is provided and is located on A2 just below A2F1.

6. Set the DIGITAL TRANSMIT to THROUGH PCM and check that a 2.048MHz ±1kHz clock can be obtained on A2 LRx CLK test point. If this clock cannot be obtained, mount A12 on an extender board and check the operation of gate A12 U402(3).

7. Connect the oscilloscope to A2 LPCM CLK and check that the LRx CLK signal can be obtained. To determine that LRx CLK has been routed through A2 U104 connect connect the DIGITAL TRANSMIT output to the DIGITAL RECEIVE input. This causes jitter to be introduced as the clock is not now derived from a crystal source.

8. Set the DIGITAL TRANSMIT to SYNTH PCM.

9. Set the rear panel DIG Tx CLOCK INT/EXT switch to EXT. Check that the A2 EXT CLK signal can be obtained at A2 LPCM CLK test point. The A2 EXT CLK can be identified by changing the frequency on the Function Generator.

10. Set the rear panel DIG Tx CLOCK INT/EXT switch to INT and disconnect the Function Generator.

11. Check that the divided down A2 PROC CLK is present at A2 LPCM CLK. To check that the clock is derived from the Processor clock, continually press the DIGITAL TRANSMIT SYNTH PCM/THROUGH PCM switch. With the instrument connected back-to-back the THROUGH PCM signal will appear with jitter.

12. If any of the LPCM clocks in Steps 7, 9 and 11 cannot be obtained, and Multiplexer U104 select lines Rx LOOP and SEL Tx EXT CLK are correct, then Multiplexer A2U104 is faulty.

13. Check operation of retriggerable monostable U401. If the PCM CLK is not present, the L INHIBIT output inhibits POS MARK and NEG MARK generation. The INHIBIT output is interrogated by the processor via buffer U402 (Address 18).

G5-10 A102 CLOCK SELECTION (3776B only)

Introduction

The 3776B 1.544MHz internal or PCM CLK can be derived from three sources, they are:

a. PCLK (A13 Processor Clock); 9.264MHz divided down to give 1/544MHz.

b. DIG Tx EXT CLK; 1.544MHz provided by external equipment.

c. N CLK Rx (3776 Receiver Clock); 1.544MHz clock recovered by the 3776 Receiver. Selected when the 3776 is set in the THRU mode.

Procedure

1. Mount assembly A102 on the extender board.

2. Check that Processor clock (test point PROC CLK) is 9.264MHz ±1kHz and that the output of divide-by-six stage U203 is 1.544MHz ±1kHz.

3. Connect a Function Generator to the 3776 rear panel DIG Tx CLOCK.

4. Set the Function Generator to give a 1.544MHz ±1kHz squarewave with approximately TTL levels (ie 0V low, +5V high).

5. Check that the Function Generator clock is present on A102 EXT CLK test point. If the clock cannot be obtained, check fuse A102 F1. A spare fuse is provided and is located on A102 just below A102 F1.

6. Set the DIGITAL TRANSMIT to THRU PCM and check that a 1.544MHz ±1kHz clock can be obtained on A102L Rx CLK test point. If this clock cannot be obtained, mount A12 on an extender board and check the operation of gate A12U402(3).

7. Connect an oscilloscope to A102 LPCM CLK and check that the LRx CLK signal can be obtained. To determine that LRx CLK has been routed through A102 U104, connect the DIGITAL TRANSMIT output to the DIGITAL RECEIVE input. This causes jitter to be introduced as the clock is not now derived from a crystal source.

8. Set the DIGITAL TRANSMIT to SYNTH PCM.

9. Set the rear panel DIG Tx CLOCK INT/EXT switch to EXT. Check that the A102 EXT CLK signal can be obtained at A102 LPCM CLK test point. The A102 EXT CLK can be identified by changing the frequency on the Function Generator.

10. Set the rear panel DIG Tx CLOCK INT/EXT switch to INT and disconnect the Function Generator.

11. Check that the divided down A102 PROC CLK is present at A102 LPCM CLK. To check that the clock is derived from the Processor clock, continually press the DIGITAL TRANSMIT SYNTH PCM/THRU PCM switch. With the instrument connected back-to-back the THRU PCM signal will appear with jitter.

12. If any of the LPCM clocks in Steps 7, 9 and 11 cannot be obtained, and multiplexer U104 select lines Rx LOOP and SEL Tx EXT CLK are correct, then Multiplexer A102 U104 is faulty.

13. Check the operation of retriggerable monostable U401. If the PCM CLK is not present, the L INHIBIT output inhibits POS MARK and NEG MARK. The INHIBIT output is interrogated by the processor via buffer U402 (Address 18).

G5-11 A2/A102 LOOP TIMING (combined 3776A/B)

Introduction

The 3776 uses a pictorial display to indicate loop timing. The RESULTS display is stationary when the clock extracted from the received PCM stream is the same frequency as the clock of the transmitted PCM stream. Frequency difference is indicated by rotation of the marker, and jitter is indicated by jitter of the marker.

Procedure

1. Mount assembly A2/A102 on the extender board.

2. Set the 3776 to DIG Tx / DIG Rx Operating Mode and connect the DIGITAL TRANSMIT output to the DIGITAL RECEIVE input. Ensure that the DIGITAL TRANSMIT output is set to SYNTH PCM.

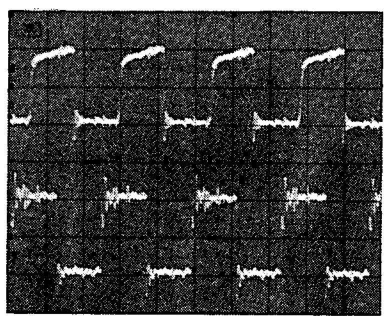
3. Set the 3776A to OTHER MEAS/LOOP TIMING, 3776B to FRAMING + SIG BITS/LOOP TIMING.

4. Press RUN and check that the following clocks can be obtained.

3776A

A2 U107 (13) Rx CLK

A2 U107 (1) LPCM CLK (Trigger)



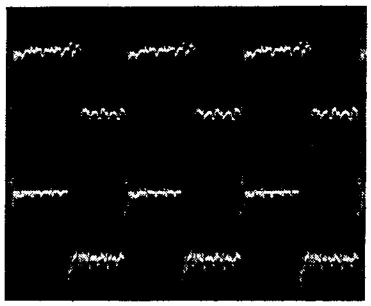
0.2V/DIV (10:1 PROBE)

0.2μs/DIV

3776B

A102 U210 (13) Rx CLK

A102 U210 (1) LPCM CLK (Trigger)



0.2V/DIV (10:1 PROBE)

0.2μs/DIV

5. With the 3776 connected back-to-back, the displayed marker should be stable. Check that the 3776A A2 U106 Loop Timing latch outputs LOOP0 to LOOP3 or 3776B A102 U211 Loop Timing latch outputs LOOP0 to LOOP3 are available. Note that the latch outputs can be either low or high. If the outputs are not stable and the clocks given in Step 4 are correct check that the L ADDR 3D signal is high. Check operation of the Loop Timing Counters and Loop Timing Latch.

6. Disconnect the DIGITAL TRANSMIT output from the DIGITAL RECEIVE input.

7. Check that the Loop Timing Latch outputs toggle. NOTE: When the DIGITAL TRANSMIT output is disconnected from the DIGITAL RECEIVE input, it is possible for the Clock Extractor on assembly A12, to lock on to PCM CLK pick-up and produce stable outputs on the Loop Timing Latch. If the Loop Timing Latch outputs are stable, check that the Rx CLK shown in Step 4 is not present before checking operation of the Loop Timing Counters and Latch.

GENERAL SERVICE SHEET G6
DIGITAL OUTPUT STAGE AND DIGITAL RECEIVER

GENERAL SERVICE SHEET G6
DIGITAL OUTPUT STAGE AND DIGITAL RECEIVER

G6-1 INTRODUCTION

G6-2 This service sheet provides troubleshooting information for the following assemblies:

3776A	3776B
A7 Digital Output Stage (03776-60007)	A107 Digital Output Stage (03776-60107)
A11 A-Law Alignment (03776-60011)	A111 U-Law Alignment (03776-60111)
A12 Digital Receiver (03776-60012)	A112 Digital Receiver (03776-60112)

G6-3 Troubleshooting consists of the following:

1. Digital Output Stage check
2. Digital Input Stage check
3. Digital Receiver Troubleshooting

(combined 3776A/B troubleshooting)

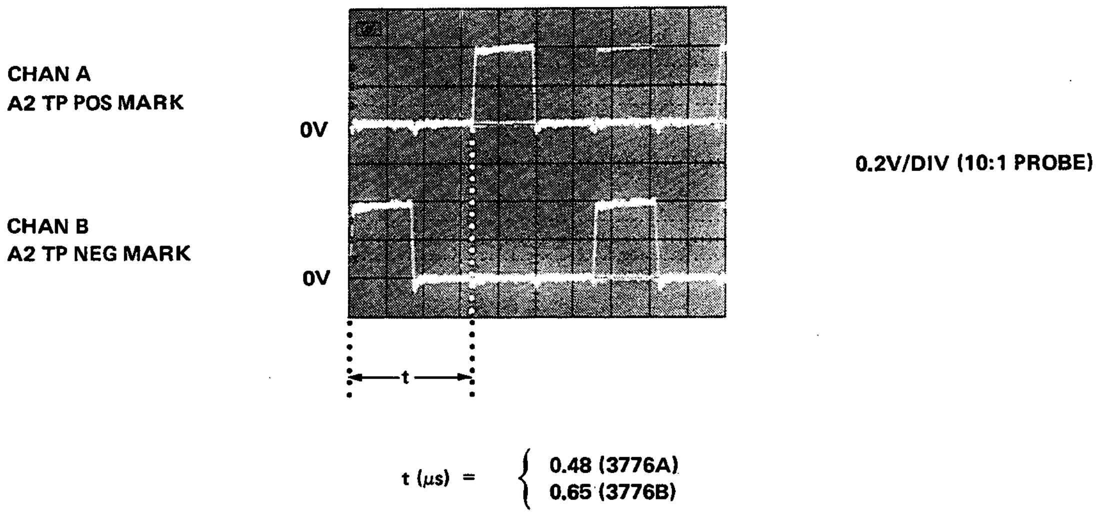
4. A111 Troubleshooting (3776B only)
5. A11 Troubleshooting (3776A only)

G6-4 DIGITAL OUTPUT STAGE

PROCEDURE

1. With the instrument power off, remove the top cover and mount the A7/A107 assembly on the extender board.
2. Connect the DIG Tx to the DIG Rx, set the A13S2 switches to 10010 and switch the power on.
3. Connect Channels A and B of an oscilloscope to A2 test points POS MARK and NEG MARK respectively and check that the positive and negative marks alternate as shown.

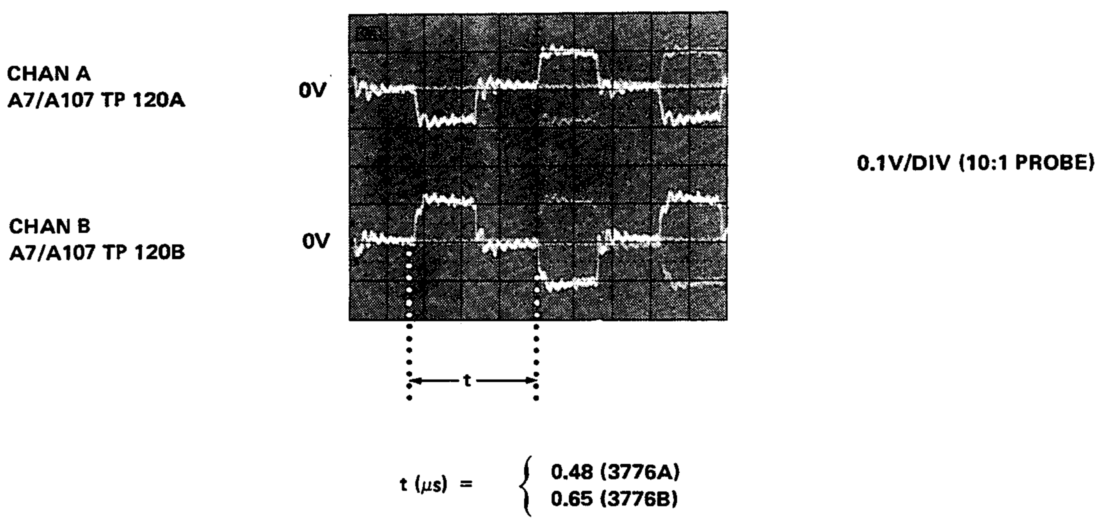
Note: Due to the nature of the data being transmitted, it is difficult to obtain clean traces in the following waveforms.



4. If alternating positive/negative marks are not present go to General Service Sheet G5.

5. Connect Channels A and B of the oscilloscope to A7/A107 test points 120A and 120B respectively. These test points are located on the bottom right-hand corner of the assembly.

6. Check that the following complementary waveforms can be obtained.



7. If the waveforms cannot be obtained, use the waveform given in Step 3 to trace the fault through A7/A107. Check +12V and −12V supplies to the U47 Data Amplifiers. Check fuse F2. Note that fuse F1 is a spare. See Assembly Service Sheet A7/A107 for Drivers and Data Amplifiers.

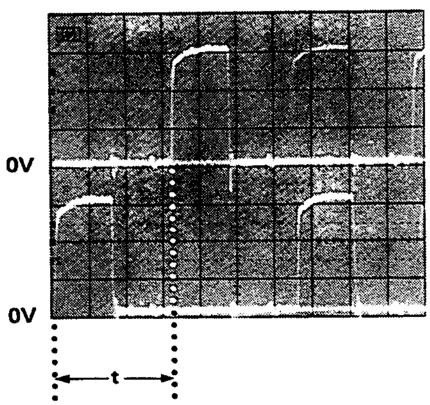
G6-5 DIGITAL INPUT STAGE

PROCEDURE

1. Switch the instrument power off and remove the top cover.
2. Connect the DIG Tx output to the DIG Rx input.
3. Mount Assembly A12 on the extender board.
4. Set A13S2 switches to 10010 and switch the power on.
5. Connect Channels A and B of the Oscilloscope to A12 test points POS MARK and NEG MARK respectively.
6. Check that the positive and negative marks alternate as shown.

CHAN A
A12 TP POS MARK

CHAN B
A12 TP NEG MARK



0.2V/DIV (10:1 PROBE)

t (μs) = { 0.48 (3776A) / 0.65 (3776B)

7. If the waveforms are not present, use the waveform given in G6-4 Step 6 to trace through the Digital Input Stage. The following notes will help troubleshoot the Input Stages.

   a. Input relays K1 and K2 can be energised to select the CAL path direct from A7 by entering the "utilities" (See General Service Sheet G1) and writing 08 to address 30.

   b. The 0/30dB (3776A) or 0/20dB (3776B) Amplifier and Data to TTL Converter can be checked by monitoring the input signal to A12 U310 pin 3 and A12 U211 pin 3 on an oscilloscope and pressing the front panel DIGITAL RECEIVE TERM/MON key. In the MON position, 30dB (3776A) or 20dB (3776B) gain is applied to the input signal.

8. With the A13S2 switches set to 10010, press A13S1 Reset button.

9. Connect a Frequency Counter to A12 CLK Rx test point and check that the receiver frequency is 1.544MHz ±1kHz (3776B) or 2.048MHz ±1kHz (3776A).

G6-6 DIGITAL RECEIVER TROUBLESHOOTING

A12 Troubleshooting Procedure

1. With the power switched off, mount assembly A12 on the extender board.

2. Connect the DIGITAL TRANSMIT output to the DIGITAL RECEIVE input.

3. Connect the HP 5005A Signature Multimeter as follows:

GND.......................................A12 DIG GND
CLOCK...................................A12 CLK Rx positive edge
START....................................A12 SA START/STOP positive edge
STOP......................................A12 SA START/STOP positive edge

4. Set the HP5005A Signature Multimeter as follows:

FUNCTION...........................NORM
DATA......................................TTL
CLOCK...................................TTL
ST-SP-QL...............................TTL

5. Set A13S2 switches to 10010 and switch the power on.

Note: Steps 6 and 7 can be omitted by connecting an HP85 to the 3776, setting the HP-IB address to 02 and sending the following HP85 basic commands.

```
OUTPUT 702; "CA OFF"
OUTPUT 702; "IO #H30, #H05"
OUTPUT 702; "IO #H3D, #H08"
```

6. Set A13S2 switches to 10001 and press the A13S1 reset button. Press AN Tx.

7. Write 05 to Data Input Buffer or Port A12 U404 Address 30 and 08 to Data Input Buffer Address 3d (See General Service G1 for Instrument Bus Access using the "utilities"). This selects A12SA and THRU ENABLE. The procedure is as follows:

a. Press the SEQ (3) key.

b. Press the SPEAKER (0) key. 30 should now be displayed on the LEVEL display.

c. Press SET FREQ.

d. Press TRANSIENTS. 05 should now be displayed on the left-hand side of the RESULTS display.

e. Press RUN. 05 is now written to address 30.

f. Write 08 to Data Input Buffer or Port Address 3d by repeating steps a. to e. (The hexadecimal key pad is contained in Paragraph G1-37).

8. Check that the signature obtained on A12U101 pin 14 (+5V supply) is 826P. This checks that counters U305, U306 and U307 used for SA START/STOP are correct. If this signature cannot be obtained, then check the counter operation using a logic probe or an oscilloscope.

9. Check that the following signatures can be obtained. Use A12 Schematic in conjunction with the signatures to locate the fault.

Note: Where indicated, only signatures that are underlined need be checked to verify the appropriate Logic Function operation.

Assembly	Logic Function	Signatures
A12	AIS, Signal Loss Detector and SA Verification Code Generator	U305 (1) 826P
		U305 (2) 0000 clock
		U305 (11) ICF0
		U305 (12) 925A
		U305 (13) H657
		U305 (14) UF4C
		U305 (15) 8A79
		U306 (1) 826P
		U306 (2) 0000 clock
		U306 (7) 8A79
		U306 (10) 8A79
		U306 (11) 1A77
		U306 (12) UPUA
		U306 (13) HAH5
		U306 (14) 0446
		U306 (15) 30P8
		U307 (1) 826P
		U307 (2) 0000 clock
		U307 (7) 30P8
		U307 (10) 30P8
		U307 (14) 6HF9

		U307 (15) F359 U301 (1) 826P U301 (2) AH9H U301 (4) 826P clock (3776B) unstable (3776A) U301 (6) 826P U301 (7) 0000 U301 (10) 826P U301 (12) 826P clock (3776B) unstable (3776A) U301 (14) F359 U301 (15) 826P U205 (4) 8A79 U205 (5) 0784 U205 (6) AH9H U502 (4) 826P U502 (5) 826P U502 (6) 826P U202 (11) 826P U202 (12) 0000 U202 (13) 826P
A12	Line Code Decoder and Time Slot Data Register	U405 (1) 826P U405 (2) 7P25 U405 (3) 0000 U405 (4) UF4C U405 (5) H657 U405 (6) 0000 U405 (7) A872 U405 (9) 0000 clock U405 (10) 0A74 U405 (12) 925A U405 (13) 1CF0 U405 (15) FPC9 U406 (1) 826P U406 (2) 417A U406 (3) 2FF7 U406 (4) 0446 U406 (5) HAH5 U406 (6) 13UF U406 (7) 2P33 U406 (9) 0000 clock U406 (10) CF24 U406 (11) 681H U406 (12) UPUA U406 (13) 1A77

		U406 (14) 5652 U406 (15) FP62 U407 (1) 826P U407 (2) 75CH U407 (3) 1702 U407 (4) 6HF9 U407 (6) 5C13 U407 (7) 826P U407 (9) 0000 clock U203 (1) 75CH U203 (2) FP62 U203 (3) CF24 U203 (4) 2P33 U203 (5) 417A U203 (6) 1702 U203 (7) 5652 U203 (8) 681H U203 (9) 13UF U203 (11) 2FF7 U203 (13) H571 U203 (14) 71UC U203 (16) FPC9 U203 (17) 0A74 U203 (18) A872 U203 (19) 7P25 U204 (1) FPC9 U204 (2) 0A74 U204 (3) CH4C U101 (11) H97H U101 (12) 6436 U101 (13) CH4C U206 (2) CH4C U206 (3) CH4C U206 (9) 71UC U206 (10) 0000 clock U206 (11) 0784 U206 (12) 85PA U206 (15) 6436 U207 (2) 85PA U207 (3) 85PA U207 (9) H571 U207 (10) 0000 clock U207 (12) 1408 U408 (2) 1408 U408 (3) F95H

		U408 (4) A7U7 U408 (5) H3UC U408 (6) 69UH U408 (8) 0000 clock U408 (10) 34UP U408 (11) 1A7U U408 (12) FP66 U408 (13) A46A
A12	Timeslot Translation Logic	U401 (4) 826P (3776A) unstable (3776B) U401 (5) 0000 U401 (6) 0000 U401 (8) 0000 U401 (9) 0000 (3776A) unstable (3776B) U401 (10) 0000 U208 (1) 0000 U208 (8) 0000 clock U208 (13) 0000 clock U308 (1) 0000 U308 (2) 0000 U308 (3) 1408 U308 (4) A46A U308 (5) 0000 U308 (6) A46A U308 (7) A46A U308 (9) 0000 U308 (10) 0000 U308 (11) A46A U308 (12) 0000 U308 (13) A46A U308 (14) 0000 U308 (15) 0000

10. The A12 Address Decoder and Processor Handshake control troubleshooting can be performed using the utility sequence outlined in Step 7. Most circuitry can be exercised by selecting the appropriate address (i.e. 10, 11, 12, 13 or 30) and pressing the front panel REPEAT key.

G6-7 A111 TROUBLESHOOTING PROCEDURE (3776B only)

1. With the power switched off, mount assembly A111 on the extender board.

2. Connect the DIGITAL TRANSMIT output to the DIGITAL RECEIVE input.

3. Connect the HP 5005A Signature Multimeter as follows:

GND	A111 GND
CLOCK	A12 CLK Rx, positive edge
START	A111 test point 4, positive edge
STOP	A111 test point 4, positive edge

4. Set the HP 5005A Signature Multimeter as follows:

FUNCTION	NORM
DATA	TTL
CLOCK	TTL
ST-SP-QL	TTL

5. Set A13S2 switches to 10010 and switch the power on.

Note: Steps 6, 7 and 8 can be omitted from the procedure by connecting an HP85 to the 3776, setting the HP-IB address to 02 and sending the following HP85 basic commands.

```
OUTPUT 702; "CA OFF"
OUTPUT 702; "IO#H33, #HA4"
OUTPUT 702; "IO#H32, #H40"
OUTPUT 702; "IO#H31, #H00"
OUTPUT 702; "IO#H30, #H05"
OUTPUT 702; "IO#H3D, #H08"
```

Note: Ignore any errors displayed when entering the HP85 basic commands.

6. Set A13S2 switches to 10001 and press A13S1 reset button.

7. Press AN Tx.

8. Write the following data to the corresponding addresses as shown:

A4 to address 33
40 to address 32
00 to address 31
05 to address 30
08 to address 3d

See General Service Sheet G1 for Instrument Bus Access using the "utilities"

9. Check that the signature obtained on A111 U101 pin 14 (+5V) is 1180. This checks that counters U313, U312 and U106 used for SA START/STOP are correct. If this signature cannot be obtained, then check counter operation using a logic probe or an oscilloscope.

10. Check that the following signatures can be obtained. Use A111 schematics in conjunction with the signatures to locate the fault.

Note: Where indicated, only signatures that are underlined need be checked to verify Logic Function operation.

Assembly	Logic Function	Signatures
A111 (3776B)	Timing Generator (A111 Schematic Part 1)	U106 (2) CFPA U106 (3) 0000 clock U106 (5) 5P75 U106 (6) 4UU5 U108 (1) 18C7 U108 (2) 0937 U108 (3) 0000 U108 (4) CFPA U108 (5) 0000 U108 (6) AH6A U109 (8) 0000 U109 (9) FUA3 U109 (10) AH6A U109 (11) 0937 U109 (12) AH6A U109 (13) UU87 U111 (1) FUA3 U111 (2) 1180 U111 (3) FUA3 U111 (4) 1180 U111 (5) 1U7C U111 (6) 1U7C U112 (12) 2281 U112 (13) 3301 U212 (1) 18C7 U212 (2) 1180 U212 (3) 1180 U212 (11) 1180 U212 (12) CFPA U212 (13) 1180 U213 (1) 052A

		U213 (2) 0108 U213 (3) 3301 U213 (4) A7A2 U213 (5) 4PCC U213 (6) AH6A U213 (12) 3301 U213 (13) 0U7U U309 (5) 0000 U309 (6) 1180 U309 (8) 2281 U309 (9) 3301 U310 (1) 377F U310 (2) 0000 clock U310 (9) 1180 U310 (11) 1100 U310 (12) 0108 U310 (13) 052A U310 (14) 0U7U U310 (15) U5F6 U311 (1) 377F U311 (2) 0000 clock U311 (7) U5F6 U311 (9) 1180 U311 (10) U5F6 U311 (11) 4PCC U311 (12) A7A2 U311 (13) 108P U311 (14) 5342 U312 (2) 0000 clock U312 (7) P6HF U312 (9) 1180 U312 (10) P6HF U312 (11) H6AA U312 (12) 0F62 U312 (13) OPOP U312 (14) 5HC4 U312 (15) 26UF U313 (2) 0000 clock U313 (4) 1U7C U313 (6) 0000 U313 (7) AH6A U313 (9) 1180 U313 (10) AH6A U313 (11) FF4F U313 (12) CU96 U313 (13) 1U7C U313 (14) 64H9

		U313 (15) P6HF U314 (2) 849C U314 (3) 1180 clock U314 (5) 424H U314 (9) 849C U314 (11) 1180 clock U314 (12) 0937
A111 (3776B)	Frame and Multiframe Alignment Logic (A111 Schematic Part 1)	U105 (4) 9612 U105 (5) PA3C U105 (6) 59FF U105 (8) 4PCC U105 (9) 4PCC U105 (10) 1180 U106 (9) U3H4 U106 (11) 0000 clock U106 (12) H528 U108 (8) 1180 U108 (9) H592 U108 (10) 0000 U108 (11) 1180 U108 (12) 63FF U108 (13) 0000 U109 (1) 4UU5 U109 (2) 1670 U109 (3) H592 U109 (4) 4UU5 U109 (5) C048 U109 (6) 63FF U110 (1) 0U7U U110 (3) 59FF U110 (4) FUCA U110 (5) 052A U110 (6) 0108 U110 (7) PA3C U110 (9) 9612 U110 (10) 1180 U110 (11) 0000 clock U110 (12) 0108 U110 (13) 052A U110 (14) 0U7U U110 (15) 1180 U111 (11) 1180 U111 (12) 1180 U111 (13) 1180

		U112 (3) 1180 U112 (4) 0000 U112 (5) 1180 U112 (6) 0000 U113 (1) 0108 U113 (2) 0U7U U113 (3) 6105 U113 (4) 2FF3 U113 (5) F5F8 U113 (6) 2HA8 U113 (12) 80F0 U113 (13) 052A U207 (1) U120 U207 (2) 8UCU U207 (3) 2FF3 U207 (4) P395 U207 (5) C50U U207 (6) F5F8 U208 (4) C048 U208 (5) 80F0 U208 (6) FUA3 U208 (11) 1180 U208 (12) 1180 U208 (13) 1180 U209 (2) 4PCC U209 (3) C5OU U209 (4) F5F8 U209 (9) 2HA8 U209 (10) 1180 U209 (11) 0000 clock U209 (12) 0000 U209 (13) 0000 U209 (14) 1180 U209 (15) 4PCC U210 (1) 7956 U210 (2) OU7U U210 (3) 052A U210 (4) 0108 U210 (5) 1100 U210 (6) FUCA U210 (7) 9612 U210 (8) PA3C U210 (9) 6105 U210 (11) U120 U210 (12) 8UCU U210 (13) P395

		U210 (14) C50U U210 (16) 5342 U210 (17) 108P U210 (18) A7A2 U210 (19) 4PCC U211 (1) 108P U211 (2) A7A2 U211 (3) P395 U211 (4) 8UCU U211 (5) 5342 U211 (6) 1100 U211 (7) 6105 U211 (9) U120 U211 (10) 1180 U211 (11) 0000 clock U211 (12) 1100 U211 (13) 5342 U211 (14) 108P U211 (15) A7A2 U212 (4) 0000 clock U212 (5) 0000 U212 (6) 0000 clock U212 (8) 0000 clock U212 (9) 0000 U212 (10) 0000 clock U308 (8) H528 U308 (9) U3U4 U308 (10) 26UF U411 (1) 1180 U411 (2) 0000 U411 (3) U3H4 U411 (4) U3H4 U411 (5) 0000 U411 (6) 0F62 U411 (7) 0F62 U411 (9) 0P0P U411 (10) 0P0P U411 (11) 0000 U411 (12) H6AA U411 (13) H6AA U412 (1) 64H9 U412 (2) 1U7C U412 (3) CU96 U412 (4) FF4F U412 (5) 5HC4 U412 (6) 7956 U412 (7) 1670

		U412 (8) C048 U412 (9) U089 U412 (11) 5271 U412 (12) 790F U412 (13) 0P10 U412 (14) UU87 U412 (15) 0000 U412 (16) 0P0P U412 (17) 0F62 U412 (18) H6AA U412 (19) U3H4
A111 (3776B)	Test Timeslot Selector (A111 Schematic Part 1)	U105 (1) P848 U105 (2) F111 U105 (3) A890 U107 (2) H091 H107 (3) H091 U107 (4) H091 U107 (5) H091 U107 (6) F111 U107 (7) 0000 U107 (9) 0000 U107 (10) 1180 U107 (11) 0000 U112 (1) H091 U112 (2) F111 U206 (10) P848 U206 (12) 1180 clock U206 (13) H091 U206 (14) H091 U208 (1) 2281 U208 (2) 0000 U208 (3) 0000 U213 (8) H091 U213 (9) 2FC3 U213 (10) 1180 U213 (11) 8911 U306 (1) 64H9 U306 (3) 4F34 U306 (6) 2FC3 U306 (9) FF4F U306 (10) 0000 U306 (11) CU96 U306 (12) 0000 U306 (13) 0000 U306 (14) 1U7C

		U306 (15) 0000 U307 (1) 1100 U307 (3) 5U3C U307 (6) 8911 U307 (9) A7A2 U307 (10) 0000 U307 (11) 108P U307 (12) 0000 U307 (13) 0000 U307 (14) 5342 U307 (15) 0000 U308 (1) 0000 U308 (2) 5HC4 U308 (3) 5HC4 U308 (4) 4PCC U308 (5) 0000 U308 (6) 4PCC U309 (10) 5U3C U309 (11) 4PCC U309 (12) 4F34 U309 (13) 5HC4 U413 (1) U089 U413 (2) 2FC3 U413 (5) 2FC3 U413 (7) 0000 U413 (9) 0000 U413 (10) 1180 U413 (11) 0000 U413 (12) 790F U413 (13) 0P10 U413 (14) 64H9 U413 (15) 5271
A111 (3776B)	Digital Filter Handshake Logic (A111 Schematic Part 2)	U101 (1) 1180 U101 (2) 1180 U101 (3) 1U7C U101 (4) 1U7C U101 (5) H091 U101 (6) 64H9 U101 (7) 64H9 U101 (9) A7A2 U101 (10) A7A2 U101 (11) 1180 U101 (12) 108P U101 (13) 108P U101 (14) 1180 U102 (1) 1180

		U102 (2) 1CH5
		U102 (3) 824P
		U102 (4) 052A
		U102 (5) 0108
		U102 (6) C6P4
		U102 (7) 19F4
		U102 (9) 1180
		U102 (10) 91F0
		U102 (11) 0CU7
		U102 (12) 1100
		U102 (13) 5342
		U102 (14) 7406
		U103 (1) 1CH5
		U103 (2) 19F4
		U103 (3) 91F0
		U103 (4) 30P1
		U103 (5) 108P
		U103 (6) 824P *AF68
		U103 (7) C6P4 *0000
		U103 (8) 0CU7 *0000
		U103 (9) 7406 *0000
		U103 (11) H199 *1180
		U103 (12) AF68
		U103 (13) 79F5 *1180
		U103 (14) U49H *0000
		U103 (16) A7A2
		U103 (17) 64H9
		U103 (18) 1U7C
		U103 (19) 1180 *0000
	Note: To fully exercise U103, after obtaining the normal signatures, write A0 to Address 33 and check that the *signatures can be obtained. After obtaining the *signatures, write A4 to Address 33 and continue with the procedure.	U104 (2) A5A2 U104 (4) 79F5 U104 (5) AF68 U104 (7) 5634 U104 (9) 1180 clock U104 (10) P8FF
		U104 (12) H199
		U104 (13) U49H
		U104 (15) UA4P
		U201 (8) 1180
		U201 (9) 1180
		U201 (10) 1180
		U202 (1) 1180
		U202 (2) 1180
		U202 (3) 1180 clock
		U202 (5) 1180
		U202 (9) 1180
		U202 (10) 1180
		U202 (13) 1180

A11 (3776B)	Peak Codes Detector (A111 Schematic Part 2)	U301 (1) A7A2 U301 (2) 1U7C U301 (5) 108P U301 (6) 5342 U301 (10) 1180 U301 (11) 0000 clock U301 (12) 5342 U301 (13) 108P U301 (14) A7A2 U301 (15) 1U7C U302 (1) 052A U302 (2) 0U7U U302 (3) A8H9 U302 (4) 8HPP U302 (5) 0108 U302 (6) 1100 U302 (7) 12A4 U302 (9) 49U8 U302 (10) 1180 U302 (11) 0000 clock U302 (12) 1100 U302 (13) 0108 U302 (14) 052A U302 (15) 0U7U U303 (1) 1180 U303 (2) 1U7C U303 (3) A7A2 U303 (4) 108P U303 (5) 5342 U303 (6) 932U U303 (7) PUP0 U303 (8) PUP0 U303 (11) 12A4 U303 (12) 49U8 U303 (13) 8HPP U303 (14) A8H9 U303 (16) 1100 U303 (17) 0108 U303 (18) 052A U303 (19) 0U7U
	Note: The outputs from U405 and U406 can be made to toggle by setting Addresses 11 and 12 respectively (see A111 Schematic) using the utilities, and pressing RUN/REPEAT. Press stop after performing this check.	U405 (1) PUP0 U405 (11) PUP0 U405 (12) 0000 U405 (17) 1180 U406 (1) PUP0 U406 (11) 932U U406 (12) 0000 U406 (17) 2C6H

G6-8 U-LAW EXPANDER TROUBLESHOOTING (3776B only)

1. Set the A13S2 switches to 00000 and press the A13S1 reset button.
2. Set the 3776 to DIG Tx/DIG Rx and ensure that the DIGITAL TRANSMIT output is connected to the DIGITAL RECEIVE input.
3. Set the 3776 to GAIN V LEVEL SYNC.
4. Press RUN and check that 2.00kHz REF 92 CODE is momentarily displayed followed by the following MEAS codes.

   127
   111
   95
   79
   63
   47
   31
   15
   1

5. For each code transmitted between 127 and 15, check that the reading displayed in the RESULTS display is within 0 ±0.5dB. For code 1, the reading should be within 0 ±0.2dB.
6. If a result for any code is out of limit and the A111 Signature Analysis has been performed successfully, then fault is in either A111 PROM U409 or U408.

G6-9 A11 TROUBLESHOOTING PROCEDURE (3776A only)

1. With the power switched off, mount assembly A11 on the extender board.

2. Connect the DIGITAL TRANSMIT output to the DIGITAL RECEIVE input.

3. Connect the HP5005A Signature Multimeter as follows:

   GND..........A12 DIG GND
   CLOCK..........A11 SA CLK, positive edge
   START..........A11 SA START/STOP test point, positive edge
   STOP..........A11 SA START/STOP test point, positive edge

4. Set the HP 5005A Signature Multimeter as follows:

   FUNCTION..........NORM
   DATA..........TTL
   CLOCK..........TTL
   ST-SP-QL..........TTL

5. Set the A13S2 switches to 10010 and switch the power on.

   Note: Steps 6, 7 and 8 can be omitted by connecting an HP85 to the 3776, setting the HP-IB address to 02 and sending the following HP85 basic commands. Ignore any errors displayed when using the HP-IB commands to set up the Input/Output port addresses and data.

   ```
   OUTPUT 702; "CA OFF"
   OUTPUT 702; "IO#H33, #HA4"
   OUTPUT 702; "IO#H32, #H40"
   OUTPUT 702; "IO#H31, #H00"
   OUTPUT 702; "IO#H30, #H05"
   OUTPUT 702; "IO#H3D, #H08"
   ```

6. Set the A13S2 switches to 10001 and press the A13S1 reset button.

7. Press AN Tx.

8. Write the following data to the corresponding addresses as shown:

A4 to address 33
40 to address 32
00 to address 31
05 to address 30
08 to address 3d

— See General Service Sheet G1 for Instrument Bus Access using the "utilities".

9. Check that the signature obtained on A11 U101 pin 14 (+5V) is 826P. This checks that counters U110, U210 and U310 used for SA START/STOP are correct. If this signature cannot be obtained, then check counter operation using a logic probe or an oscilloscope.

10. Check that the following signatures can be obtained. Use the A11 schematics in conjunction with the signatures to locate the fault.

Note: Where indicated, only signatures that are underlined need be checked to verify Logic Function operation.

Assembly	Logic Function	Signatures
A11 (3776A)	Timing Generator (See A11 Part 1 Schematic)	U110 (2) 0000 clock U110 (9) 826P U110 (11) ICF0 U110 (12) 925A U110 (13) H657 U110 (14) UF4C U110 (15) 8A79 U210 (2) 0000 clock U210 (7) 8A79 U210 (9) 826P U210 (10) 8A79 U210 (11) 1A77 U210 (12) UPUA U210 (13) HAH5 U210 (14) 0446 U210 (15) 30P8 U310 (2) 0000 clock U310 (7) 30P8 U310 (9) 826P U310 (10) 30P8 U310 (11) 7P61 U310 (12) 2F6A U310 (13) 4UC2 U310 (14) 6HF9 <u>U310 (15) F359</u>
A11 (3776A)	Frame and Multi-Frame Alignment Detector. (See A11 Part 1 schematic)	U101 (8) 826P U101 (9) 6C36 U101 (10) 826P

	Note: Signatures marked ** should be checked with the HP5005A Signature Analyzer Multimeter connected as follows: GND : A12 DIG GND CLOCK : A12 CLK Rx, Polarity +ve edge START : A12 SA START/STOP, Polarity +ve edge STOP : A12 SA START/STOP, Polarity +ve edge	U103 (2) 826P U103 (9) 0000 clock U103 (10) 0000 clock U103 (11) 0000 clock U103 (12) 0000 clock U103 (13) 0000 clock U105 (1) 826P U105 (2) U6FA** U105 (3) H657 U105 (4) H657 U105 (5) P1H4** U105 (6) UF4C U105 (7) UF4C U105 (9) ICF0 U105 (10) ICF0 U105 (11) FP66** U105 (12) 925A U105 (13) 925A U105 (14) 0000 U106 (1) 1A77 U106 (4) FHU3 U106 (6) UPUA U106 (7) 1974 U106 (10) 826P U106 (11) 0000 clock U106 (12) UPUA U106 (14) 1A77 U107 (1) 1A77 U107 (2) 9819 U107 (3) 7P61 U107 (4) UF0U U107 (5) AAU3 U107 (6) 289H U107 (8) C6PU U107 (9) 3481 U107 (10) 0000 U107 (11) 826P U107 (12) 0000 U107 (13) 826P

	Note: Signatures marked ** should be checked with the HP5005A Signature Analyzer Multimeter connected as follows: GND : A12 DIG GND CLOCK : A12 CLK Rx, Polarity +ve edge START : A12 SA START/STOP, Polarity +ve edge STOP : A12 SA START/STOP, Polarity +ve edge	U111 (3) UF4C U111 (4) H657 U111 (5) 925A U111 (6) UNSTABLE U111 (8) 68P8 U111 (9) HAH5 U111 (10) ICF0 U111 (11) 0446 U112 (4) P1H4** U112 (5) 102P** U112 (6) U6FA** U112 (8) 1A77 U112 (9) 1A77 U112 (10) 826P U112 (11) 3481 U112 (12) 68P8 U112 (13) 7F94 U205 (1) UF4C U205 (2) H657 U205 (3) 925A U205 (4) ICF0 U205 (5) 0446 U205 (6) 5965 U205 (7) 6C36 U205 (8) 1974 U205 (9) FHU3 U205 (11) HCU2 U205 (12) C5PA U205 (13) 3655 U205 (14) UA59 U205 (15) 0000 U205 (16) HAH5 U205 (17) UPUA U206 (1) 0446 U206 (4) 5965 U206 (5) HAH5 U206 (7) 826P U206 (9) 826P U206 (10) 826P U206 (11) 0000 clock U206 (12) 826P U206 (13) HAH5 U206 (14) 0446 U207 (4) HH63 U207 (5) UF0U

		U207 (6) F3PF U211 (1) H579 U211 (2) 68P8 U211 (3) UF0U U211 (4) FF61 U211 (5) HH63 U211 (6) H72A U211 (8) FF61 U211 (9) 08PC U211 (10) H579 U211 (11) 68P8 U211 (12) 1874 U211 (13) 747U U212 (1) 0000 U212 (2) 826P U212 (3) 1874 U212 (4) 0000 clock U212 (5) 826P U212 (6) H72A U212 (8) 0000 U212 (9) 0000 U212 (10) 826P U212 (11) FF61 U212 (12) 826P U212 (13) 0000 U302 (1) UF4C U302 (2) H657 U302 (8) 0000 U302 (9) 0000 U302 (10) 7P61 U302 (11) 826P U302 (12) AAU3 U302 (13) 925A U305 (4) UA59 U305 (5) 6HF9 U305 (7) 3655 U305 (9) HCU2 U305 (10) 826P U305 (11) 0000 clock U305 (12) 826P U305 (13) 6HF9 U305 (14) 826P U305 (15) 0000

	Note: Signatures marked ** should be checked with the HP5005A Signature Analyzer Multimeter connected as follows: GND : A12 DIG GND CLOCK : A12 CLK Rx, Polarity +ve edge START : A12 SA START/STOP, Polarity +ve edge STOP : A12 SA START/STOP, Polarity +ve edge	U311 (1) 1A77 U311 (2) UPUA U311 (3) 6HF9 U311 (4) 4UC2 U311 (5) 2F6A U311 (6) HH63 U311 (8) 08PC U311 (9) 0000 U311 (10) 9819 U311 (12) 747U U311 (13) 0000 U312 (1) 0000 U312 (2) 0000 clock U312 (3) 0000 clock U312 (4) 0000 U312 (5) 0000 clock U312 (6) 0000 clock U312 (8) 826P U312 (9) C5PA U312 (10) 826P U411 (9) 0000 U411 (10) 4AC9** U411 (11) ** U411 (12) 826P U411 (13) FP66** U412 (1) UPUA U412 (2) 0000 U412 (3) 7F94 U412 (8) 6HF9 U412 (9) UPUA U412 (10) 115H U511 (2) H3UC** U511 (3) 69UH** U511 (4) 826P U511 (5) A7U7** U511 (6) F95H** U511 (7) 102P** U511 (9) P1H4** U511 (10) A46A** U511 (11) FP66** U511 (12) 826P U511 (13) 1A7U** U511 (14) 34UP** U512 (1) 69UH** U512 (2) 34UP**

		U512 (4) A[illegible]** U512 (5) F95H** U512 (6) 4AC9**
A11 (3776A)	Test Timeslot Selector. (See A11 Schematic Part 1). Note: Signatures marked ** should be checked with the Signature Multimeter connected as follows: GND : A12 DIG GND CLOCK : A12 CLK Rx, Polarity +ve edge START : A12 SA START/STOP, Polarity +ve edge STOP : A12 SA START/STOP, Polarity +ve edge	U102 (7) 4H18 U102 (9) FU76 U102 (11) FU76 U102 (12) 4H18 U102 (13) 0000 U201 (1) 6H18 U201 (2) PUA7 U201 (10) 4H18 U201 (11) FU76 U201 (12) 7F94 U201 (13) UPUA U203 (1) 6HF9 U203 (2) F3PF U203 (5) F3PF U203 (7) 0000 U203 (9) 0000 U203 (10) 826P U203 (11) 0000 U203 (12) 7F94 U203 (13) UPUA U203 (14) F3PF U203 (15) PUA7 U207 (1) 7P48 U207 (2) F3PF U207 (3) FU76 U207 (8) 0000 clock U207 (9) 4H18 U207 (10) FU76 U303 (1) 2F6A U303 (6) F3PF U303 (9) 6HF9 U303 (10) 0000 U303 (11) 4UC2 U303 (12) 0000 U303 (13) 0000 U303 (14) 7P61 U303 (15) 0000 U304 (1) HAH5 U304 (3) 9819 U304 (6) 7P48 U304 (9) 1CF0

		U304 (10) 0000 U304 (11) 0446 U304 (12) 0000 U304 (13) 0000 U304 (14) UPUA U304 (15) 0000 U412 (11) 9819 U412 (12) 0000 U412 (13) 1A77
A11 (3776A)	Digital Filter Handshake Logic. (See A11 Schematic Part 2) Note: To fully exercise **PROM U308** after obtaining the normal signatures, write **A0** to Address 33, using the utility, and check that the *signatures, can be obtained. After obtaining the *signatures, write A4 to Address 33 and continue with the procedure.	U112 (1) 826P U112 (2) 826P U112 (3) 826P U202 (1) 826P U202 (2) 826P U202 (3) 0000 U202 (5) 826P U202 (9) 826P U202 (10) 826P U202 (13) 826P U208 (1) 826P U208 (2) 826P U208 (3) UPUA U208 (4) UPUA U208 (5) 826P U208 (6) HAH5 U208 (7) HAH5 U208 (9) 4UC2 U208 (10) 4UC2 U208 (11) 826P U208 (12) 6HF9 U208 (13) 6HF9 U208 (14) FU76 U307 (2) P63A U307 (4) 4AF7 U307 (5) 5714 U307 (7) 2C8A U307 (9) 826P U307 (10) 172P U307 (12) 2P5H U307 (13) C7HC U307 (15) 5CPH U308 (1) A872 U308 (2) 0A74 U308 (3) FPC9 U308 (4) 417A U308 (5) HAH5 U308 (6) 5AP5 *2P5H

		U308 (7) F534 *0000 U308 (8) AFUA *0000 U308 (9) 8849 *0000 U308 (11) 5714 *826P U308 (12) 2P5H U308 (13) 4AF7 *826P U308 (14) C7HC *0000 U308 (16) UPUA U308 (17) 6HF9 U308 (18) 4UC2 U308 (19) 826P 0000
A11 (3776A)	Peak Codes Detector. (See A11 Schematic Part 2)	U108 (1) 826P U108 (2) 4UC2 U108 (3) UPUA U108 (4) HAH5 U108 (5) 0446 U108 (6) 4663 U108 (7) H370 U108 (8) CA1F U108 (11) 90U3 U108 (12) 5P37 U108 (13) U161 U108 (14) 755F U108 (16) 1CF0 U108 (17) 925A U108 (18) H657 U108 (19) UF4C U109 (1) H657 U109 (2) UF4C U109 (3) 755F U109 (4) U161 U109 (5) 925A U109 (6) 1CF0 U109 (7) 90U3 U109 (9) 5P37 U109 (10) 826P U109 (11) 0000 clock U109 (12) 1CF0 U109 (13) 925A U109 (14) H657 U109 (15) UF4C U209 (1) UPUA U209 (2) 4UC2 U209 (3) FU76 U209 (4) Toggles U209 (5) HAH5 U209 (6) 0446

		U209 (7) 3A4H U209 (9) 0HPP U209 (10) 826P U209 (11) 0000 clock U209 (12) 0446 U209 (13) HAH5 U209 (14) UPUA U209 (15) 4UC2 U405 (1) CA1F U405 (9) 826P U405 (11) 4663 U405 (12) 0000 clock U405 (17) 0HPP
	Note:- The outputs from U405 and U406 can be made to toggle by setting Address 12 and 11 respectively, using utilities, and pressing RUN/REPEAT. Press STOP after doing this check.	U406 (11) CA1F U406 (9) 826P U406 (11) H370 U406 (12) 0000 clock U406 (17) 3A4H
A11 (3776A)	ADI Control (See A11 Part 2 Schematic)	U412 (4) Toggles U412 (5) 7P25 U412 (6) Toggles U512 (8) 7P25 U512 (10) UF4C

G6-10 A-LAW EXPANDER TROUBLESHOOTING (3776A only)

1. Set the A13S2 switches to 00000 and press the A13S1 reset button.

2. Set the 3776 to DIG Tx/DIG Rx and ensure that the DIGITAL TRANSMIT output is connected to the DIGITAL RECEIVE input.

3. Set the 3776 to GAIN V LEVEL SYNC.

4. Press RUN and check that 2.00kHz REF 92 CODE is momentarily displayed followed by the following MEAS codes.

   127
   111
   95
   79
   63
   47
   31
   15
   0

5. For each code transmitted between 127 and 15, check that the reading displayed in the RESULTS display is within 0 ±0.5dB. For code 0, the reading should be within 0 ±0.2dB.

6. If a result for any code is out of limit and the A11 Signature Analysis has been performed successfully, then the fault is in either A11 PROM U409 or U408.

GENERAL SERVICE SHEET G7
ANALOG TRANSMITTER/RECEIVER

Analog Transmitter & Receiver
(A3, A6 & A7/A107)

G7

GENERAL SERVICE SHEET G7
ANALOG TRANSMITTER/RECEIVER

G7-1 INTRODUCTION

G7-2 This service sheet covers troubleshooting for the following assemblies.

A3 Analog Transmitter (03776-60003)

A6 Analog Receiver (03776-60006)

A7/A107 Secondary Autoranging, A/D Converter and Digital Output Stage (03776-60007/60107)

G7-3 The calibration routines 2 to 10 of the 3776 Self Test are used to troubleshoot the above assemblies. A routine for checking the A6 Level Detector is also provided. Therefore, troubleshooting consists of the following:

1. Analog Transmitter Attenuators and Analog Receiver Autoranging (Paragraphs G7-4 to G7-7).
2. A6 Level Detector Check (Paragrah G7-8).
3. Typical Calibration Results and Limits (Paragraph G7-9).

G7-4 ANALOG TRANSMITTER ATTENUATORS AND ANALOG RECEIVER AUTORANGING TROUBLESHOOTING

G7-5 Introduction

Troubleshooting is performed by running the 3776 SELF-TEST calibration routine (ie Calibration Points 2 to 10) and checking for Calibration Point FAILS. The results of calibration points can be obtained by connecting an 80 column printer (eg HP2671G) to the HP-IB connector and setting the HP-IB switch to TO (Talk Only) and PRINT FORMAT to 2. The troubleshooting procedure can be performed without the printed results but they are useful in quickly determining the faulty stage. Typical Calibration results are given in Paragraph G7-9 with associated maximum and minimum limits.

When a FAIL has been detected, the appropriate Calibration Point can be run continuously in the WAIT state, see Paragraph G7-6. This enables troubleshooting to be performed with a test signal available and the faulty stage selected. **When a FAIL appears on a Sub-Point of a calibration point, always complete the Sub-Point sequence noting any other failures occurring.** This will help determine the location of the fault.

G7-6 Continuously Running a Calibration Point

A calibration point automatically halts when an error occurs. To continually run the calibration point, press RUN/WAIT. Unfortunately, sub-point identification may be lost due to an error code being displayed. To select a CAL Sub-Point, carry out the following procedure:

1. If a printer is connected, switch the Printer power off.

2. Use the NEXT PARAM key to select the desired CAL Pt.

3. When the CAL Pt selected is displayed, use the S/STEP key to increment through the sub-points. If the sub-point number is not displayed, the sub-point number reached can only be determined by the number of times the S/STEP key is pressed.

Example: To select CAL Pt 5, Sub-Pt 3.

a. Use the NEXT PARAM key to select the CAL Pt.

b. Press the S/STEP key 3 times then press RUN/WAIT. CAL Pt 5, Sub-Pt 3 is now available for troubleshooting.

G7-7 TROUBLESHOOTING PROCEDURE

1. If available, connect an 80 column printer (eg HP2671G) to the 3776 HP-IB connector. Set the 3776 HP-IB switches to T0 (TALK ONLY) and PRINT FORMAT to 2.

Note: Troubleshooting can be performed without the printer connected, but the printed results obtained are useful in quickly determining the out-of-limit or nearly out-of-limit calibration sub points and sections. See Paragraph G7-9.

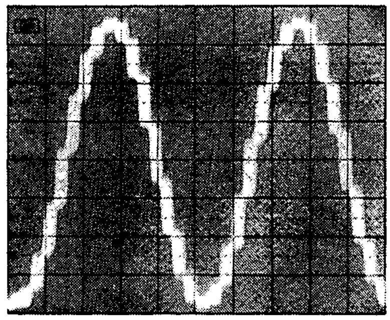
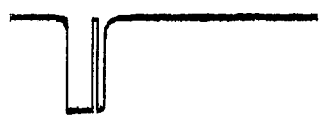
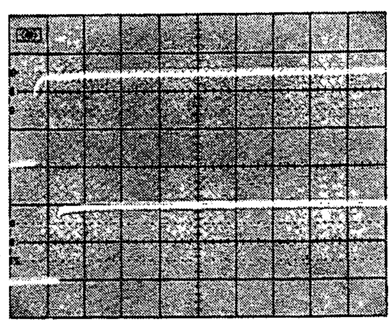
2. Press SELF-TEST then NEXT PARAM. Pt2 should now appear on the LEVEL display.

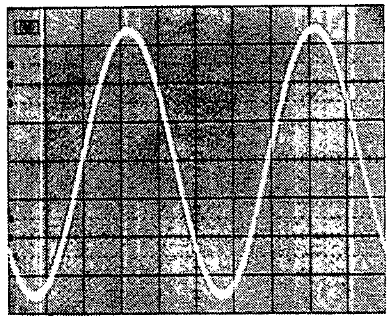
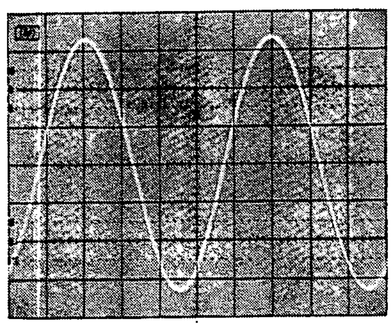
3. Press RUN at each calibration point and check if PASS or FAIL is displayed (or printed if the printer is connected). Use the NEXT PARAM key to step to the next Calibration Point. If a Calibration Point fails, continuously run the failed point for troubleshooting (see Paragraph G7-6 Continuously Running a Calibration Point). The following Table lists the stages tested and suspected faulty components for failed calibration points.

Note 1. Calibration Points 2 to 10 need only be run to check the Analog Transmitter Attenuators and Analog Receiver Autoranging.

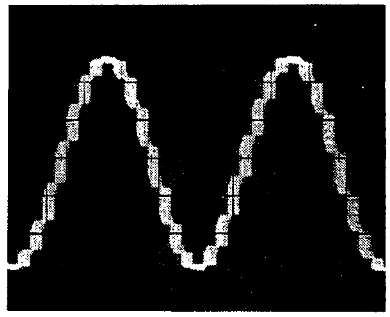
2. Typical Calibration results are given in Paragraph G7-9 with associated maximum and minimum limits.

3. Some Calibration Points are inter-related. If the troubleshooting is performed successfully for a failed Calibration Point move on to the next failed Calibration Point.

CAL Pt	SUB Pt	Stages Tested	Troubleshooting
2		**A3 Analog Transmitter Unity Gain.** The Receiver Section is bypassed and the Transmitter Output is fed directly into the Receiver A to D Converter. The Transmitter is connected to the Receiver via the CAL2 path.	1. Continuously run this CAL Pt (refer to Paragraph G7-6 and check that the output from the A3 D to A Converter is present on A3TP11 as shown. OV  0.05V/DIV (10:1 PROBE) 0.2ms/DIV If the waveform on A3TP11 is not present check operation of the D to A Converter Data Latches. TP8 and TP10 should be at +10V. Check that the Data Latches Clock and Enable signals are shown with a 16kHz rep rate.
		Note: If the waveform at A3TP11 is not present and the A3 D/A Converter Clock and Enable waveforms are correct, check operation of the Digital Signal Synthesiser (General Service Sheet G5) before replacing the DAC A3U33.	A3TP9 sometimes =  A3TP9 CLOCK OV A3TP4 ENABLE OV  0.2V/DIV (10:1 PROBE) 2µs/DIV

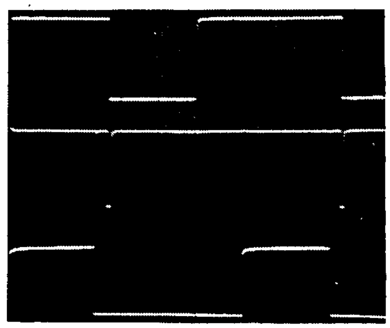
			2. Check that the waveform on A3TP12 and A3TP13 is as shown. A3TP12, A3TP13 0V  0.05V/DIV (10:1 PROBE) 0.2ms/DIV In this mode, the A3 16kHz Anti-Aliasing Filter is selected. If A3TP12 waveform is not present, check for obvious type failures in the 16kHz filter or the Phase Correction circuit. These circuits are checked in more detail when calibration point 8 is run. 3. All amplifiers in the A3 Attenuator stage are set to unity gain. Check the Attenuator path using the waveform obtained on A3TP12. The 3/6dB Amplifier is set to 6dB of gain.
3		**A6/A7 Analog Receiver Unity Gain.** Same as calibration point (CAL Pt) 2 except the Receiver Section is inserted with all main path amplifiers set to unity gain. The signal is routed though the A6 16kHz Anti-Aliasing Filter.	1. Continuously run this CAL Pt (refer to Paragraph G7-6 and check that A3TP14 and A6TPINPT waveforms are as shown. A3TP14 or A6TPINPT 0V  0.1V/DIV (10:1 PROBE) 0.2ms/DIV 2. Check that the waveform at A6TPINT is routed through the A6 Primary Autoranging, 16kHz Anti-Aliasing Filter, Equaliser, A7/A107 Secondary Autoranging, Attenuator and A7/A107 Analog B switch. The signal is attenuated slightly by R42/R41 on A7/A107.

3. Check that the following waveform can be obtained at A7/A107 ADC IN Test Point.



0.1V/DIV (10:1 PROBE) 0.2ms/DIV

If the ADC IN waveform is incorrect or a fault is suspected in the A7/A107 A/D Sample Hold Logic, check the following timing waveforms are present.



0.2V/DIV (10:1 PROBE) 0.01ms/DIV

1. **A7/A107 LOAD DATA**
   U85 pin 11
2. **A7/A107 L CONVERT**
   U11 pin 15
3. **A7/A107 L HOLD TP**
   (Trigger)

See Assembly Service Sheet A7/A107 for further A/D Sample Hold Logic timing waveforms.

4	0-9	**Receiver Auto-Range Gain Paths.** Always passes, results are used in calibration Point 5. If results are exessively out of limit, Error 26 is flagged. Each stage, shown in the Table G7-1, has a limit of ±1dB.	

Table G7-1 Autorange Paths

Path* No	Transmitter (dB)				Receiver (dB)				
	DIGITAL ATTEN	0/36 ATTEN	0/42 ATTEN	3/6 GAIN	PAR B	PAR A	SAR D	SAR C	ATTEN
0	-12	-6	0	6	0	0	0	0	0
1	-12	-6	0	6	10	0	0	0	0
2	-10	-18	0	6	10	0	0	0	0
3	-10	-18	0	6	20	0	0	0	0
4	-10	-18	0	6	0	20	0	0	0
5	-12	-6	0	6	0	0	10	0	0
6	-10	-18	0	6	0	0	20	0	0
7	-14	-24	0	6	0	0	20	0	0
8	-14	-24	0	6	0	0	0	30	0
9	-12	-6	0	6	0	0	0	0	-4

*Path Numbers correspond to calibration Sub-Point numbers.

5		**Receiver Autorange Gains.** Combines the autorange gain paths results in CAL Pt 4 to give the gains for all used paths, and stores them in the relevant CAL Table. If a Sub-Point fails, then troubleshooting is performed using the paths set up in CAL Pt 4.	
5	0	A6 Primary Auto-Range (PAR) 0dB test. Error PAR 0 = 0 ±100mB.	Always passes.
5	1	A6 PAR B 10dB test. Error PAR B 10 = Path 1 - Path 0 = -6.3 ±100mB. See Table G7-1 for paths selected.	1. Set the calibration routine to CAL pt 4 subpoint0. Continuously run this CAL pt by pressing RUN/WAIT (refer to Paragraph G7-6). This selects Path 0 (see Table G7-1 Autorange Paths). 2. Assuming that the Digital Attenuator works and CAL Pts 2 and 3 pass, check the A3 Q1/Q9 6dB Attenuator. Check path through Transmitter and Receiver. 3. Set the 3776 to CAL Pt 4, Sub-Point 1 by pressing RUN/WAIT. This selects path 1 in Table G7-1.

			4. Check the operation of the 10dB PAR gain, A6 Q4, R13/R12.
5	2	A6 PAR B 20dB test. Error PAR B 20 = Path 3 - Path 2 + Error PAR B 10 = 11.7 ±100mB. See Table G7-1 for paths selected.	1. Set the 3776 to CAL Pt 4, Sub-Point 2 by pressing RUN/WAIT. This selects path 2 in Table 7-1. 2. Check the operation of A3 Q1/Q9, Q4/Q10 and Q3/Q11 18dB attenuator. 3. Set the 3776 to CAL Pt 4, Sub-Point 3 by pressing RUN/WAIT. This selects path 3 in Table G7-1. 4. Check the operation of A6 Q2/Q4, R14/R13/R12 PAR B 20dB gain.
5	3	A6 PAR 30dB test. Error PAR 30 = Path 4 - Path 2 + 2 (Error PAR A 10) = 9.1 ±100mB. See Table G7- for paths selected.	1. Assuming CAL Pts 5-1 and 5-2 pass, set the 3776 to CAL Pt 4 Sub-Point 4 by pressing RUN/WAIT. This selects path 4 in Table G7-1. 2. Check operation of A6Q6, R10/R9 PAR A 20dB gain.
5	4	A6 PAR 40dB test. Error PAR 40 = Path 4 - Path 2 + Error PAR A 10 + Error PAR A 20 = 14.5 ±100mB. See Table G7-1 for paths selected.	Always passes if CAL Pts 5-1, 5-2 and 5-3 pass.
5	5	A7 SAR 0dB test. Error SAR 0 = 0 ±100mB.	Always passes
5	6	A7 SAR D 10dB test. Error SAR D 10 = Path 5 - Path 0 = -4.2 ±100mB. See Table G7-1 for paths selected.	1. Set the 3776 to CAL Pt 4, Sub-Point 5 by pressing RUN/WAIT. This selects path 5 Table G7-1. 2. Check operation of A7 Q15, R24/R23 SAR D 10dB gain stage.
5	7	A7 SAR D 20dB test. Error SAR D 20 = Path 6 - Path 2 + Error PAR B 10 = -8.9 ±100mB. See Table G7- for paths selected.	1. Assuming calibration Pt 5 Sub-Point 2 passes, set the 3776 to CAL Pt 4 Sub-Point 6 in by pressing RUN/WAIT. This selects path 6 Table G7-1. If 5-2 and 5-7 both fail, then use troubleshooting procedure in 5-2. 2. Check operation of A7 Q16/Q15 and R25/R24/R23 SAR D 20dB gain stage.
5	8	A7 SAR C 30dB test. Error SAR C 30 = Path 8 - Path 7 + Error SAR D 20 = +16.1 ±100mB. See Table G7-1 for paths selected.	1. Set the 3776 to CAL Pt 4, Sub-Point 7 by pressing RUN/WAIT. This selects Path 7, see Table G7-1. 2. If 5-7 passes, then check operation of A3 Q2/Q7/Q8 24dB Attenuator. If 5-7 fails then use troubleshooting procedure in 5-7. 3. Set the 3776 to CAL Pt 4 Sub-Point 8 by pressing RUN/WAIT. This selects path 8, see Table G7-1.

			4. Check operation of A7 Q19, R36/R34 SAR C 30dB gain stage.
5	9	A7 SAR 40dB test. Error SAR 40 = Error SAR D 10 + Error SAR C 30 = +11.8 ±100mB.	Always passes if CAL Pts 5-6 and 5-8 pass.
5	10	A7 SAR 50dB test. Error SAR 50 = Error SAR D 20 + Error SAR C 30 = +7.3 ±100mB.	Always passes if CAL Pts 5-7 and 5-8 pass.
5	11	A7 SAR 4dB Attenuator Pad test. Error SAR -4 = Path 9 - Path 0 = +12.2 ±100mB. See Table G7-1 for paths selected.	1. Assuming CAL Pt 5-1 passes (ie Path 0 test), set the 3776 to CAL Pt 4, Sub-Point 9 by pressing RUN/WAIT. This selects path 9, see Table G7-1. 2. Check operation of A7 Q17/Q18, R39 4dB Attenuator.
6	0-9	**Transmitter Attenuator.** Always passes, results are used in calibration Point 7 tests. If results are excessively out of limit, Error 26 is flagged). Each stage in the Table G7-2 shown below, has a limit of ±1dB.	

Table G7-2 Attenuation Paths

Path* No	Transmitter (dB)				Receiver (dB)			
	DIGITAL ATTEN	0/36 ATTEN	0/42 ATTEN	3/6 GAIN	PAR B	PAR A	SAR D	SAR C
0	-8	0	0	6	0	0	0	0
1	-8	0	0	3	0	0	0	0
2	-8	-6	0	6	0	0	0	0
3	-8	-12	0	6	10	0	0	0
4	-14	0	0	6	0	0	0	0
5	-14	-18	0	6	20	0	0	0
6	-8	-24	0	6	20	0	0	0
7	-8	-30	0	6	20	0	10	0
8	-14	-36	0	6	20	0	20	0
9	-8	0	-42	6	20	0	20	0

*Path number corresponds to calibration Sub-Point numbers

7		**Transmitter Attenuation** combines the attenuation path results in CAL pt 6 to give the attenuation for all used paths, and stores them in the relevant CAL Table. If a Sub-Point fails, then troubleshooting is performed using the paths set up in CAL pt 6.	
7	0	A3, -3dB Attenuation test. Error -3dB = Path 0 - Path 1 = 32.9 ±100mB. See Table G7-2 for paths selected.	1. Assuming that CAL Pts 2 and 3 pass (ie Path 0 is okay), set the 3776 to CAL Pt 6, Sub-Point 1. Continuously run the CAL Pt by pressing RUN/WAIT (refer to Paragraph G7-6). See Table G7-2. 2. Check operation of the A3 3/6dB Amplifier. Amplifier is set to 3dB ie Q14 off).
7	1	A3, -6dB Attenuation test. Error -6 = Path 0 - Path 2 = -14.5 ±100mB. See Table G7-2 for paths selected.	1. Assuming that CAL Pt 2 and 3 pass (ie Path 0 is okay), set the 3776 to CAL Pt 6, Sub-Point 2 by passing RUN/WAIT. This selects path 2, see Table G7-2. 2. Check operation of the A3 6dB Attenuator Q9/R18.
7	2	A3, -12dB Attenuation test. Error -12 = Path 0 - Path 3 + Error PAR B 10 = 12.2 ±100mB. See Table G7-2 for paths selected.	1. Assuming that CAL Pts 2, 3 and 5-1 pass, set the 3776 to CAL Pt 6, Sub-Point 3 by pressing RUN/WAIT. This selects path 3, see Table G7-2. 2. Check operation of A3 12dB Attenuator Q9/R18, Q10/R19.
7	3	A3, -18dB Attenuator test. Error -18 = Path 4 - Path 5 + Error PAR B 20 = -3.4 ±100mB. See Table G7-2 for paths selected.	1. Assuming that CAL Pts 2, 3 and 5-2 pass, set the 3776 to CAL Pt 6, Sub- Point 5 by pressing RUN/WAIT. This selects path 5, see Table G7-2. 2. Check the operation of the A3 18dB Attenuator Q9/R18, Q10/R19, Q11/R20.
7	4	A3, -24dB Attenuator test. Error -24 = Path 0 - Path 6 + Error PAR B 20 = 9.3 ±100mB. See Table G7-2 for paths selected.	1. Assuming that CAL Pts 2, 3 and 5-2 pass, set the 3776 to CAL Pt 6, Sub-Point 6 by pressing RUN/WAIT. This selects path 6, see Table G7-2. 2. Check operation of the A3 24dB Attenuator Q7/Q8, R14/R15/R16.
7	5	A3, -30dB Attenuator test. Error -30 = Path 0 - Path 7 + Error PAR B 20 + Error SAR D 10 = -4.2 ±100mB. See Table G7-2 for paths selected.	1. Assuming that CAL Pts 2, 3, 5-2 and 5-6 pass, set the 3776 to CAL Pt 6, Sub-Point 7 by pressing RUN/WAIT. This selects path 7, see Table G7-2. 2. Check the operation of the A3 30dB Attenuator Q10/R19, Q7/Q8, R14/R15/R16.
7	6	A3, -36dB Attenuator test. Error -36 = Path 4 - Path 8 + Error PAR B 20 + Error SAR D 20 = -5.1 ±100mB.	1. Assuming that CAL Pts 5-7 and 7-3 pass, set the 3776 to CAL Pt 6, Sub-Point 8 by pressing RUN/WAIT. This selects path 8, see Table G7-2.

			2. Check the operation of the A3 36dB Attenuator Q7/Q8, R14/R15/R16, Q10/R19, Q11/R20.
7	7	A3, -42dB Attenuation test. Error -42 = Path 0 - Path 9 + Error PAR B 20 + Error SAR D 20 = -12.1 ±100mB. See Table G7-2 for paths selected.	1. Assuming CAL Pt 7-6 passes, set the 3776 to CAL Pt 6, Sub-Point 9 by pressing RUN/WAIT. This selects path 9, see Table G7-2. 2. Check operation of A3 42dB Attenuator Q12/Q13, R22/R23/R24.
8		**Analog Transmitter Flatness (With Transmitter 16kHz Anti-Aliasing Filter selected).**	

In this mode the Analog Transmitter output is connected directly to the Receiver A/D Converter. The gain v frequency of the Analog Transmitter 16kHz path is measured relative to 1010Hz at a number of frequency points. At each point, the gain is tested against a predefined limit. The frequency points with Calibration Sub-Points and test limits are given in Table G7-3. It is important to note that the limits given do not correspond to the actual shape of the 16kHz filter, but in fact are a composite of the true filter and a SIN X/X roll-off.

Table G7-3

Cal Sub-point	Test Freq (Hz)	Test Limits (mB)
0	190	5.2 ±50
1	610	9.4 ±50
2	1010 (ref)	0 ±50
3	1440	-12.6 ±50
4	1810	-23.6 ±50
5	2140	-32.1 ±50
6	2510	-39.4 ±50
7	2740	-42.5 ±50
8	3110	-46.1 ±50
9	3340	-48.7 ±50
10	3610	-54.3 ±50
11	4110	-84.8 ±50
12	4440	-134.0 ±50
13	4710	-202.0 ±50

A3 16kHz Anti-Aliasing Filter Troubleshooting

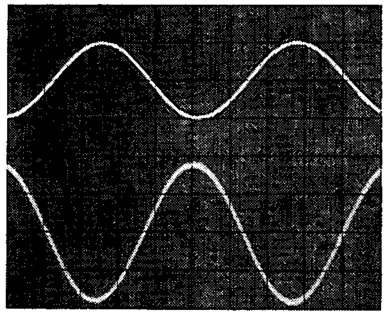
1. Set the 3776 to CAL Pt 8, Sub-Point 0. Continuously run this CAL Pt by pressing RUN/WAIT (refer to Paragraph G7-6). This selects the 190Hz test frequency.

2. Remove A3 test links TL1 and TL2 and check that the following waveforms can be obtained.

A3 U10 pin 14
and A3 TP5 **0V**
0.5V/DIV (10:1 PROBE)

1ms/DIV

A3 TP11 **0V**
0.1V/DIV (10:1 PROBE)

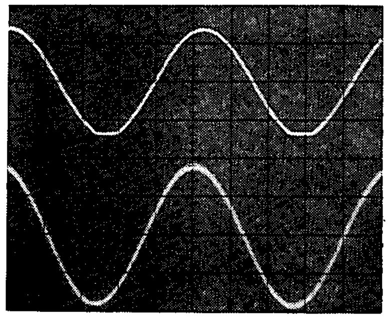


(a) 190Hz

A3 U10 pin 8
and A3 TP7 **0V**
1V/DIV (10:1 PROBE)

1ms/DIV

A3 TP11 (Trigger) **0V**
0.1V/DIV (10:1 PROBE)



(b) 190Hz

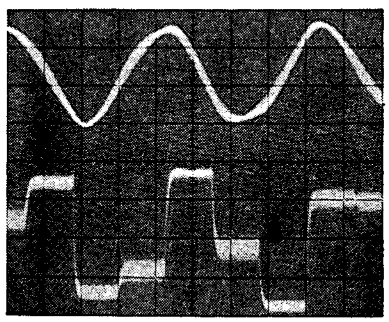
3. Set the 3776 to CAL Pt 8, Sub-Point 13 by replacing A3TL1 and TL2 and by pressing RUN/WAIT. This selects the 4710Hz test frequency.

4. With A3 test links TL1 and TL2 removed, check that the following waveforms can be obtained.

A3 U10 pin 14 **0V**
0.2V/DIV (10:1 PROBE)

0.05ms/DIV

A3 TP11 (Trigger) **0V**
0.1V/DIV (10:1 PROBE)

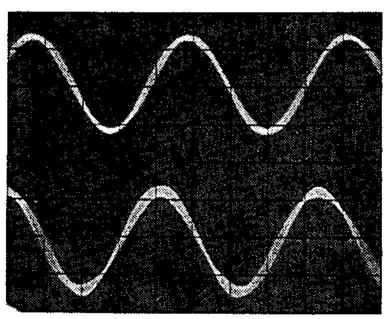


(c) 4710Hz

A3 TP5 **0V**
0.1V/DIV (10:1 PROBE)

0.05ms/DIV

A3 U10 pin 14 (Trigger) **0V**
0.2V/DIV (10:1 PROBE)

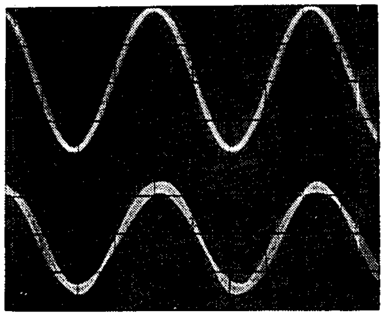


(d) 4710Hz

A3 U10 pin 8
0.1V/DIV (10:1 PROBE)

0.05ms/DIV

A3 U10 pin 14 (Trigger)
0.2V/DIV (10:1 PROBE)

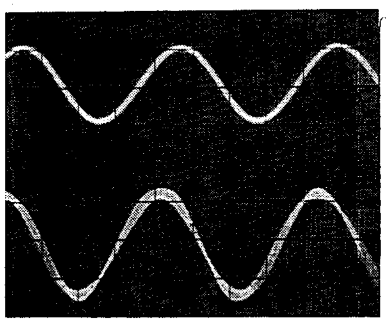


(e) 4710Hz

A3 TP7
0.1V/DIV (10:1 PROBE)

0.5ms/DIV

A3 U10 pin 14 (Trigger)
0.2V/DIV (10:1 PROBE)



(f) 4710Hz

9		**Analog Receiver Flatness (Includes A6 16kHz Anti-Aliasing Filter).** Measures the gain v frequency of the total transmit/receive back-to-back calibration path. The Transmitter Flatness results obtained in CAL Pt 8 are subtracted from the total transmit/receive flatness to give the Receiver flatness. The limits given in the Table G7-4 reflect the true shape of the Receiver Flatness.

Table G7-4

CAL SUB-POINT	Test Frequency (Hz)	Test Limits (mB)
0	190	8.2 ±50
1	610	-4.9 ± 50
2	1010	0 ±50
3	1440	3.2 ±50
4	1810	2.5 ±50
5	2140	-0.4 ±50
6	2510	-5.2 ±50
7	2740	-3.9 ±50
8	3110	-1.8 ±50
9	3340	0.1 ±50
10	3616	-5.4 ±50
11	4110	-9.8 ±50
12	4440	-1.2 ±50
13	4710	

A6 16kHz Anti-Aliasing Filter Troubleshooting

1. Catastrophic component failures can probably be detected using a single 4710Hz sinewave as given below.

2. Set the 3776 to CAL Pt 9, sub-point 13 by pressing RUN/WAIT. This selects the 4710Hz test frequency. Remove A6 TL2 and check that the following waveform can be obtained.

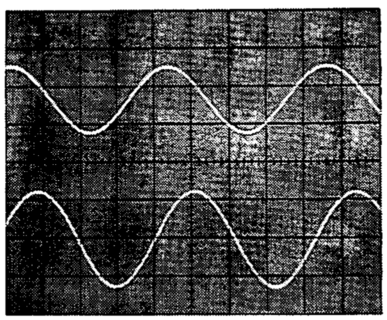
A6 U65 pin 7
0.1V/DIV (10:1 PROBE)

0.05ms/DIV

A6 TP1
0.2V/DIV (10:1 PROBE)

0V

0V



4710Hz

3. Replace A6 TL2, remove A6TL3 and check that the following waveform can be obtained.

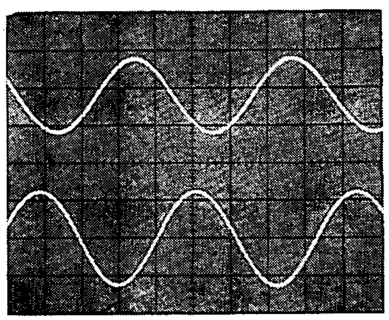
A6 U65 pin 1
0.1V/DIV (10:1 PROBE)

0.05ms/DIV

A6 TP1
0.2V/DIV (10:1 PROBE)

0V

0V



4710Hz

4. Replace A6 TL3, remove A6 TL4 and check that the following waveform can be obtained.

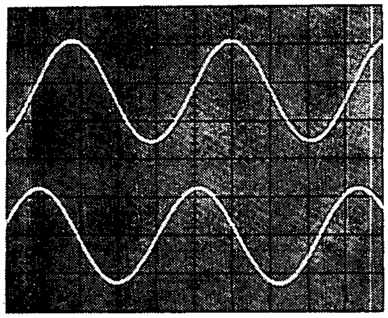
A6 U75 pin 7
0.2V/DIV (10:1 PROBE)

0.05ms/DIV

A6 TP1
0.2V/DIV (10:1 PROBE)

0V

0V



4710Hz

5. Replace A6 TL4 and check that the following waveform can be obtained.

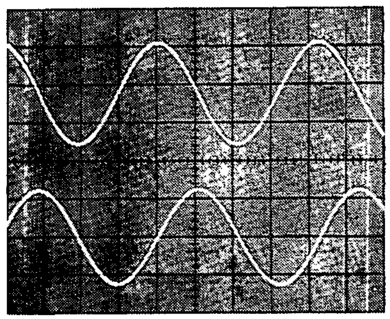
A6 FILT OUT Test Point
0.2V/DIV (10:1 PROBE)

0.05ms/DIV

A6 TP1
0.2V/DIV (10:1 PROBE)

0V

0V



4710Hz

10 | 0-3

Analog Transmitter Flatness with the Transmitter 8kHz Anti-Aliasing Filter selected.

This calibration point is identical to CAL Pt 8 except the Transmitter 8kHz filter is selected instead of the 16kHz filter. The frequency points with Calibration sub-points and test limits are given in Table G7-4.

Table G7-5

CAL Sub-Point	Test Frequency (Hz)	Test Limits (mB)
0	190	45.2
1	450	39.1
2	860	35.9
3	1380	26.6

A3 8kHz Anti-Aliasing Filter Troubleshooting.

1. Set the 3776 to calibration Pt 10, sub-point 0 by pressing RUN/WAIT. This selects 190Hz Test frequency.

2. Remove test links A3TL4 and A3TL3 and check that the following waveforms can be obtained.

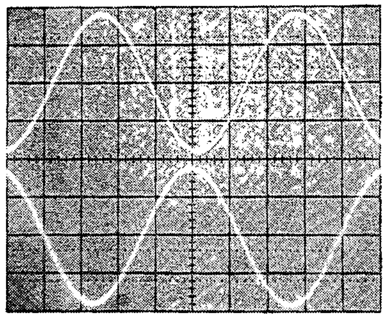
A3 TP1 and U20 pin 7
0.2V/DIV (10:1 PROBE)

190Hz : 1ms/DIV

A3 TP11 (Trigger)
0.1V/DIV (10:1 PROBE)

0V

0V



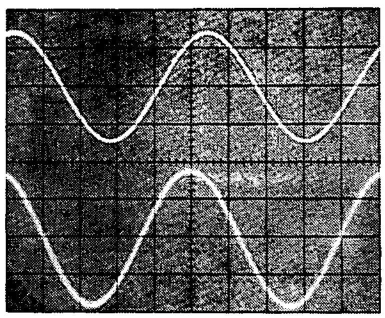
A3 TP2 and U20 pin 14
0.5V/DIV (10:1 PROBE)

190Hz : 1ms/DIV

A3 TP11 (Trigger)
0.1V/DIV (10:1 PROBE)

0V

0V



3. Replace A3TL3 and A3TL4. Set the 3776 to calibration point 10, sub-point 3 and press WAIT. This selects 1380Hz test frequency.

4. With test links A3TL4 and A3TL3 removed, check that the following waveforms can be obtained.

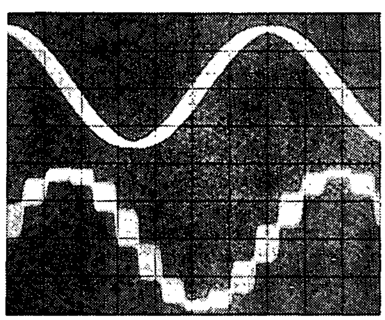
A3 U20 pin 7
0.2V/DIV (10:1 PROBE)

1380Hz : 0.1ms/DIV

A3 TP11 (Trigger)
0.1V/DIV (10:1 PROBE)

0V

0V



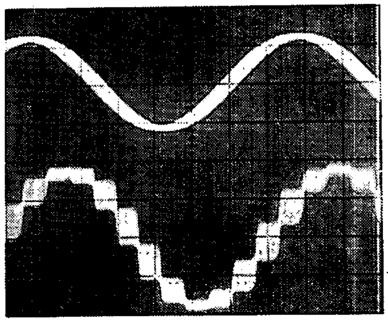
A3 TP1
0.2V/DIV (10:1 PROBE)

1380Hz : 0.1ms/DIV

A3 TP11 (Trigger)
0.1V/DIV (10:1 PROBE)

0V

0V



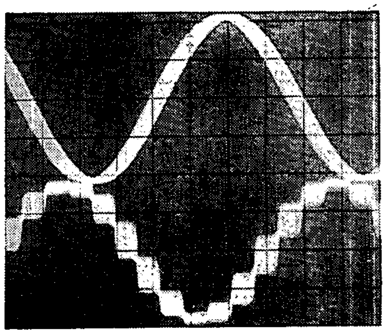
A3 U20 pin 14
0.2V/DIV (10:1 PROBE)

1380Hz : 0.1ms/DIV

A3 TP11 (Trigger)
0.1V/DIV (10:1 PROBE)

0V

0V



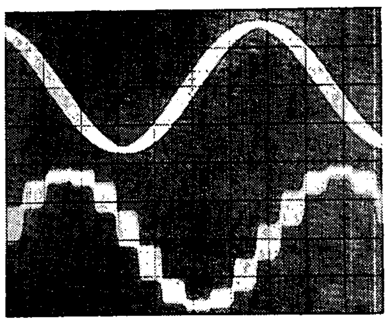
A3 TP2
0.2V/DIV (10:1 PROBE)

1380Hz : 0.1ms/DIV

A3 TP11 (Trigger)
0.1V/DIV (10:1 PROBE)

0V

0V



G7-8 A6 LEVEL DETECTOR CHECK

1. Remove the top cover and set A13S2 switches to 10001 and press A13S1 reset button.

2. Press the 3776 AN Tx button.

3. Connect a 600 ohm output Test Oscillator to the 3776 ANALOG RECEIVE input and connect an AC Voltmeter to A6 ANA A test point.

4. Using the Utilities (see General Service Sheet G1) write 00 to Data Input Buffer Address 34 and write 03 to Data Input Buffer Address 35. This selects the ANALOG RECEIVE Input, terminates in 600 ohms, applies 10dB gain and resets the Level Detector.

5. Set the Test Oscillator output level to give 0.70V displayed on the AC Voltmeter.

6. Write 03 then 0b to Data Input Buffer Address 35.

7. Select Data Output Buffer Address 16 and press REPEAT.

8. Check that X0 is displayed. (X = Don't Care). In most instances X will be 0.

9. Gradually increase the Test Oscillator output level and check that when the following voltages on ANA A Test Point are reached that the corresponding codes are displayed.

Approx Voltages On ANA A Test Point	Code Displayed
0.73V	X2 or X4
0.84V	X6
3.30V	X7 or XE
3.43V	XF

Note: Care must be taken when increasing the voltage level on ANA A test point. If a threshold level is exceeded by applying too high a voltage (eg using the Test Oscillator 10dB stepped attenuator output), step 6 of the procedure must be repeated to reset and enable the Level Detector.

10. If the displayed codes can be obtained but at the wrong voltage levels, check that the Level Detector REF voltages at U22 are as follow:

U22 pin 14 REF 1 = +1.30V ±0.1V
U22 pin 2 RF 2 = +0.30V ±0.1V
U22 pin 9 -VE REF 1 = -1.34V ±0.1V
U22 pin 7 -VE REF 2 = -0.33V ±0.1V

11. If the displayed code never changes, check that voltage on U32B pin 14 varies proportionally with that on ANA A Test Point and that the REF thresholds are exceeded. Check operation for U32, U22, U21 and Data Output Buffer U82.

G7-9 TYPICAL CALIBRATION RESULTS AND LIMITS

G7-10 The following Lists are typical Calibration results printed using the HP2671G 80 column printer. Results are obtained by setting the 3776 to Talk Only mode and Print Format 2 and running Calibration Points 2 to 10. If a FAIL is printed, refer to the appropriate CAL Pt in the Troubleshooting Procedure G7-5. Maximum and Minimum Limits stored in the 3776 are provided for failure analysis. The limits, which apply to all instruments, are not printed by the 80 column printer.

**Note 1. Results and limits are given as 1/3200 of a dB. For example:
500 = 500/3200 = 0.156dB.**

Note 2. The printed Sections are the Calibration Sub-Points referred to in text.

Pt 2 ATX GAIN			Max	Min	HP3776A
Section: 0	PASS		-2112		

Pt 3 ARX GAIN			Max	Min	HP3776A
Section: 0	PASS		3021		

Pt4 ARX AUTORANGE GAIN			Max	Min	HP3776A
Section: 0	PASS	451	3200	-3200	
Section: 1	PASS	180	3200	-3200	
Section: 2	PASS	563	3200	-3200	
Section: 3	PASS	412	3200	-3200	
Section: 4	PASS	821	3200	-3200	
Section: 5	PASS	347	3200	-3200	
Section: 6	PASS	558	3200	-3200	
Section: 7	PASS	941	3200	-3200	
Section: 8	PASS	1651	3200	-3200	
Section: 9	PASS	811	3200	-3200	

Pt5 ARX AUTORANGE CAL			Max	Min	HP3776A
Section: 0	PASS	0	3200	-3200	
Section: 1	PASS	-272	2998	-3401	
Section: 2	PASS	-422	2825	-3574	
Section: 3	PASS	-286	2908	-3491	
Section: 4	PASS	-436	3664	-2736	
Section: 5	PASS	0	3200	-3200	
Section: 6	PASS	-105	3065	-3334	
Section: 7	PASS	-276	2915	-3484	
Section: 8	PASS	433	3715	-2684	
Section: 9	PASS	328	3211	-3188	
Section: 10	PASS	157	3207	-3192	
Section: 11	PASS	360	3590	-2809	

Pt 6 ATX ATTENUATOR GAIN			Max	Min	HP3776A
Section: 0	PASS	909	3200	-3200	
Section: 1	PASS	1960	3200	-3200	
Section: 2	PASS	471	3200	-3200	
Section: 3	PASS	287	3200	-3200	
Section: 4	PASS	905	3200	-3200	
Section: 5	PASS	404	3200	-3200	
Section: 6	PASS	803	3200	-3200	
Section: 7	PASS	226	3200	-3200	
Section: 8	PASS	44	3200	-3200	
Section: 9	PASS	-200	3200	-3200	

Pt 7 ATTX ATTENUATOR CAL			Max	Min	HP3776A
Section: 0	PASS	1050	4252	-2147	
Section: 1	PASS	-438	2736	-3664	
Section: 2	PASS	-351	2809	-3590	
Section: 3	PASS	-78	3091	-3308	
Section: 4	PASS	315	3497	-2902	
Section: 5	PASS	-157	3065	-3334	
Section: 6	PASS	-161	3036	-3363	
Section: 7	PASS	-412	2812	-3587	

Pt 8 ATX FLATNESS (16kHz PATH)			Max	Min	HP3776A
Section: 0	PASS	477	2086	-1113	
Section: 1	PASS	292	1900	-1299	
Section: 2	PASS	-1	1600	-1600	
Section: 3	PASS	-390	1196	-2003	
Section: 4	PASS	-731	844	-2355	
Section: 5	PASS	-995	572	-2627	
Section: 6	PASS	-1217	339	-2860	
Section: 7	PASS	-1311	240	-2960	
Section: 8	PASS	-1420	124	-3075	
Section: 9	PASS	-1501	41	-3138	
Section: 10	PASS	-1679	-137	-3337	
Section: 11	PASS	-2662	-1113	-4313	
Section: 12	PASS	-4246	-2688	-5888	
Section: 13	PASS	-6432	-4864	-8064	

Pt 9 ARX FLATNESS

			Max	Min	HP3776A
Section: 0	PASS	-229	1862	-1337	
Section: 1	PASS	-129	1443	-1756	
Section: 2	PASS	2	1600	-1600	
Section: 3	PASS	72	1702	-1497	
Section: 4	PASS	26	1680	-1520	
Section: 5	PASS	-83	1587	-1612	
Section: 6	PASS	-210	1433	-1766	
Section: 7	PASS	-246	1475	-1724	
Section: 8	PASS	-193	1542	-1657	
Section: 9	PASS	-107	1603	-1596	
Section: 10	PASS	-20	1427	-1772	
Section: 11	PASS	-118	1286	-1913	
Section: 12	PASS	-177	1561	-1638	
Section: 13	PASS	185			

Pt 10 ATX FLATNESS (8kHz PATH)

			Max	Min	HP3776A
Section: 0	PASS	1198	1446	-	
Section: 1	PASS	1001	1251	-	
Section: 2	PASS	863	1148	-	
Section: 3	PASS	633	851	-	

GENERAL SERVICE SHEET G8
DIGITAL FILTER

GENERAL SERVICE SHEET G8
DIGITAL FILTER

G8-1 INTRODUCTION

G8-2 This service sheet covers troubleshooting of the Digital Filter Assembly A9 (03776-60009). Troubleshooting is performed using Self-Test Point 20, Sub-Points 0 to 7.

G8-3 SELF-TEST Pt 20 DESCRIPTION

G8-4 Self-Test Pt 20 has eight-Sub-Points (ie 0 to 7).

Sub-Point 0: The Digital Filter program from the Processor (A13/A14) is written into and read back from the A9 Digital Filter Program RAM.

Sub-point 1: Operation of LDATA READY checked. The following filter operation times, with associated data sources are checked:

AN Rx data with H ENABLE DIVIDE = 1; 1ms
AN Rx data with H ENABLE DIVIDE = 0; 62us
DIG Rx data with H ENABLE DIVIDE = 1; 2ms
DIG Rx data with H ENABLE DIVIDE = 0; 125us

Sub-Point 2: Filter Input Bus (ie FD8 to FD23) is checked with data applied from the AN Rx (ie Assembly A7/ A107).

Sub-Point 3: As Sub-Point 2 but with DIG Rx selected (ie Assembly A11/A111).

Sub-Point 4: Checks Digital Filter (U65) internal RAM reset operation.

Sub-Point 5: Tests the Digital Filter's ability to integrate (add function). Also checks the carry-out accumulated in U13 and transferred to the least significant 4-bits (ie D0, D1, D2, D3) of U22 Status Register.

Sub-Point 6: Checks the ability of the Digital Filter to generate 24 and 28 bits overflows. Checks OVR24 (TP4) and OVR28 (TP3) overflows via Status Register U22. The 24 bit field is used for Secondary Autoranging on Assembly A7/A107.

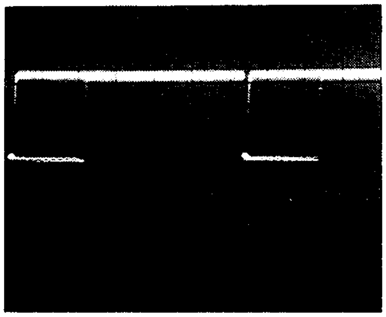
Sub-Point 7: Program loaded into the Filter Program RAM (U34) with every filter instruction in sequence. A check is performed at the Detector Output. The program loaded is used for signature analysis (see Paragraph G8-8).

G8-5 TROUBLESHOOTING PROCEDURE

1. (a) Connect an oscilloscope to A9 TP2 (L FILTER START). Set the 3776 to DIG Tx to DIG Rx GAIN-TONE and press RUN then REPEAT. Check that the following waveform can be obtained. If

the waveform cannot be obtained go to General Service Sheet G6 Digital Output Stage and Digital Receiver Troubleshooting.

(b) Set the 3776 to AN Tx to AN Rx GAIN-TONE and press RUN then REPEAT. Check that the waveform at TP2 can be obtained. If the waveform cannot be obtained go to General Service Sheet G7 Analog Transmitter/Receiver Troubleshooting.



Note: The waveform at A9TP2 is a 16kHz stable clock with pulse width of approximately 1us changing to a pulse width of approximately 20us when in the RUN/REPEAT mode.

2. If available, connect an 80 column printer (eg HP2671G) to the 3776 HP-IB connector and set the 3776 HP-IB switch to TALK ONLY and PRINT FORMAT to 2. The Troubleshooting procedure can be performed without the printer but it is useful in detecting filter bus faults if Self-Test Point 20 Sub-Points 2 or 3 fail.

3. Ensure the A13S2 switches are set to 00000. Press SELF TEST then press NEXT PARAM until "Pt 20" is displayed.

4. Press S/STEP and check that PASS 0 is displayed on the 3776 display. Record if FAIL and continue. If a printer is connected, the appropriate response will be printed.

5. Continually press the S/STEP key checking SELF TEST 20 Sub-Points 1 to 7. If all Sub Points pass, then the Digital Filter assembly is operating correctly.

Print-Out Example with Sub Points or Sections 2 and 3 Failed

DIGITAL FILTER CHECK

Section: 0	PASS	0
Section: 1	PASS	0
Section: 2	FAIL	9
Section: 3	FAIL	9
Section: 4	PASS	0
Section: 5	PASS	0
Section: 6	PASS	0
Section: 7	FAIL	137

Notes: 1. **Numbers at the right hand column indicate the appropriate Error Codes with the exception of Section 2 and Section 3.**

2. **Numbers at the right hand column opposite Section 2 and Section 3 indicate the faulty Filter Bus (ie FD8 to FD23) line(s) in binary. In the example given the lines corresponding to binary weighting 1 and 8 (ie FD8 and FD11) are faulty.**

G8-6 SELF-TEST SUB-POINT FAILURE

Use the following information to determine the next troubleshooting step.

Sub-Point Failed	Troubleshooting
0	Possible A9U34 RAM failure, go to Paragraph G8-7.
*1	Possible A9 Interrupt Rate Control fault, go to Paragraph G8-8.
*2	Filter Input Bus fault (ie FD8 to FD23) from the AN Rx (ie Assembly A7/A107). If an 80 column printer has been used in the Troubleshooting Procedure, Paragraph G8-5, then Filter Bus fault location can be computed from the print-out (see Print-Out example). Go to Paragraph G8-8.
*3	Filter Input Bus fault (ie FD8 to FD23) from the DIG Rx (ie Assembly A11/A111). Troubleshoot as per Sub-Point 2 Failed.
*4	Possible Digital Filter A9U65 fault, go to Paragraph G8-8.
*5	Possible A9U65 filter or U13/U22 Status Register fault, to to Paragraph G8-8. If Paragraph G8-8 is performed successfully then fault is in the U13/U22 Status Register.
*6	Possible A9U65 filter, U22 Status Register or Detector Output fault. Go to Paragraph G8-8. If Paragraph G8-8 is performed successfully then fault is in the U13/U22 Status Register.
*7	Possible Detector Output fault. Go to Paragraph G8-8.

*Note: **Sub-Point 0 must PASS before troubleshooting in Paragraph G8-8 can be used.**

G8-7 SUB-POINT 0 FAIL TROUBLESHOOTING

1. Switch the instrument power off, then switch the power on. Check that Error 107 with port addresses 02 to 07 and 20 to 27 is NOT displayed. This ensures that the A9 Address Decoder and Handshake Circuit operate correctly.

2. Switch the power off, remove the top cover, place A9 assembly on the extender board and check that the test link between U52 and U62 is in the N (Normal) position.

3. Connect an oscilloscope to A9TP6 and check that a 4.096MHz clock is present if the instrument is a 3776A and a 4.632MHz clock if the instrument is a 3776B.

4. The following A9 Logic Circuits can now be checked using the Utilities. (See General Service Sheet G1 Instrument Bus Access Using the Utilities).

   (a). A9 U14 Control Register Troubleshooting.

   (b). Program RAM Read/Write Control Troubleshooting.

   (c). A9U23 Input/Output Buffer Troubleshooting.

   (d). A9 U33/U43/U44 Program RAM Address Counter Troubleshooting.

Note: The following Troubleshooting must be performed in the sequence given.

5. **A9U14 Control Register Troubleshooting**

   (a) Set the A13S2 switches to 00001 and press A13S1 reset button.

   (b) Press SELF TEST then AN Tx. "Util 00" should now be displayed.

   (c) Press PHASE JITTER then FRAMING + SIG BITS. "21" should now be displayed on the LEVEL display

   (d) Press SET FREQ and then press the SPEAKER key twice to give 00 displayed on the left hand side of the RESULTS display.

   (e) Press REPEAT and check using a logic probe or oscilloscope that a clock is present at U14 pins 3 and 11 (negative-going ≃0.25us pulse, rep rate ≃28kHz). Check also that U14 pins 5 and 9 are held low and the DIS PC led is off.

   (f) Press STOP press SET FREQ and then press GAIN v FREQ twice to give "FF" displayed on the left hand side of the RESULTS display.

   (g) Press REPEAT and check that a clock is present at U14 pins 3 and 11. Check also that U14 pins 5 and 9 are held high and that the DIS PC led is on.

(h) Press STOP. The DIS PC led should remain on.

6. **Program RAM Read/Write Control Troubleshooting**

(a) With the DIS PC led on (ie Disable Program Counter), check that the output of gate U52A(8) is held low. Check also that U41(13) LRAM EN is high, U36B(8) BUF EN is high and that U41D(10) L READ is high.

(b) Press PHASE JITTER then I/MOD (3776A) or QUAN DIST (3776B); "27" should now be displayed on the LEVEL display.

(c) Press SET FREQ then press SPEAKER twice to give 00 displayed on the left hand side of the RESULTS display.

(d) Press REPEAT and check that a ≈0.25us negative going pulse is present with a clock rate of ≈28kHz (3776A) or 31.8kHz (3776B) at U41(13) LRAM EN, U36(8) BUF EN and U41(10) LREAD.

7. **A9 U23 Input/Output Buffer Troubleshooting**

(a) With 00 repeatedly written to address 27, check that an approximately 28kHz (3776A) or 31.8MHz (3776B) clock is present at U23 Pin 1. Check also that U23 pins 11 to 18 are held low. **Note: The clock present at U23 pin 1 may have a peculiar shape. This is normal.**

(b) Press STOP, then press SET FREQ.

(c) Press GAIN v FREQ twice to give "FF" displayed on the left hand side of the RESULTS display.

(d) Press REPEAT and check that U23 pins 11 to 18 are held high.

8. **A9 U33/U43/U44 Program RAM Address Counter Troubleshooting**

(a) Press STOP.

(b) Set the LEVEL display to 26. This can be performed using the DECR and INCR keys or by pressing PHASE JITTER then QUANT DIST (3776A), I/MOD (3776B).

(c) Press SET FREQ.

(d) Write "FF" to address 26. This appears automatically if FF was used in previous test, otherwise press GAIN v FREQ twice.

(e) Press REPEAT

(f) Check that approximately 28kHz (3776A) or 31.8kHz (3776B) clock is present at U44 pin 9 and U43 pin 9. Check also that U44 and U43 pins 11 to 15 are held high.

(g) Press STOP then press SET FREQ.

(h) Press SPEAKER twice to give "00" displayed on the left hand side of the RESULTS display.

(i) Press REPEAT and check that approximately 28kHz (3776A) or 31.8kHz (3776B) clock is present at U44 pin 9 and U43 pin 9. Check that U44 and U43 pins 11 to 15 are held low.

(j) Press STOP.

(k) Set the LEVEL display to 25. This can be achieved using the DECR key or by pressing PHASE JITTER then TRANSIENTS.

(l) Press SET FREQ. "00" should be displayed on the left-hand side of the RESULTS display.

(m) Press REPEAT and check that approximately 28kHz (3776A) or 31.8kHz (3776B) clock is present at U33(9). Check also that U33 pins 13 and 14 are held low.

(n) Press STOP then SET FREQ.

(o) Press the GAIN v FREQ key twice to give "FF" displayed on the left hand side of the RESULTS display.

(p) Press REPEAT and check that approximately 28kHz (3776A) or 31.8kHz (3776B) clock is present at U33(9). Check that U33 pins 13 and 14 are held high.

9. If Sub-Point 0 failed and Steps 1 to 8 have been performed successfully, then Filter Program RAM U34 is faulty.

G8-8 DIGITAL FILTER SIGNATURE ANALYSIS

Note: The following procedure can only be performed if Self-Test Pt 20, Sub-Point 0 passes.

1. Switch the power off and mount Assembly A9 on the extender board. Switch the power on.
2. Ensure that A13S2 switches are set to 00000.
3. Press A13S1 Reset button.
4. Press SELF TEST and continually press the NEXT PARAM key until Pt 20 is displayed.
5. Set A13S2 switches to 00101.
6. Connect an oscilloscope or logic probe to A9TP2. This is used to check that the Digital Filter is in the cycle mode when Step 7 has been performed.

Note: In order to set the Digital Filter in the cycle mode for Signature Analysis, the SELF TEST key must be pressed immediately following the PASS/FAIL display for Sub-Point 7 in Step 7.

7. Press RUN and the instant PASS or FAIL is displayed for Sub-Point 7, press SELF TEST.
8. Check that approximately 16kHz (3776A) or 8kHz (3776B) clock is present at A9TP2. If this clock is not present then repeat Steps 2 to 7 until a clock is obtained.
9. Press Tx dBr/CHAN if the instrument is a 3776A or Tx TLP/T-SLOT if the instrument is a 3776B.
10. Press RUN. If Sub-Point 7 passes then XX00bFCE should be displayed. It is not necessary for the display to be correct for signatures analysis.
11. Set A9 Test link (located between U52 and U62) to the T(Test) position.
12. Connect and set the HP5005A Signature Multimeter as follows:

Set FUNCTION to QUAL

CLOCK............A9TP6; TTL positive edge
START............A9TP7; TTL positive edge
QUAL/STOP............A9TP1; TTL QUAL positive level, STOP negative edge
GND............A9 GND test point

13. Check that the following signatures can be obtained.

Note: Where indicated, only signatures that are underlined need be checked to verify the appropriate Logic Function Operation.

Assembly	Logic Function	Signatures
A9	Program RAM Address Counter	U33 (1) 1013 clock U33 (2) 0000 clock U33 (7) 1013 U33 (9) 1013 U33 (10) AH50 U33 (13) 0000 U33 (14) PF29 U43 (1) 1013 clock U43 (2) 0000 clock U43 (7) 1013

			U43 (9) 1013 U43 (10) 3H8F U43 (11) 6P71 U43 (12) 3194 U43 (13) 0739 U43 (14) 9F62 U43 (15) AH50 U44 (1) 1013 clock U44 (2) 0000 clock U44 (7) 1013 U44 (9) 1013 U44 (10) 1013 clock U44 (11) 9092 U44 (12) A988 U44 (13) 5UU4 U44 (14) P01H U44 (15) 3H8F
A9	SYNC **Note: 1 of 3 signatures can be obtained at the *ASYNC nodes.**	*ASYNC	U11 (5) C6H6, 207C, 8UP4 U11 (6) A6F5, 3068, 9UU7 U11 (12) 1013 clock U11 (13) 0000 clock U13 (1) 0000 clock U13 (3) 0000 clock U15 (4) 0000 clock
		*ASYNC	U15 (5) F4C2, P9P9, C6H6 U15 (6) A6F5, 3068, 9UU7 U16 (1) 0000 clock U16 (2) 1013 clock U16 (3) 1013 clock U16 (4) 1013 clock U16 (5) 0000 clock
		*ASYNC	U21 (4) 207C, 7AFF, F4C2 U21 (5) F4C2, P9P9, C6H6 U21 (6) F4C2, P9P9, C6H6 U21 (7) C6H6, 207C, 8UP4 U21 (9) 0000 clock U36 (4) 0000 clock U36 (5) 1013 U36 (6) 1013 clock U63 (1) 0000 clock U63 (2) 1013 clock U63 (3) 1013 clock

		U63 (4) 0000 clock U63 (12) 0000 clock U63 (13) 1013 clock
A9	Filter Program RAM	U34 (1) 6P71 U34 (2) 3194 U34 (3) 0739 U34 (4) 9F62 U34 (5) 9092 U34 (6) A988 U34 (7) 5UU4 U34 (8) P01H U34 (9) 01AU U34 (10) HHF6 U34 (11) 15C8 U34 (13) A2CA U34 (14) 68FH U34 (15) 6P99 U34 (16) 0F5F U34 (17) U4F3 U34 (18) 0000 U34 (20) 0000 U34 (21) 1013 U34 (22) 0000 U34 (23) PF29
A9	Instruction Decoder	U15 (1) C2A9 U15 (2) A2CA U15 (3) HHF6 U24 (1) 15C8 U24 (2) 68FH U24 (3) 6P99 U24 (4) 01AU U24 (5) 9H74 U24 (6) C2A9 U24 (10) 8PAP U24 (11) H981 U24 (14) 1013 clock U24 (15) 3659 U25 (2) 8336 U25 (3) 3659 U25 (4) 8PAP U25 (5) 5U4H U25 (6) 5U4H U25 (7) C7CF
	Interrupt rate control	U25 (11) 0540 U25 (12) F3F4 U25 (13) C7CF

		U25 (14) H981 U25 (15) U4HA
A9	Digital Filter and output gating.	U15 (9) 18HA U15 (10) 08F9 U52 (1) 1013 U52 (2) 70FA U52 (3) 60H9 U52 (11) 70FA U52 (12) 60H9 U52 (13) 1013
	*Note: For these signatures, set the Signature Analyzer as follows: **FUNCTION**..............................**NORM** **CLOCK**............**A9TP6 positive edge** **START**............**A9TP1 positive edge** ***STOP**..............**A9TP1 positive edge** ***negative edge for 3776B** **Two signatures are given corresponding to the 3776A and 3776B. Signatures for the 3776B are in brackets.**	U63 (8) AU13 U63 (9) CU00 U63 (10) 0000 clock U63 (11) 1013 clock *U65 (2) 84U5 (84U5) *U65 (3) 0000 (0000) U65 (6) 01AU U65 (7) HHF6 U65 (8) 15C8 U65 (9) A2CA U65 (10) 68FH U65 (11) 6P99 U65 (12) 0F5F U65 (13) U4F3 *U65 (14) 0000 (0000 clock) U65 (16) 18HA U65 (17) CU00 U65 (18) 60H9 U65 (19) 0000 clock *U65 (20) 0000 (0000) *U65 (22) 0000 (84U5) *U65 (23) 0000 (84U5) *U65 (24) 0000 (84U5) *U65 (25) 0000 (84U5) *U65 (26) 0000 (84U5) U65 (28) 0000 U65 (29) 1013 U65 (30) 1013 U65 (31) 1013 clock U65 (32) 1013 *U65 (33) F7P4 (F7P4) *U65 (35) 0000 (84U5) *U65 (36) 84U5 (0000 clock) *U65 (37) 0000 (0000) *U65 (38) 84U5 *U65 (39) 84U5 *U65 (40) 0000

A9	Interrupt Rate Control	U11 (1) 2876 U11 (2) 3865 clock U15 (11) 3865 U15 (12) 60H9 U15 (13) 1553 U21 (9) 0000 clock U21 (14) 60H9 U21 (15) 2876 U25 (9) 0000 clock U25 (10) 1ACA U25 (11) 0540 U26 (1) 1ACA U26 (2) 0000 U26 (3) 1013 U26 (4) 1013 U26 (5) 1013 U26 (6) 0000 U26 (8) 0540 U26 (9) 1553 U26 (10) 1013 U46 (2) 0000 clock U46 (7) 1553 U46 (9) 0000 U46 (15) 1013
A9	Detector Output ***Note: If these signatures are correct, then this should give a high confidence level that the Detector Output is okay.**	U32 (1) 60H9 U32 (2) 1013 U32 (11) 9669 U32 (12) 0000 clock *U32 (17) 4C25 U42 (1) 60H9 U42 (2) 1013 U42 (11) 276A U42 (12) 0000 clock *U42 (17) 9669 U53 (1) 60H9 U53 (2) 1013 U53 (11) 08F9 U53 (12) 0000 clock *U53 (17) 276A

14. When Signature Analysis has been completed remember to set A9TL back to the N (Normal) position.

GENERAL SERVICE SHEET G9 (OPTION 001)
ENVELOPE DELAY, GROUP DELAY, ABSOLUTE DELAY, PHASE JITTER AND TRANSIENTS

GENERAL SERVICE SHEET G9 (OPTION 001)
ENVELOPE DELAY, GROUP DELAY, ABSOLUTE DELAY, PHASE JITTER AND TRANSIENTS

G9-1 INTRODUCTION

G9-2 This service sheet provides troubleshooting information for assemblies A4 (03776-60004), A204 (03776-60204), A5 (03776-60005) and A8 (03776-60008).

G9-3 Signal Routing

G9-4 The following diagrams illustrate the signal routing for the appropriate measurement. The G9 troubleshooting procedures assume that assemblies A6, A7/A107 and A9 operate correctly.

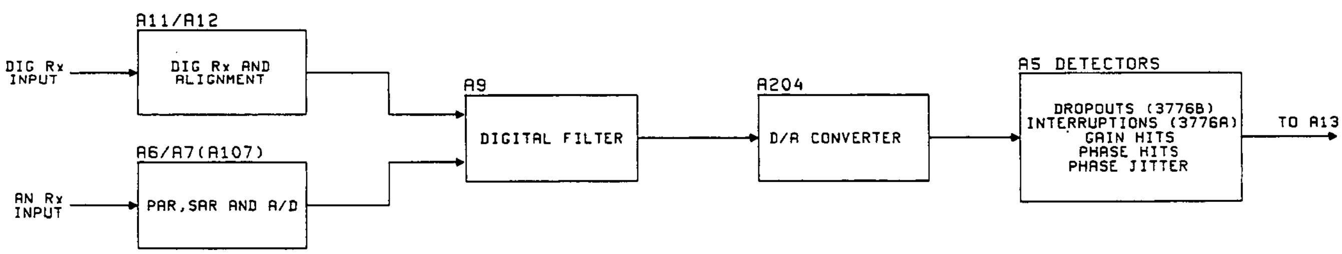


Figure G9-1 Dropouts/Interruptions, Gain Hits Phase Hits and Phase Jitter Signal Routing

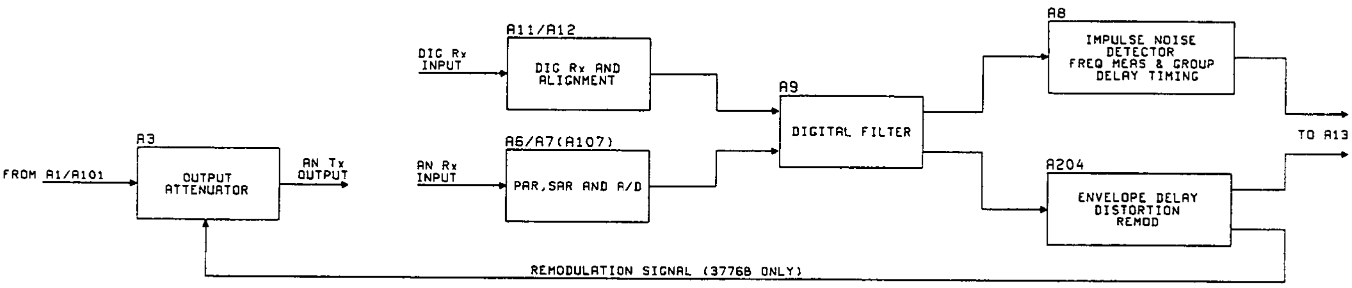


Figure G9-2 Impulse Noise, Frequency Measurement, Group Delay and Envelope Delay Distortion Signal Routing

G9-5 General Service Sheet G9 is divided into five subsection. If the fault is peculiar to a specific measurement mode, then select the corresponding subsection for troubleshooting. If the fault appears on more than one measurement mode and "Selftest 11" fails, then perform the troubleshooting using the Subsections in the order given. The five Subsections are as follows:

Note: The continuity of the signal path through Assembly A204 is best checked using Subsection 1 (ie Dropouts (3776B), Interruptions (3776A) and Gain Hits Troubleshooting).

1. Dropouts (3776B), Interruptions (3776A) and Gain Hits Troubleshooting
2. Phase Jitter Troubleshooting
3. Phase Hits Troubleshooting
4. Group Delay Timing, Impulse Noise and Frequency Detector Troubleshooting
5. Envelope Delay Distortion and Absolute Delay Troubleshooting

G9-6 DROPOUTS (3776B)/INTERRUPTIONS (3776A) AND GAIN HITS TROUBLESHOOTING

Equipment Required

Pulse Generator	HP8005B
Function Generator	HP3312A
Oscilloscope	HP1740A
Frequency Counter	HP5328A
AC Voltmeter	HP3455A

Dropouts/Interruptions Troubleshooting Procedure

1. Set the 3776 as follows:

Operating Mode	AN Rx
Measurements	Transients
Analog Receive	600 ohm (Terminated)
Rx TLP/Rx dBr	0.0dB

2. Use the PARAMETER and SET keys to set the 3776 transient parameters to FAST count, Cont hr and -12dB d.out (3776B) or -10dB Irpt (3776A). Press STORE to store the parameters in the 3776. The stored parameter are recalled when the RECALL led is lit.

3. Connect the test circuit as shown in Figure G9-3.

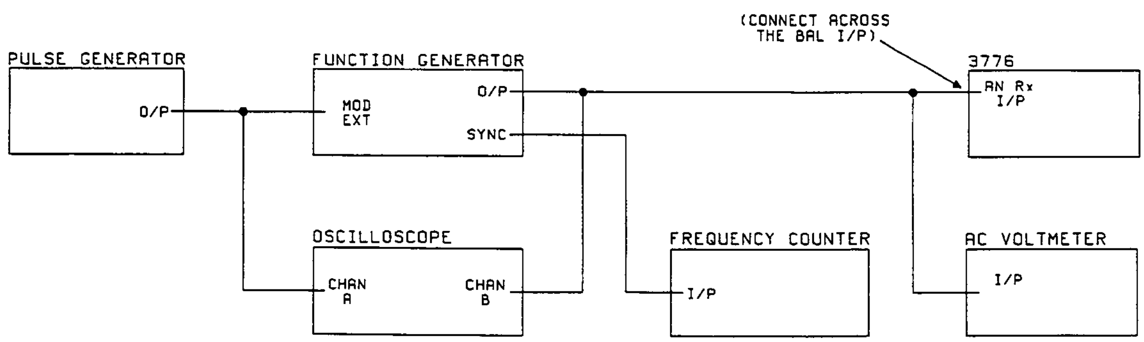


Figure G9-3 Dropouts and Interruptions

4. Adjust the Pulse Generator to display a signal on the oscilloscope with the following parameters.

Repetition rate	25Hz (nominal)
Amplitude	-4V (nominal)
Pulse polarity	-ve
Pulse Width	7ms ±1ms

5. Set the Pulse Generator operating mode to GATED. The level displayed on the oscilloscope should be 0V ac.

6. Set the Function Generator to sinewave and adjust the frequency (if using an HP3312A see the following settings) to display 1010Hz ±10Hz on the Frequency Counter. Adjust the Function Generator amplitude control for a reading of 2.450V ±0.005V (+10dBm into 600Ω) as displayed on the AC Voltmeter.

3312A settings

MODULATION	EXT, AM, % control to mid-range
FUNCTION	∼
TRIGGER PHASE	FREE RUN
RANGE HZ	100Hz
OFFSET	CAL
SYM	CAL

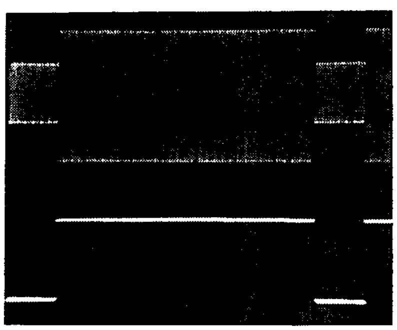
7. Set the 3776 CONTROL to RUN and press the NEXT PARAM key to display -12dB d.out (3776B) or -10dB Irpt (3776A).

8. Set the Pulse Generator operation to NORMAL. With the oscilloscope triggered from CHAN A the following approximate waveform should be obtained.

Note: The Function Generator % MOD control affects the depth of the dropout.

CHAN B 0V

0V CHAN A



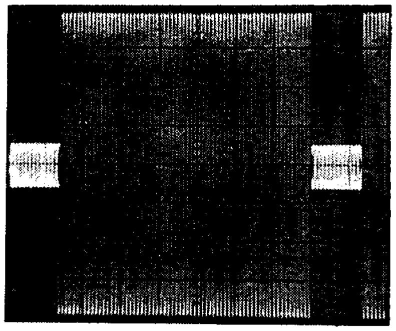
2V/DIV 5ms/DIV

9. Monitor only the Function Generator output on the oscilloscope (ie CHAN B).

10. Adjust the Oscilloscope VOLTS/DIV control so that the waveform occupies 8 divisions on the oscilloscope vertical graticule. (See waveform in Step 11).

11. Adjust the Function Generator % MOD control to obtain the waveform given.

CHAN B **0V**



0.5V/DIV approx
Adjust CAL control so that waveform occupies 8 divisions

5ms/DIV
Trigger from Pulse Generator output

12. Check that the dropout counts register on the 3776 display. If counts do not register then perform the following procedure.

> **Note: Always set the Pulse Generator output to GATED (ie 0V outputs) to establish a holding time before running the dropout measurement. After approximately 5 seconds after the 3776 RUN key is pressed, the Pulse Generator output can be set to NORM. This procedure must be performed every time a dropout measurement has to be re-run.**

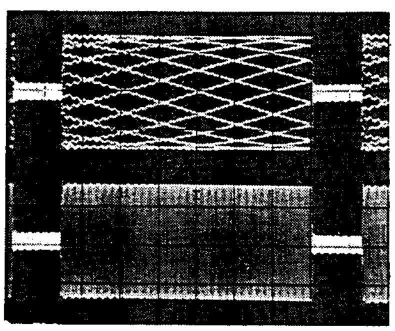
a. Switch the 3776 power off and mount assembly A204 on the extender board.

b. Switch the 3776 power on and re-run the dropout measurement. See the Note at the beginning of Step 12.

c. Check that the following waveforms can be obtained. Ensure that the oscilloscope Volts/DIV is set to CAL.

A204 TP5 / A204 TP6 **0V**

A204 TP8 **0V**



0.2V/DIV (10:1 PROBE)

5ms/DIV
Trigger from Pulse Generator output

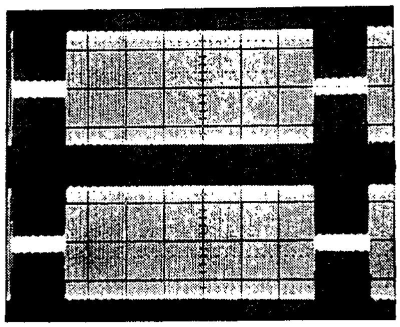
d. If the waveform at A204TP5 cannot be obtained, then the fault is in A204U47 the D/A Convertor or the A4 Serial and Parallel Input Data Latch. Use a logic probe and check that BITS 1 to BIT 12 toggle. Also check that A204U35, 45 and U55 are in the serial shift mode (ie pin 9 high) with their outputs toggling.

e. If waveform A204TP5 can be obtained, and A204TP8 cannot be obtained then the fault is in the Low Pass Filter. The following waveform should help troubleshoot the Low Pass Filter.

f. Remove A204TL2 and check that the following waveforms can be obtained.

A204 U27 pin 14 0V

A204 U27 pin 8 0V

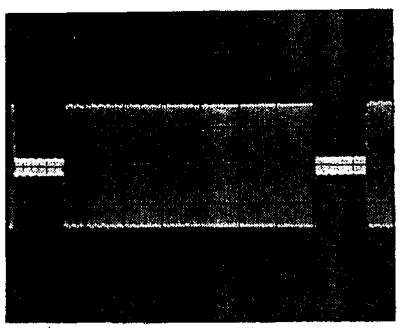


0.5V/DIV (10:1 PROBE)

5ms/DIV
Trigger from Pulse Generator output

g. Replace A204TL2, remove A204TL1 and check that the following waveform can be obtained.

A204 U28 pin 1 0V



0.5V/DIV (10:1 PROBE)

5ms/DIV
Trigger from Pulse Generator output

h. Replace A204TL1. Ensure that both A204TL1 and A204TL2 are inserted.

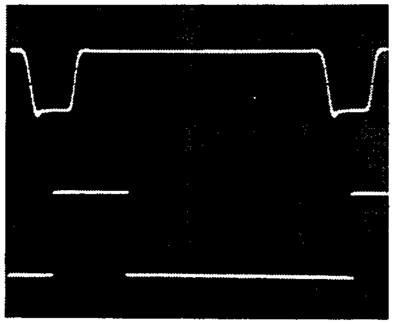
i. Switch the 3776 power off and mount assembly A5 on the extender board.

j. Switch the 3776 power on and re-run the dropout measurement. See the Note at the beginning of Step 12.

k. Check that the following waveforms can be obtained.

A5 TP7

0V



A5 TP3

0V

0.2V/DIV (10:1 PROBE)

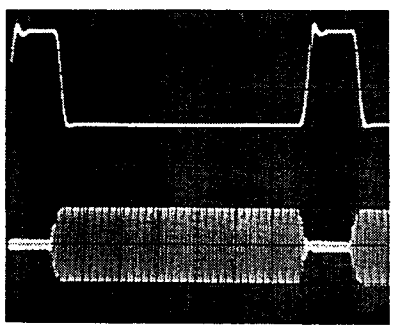
5ms/DIV
Trigger from Pulse Generator output

l. If the waveform at A5TP7 cannot be obtained, then the fault is in the Temperature Compensated Log Converter, proceed to Step m. If the waveform at A5TP3 cannot be obtained then fault is in either the Dropouts D/A Converter, Dropouts Threshold Comparator, Qualification Period Compensation Logic or the Qualification Period Monostable circuitry, proceed to Step 0. If both A5TP7 and A5TP3 waveforms are correct, proceed to Step i.

m. Waveform at A5TP7 (see Step k) cannot be obtained. Check that the following waveforms can be obtained.

A5 U68 pin 7

0V



A5 U86 pin 14

0V

Upper Trace : 0.2V/DIV
Lower Trace : 0.5V/DIV
(both with 10:1 PROBE)

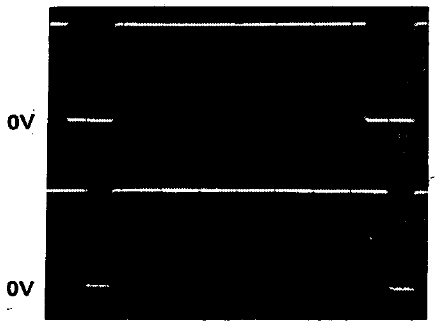
5ms/DIV
Trigger from Pulse Generator output

n. If the waveform at U86 pin 14 cannot be obtained then the fault is in the Transient Input Bandpass Filter. If the waveform at U68 pin 7 cannot be obtained then the fault is in the Temperature Compensation Log Converter Full Wave Rectifier or the Low Pass Filter. If the waveform at U68 pin 7 is correct and the A5TP7 waveform (see Step K waveform) is incorrect then check the signal routing through the Summing Amplifier, Switch and Low Pass Filter using an oscilloscope.

o. Waveform at A5TP3 (see Step k) cannot be obtained. Check that the following waveforms can be obtained.

A5 U53 pin 7

A5 U51 pin 2

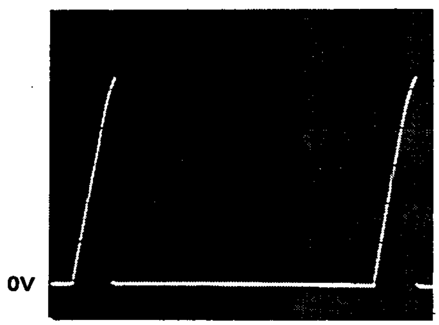


0.2V/DIV (10:1 PROBE)
5ms/DIV
Trigger from Pulse Generator output

p. If A5U53 pin 7 waveform cannot be obtained, check that A5U85 pin 1 output is approximately 2V below TP7 level if the instrument is a 3776B or approximately 1.7V if the instrument is a 3776A. Operation of the Data Input Latch and D/A Converter can be checked by setting the Pulse Generator output to GATED and by reducing the carrier level. The difference between TP7 level and the D/A Converter should always be ≃2V (3776B) or ≃1.7V (3776A). The status of the Data Input Latch U93 can also be changed using the Utilities Instrument Bus Access (see General Service Sheet G1).

q. If A5U51 pin 2 waveform cannot be obtained, check that the output from the Qualification Period Compensation circuitry is as shown.

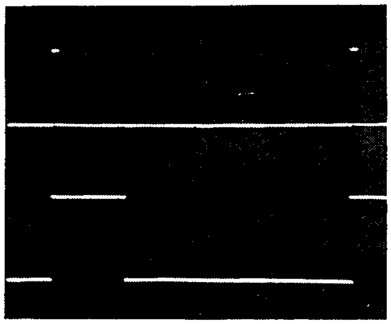
A5 U43 pin 12



0.2V/DIV (10:1 PROBE)
5ms/DIV
Trigger from Pulse Generator output

r. The Qualification Period Monostable can be checked by varying the width of the Pulse Generator output pulses. With the pulse width set to less than 2.5ms, Dropouts on Interruptions should be inhibited. With the pulse width set to 4ms or greater, Dropouts or Interruption should be enabled.

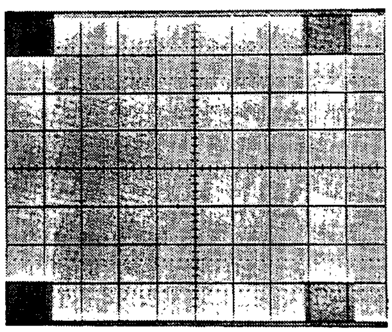
s. If the waveform at A5TP3 (see Step k) is correct and Dropouts/ Interruptions do not register, check operation of A5 TRANSIENT LATCHES, the following waveform should be obtained.



Gain Hits Troubleshooting

13. With CHAN B of the oscilloscope connected to the Function Generator, adjust the Function Generator % MOD control to obtain the waveform given.

Note: 2.5dB = 20 log 4DIV/3DIV.



14. If assembly A5 is not already mounted on the extender board, switch the power off, mount A5 on the extender board and switch the power on.

15. Ensure that the 3776 is set as follows:

OPERATING MODE..................................AN Rx
RxTLP/RxdBr..0.0dB
ANALOG RECEIVE..................................600Ω (Terminated)
MEASUREMENTS.......................................TRANSIENTS

16. Using the PARAMETERS and SET keys, set the 3776 for FAST Count; 4.00hr; 2dB G.hit.

17. Set the Pulse Generator to GATED output (ie 0V output).

18. Set the 3776 CONTROL to RUN and press the NEXT PARAM key to display 2dB G.hit.

19. Set the Pulse Generator operation to NORMAL (ie modulation now present on the carrier at the Function Generator output).

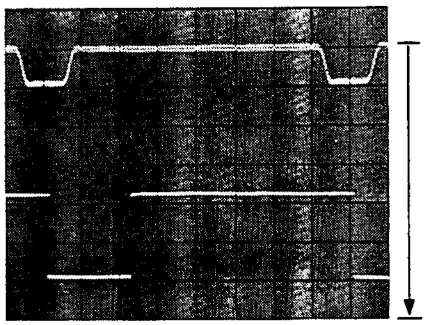
20. Check that Gain Hits register on the 3776 display. If counts do not register, then perform the following procedure. If counts do register, then go to Step 21.

   a. Check that the following waveforms can be obtained. Ensure that the oscilloscope Volts/DIV is set to CAL.

A5 TP7

A5 TP2

0V



0V

Upper Trace : 0.05V/DIV
Lower Trace : 0.2V/DIV
(Both with 10:1 PROBE)

5ms/DIV
Trigger from Pulse Generator output

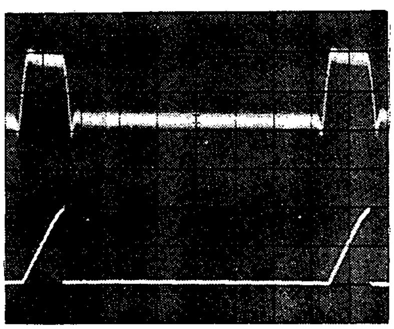
b. If the waveform at A5TP7 is not correct, repeat the assembly A204 troubleshooting section of the Dropouts on Interruption troubleshooting to locate the fault. If the waveform at A5TP2 cannot be obtained then the fault is in GAIN HITS detection circuitry. The following waveforms should help troubleshoot the GAIN HITS detection circuitry.

A5 U24 pin 1

0V

A5 U31 pin 13

0V



Upper Trace : 0.02V/DIV
Lower Trace: 0.5V/DIV
(Both with 10:1 PROBE)

5ms/DIV
Trigger from Pulse Generator output

c. If the A5U24 pin 1 waveform cannot be obtained, the fault is in the Full Wave Rectifier circuit. If the A15U31 pin 13 waveform cannot be obtained, then the fault is in either the Gain Hit Thresholds Multiplexer, Gain Hits Threshold Comparator or possibly the Qualification Period Compensation logic. The Gain Hit Threshold Multiplexer output level versus the thresholds set on the 3776 are as follows:

Gain Hit Threshold	Mux. Output Level (U64 pin 8)
6dB	≃1.0V
4dB	≃10.7
3dB	≃0.5V
2dB	≃0.3V

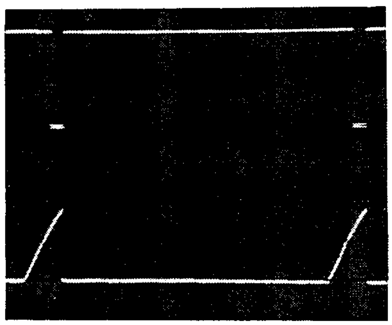
d. The Qualification Period Compensation logic can be checked by varying the width of the Pulse Generator output pulses. With the pulse width set to less than 3.5ms, Gain Hits should be inhibited. With the pulse

A5 U62 pin 2

0V

A5 U31 pin 13

0V



Upper Trace : 0.2V/DIV
Lower Trace : 0.5V/DIV
(Both with 10:1 PROBE)

5ms/DIV
Trigger from Pulse Generator output

5ms/DIV, EXT TRIG (Pulse Gen. O/P)

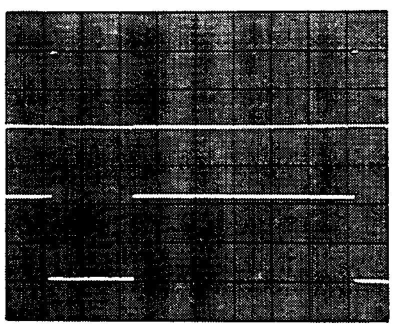
e. If the waveform at A5U62 pin 2 cannot be obtained, check the reference voltage (6.6V) at U62 pin 5.

A5 U71 pin 9

0V

A5 TP2

0V

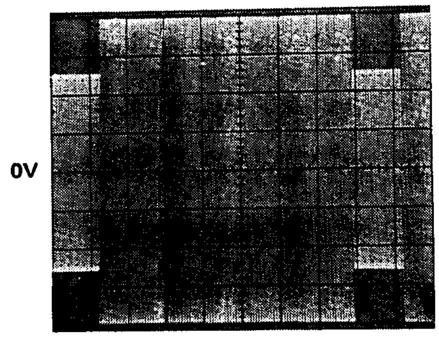


0.2V/DIV (10:1 PROBE)

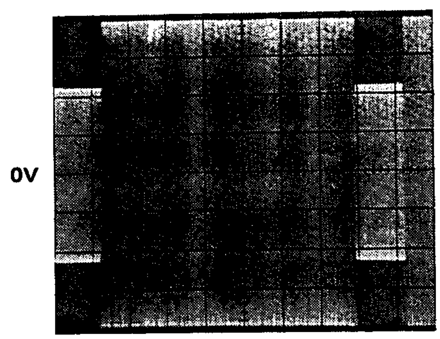
5ms/DIV
Trigger from Pulse Generator output

f. If the waveform at A5U71 pin 9 cannot be obtained check TRANSIENTS latch A5U71A.

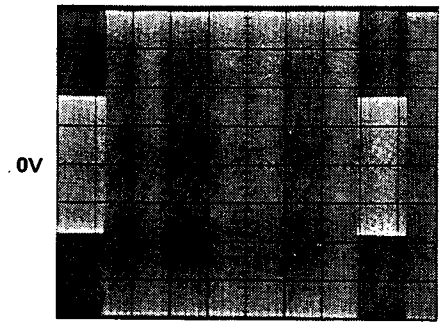
21. If counts register with the Gain Hit Threshold set to 2dB, the 3dB, 4dB and 6dB thresholds can be checked by setting the 3776 to the appropriate threshold and adjusting the modulation on step 12 waveform as shown.



Gain Hit Threshold set to 3dB



Gain Hit Threshold set to 4dB



Gain Hit Threshold set to 6dB

G9-7 PHASE JITTER TROUBLESHOOTING

Equipment Required

Two Test Oscillators (A and B)....	HP651B
Frequency Counter..............................	HP5328A
AC Voltmeter...	HP3455A
Three 200Ω Resistors..........................	HP0757-0407

Procedure

1. Connect the test circuit as shown with the 3776 Assembly A5 mounted on the extender board.

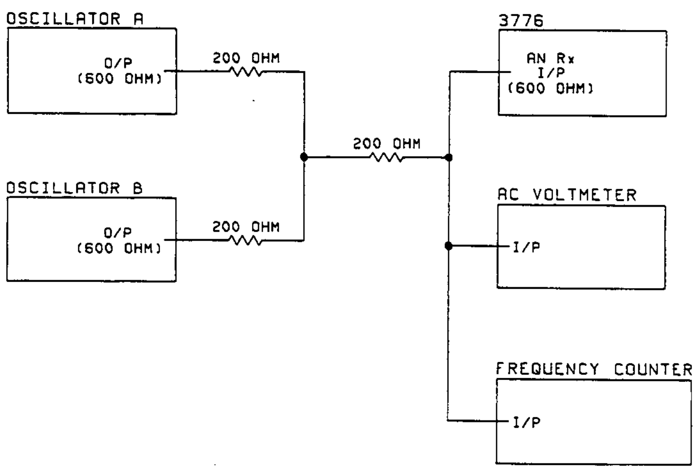


Figure G9-4 Phase Jitter Test Set up

2. Set the 3776 as follows:

OPERATING MODE........................AN Rx
ANALOG RECEIVE........................600Ω (Terminated)
RxTLP/RxdBr..0.0dB
MEASUREMENT................................PHASE JITTER

3. Adjust the controls of Oscillator A to give an output frequency of 1010Hz ±1Hz displayed on the Frequency Counter and a voltage of 0.7745V ±0.0005V displayed on the AC Voltmeter.

Note: To set the output voltage or frequency from either Oscillator accurately and also maintain the circuit impedances, the output voltage from the other Oscillator must be set to a minimum level. If HP651B Oscillators are used, the OUTPUT ATTENUATOR switch should be adjusted to reduce the output voltage to its minimum.

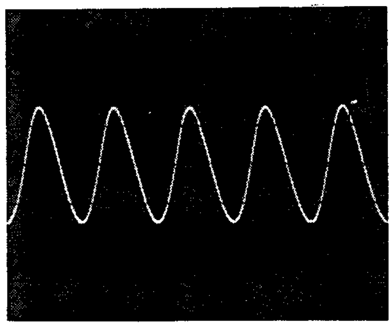
4. With Oscillator A output level set to a minimum level, set Oscillator B to give an output frequency of 910Hz ±1Hz displayed on the Frequency Counter and a voltage of 0.201V ±0.001V displayed on the AC Voltmeter.

5. Return Oscillator A OUTPUT ATTENUATOR switch to the position set in Step 3. The combined outputs from Oscillator A and Oscillator B should now be applied to the 3776 ANALOG RECEIVE input.

6. Press the 3776 RUN key and check after approximately 5 seconds that the phase jitter displayed on the 3776 is between 28 degrees to 32 degrees. If the phase jitter reading is incorrect, perform the following troubleshooting procedure.

a. Check that the following waveform can be obtained.

Note: Because of the jitter present on the analog signals, triggering the oscilloscope is difficult. The following waveforms were obtained from a single sweep trace.



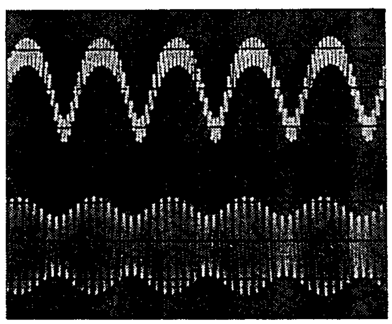
A5 TP5 0V

0.2V/DIV (10:1 PROBE)

5ms/DIV

b. If the waveform at A5TP5 is correct then go to step g.

c. If the waveform at A5TP5 cannot be obtained, then the fault is in the Phase Jitter Bandpass Filter Limiter, Frequency to Voltage Converter and Low Pass Filter or the Bandpass Filter (LO/ Normal Centre Frequency). The following waveforms should help locate the fault.



A5 U36 pin 1 0V

A5 U66 pin 2 0V

0.2V/DIV (10:1 PROBE)

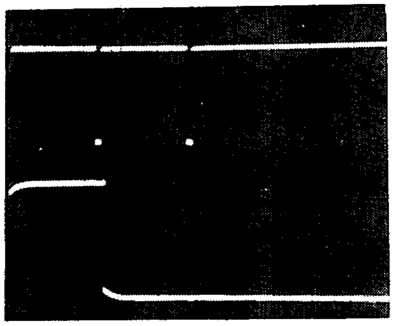
5ms/DIV

d. If the waveform at A5U66 pin 2 cannot be obtained, the fault is in U66B Analog Switch (S2 selected) on the Phase Jitter Bandpass Filter.

e. If the waveform at A5U36 pin 1 cannot be obtained, the fault is in the Frequency to Voltage Converter and Low Pass Filter.

f. If both waveforms A5U66 pin 2 and A5U36 pin 1 are correct and ATP5 is incorrect then the fault is in the Bandpass Filter (LO/ Normal Centre Frequency) circuit.

g. Check that the output of the Positive Peak Detector is approximately +3V DC and the output of the Negative Peak Detector is approximately -3V DC. Check that the following waveform can be obtained.



h. If the waveform at A5U63 pin 17 cannot be obtained then check the operation of the Input/Output Port A5U72.

i. If waveform A5U64 pin 9 cannot be obtained and the output levels from the Peak Detectors are correct, then the fault is in Mux A5U64B. Check that the output of the sample and Hold IC A5U55 pin 5 is identical to the waveform at A5U64 pin 9.

j. If the waveforms at A5U63 pin 17 and A5U64 pin 9 are correct and the output of the A5U55 Sample and Hold IC is correct then the fault is in the A5U63 A/D Converter or Output Buffer A5U73.

G9-8 PHASE HITS TROUBLESHOOTING

Equipment Required

Pulse Generator.................................HP8005B
Function Generator..........................HP3312A
Oscilloscope...HP1740A
Frequency Counter...........................HP5328A

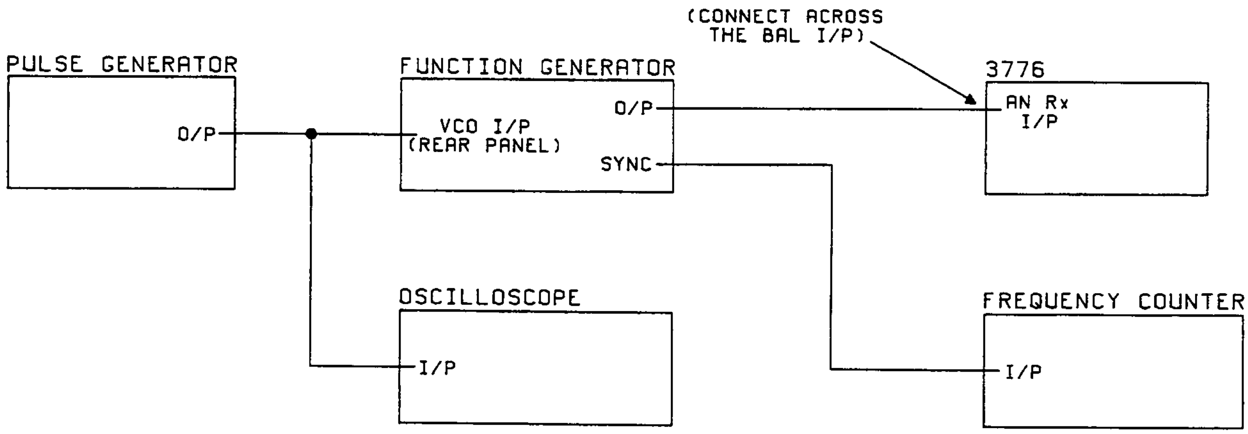


Figure G9-5 Phase Hits Test Set-Up

Procedure

1. Connect the test circuit as shown in Figure G9-5 with 3776 Assembly A5 mounted on the extender board.

2. Set the Pulse Generator to give -1.0V ±0.1V negative-going pulses with a repetition rate of approximately 1kHz and a pulse width of exactly 0.2ms. The oscilloscope timebase should be set to 20us/DIV for best resolution.

3. Set the Pulse Generator repetition rate to approximately 10Hz.

4. Set the Pulse Generator to EXT-MAN or GATED mode (ie sets the Pulse Generator output to 0V, with no DC offsets). Check that the Pulse Generator output is 0V on the Oscilloscope.

5. Adjust the frequency control of the Function Generator to give 1010Hz ±5Hz displayed on the Frequency Counter. When a HP3312A Function Generator is used, the front panel controls should be set as follows:

MODULATION	~ , ∧∨ , ⊓⊔ switches all out
FUNCTION	~ switch depressed
TRIGGER PHASE	FREE RUN
RANGE Hz	100
OFFSET	CAL
SYM	CAL
AMPLITUDE	10

6. Set the 3776 as follows:

OPERATING MODE........................AN Rx
ANALOG RECEIVE........................600Ω (Terminated)
Rx TLP/Rx dBr........................0.0dB
MEASUREMENT........................LEVEL-SEL FILTER

7. Press the 3776 NEXT PARAM key, set the MEAS frequency to 1.01kHz and press RUN/REPEAT.

8. Adjust the output amplitude of the Function Generator to give 0dBm ±0.1dBm displayed on the 3776 RESULTS display.

9. Press the 3776 STOP key.

10. Set the 3776 as follows:

OPERATING MODE........................AN Rx
ANLOG RECEIVE........................600Ω (Terminated)
MEASUREMENT........................TRANSIENTS

11. Scroll the Transient parameters using the NEXT PARAM key and set as follows:

FAST Count
4-00 hr
5 deg P.hit

12. Press the 3776 RUN key and press the NEXT PARAM key to display 5 deg P.hit.

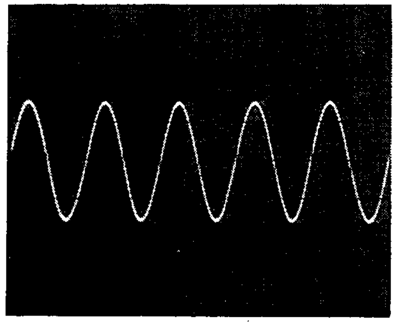
13. Set the Pulse Generator to NORMAL mode (ie 0.2ms, -1V negative- going pulse at approximately 10Hz).

14. Check that Phase Hits register on the 3776 display. If the hits do not register, then perform the following procedure.

a. Check that the following waveform can be obtained.

A5 U66 pin 2

0V



0.1V/DIV (10:1 PROBE)

0.5ms/DIV
(Note: a small amount of jitter will be visible on the signal)

b. If the waveform at A5U66 pin 2 is not present, then check the signal routing through the Transients Input Bandpass Filter (ie S1 selected on U66B Analog Switch) and A204 D/A Converter and Low Pass Filter.

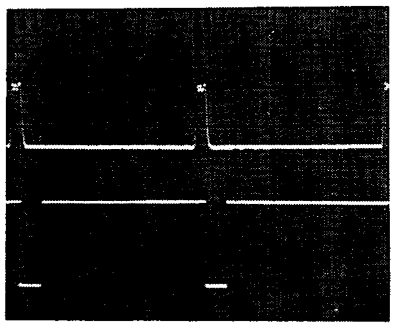
c. Check that the following waveforms can be obtained.

A5 TP6

0V

A5 TP1

0V



Upper Trace: 0.1V/DIV
Lower Trace : 0.2V/DIV
(Both with 10:1 PROBE)

0.02ms/DIV
Trigger from Pulse Generator output

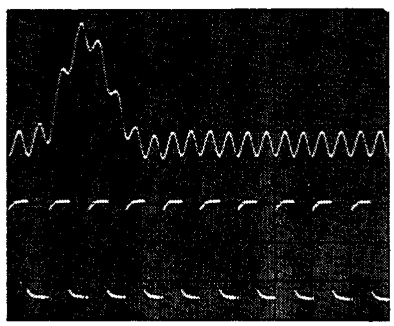
d. If the Waveform at A5TP6 cannot be obtained, then the fault is in the Limiter U56A, Frequency to Voltage Converter & Low pass Filter or the Phase Hit Filter. The following waveforms should help locate the fault.

A5 U36 pin 1

0V

A5 U56 pin 7

0V



0.2V/DIV (10:1 PROBE)

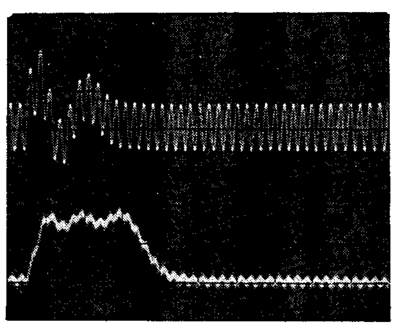
1ms/DIV
Trigger from Pulse Generator output

A5 U36 pin 7

0V

A5 U36 pin 14

0V



Upper Trace : 0.1V/DIV
Lower Trace : 0.02V/DIV
(Both with 10:1 PROBE)

2ms/DIV
Trigger from Pulse Generator output

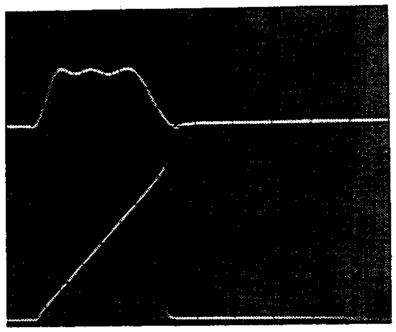
e. If the waveform at A5TP1 cannot be obtained then the fault is in the Loop Recovery circuit, Full Wave Rectifier, Phase Hits Threshold Comparator or the Phase Hit Qualification Period Compensation and Monostable circuit. The following waveforms should help locate the fault.

A5 U34 pin 7

0V

A5 U31 pin 14

0V



Upper Trace : 0.1V/DIV
Lower Trace : 0.2V/DIV
(Both with 10:1 PROBE)

2ms/DIV
Trigger from Pulse Generator output

2ms/DIV EXT TRIG (Pulse Gen O/P)

f. If the waveform A5U34 pin 7 cannot be obtained, then check the Loop Recovery circuit and the Full-Wave Rectifier. If waveform A5U31 pin 14 cannot be obtained, check that the level at U84 pin 8 is 0.2V. The Phase Hit Thresholds versus U84 output levels are as follows:

Phase Hit Threshold degs	**U84 Input** Selected	**U84 Output** Level V (DC)
40	0	1.6
35	1	1.4
30	2	1.2
25	3	1.0
20	4	0.8
15	5	0.6
10	6	0.4
5	7	0.2

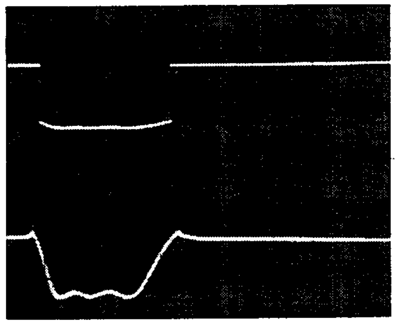
g. Check that the following Qualification Period Compensation and Monostable circuit waveforms can be obtained.

A5 U33 pin 1

0V

0V

A5 U33 pin 14



Upper Trace : 1V/DIV
Lower Trace : 0.1V/DIV
(Both with 10:1 PROBE)

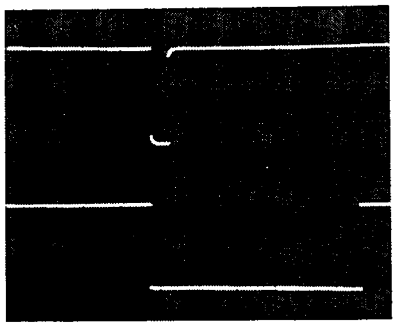
2ms/DIV
Trigger from Pulse Generator output

A5 U51 pin 14

0V

A5 TP1

0V



0.2V/DIV (10:1 PROBE)

2ms/DIV
Trigger from Pulse Generator output

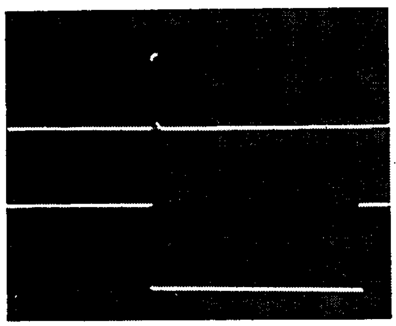
h. Check that the following Phase Hit Transient Latches output waveform can be obtained.

A5 U71 pin 5

0V

A5 TP1

0V



0.2V/DIV (10:1 PROBE)

2ms/DIV
Trigger from Pulse Generator output

G9-9 GROUP DELAY TIMING, IMPULSE NOISE AND FREQUENCY DETECTOR TROUBLESHOOTING

Equipment Required

Signature Analyzer	HP5005A
Oscilloscope	HP1740A

Procedure

1. Switch the 3776 power off and mount assembly A8 on the extender board.

2. Connect and set the HP5005A Signature Analyzer as follows:

FUNCTION	NORMAL
CLOCK	A8 TP2;TTL positive edge
START	A8TP1(SA);TTL negative edge
STOP	A8TP1(SA);TTL positive edge
GND	A8GND TP

3. Set A8TL1 to the TEST position.

4. Switch the 3776 power on.

5. Set A13S2 switches to 10001 and press A13S1 reset button.

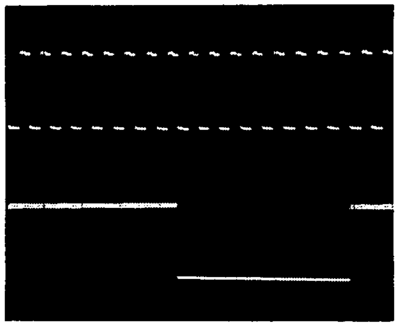
6. Press AN Tx.

7. Write 02 (hex) to Status Register address 2d (hex). See General Service G1, Instrument Bus Access using the utilities.

8. Check that the +5V signature is 12A5. If this signature cannot be obtained, check operation of the Timing Chain/Frequency Gate Counter using an oscilloscope. Check that the following waveform can be obtained.

A8 TP4 LFREQ GATE

0V



0.2V/DIV (10:1 PROBE)

0.01s/DIV

A8 TP1 SA

0V

9. Check that the following signatures can be obtained.

Note: Only signatures underlined need be checked to verify correct Logic Function operation.

Assembly	Logic Function	Signatures	
A8 Part 1	Threshold Detector	U22(1) 8C43 U22(2) 5U90 U22(3) 20U0 U22(4) 0000 clk U22(5) P050 U22(6) AH3A U22(7) A64P U22(9) 549P U22(10) 7111 U22(11) 29PC U31(1) 12A5 U31(2) 86CP U31(3) 941C U31(8) P050 U31(9) 12A5 U31(10) U2U5 U31(11) A64P	U31(12) 20U0 U31(13) 86CP U32(2) 0000 clk U32(7) 941C U32(9) A64P U32(11) 5U90 U32(12) 8C43 U32(13) AH3A U32(14) U2U5 U32(15) 86CP U43(1) 0000 U43(2) 20U0 U43(4) 20U0
A8 Part 1	Fast/Slow Detector	*U11(3) 2PFF(3F69) U31(4) 3255 U31(5) 12A5 U31(6) 20U0	*U44(1) 2PFF/3F69 U44(8) 0345 U44(9) 942F U44(10) 12A5 U44(11) 20U0 U44(12) 20U0 U44(13) 0000

			U54(8) 0000 clk U54(10) 3255 U54(13) P865 ***Signatures in brackets are obtained in a 3776B only.**
A8 Part 1	Impulse Reset **Note: Connect a shorting link between the A8 GND Test Point and A8U42 pin 6 for these signatures. Remove link after checking this Logic Function.**	U42(1) A64P U42(2) 12A5 U42(3) A64P U42(4) A64P U42(5) 12A5 U42(6) 0000	U43(1) 0000 U43(12) A64P U43(14) A64P U44(2) 12A5 U44(3) 0000 U44(4) A64P U44(5) 12A5/C4PC U44(6) C4PC/12A5
A8 Part 2	Frequency Counter	U43(1) 0000 U43(5) 0000 clk U43(6) 0000 U43(7) 0000 clk *U53(1) 3365(HA05) U53(2) 0000 clk *U53(3) 284A(5A1P) *U53(4) F95A(HC67) *U53(5) F656(1CU3) *U53(6) 33HU(AH91) *U53(8) 3365(HA05) *U53(9) A751(3A2C) *U53(10) P107(C653) *U53(11) 17AA(PA23) U53(12) 0000 clk U53(13) 8H97	*U54(1) 33HU(AH91) U54(2) 0000 clk *U54(3) 635C(4127) *U54(4) 496P(UP8U) *U54(5) 3P34(PH74) U55(8) 0000 U55(9) 0000 U55(10) 0000 U56(1) 0000 *U56(2) H0FC(P865) *U56(3) H0FC(P865) *U56(4) H0FC(P865) U56(5) 61U1 U56(6) 8H97 U66(2) 0000 U66(3) 61U1 U66(4) 0000 U66(6) 0000 U66(9) 0000 U66(11) 12A5 U66(12) 12A5 U66(13) 0000 ***Signatures in brackets are obtained in a 3776B only.**

10. Write 0C (hex) to Status Register address 2d (hex). See General Service Sheet G1, Instrument Bus Access using Utilities.

11. Check that the following signatures can be obtained.

Note: Only signatures underlined need be checked to verify correct Logic Function operation.

Assembly	Logic Function	Signatures	
A8 Part 3	Timing Chain Sync Generator	U11(9) 61U1 U11(11) UFC6 U11(12) 20U0 U12(11) 3255 U12(12) 20U0 U12(13) 12A5 U15(4) 20U0 U15(5) 0000 U15(6) 3255	U16(11) 12A5 U16(12) 0000 U16(13) 82FP U24(9) 12A5 U24(10) UFC6 U24(12) U8H6 U26(4) FH19 U26(5) 82FP U26(6) U8H6 U52(4) 20U0 U52(5) 12A5 U52(6) 20U0
A8 Part 3	Timing Chain	U11(5) 3F34 U11(7) 866F U11(9) 61U1 U11(13) P4HC U11(15) H68P U12(1) 0247 U12(2) 4UUU U12(3) 9CHP U12(8) 3255 U12(9) 20U0 U13(2) 61U1 U13(7) H68P U13(9) 3255 U13(10) H68P U13(15) 6516 U14(2) 61U1 U14(4) 20U0	U15(1) 1A73 U15(2) 20U0 U15(3) 2826 U15(11) H68P U15(12) 20U0 U15(13) P4HC U34(9) H629 U34(10) 0247 U34(11) 4UUU U34(12) 3F34 U34(13) 82FP U34(14) 20U0 U34(15) H629 U418(8) HUCF U41(9) FH19 U41(11) 866F U41(12) 9CHP

		U14(7) 6516 U14(9) 1A73 U14(10) 6516 U14(11) 3F34 U14(15) 2826	U41(13) 12A5
A8 Part 3	Sync Loss Detector	U12(4) HUCF U12(5) 82FP U12(6) 276A U15(8) 0000 U15(9) U8H6 U15(10) PA73 U16(1) 35FU U16(2) PA73 U16(3) 12A5	U16(4) 12A5 U16(5) 0000 U16(6) 12A5 U16(8) 0000 U16(9) 12A5 U16(10) 12A5 U24(5) 3255 U24(6) 276A U24(7) 35FU

Self-Blocking Timers (LO, MID, HI) Troubleshooting

12. Set the A13S2 switches to 00000.

13. Set A8 TL1 to the NORM position.

14. Press SELF TEST. CAL should be displayed.

15. Press PREVIOUS PARAM until Pt 20 is displayed (ie Digital Filter Self Test).

16. Press RUN and when PASS 7 is displayed on the RESULTS display, press REPEAT.

17. Set A13S2 switches to 00101.

18. Press SELF TEST to access the Utilities.

Note: The 3776 should now be in the middle of its Digital Self test routine, with the A8 assembly being driven at an 8kHz rate (ie not the usual 16kHz rate).

19. Check that the following waveforms can be obtained.

A8 TP3 SMP CLK........................8kHz 0.1us negative-going pulses
A8 TP6 ENLDCNTR................≈31Hz squarewave (ie 32ms period)

20. Press Rx dBr/CHAN (Rx TLP/T SLOT).

21. Press OTHER MEAS then PHASE JITTER. "042" should be displayed on the LEVEL display.

22. Press RUN. "t5t" should be displayed on the RESULTS display.

23. Press TRANSIENTS then PHASE JITTER. "052" should be displayed on the LEVEL display.

24. Press RUN. "noP" should be displayed on the RESULTS display.

25. Press SET FREQ, then GAIN v FREQ. SPEAKER "F0" should be displayed on the RESULTS display.

26. Press RUN. "t5t" should be displayed on the RESULTS display.

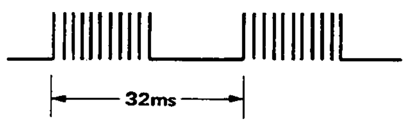
27. Press DECR. "051" should be displayed on the LEVEL display.

28. Press SET FREQ, then OTHER MEAS. FRAMING + SIG BITS. "41" should be displayed on the RESULTS display.

29. Press RUN. "Sub 1" should be displayed on the RESULTS display.

30. Check that the following waveforms can be obtained.

A8 TP6 ENLD CNTR
(see Step 36)

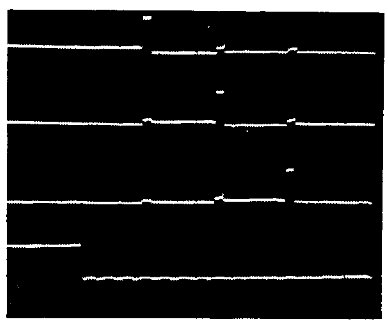


A8 TP6 ENLD CNTR

A8 TP7 LLO

A8 TP8 LMID

A8 TP9 LHI



0.5V/DIV (10:1 PROBE)

$0.5\mu s$/DIV
(Note: Trigger on positive edge of A8 TP6)

31. Press AN Tx, then PHASE JITTER, STORE. "2d" should be displayed on the LEVEL display.

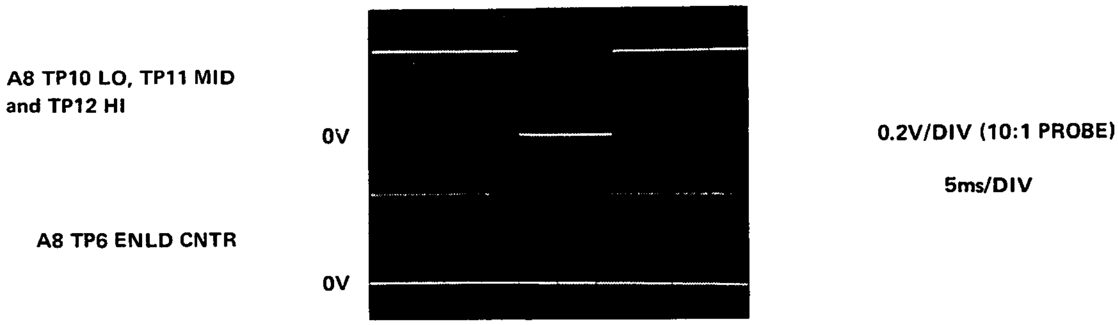
32. Press SET FREQ, then TRANSIENTS. INCR. "06" should now be displayed on the RESULTS display.

33. Press RUN. This sets A8 for Fast Count (ie 10ms Self-Blocking).

34. Press NOISE + TONE (3776A)/NOTCHED NOISE (3776B). "0C" should be displayed on the LEVEL display.

35. Press REPEAT. This action repeatedly clears any recorded impulses, enabling further impulses to be recorded.

36. Check that the following waveforms can be obtained.



37. If the above waveform can be obtained on A8TP10, TP11 and TP12 then this verifies the operation of the Self-Blocking Timers. If a waveform cannot be obtained at one of the test points, use the waveforms obtained on a working Self-Blocking Timer to compare against the faulty Self-Blocking Timer.

Note: The reset input to latches U24B, U25B and U25D is a very narrow (ie approximately 50ns) negative-going pulse.

G9-10 ENVELOPE DELAY DISTORTION AND ABSOLUTE DELAY TROUBLESHOOTING

Equipment Required

Oscilloscope.................................... HP1740A
Logic Probe..................................... HP545A

Procedure

1. Switch the 3776 power off and mount assembly A204 on the extender board.

2. Connect the ANALOG TRANSMIT output to the ANALOG RECEIVE input.

3. Switch the power on and set the 3776 as follows:

OPERATING MODE................AN Tx, AN Rx
ANALOG TRANSMIT
and ANALOG RECEIVE.......600Ω terminated
Rx TLP/Rx dBr and
Tx TLP/Rx dBr...........................0.0dB
MEASUREMENT........................OTHER MEAS/ENVEL DELAY

4. Set the REF frequency to 1.81kHz and the LEVEL to -5.0dBm0.

5. Press RUN then REPEAT. The Transmitter should now repeatedly generate a 1.81kHz, -5.0dBm0 carrier with 41 2/3Hz (3776A) or 83 1/3Hz (3776B) amplitude modulation.

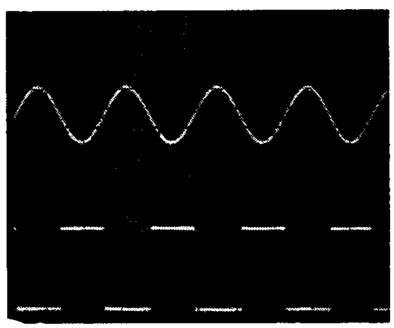
6. Check that the following waveforms can be obtained. Note: Repetition Rate is 41 2/3Hz (3776A) and 83 1/3Hz (3776B). If the waveform A204TP3 cannot be obtained, check operation of Limiter U38A.

A204 (A4 : 3776A) TP8
0.1V/DIV (10:1 PROBE)

5ms/DIV

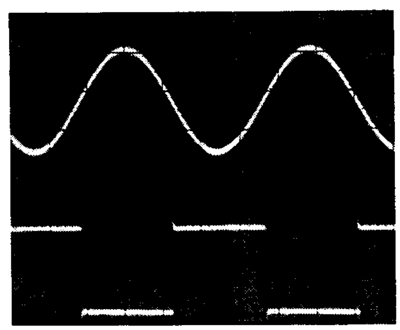
A204 (A4 : 3776A) TP3
0.2V/DIV (10:1 PROBE)

0V
0V



3776B

0V
0V



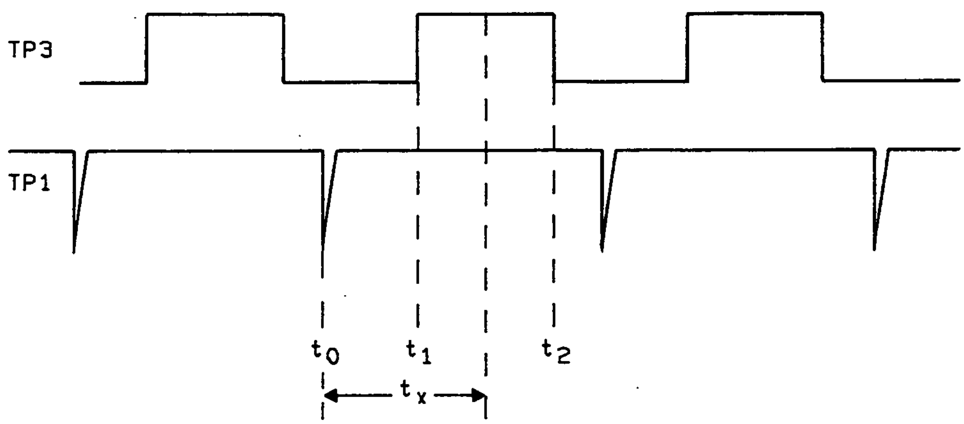
3776A

7. Check that the signal at A204 TP1 is an approximately 0.2us negative-going pulse with a repetition rate of 41 2/3Hz (3776A) or 83 1/3Hz (3776B). Use an oscilloscope with a viewing hood or storage facilities. If the signal at A204TP1 cannot be obtained check the operation of the A204 Reference Phase Counter (÷192). The DA CONV WRITE signal should be approximately 2.5us negative-going pulses with a 16kHz repetition rate. The 41 2/3Hz SELECT signal should be held high if the instrument is a 3776A or low if the instrument is a 3776B.

8. Use a logic probe or an oscilloscope to check the Phase Comparator, Decoder, Measurement Cycle Counter and the Initializing Circuit.

Note that the output of the Measurement Cycle Counter U20 pin 7 and Initializing Circuit Flip-Flops should toggle at a very low repetition rate (ie approximately 1Hz).

9. Check that LCLK present at the input to the divide by 1/2 Counter switches between 4MHz and 2MHz depending on the phase relationship between the signal at A204 TP3 and A204 TP1. For example, if the signals are as follows; the 4MHz clock is enabled between t0 and t1 and the 2MHz clock enabled between t2 and t1.



Relative Delay $\alpha\ t_x = \frac{(t_2 - t_1) + (t_1 - t_0)}{2}$

10. Set A204 TL3 to the Test position and check the operation of the Up/Down Phase Counter using an oscilloscope or logic probe. Setting TL3 to the Test position inhibits LCLR PH CNT line. Set A204 TL3 to the NORMAL position after performing the Phase Counter Troubleshooting.

11. Ensure that the 3776 is in the RUN/REPEAT mode.

12. Using a logic probe, check that the negative-going signals L BYTE 1 and L BYTE 2 enable Output Buffers U33 and U43 at an approximately 1 second rate. If L BYTE 1 or L BYTE 2 cannot be obtained, check the operation of the Address Decoder A204 U50 using the "Instrument Bus Access using the Utilities" given in General Service Sheet G1.

TROUBLESHOOTING
ASSEMBLY SERVICE SHEETS

ASSEMBLY SERVICE SHEET A1/A101
DIGITAL SYNTHESIZER & PCM GENERATOR
A1 (3776A)/A101 (3776B)

A1-1 INTRODUCTION

A1-2 Assembly A1/A101 generates the following test signals for 3776 measurements;

1 sinewave,
2 2 Tones,
3 4 Tones,
4 Group Delay (3776A), Envelope delay (3776B),
5 350Hz to 550Hz Band Limited Noise (3776A),
6 Echo Return Loss - ERL (3776B),
7 Dual Tone Multifrequency (DTMF) Dialling.

These signals digitally synthesized on A1/A101 are converted to an analog form on Assembly A3 for A to A and A to D measurements. In their digital form, these signals are inserted into a PCM frame structure on A1/A101, for D to A and D to D measurements. Before insertion into the PCM frame structure the digital signals are attenuated and compressed as if on an actual digital transmission system.

A1-3 It is the A1/A101 software along with data from the processor on A13 which allows the A1/A101 hardware to be so versatile. The A1/A101 software is a linear program which repeats every 125us. Stored in software are routines to perform all the following operations:

3776A	3776B
signal generation (see Para A1-2)	signal generation (see Para A1-2)
digital attenuation routine	digital attenuation routine
A-LAW compression	u-LAW compression
PCM Frame Structure: CCITT G.732	PCM Frame Structure: Bell std 24 Channel/ Extended Frame (FE) (Selections from A13)

A1-4 The PCM Frame structures conforming to CCITT G.732 and the BELL Std and the Extended Bell structure are illustrated in APPENDIX A.

A1-5 The main signal flow of Assembly A1/A101 is illustrated in Figure A1-1.

A1-6 The Bit Slice Processor shown in Figure A1-1, is fundamental to the operation of Assembly A1/A101. Under the control of the processor on A13 and the software stored in the Program Constant ROMs and Microcode Instruction ROMs, the Bit Slice Processor processes all data (test signals, attenuation, compression and PCM Frame structure) fed to it from the Control RAM Memory.

A1-7 The Program Counter sequentially addresses the software contained in the Program Constant ROMs and Microcode Instruction ROMs. The Program Constant ROMs contain address information and program constants used in the A1/A101 software. The Microcode Instruction ROMs contain the instructions and timing information which make up the A1/A101 software. During the 125us cycle time of the Program Counter 512 address words are produced for the 3776A and 386 for the 3776B. The 125us cycle time equals the length of 1 frame in a PCM frame structure.

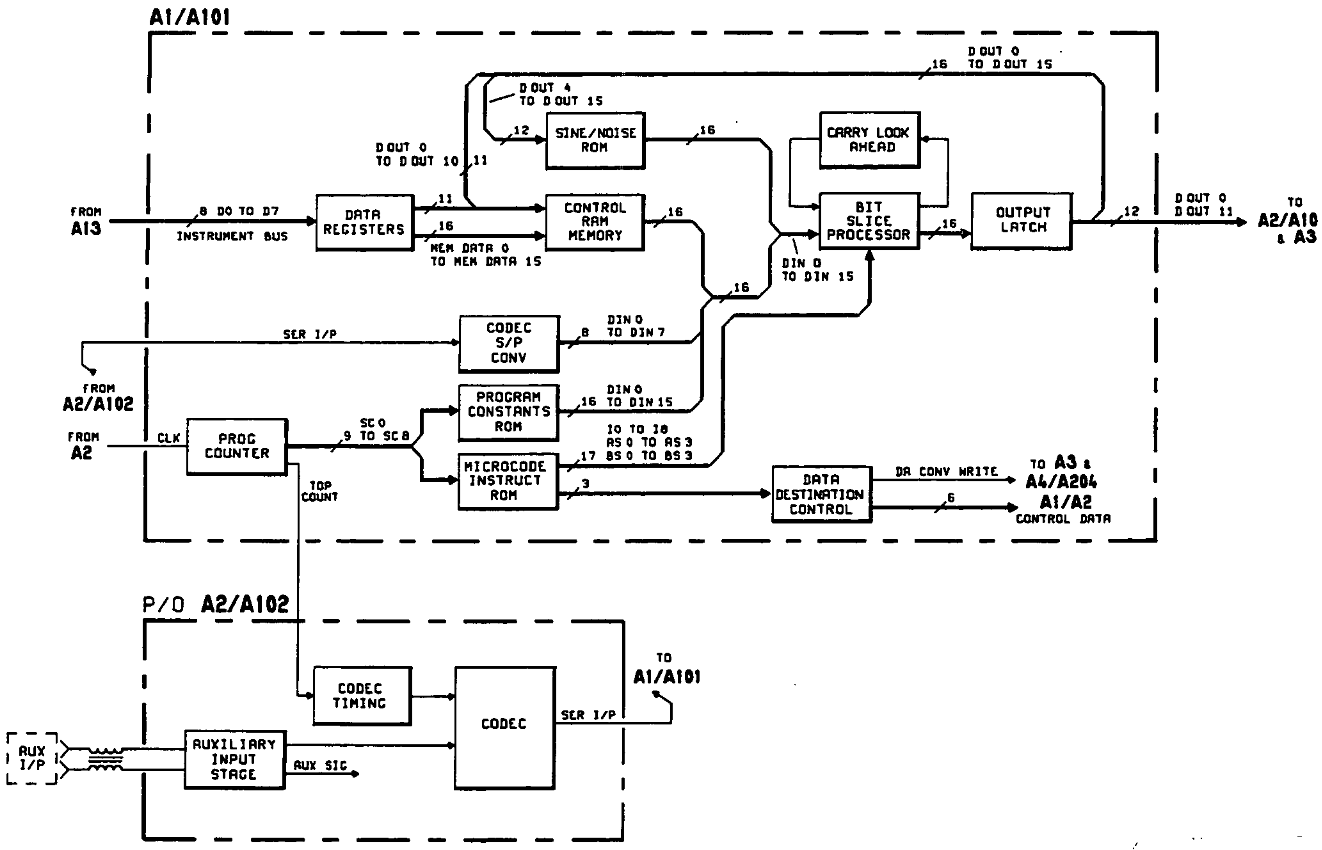


Figure A1-1 A1/A101 Block Diagram

A1-8 With the Bit Slice Processor being made up of 4 individual bit slice devices a circuit comprising U805 and U806 (see schematic A1/A101 PART 2) is necessary. This circuit allows the shifting of instructions between devices. Instructions include arithmetic right, logic left as well as rotation. The 4 bit slice devices form a processor with a 16 bit ALU, a 32 bit shift register and 16 X 16 shift registers.

A1-9 The Carry Look Ahead circuit, shown in Figure A1-1, is used along with the 4 bit slice devices during add and subtract instructions.

A1-10 Generating a Sinewave

A1-11 Sinewaves in the range 50Hz to 4.6kHz are digitally synthesized on A1/A101. A simplified illustration of digital sinewave synthesis is given here, followed by a description of how the A1/A101 assembly performs this function.

A1-12 Basic Concept

A1-13 A stepped sinewave can be generated by presenting a series of sinusoidally-varying binary words representing a full 360 degree cycle to a digital-to-analogue converter (see Figure A1-2). Band Limited Noise is produced in a similar manner.

A1-14 Good spectral purity of the stepped waveforms is easily obtained by low-pass filtering. This is the technique employed by the 3776.

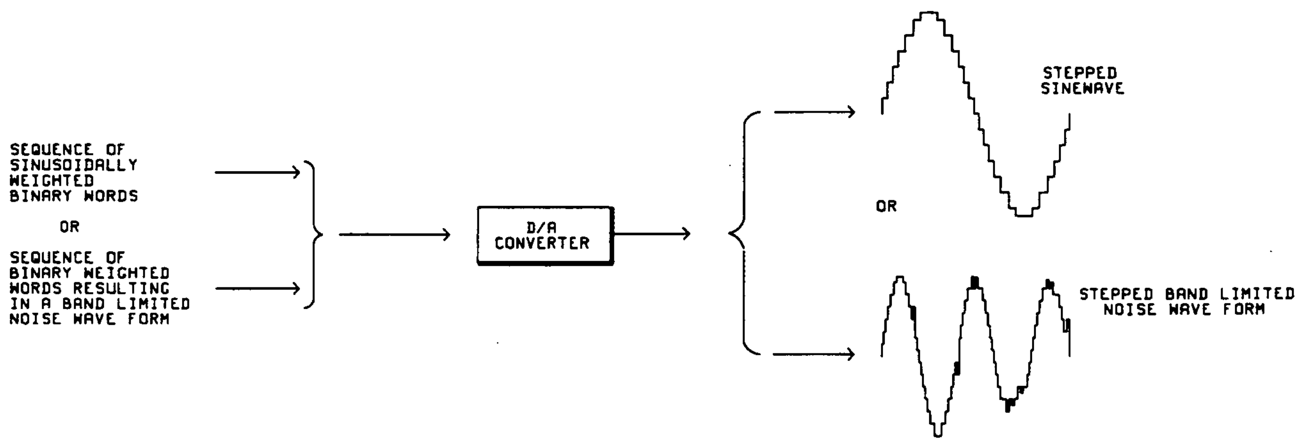


Figure A1-2 D/A Function

A1-15 The 3776 uses a SINE ROM to produce a sequence of sinusoidally-weighted binary words from a sequence of linearly-weighted words (see Figure A1-3). The SINE ROM is programmed such that when its input is addressed by a sequence of linearly-varying binary words, then its output is a sequence of sinsusoidally-varying binary words.

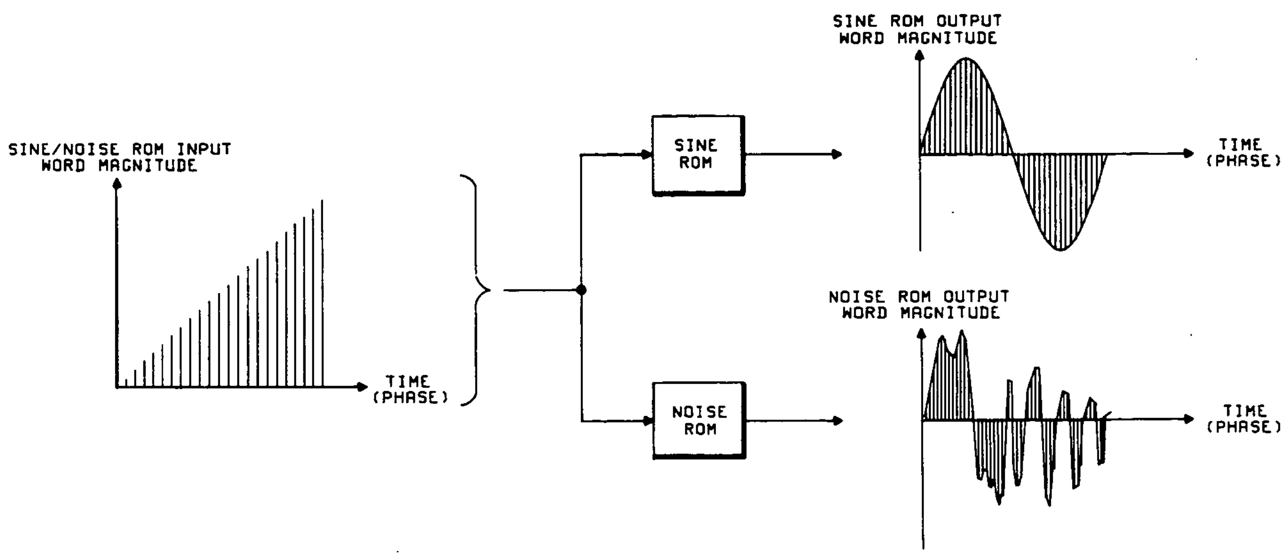


Figure A1-3 ROM Function

A1-16 The linearly-varying binary word sequence is generated by an ACCUMULATOR. This consists of an adder and a register, connected as shown in Figure A1-4 (a). Imagine the register contents (and output word) to be initially all zeros. A binary word (the INCREMENT) is input to the adder, and will be clocked through to the register output. The output is added to the INCREMENT, and becomes the new value offered to the register. This new value will be clocked into the register on the next clock pulse, and the process will be repeated. Thus the accumulator output will, on each clock pulse, increase by an amount equal to the INCREMENT (see Figure A1-4 (b)). This gives the linearly-weighted binary sequence required to drive the ROM.

A1-17 Different frequencies are obtained by altering the size of the INCREMENT. The smallest INCREMENT steps through the maximum number of sinewave values stored in SINE ROM (see Figure A1-3), to define the lowest frequency. If the INCREMENT size is doubled the number of steps required to define one cycle of the sinewave halves, and so the frequency doubles.

A1-18 Band limited noise is produced in an identical way to the sinewave except that the NOISE ROM addresses are accessed on A1/A101.

A1-19 The "basic concept" described in the previous paragraphs is implemented on A1/A101 under the control of the processor on A13 and the A1/A101 software.

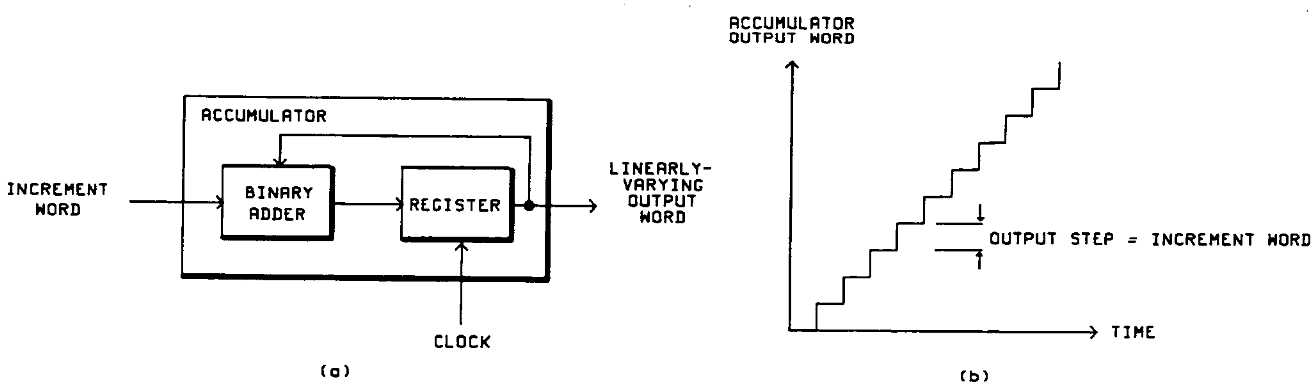


Figure A1-4 The Accumulator

A1-20 When the frequency of a test signal is keyed in via the front panel, the processor on A13 reads the frequency and produces a 16 bit binary word representing the INCREMENT described in paragraph A1-17. This INCREMENT is stored in a specific address in the Control RAM Memory (see Figure A1-5). When the Bit Slice Processor is not busy, the A13 assembly applies the INCREMENT and address word to the Control RAM Memory via the Data Latch.

A1-21 When the A1/A101 software starts its routine for sinewave generation, it first produces the address required to access the INCREMENT in RAM. This address applied to the DIN (0 to 15) bus, is fed via the Bit Slice Processor and Output Latch to the Control RAM Memory. The INCREMENT, accessed by the address word, is added to the register holding the accumulated phase in the Bit Slice Processor. The result addresses the sinewave locations on the Sine/Noise ROM. The output of the ROM is thus a sinusoidally-weighted binary word, see Paragraph A1-15. This action continually repeats, producing a sequence of sinusoidally varying words as per Paragraph A1-16. The frequency is altered by changing the size of the INCREMENT (see Paragraph A1-17).

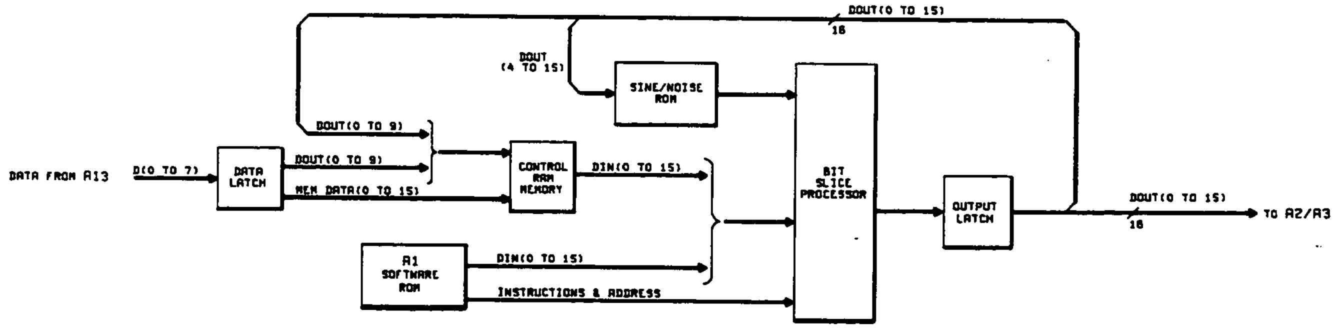


Figure A1-5 Sinewave Generation

A1-22 The Bit Slice Processor also digitally attenuates the sinusoidally varying words according to the level set via the front panel. Attenuation is provided in coarse 6dB steps and fine 0.1dB steps over a sinewave range of 3.1dBm0 to -60dBm0.

A1-23 Multiple tones (i.e. 4 sinewaves in the 3776B) are generated in a similar manner to the previously described sinewave. Each of the 4 sinewaves has its own INCREMENT register in the Bit Slice Processor and the routine previously described repeats for each of the 4 frequencies. The 4 sinewaves are combined in the Bit Slice Processor to produce a 4 Tone Complex Signal.

A1-24 Group Delay (GD) Echo Return Loss (ERL) and Envelope Delay Distortion (EDD) signals are also produced by the Bit Slice Processor. A typical example of a GD signal is illustrated in Figure A1-6.

A1-25 If the 3776 is operating as an analog transmitter (ANTx) the output of the Data Latch will be applied to the Analog Transmit Assembly A3.

A1-26 However if the 3776 operates as a digital transmitter (DIGTx) the digitally synthesized signal must be inserted into a PCM frame structure.

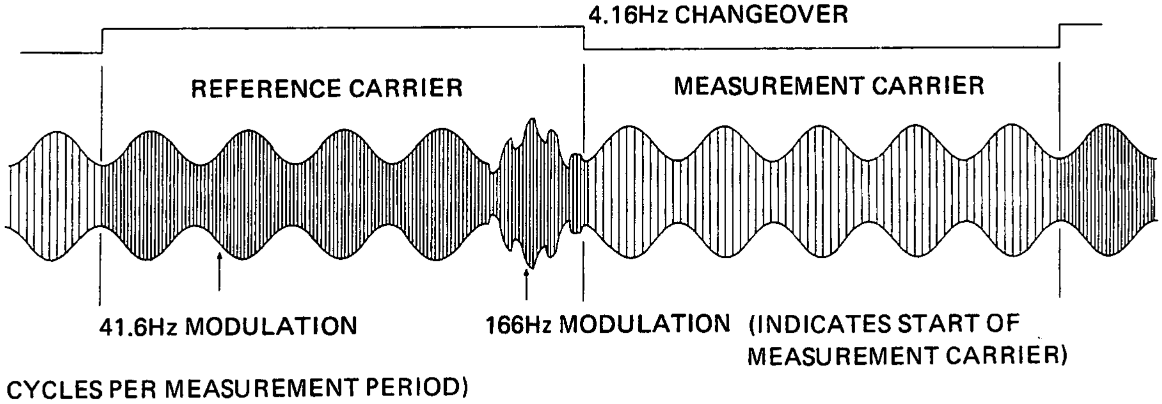


Figure A1-6 Example of Group Delay CCITT 0.81 Waveform (3776A)

A1-27 PCM Frame Structure

A1-28 The PCM Frame Structures for the 3776A and 3776B are illustrated in APPENDIX A. For this description consider the structure for the 3776A.

A1-29 The A1/A101 software program and a PCM frame run for the same length of time 125us.

A1-30 When the 3776A operates as a digital transmitter (DIGTx), the processor on A13 provides framing and signalling information etc associated with the CCITT 2,048kb/s PCM System (3776A). The A13 assembly also supplies the addresses in the Control RAM Memory into which the framing and signalling information is to be stored. The Control RAM Memory is loaded when the Bit Slice Processor is not busy. Framing, signalling and Frame Word Bit Error Rate data can be programmed into a PCM frame structure via the front panel.

A1-31 The A1/A101 software contains the CCITT PCM Frame Structure - the basic frame comprises 32 timeslots (TS). The PCM Frame Structure is constructed by accessing the framing and signalling information stored in RAM at the appropriate time e.g. the FRAME ALIGNMENT WORD stored in RAM is addressed by the A1/A101 software at a time equivalent to TSO every alternate frame. The address information is fed to the Control RAM Memory via the Bit Slice Processor and Output Latch (see Figure A1-5).

A1-32 Transmitting a test signal digitally, requires the test signal (Foreground PCM) to be allocated a timeslot within a frame. This is done via the front panel DIGITAL Tx TIMESLOT key. All other timeslots except for the framing and signalling timeslots are allocated a reference (Background PCM) binary sequence, which is set up by "storing" the DIG Tx-Rx parameters.

A1-33 Test signals are generated as per the previous section, Paragraph A1-19 to 24. However in addition to being attenuated test signals are compressed (A-LAW compression for 3776A and U-LAW for 3776B) by the Bit Slice Processor before being inserted into the selected timeslot.

A1-34 The Foreground PCM (test, framing and signalling) and the Background PCM signals are applied to the Control RAM Memory from A13. As the A1/A101 software performs its program the Foreground and Background PCM signals are accessed and allocated their appropriate timeslots. The Foreground PCM test signals vary, while the Background PCM, and the framing and signalling Foreground PCM signals are sequences of constants.

A1-35 The output of the Bit Slice Processor is applied to an 8 bit bus. The PCM data is converted to a serial form on A2/A102.

A1-36 On A2/A102 the Foreground and Background PCM are stored in their respective latches (see A2/A102 schematic) prior to being converted to an 8 bit serial word, ready for HDB3/AMI Encoding.

A1-37 An external audio signal may be inserted into the PCM Frame Structure. The signal is applied to the A2 Assembly via the AUXILIARY INPUT on the rear panel, where it is converted to a binary form. From A2 the binary signal is stored in the Bit Slice Processor on A1/A101 ready for insertion to the PCM frame structure.

A1-38 Signature Analysis is used in the troubleshooting of the A1/A101 Assembly (see GENERAL SERVICE SHEET G5).

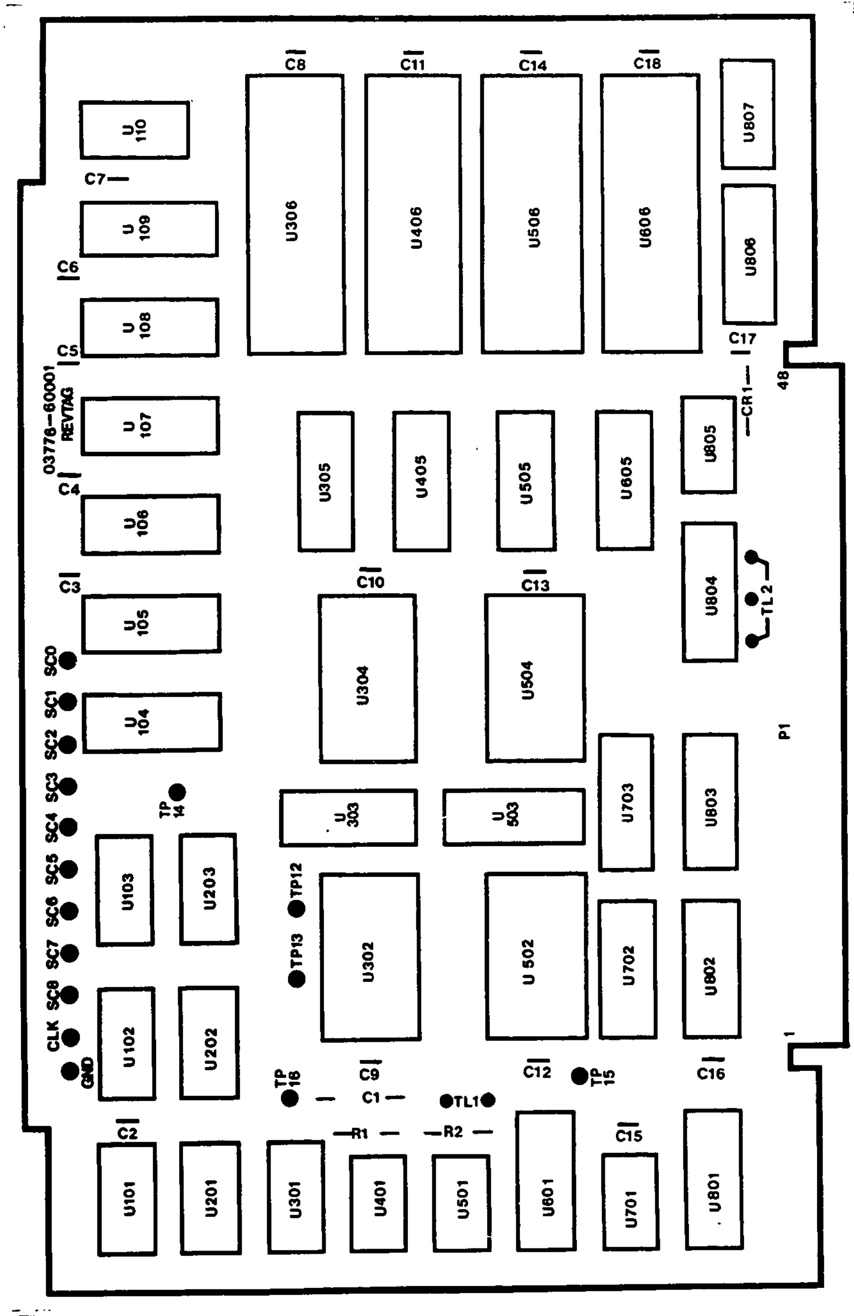


Figure A1-7 A1/A101 Component Location

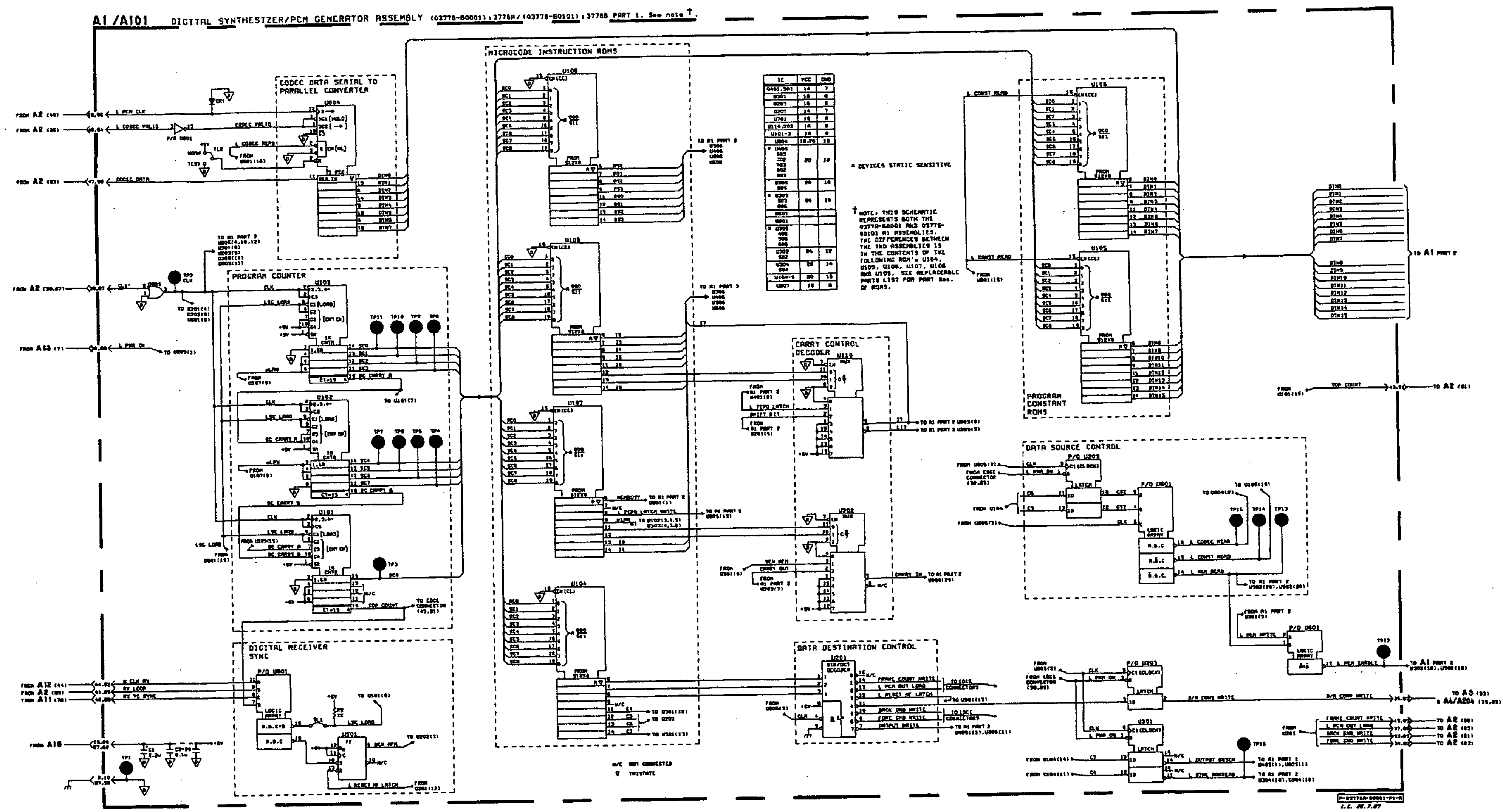


Figure A1-8 A1/A101 Schematic – Part 1

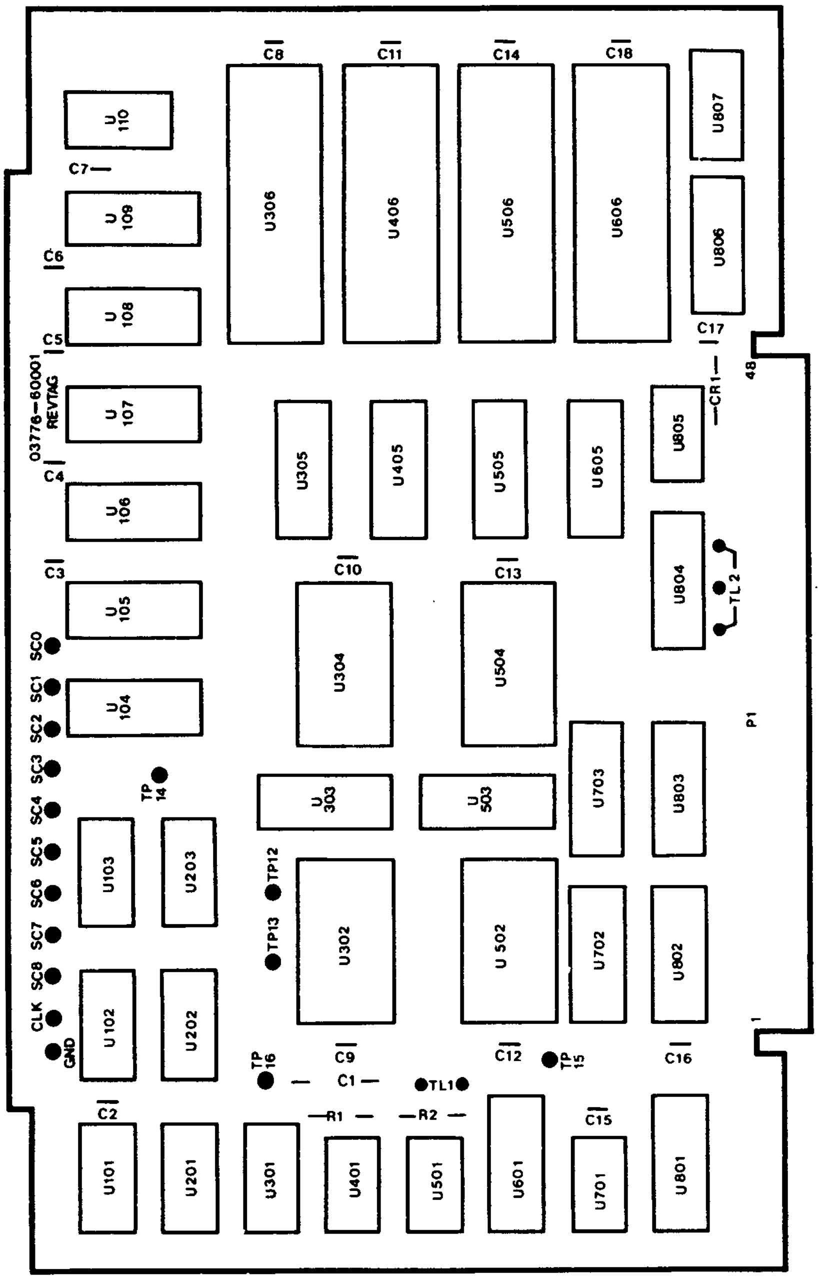


Figure A1-7 A1/A101 Component Location

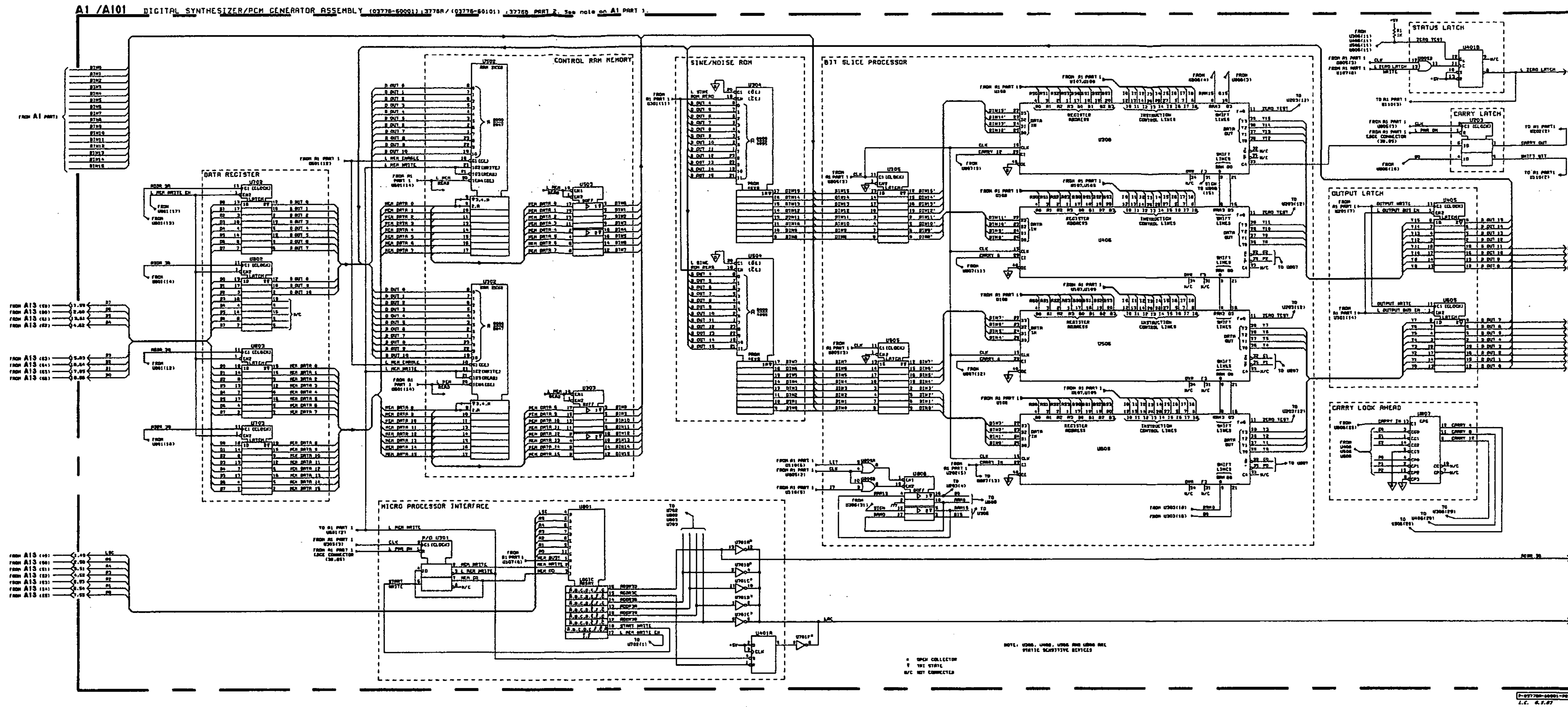


Figure A1-9 A1/A101 Schematic – Part 2

ASSEMBLY SERVICE SHEET A2/A102
DIGITAL PCM TRANSMITTER
A2 (3776A)/A102 (3776B)

A2-1 INTRODUCTION

A2-2 A major portion of the circuitry on A2/A102 forms the 3776 Digital PCM Transmitter, see Figure A2-1. The remaining circuitry forms two circuits and their functions are as follows:

1 Converts audio signals from an external generator or microphone to a binary form for insertion into a timeslot in the 3776 synthesized PCM frame structure. The external audio is applied to A2/A102 via the rear panel AUXILIARY INPUT.

2 Provides clock signals for use on the A1/A101 and A2/A102 assemblies.

A2-3 Digital PCM Transmitter

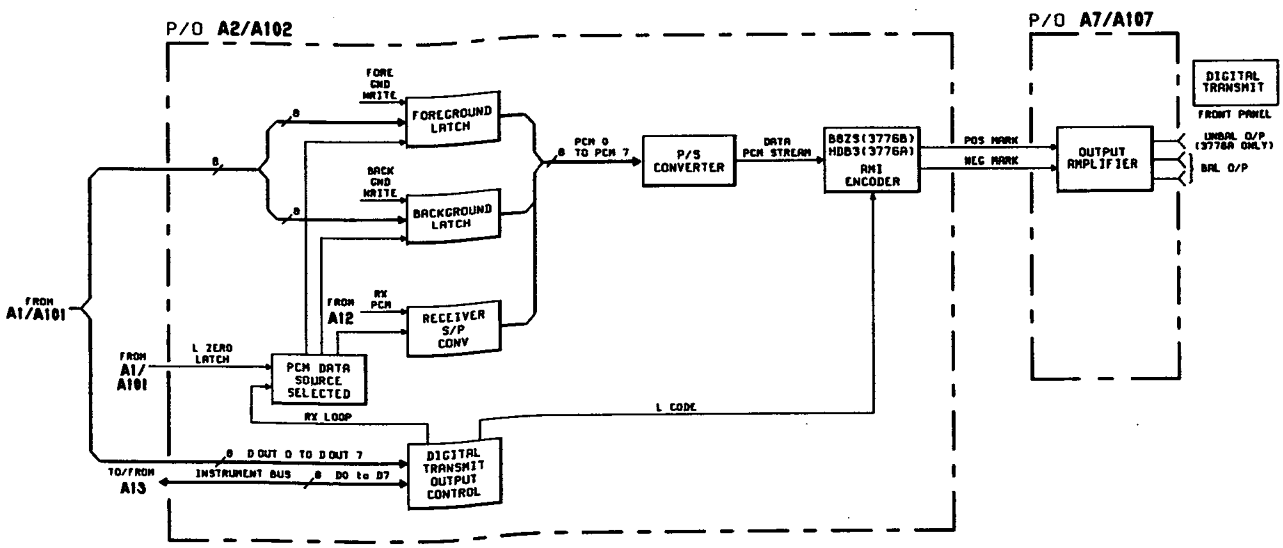


Figure A2-1 Digital PCM Transmitter

A2-4 The circuits forming the Digital PCM Transmitter are illustrated in Figure A2-1.

A2-5 Data for transmission is applied to the transmitter from two sources;

1 **Assembly A1/A101**: when the 3776A is performing D to A or D to D measurements or when an external signal is applied to the AUXILIARY INPUT.

2 **Assembly A12**: when the 3776A is in the THRU MODE and performing an A to A measurement on a 2 or 4-wire system. In a 2-wire system timeslot translation is normally required (see Paragraph A2-17).

A2-6 Data from A1/A101 is applied to A2/A102 as a sequence of 8-bit binary words D OUT (0 to 7). These words are latched into either the Foreground or Background PCM Latches (see Paragraphs A1-31 to 36) by either FORE GND WRITE or BACK GND WRITE depending on the output status of the PCM Data Source Selector. The outputs of the latches are then converted to a serial 2,048kb/s (3776A) stream of pulses (1,544kb/s for the 3776B). This bit stream is then HDB3/AMI (3776A) encoded and amplified (on A7/A107) prior to being transmitted at the 3776A DIG Tx output. In the 3776B the 1.544kb/s bit stream is B8ZS/AMI (AZS) encoded. The PCM Data Source Selector, controlled from A1/A101, determines whether Foreground or Background data is inserted into a timeslot.

A2-7 Test signals generated on A1/A101 are allocated specific timeslot(s) (via the front panel). These signals are known as the Foreground PCM signals.

A2-8 All timeslots not containing a Foreground PCM signal contain a Background PCM signal. This is set up by using the measurement DIG Tx-Rx front panel key.

A2-9 HDB3/AMI Encoding (3776A)

A2-10 AMI Code. AMI (Alternate Mark Inversion) is a bipolar or ternary (ie three level) code in which every second logic 1 or mark is transmitted as a negative-going pulse. This enables the PCM transmission line to be transformer coupled, ie the line can be used to carry the bit stream and the dc power supply to the regenerators. Because a single error on a line will always produce either two consecutive negative or positive pulses, errors can be detected using a simple Bipolar Violation Detector.

A2-11 HDB3 Code. Since there is no separate clock line, the regenerators in a PCM line need to extract clock timing information from the incoming stream. If long runs of zeros occur, the clock extraction circuitry drifts off the system frequency. This is overcome by substituting preselected zeros with marks. HDB3 (High Density Bipolar 3) code is similar to AMI code but makes a substitution whenever there are four or more zeros. The substitution must obey two rules, as follows:

1 The bipolar violation inserted, in place of the fourth zero must be of opposite polarity to the previous bipolar violation.

2 The fourth zero has to be a mark of the same polarity as the immediately preceding mark, thus violating the AMI rule (ie bipolar violation is introduced).

A2-12 In some instances the first zero in the more than three consecutive zeros pattern, may have to be changed in order to satisfy both of the conditions in Paragraph A2-11. This extra mark is added when there would be an even number of marks between successive bipolar violations (ie to satisfy rules 1 and 2 in Paragraph A2-11 there must be an ODD number of marks between violations). Figure A2-2 illustrates these points in diagram form.

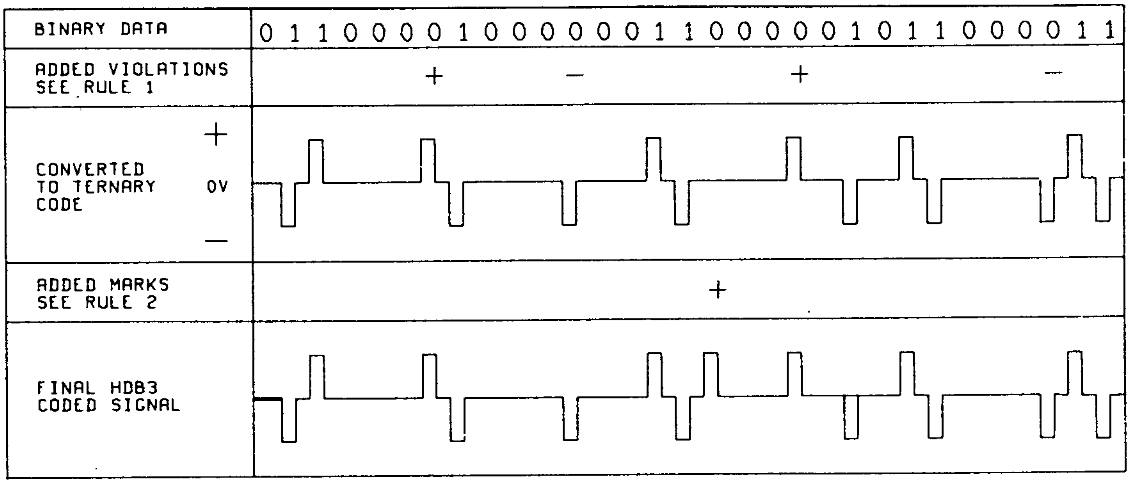


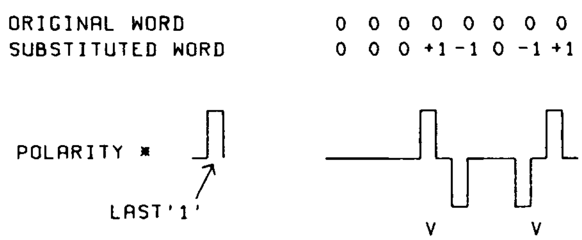
Figure A2-2 HDB3 Code Structure Diagram

NOTE: The illustration shows the positive & negative marks combined. On assembly A2/A102, they are coded and transmitted to the A7/A107 Output Stages separately.

A2-13 The HDB3/AMI Encoder encodes the input binary data as described in Paragraph A2-10 to A2-12, and applies the coded data to the Output Stage on A7/A107.

A2-14 B8ZS/AMI (AZS) Encoding (3776B)

A2-15 B8ZS Code. Since there is no separate clock line, the regenerators in a PCM line need to extract clock timing information from the incoming stream. If long runs of zeros occur, the clock extraction circuitry drifts off the system frequency. This is overcome by substituting preselected zeros with marks. B8Z3 (Bipolar 8 zeros substitution) code is similar to AMI code but makes a substitution whenever there are eight or more zeros. The substitution must obey the rules, shown in Figure A2-3.



*Assume last "1" transmitted was a positive "1". If last "1" transmitted was negative the POLARITY reverses. Bipolar violations (V) always occur at the 4th and 7th bit positions of the substituted word.

Figure A2-3 B8ZS Coding

ASSEMBLY SERVICE SHEET A2/A102
DIGITAL PCM TRANSMITTER
A2 (3776A)/A102 (3776B)

A2-1 INTRODUCTION

A2-2 A major portion of the circuitry on A2/A102 forms the 3776 Digital PCM Transmitter, see Figure A2-1. The remaining circuitry forms two circuits and their functions are as follows:

1 Converts audio signals from an external generator or microphone to a binary form for insertion into a timeslot in the 3776 synthesized PCM frame structure. The external audio is applied to A2/A102 via the rear panel AUXILIARY INPUT.

2 Provides clock signals for use on the A1/A101 and A2/A102 assemblies.

A2-3 Digital PCM Transmitter

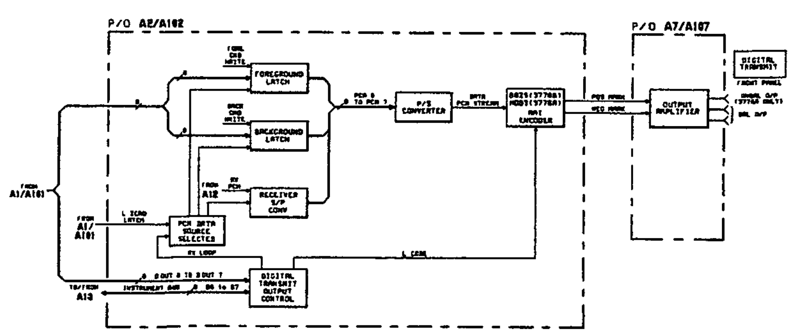


Figure A2-1 Digital PCM Transmitter

A2-4 The circuits forming the Digital PCM Transmitter are illustrated in Figure A2-1.

A2-5 Data for transmission is applied to the transmitter from two sources;

1 Assembly A1/A101: when the 3776A is performing D to A or D to D measurements or when an external signal is applied to the AUXILIARY INPUT.

2 Assembly A12: when the 3776A is in the THRU MODE and performing an A to A measurement on a 2 or 4-wire system. In a 2-wire system timeslot translation is normally required (see Paragraph A2-17).

A2-6 Data from A1/A101 is applied to A2/A102 as a sequence of 8-bit binary words D OUT (0 to 7). These words are latched into either the Foreground or Background PCM Latches (see Paragraphs A1-31 to 36) by either FORE GND WRITE or BACK GND WRITE depending on the output status of the PCM Data Source Selector. The outputs of the latches are then converted to a serial 2,048kb/s (3776A) stream of pulses (1,544kb/s for the 3776B). This bit stream is then HDB3/AMI (3776A) encoded and amplified (on A7/A107) prior to being transmitted at the 3776A DIG Tx output. In the 3776B the 1.544kb/s bit stream is B8ZS/AMI (AZS) encoded. The PCM Data Source Selector, controlled from A1/A101, determines whether Foreground or Background data is inserted into a timeslot.

A2-7 Test signals generated on A1/A101 are allocated specific timeslot(s) (via the front panel). These signals are known as the Foreground PCM signals.

A2-8 All timeslots not containing a Foreground PCM signal contain a Background PCM signal. This is set up by using the measurement DIG Tx-Rx front panel key.

A2-9 HDB3/AMI Encoding (3776A)

A2-10 AMI Code. AMI (Alternate Mark Inversion) is a bipolar or ternary (ie three level) côde in which every second logic 1 or mark is transmitted as a negative-going pulse. This enables the PCM transmission line to be transformer coupled, ie the line can be used to carry the bit stream and the dc power supply to the regenerators. Because a single error on a line will always produce either two consecutive negative or positive pulses, errors can be detected using a simple Bipolar Violation Detector.

A2-11 HDB3 Code. Since there is no separate clock line, the regenerators in a PCM line need to extract clock timing information from the incoming stream. If long runs of zeros occur, the clock extraction circuitry drifts off the system frequency. This is overcome by substituting preselected zeros with marks. HDB3 (High Density Bipolar 3) code is similar to AMI code but makes a substitution whenever there are four or more zeros. The substitution must obey two rules, as follows:

1 The bipolar violation inserted, in place of the fourth zero must be of opposite polarity to the previous bipolar violation.

2 The fourth zero has to be a mark of the same polarity as the immediately preceding mark, thus violating the AMI rule (ie bipolar violation is introduced).

A2-12 In some instances the first zero in the more than three consecutive zeros pattern, may have to be changed in order to satisfy both of the conditions in Paragraph A2-11. This extra mark is added when there would be an even number of marks between successive bipolar violations (ie to satisfy rules 1 and 2 in Paragraph A2-11 there must be an ODD number of marks between violations). Figure A2-2 illustrates these points in diagram form.

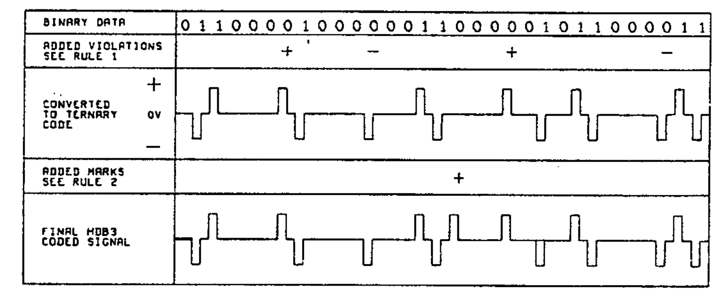


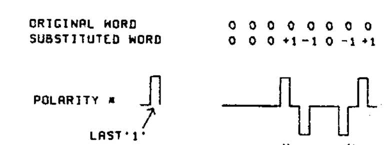
Figure A2-2 HDB3 Code Structure Diagram

NOTE: The illustration shows the positive & negative marks combined. On assembly A2/A102, they are coded and transmitted to the A7/A107 Output Stages separately.

A2-13 The HDB3/AMI Encoder encodes the input binary data as described in Paragraph A2-10 to A2-12, and applies the coded data to the Output Stage on A7/A107.

A2-14 B8ZS/AMI (AZS) Encoding (3776B)

A2-15 B8ZS Code. Since there is no separate clock line, the regenerators in a PCM line need to extract clock timing information from the incoming stream. If long runs of zeros occur, the clock extraction circuitry drifts off the system frequency. This is overcome by substituting preselected zeros with marks. B8Z3 (Bipolar 8 zeros substitution) code is similar to AMI code but makes a substitution whenever there are eight or more zeros. The substitution must obey the rules, shown in Figure A2-3.



*Assume last "1" transmitted was a positive "1". If last "1" transmitted was negative the POLARITY reverses. Bipolar violations (V) always occur at the 4th and 7th bit positions of the substituted word.

Figure A2-3 B8ZS Coding

A2-16 AZS: All Zero Suppression is used to eliminate the maximum PCM code level 0000 0000 in u-Law systems. With AZS, whenever this code occurs it is replaced by the next usable level down, ie 0000 0010 (the extreme right-hand digit is a signalling bit in bit stealing frames). This limits the length of runs of zeros and so simplifies clock extraction. Note that AZS is not a line code; the PCM code level 0000 0010 is a valid code level and can not be compensated for at the receive end. However, the error of 2 code level is only significant at very high signal levels.

A2-17 THRU MODE (see Paragraph A2-5)

A2-18 When operating in the PCM looped THRU MODE, PCM data (RX PCM) is applied to the transmitter from the Digital Receiver A12. RX PCM is a serial data stream, it is first converted to an 8 bit parallel form for insertion into a Timeslot and then latched into the Receiver PCM Latch on A2/A102. This data is converted to a serial 2,048kbit/s stream of pulses, HDB3/AMI encoded and amplified (on A7/A107) prior to being transmitted at the 3776A DIG Tx output. In the 3776B the bit rate is 1.544kb/s and is B8ZS/AMI encoded.

A2-19 Figure A2-4 illustrates how the 3776 is connected up for an A to A measurement on a 2-wire system using the Digital THRU and Timeslot Translation facility.

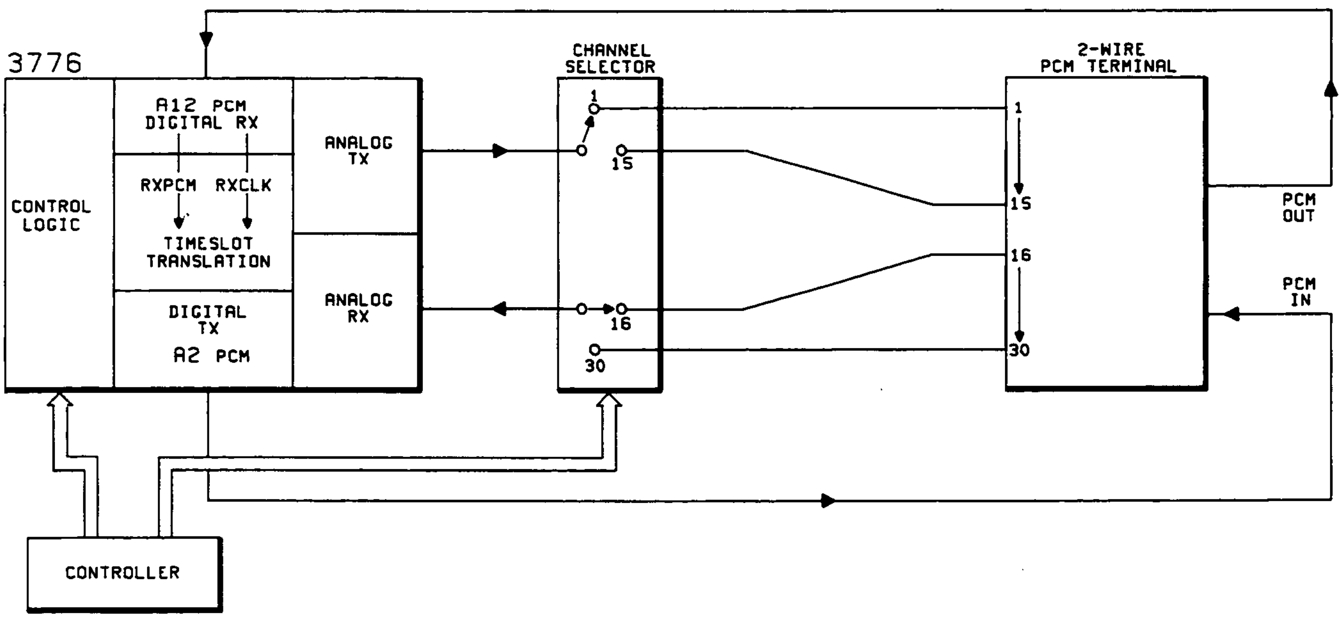


Figure A2-4 A-A Measurement

A2-20 The RX PCM signal, and the synchronising signal RX CLK, on A12, are looped back to the transmitter on A2/A102 with timeslot tanslation if required (see Paragraph A12-41).

A2-21 AUXILIARY INPUT (rear panel)

A2-22 Under certain circumstances the 3776 operator may require to transmit an externally applied audio signal. This is achieved by applying the audio signal from a microphone or external generator, to the rear panel AUXILIARY INPUT.

A2-23 The audio signal is sampled in a codec at an 8kHz rate by the Codec Timing circuit. This sampled audio signal is then converted to a binary form by the codec for insertion into a timeslot in the PCM frame structure. This signal compressed by the codec is put into the required timeslot by the Bit Slice Processor on A1/A101. Timeslot selection is done manually via the front panel DIGITAL Tx TIMESLOT key or by HP-IB. The data from A1/A101 is transmitted as per Paragraph A2-6. Figure A2-5 illustrates the data flow of the AUXILIARY INPUT.

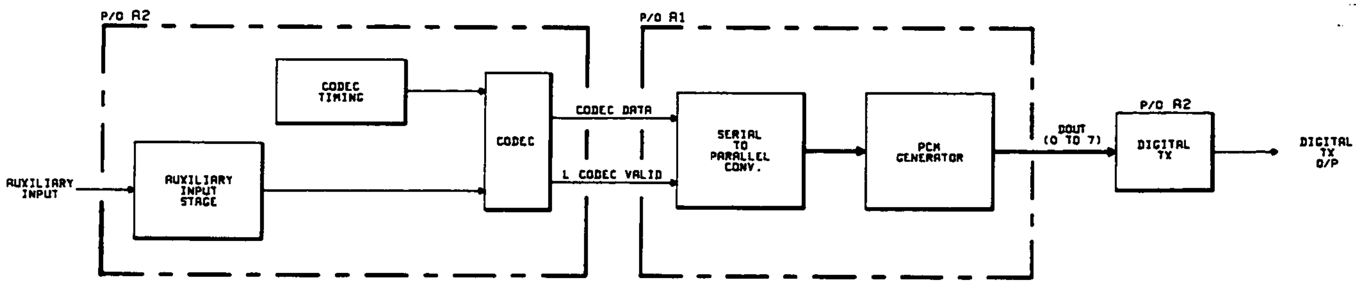


Figure A2-5 AUXILIARY INPUT

A2-24 Clock Selection

A2-25 The main clock signals required for the circuits on the A1/A101 and A2/A102 assemblies are provided by the Clock Selection circuit on A2/A102.

A2-26 CIRCUIT DESCRIPTION

A2-27 PCM Data Source Selector

A2-28 Foreground, Background or Receiver PCM data is inserted into a timeslot during a digital transmission. However only one source of PCM data can be selected. PCM data source selection is achieved using two 2 to 4 line decoders U303A and U303B. These decoders are enabled at a 2,048kb/s (3776A) or 1,544kb/s (3776B) rate by L PCM CLK. When enabled, the decoders select the appropriate PCM data source by enabling the outputs of the appropriate PCM Latch. The enable signals L FORE READ, L BACK READ and L RX READ are produced by decoding L ZERO LATCH and RX LOOP.

Table A2-1 Source Selector

L ZERO LATCH	RX LOOP	L PCM CLK	Description
0	DON'T CARE	↓	Foreground PCM Enabled
1	0	↓	Background PCM Enabled
1	1	↓	Receiver PCM Enabled

A2-29 Foreground and Background PCM Latches

A2-30 Foreground and Background Latches U404 and U405 store the PCM Frame data D OUT (0 to 7) from the Bit Slice Processor on A1/A101. The timing of when to store data in U404 is determined by FORE GND WRITE and for U405 by BACK GND WRITE from A1/A101.

A2-31 Receiver Serial to Parallel Converter and Receiver PCM Latch

A2-32 When the 3776A is in the PCM looped THRU MODE for an A to A measurement, digitally received data on A12 (RX PCM) is applied to the Receiver Serial to Parallel Converter. This RX PCM data is converted to a parallel form for insertion into a timeslot in the PCM Frame Structure. The parallel data is allocated its timeslot by the timing of L RX LOAD, L RX READ from U303B and the L RX CLK signal together with RX TC SYNC from A11/A111 to A1/A101. These signals determine when the parallel data is stored in U406.

A2-33 Parallel to Serial Converter

A2-34 Each set of 8 bits (timeslot word) from the Foreground, Background and Receiver PCM Latches is converted to a serial format by U306. This serial data is then encoded before transmission via the DIG Tx output. The L PCM OUT LOAD signal routed via flip flop U305B latches the PCM (0 to 7) data into U306 at an 8kHz rate. The data stored in U306 is serially shifted to the HDB3/AMI Encoder (3776A) or B8ZS/AMI(AZS) (3776B) by L PCM CLK at a 2,048kHz (3776A) or 1,544kHz (3776B) rate.

A2-35 HDB3/AMI Encoder (3776A)

A2-36 This circuit implements either AMI or HDB3 encoding, see Paragraphs A2-9 to 13, depending on the level of L CODE. When L CODE is high the encoder is AMI encoding when low it HDB3 encodes.

A2-37 When the circuit is AMI encoding the logic '1' levels or marks in the input DATA BIT STREAM appear at the output as alternate POS and NEG MARKS.

A2-38 When the circuit is HDB3 encoding the circuit can be split in two sections;

1 four zeros detector and substitute "1000" generator (inserts a bipolar violation in place of fourth zero)

2 circuitry implementing HDB3 and AMI encoding

A2-39 The flip flops U309A to U309D and NOR gate U310B detect the four zeros and insert the bipolar violation. The rest of the circuitry implements the rules outlined in Paragraphs A2-9 to 13.

A2-40 AUXILIARY INPUT - Auxiliary Amplifier, Codec and Codec Timing

A2-41 When an external balanced audio signal is applied via the 600ohm AUXILI INPUT, it is converted to a single ended form by a unity gain amplifier comprising U312A to U312C. The output of U312C splits into two signal paths; to the Codec for digital transmission and to U312D for analog transmission of AUX SIG via A3.

A2-42 The audio signal in the digital path is sampled at an 8kHz rate by CODEC SYNC, from the Codec Timing circuit (see Figure A2-6), to enable audio signal samples to be synchronised to the PCM System. The sampled signal decoded by codec U212 is applied to A1/A101 as a binary sequence along with L CODEC VALID which latches the binary sequence into a register on A1/A101.

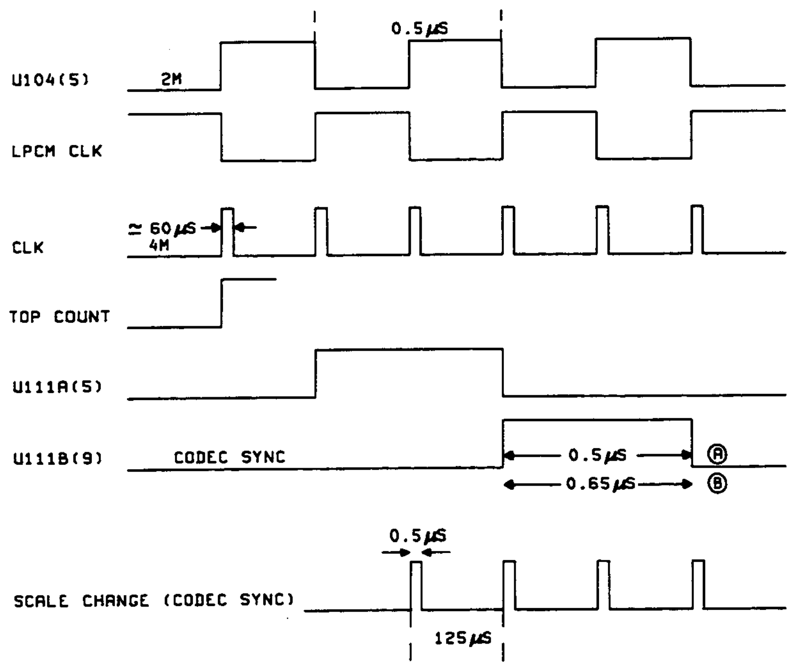


Figure A2-6 Codec Timing Diagram

A2-43 Digital Transmit Output Control

A2-44 This circuit receives data from A1/A101 and also transmits/receives data to/from the processor on A13 to control the operation of the circuits on Assembly A2/A102. The Handshake logic between the A2/A102 and A13 assemblies is contained on A1/A101 (ADDR 3D). When using Signature Analysis (SA) to troubleshoot A2/A102, the END OF MF signal at U304(12) is used as the SA start/stop control signal.

A2-45 Clock Selection

A2-46 This circuit comprising U203, U104 and monostable U401 provides the clock signals for Assemblies A1/A101 and A2/A102. Most clocks run at 2,048kHz (3776A) or 1.544kHz (3776B) rate with the exception of CLK which runs at 4,096 (3776A) or 3,088kHz (3776B). These clocks are derived from either the P CLK from A13; the DIG TX EXT CLK from the rear panel or the N CLK RX from A12. Selection is controlled from the Digital Transmit Output Control.

A2-47 CLK is produced by adding a delay to one of the signal paths to the Exclusive OR gate U205A (see Figure A2-7). By running at twice the other clock rates CLK enables the Program Counter on A1/A101 to provide enough addresses (256) in 125us to perform the A1/A101 software routine. CLK also enables all the Bit Slice Processor instruction to be carried out over one period of CLK because the narrow pulses disable the Bit Slices for only 60ns.

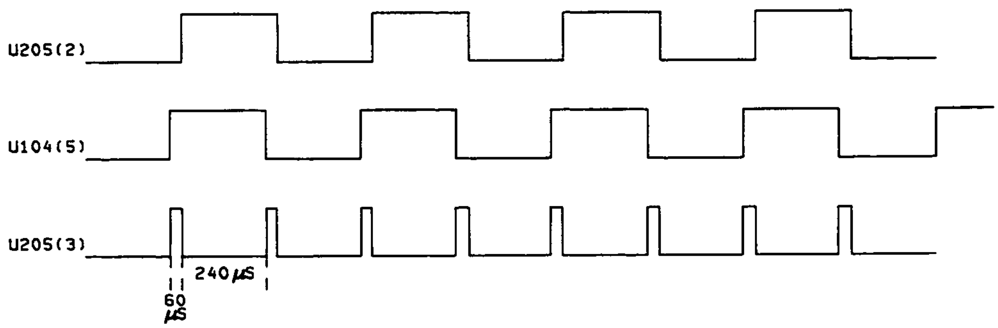


Figure A2-7 CLK Generation

A2-48 If there is loss of clock, monostable U401 triggers, producing INHIBIT and L INHIBIT. The INHIBIT signal fed via U402(4) informs the processor on A13 of the loss of clock signal while the L INHIBIT disables the output of the HDB3/AMI Encoder (3776A or the B875/AMI (ASZ) Encoder (3776B) at U409 (5,9), forcing zero on to the output of the PCM transmitter.

A2-49 Loop Timing

A2-50 The clock recovery circuits in PCM systems are checked by the Loop Timing circuit. This circuit checks to see that the system clock extracted from the received PCM stream is synchronised with the clock in the 3776 transmitted PCM stream. The 3776 gives a pictorial indication of Loop Timing on the front panel RESULTS display. When the received clock is at the same frequency as the 3776 transmitted clock a stationary pattern is obtained. When the clock frequencies are different a rotating pattern is obtained.

A2-51 The Loop Timing circuit on A2/A102 (comprising two counters and a Latch) compares the clocks L PCM CLK and RX CLK. When the clocks are synchronised the same bit pattern (Loop 0 to Loop 3) is continuously obtained at the output of the Loop Timing circuit. This pattern is fed back to the A13 assembly and finally produces a stationary pattern on the front panel RESULTS display.

A2-52 Digital transmitter troubleshooting information is contained in GENERAL SERVICE SHEET G5.

CODEC GAIN
ADJUSTMENT

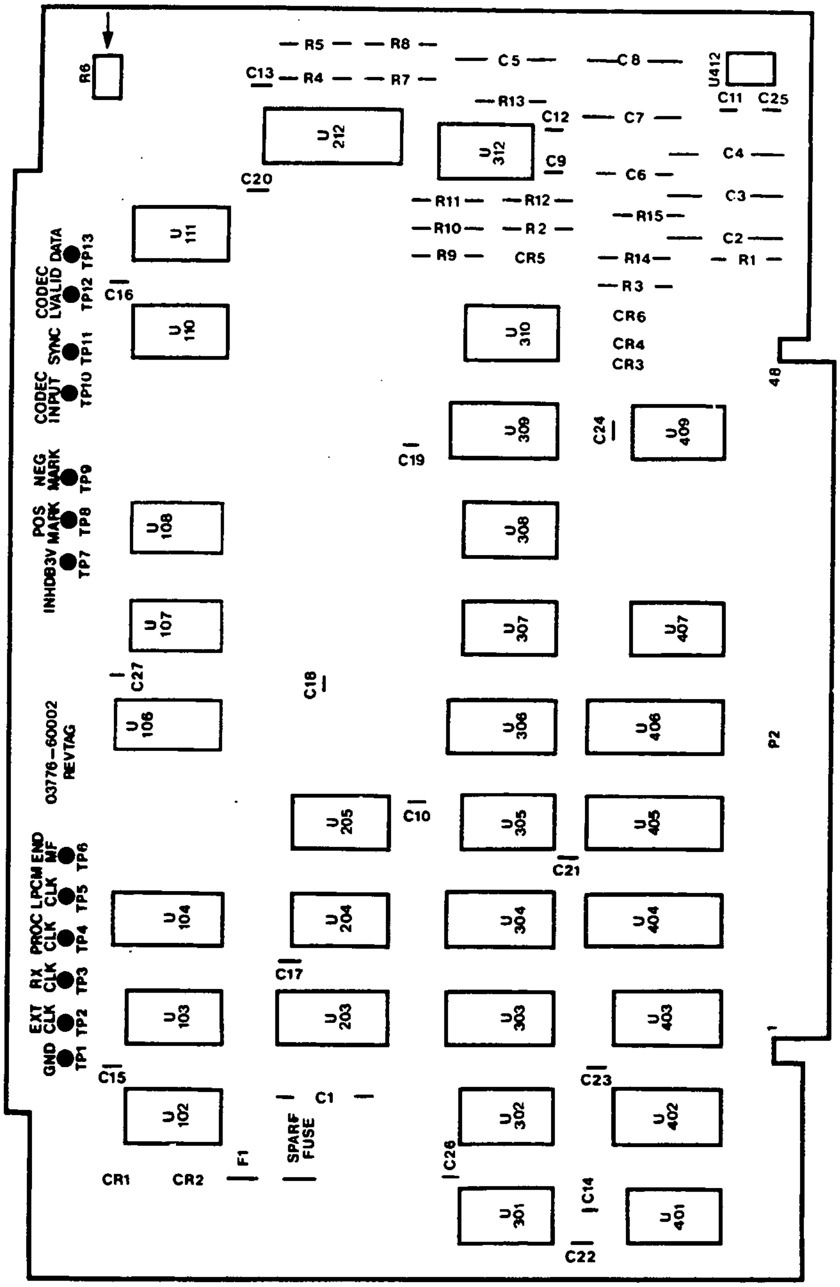


Figure A2-8 A2 Component Location

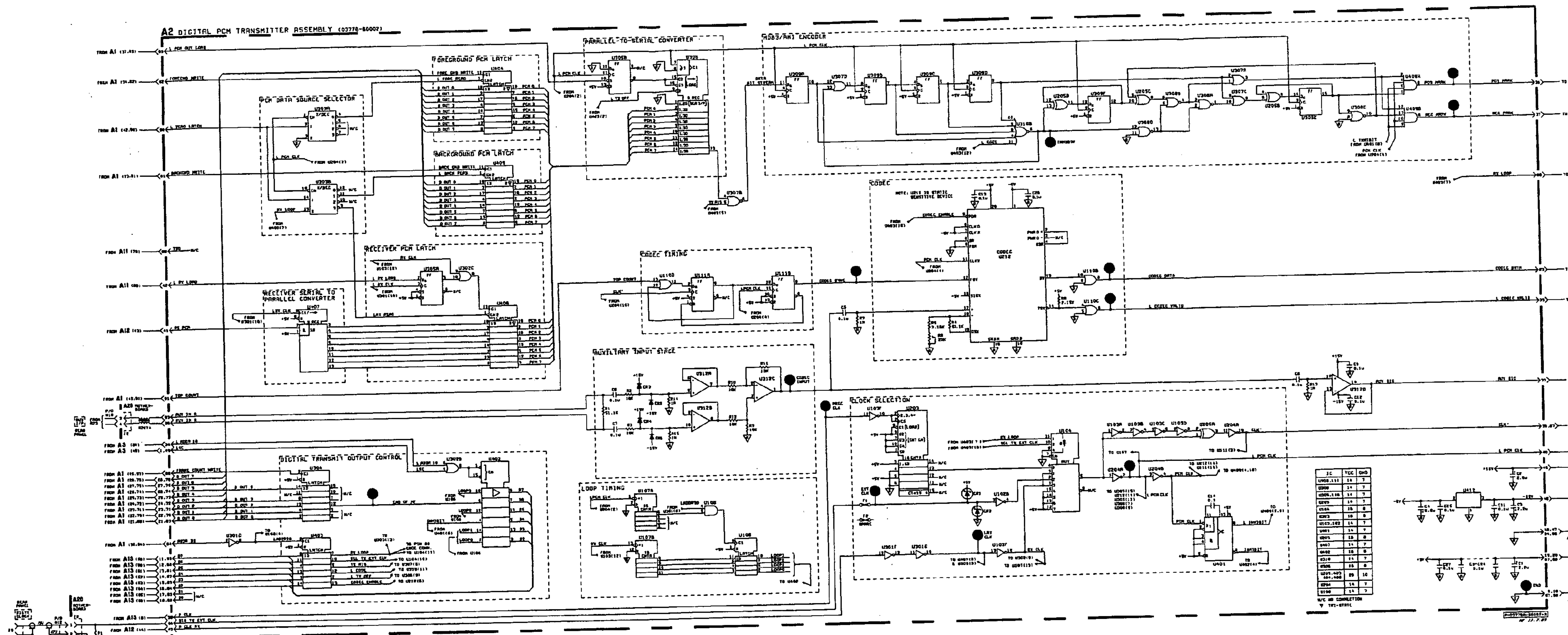


Figure A2-9 A2 Schematic

CODEC GAIN
ADJUSTMENT

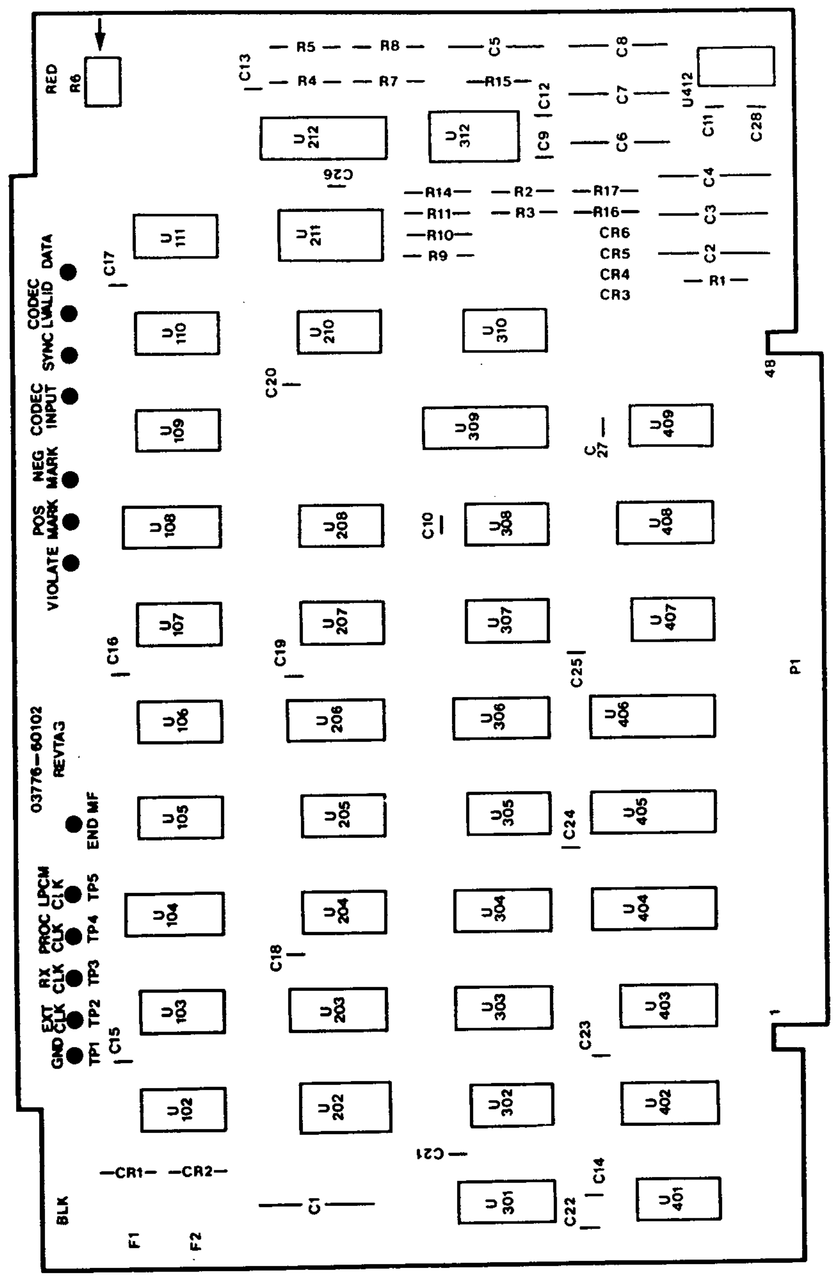


Figure A2-10 A102 Component Location

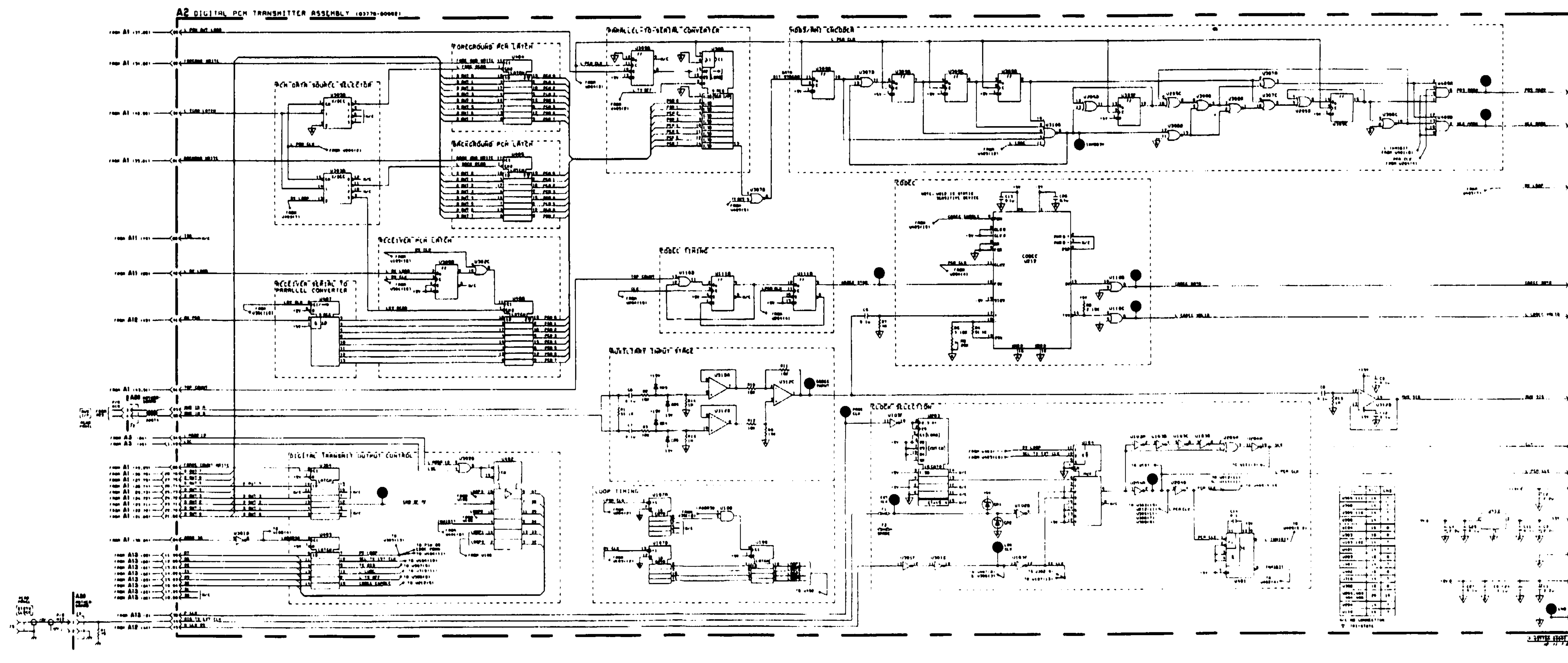


Figure A2-9 A2 Schematic

CODEC GAIN
ADJUSTMENT

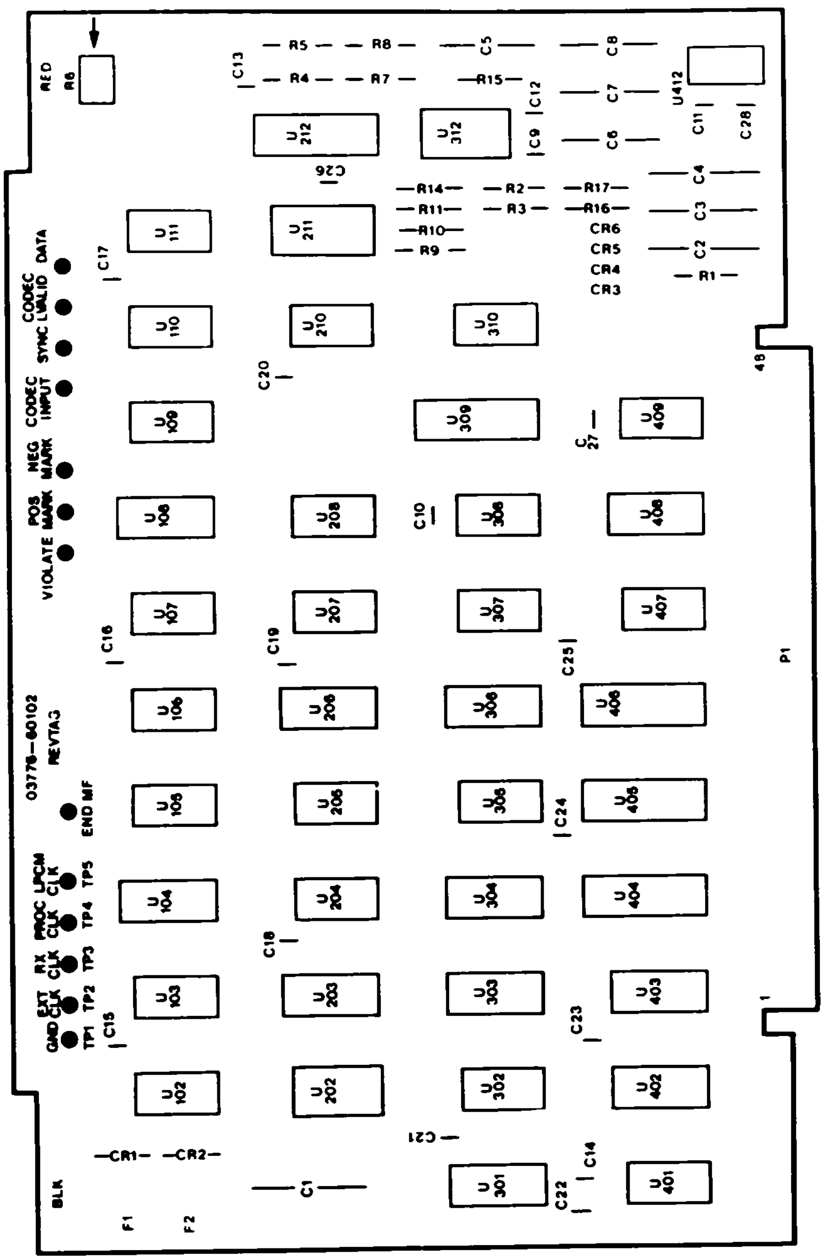


Figure A2-10 A102 Component Location

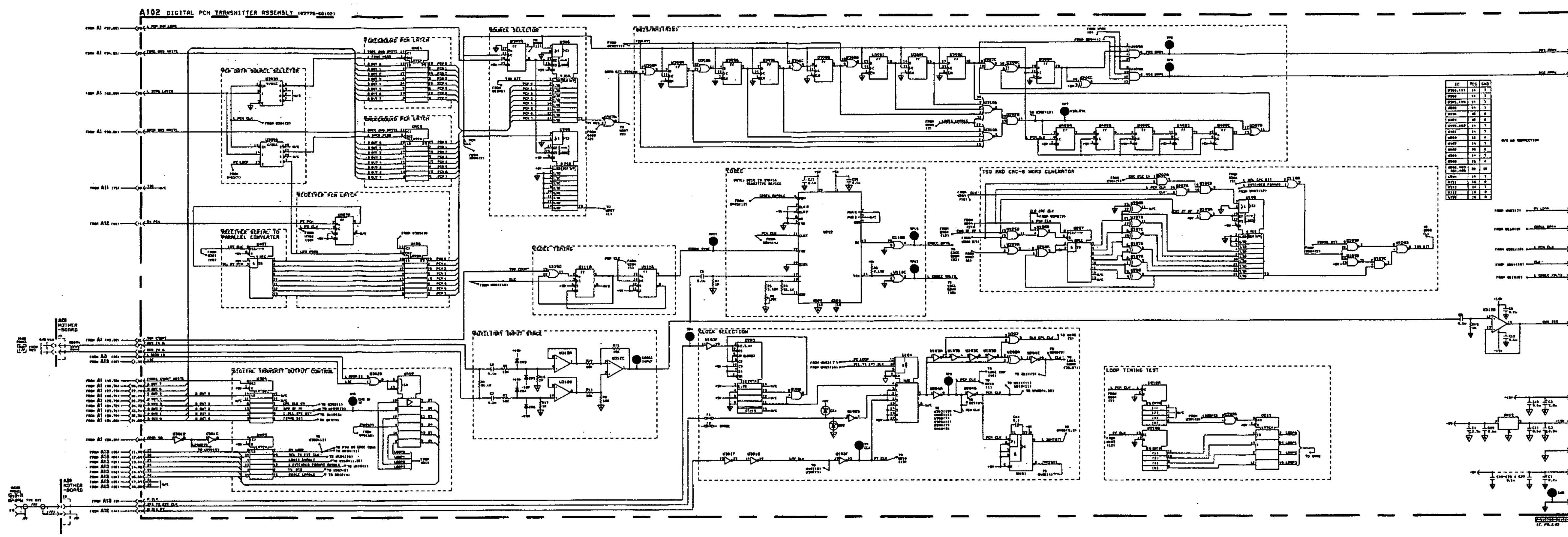


Figure A2-11 A102 Schematic

ASSEMBLY SERVICE SHEET A3
ANALOG TRANSMITTER

A3-1 INTRODUCTION

A3-2 When operating the 3776 in the ANALOG TRANSMIT mode, the level and frequency parameters for transmission are keyed in via the front panel. The selected frequencies synthesized as 12 bit binary words on A1/A101 are converted to an analog form on A3, prior to transmission. The required signal level is determined by the gain and attenuator stages on A3 and by the digital attenuators on A1/A101 and A2/A102. Figure A3-1 illustrates the main circuit elements on A3.

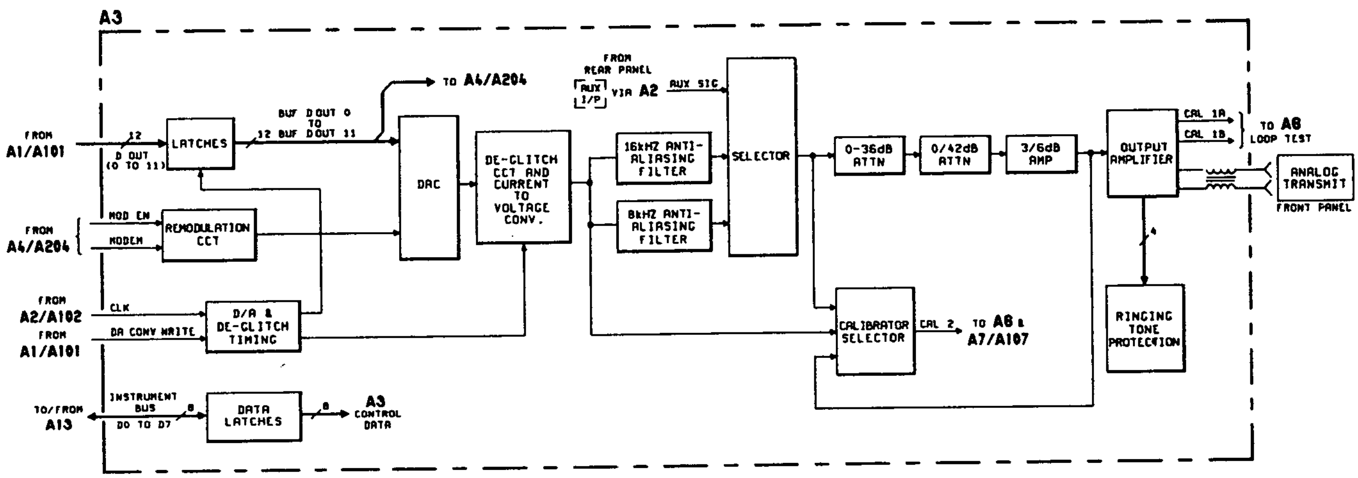


Figure A3-1 A3 Block Diagram

A3-3 The binary data D OUT 0 to D OUT 11 from A1/A101 is stored in latches on A3 prior to analog conversion by a DAC (digital to analog converter). The outputs of the Latches are also applied to A4/A204 during self-test.

A3-4 Analog signals from the DAC are applied to 3 paths via a De-glitch circuit and a Current to Voltage Converter (see Figure A3-1). The De-glitch circuit open-circuits the DAC output path during changes in the binary input data. This prevents transients from corrupting the analog output waveform. De-glitch timing is controlled from A1/A101 by D/A CONV WRITE.

A3-5 Analog waveforms from the DAC are applied to the 16kHz and 8kHz Anti-aliasing Filters and to the Calibrator Selector. The 16kHz Anti-aliasing Filter has a flat response to 4kHz and then falls off to attenuate by 60dB aliasing signals around 16kHz. The 8kHz Anti-aliasing Filter is flat to 1.6kHz and rejects aliasing signals around 8kHz. The Calibration Selector path is used during the 3776 Calibrator routines. A Phase Correction circuit is inserted in the 16kHz Anti-aliasing Filter path to correct phase distortion.

A3-6 Both Anti-aliasing filters and the AUX SIG from the rear panel AUX I/P are applied to the Selector on the main signal path. Path selection is controlled by the processor on A13 via the Data Latches. The output of the Selector is applied to the transmitter attenuator and gain stages and to the Calibrator Selector.

A3-7 Attenuator and gain stages (0->36dB and 0/42dB Attenuators and the 3/6dB Amplifier) are controlled by the processor on A13 via the Data Latches. The attenuation and gains of these circuits are accurately determined during the 3776 Calibrator routine.

A3-8 The Selector and 3/6dB Amplifier outputs are applied to the Calibrator Selector and then routed to A8 during the 3776 Calibration routine.

A3-9 The Output Amplifier provides analog transmit output buffering and also provides either a balanced or single-ended output termination.

A3-10 The ANALOG TRANSMIT output is protected against the improper application of a ringing tone. When this occurs the Output Protection circuit operates relays within the Output Amplifier which open circuit the ANALOG TRANSMIT output paths.

A3-11 REMOD Mode

A3-12 The 3776 operates in the REMOD mode during Group Delay (3776A) and Envelope Delay Distortion (3776B) measurements (see Figure A3-2). The envelope from the GO path is demodulated in the receiver of the SLAVE 3776 then remodulated on A3 (see Figure A3-1) onto a new carrier prior to retransmission along the RETURN path.

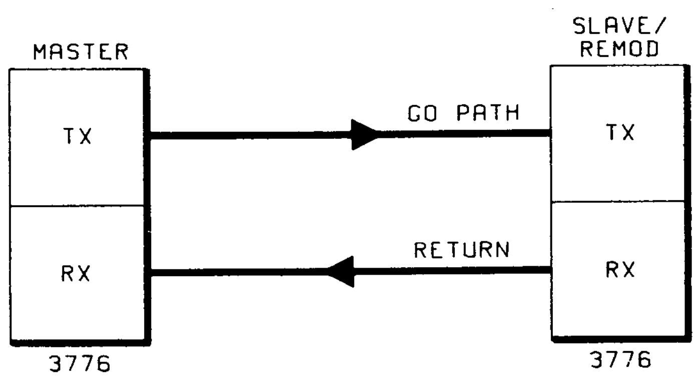


Figure A3-2 Group Delay/Envelope Delay Distortion Measurement

A3-13 CIRCUIT DESCRIPTION

A3-14 D/A Converter

A3-15 When D/A CONV WRITE goes low, counter U43 is incremented from its preloaded value (6) by CLK from A2. When U43(11) goes high the de-glitch FET Q31 goes high impedance (drain to source), the Data Latches U53 and U54 are also enabled. When the change in level at U43(12) is low to high (↑) the binary data D OUT 0 to D OUT 11 is latched into U53 and U54 and converted to an analog form by DAC U33. After the DAC has settled U43(11) goes low and removes the enable signal from the Data Latches and also switches-on FET Q31. The current drive from U33 is now converted to a voltage at TP11 by U34/C40.

A3-16 8kHz, 16kHz Anti-aliasing Filters and Phase Correction

A3-17 These circuits are active networks with complex feedback loops. If either anti-aliasing filter is suspected of being faulty, they may be checked out by removing test links TL1 to TL4 and by following the appropriate section in GENERAL SERVICE SHEET G7.

A3-18 Selector & Calibration Selector

A3-19 These two circuit elements each comprises three similar switch networks which comprise a FET switch and op amp driver. The op amps are controlled by path selection data from Data Latch U31. The output of the Calibration Selector has FETs Q19/Q24 in the CAL2 path. When Q19/Q24 are high impedance (drain to source), CAL2 is isolated from A6 and A7/A107.

A3-20 0 ->36dB Attenuator, 0/42dB Attenuator and 3/6dB Amplifier

A3-21 The resistor networks which make up the 0 ->36dB and 0/42dB Attenuators are all switched to GND by similar switching networks. When 6dB of attenuation is selected, L 6dB ATT from U32 allows Q1 to saturate and 3V is applied to Q9 via R3C which in turn saturates Q9; R18 is effectively shorted to GND. The gain of U14 is similarly switched between 3 and 6dB by the signal H 3dB to the base of Q5. The amount of A3 autoranging is shown by the LEDs listed in Table A3-1.

Table A3-1 Autoranging LED Indicators

LEDs	0 —> 36dB Attenuator						0/42dB Attenuator		3/6dB Amplifier	
	6dB	12dB	18dB	24dB	30dB	36dB	0dB	42dB	3dB	6dB
CR14	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
CR15	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
CR16	OFF	ON	ON	OFF	ON	ON	OFF	OFF	OFF	OFF
CR17	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF
CR18	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
CR19	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF

A3-22 Output Amplifier

A3-23 The Output Amplifier sets the ANALOG TRANSMIT output terminations and provides output buffering. In the BALance 600ohm termination mode H ATX DCNCT, L BAL OP and L 600 TERM are all low. This causes Q15 and Q16 to short circuit, which allows the signal at TP14 to be routed via TP15 and TP16 and K4A/B to produce a 600ohm BALanced signal at the front panel ANALOG TRANSMIT output. In the unbalanced mode Q15 is open circuit and the signal at TP14 is applied to the transmitter output via TP16. The other transmitter output is GND via K3B.

A3-24 Ringing Tone Protection and Relays

A3-25 Four points at the ANALOG TRANSMIT output are monitored for ringing tone. If a ringing tone is detected U21 is triggered which causes the output of U55 (V RELAY) to crash. This causes the relays to set to their normally closed (NC) position which isolates the ANALOG TRANSMIT output.

A3-26 Remodulation Mode

A3-27 The Remodulation circuit comprising U21/U22 and Q29 is enabled by applying MOD EN to the source of Q29. The demodulated envelope from A4/A204 is then fed to U33(6, 8) to modulate the current output of the DAC (see Paragraph A3-12).

A3-28 LEDs

A3-29 The LEDs are located at the output of the Data Latches to give an indication of the A3 set-up conditions.

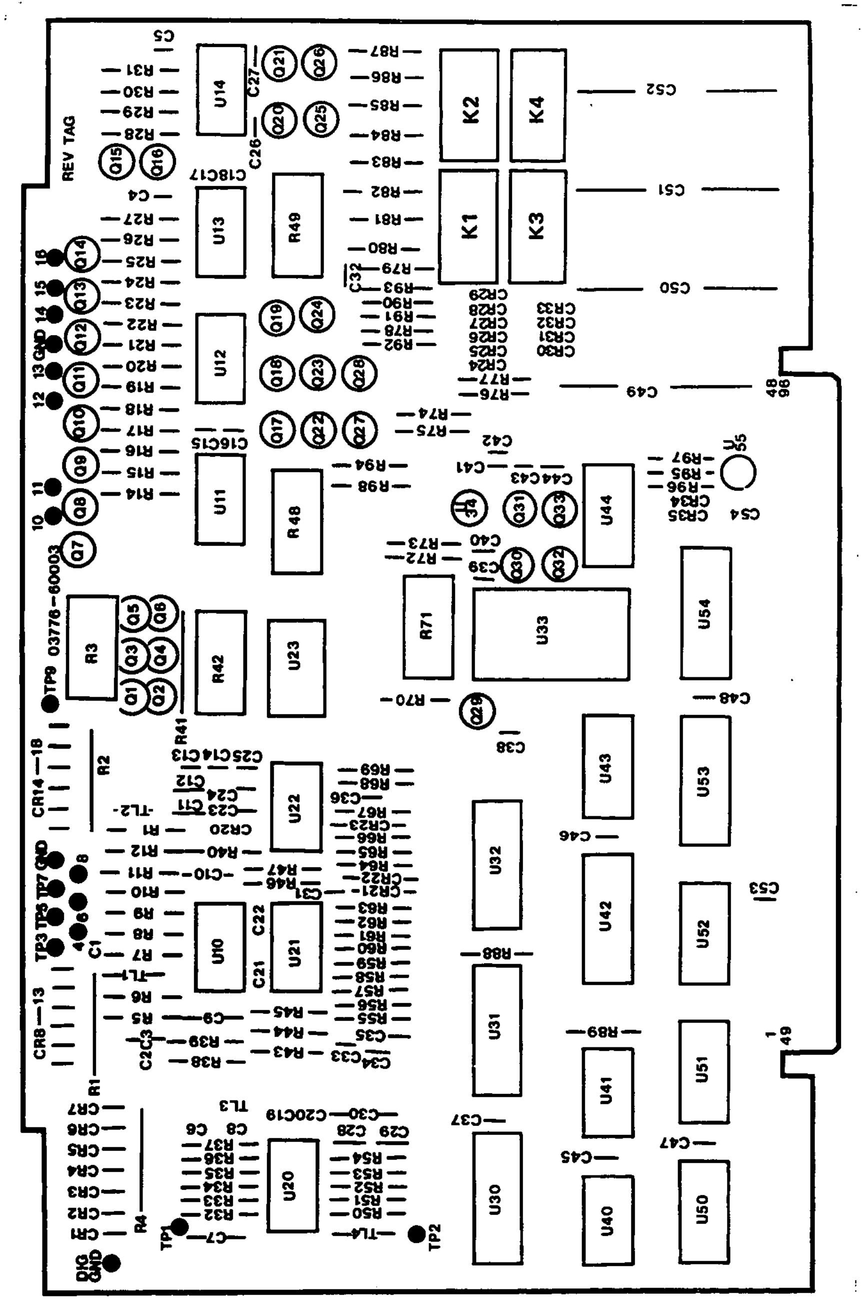


Figure A3-3 A3 Component Location

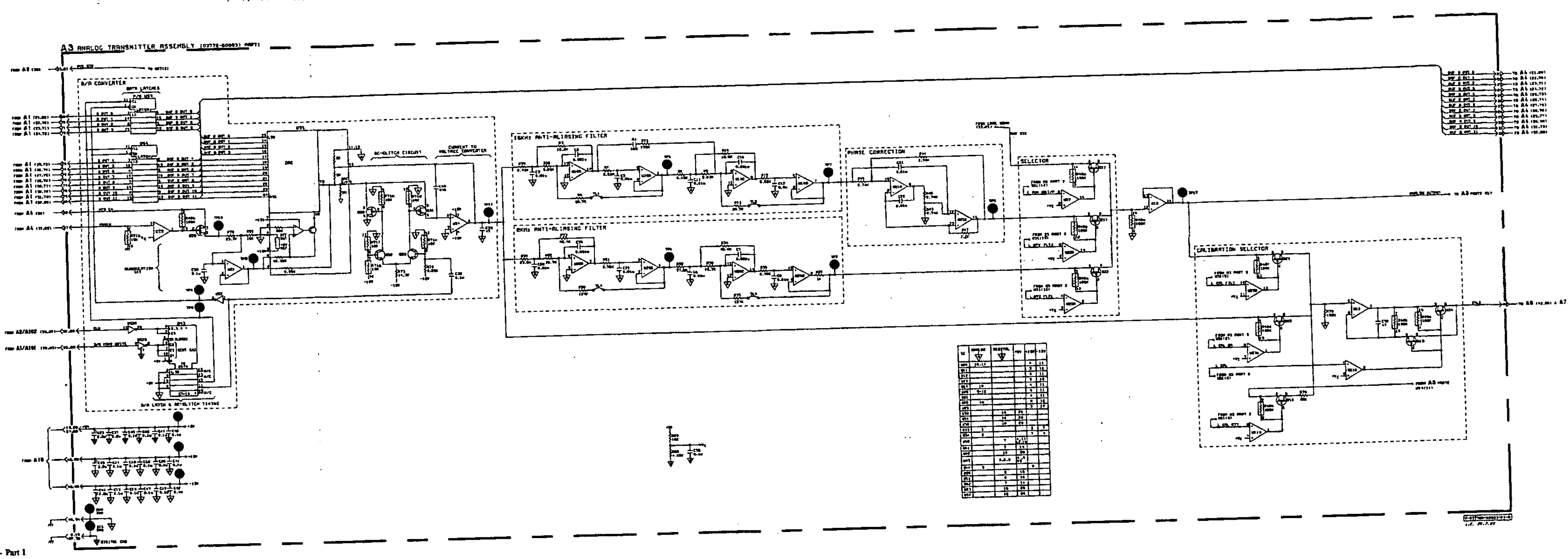


Figure A3-4 A3 Schematic – Part 1

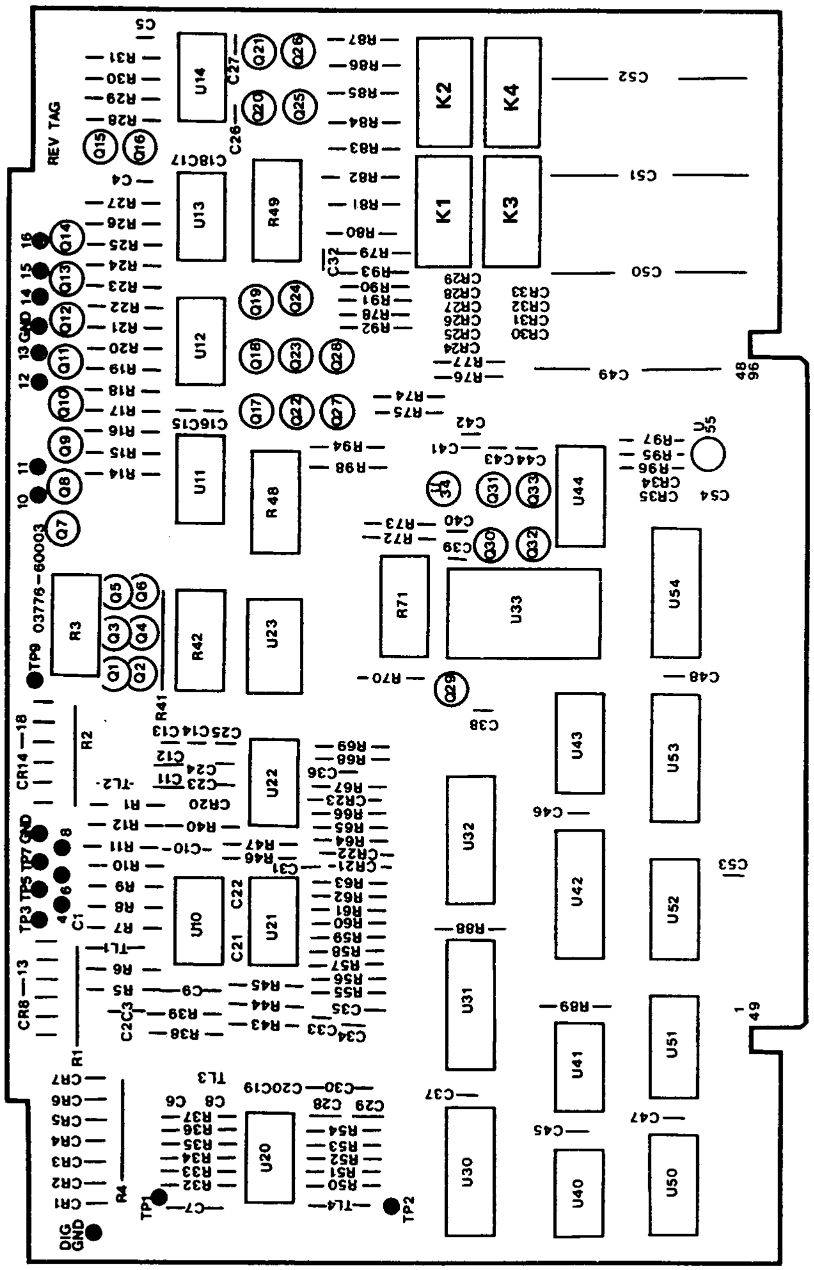


Figure A3-3 A3 Component Location

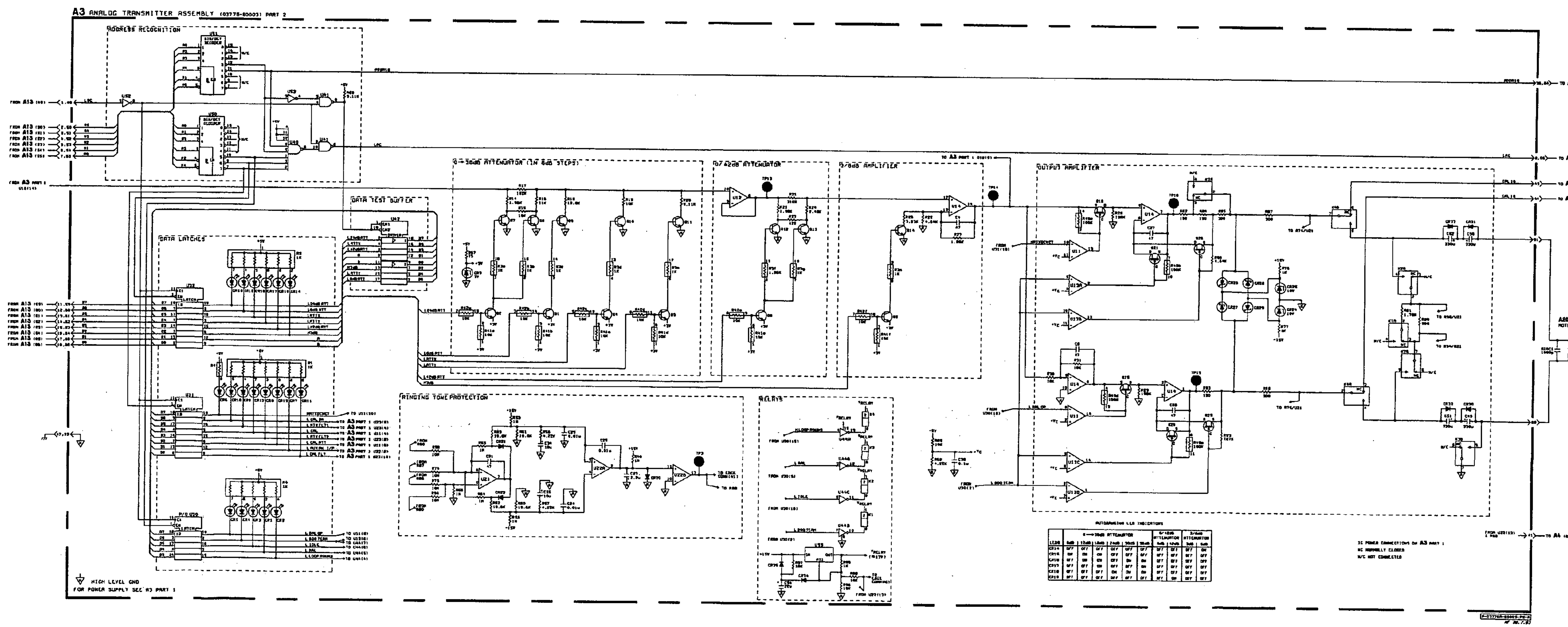


Figure A3-5 A3 Schematic – Part 2

ASSEMBLY SERVICE SHEET A4/A204
ANALOG MONITOR
A4 (STANDARD)/A204 (OPTION 001)

A4-1 INTRODUCTION

A4-2 Parallel data from Transmitter A3 or serial data from the Receiver Digital Filter on A9 is converted to an analog form by the D/A Converter on A4/A204. The filtered output DA CONV OUT is then applied to one of the following for further processing (also see Figure A4-1 A4/A204 Block Diagram):

1 Audio Output (standard and option)
*2 external 600ohm MONITOR OUTPUT
*3 A5 transients
*4 A3 for remodulation
*5 Envelope Delay Distortion circuits

*A204 (Option 001) only

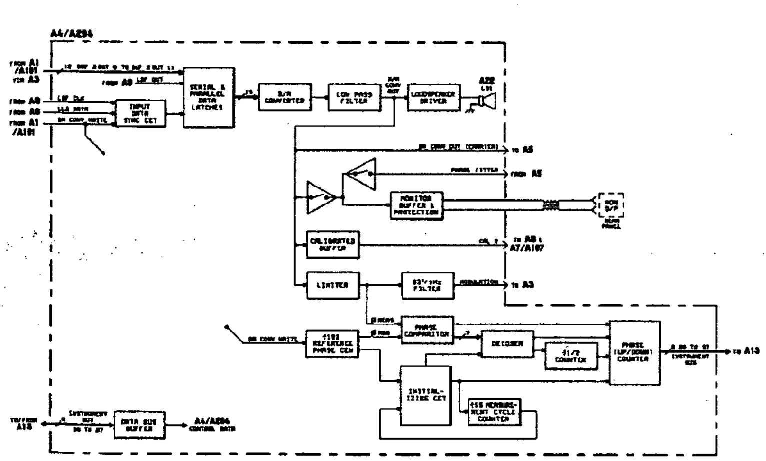


Figure A4-1 A4/A204 Block Diagram

A4-3 An audio output, in the form of a loudspeaker A22LS1, enables the operator to listen to test information. The Monitor Buffer and Protection circuit provides a 600ohm balanced MONITOR OUTPUT which allows test data to be processed by other instruments. When the 3776 is in the TRANSIENTS and REMOD mode, DA CONV OUT is routed to the A5 and A3 Assemblies respectively.

A4-4 DA CONV OUT is also utilised during the calibration routine, producing CAL2 which is then applied to A6.

A4-5 Envelope Delay Distortion/Absolute Delay Distortion

A4-6 Envelope Delay Distortion (EDD) is measured using the waveform as illustrated in Figure A4-2. The two main configurations for measuring EDD are illustrated in Figure A4-3. They are the loop back and end to end configurations. The end to end mode uses the REMOD facility described in the following paragraphs. During the EDD measurement the processor performs an attenuation distortion measurement on carrier signals.

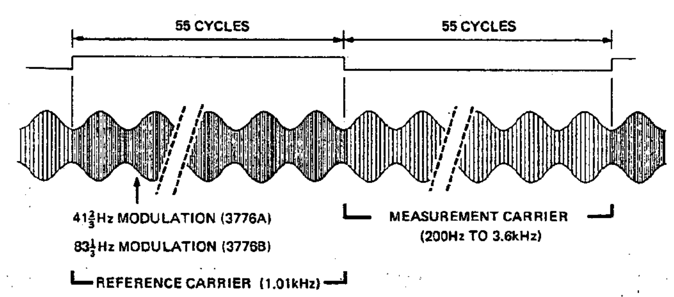


Figure A4-2 Envelope Delay Distortion Waveform

A4-7 In Envelope Delay Distortion measurements, the Master 3776 (in the EDD mode) applies a 83 1/3Hz (3776B) or 41 2/3Hz (3776A) modulated carrier (200Hz to 3.6kHz) signal to a test channel. Slave (in the REMOD mode) 3776 recoevers the 83 1/3Hz or 41 2/3Hz envelope and remodulates it on to a 1.10kHz reference carrier which is then transmitted back to the Master 3776, where the phase of the 83 1/3Hz or 41 2/3Hz envelope is checked against a reference and the Envelope Delay Distortion computed. Consider the 83 1/3Hz envelope for the remainder of the description.

A4-8 Two measurement steps are necessary in computing the Envelope Delay Distortion. First 55 cycles of the 83 1/3Hz modulated 1.01kHz reference signal IP PH-REF are applied around the loop of Figure A4-3b and the phase of the 83 1/3Hz envelope compared against an absolute reference R PH-ABS (a reference signal produced in the 3776). The result is stored in the processor. The next step is to apply 55 cyles of 83 1/3Hz modulated measurement carrier IP PH-MEAS (in the range 200Hz to 3.6kHz) around the loop as described in paragraph A4-7. Both the reference and measurement phases are averaged over 55 cycles to overcome any jitter in the carrier frequencies. The IP PH-MEAS is compared against the absolute reference R PH-ABS. The Envelope Delay Distortion (EDD) is computed as illustrated in Figure A4-4.

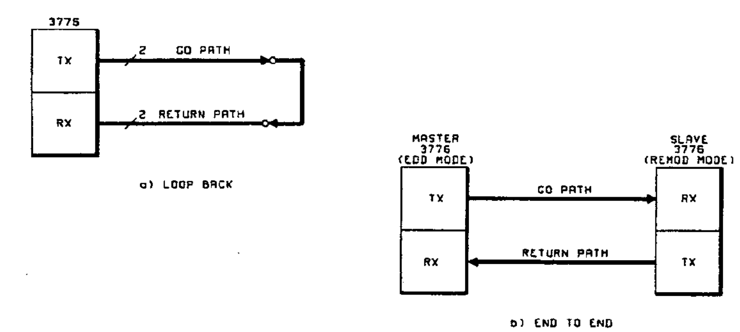


Figure A4-3 Envelope Delay Distortion Set-up

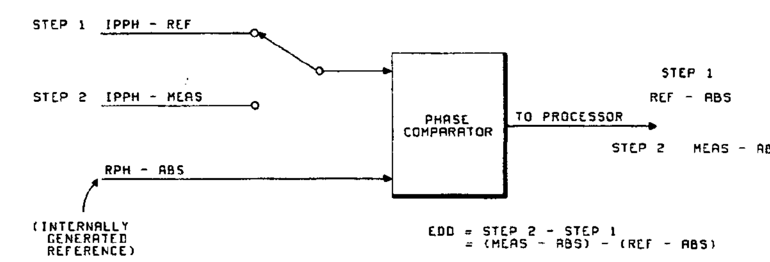


Figure A4-4 Computing EDD

A4-9 The Envelope Delay Distortion (EDD) circuits which form a major part of the A204 option assembly are described in the following paragraphs.

A4-10 The 83 1/3Hz envelope is applied to A204 (from A9) as a serial digital data stream L DF OUT. This is converted to a parallel form then to an analog form by the D/A Converter. The filtered output of the D/A Converter DA CONV OUT is then applied to the input Limiter of the EDD circuits.

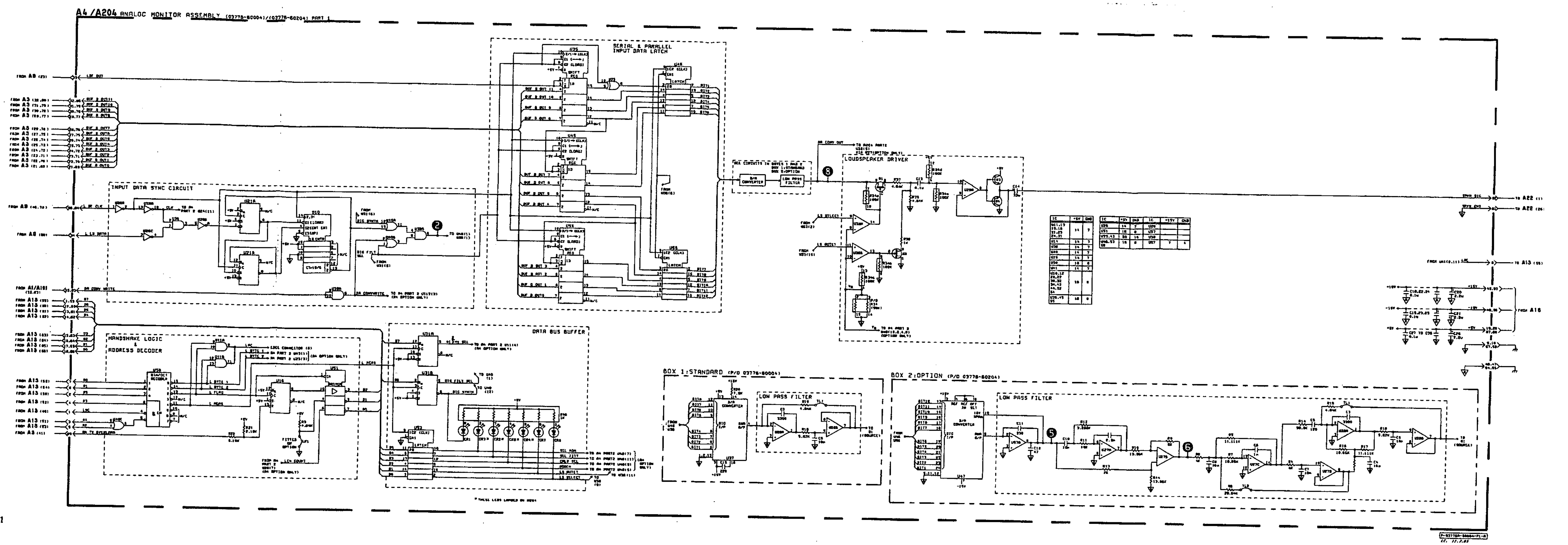


Figure A4-11 A4/A204 Schematic – Part 1

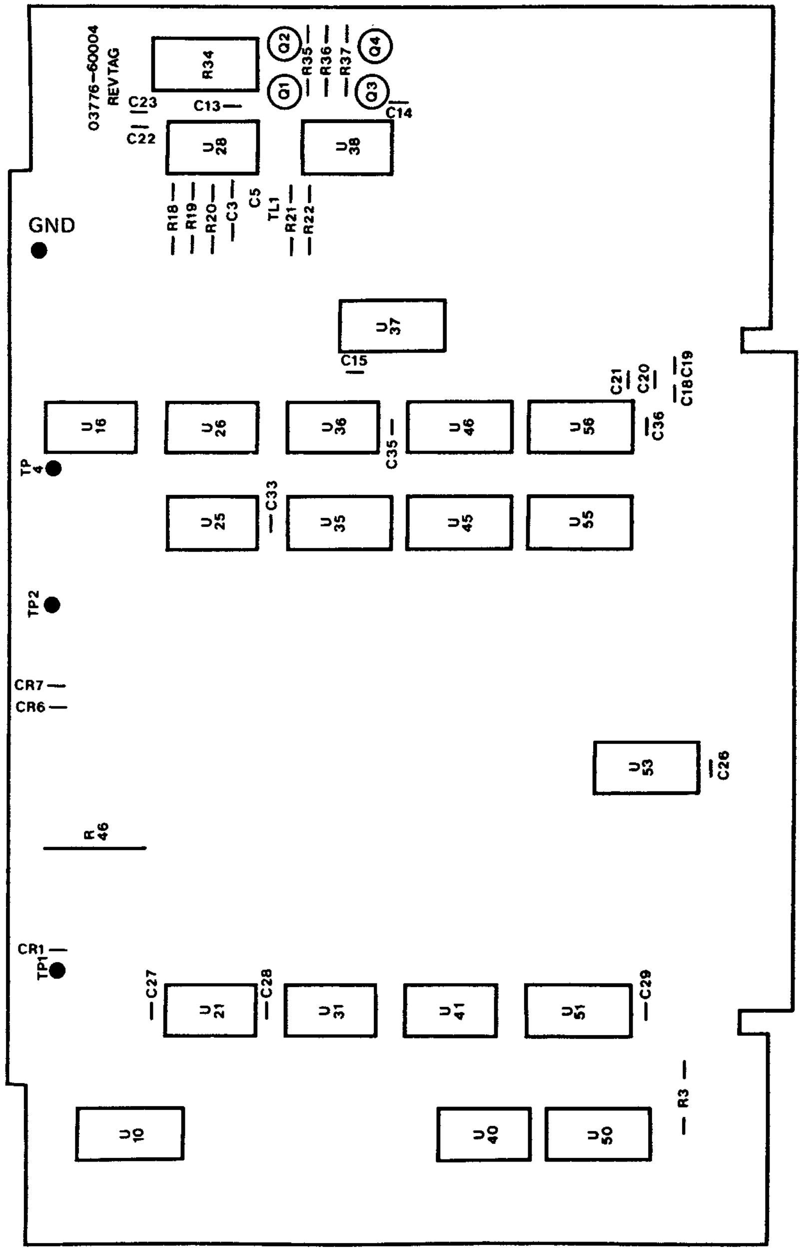


Figure A4-9 A4 Component Location

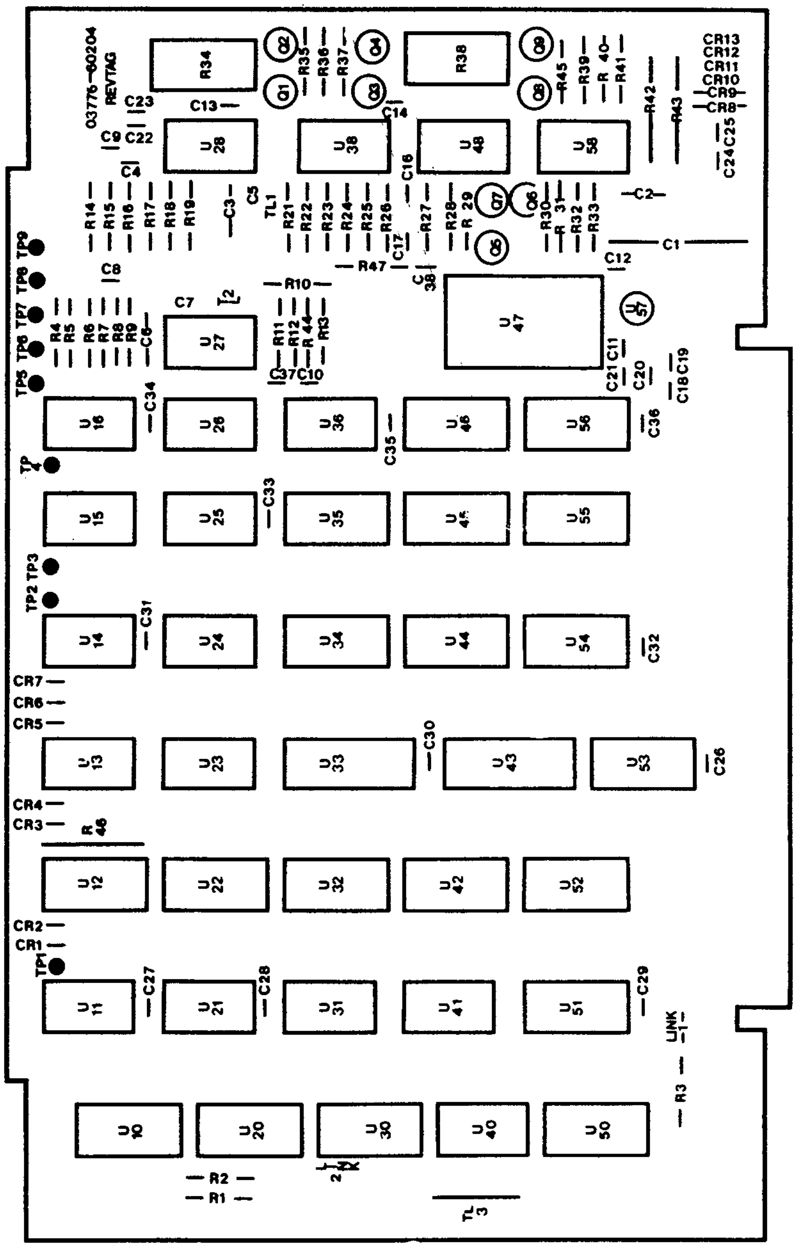


Figure A4-10 A204 Componert Location

8-A4-8 LOCATED INSIDE FOLD { **Figure A4-9 A4 Component Location**
Figure A4-10 A204 Component Location }

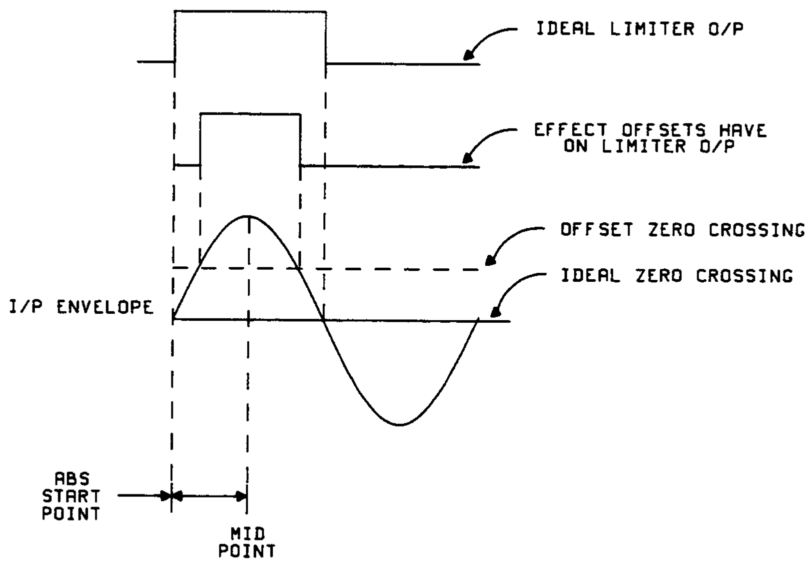


Figure A4-5 Limiter Output Affected by dc Offset

A4-11 The Limiter applies TTL levels to the Phase Comparator, changes in level occur each time there is a zero crossing of DA CONV OUT. The Phase Comparator stores the IP PH and R PH signals from the Limiter and Reference Phase Generator respectively. The Decoder decodes IP PH and R PH according to the timing relationship between the two signals (see Paragraph A4-13). Due to dc off-sets, the zero crossings of the DA CONV OUT may produce IP PH with a mark space ratio which may vary from cycle to cycle (see Figure A4-5). This would insert errors into the EDD measurement if the rising edges of IP PH and R PH were used to measure EDD. This is overcome by comparing the leading edge of R PH to the midpoint of the IP PH mark (positive peak of DA CONV OUT) see Figure A4-6. Although the mark space ratio of IP PH changes, the timing between the leading edge of R PH and the midpoint of IP PH remains constant (see Figure A4-6). A further complication is that jitter may affect the IP PH signal. This is overcome by averaging the EDD measurement over 55 cycles of the 83 1/3Hz envelope in both the reference and measurement periods (see Figure A4-2).

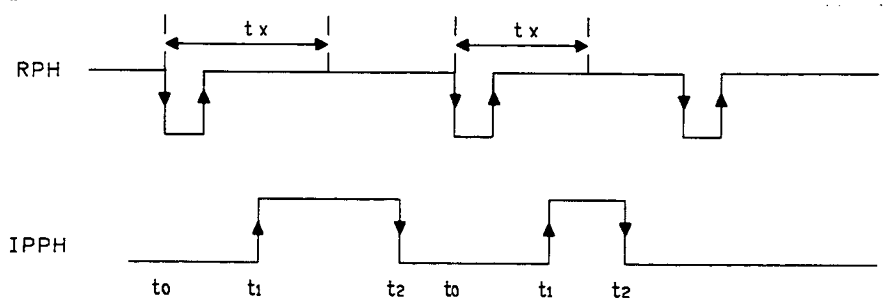


Figure A4-6 Timing Between R PH and IP PH

A4-12 Three cycles with jitter on IP PH are illustrated in Figure A4-7 together with the timing information between the leading edge of R PH and the midpoint of IP PH. Note that in Figure A4-7 the timing does vary.

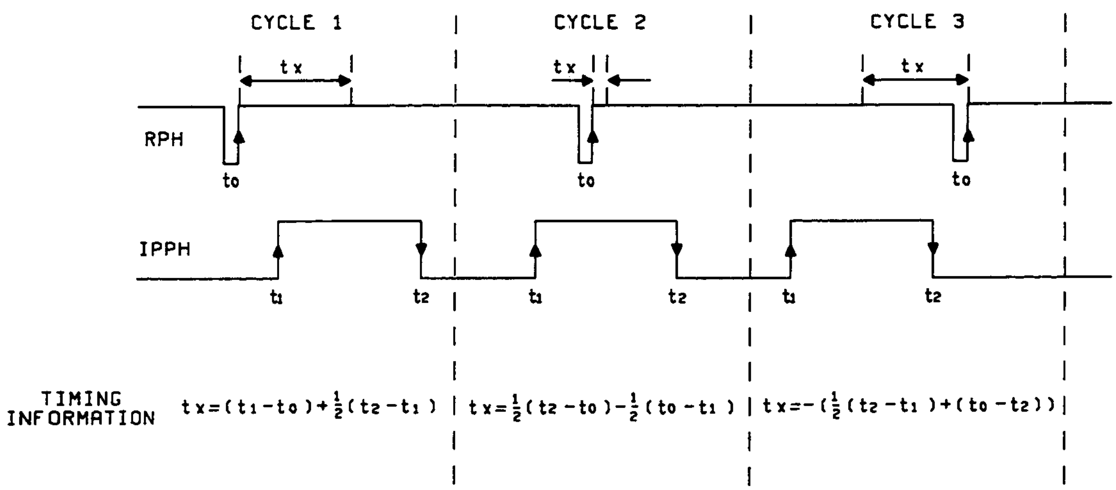


Figure A4-7 Jitter and IP PH

A4-13 The timing information (t0, t1 and t2) shown in Figure A4-7 is decoded from R PH and IP PH by the Decoder. This information allows the Phase Counter to be incremented up or down over each cycle by either L CLK or 1/2 L CLK as per the decoder output instructions (see Figure A4-8). After 55 cycles the Measurement Cycle Counter flags the Initialising circuit which then instructs the Phase Counter to stop counting and loads the count into the processor on A13. On A13 the Count is scaled: converted to ms for display on the front panel.

A4-14 DESCRIPTION

A4-15 Serial and Parallel Input Data Latch

A4-16 Data may be applied to A4/A204 from two sources:

1 serial MEASUREMENT and REFERENCE (IP PH) data L DF OUT (comprising 24 bits) from A9.

2 parallel self-test data BUF D OUT 0 to BUF D OUT 11 from A1/A101 via A3.

A4-17 When serial data is selected (DIG FILT SEL is high), the Serial & Parallel Input Data Latch, clocked by inverted L DF CLK, serially shifts L DF OUT through U35, U45 and U55. As only the 12 most significant bits (MSB) of the 24 bits of L DF OUT are converted to an analog form, the Input Data Sync Circuit is synchronised to L DF OUT.

A4-18 Prior to the 24 bits of L DF OUT being applied to A4/A204, L LD DATA allows the counter circuit of the Input Data Sync to be incremented by L DF CLK. After 24 clock pulses the Input Data Sync Circuit produces a clock pulse at TP2 which latches the 12 MSB of the serially shifted L DF OUT signal into U46 and U56. The outputs of these latches, BIT 1 to BIT 12, are then converted to an analog form by a D/A Converter.

A4-19 When parallel data BUF D OUT 0 to BUF D OUT 11 is latched into the Serial & Parallel Input Data Latches U35, U45 and U55 by L DF CLK, DIG FILT SEL is low. The data at the output of these latches are latched into U46 and U56 by a clock pulse at TP2. This pulse is generated when DIG SYNTH SEL from the Data Bus Buffer and DA CONV WRITE are true.

A4-20 The Handshake Logic and Address Decoder is the interface between the A4/A204 and A13 Assemblies. A list of the control signals together with a brief description follow:

LAC; part of handshake protocol (see Assembly Service Sheet A13)

L BYTE 1 & L BYTE 2; at the end of an envelope delay measurement these signals allow the processor to read back the results of the measurement in the form of 2 X 8 bit words ie they enable the Output Buffers U33 and U43 in turn.

L FLAG; produced when the processor interrogates certain status condition on A4/A204 via U51:-
LEN COUNT: indicates status of envelope delay measurement. Low: indicates measurement in progress. High: measurement completed. When processor receives this signal L BYTE 1 and L BYTE 2 are applied to A4/A204 and allow the envelope delay measurement result to be read back to the processor.

LK1; indicates whether the assembly is A4 or A204 (LK1 fitted for option A204)

L MEAS; loads A4/A204 control data from the D0 to D7 instrument bus into U53, the Input Data Latch.

ANTx OVERLOAD; flags the processor when a ringing tone has been applied to the ANALOG TRANSMIT output of the 3776.

A4-21 The LEDs at the output of U53 are illuminated when the control signals are NOT activated (ie all signals are active high).

A4-22 D/A Converter and Lowpass Filter

A4-23 In the standard A4 Assembly only BIT 1 to BIT 8 are converted to an analog form (see BOX 1 on schematic). The output of D/A Converter U37 is then filtered.

A4-24 In the optional A204 Assembly BIT 1 to BIT 11 are converted to an analog form (see Box 2 in schematic), then filtered. Test links enable the filter to be checked out when suspected of being faulty (see GENERAL SERVICE SHEET G9).

A4-25 The Loudspeaker Driver is enabled by LS SELECT from U53. A further LS QUIET signal may be applied to this circuit to reduce the Loudspeaker output level.

A4-26 The filtered output DA CONV OUT of the D/A Converter at TP8 is applied to five paths:

1 via a Limiter to the envelope delay circuits (TP3)
2 via a Limiter to the 83 1/3Hz Filter,
3 DA CONV OUT routed as (CARRIER) to A5,
4 Calibration path via Calibration Buffer,
5 Monitor Output Path to rear panel output.

A4-27 The Limiter common to the envelope delay and 83 1/3Hz Filter paths detects zero crossings of DA CONV OUT and produces TTL signals.

A4-28 The envelope delay circuits at TP3 have DA CONV OUT applied to TP3 at all times.

A4-29 The REMOD front panel switch controls the signal flow into the 83 1/3Hz Filter. When REMOD is pressed MODEM is produced at U53(5) which allows Q6 to saturate via U48D.

A4-30 When the A5 option 001 Assembly is fitted there is a direct path between the DA CONV OUT (CARRIER) and the A5 Assembly.

A4-31 During self-test routines CAL 2 SEL enables the Calibration Buffer - CAL 2 is applied to A6.

A4-32 DA CONV OUT is applied to the rear panel MONITOR OUTPUT via the Monitor Output Buffer. This buffer has a differential output which is protected against overloads by the Monitor Output Protection circuit.

001 ONLY

A4-33 When option 001 is fitted the Phase Jitter output from A5 may be routed to the rear panel MONITOR OUTPUT via Q7. FET Q5 isolates the DA CONV OUT output at TP8 during the Phase Jitter measurement.

A4-34 Envelope Delay Measurement Circuits

A4-35 During an envelope delay measurement LEN COUNT at the output of the Measurement Cycle Counter is held low at U20(7). When the envelope delay measurement is completed (after 55 counts) LEN COUNT goes high, informing the processor via U51 (on A4/A204 Part 1) that the measurement is complete and the result contained at the output of the Up/Down Phase Counter is ready to be read by the processor. The processor responds by sending L BYTE 1 and L BYTE 2 which enable the Output Buffers U43 and U33 in turn. The Output Buffer loads (2 X 8 bits) the envelope delay measurement result on to the D0 to D7 instrument bus.

A4-36 The Initialising Circuit produces a low reset signal at U24(6) when LEN COUNT goes high. The low reset signal resets the Phase Comparator flip-flops via synchronising bistable U13B of the Decoder.

A4-37 L BYTE 2 is also applied to the Initialising Circuit to produce a low L CLR PH CNT signal at U23(6). This signal presets the Measurement Cycle Counter U20 and U30 prior to the start of the next measurement. L CLR PH CNT is then set high by a positive transition (↑) at the input to the Initialising Circuit at U24(3) which produces a reset signal for U23 and also removes the reset from the Phase Comparator flip-flop via U13B. A high L CLR PH CNT allows the Measurement Cycle Counter to increment, ie the Envelope Delay circuits are in the "armed state" ready to make the next measurement.

A4-38 Envelope delay is measured using a Phase Comparator, Decoder, ÷1/2 Counter and Up/Down Phase Counter. Reasons for using this method are given in Paragraph A4-11.

A4-39 Phase Comparator and Decoder

A4-40 Three basic timing conditions relating the reference signal or Reference Phase R PH at TP1 and the measurement signal or input Phase IP PH at TP3 may be detected during an envelope delay measurement. These timing conditions produce control signal that drive the Up/Down Phase Counter. The Counter is incremented up or down at L CLK or 1/2 L CLK depending on which timing relationship is detected at the input of the Phase Comparator. Figure A4-8 illustrates the three timing conditions.

A4-41 The Measurement Cycle Counter is incremented each time U13(9) goes high (see Figure A4-8). When the measurement cycle count reaches 55 (see Paragraph A4-11) the total count in the Up/Down Phase Counter is applied to A13 for processing ie LEN COUNT at U20(7) informs the processor that the envelope delay measurement is completed.

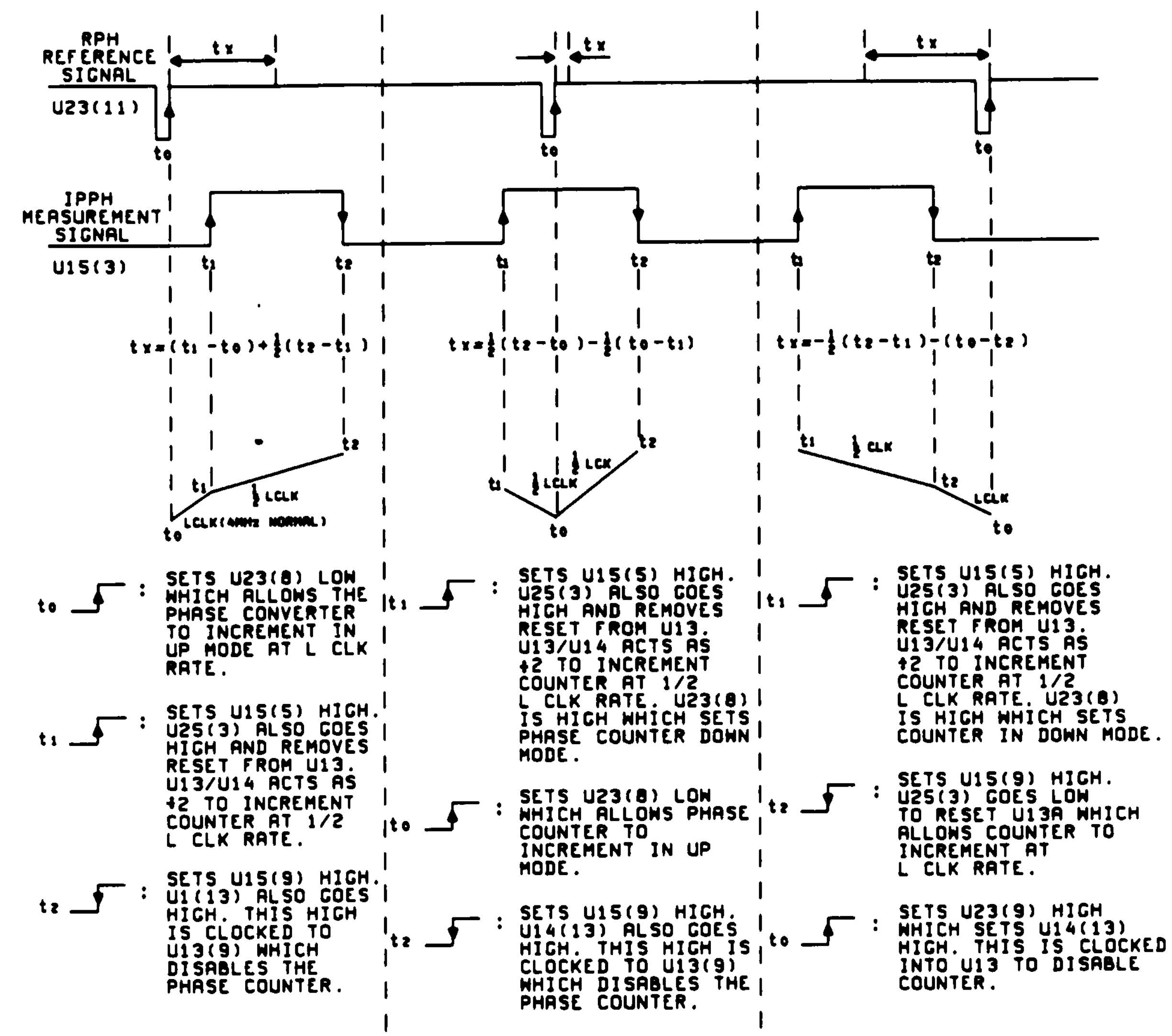


Figure A4-8 Timing at the Phase Comparator Input

001 ONLY

8-A4-6 LOCATED INSIDE FOLD { Figure A4-9 A4 Component Location
Figure A4-10 A204 Component Location }

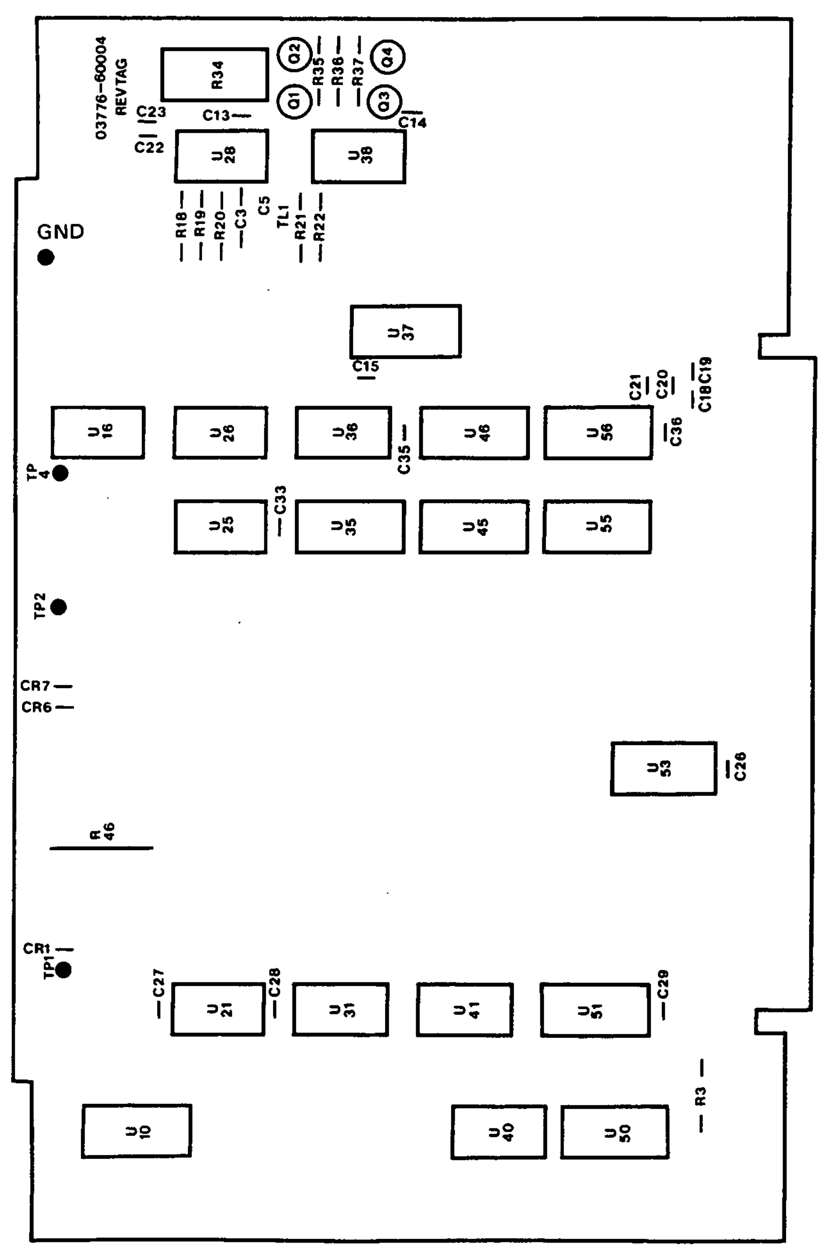


Figure A4-9 A4 Component Location

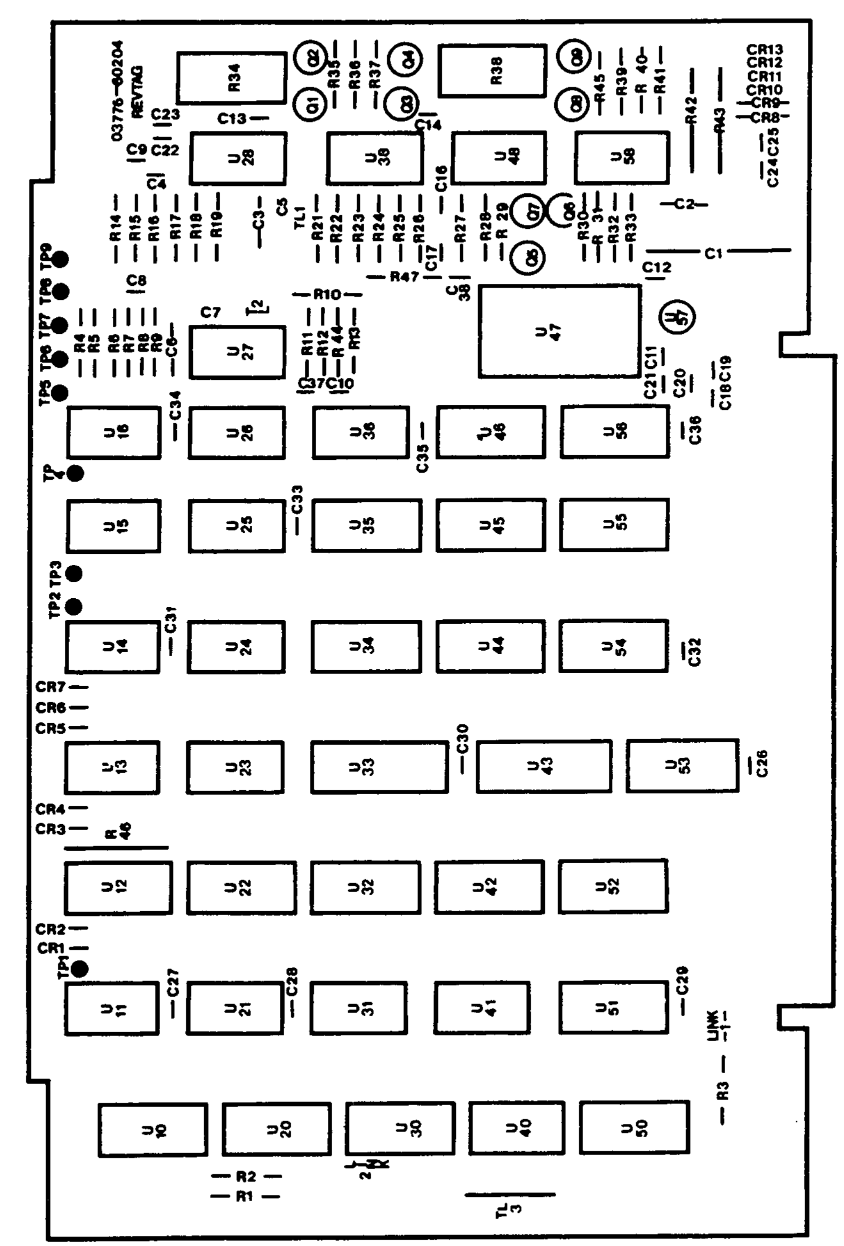


Figure A4-10 A204 Component Location

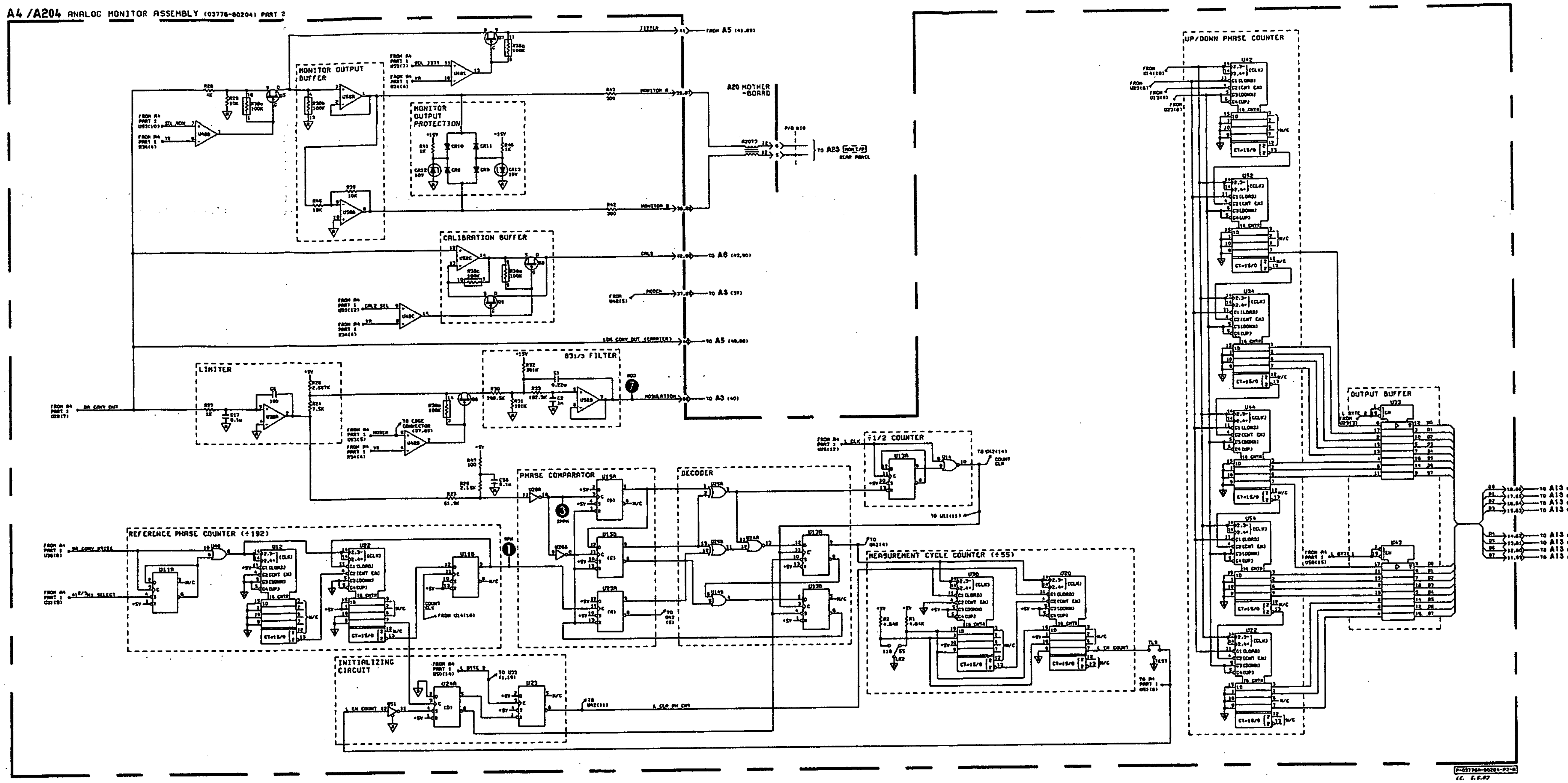


Figure A4-12 A4/A204 Schematic – Part 2

ASSEMBLY SERVICE SHEET A5
TRANSIENTS (OPTION 001)

A5-1 INTRODUCTION

A5-2 Transient and phase jitter measurement circuitry is contained on the A5 Assembly. Figure A5-1 details the circuit elements which make up the A5 Assembly, listed below are the five main functional elements.

*1 Temperature Compensated log Converter
*2 Dropouts/Interruptions
*3 Gain Hits
*4 Phase Hits
5 Phase Jitter

*Transients

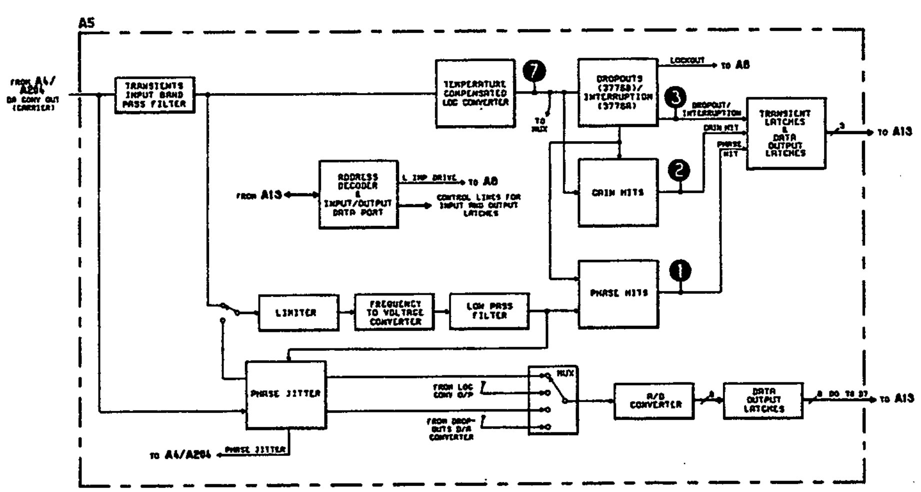


Figure A5-1 Transients Block Diagram

A5-3 Transients Measurements

Table A5-1 Transient Parameters

	3776A	3776B
Dropout/Interruption	10dB (interruption)	12dB (dropout)
Qualification Period	3ms (nominal)	4ms (nominal)
Self blocking deadtime	3ms/125ms	6ms/1s
Maximum Count Rate	150/8 per s	100/8 per s
Cross blocking of other transients	duration of the interruption +1s	6ms/1 s
Gain Hits thresholds	± 2, 3, 4, 6dB	Same as 3776A
Phase Hits thresholds	± 5° to 40° in 5° steps	Same as 3776A
Qualification Period	4ms	
Deadtime	125ms	10ms/125ms
Maximum Count Rate	8 per s	100/8 per s

A5-4 Transient measurements - Dropouts (3776B)/Interruptions (3776A), Gain Hits, Phase Hits and Impulse Noise are made simultaneously on a 1010Hz carrier generated from the 3776 transmitter.

A5-5 Dropouts (3776B) - *See also Paras A5-25 and A5-59*

A5-6 A dropout exists if the carrier level drops 12dB below the reference level which is established at the start of each measurement. A dropout is registered if the carrier level drops by 12dB or more for a period of >4ms. This period is called the Qualification Period or Guard Interval.

A5-7 The dropout count rate is selectable (see Table A5-1) and produces lockout or deadtime periods of 1s (slow) and 6ms (fast). During deadtimes, Dropout, Gain Hit, Phase Hit and Impulse Noise counting is inhibited. Dropouts block the counting of hits and impulse noise for the duration of the dropout +1s in slow counts and the duration of the dropouts +6ms in the fast count (also self block for the same periods). Dropouts lasting longer than the times specified in Table A5-1 have a 6ms recovery period inserted after the dropout recovers. This provides a settling period for the transient detection circuits.

A5-8 Interruptions (3776A Only) - *See also Paras A5-25 and A5-59*

A5-9 An interruption exists if the carrier level falls 10dB below the reference level which is established at the start of the measurement. An interruption is registered if the level falls 10dB below the reference level for >3ms. The 3ms period is called the Guard Interval or Qualification Period.

A5-10 The Interruption count rate is selectable see Table A5-1. After an interruption has recovered, a 1 second lockout period or deadtime is always applied to the Gain Hit, Phase Hit and Impulse Noise Detectors, ie the counting of hits and impulse noise is inhibited for the duration of the interruption +1s. In the 8 counts/s and 150 counts/s modes, self-lockouts of 125ms and 3ms respectively are applied to the dropout detector only.

A5-11 Gain Hits and Phase Hits - *See also Paras A5-33, A5-39, A5-65 and A5-70*

A5-12 Gain Hits are abrupt changes in the amplitude of a received sinewave. If the change exceeds a preset selectable threshold, a count is registered. The selectable thresholds are +/-2, 3, 4 and 6dB. Phase Hits are abrupt changes in the phase of a received sinewave. If the Phase Hit exceeds a preselected threshold a count is registered. The selectable thresholds are 5 degrees to 40 degrees in 5 degree steps.

A5-13 Both Gain Hits and Phase Hits must last for 4ms or more before a hit is registered (Qualification Period or Guard Interval). In the 3776A, the count rate for both Gain Hits and Phase Hits is 8 counts/s (ie a self-lockout period of 125ms or 10ms is applied after a hit has been detected). In the 3776B, the count rate is selectable between 8 counts/s and 100 counts/s (ie self-lockout periods of 125ms and 10ms respectively after a hit has been detected).

A5-14 The carrier signal in both the Transients and Phase Jitter measurements is applied to A5 via the A4/A204 Assembly. During transient measurements the carrier signal is first filtered by the Transients Bandpass Filter then applied to two signal paths. The signal applied to the Temperature Compensated Log Converter is analysed for Dropouts/Interruptions and Gain Hits while the other path is used to measure Phase Hits (see Figure A5-1).

A5-15 Phase Jitter Measurement - *See also Paras A5-44 and A5-75*

A5-16 Phase Jitter is measured by transmitting a 1010Hz sinewave through the channel under test and measuring zero crossings of the sinewave at the Receiver. The peak to peak deviation in the zero crossings of the sinewave are detected and displayed in degrees. Two Jitter frequency ranges are available, they are:

```
1  Low Frequency Phase Jitter      4Hz to 300Hz
2  Normal Phase Jitter            20Hz to 300Hz
```

A5-17 During a phase jitter measurement the carrier signal is passed through the Phase Jitter Bandpass Filter then demodulated using a Frequency to Voltage Converter. After further filtering a signal proportional to phase is derived and fed to the Positive and Negative Peak Detectors. These voltages are converted to a digital form then applied to A13 for processing.

A5-18 Temperature Compensated Log Converter - *See also Para A5-48*

A5-19 The Temperature Compensated Log Converter illustrated in Figure A5-2 provides the following:

1 A dynamic range compression (produces small changes in output voltages for large changes in input current) during dropout measurements (Figure A5-3 illustrates a typical logarithmic characteristic).

2 Preserves the magnitude of the gain hit signal independent of the polarity of the hit.

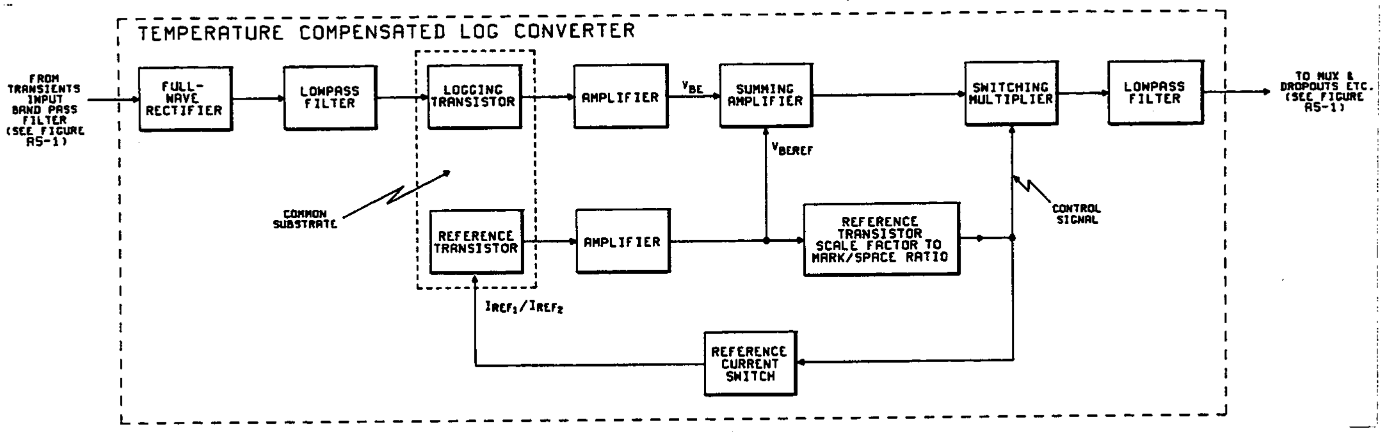


Figure A5-2 Temperature Compensated Log Converter

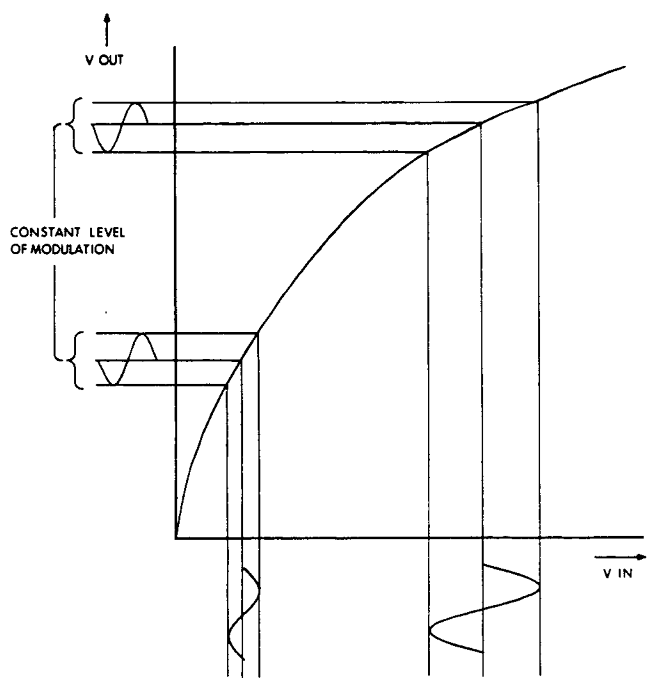


Figure A5-3 Typical Logarithmic Characteristic

A5-20 The basic logging action, performed by a transistor, ensures the dynamics of the hit signal are independent of the absolute carrier amplitude. The logging transistors base emitter voltage V_{BE} is proportional to the log of the collector current I_C i.e.

$$V_{BE} \propto \ln(I_C/I_S)$$
$$V_{BE} = kT/q.\ln(I_C/I_S) \qquad \textbf{Equation 1}$$

where; I_S = saturation current
and kT/q = temperature dependent constant

Temperature changes around the logging transistor create inaccuracies in the Log conversion. These are cancelled out by using two transistors on the same substrate in the Log Converter shown in Figure A5-2. The Reference Transistor, Reference Tansistor Scale Factor to Mark Space ratio, Switching Multiplexer and Current Switching circuits compensate for I_S and kT/q in equation 1.

A5-21 The V_{BE} of the Reference Transistor is subtracted from the Logging Transistor V_{BE} to compensate for the saturation current I_S. This subtraction is performed by the Summing Amplifier, i.e.

$$V_{BE} - V_{BEREF} = kT/q.\ln(I_C/I_S) - kT/q.\ln(I_{REF}/I_S)$$

$$V_{BE} - V_{BEREF} = kT/q.\ln(I_C/I_{REF}) \qquad \textbf{Equation 2}$$

A5-22 kT/q is cancelled out from equation 2 by routing the output of the Difference Amplifier via the Switching Multiplier for a time inversely proportional to kT/q. Relating temperature to time is described in the following paragraphs.

A5-23 Two known reference currents I_{REF1} and I_{REF2} are applied alternately to the Reference Transistor and produce a change in V_{BEREF} i.e.

$$V_{BEREF} = kT/q.\ln(I_{REF1}/I_S) - kT/q.\ln(I_{REF2}/I_S)$$

$$V_{BEREF} = kT/q.\ln(I_{REF1}/I_{REF2})$$

$V_{BEREF} \propto kT/q \propto$ temperature (as I_{REF1} and I_{REF2} are fixed).

The change in V_{BEREF} is monitored by the Reference Transistor Scale Factor to Mark Space Ratio circuit (comprising Sample and Hold device, integrator and monostable) which produces an output signal with a mark space ratio inversely proportional to the change in V_{BEREF}. The output signal controls the Switching Multiplier and the Reference Current Switch.

A5-24 The length of time the Switching Multiplier routes the output of the Summing Amplifier to TP7 is inversely proportional to kT/q. Therefore the voltage at TP7 accurately represents the log of the input current I_C independent of temperature.

A5-25 Dropouts (3776B)/Interruptions (3776A)

A5-26 Dropouts and Interruptions are detected and registered in an identical manner. Therefore only Dropouts are described. The dropouts circuit is illustrated in Figure A5-4.

A5-27 Prior to a dropout measurement the carrier level is monitored at TP7 to establish a reference carrier level. The carrier at TP7 is routed via the MUX and the A/D Converter to the processor on A13. Once the reference level is established the processor applies a level equivalent to 12dB below the reference carrier to the Dropouts Threshold Comparator via the Dropouts D/A Converter.

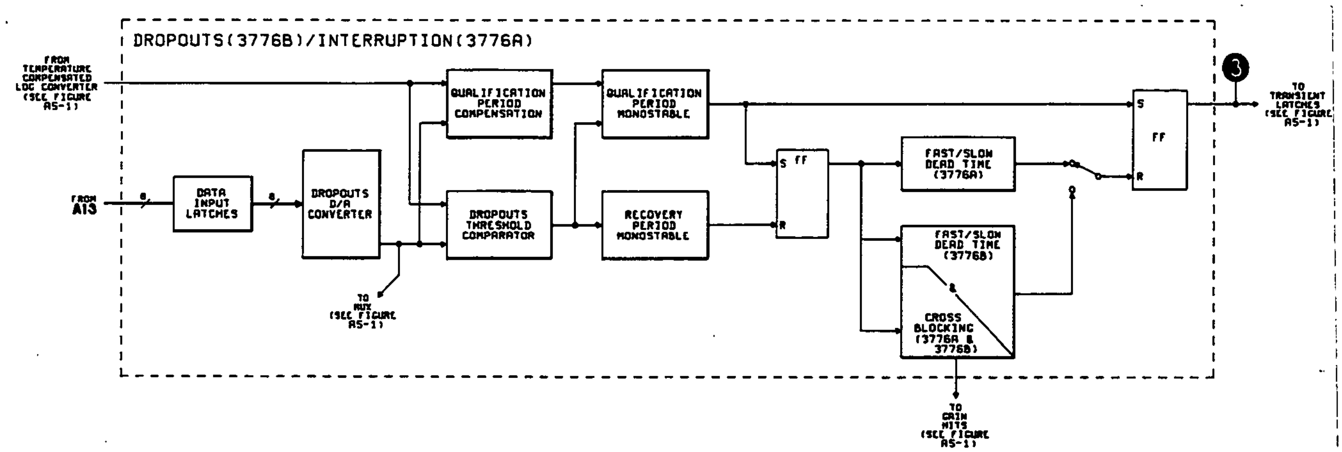


Figure A5-4 Dropouts/Interruptions

A5-28 When the carrier level falls by 12dB or more the Dropouts Threshold Comparator enables the Qualification Period Monostable. If the comparator monitors a fall in carrier level for >4ms the Qualification Period Monostable registers the dropout by setting TP3 high. This high is then latched into the Transient Latches. If the drop in carrier level is NOT maintained the Qualification Period Monostable is reset and no dropout is registered.

A5-29 Dropouts are registered for falls in carrier level from 12dB down to total loss of signal. Since the carrier signal requires finite time to fall due to the input bandpass filter and other processing filters, the time to reach the 12dB down threshold varies depending on the overall change in the carrier signal. This timing variation affects the Qualification Period and is therefore compensated for by the Qualification Compensation circuit.

A5-30 When a dropout is registered the output of the Qualification Period Monostable triggers the Cross Blocking circuit via a flip-flop. The Cross Blocking circuit ensures that the Gain Hits and Phase Hits circuits are disabled during a dropout.

A5-31 The Recovery Period Monostable also monitors the carrier level (via the Dropout Threshold Comparator) to determine when the reference level has been re-established after a dropout. If the level is maintained for 2ms or more the reference carrier level is considered to be re-established and the Recovery Period Monostable enables the Fast/Slow Deadtime circuit via a flip-flop.

A5-32 The Fast/Slow Deadtime circuit prevents further dropouts being registered for either 6ms/1ms (3776B) or 125ms (3776A).

A5-33 Gain Hits

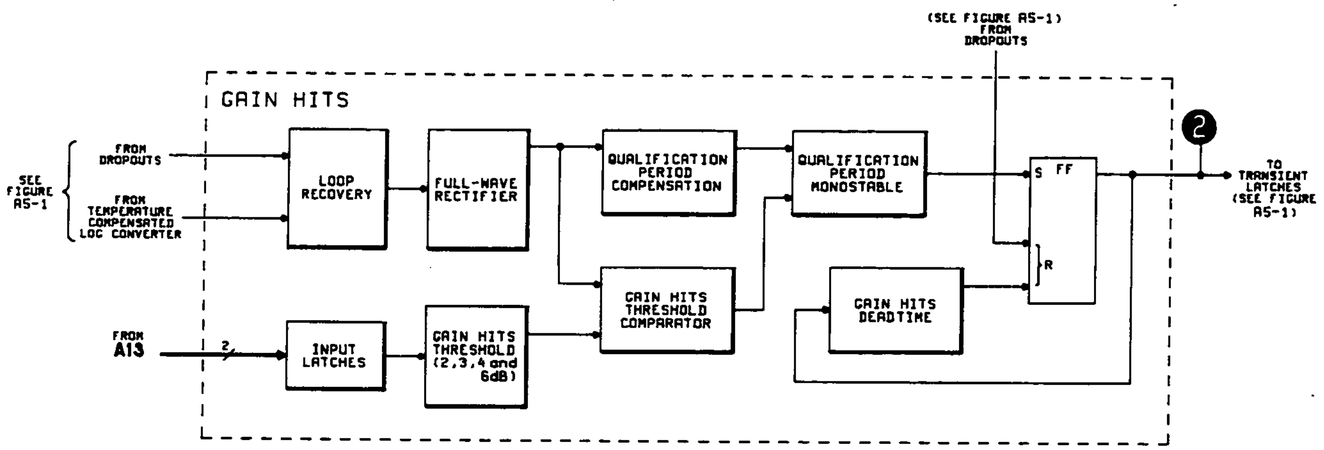


Figure A5-5 Gain Hits

A5-34 Prior to a Gain Hit measurement a reference carrier level is established, see Paragraph A5-27. When an abrupt change in the carrier level of 2, 3, 4 or 6dB exists for 4ms or more a gain hit is registered. The gain hit threshold is keyed in via the front panel and applied to the Gain Hits Threshold circuit via the processor on A13. The Gain Hit circuits are illustrated in Figure A5-5.

A5-35 The highpass filter Loop Recovery circuit routes abrupt changes in carrier level to the fullwave rectifier. Since a gain hit can be an abrupt increase or decrease in carrier level the fullwave rectifier allows detection of changes in either direction. The output of the fullwave rectifier is applied to the Gain Hit Threshold Comparator. It should be noted that slow varying changes in carrier level are blocked by the Loop Recovery circuit, therefore NO gain hits are detected.

A5-36 When an abrupt change in the reference carrier exceeds the threshold stored in the Gain Hit Threshold circuit, the Gain Hit Comparator alerts the Qualification period Monostable. If the threshold is exceeded for 4ms or more the Qualification Period Monostable registers a gain hit by setting TP2 high. This high is then latched into the Transients Latches. If the threshold is NOT exceeded for 4ms or more, the Qualification Period Monostable is reset and no gain hit is registered.

A5-37 The carrier level requires finite time to rise or fall and accordingly the apparent duration of the hit above the threshold also varies, dependent on the magnitude of the hit. This timing variation affects the Qualification Period and is therefore compensated for by the Qualification Period Compensation circuit.

A5-38 Once a gain hit is registered the Gain Hit Deadtime circuit is enabled and prevents further gain hits being registered for either 10ms or 125ms.

A5-39 Phase Hits

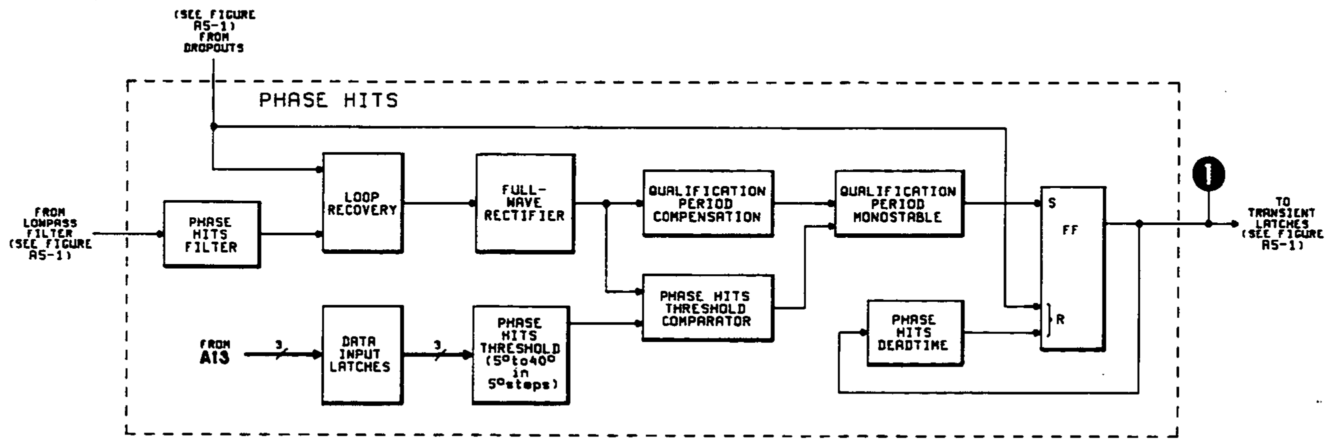


Figure A5-6 Phase Hits

A5-40 For Phase Hits measurements the carrier is routed via the Transients Bandpass Filter, a Limiter, Frequency to Voltage Converter and a Lowpass Filter with a controlled impulse response duration. Figure A5-6 illustrates the Phase Hits circuits.

A5-41 The Limiter detects the zero crossings of the carrier signal and produces a TTL squarewave output. If the phase of the carrier varies the mark space ratio of the Limiter output will also vary. This variation is converted to voltage prior to being applied to the Phase Hit circuit.

A5-42 A phase hit is registered if an abrupt change of phase in the range 5 degrees to 40 degrees is detected for 4ms or more. The phase threshold is keyed into the 3776 via the front panel and can be between 5 degrees and 40 degrees and is selected in 5 degrees steps.

A5-43 The Phase Hit circuit operates in an identical manner to the Gain Hit circuit except that the input signal is applied to the Loop Recovery via the Phase Hit Filter (see Paragraphs A5-33 to A5-38). This filter in conjuction with the Filter in Paragraph A5-40 has a step response constrained to last for <10ms so that phase hits separated by 10ms or more do not interact, allowing the Phase Hit Detector circuit to count phase hits at up to 100 counts/s without degrading the measurement accuracy.

A5-44 Phase Jitter

A5-45 The carrier signal is applied to the Phase Jitter circuit via the Phase Jitter Filter and Limiter/Frequency to Voltage converter. The Limiter and Frequency to Voltage Converter are described in Paragraph A5-41.

A5-46 The output of the Frequency to Voltage Converter produces a voltage proportional to the frequency of the carrier signal. A shift in the carrier frequency produces a change in the Frequency to Voltage Converter output voltage. This voltage is then filtered, producing a signal proportional to the change in phase of the carrier signal. The positive and negative peaks of this signal are detected and applied to the processor on A13 via the MUX and A/D Converter. The processor supplies the detected peak values to the front panel displays.

A5-47 DESCRIPTION

A5-48 Temperature Compensated Log Converter

A5-49 The Transient Bandpass Filter complies with the IEEE standard and has a bandpass response nominally 700Hz to 1300Hz.

A5-50 Diodes CR20, CR21 and op amps U86C and U86D rectify the input carrier, driving the appropriate amount of current into the virtual earth of U95(2) of the Lowpass Filter.

A5-51 The Lowpass Filter reduces ripple and drives the emitter of the Logging Transistor p/o U87. The current from the Logging Transistor balances the current from the Fullwave Rectifier at U95(2).

A5-52 Amplifier U96A acts as a pre-amp for the base emitter voltage V_{BE} of the Logging Transistor and R118 provides a high impedance at the emitter of the Logging Transistor.

A5-53 The Summing Amplifier sums the V_{BE} of the Logging and Reference Transistors.

A5-54 Reference Transistor U87 has two reference currents applied alternately to it from the Reference Current Switch. The Reference Transistor V_{BE} is applied to the Summing Amplifier via U96B.

A5-55 Both reference currents are derived from the $10V_{REF}$ line via R108 and R109. The time each reference current is applied to the Reference Transistor is controlled by the Reference Transistor Scale Factor to Mark Space Ratio circuit.

A5-56 The Reference Transistor V_{BE} changes with a change in the reference current. Op Amp U96B amplifies the small changes in V_{BE} and produces an output signal as illustrated in Figure A5-7.

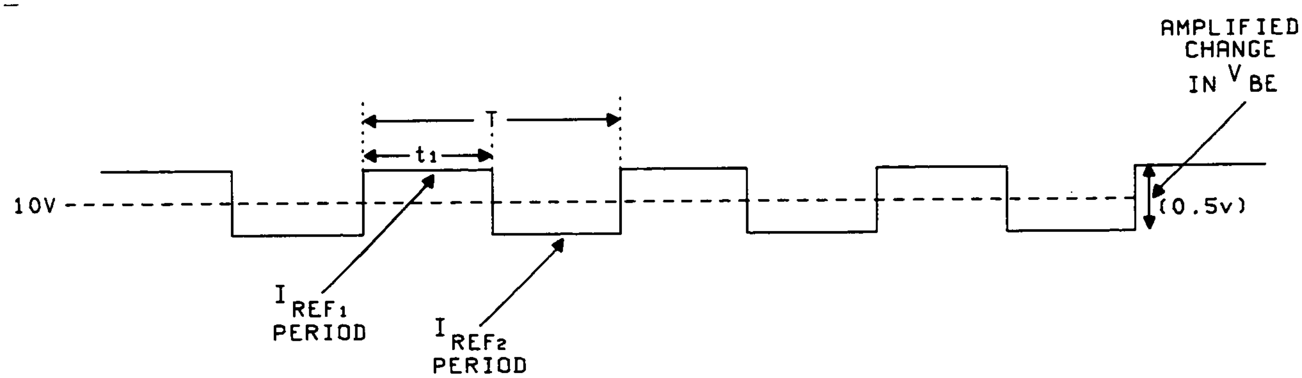


Figure A5-7 Input Signal to Reference Scale Factor to Mark Space Ratio Circuit

A5-57 The most positive part of Figure A5-7 is shifted to 0V by operating the sample and hold device U76 as a clamp, ie the 10Vdc component of Figure A5-7 is removed leaving a 0 to -0.5V signal at U76(5).

A5-58 A current balance integrator circuit U75B/C81 is used to relate the change in V_{BE} and time t_1 of Figure A5-7. A fixed positive reference current is applied to the integrator via R110 and a negative current is applied via R111 to balance the reference current, i.e.

$$I_{REF\,(R110)} = -I_{(R111)} \propto \Delta V_{BE} \cdot t_1/T$$

The output of U75B ramps until current balance is achieved. This is done by varying the mark space ratio (t_1/T) of the oscillator (U67) which forces t_1/T to be inversely proportional to ΔV_{BE}.

A5-59 Dropouts (3776A)/Interruptions (3776B)

A5-60 The incoming carrier signal, after autoranging, is passed through the transients input band-pass filter (U86A, B), fullwave rectified (U86C, D) and after low-pass filtering (U95A, U68A) the mean carrier level is converted to a logarithmic form using a transistor (p/o U87). This signal is temperature compensated using a matched transistor on the same substate (p/o U87) and the temperature compensation circuitry (see Temperature Compensated Log Converter section). Further low-pass filtering (U68D, C) is used to remove the switching waveform from the temperature compensation giving a stable logarithmic representation of the mean carrier level at TP7. This signal is compared with the dropout threshold (U53) established at the start of the measurement. If the carrier level falls below this threshold the qualification period monostable is enabled.

A5-61 The carrier level signal will have finite rise and fall times due to the input bandpass filter and other processing filters, and the observed width of the dropout will therefore vary dependent on the carrier level immediately prior to the dropout, both related to the dropout threshold level. These parameters are used to modify the qualification period monostable timing current (U43A, B, C, D, U42, U54C, D, U52A, U51A) to compensate for this effect.

A5-62 If the dropout satisfies the magnitude and duration criteria, and provided that the deadtime monostable U52C, U62A, B, C2 (3776A) or U52D, U62B, C (3776B) has completed an operation after a previous dropout, a valid dropout count is generated and passed via a latch (U61B) to the dropout register. During the dropout and for a subsequent period, set by U52B, U52C, the counting of phase hits, gain hits and impulses are inhibited.

A5-63 After the carrier level has recovered above the dropout threshold for greater than approximately 2msec (U52B, U51B) the self-blocking and cross-blocking, deadtime monostables are initiated via a latch (U61D).

A5-64 The dropout threshold is established at the beginning of the measurement by using the digital filter (on A9) to reduce the carrier level by a precisely known amount and then matching the threshold level (from D/A Converter U94 and U85A) to the level at TP7, evaluated by the A/D converter (U64, U55, U63). This method relies only on the stability of the signal processing stages prior to TP7 and the stability of the D/A converter, rather than absolute accuracy and linearity.

A5-65 Gain Hits

A5-66 The gain hit signal is derived from the logarithmic carrier level signal present at TP7 by high-pass filtering. The resultant signal is equivalent to that obtained using an AGC circuit, with the loop recovery time set by the time constant of the high-pass filter. This time constant is the same for positive or negative hits, and due to the logarithmic nature of the carrier level signal equal magnitude gain hit signals are obtained for positive or negative hits. A fullwave rectifier (U24A, B) is used to allow a single threshold for either polarity hit, and the gain hit threshold from U64 is compared with the rectified gain hit signal by U31A.

A5-67 Due to the finite rise and fall times, the observed width of a gain hit is dependent on the magnitude of the hit and the gain hit threshold. The qualification period monostable timing current is modified (U54A, U23A, B, C, D U22) to compensate for this effect.

A5-68 If the gain hit satisfies the magnitude and duration criteria and provided that it is not inhibited by the dropout cross blocking or the gain hit deadtime self blocking, a valid gain hit count signal is passed to the processor A13 via the deadtime latch (U61C) and the gain hit register. The gain hit deadtime monostable (U31A, U41A, U51D) inhibits further counting for the duration of the deadtime.

A5-69 During a dropout and while the carrier level is settling after a dropout the loop recovery time filter is switched to a short time constant to allow rapid acquisition of the new carrier level.

A5-70 Phase Hits

A5-71 The received carrier after autoranging is bandpass filtered by U86A, U86D and then passed via the input filter selector switch (U66B) to the limiter (U56A) and frequency to voltage converter (U57, U35A). The resulting signal is low-pass filtered (U36A, B, C, D and U35C) so that for a step in phase of the input carrier an equi-ripple approximation to a flat-topped pulse is obtained at TP6. The total duration of this pulse is constrained to be less than 10msec in order that phase hits at a rate of 100 per second can be detected without interaction.

A5-72 The conversion of a step in carrier phase to an output defined duration pulse also simulates the loop recovery time requirement, so that slow changes in phase are rejected. A further high-pass filter is used after this filtering in order to reject dc offsets and static frequency offsets. The high pass filter time constant is shortened (U11) during a dropout and associated cross-blocking period in order to achieve rapid acquisition of carrier frequency and phase after a dropout has ended.

A5-73 The phase hit signal is then fullwave rectified (U34A & B) so that positive and negative phase hits can be compared with a single threshold in the threshold comparator (U31A). The threshold is selected by the user via the processor (on A13) and the threshold selector multiplexer (U84). Due to the finite rise and fall times imposed by the input band-pass and other filtering, the apparent duration of a phase hit depends on the magnitude of the hit and the hit threshold. These parameters are used to modify the Qualification Period monostable timing current (U33, A, B, C, D U54B, U32, U51C) to compensate for this effect.

A5-74 If a phase hit satisfies the magnitude and duration criteria, and is also not prevented by the dropout cross-blocking or the phase hit deadtime a valid phase hit count is passed to the phase hit register to be read by the processor.

A5-75 Phase Jitter

A5-76 The incoming carrier is passed through the Phase Jitter BP filter (U85A, B, C) via the input filter selector switch (P/o U66B) and limiter (U56) to the frequency to voltage converter (U57, U35A). The resulting voltage proportional to carrier frequency deviation is low-pass filtered (U36D and U35A) and converted into a voltage proportional to phase deviation (U35B). This signal is buffered (U44A) and passed to the rear panel MONitor output via A4/A204.

A5-77 The demodulated phase signal is also fed to the positive peak detector (U45A, U25A, U25B) and the negative peak detector (U45C, U25C, U25D). The peak detectors have a second order decay response in order to achieve fast settling times with good ripple rejection. The peak detector outputs are A/D converted (U64, U55, U63) and passed to the processor (on A13) which supplies the peak to peak phase jitter to the front panel displays.

A5-78 Selection of different frequency response and decay time for Low frequency and Normal phase jitter is performed by U12.

A5-79 Further Transient Troubleshooting is contained on GENERAL SERVICE SHEET G9.

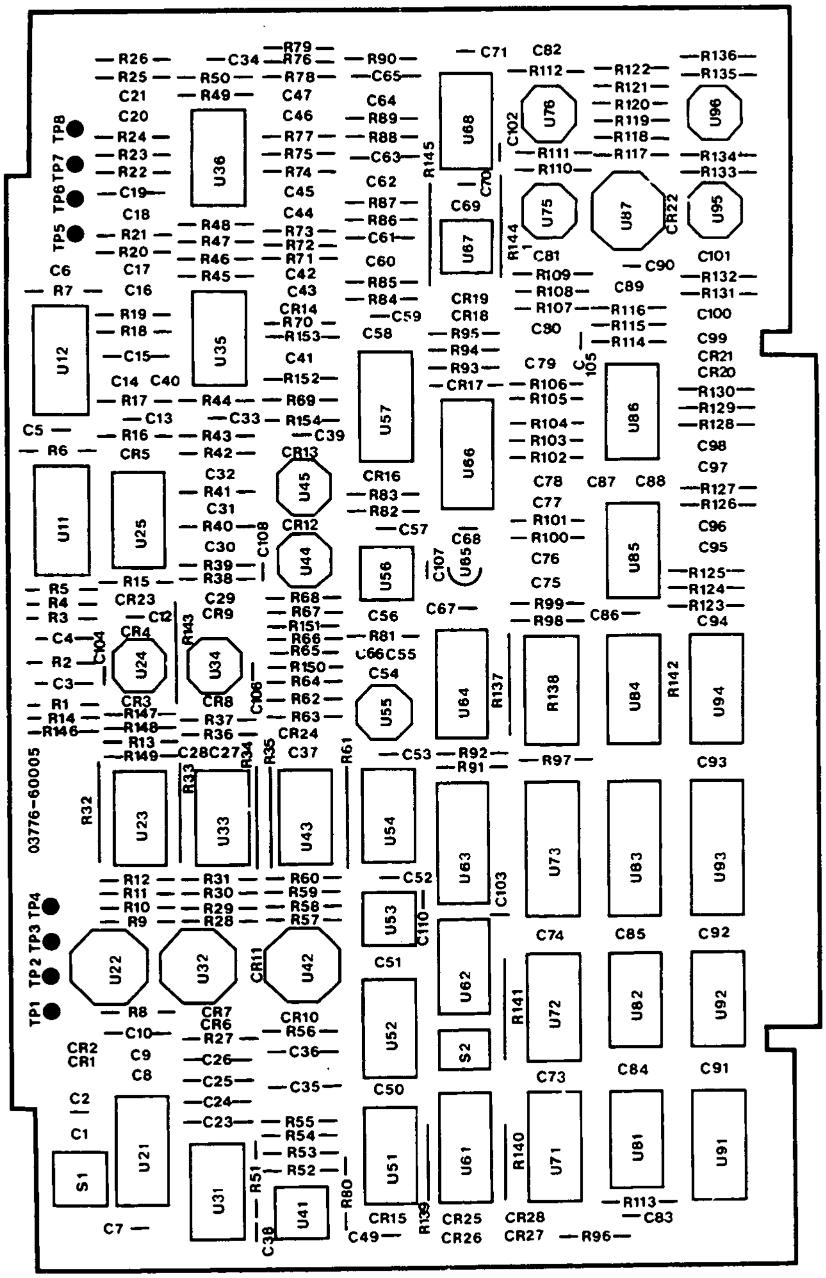


Figure A5-8 A5 Component Location

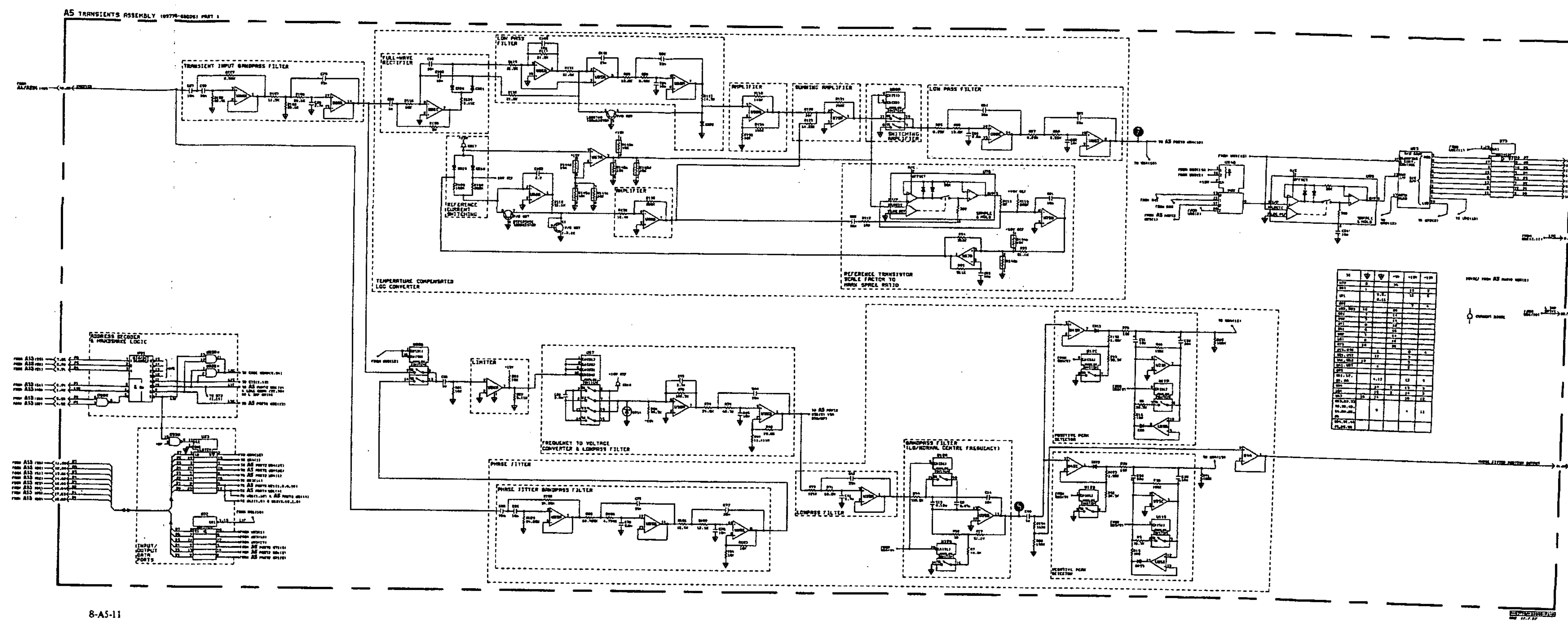


Figure A5-9 A5 Schematic – Part 1

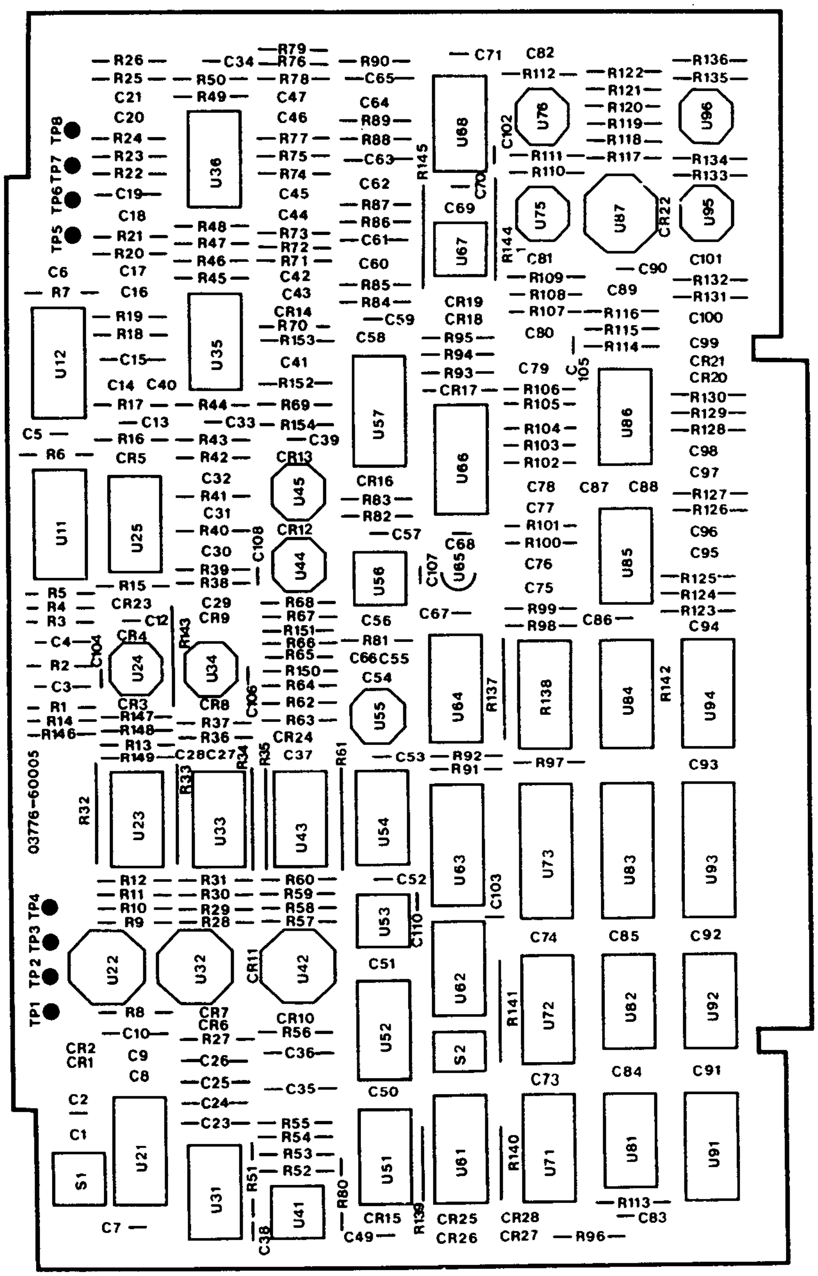


Figure A5-8 A5 Component Location

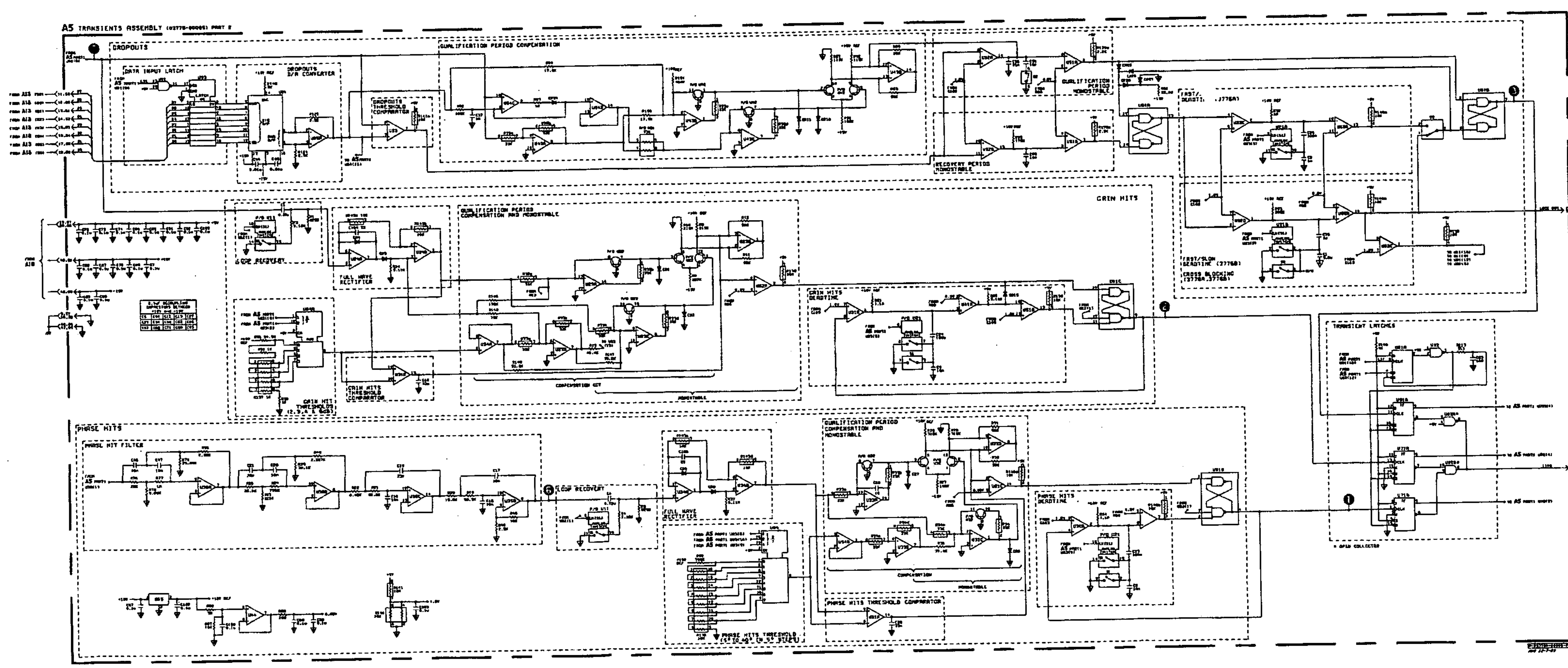


Figure A5-10 A5 Schematic – Part 2

ASSEMBLY SERVICE SHEET A6
ANALOG RECEIVER

A6-1 INTRODUCTION

A6-2 An overall description of the Analog Receiver is given in this section. Figure A6-1 illustrates the main circuit elements.

A6-3 The 3776 uses digital circuits on assemblies A9 and A13 to measure incoming analog signals. However to make a measurement, the analog signals must be converted to a digital form. This is done by the Analog Receiver contained on assemblies A6 and A7/A107 (see Figure A6-1). Autoranging and calibration routines, contained in software on A13, control the Analog Receiver circuits to ensure that the sequence of 16 bit binary words obtained at the output of A7/A107 accurately represent the incoming analog signals.

A6-4 Accuracy in converting the analog signal to a digital form is obtained by operating the A/D Converter, at the output of A7/A107, over its optimum operating range. This is achieved by using an autoranging technique to place the peak levels of the incoming analog signals within the 12dB window illustrated in Figure A6-2. From Figure A6-2 it can be seen that the range of binary words of the signal with autoranging (B) is greater than that without autoranging (A). Therefore signal B is more accurately represented in binary form than A.

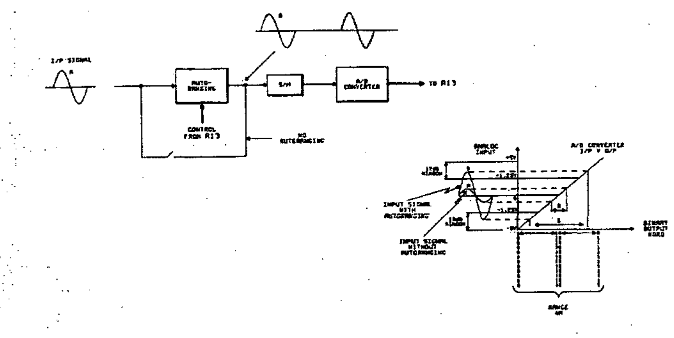


Figure A6-2 A/D Accuracy

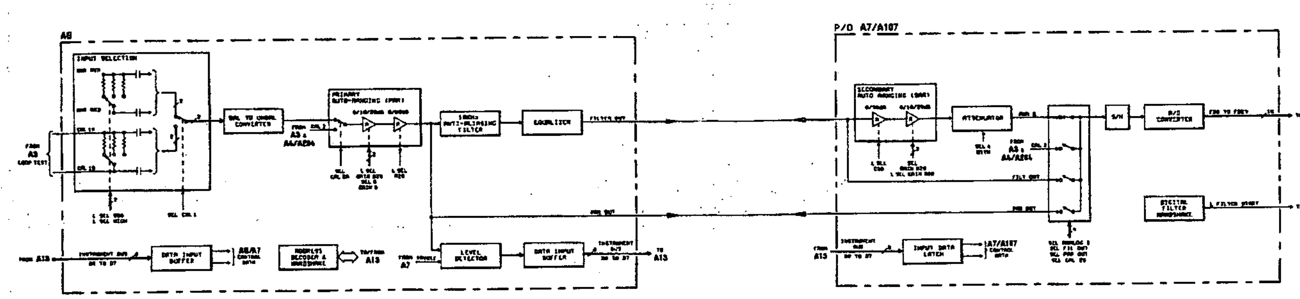


Figure A6-1 Simplified Receiver Block Diagram

A6-5 Autoranging

A6-6 Autoranging is split into:

1 Primary Autoranging PAR on A6,

2 Secondary Autoranging SAR on A7/A107.

A6-7 When an input analog signal is applied to the receiver, the Level Detector at the output of the PAR circuit on A6 monitors the peak signal level and instructs the processor on A13 to initiate the PAR routine. If the peak level is within the 12dB window illustrated in Figure A6-2 no autoranging occurs. However if the level is low the processor on A13 instructs the autoranging circuit to increase its gain by 10dB. The Level Detector then rechecks the peak level. If the level is within the 12dB window no further autoranging takes place. However if the level is still low another 10dB of gain is inserted. This procedure repeats until the peak level is within the 12dB window or until all 40dB PAR gain is inserted.

A6-8 After the PAR routine is completed, the SAR routine goes into action. In SAR, the peak level is monitored directly by A9 and A13 via the A/D Converter. The processor on A13 instructs the SAR circuits to insert in 10dB steps, the necessary gain between 0 and 50dB required to bring the peak level within the 12dB window.

A6-9 For all measurements except Group Delay (3776A) and Envelope Delay Distortion (3776B) the autoranging circuits place the peak levels of the signal at the input of the A/D Converter in a 12dB window, see Figure A6-2. In Group Delay and Envelope Delay Distortion measurements the SAR circuits together with a 4dB Attenuator place the peak level at the input of the A/D Converter within a 6dB window. All peak levels which fall between 7dB and 10dB of the 12dB window are boosted another 10dB by the SAR and then attenuated by 4dB to place the signal within the 6dB window.

A6-10 16kHz Anti-Aliasing Filter

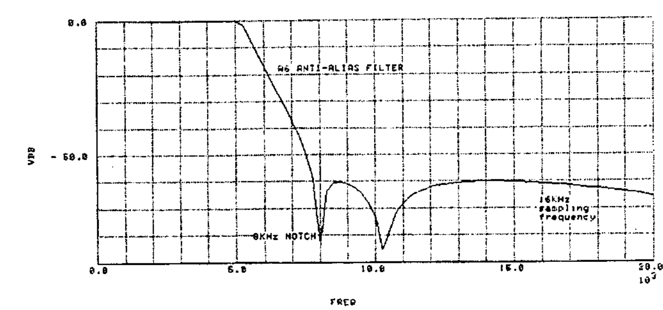


Figure A6-3 Anti-aliasing Filter Response

A6-11 To ensure that out-of-band signals do not corrupt the in-band voice channel with aliasing signals (see APPENDIX B) during a 3776 measurement, an anti-alaising filter is used in the Analog Receiver. This filter rejects the out-of-band components.

A6-12 In a PCM environment an 8kHz component may be received. The Anti-aliasing Filter has a notch specifically designed to attenuate the 8kHz by 60dB. A plot of Anti-aliasing Filter Response is shown in Figure A6-3.

A6-13 The 16kHz Anti-aliasing filter is placed between the PAR and SAR circuits for optimum in-band to out-of-band signal rejection.

A6-14 Calibration

A6-15 A calibration routine contained in the software of the A13 Assembly ensures that the various gain stages in the PAR and SAR circuits and the anti-aliasing filter response are accurately checked after every analog measurement (see APPENDIX C). Any ERRORS due to termperature and tolerances in the gain stages of the autoranging circuits or ERRORS in the filter response are stored in the processor. These ERRORS together with the the amount of gain used in autoranging and the binary words at the output of the A/D Converter are used to compute, accurately, the level of the incoming analog signal.

A6-16 Input Selection and Bal to Unbal Converter

A6-17 The Input Selection circuit terminates the balanced calibration signal and the incoming balanced signal in one of three impedances; 600ohms, 900ohms or 50kohms. Both paths are always terminated to prevent damage to the input circuits when switching between paths.

A6-18 The Bal to Unbal Converter converts the differential input signal to a single ended signal.

A6-19 Input/Output Buffers and Handshake Logic

A6-20 These circuits interface with the processor on A13 to allow the control signals on A6 and A7/A107 to provide autoranging and calibration.

A6-21 CIRCUIT DESCRIPTION

A6-22 Input Selection, Impedance Selection and Bal to Unbal Converter

A6-23 Relays K1A and K1B route either the external balanced ANALOG RXA and RXB signal or the balanced calibration CAL1A and 1B signal to the Bal to Unbal Converter.

A6-24 Relays K2A/K3A and K2B/K3B terminate both balanced signal paths in either 600ohms, 900ohms or 50kohms. Both paths are always terminated by equal termination impedances.

A6-25 The relay control signals L SEL CAL1, L SEL 900 and L SEL HIGH are derived from the processor on A13.

A6-26 The Bal to Unbal Converter comprising four amplifiers U17A/B/C/D converts the balanced or unbalanced signal to a single-ended signal.

A6-27 Primary Autoranging (PAR)

A6-28 There are two analog signal paths to the PAR circuits:

1 the analog receiver input signal, from the Bal to Unbal Converter;
2 the calibration signal, CAL2 from A3.

The signal from the Bal to Unbal Converter is applied to the first gain stage of the PAR via a switching network comprising U55A and FET's Q1/Q3. The CAL 2 signal is applied to the same PAR gain stage via U55B and Q5/Q7. The switching networks are controlled by SEL CAL 2A. When SEL CAL 2 is low, Q1/Q3 are switched on and Q5/Q7 are off; the analog receiver input signal is selected.

A6-29 The first gain stage of the PAR comprises selectable gain amplifier U55C. The gain of U55C is set at 0dB, 10dB or 20dB by either SEL GAIN B20 or SEL 0 GAIN B. When SEL GAIN B20 goes high, Q2 switches on and shorts out R14 to set the gain to 10dB. When SEL GAIN B is low, Q2 is switched off and R14 increases the gain to 20dB. If SEL 0 GAIN B goes high, Q4 shorts out R13 and R14 to set the gain of U55C to 0dB.

A6-30 The second stage of the PAR is U55D. This amplifier has two selectable gains 0dB or 20dB. Gain selection is controlled by L SEL A20. When L SEL A20 is high, Q6 shorts out R10 to set the gain to 0dB (see Table A6-1).

Table A6-1 Primary Autoranging Gain Selection

GAIN (dB)	LEDs			PAR FET STATUS		
SELECTED	B10	B20	A20	Q4	Q2	Q6
0	OFF	OFF	OFF	ON	DONT CARE	ON
10	ON	OFF	OFF	OFF	ON	ON
20	OFF	OFF	ON	ON	DONT CARE	OFF
30	ON	OFF	ON	OFF	ON	OFF
40	OFF	ON	ON	OFF	OFF	OFF

NOTE: The measurement software selects only the given LED patterns to produce the appropriate gain.

A6-31 16kHz Anti-aliasing Filter

A6-32 The 16kHz Anti-aliasing Filter comprises three similar networks. Test Links TL1, TL2, TL3 and TL4 allow the technician to isolate each of the three filter sections during troubleshooting. See GENERAL SERVICE SHEET G7 for troubleshooting hints.

A6-33 Equaliser

A6-34 The Equaliser comprising U85C and U85D has an all pass frequency response. It also has a phase response that cancels out the phase non-linearities of the 16kHz Anti-aliasing Filter to produce constant group delay which is essential in Group Delay (3776A) and Envelope Delay Distortion (3776B) measurements.

A6-35 Address Decoder, Handshake logic, Input and Output Buffers

A6-36 The calibration and autoranging routines, the input selection and input impedance selection are all carried out on A6 under the control of the processor which is located on A13. Communication between A6 and A13 is via the Address Decoder U81 and the Handshake Logic. The Handshake protocol is described in Assembly Service Sheet A13.

A6-37 Data is latched into the Input and Output Buffers by control signals from the Address Decoder and Handshake Logic.

A6-38 The Address Decoder also provides the control signals for the A7/A107 Assembly (i.e. L ADDR 33 and L ADDR 35).

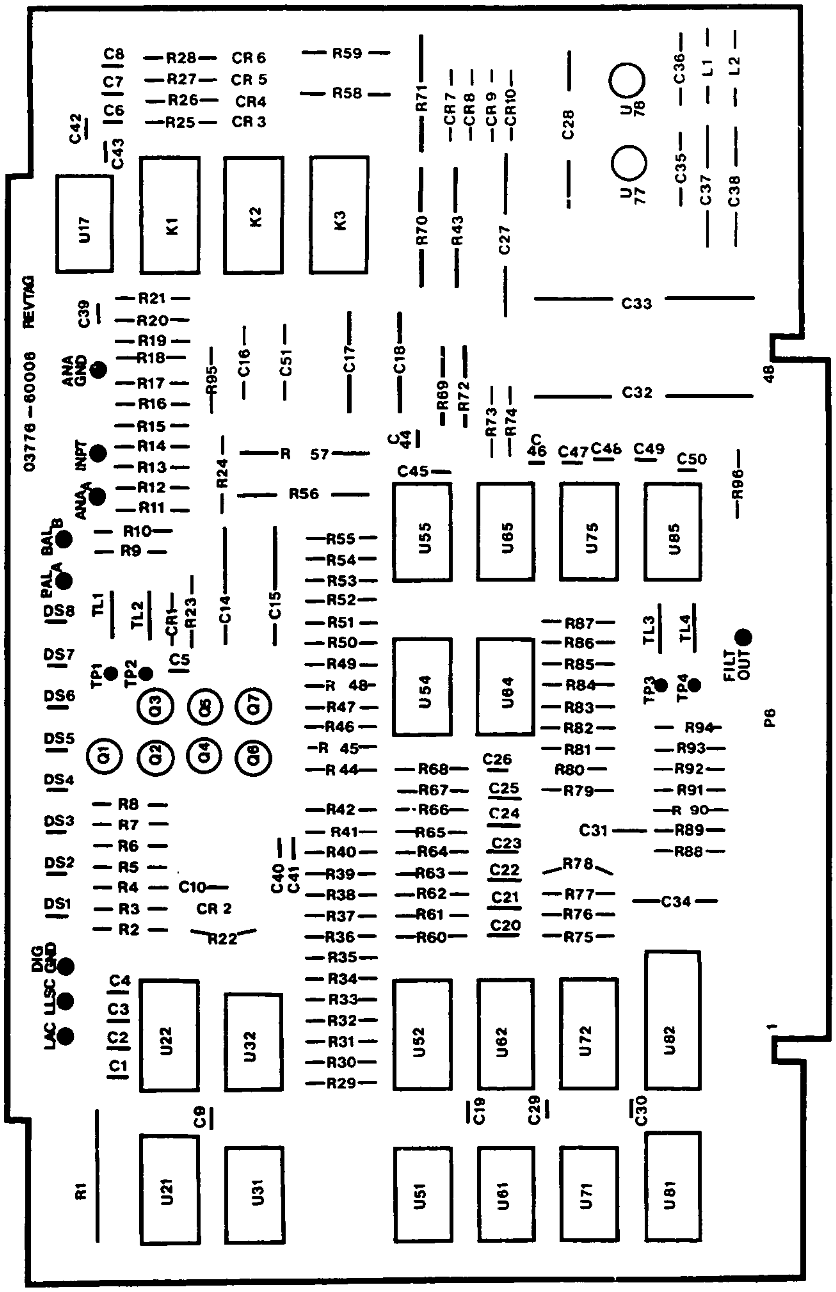


Figure A6-4 A6 Component Location

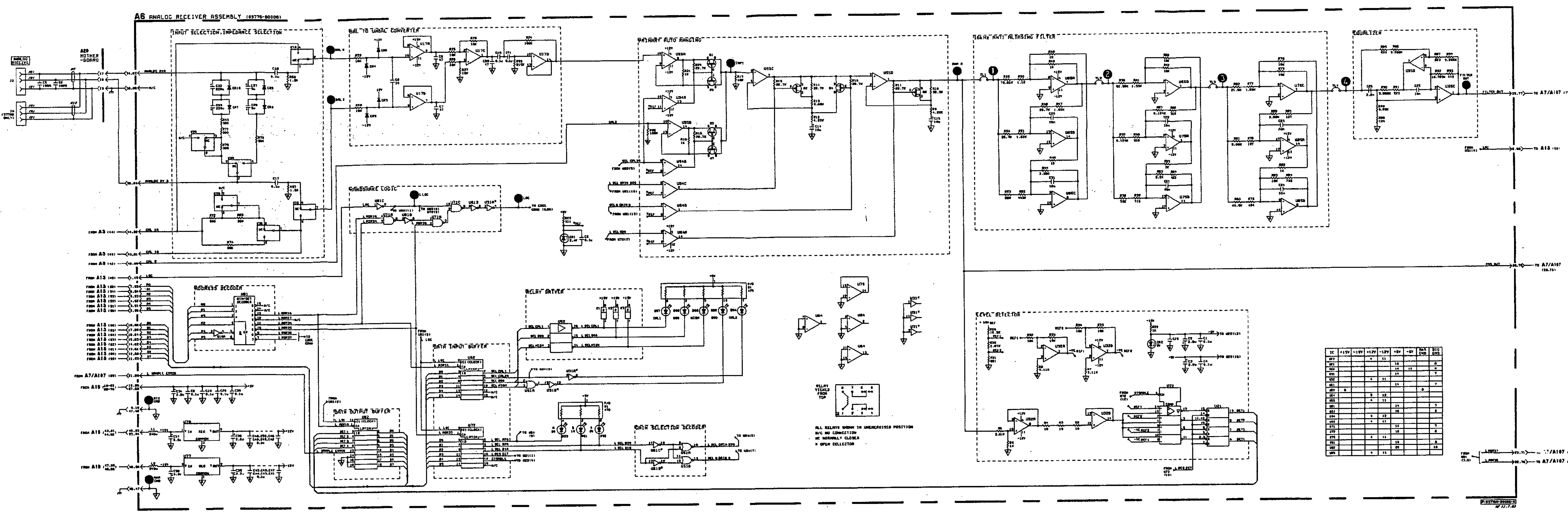


Figure A6-5 A6 Schematic

ASSEMBLY SERVICE SHEET A7/A107
A7 (3776A)
A107 (3776B)
SECONDARY AUTORANGING, A/D CONVERTER AND DIGITAL OUTPUT STAGE

A7-1 INTRODUCTION

A7-2 Assemblies A6 and A7/A107 form the Analog Receiver; a general description of the A7/A107 section of the receiver is given in Assembly Service Sheet A6.

A7-3 CIRCUIT DESCRIPTION

A7-4 Data Input Buffers

A7-5 Latches U72 and U82 receive and store data from A13. This data controls:

1 the Secondary Autoranging (SAR) circuits,
2 signal path selection, during calibration,
3 the Digital Filter Handshake Control.

A7-6 Secondary Autoranging (SAR)

A7-7 The SAR circuit comprising two selectable gain stage amplifiers U64A and U64B provides between 0dB to 50dB of gain. The first gain stage provides either 0dB or 30dB. The second gain stage provides either 0dB, 10dB or 20dB.

A7-8 Gain selection is controlled by L SEL C30, SEL GAIN D20 and L SEL GAIN D00. When L SEL C30 is low; Q19 is switched off and R35/R34 set the gain of U64A to 30dB. When L SEL C30 is high, Q19 is switched on and R35 is shorted out to set the gain to 0dB. The 0dB, 10dB and 20dB gains of U64B are selected in a similar manner to U64A (see Table A7-1). The autoranging routine is described in Paragraphs A6-7 to A6-9 in Assembly Service Sheet A6.

Table A7-1. Secondary Autoranging Selection

GAIN (dB)	LEDs			SAR FET STATUS		
SELECTED	D10	D20	C30	Q15	Q16	Q19
0	OFF	OFF	OFF	ON	DON'T CARE	ON
10	ON	OFF	OFF	OFF	ON	ON
20	OFF	ON	OFF	OFF	OFF	ON
30	OFF	OFF	ON	ON	DON'T CARE	OFF
40	ON	OFF	ON	OFF	ON	OFF
50	OFF	ON	ON	OFF	OFF	OFF

A7-9 Attenuator

A7-10 The 4dB attenuator comprising R38/R39 may be switched into the analog signal path by SEL 4 ATTN during Group Delay (3776A) and Envelope Delay Distortion (3776B) measurements, see Paragraph A6-9 on Assembly Service Sheet A6.

A7-11 Analog B Switch, Filter Out Switch, Analog A Switch and CAL2 Switch

A7-12 Four signal paths are applied to the input of the A/D Sample Hold Logic via four switching networks. These switching network are all similar and are enabled one at a time. The Analog B Switch routes the incoming analog signal to U25D. The other three switching networks are utilised during a calibration cycle.

A7-13 When SEL ANALOG B from the Data Input Buffer goes high it switches on Q2/Q4 and routes the incoming signal to the A/D Sample & Hold Logic. When SEL ANALOG B goes low, Q2/Q4 switches off and breaks the signal path. All the other switching networks operate in a similar manner and are controlled by SEL FILT OUT, SEL PAR OUT and SEL CAL 2B.

A7-14 A/D Sample & Hold Logic

A7-15 The sample and hold circuit is contained in U45. Incoming analog signals at U45(3) are sampled at a 16kHz rate by L HOLD to produce a staircase waveform at U45(5), see Figure A7-1. The sampled signal levels are then converted to a digital form everytime a low L CONVERT is applied to the enable input of the A/D Converter U65.

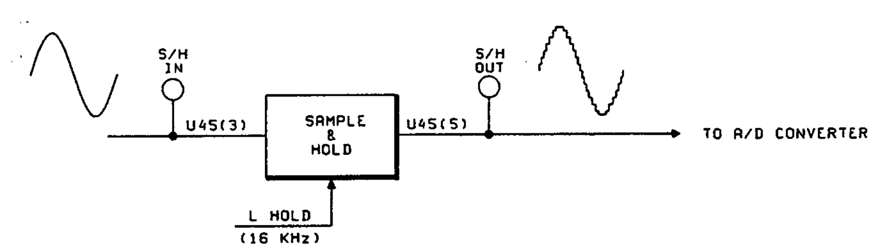


Figure A7-1 Sample and Hold Waveforms

A7-16 The digital word at the output of U65 is latched into U75 and U85 by LOAD DATA. The data stored in the latches is then applied to A9 when the Digital Filter Handshake signal L READ DATA goes low (see Figure A7-2 Timing Diagram).

A7-17 600ohms BAL Output

A7-18 A 600ohms BAL Output circuit is placed at the input of the Sample and Hold circuit as an aid when troubleshooting the Analog Receiver.

A7-19 Digital Filter Handshake Logic; Sample Error Detector; Hold Control Logic and Delay and Sample Control Logic

A7-20 These four digital circuit elements allow analog signals to be sampled and converted to a digital form. They also determine when the digital words at the output of A7/A107 are to be applied to A9. The following paragraphs should be read in conjunction with the Timing Diagram in Figure A7-2.

A7-21 The Hold Control Logic comprising U32D and U22B produces L HOLD. This signal allows U45 to hold the sampled incoming signal for 50us in every 62.5us. The cumulative effect of L HOLD on U65 is to produce a staircase waveform as illustrated in Figure A7-1. However only one sample is considered in the Timing Diagram of Figure A7-2.

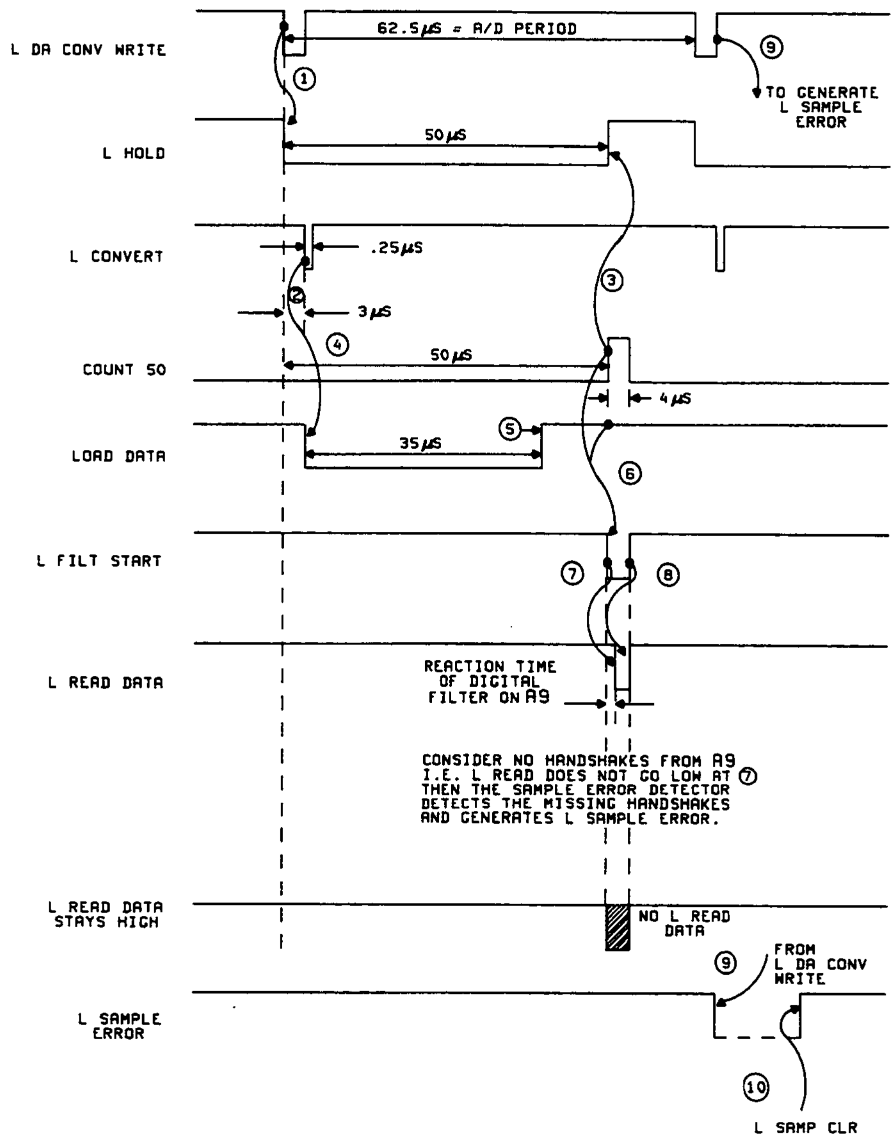
A7-22 The Delay and Sample Control Logic ensures that there is a delay of nominally 3us between the sample enable signal L HOLD and the A/D Converter enable signal L CONVERT. The delay allows the sampled analog signal to settle before it is digitised by U65.

A7-23 The 50us Counter is initiated at the beginning of an A/D conversion. Only after COUNT 50 goes high at U31(15) does the Digital Filter Handshake Logic produce L FILT START. This signal informs the Digital Filter that a digital word at the output of A7/A107 is ready to be applied to A9. Once A9 has received L FILT START it sends L READ DATA which enables the outputs of U75 and U85 and allows the output of A7/A107 to be applied to A9.

A7-24 After an A/D conversion, LOAD DATA and COUNT 50 flag the Digital Filter Handshake Logic. LOAD DATA from the A/D Converter informs the Digital Handshake Logic that digital data at the output of A7/A107 is ready to be applied to A9. COUNT 50 is a synchronising signal, generated by the 50us Counter, it determines when the data is to be applied to A9 and is always produced 50us after L HOLD. A complete A/D conversion takes nominally 40us, the 50us time delay between L HOLD and COUNT 50 ensures that the A/D Conversion will have been completed before the data stored in U75 and U85 is applied to A9.

A7-25 The Sample Error Detector illuminates DS9 when it detects no handshake between A9 and A7/A107 ie no L READ DATA.

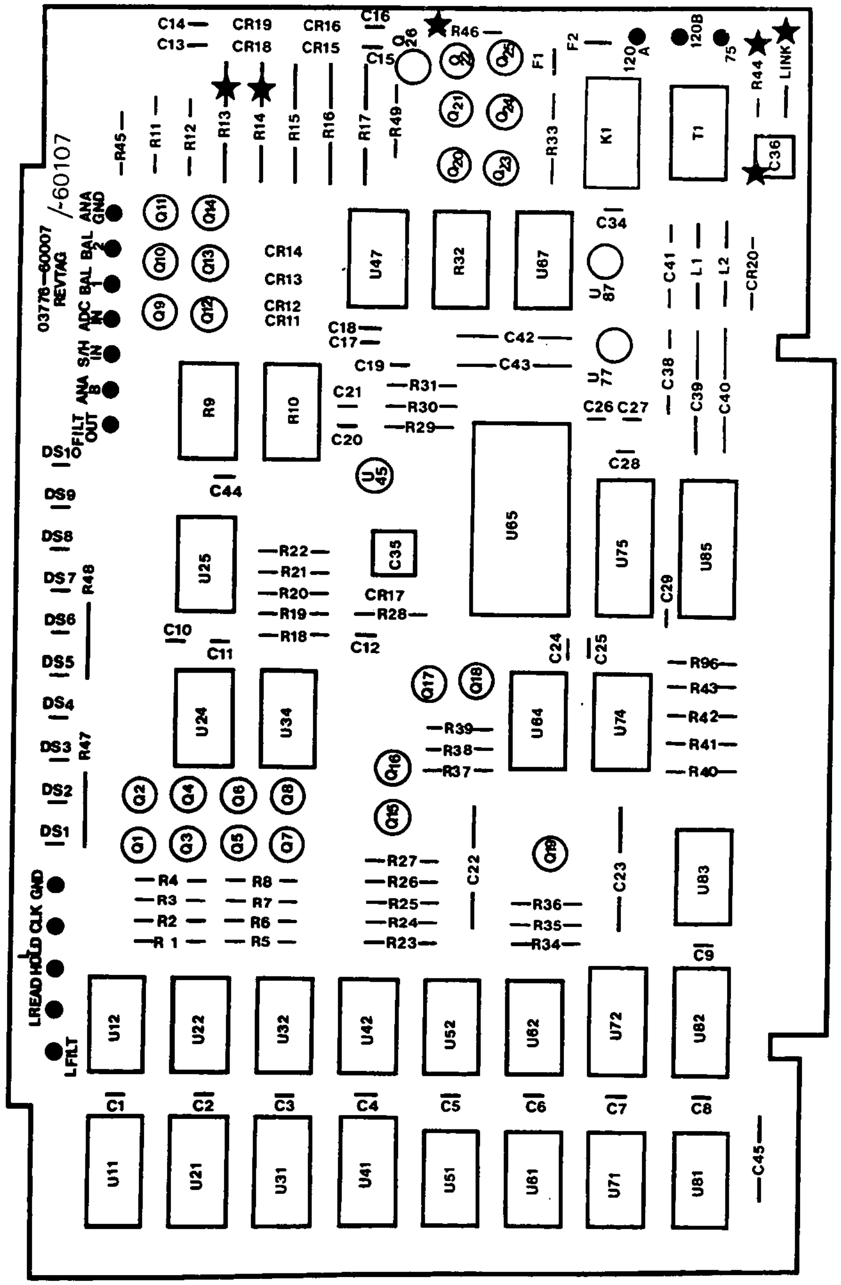
A7-26 Further troubleshooting information regarding this assembly is contained on GENERAL SERVICE SHEET G7.



NOTES

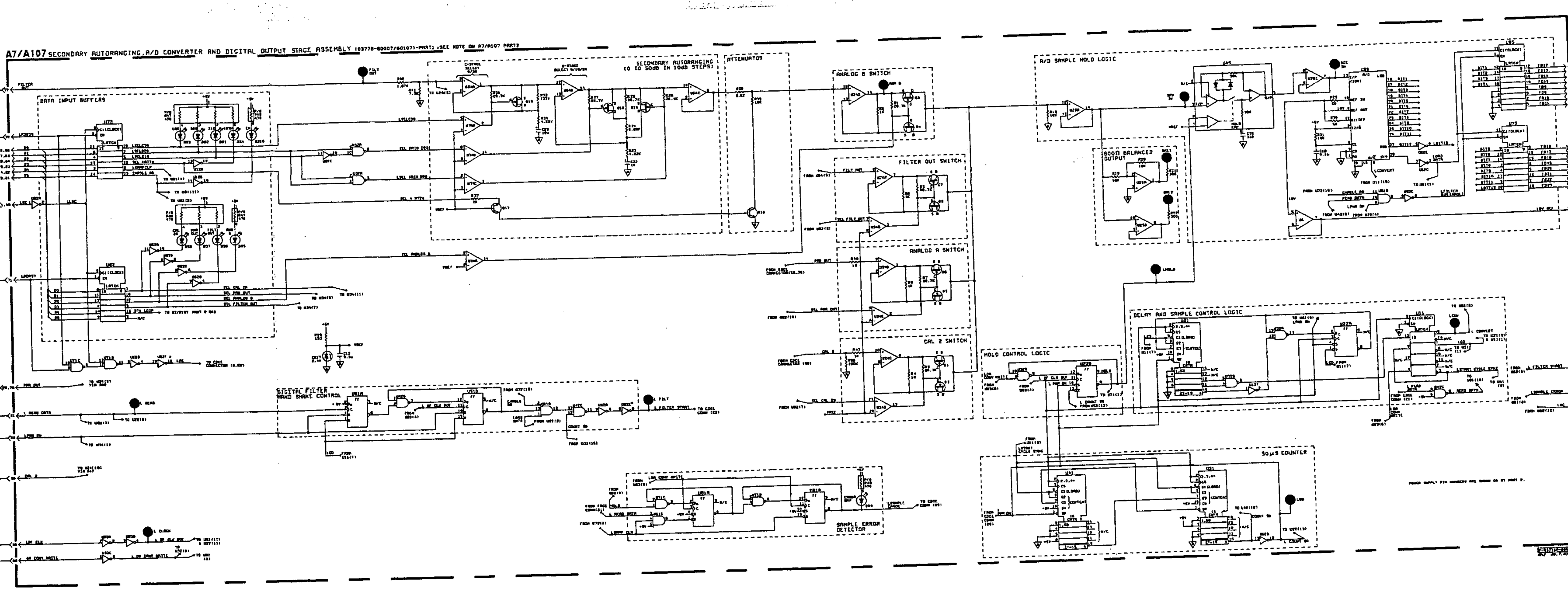
1. L DA CONV WRITE SETS L HOLD LOW
2. 3µS DELAY BETWEEN L HOLD AND L CONVERT
3. 50µS AFTER L DA CONV WRITE, L COUNT 50 SETS L HOLD HIGH
4. L CONVERT SETS LOAD DATA LOW
5. AFTER 35µS LOAD DATA GOES HIGH
6. LOAD DATA AND COUNT 50 SET L FILT START LOW
7. L READ DATA SET LOW AFTER L FILT START GOES LOW
8. L READ DATA SET HIGH WHEN L FILT START GOES HIGH
9. RISING EDGE OF L DA CONV WRITE SETS L SAMPLE LOW IF L READ DATA IS NOT SET LOW
10. L SAMPLE ERROR SET HIGH BY L SAMP CLR FROM A13 VIA A6

Figure A7-2 Timing Diagram

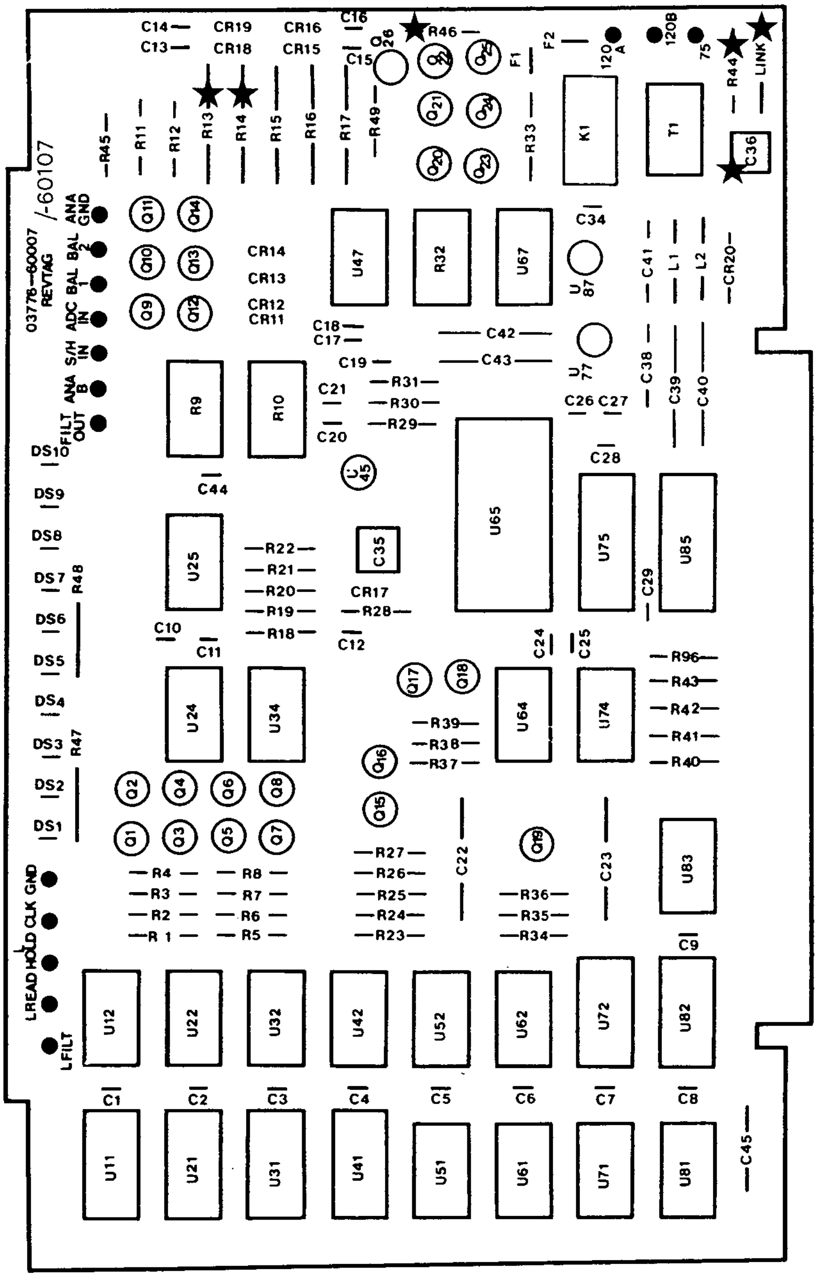


★ HIGHLIGHTS DIFFERENCES BETWEEN A7 AND A107.
REFER TO NOTES ADJACENT TO COMPONENTS ON A7/A107 SCHEMATIC.

Figure A7-3 A7/A107 Component Location



A7-4 A7/A107 Schematic Diagram - Part 1



★ HIGHLIGHTS DIFFERENCES BETWEEN A7 AND A107.
REFER TO NOTES ADJACENT TO COMPONENTS ON A7/A107 SCHEMATIC.

Figure A7-3 A7/A107 Component Location

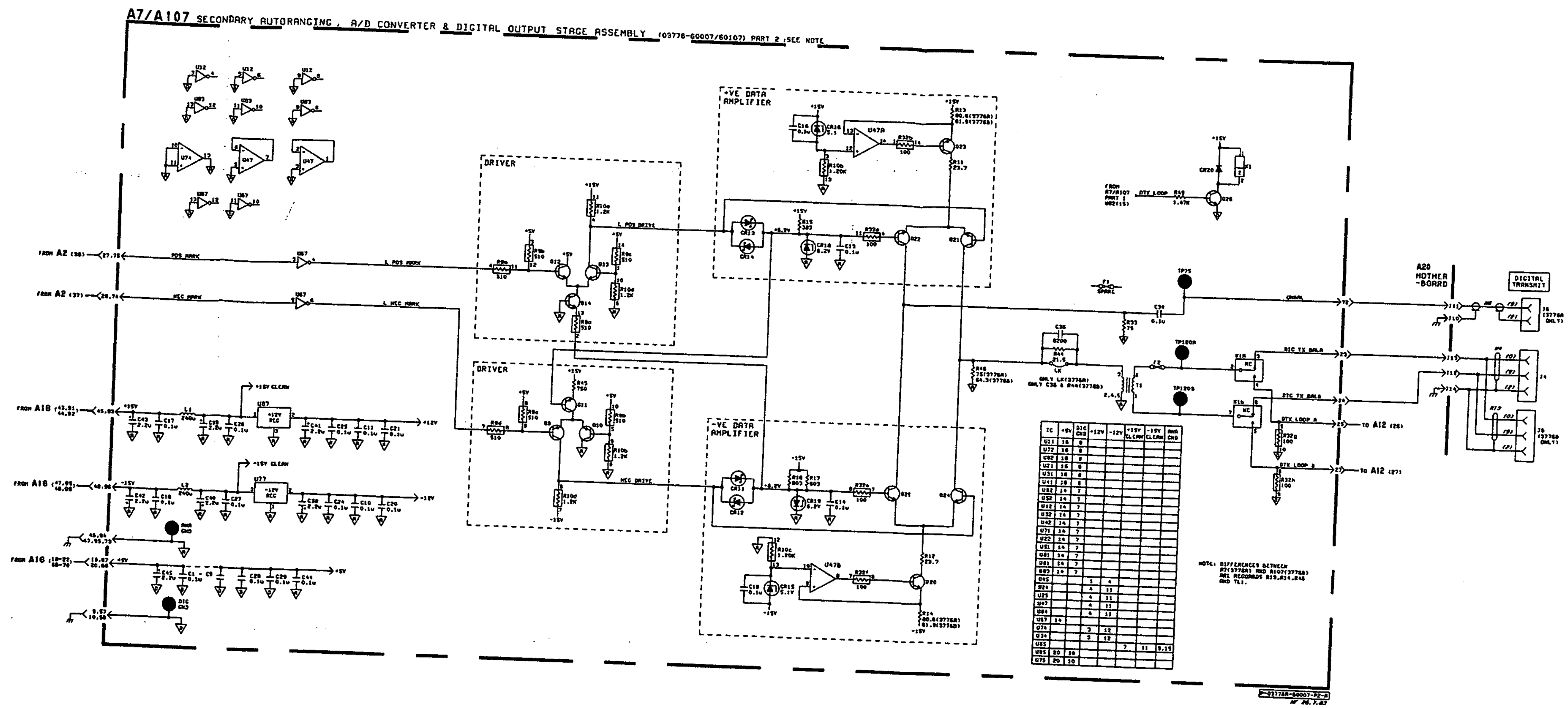


Figure A7-5 A7/A107 Schematic Diagram - Part 2

ASSEMBLY SERVICE SHEET A8
GROUP DELAY TIMING, IMPULSE NOISE FREQUENCY DETECTOR
(OPTION 001 ONLY)

A8-1 INTRODUCTION

ASSEMBLY SERVICE SHEET A8
GROUP DELAY TIMING, IMPULSE NOISE FREQUENCY DETECTOR
(OPTION 001 ONLY)

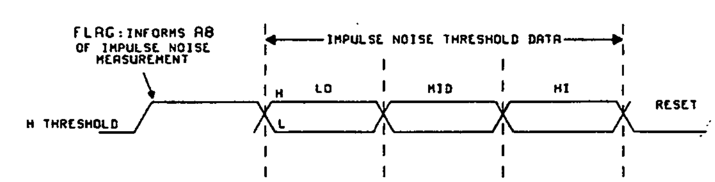
A8-1 INTRODUCTION

A8-2 Assembly A8 breaks down into the following four sections:

1 Impulse Noise;
2 Frequency Counter (Group Delay and Envelope Delay Distortion measurements);
3 Group Delay Timing (3776A only);
4 Handshake, Decoder, Timing Generator and Status Register.

A8-3 Impulse Noise

A8-4 In a typical impulse noise measurement a -10dBm0, 1kHz tone is applied to the system under test, the 3776 notches out the 1kHz tone and then monitors the noise level. The 3776 measures impulse noise in the TRANSIENTS mode by comparing the input noise against three threshold levels Lo, MID and Hi. The Lo threshold is keyed into the 3776 via the front panel while the MID and Hi threshold levels, derived from the 3776 software, are 3dB and 6dB (3776A) or 4dB and 8dB (3776B) above the Lo threshold.



H denotes that a threshold has been exceeded

Figure A8-1 Serial Impulse Threshold Data

A8-5 Impulse noise data is applied serially to A8 along the H THRESHOLD line in the order shown in Figure A8-1. H THRESHOLD is set high prior to an impulse noise measurement and then reset low. The A8 Assembly extracts the threshold data from H THRESHOLD for processing on A13.

A8-6 Figure A8-2 shows the Impulse Noise circuits of A8. The Threshold Detector converts the serial data of H THRESHOLD to a parallel format, LLO, LMID and LHi which is then applied to three similar Latch/Self-blocking Timers. These networks first latch the status of LLO, LMID and LHi, then prevent any updating for either 125ms or 10ms. This blocking action is controlled by the Fast/Slow Selector which

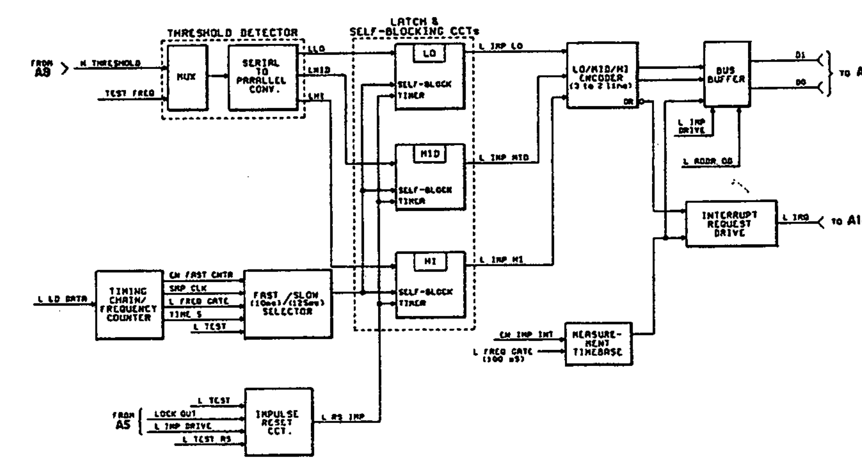


Figure A8-2 Impulse Noise

is a parameter of the Transients measurements. The signals at the outputs of the Latch/Self-blocking Timers L IMP LO, L IMP MID and L IMP Hi are converted from 3 to 2 lines by the Lo/MID/Hi Encoder. The encoder also flags the Interrupt Request Driver which instructs the processor on A13 to read the impulse noise data from A8.

A8-7 The processor services the interrupt request via the A5 Assembly. When the processor services the A8 interrupts, L IMP DRIVE is generated. This signal enables the Bus Buffers which present D0 and D1 to A13 for processing. The L IMP DRIVE signal is also used to remove L IRQ after the impulse noise interrupt has been serviced. In the Impulse Reset circuit L IMP DRIVE produces L RS IMP which resets the Latch/Self-blocking Timers and removes the low L IRQ signal. Although the Latch/Self-blocking Timers have been reset they cannot be updated until after the 125ms or 10ms blocking period.

A8-8 Frequency Counter

A8-9 In Group Delay (3776A) and Envelope Delay Distortion (3776B) measurements it is necessary that the carrier frequencies be measured and presented to the front panel displays. This is done on A8 by the Frequency Counter shown in Figure A8-3.

A8-10 When the EN FREQ GATE line is true the Timing Chain/Frequency Counter increments to its full count then waits to be reset by L ADDR 2E. Each time L ADDR 2E is pulsed, the Frequency Gate Counter resets to zero then starts incrementing to its full count again. During this sequence the gating signal L FREQ GATE is low for 50ms then high for 50ms. While L FREQ GATE is low the Frequency Counter can increment.

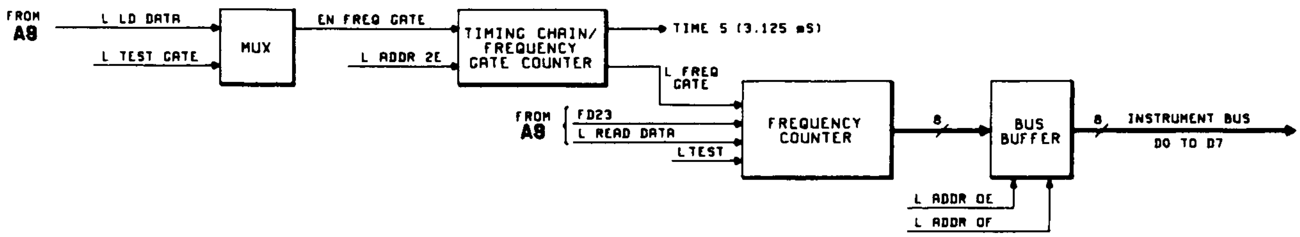


Figure A8-3 Frequency Counter

A8-11 The low L FREQ GATE signal allows the Frequency Counter to increment each time there is a zero crossing of the carrier signal, ie a change in state of the sign bit, FD23, of the digital filter data bus during the L READ DATA instruction. When the gating signal is removed the zero crossing count is applied via the Bus Buffer to A13 for processing.

A8-12 There are two zero crossings in 1 cycle, the number of zero crossings in 50ms equals the number of cycles in 100ms. Therefore the number of zero crossings counted multiplied by 10 gives the carrier frequency in Hz.

A8-13 Group Delay Timing

A8-14 The 3776 uses the recommended CCITT (0.81) method to measure Group Delay. The 3776 measures group delay in the PCM domain or in the analog domain, Figure A8-4 shows a typical analog group delay waveform. The 41 2/3Hz and 166 2/3Hz modulation envelopes shown in Figure A8-4 are used by the 3776 to measure Group Delay.

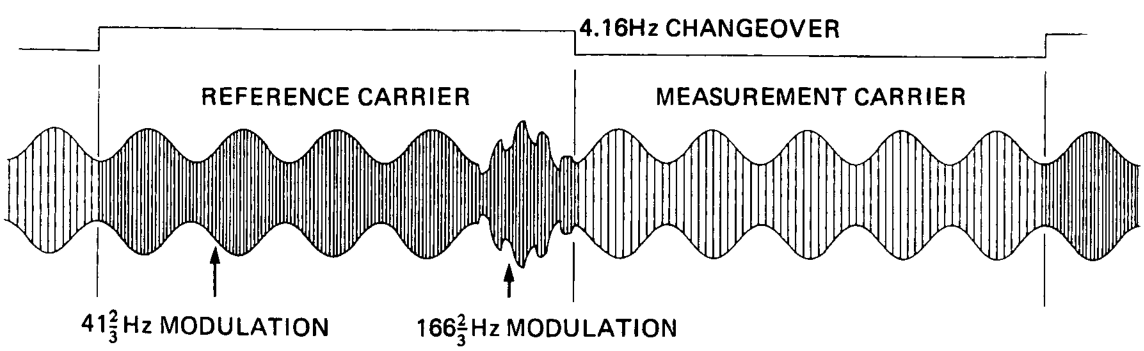


Figure A8-4 Group Delay Waveform

A8-15 The phase of the 41 2/3Hz modulation envelope is measured alternately in the Reference and Measurement carrier periods by the 3776. Differences in phase define the group delay.

A8-16 The 166 2/3Hz modulation is a synchronising marker and indicates the start/finish of the Measurement/Reference carrier. This marker detected on A9 is applied to the Group Delay Timing on A8 to generate the timing signals which determine where in the Reference and Measurement periods the 41 2/3Hz modulation is sampled. Figure A8-5 shows the Group Delay Timing circuits.

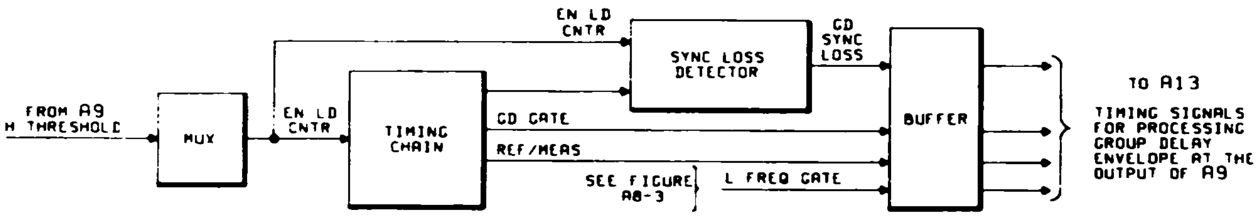


Figure A8-5 Group Delay Timing

A8-17 Signature Analysis (SA)

A8-18 The Impulse Noise, Group Delay and Frequency Counter circuits are covered by signature analysis. If a fault condition is suspected in any of these circuits refer to the GENERAL SERVICE SHEET G9 and check the signatures obtained against the listed ones. Because these circuits can be checked using SA, NO detailed description of the Group Delay circuits is given.

A8-19 Handshake, Address Decoder, Status Register

A8-20 These circuits allow the Impulse Noise and Group Delay circuits to perform their respective functions by supplying the appropriate control data.

A8-21 The Address Decoder and Handshake Logic implements the handshake protocol between the A8 and A13 Assemblies (see Handshake Protocol in Assembly Service Sheet A13). The Status Register latches control data from the processor on A13.

A8-22 CIRCUIT DESCRIPTION

A8-23 Impulse Noise

A8-24 The Threshold Detector comprises a MUX, counter and a decoder. The MUX routes serially encoded impulse threshold information (see Figure A8-1) or a test signal TEST FREQ (used during a self test check) to the counter and decoder. These two devices U32 and U22 convert the serial data at TP6 to a parallel form at TP7, 8 and 9.

A8-25 The L Lo, L MID and L Hi lines from TP7, 8 and 9 are applied to three identical Latch/Self-blocking Timers - only the LO network is described. The L LO signal is latched into the SR flip-flop U24A to produce L IMP LO which is applied to the Lo/MID/Hi Encoder U23 and to SR flip-flop U24B. No subsequent impulses can be recorded by U24A until:

1 the processor on A13 has read this particular impulse (the reading action produces a pulse on L RS IMP which resets U24A);

2 the self blocking mechanism times out.

A high LATCH Lo at the output of U24B prevents further impulse threshold updating (self-blocking) by holding the reset input of U24A high. LATCH Lo allows the Self blocking Timer U34A/U45A to be incremented by the clock signals from the Fast/Slow Selector. Further impulses may be latched after the Self blocking Timer has incremented through to reset U24B, ie LATCH Lo set low. The times to reset U24B, 125ms (SLOW) and 10ms (FAST) are TRANSIENT parameters and are determined by the clock rates produced at the output of the Fast/Slow Selector.

A8-26 The outputs of the three Latch/Self blocking Timers are applied to the highest-priority-to-binary encoder U23 which operates as a 3 to 2 line encoder. When any of the inputs to U23 go low, the encoder also produces an impulse threshold interrupt flag which drives L IRQ at U42(8). When the processor services the interrupt L IMP DRIVE is generated on A5 and applied to the bus buffer U64 and to the Impulse Reset circuit to produce L RS IMP. This signal removes the interrupt flag at U23(14) by setting all the lines L Lo, L MID and L Hi high.

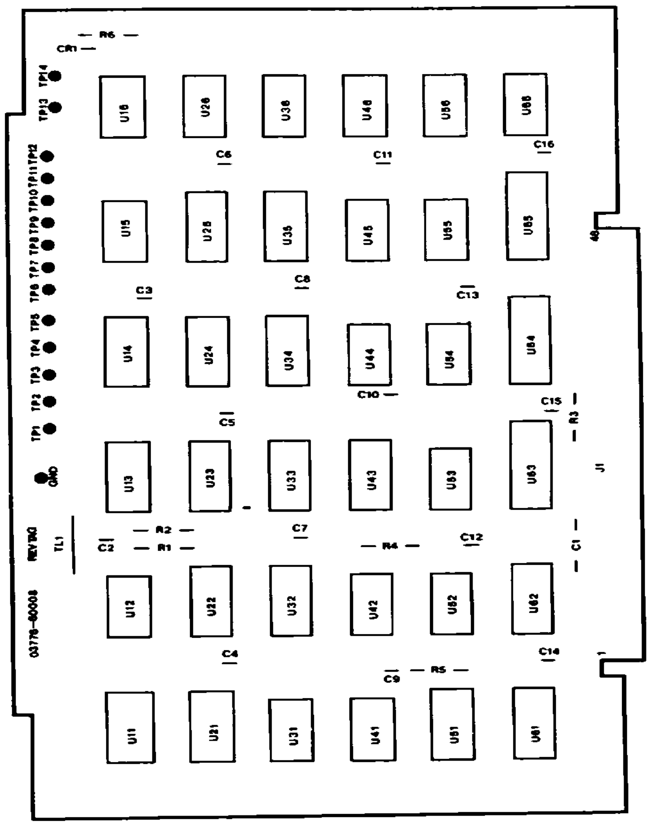


Figure A8-6 A8 Component Location

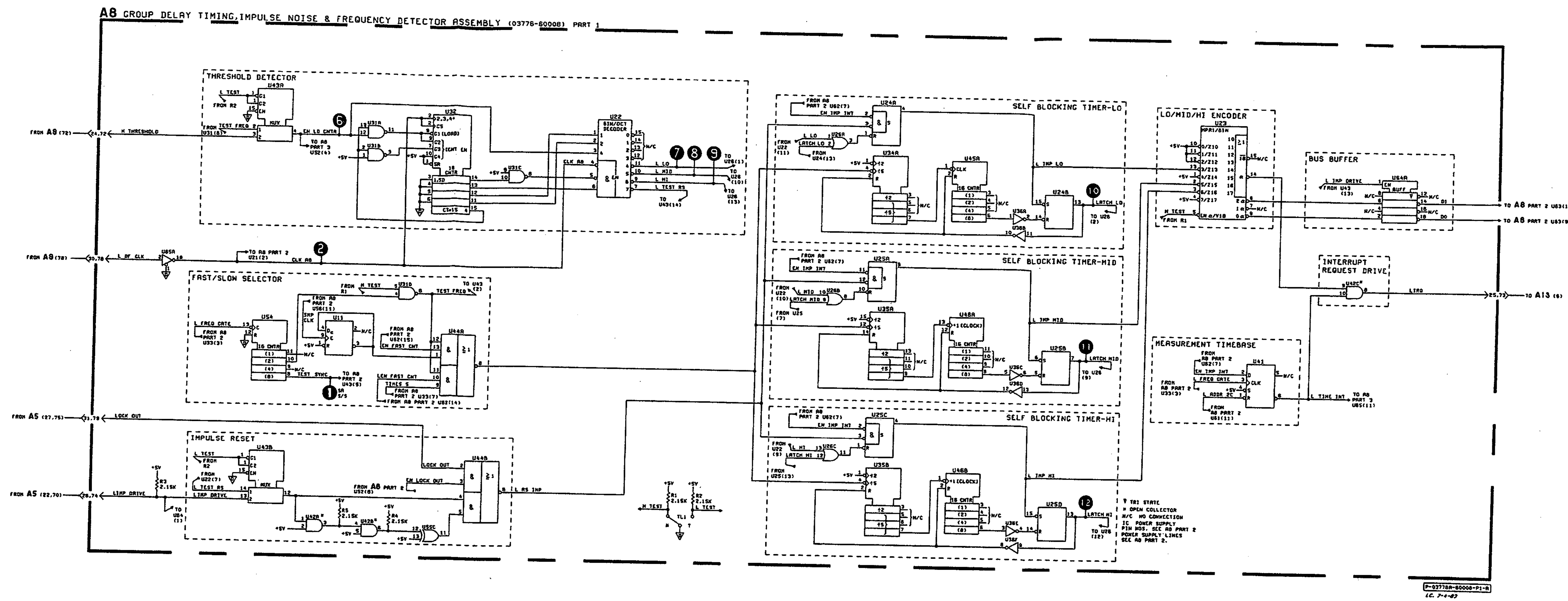


Figure A8-7 A8 Schematic – Part 1

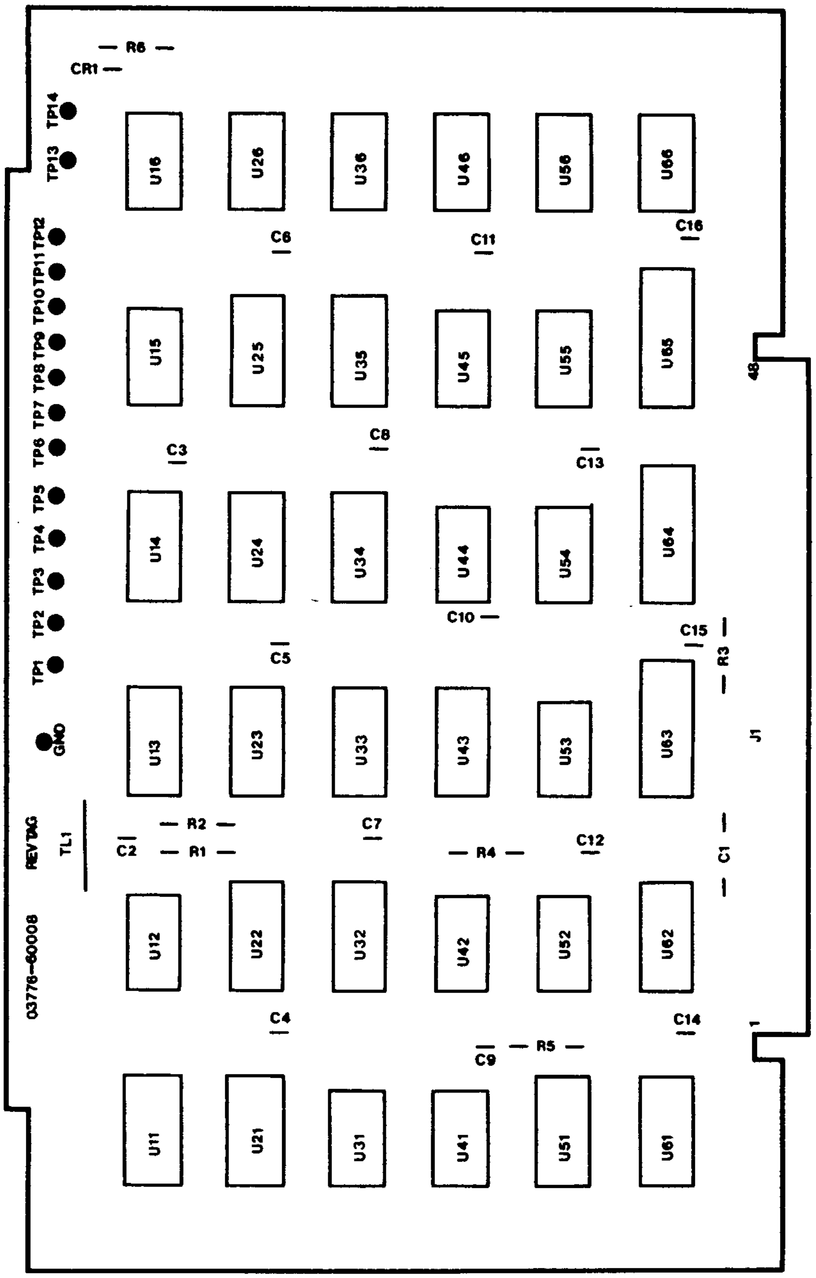


Figure A8-6 A8 Component Location

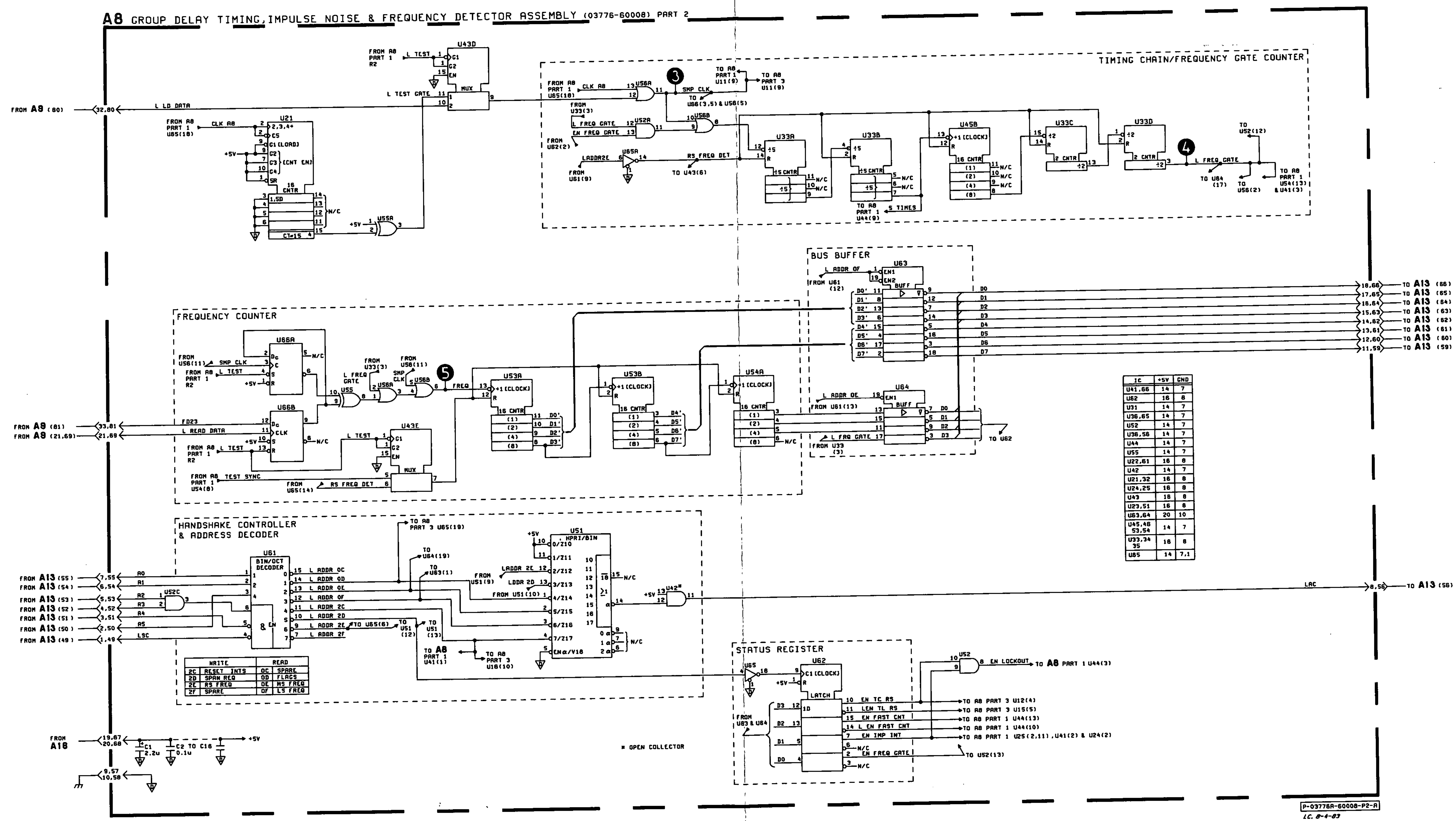


Figure A8-8 A8 Schematic – Part 2

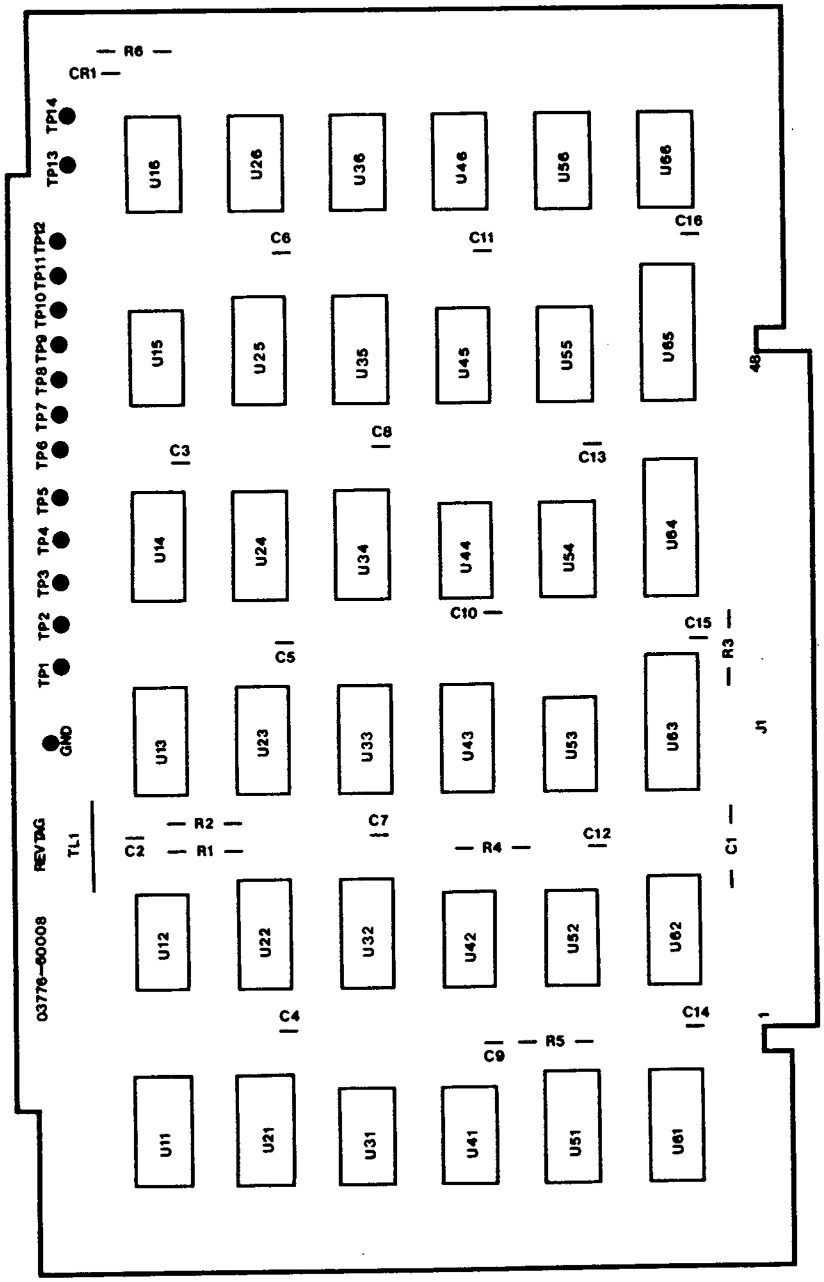


Figure A8-6 A8 Component Location

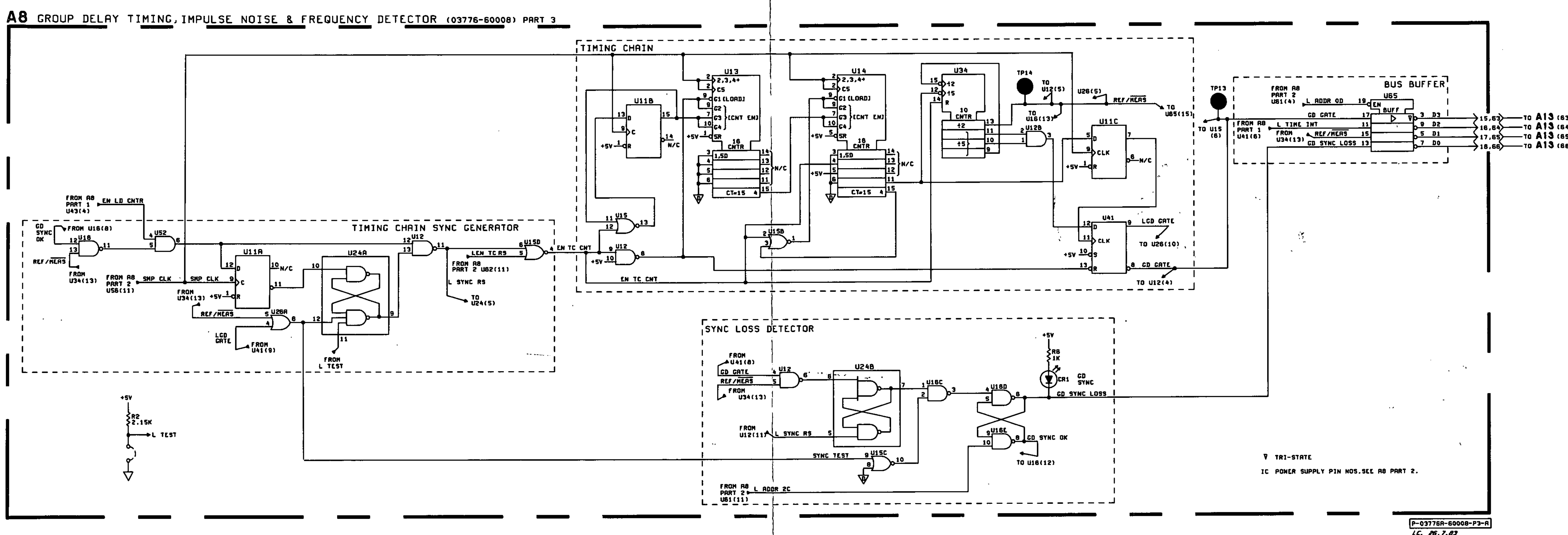


Figure A8-9 Schematic – Part 3

Only one data source is connected to A9 for processing at a time and the data for filtering is applied to the Digital Filter chip via the Filter Input Bus (FD8 to FD23).

A9-9 When either the Digital Receiver or Analog Receiver output data is ready for processing L FILTER START initiates the digital filtering routine by resetting the RAM Address Counter. The reset address at the output of the counter locates an instruction in the Filter Program RAM which produces L READ DATA at the output of the Instruction Decoder. L READ DATA allows the receiver data to be applied to the Digital Filter Chip via the Filter Input Bus. During the execution of the digital filtering the Filter Program RAM is in the READ mode.

A9-10 The RAM Address Counter clocked by P CLK divided by 2 (H CLK) increments through the Filter Program RAM addresses. Instructions contained in the addressed locations are applied to the Instruction Decoder and the Digital Filter chip. These circuit elements contain the required logic necessary to filter binary input data. A typical 2nd order filter is shown in Figure A9-3.

A9-11 The Digital Filter chip has two serial outputs, data from these are applied in bursts of 24 bits to:-

1 The processor on A13 for further processing via the serial to parallel Detector Output - 2 The rear panel MONitor O/P via the D/A Converter on A4/A204.

A9-12 The 24-bits, clocked into the Detector Output are applied to the processor on A13 in 3 X 8bit bursts via the Processor Data Bus D0 to D7.

A9-13 DC thresholds required during digital filtering are applied to the Digital Filter chip from A13 via the Processor Data Bus and Threshold Register.

A9-14 Analog and Digital Filters

A9-15 Digital and analog filters are frequency-selective systems which discriminate between predetermined bands of frequency. They may be represented analytically in the frequency domain by transfer functions which in turn may be transformed to the time domain as differential equations for analog filtering and difference equations for digital filtering. Figure A9-3 illustrates the transfer functions for a 2nd order analog and digital filter.

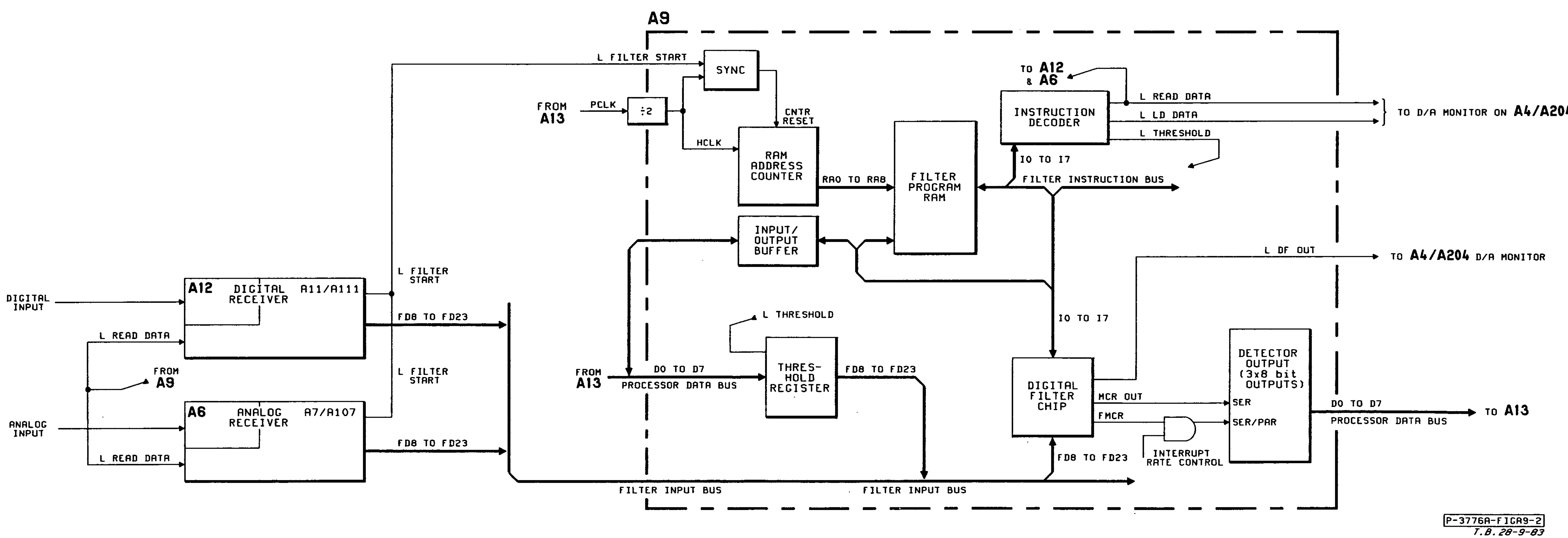


Figure A9-2 Digital Filtering of Input Data

ASSEMBLY SERVICE SHEET A9
DIGITAL FILTER

A9-1 INTRODUCTION

A9-2 A filter response may be expressed as a mathematical equation (see Paragraph 9-15), ie can be expressed as a series of add, subtract and shift operations. The A9 Assembly performs these arithmetic operations to digitally filter binary data.

A9-3 Programming the Digital Filter Hardware on A9

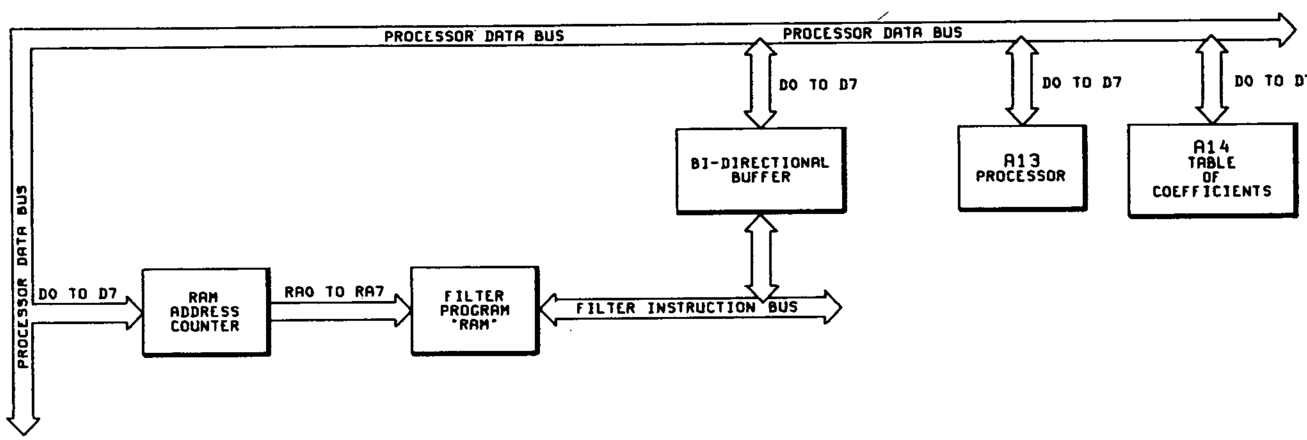


Figure A9-1 Loading Digital Filter Instructions into RAM

A9-4 When the 3776 front panel RUN key is pressed, the MPU on A13 assembles the filter coefficients into a sequence of add, subtract and shift operations and down loads these into the Filter Program RAM (see Figure A9-1). The MPU's initial tasks (in the RUN state) are to:-

1 select the appropriate measurement filter coefficients
2 program the A9 hardware.

A9-5 Once programmed A9 realises the digital filtering of sampled signals as represented by 2's complement binary words. Digital filtering commences on A9 shortly after the RUN key is pressed.

A9-6 Figure A9-1 illustrates the data flow for loading digital filter instructions into the Filter Program RAM. To load an instruction the processor first addresses the Filter Program RAM via the RAM Address Counter, then loads the appropriate instruction into the addressed location via the Bi-directional Buffer. This action is repeated until all instructions defining the filter are stored. A9 is now ready to filter the incoming data.

A9-7 Real Time Filtering

A9-8 Input data for digital filtering is applied to A9 from two sources (see Figure A9-2), these are:-

1 Digital Receiver (A12/A11/A111)
2 Analog Receiver (A6/A7/A107).

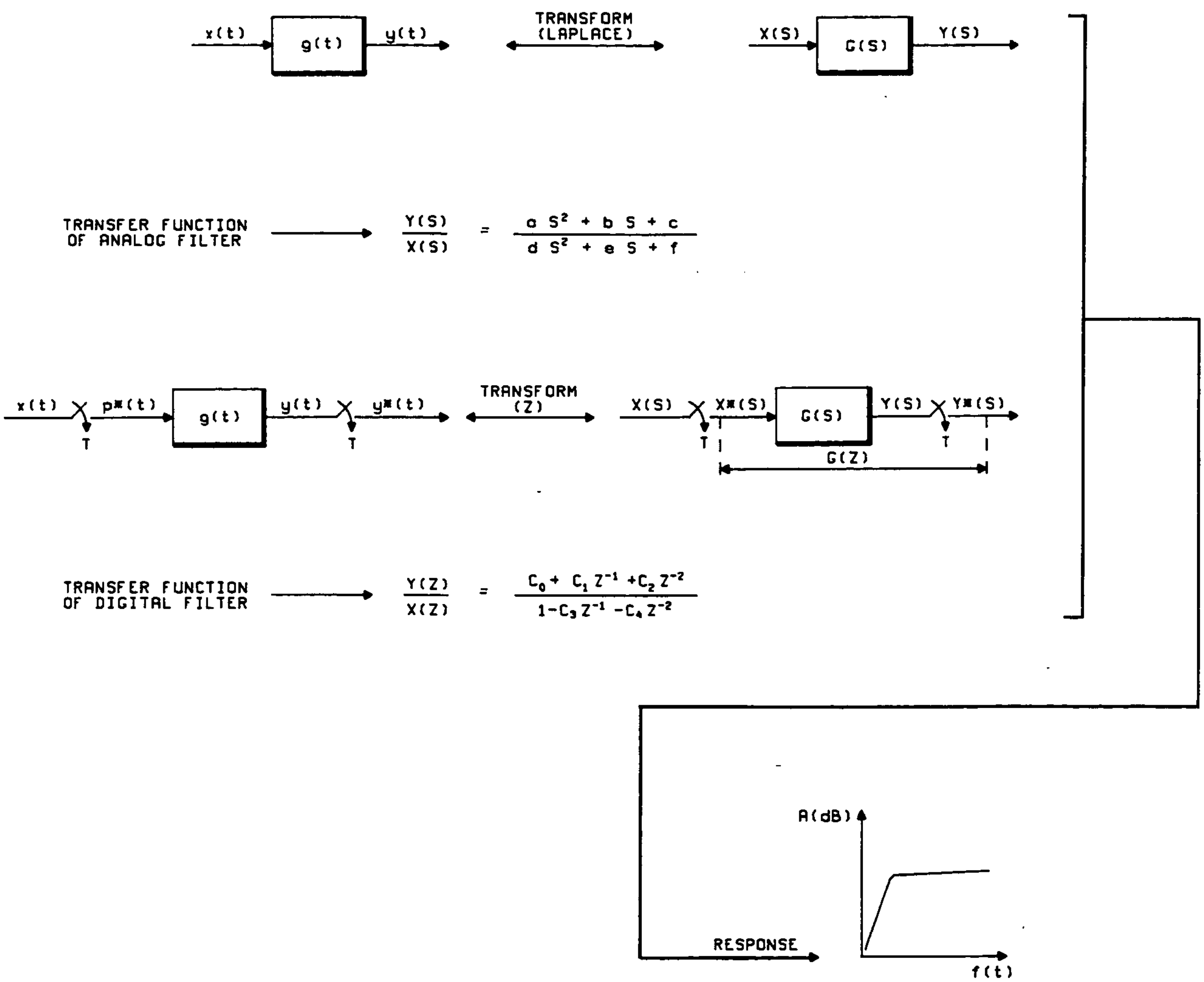


Figure A9-3 Transfer Functions and Response of 2nd Order Filter

A9-16 The A9 Assembly controlled by A13/A14 uses the transfer function of the digital filter as shown in Figure A9-3 to filter sampled signals. The transfer function is transformed to the time domain by the inverse (Z) transform, ie

$$Y(Z)\,(1-C_3\,Z^{-1}-C_4Z^{-2}) = X(Z)\,(C_0+C_1Z^{f-1}+C_2Z^{-2})$$

uses inverse transform to produce difference equation

$$Y_{nT} = C_0X_{nT} + C_1X_{(n-1)T} + C_2X_{(n-2)T} + C_3Y_{(n-1)T} + C_4Y_{(n-2)T}$$

where, nT is current sampling time.

The difference equation represents the basic model for the 2nd order digital filter and is implemented by the 3776 operating program on A13/A14 and is diagramatically shown in Figure A9-4.

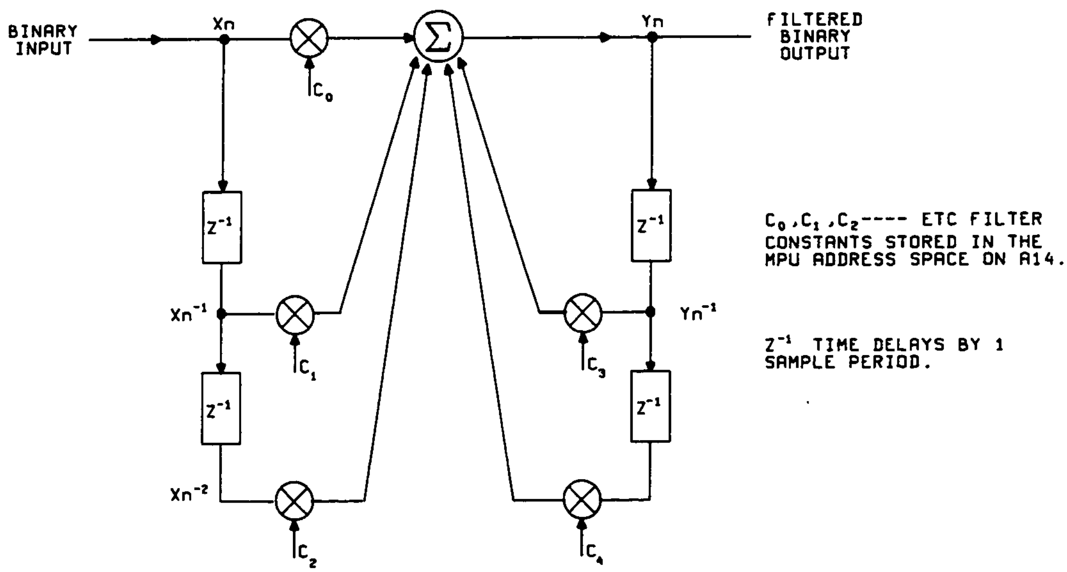


Figure A9-4 Model of 2nd Order Filter

A9-17 The basic model can be cascaded by the 3776 software to produce a series of n^{th} order filters, ie y_n, y_{n-1} and y_{n-2} become X_n, X_{n-1} and X_{n-2} of the next stage.

A9-18 Digital Filter troubleshooting information is contained in GENERAL SERVICE SHEET G8.

A9 Component Location is printed on the reverse of this sheet to facilitate its use in conjunction with the A9 Schematic.

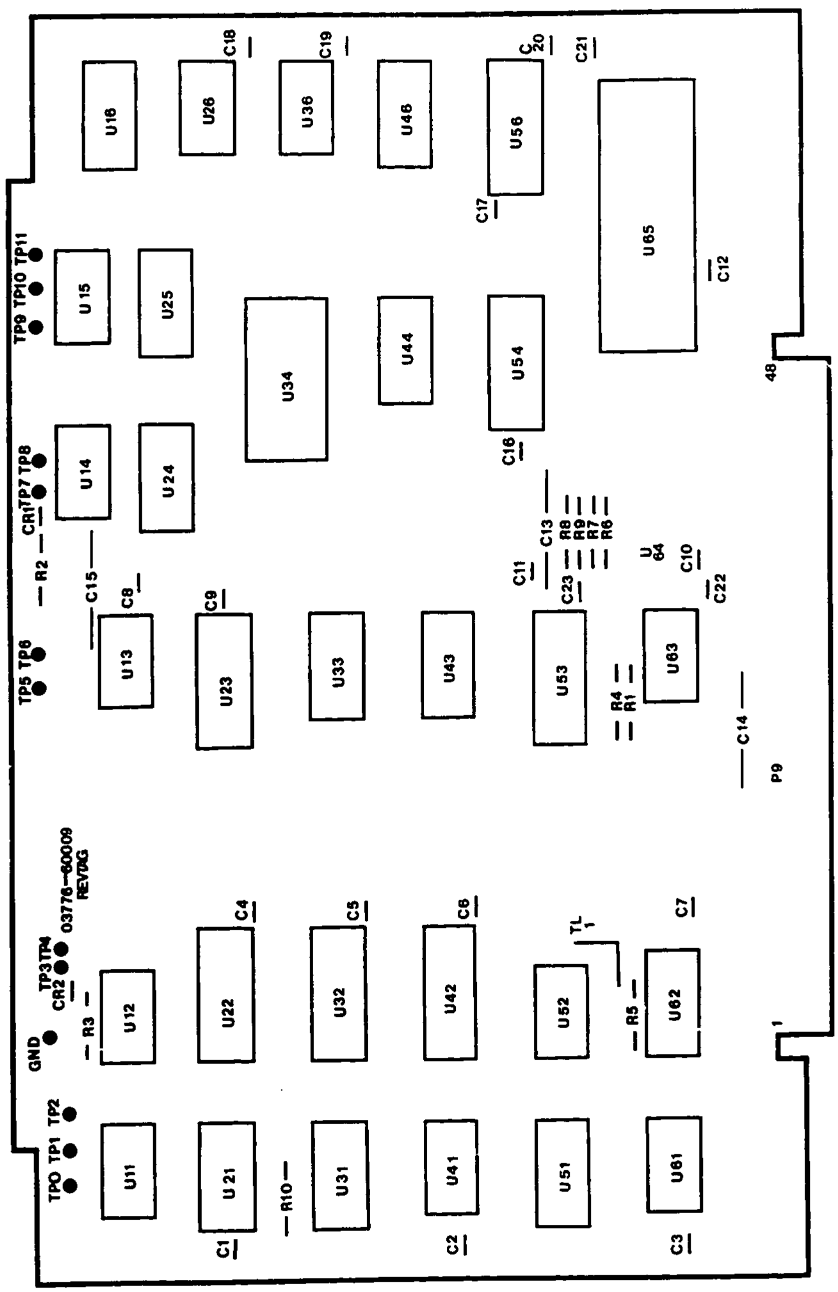


Figure A9-5 A9 Component Location

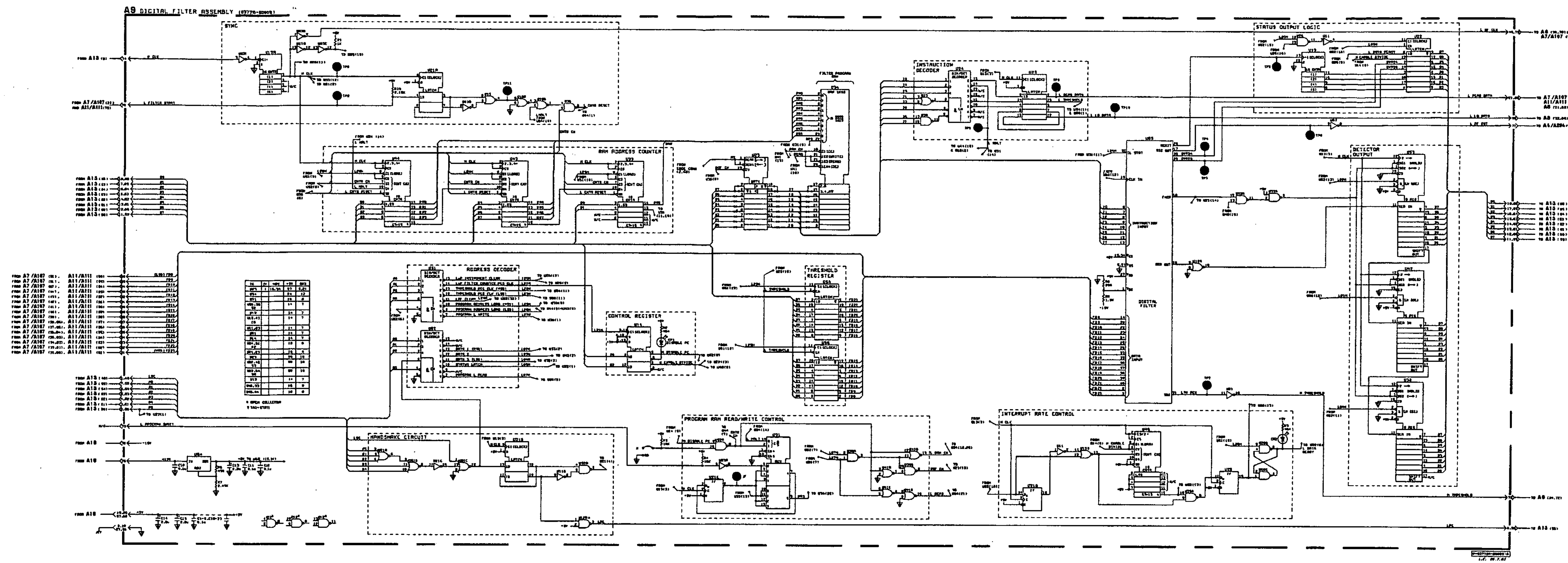


Figure A9-6 A9 Schematic

ASSEMBLY SERVICE SHEET A11/A111
A11 A-LAW ALIGNMENT (3776A)
A111 U-LAW ALIGNMENT (3776B)

A11-1 INTRODUCTION

A11-2 The 3776 Digital Receiver is made up of assemblies A11/A111 and A12, a general description of these assemblies is given in this section. A block diagram of the Digital Receiver is illustrated in Figure A11-1.

A11-3 PCM data is organised and transmitted in formal structures (timeslots, frames and multiframes), the most commonly used are illustrated in APPENDIX A. The 3776 Digital Receiver accesses data within PCM structures and applies the accessed data to A9 or A13 for processing.

A11-4 To access data within a PCM structure the Digital Receiver (A12) first converts the PCM data stream to a binary data stream and removes the transmission line code (see Figure A11-1). If required (ie when the 3776 is connected to a -30dB monitor point) the A12 assembly boosts the level of the incoming PCM data and also extracts the Digital Receiver clock signals which are used throughout assemblies A11/A111 and A12. In two-wire PCM systems timeslot translation may be required, this is also implemented on A12.

A11-5 The binary data stream (TTL DATA in Figure A11-1) is applied to A11/A111. To access the appropriate data in TTL DATA it is necessary to synchronise the Timing Generator on A11/A111 to TTL DATA, ie align the Digital Receiver to the structure of the incoming PCM stream. When alignment is achieved the timeslot containing the data to be processed may be accessed using the Test Timeslot Selector. The accessed data is then stored in the Test Timeslot Register prior to processing, it is also applied to the Peak Codes Detector.

A11-6 When access is required to data in a particular timeslot the instruments MPU will down load the appropriate control bits to the Test Timeslot Selector via the Test Word Register.

A11-7 Aligning the Digital Receiver to the PCM Data Structure

A11-8 Fundamental to any Digital Receiver operation is alignment. Alignment information is contained in all PCM structures shown in APPENDIX A. The Frame and Multiframe Alignment Detector and Timing Generator interrogate the TTL DATA looking for the alignment information.

A11-9 When a bit/pattern matching the alignment bit/pattern is detected the Timing Generator is enabled by INITIATE COUNT (see Figure A11-2) and starts counting clock pulses to the next alignment bit/pattern. The Frame and Multiframe Alignment Detector rechecks the TTL DATA for each alignment bit/pattern. If the alignment pattern remains good the Timing Generator continues counting and the next alignment pattern is re-checked. This action is repeated, and when the frame and multiframe alignment criteria are satisfied (see APPENDIX A) alignment is considered to be achieved. If alignment is achieved then the alignment loop produces the ALIGNMENT ACHIEVED signal as illustrated in Figure A11-2.

A11-10 If however, the frame and multiframe criteria are NOT met, the Timing Generator is reset and held in the reset state until an alignment pattern is detected. It should be noted that it may take many attempts before alignment is achieved.

A11-11 Once alignment is achieved the Frame and Multiframe Alignment Detector continuously monitors the status of TTL DATA for frame and multiframe errors and informs the Status Condition Detector circuit when the frame and multiframe alignment error criterion are violated. The Frame and Multiframe Alignment Detector then tries to re-align the Digital Receiver with the PCM data structure.

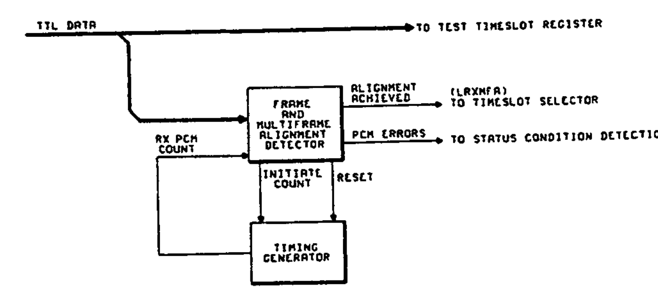


Figure A11-2 Simplified Alignment Loop

A11-12 Test Timeslot Selector

A11-13 Once alignment is achieved the Test Timeslot Selector allows data to be accessed and extracted from the timeslot under test. The Test Timeslot Selector compares the Receiver timing data (RXTC and RXFC see Figure A11-1) from the Timing Generator with the control pattern for the required timeslot (TEST WORD in Figure A11-1). When the bit pattern on both sets of inputs of the Test Timeslot Selector Comparator are the same, TTL DATA is the data contained in the test timeslot. The Comparator output RX SEL TS goes true indicating that the required data is available and may be clocked into the Test Timeslot Register and Peak Detector.

A11-14 Expander

A11-15 The Expander decodes the timeslot data stored in the Test Timeslot Register in accordance with the A-Law characteristic for the 3776A and U-Law characteristics for the 3776B. When the Expander receives an enable signal from the Digital Filter Handshake Control, it decodes the test timeslot data and applies it to the digital filter on A9 for processing.

A11-16 Digital Filter Handshake Control

A11-17 The Digital Filter Handshake Control produces L FILTER START (see Figure A11-1) when RX SEL TS goes low. L FILTER START informs the digital filter on A9 that data on A11/A111 is ready for processing. When the digital filter is ready for new data L READ DATA is applied to the Digital Filter Handshake Control which in turn produces the enable signal for the Expander.

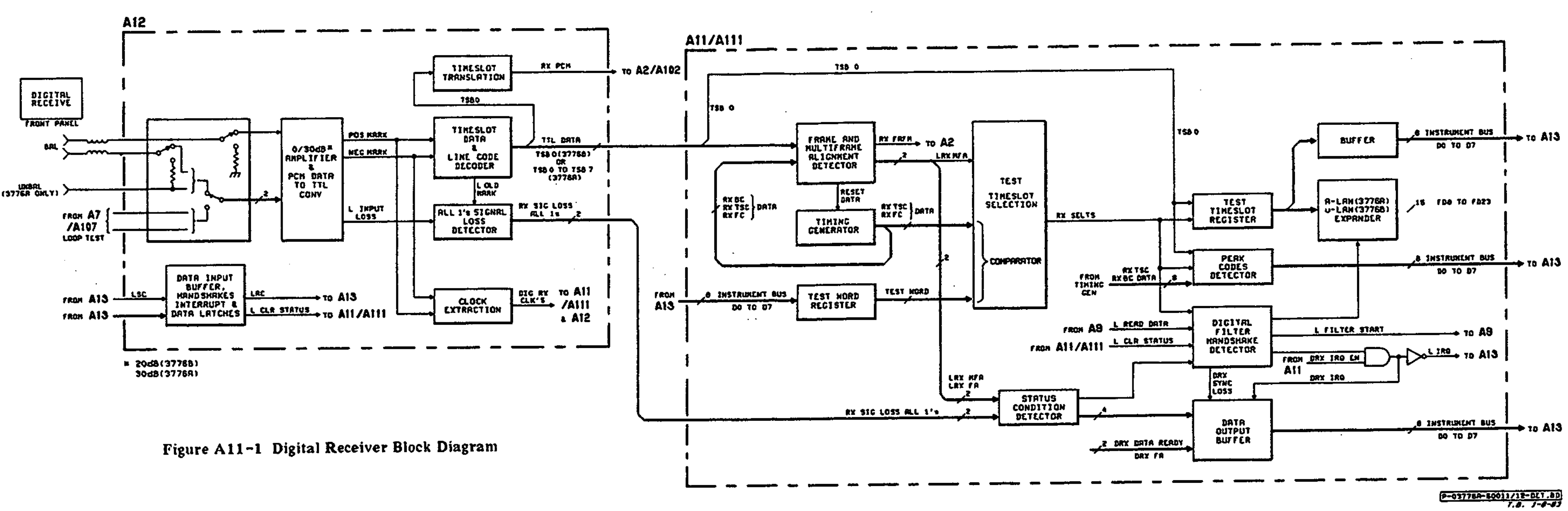


Figure A11-1 Digital Receiver Block Diagram

A11-18 Digital Receiver Interrupts (LIRQ)

A11-19 If the frame or multiframe alignment status changes or the input signal status changes the Digital Receiver generates LIRQ which interrupts the processor on A13. The processor then interrogates the Status Condition Detector circuit via the Data Output Buffers. LIRQ can be disabled or masked by the Processor until it is ready to service the interrupt.

A11-20 Signature Analysis (SA) and Self Test Routines

A11-21 Due to the complexity of the A11/A111 Assembly, fault finding is performed using signature analysis (SA) and self test routines. These routines are stored in special utility programs, see GENERAL SERVICE SHEET G6. Figure A11-3 illustrates the circuits checked by SA.

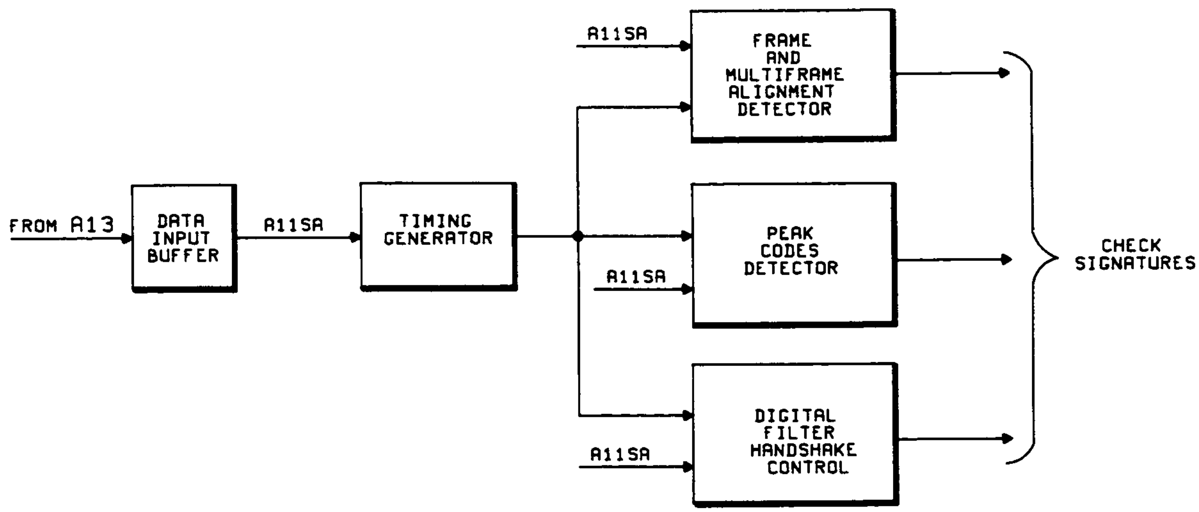


Figure A11-3 Signature Analysis

A11-22 The SA routine on A13 generates the A11 SA signal. This signal sets the circuits in Figure A11-3 to their SA mode.

A11-23 In the SA mode the Timing Generator is continuously incremented. Its outputs are applied to the circuits illustrated in Figure A11-3 and the signatures monitored (see GENERAL SERVICE SHEET G6).

A11-24 The Expander on A11/A111 is checked by a special self test routine (see GENERAL SERVICE SHEET G6).

A11-25 Peak Codes Detector

A11-26 The Peak Codes Detector is a ROM based state machine controlled by RX SEL TS and DRX PK EN. When both signals are true the incoming TTL DATA is compared with the stored PEAK POSitive and PEAK NEGative data. Depending on their magnitude relative to TTL DATA either of the PEAK values may be replaced by TTL DATA. If either RX SEL TS or DRX PK EN are false the stored PEAKS are held unchanging.

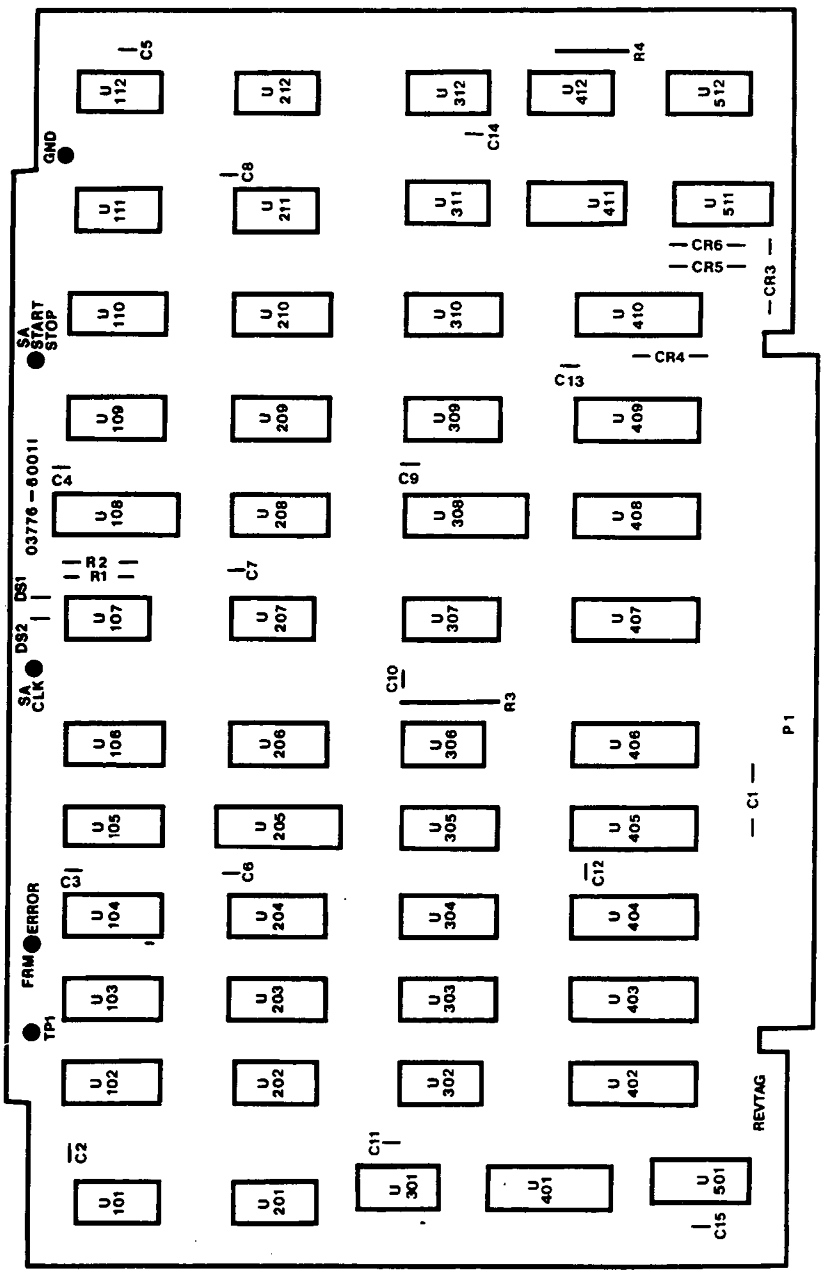


Figure A11-4 A11 Component Location

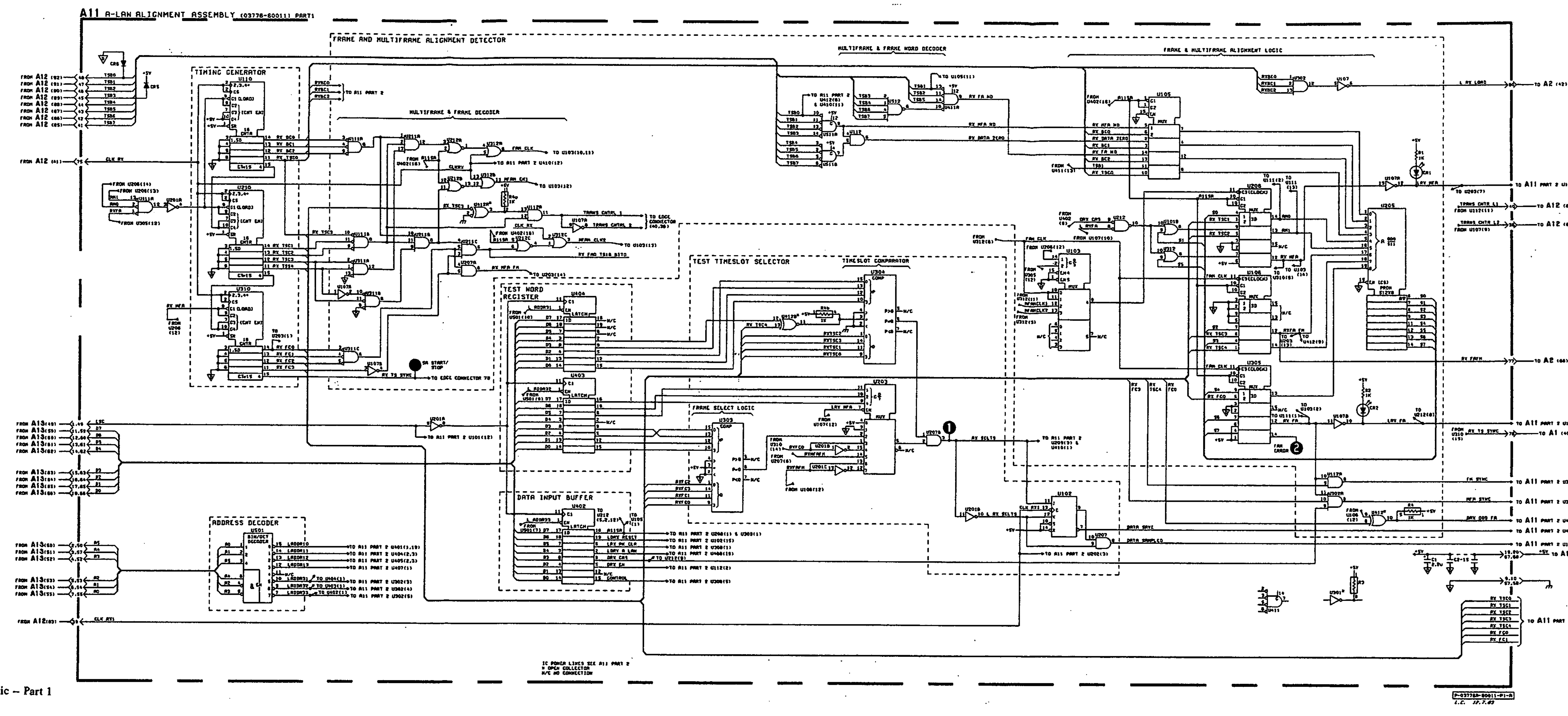


Figure A11-5 A11 Schematic – Part 1

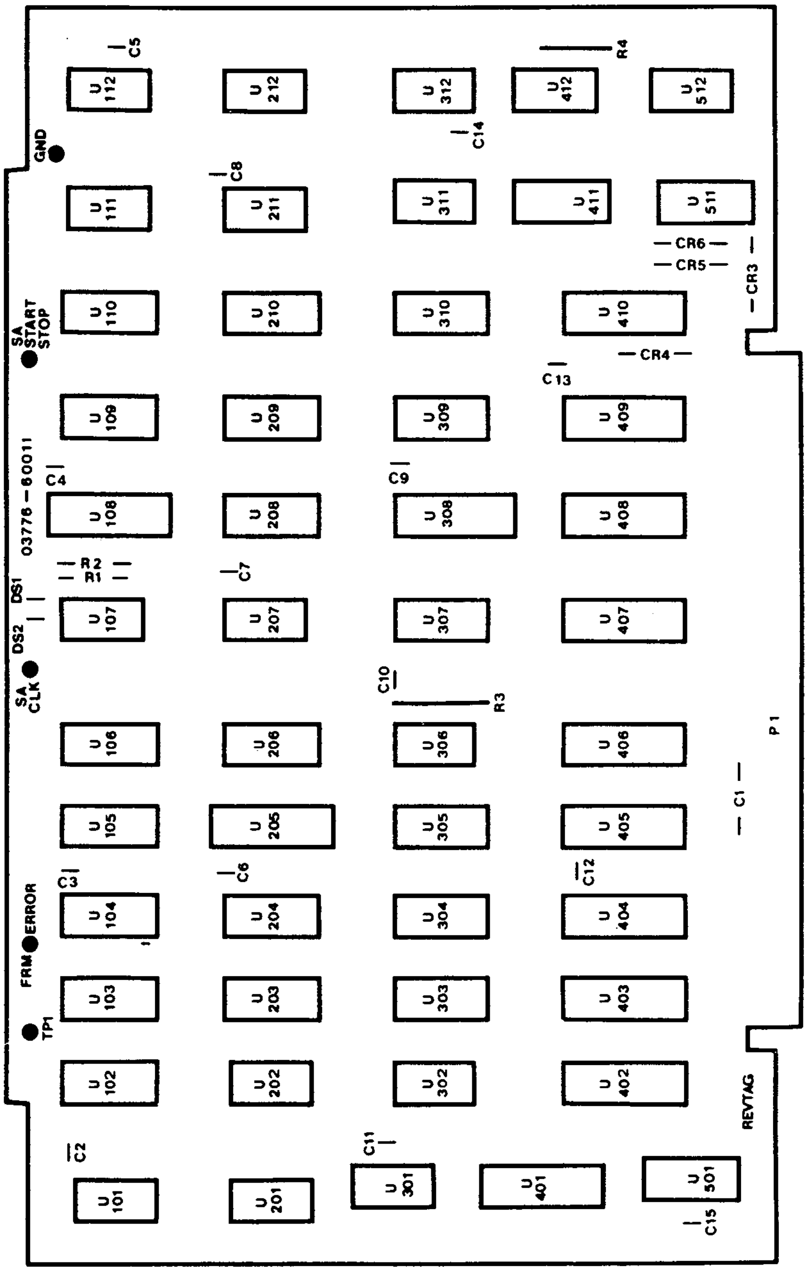


Figure A11-4 A11 Component Location

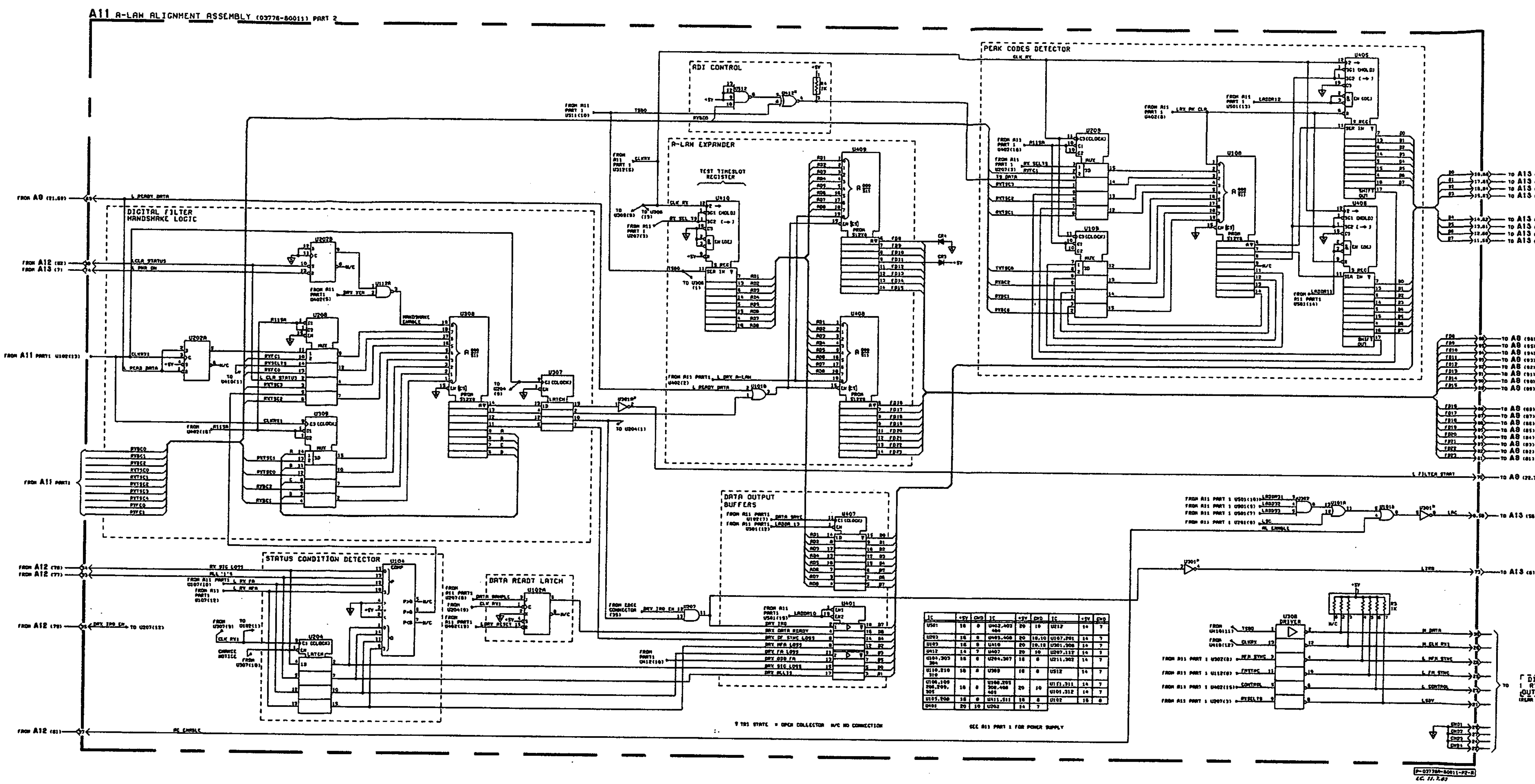


Figure A11-6 A11 Schematic – Part 2

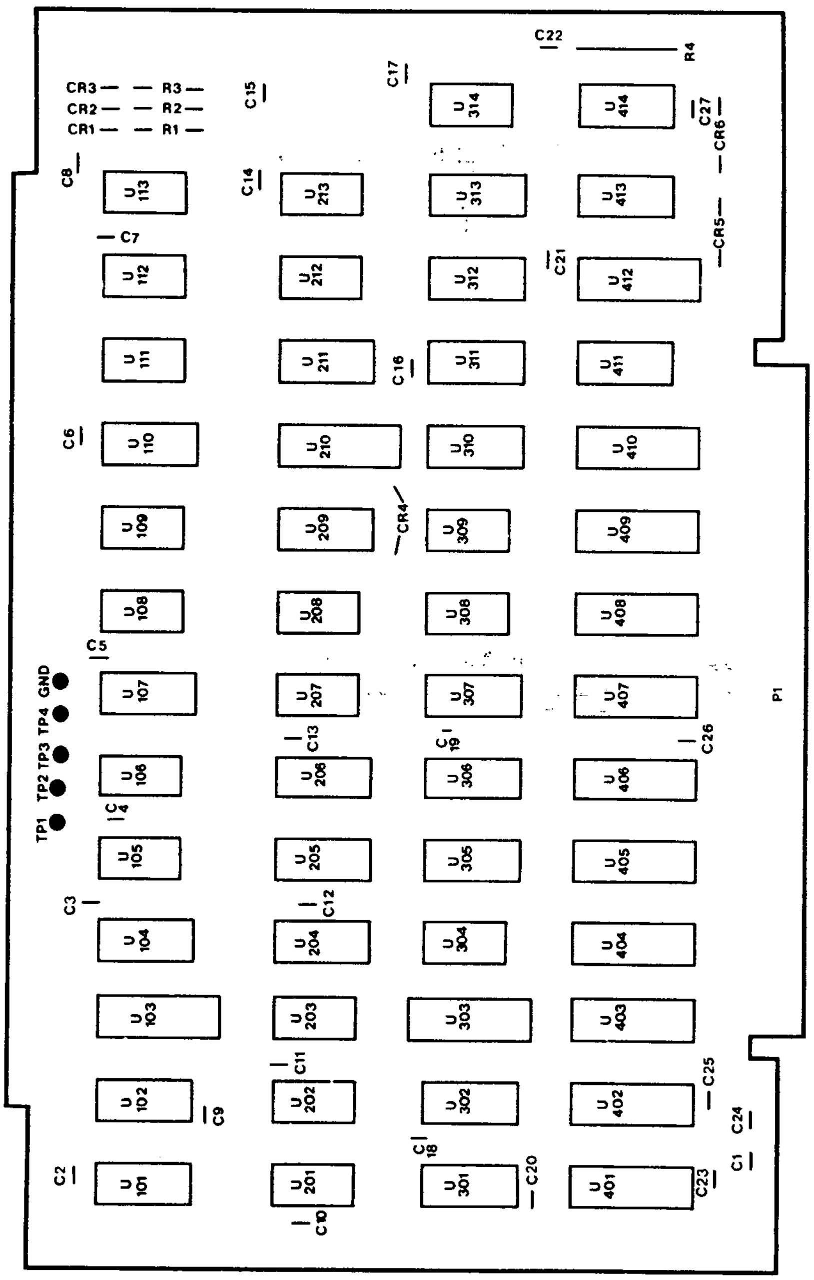


Figure A11-7 A111 Component Location

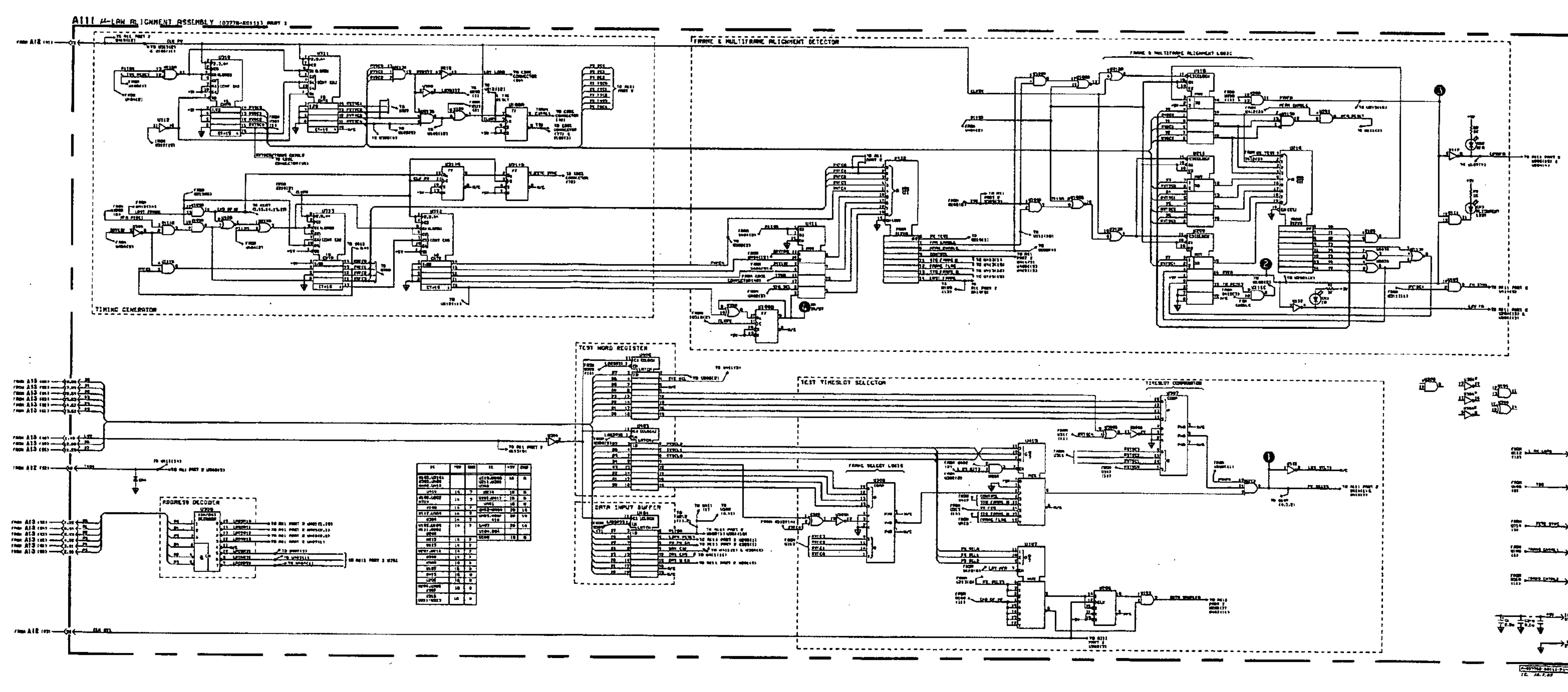


Figure A11-8 A111 Schematic – Part 1

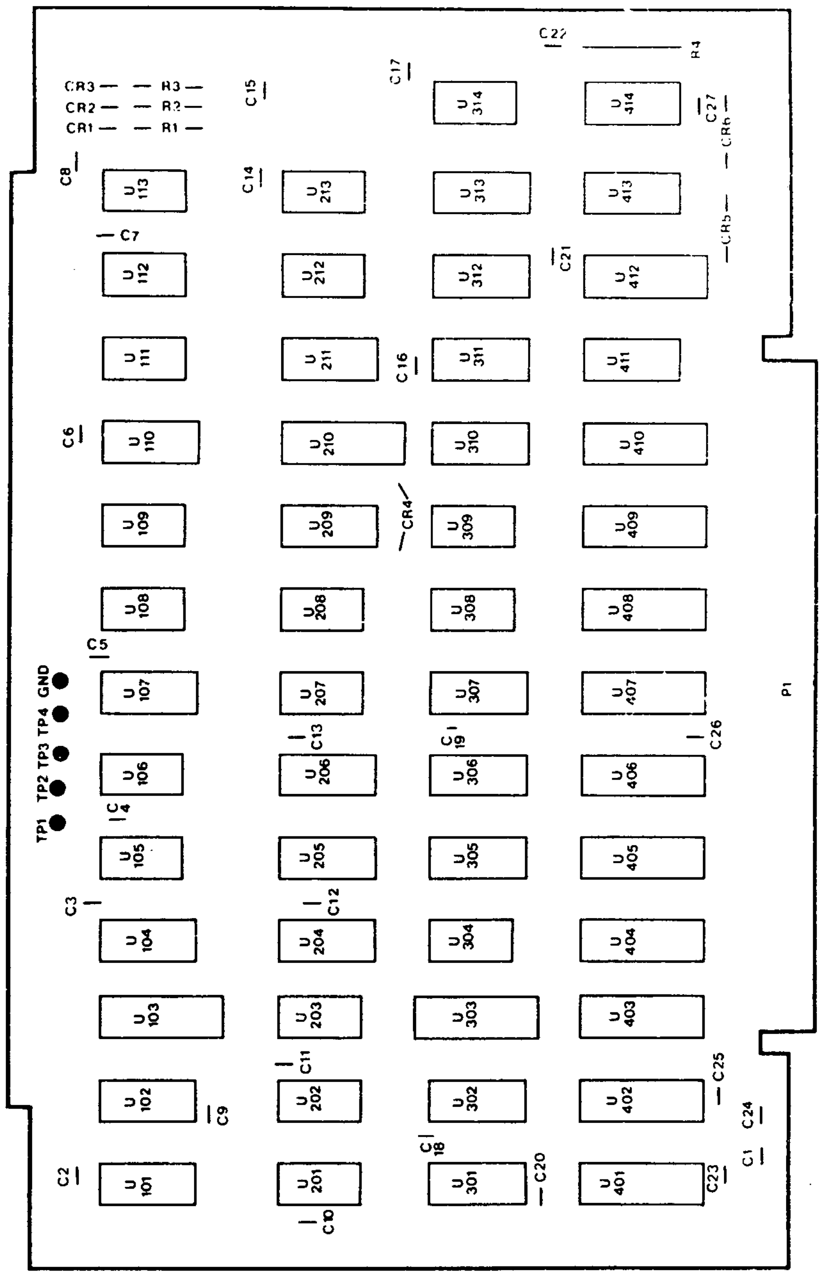


Figure A11-7 A111 Component Location

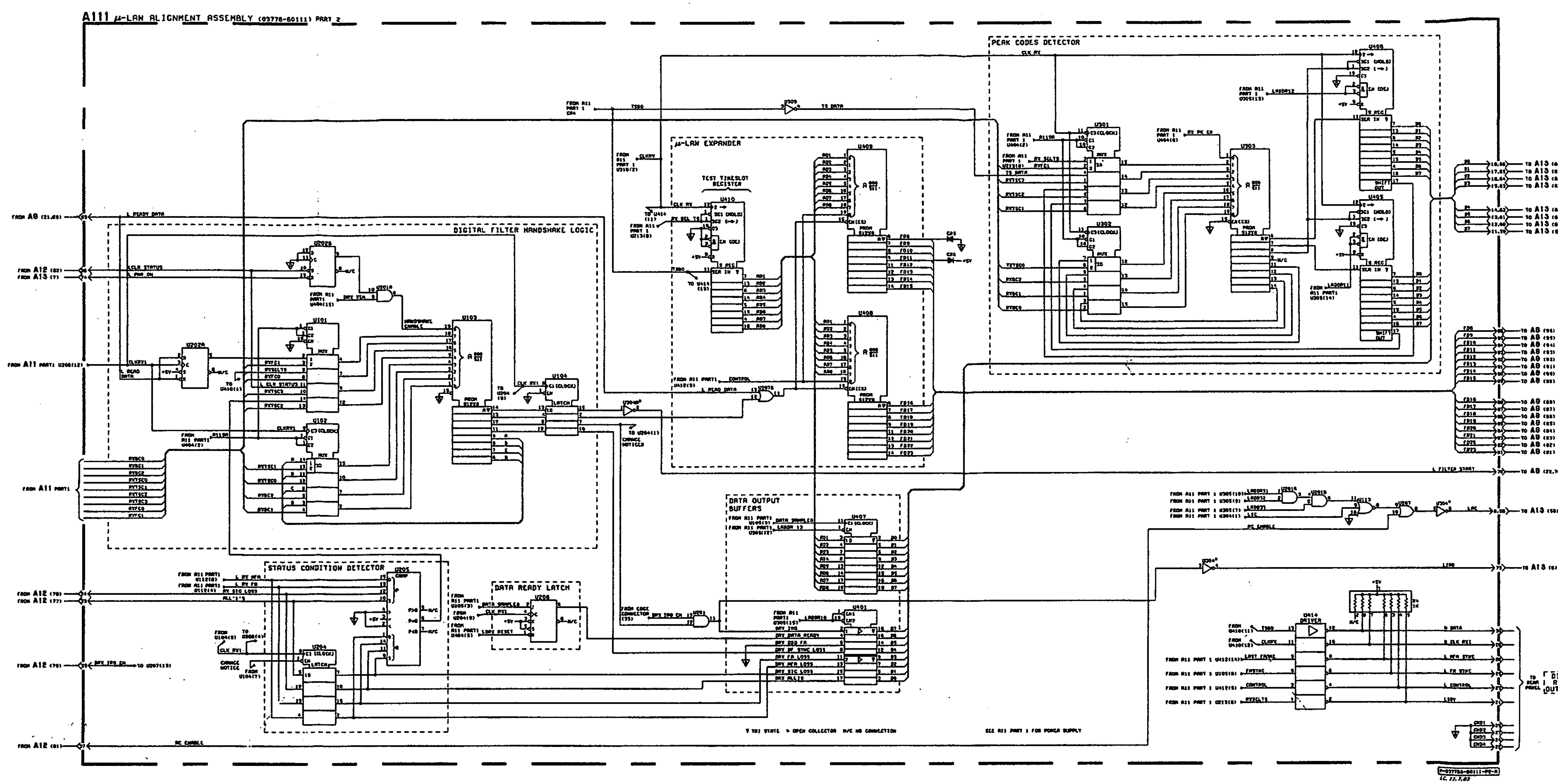


Figure A11-9 A111 Schematic – Part 2

ASSEMBLY SERVICE SHEET A12/A112
A12(3776A)/A112(3776B)
DIGITAL RECEIVER

A12-1 INTRODUCTION

A12-2 A general description of the A12 Assembly together with a block diagram is given in the Digital Receiver description contained in Assembly Service Sheet A11/A111. Further details of the A12 Assembly are given in this section.

A12-3 PCM data may be applied to the A12 Assembly from an external source or internally from the Digital Transmitter O/P Assembly A7/A107. Source selection is controlled by PCM LOOP DRX and implemented by relays (see Figure A11-1). PCM LOOP DRX is derived from A13 via the Data Input Buffers.

A12-4 When the 3776A is connected to a -30dB monitor point (3776B is connected to -20dB monitor point) in a PCM system, the operator boosts the gain of the 0/30dB Amplifier (see Figure A11/A111-1) from 0dB to 30dB (20dB in 3776B) by pressing the front panel MONITOR key.

A12-5 Before any external PCM data can be processed it is necessary to convert it from its bipolar form to TTL binary form. This conversion is performed by the Data to TTL Converter.

A12-6 Again before any PCM Data can be processed the PCM Data transmission line code (see Assembly Service Sheet A2/A102 for codes) must be removed. This is done by the Line Code Decoder. After the transmission line code is removed the binary TTL DATA is applied to A11/A111 (see Assembly Service Sheet A11/A111) for further processing. Since the Line Code Decoder is a ROM based machine, signature analysis (SA) is used to check the circuit.

A12-7 While checking the Line Code Decoder using SA, the SA Verification Code Generator operates as a continuously incrementing counter. The outputs of the counter RXVC (0 to 8) are applied to the input of the Line Code Decoder and the signatures at the outputs checked (see GENERAL SERVICE SHEET G6).

A12-8 The clock signals which drive the circuit elements on A11/A111 and A12 are extracted from the PCM data by the Clock Extraction circuit.

A12-9 The Data Input Buffer, Address Decoder and Processor Handshake Control interface the Digital Receiver (A11/A111/A12) with the Processor on A13.

A12-10 In a two-wire PCM system it may be necessary to perform timeslot translation. This is performed on A12 by the Timeslot Translation Logic. In this mode of operation the PCM Data is transferred from one timeslot to another in a predetermined manner.

A12-11 The status of the PCM data is monitored on A12 by the ALL 1s Signal Loss Detector. When changes in status are detected, the processor on A13 is informed by the ALL 1s or RX SIG LOSS signals. These signals are fed to A13 via the A11/A111 Assembly.

A12-12 CIRCUIT DESCRIPTION

A12 PART 1

A12-13 Input Signal Switching and Termination

A12-14 The input PCM data stream is:-

2,048kb/s for the 3776A
1,544kb/s for the 3776B

There are two digital input terminations for the 3776A:-

120ohms BALanced Input,
75ohms UNBALanced Input.

In the 3776B there are two 110ohms BALanced inputs which are combined before presentation to A12.

A12-15 Test Links enable the A12(03776-60012) Assembly to be modified for 3776A and 3776B operation, see Test Link Table on the A12 Schematic.

A12-16 Switching between the BAL and UNBAL inputs in the 3776A is controlled by relays K1 and K2.

A12-17 Amplifier and Data to TTL Converter

A12-18 All PCM data is fed via T1 or T2 to the selectable 0/30dB (3776A) or 0/20dB (3776B) Amplifier. T1 ensures all data is single ended prior to reaching the amplifier. The differential outputs of the amplifier are then applied to the Data to TTL Converter. When the gain of the amplifier is changed from 0dB to 30dB the MONITOR signal effective switches on Q7 and connects the emitters of Q5 and Q6 in the 3776A instrument. However, in a 3776B instrument TL3 is removed and R48 is between the emitters of Q5 and Q6, which sets the gain at 20dB.

A12-19 The Data to TTL Converter comprises two comparators U310/U211 and two JK flip-flops U210A/B. The +ve marks of a bipolar PCM signal are detected by U310 and the -ve marks by U211.

A12-20 As soon as U211 detects a -ve mark, U210(9) is set low and disables U310, ie U310(7) is set high. The disable signal is removed from U310 by the next N CLK RX2 pulse to U210B. This allows the next mark in the PCM data to be detected. When U310 detects a +ve mark U210A disables U211, ie U211(7) is set high. Again the next N CLK RX2 pulse triggers flip-flop U210A which removes the low disable signal at U211(6). The detected +ve and -ve marks POS and NEG MARK at the output of the Data to TTL Converter are applied to the Clock Extraction and Line Code Decoder circuits.

A12-21 If there is a loss of input signal, comparator U111 detects this condition and produces L INPUT LOSS. The L INPUT LOSS signal disables comparaters U211 and U310 which sets POS and NEG MARK low. This condition allows the Clock Extraction circuit to free run at the PCM data rate. By allowing clock circuits to operate the Handshake protocol between the processor on A13 and the Digital Receiver (A11/A111/A12) is maintained.

A12-22 The L INPUT LOSS signal is routed via A11/A111 to the processor on A13 to inform the processor of the change in status of the PCM data, ie loss of input signal.

A12-23 Clock Extraction

A12-24 The A12 Assembly provides the clock signals for the Digital Receiver (A11/A111/A12) by generating the clock signals from the PCM data stream. The Clock Extraction circuit uses an injection - locked oscillator to extract the clocks from the PCM data.

A12-25 The oscillator operates at 2,048kb/s for the 3776A and 1,544kb/s for the 3776B. It comprises two tuned sections buffered by U108A/B. In the absence of a PCM input the circuit will free-run at the natural frequency of the two tank circuits L3/L4/C3/R3 and L1/L2/C1,C2/R2. When a PCM input is present the POS and NEG MARKs continually nudge the oscillator into SYNC with the PCM input.

A12-26 The CR time constants of the tank circuits are set to suit the PCM bit rates by test links TL1 and TL2 (See Test Links Table on A12 schematic). To set the natural frequency of the oscillator the PCM input is removed and C1 adjusted to give an output at CLK RX of 2,048kb/s for the 3776A and 1,544kb/s for the 3776B.

A12 PART 2

A12-27 ALL 1s & Signal Loss Detector

A12-28 The 3776 considers a sequence of 4096 consecutive marks constitute the ALL 1s condition.

A12-29 The counters U305 to U307 along with U205 and U301 form the ALL 1s and Data Loss Detector circuit. So long as RX MARK equals the preceding value of RX MARK at U206(15) then the counters will increment. If the two signals are different the counters are reset. If the counter at U305(15) flags a carry and the value of L OLD MARK is zero then a DATA LOSS flag is set into U301A. If the counters count to 4096 then U307(15) goes high and an ALL 1s flag is set in U301B.

A12-30 If a loss of PCM input is detected by U111 on A12 part 1, L INPUT LOSS is produced. This signal considered with DATA LOSS produces a high RX SIG LOSS at U202(11). The RX SIG LOSS signal is applied to the processor on A13 via the Status Condition Detector on A11/A111.

A12-31 SA Verification Code Generator

A12-32 When A12SA is true, the counter U305 to U307 continuously increments. The outputs of the counter are applied to the Line Code Decoder and the output signatures checked (see GENERAL SERVICE SHEET G6).

A12-33 Data Input Buffer, Address Decoder

A12-34 The two chips U404 and U403 interface the A12 assembly with the A13 assembly.

A12-35 Processor Handshake Control

A12-36 The handshake circuitry implements conventional handshake protocol between the A13 Assembly and the Digital Receiver A12, see Assembly Service Sheet A13.

A12-37 When A13 interrogates Data Buffer addresses 10, 11, 12 and 13 on A11/A111, the completion of the handshake is delayed by 2 CLK RX2 pulses by AC ENABLE. The delay ensures that the instrument bus D0 to D7 at the output of A11/A111 has settled before the accept data signal LAC is fed back to A13. The delay is provided by flip-flops U201A and U201B.

A12-38 The L CLR STATUS signal has a delay inserted by U303A and U303B and U304. The delay ensures that there is no updating of the PCM status data until A11/A111 has been serviced by A13. When L CLR STATUS goes low new status changes can be stored on A11/A111.

A12-39 Under certain conditions (such as searching for alignment) the Digital Receiver may send out continuous interrupts. This is undesirable as it may continuously tie-up the processor, due to the Digital Receiver's high IRQ priority.

A12-40 To prevent continuous interrupts U501 produces a low DRX IRQ EN pulse. This pulse inhibits the IRQ gate A11U201 and ensures a 100us (nominal) delay between the Data Output Buffer A11U401 being serviced by the processor and any subsequent Digital Receiver interrupts. During the 100us delay the processor services other assemblies in the 3776.

A12-41 Timeslot Translation Logic

A12-42 In the A-A LOOP mode of operation in a 2 wire system two different channels are used in the measurement, the timeslot contents from the GO path are transposed into a different timeslot in the Return path. The transposing of data from one timeslot to another is achieved by the Timeslot Translation circuit. Figure A12-1 illustrates the 3776 in the Loop mode and Table A12-1 shows the 3776A and 3776B Timeslot translations.

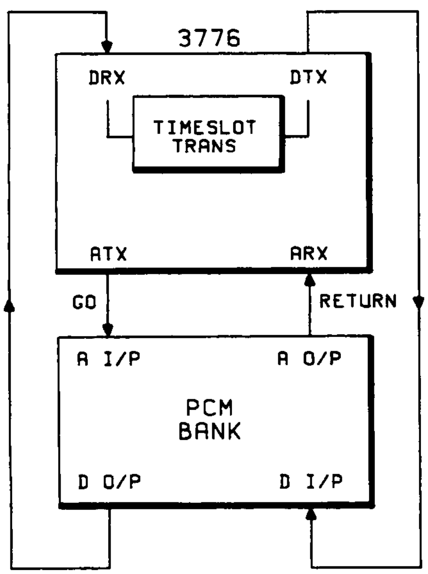
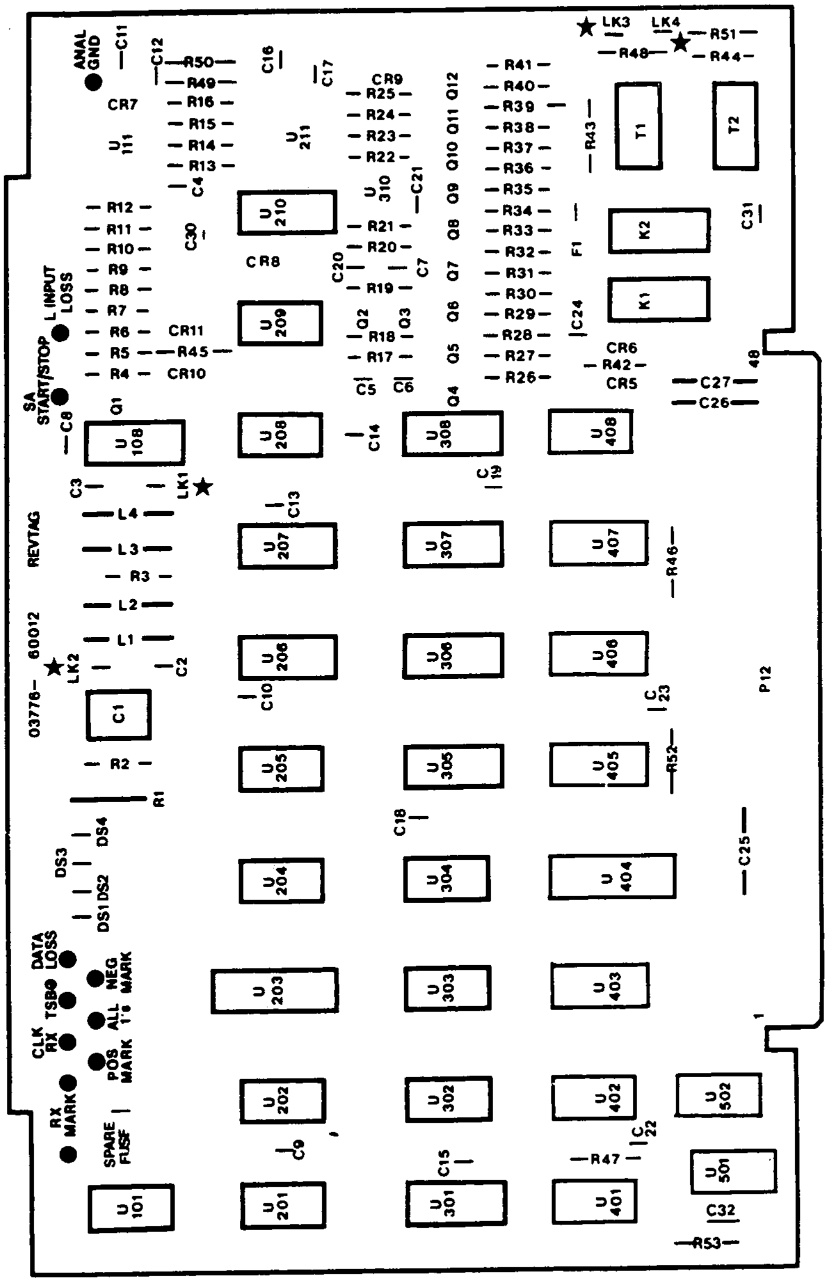


Figure A12-1 3776 Timeslot Translation

3776A	3776B
TS1 - TS17	TS1 - TS2
TS2 - TS18	TS3 - TS4
TS3 - TS19	TS5 - TS6
TS4 - TS20	TS7 - TS8
TS5 - TS21	TS9 - TS10
TS6 - TS22	TS11 - TS12
TS7 - TS23	TS13 - TS14
TS8 - TS24	TS15 - TS16
TS9 - TS25	TS17 - TS18
TS10 - TS26	TS19 - TS20
TS11 - TS27	TS21 - TS22
TS13 - TS29	TS23 - TS24
TS14 - TS30	
TS15 - TS31	

Table A12-1 Timeslot Translation



★ASSEMBLIES A12 & A112 ARE IDENTICAL EXCEPT FOR LINKING LK1, LK2, LK3 & LK4. REFER TO TABLE ON SCHEMATIC FOR DETAILS (A12 : 3776A/A112 : 3776B).

Figure A12-2 A12/A112 Component Location

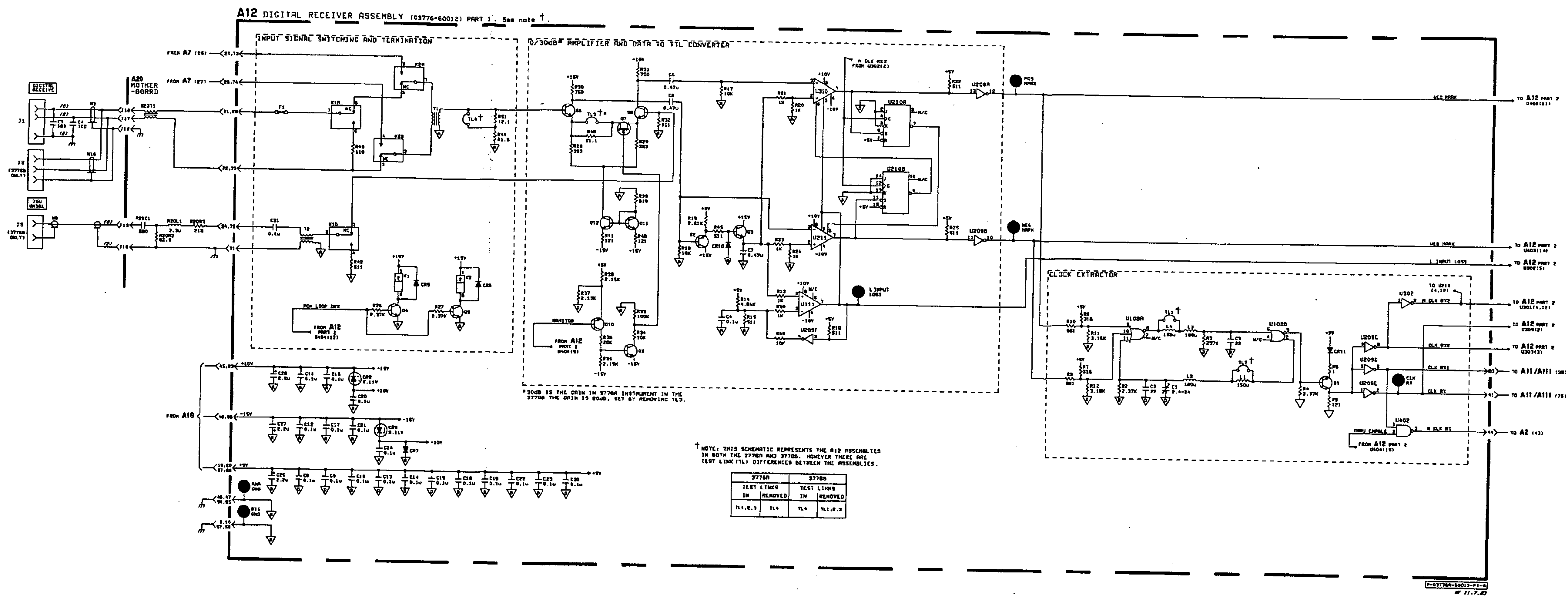
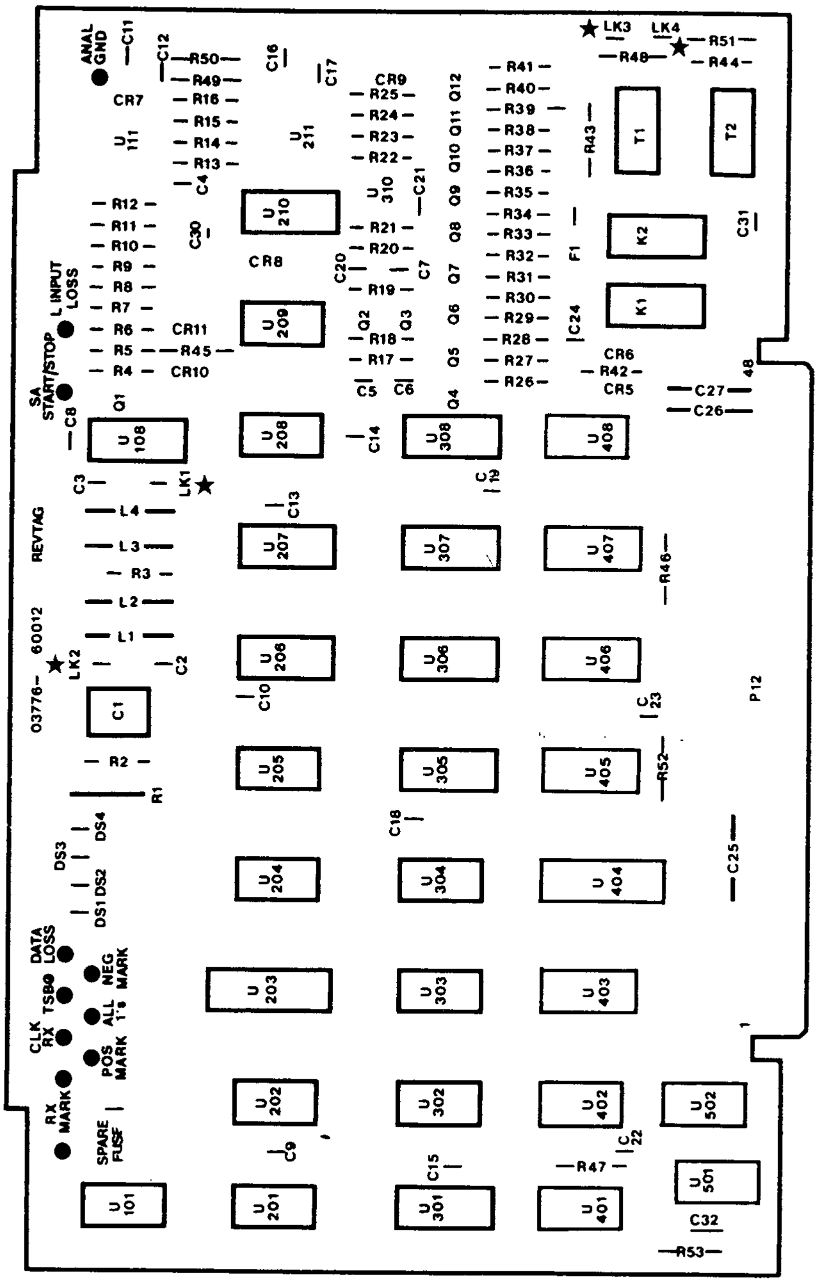


Figure A12-3 A12/A112 Schematic – Part 1



★ASSEMBLIES A12 & A112 ARE IDENTICAL EXCEPT FOR LINKING LK1, LK2, LK3 & LK4. REFER TO TABLE ON SCHEMATIC FOR DETAILS (A12 : 3776A/A112 : 3776B).

Figure A12-2 A12/A112 Component Location

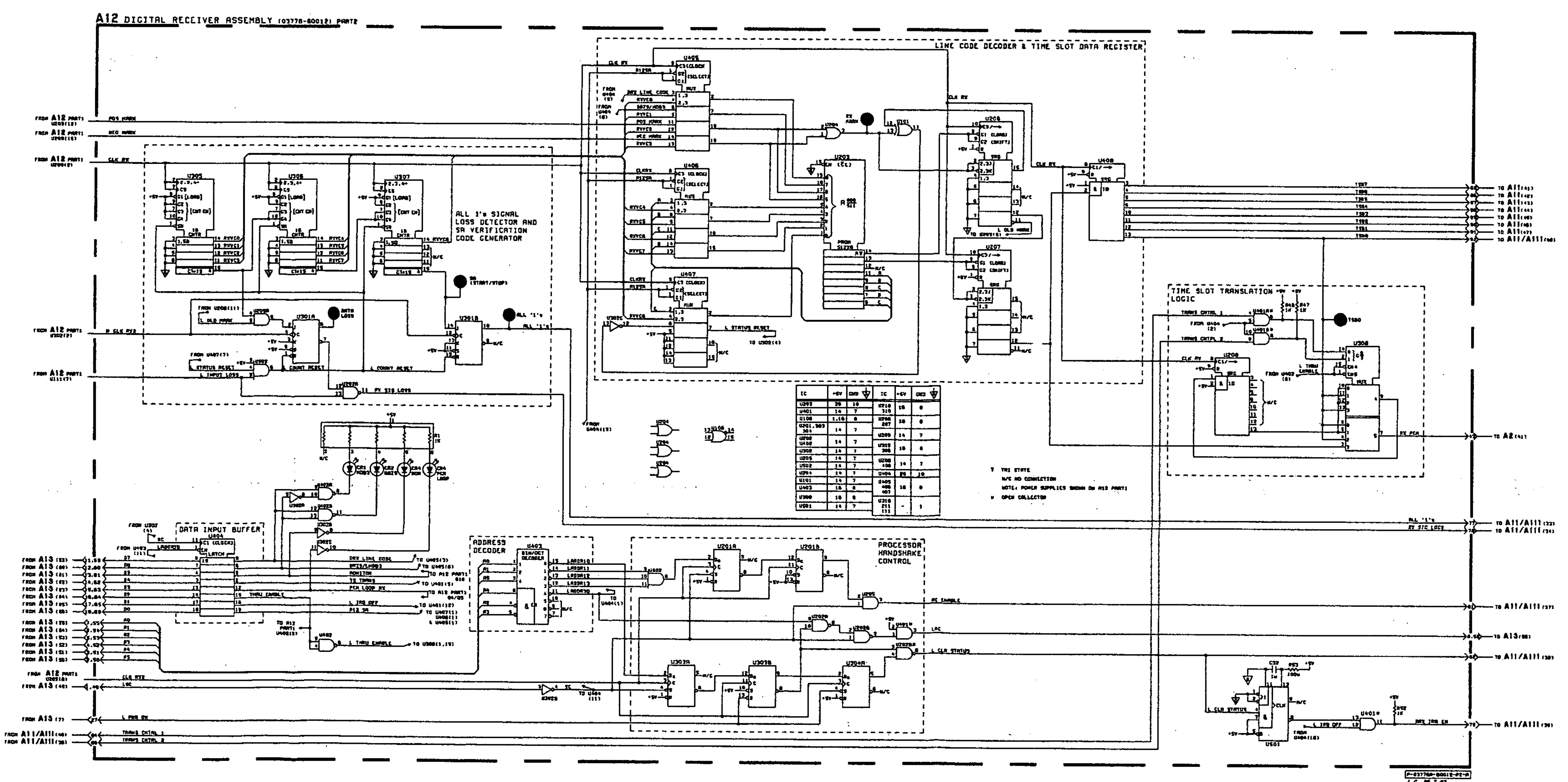


Figure A12-4 A12/A112 Schematic – Part 2

A13-7 Interrupt requests (LIRQ) to the MPU can be issued by the following six sources:-

HP-IB Chip,
Front panel keys,
Rear panel switches,
A11/A111/A12 Digital Receiver,
A8 Impulse Noise & Frequency Detector,
A5 Transients.

These are maskable interrupts and can be enabled or disabled by the MPU. If enabled and LIRQ occurs the main 3776 operating program jumps to an "interrupt-request-service" routine. The operating program then instructs the MPU to address each of the six sources to see which requires attention.

A13-8 There is also a non-maskable interrupt (LNMI) which when detected by the MPU immediately breaks into the operating program to service the interrupt request. This interrupt occurs under power failure (L PWR FAIL) conditions or when an instrument bus or keyboard bus time-out condition is detected. A time-out occurs when the bus Handshake Protocol initiated by LSC, is NOT completed by LAC. The NMI is fed to the MPU via the Peripheral Interface Adapter (PIA).

A13-9 Data is transferred to the front panel assemblies (A21/A22) via the Keyboard Bus, the remaining assemblies utilise the Instrument Bus. There are also buffered versions of the processor address and data buses. The A13 Assembly issues a start signal (LSC) and the instrument assembly replies with an acknowledge signal (LAC) when it has accepted or provided the data. (As far as the MPU is concerned the instrument and keyboard buses behave like slow memory).

A13-10 The 8k byte ROM on A13 contains the power on sequence and special utility programs which check the processor in isolation from the rest of the instrument.

A13-11 All circuit elements on A13 are controlled by the Address Decoder.

A13-12 The non-volatile memory NVM RAM on A14 is used to store set-up and default parameters. It is also used when there is a power failure. Under these conditions the operating program has 20ms to load all data being processed into the NVM RAM.

A13-13 The RAM Standby Power Supply provides a 2.8V line to the NVM RAM under power down conditions.

A13-14 CIRCUIT DESCRIPTION

A13-15 Microprocessor (MPU)

A13-16 At switch-on the MPU is reset by the Power-on circuitry on A15. The MPU then reads a reset word from a pre-defined start address and thereafter performs a series of operations in accordance with the operating program stored in ROM.

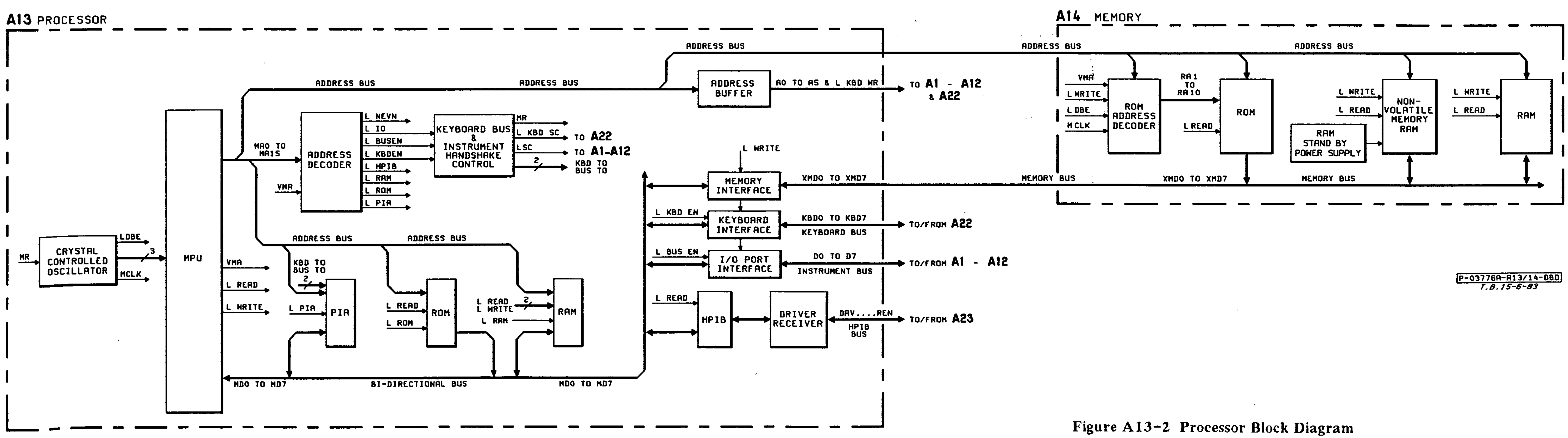


Figure A13-2 Processor Block Diagram

ASSEMBLY SERVICE SHEET A13/A113
A13 (3776A)/A113 (3776B)
PROCESSOR

A13-1 INTRODUCTION

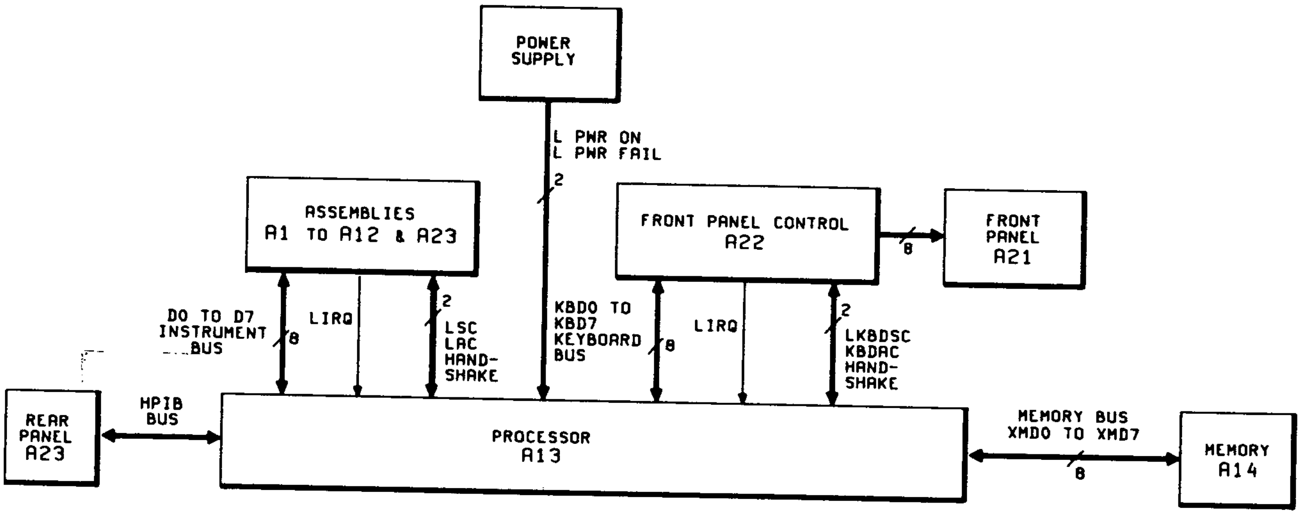


Figure A13-1 Processor Control

A13-2 The 3776 is microprocessor controlled, Figure A13-1 illustrates the communication buses and Handshake Control signals between the Processor Assembly A13 and the remainder of the 3776. Assemblies A13 and A14 form the instrument's main processing and memory store. The 3776 operating program stored in these assemblies allows the instrument to perform a wide variety of measurements.

A13-3 Figure A13-2 shows the main circuit elements of Assemblies A13 and A14.

A13-4 Processor and Memory

A13-5 The main processor (MPU) located on A13 is a 68B00. The 3776 operating software is contained in 72k bytes of ROM. 8k bytes are located on A13 and the remainder on A14. A13 and A14 are linked by address bus MA0 - MA15 and memory bus XMD0 - XMD7 (see Figure A13-2).

A13-6 During the running of the operating program the MPU interfaces with four bus systems: Memory, Keyboard, Instrument and HP-IB.

A13-17 The MPU address and data buses (MA0 to MA15 and MD0 to MD7) have to interface with:

1 RAMS,
2 ROMS,
3 HP-IB Chip,
4 Keyboard and Front panel bus,
5 Instrument bus.

In order to meet the access times of the RAMs and ROMs and the data set-up times of the MPU, a stretched form of M CLK is applied to the MPU data-bus-enable (DBE) input (see Figure A13-3 and the A13 schematic). A high DBE signal enables the data bus interface drivers which output data during a write cycle.

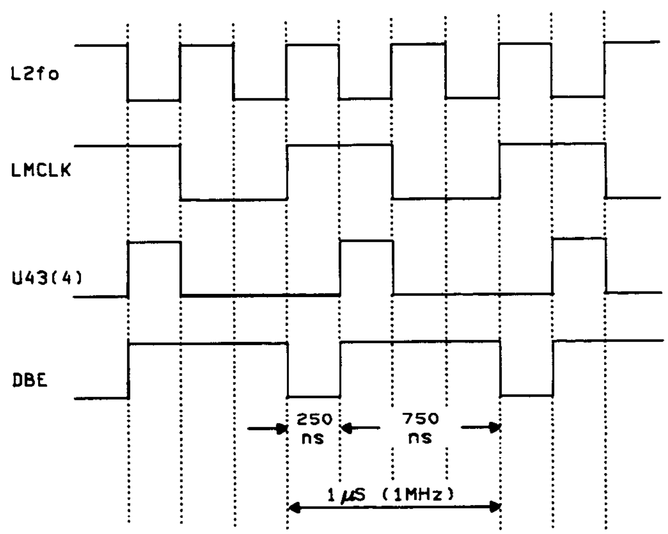


Figure A13-3 Clock Signals

A13-18 All signals illustrated in Figure A13-3 are derived from the 8MHz (nominal) Crystal Controlled Oscillator, ie 8.192MHz (3776A) and 9.264MHz (3776B).

A13-19 Interrupts

A13-20 Sources of Interrupt;

LNMI (non-maskable interrupt)

A logic '0' on this line will immediately interrupt the MPU. These interrupts cannot be masked off by software.

Sources of LNMI

1. Instrument Bus and Keyboard Bus time-outs (routed through the PIA),
2. Power Fail (LPWRFAIL)

LIRQ (interrupt request)

These interrupts can be masked off by software:-

Sources of LIRQ

1. HPIB chip (I8291A)
2. Front panel key
3. Rear panel switch
4. A11/A12 Digital Receiver
5. A8 Impulse Noise & Frequency Detector
6. A5 Transients Option

A13-21 Test Facilities

A13-22 This assembly contains test switches (S2) and signature analysis (SA) links. The test switches can be set at power-on to select specialised self-test/diagnostic test routines. The SA links enable the MPU to be set to a non-operating or cycle mode. This allows signature analysis of the A13 and A14 Assemblies, see GENERAL SERVICE SHEET G3.

A13-23 Memory

A13-24 The organisation of the processor ROM and RAM memory is conventional, with minor differences being expanded upon in the following paragraphs.

A13-25 Read Only Memory (ROM)

A13-26 The 8k byte ROM on A13 contains the power-on sequence and special utility routines. This enables the A13 Processor Assembly to be tested in isolation.

A13-27 The main operating program memory is in the 64k bytes on A14. However, A14 can hold up to 80k bytes of memory in ROM.

A13-28 Random Access Memory (RAM)

A16-29 5.5k bytes of RAM are available, 2k bytes on A13 and 3.5k bytes on A14. The 2k bytes of RAM on A13 is used as the main scratchpad. The 1.5k bytes of RAM (U43 on A14) is provided with a battery power source which takes over whenever the instrument +5V supply is not present. This effectively makes the RAM non-volatile memory (NVM) which is used to store set-up or default parameters. The remaining 2k of RAM (on A14) is used in measurement calculations.

A13-30 Input Output Interfaces

A13-31 Four bi-directional buffers interface the Processor with the rest of the 3776. These are the Memory, Keyboard, Instrument and HP-IB interfaces.

A13-32 HP-IB Interface

A13-33 The A13 HP-IB Interface U55/U65/U75 links an external HP-IB system to the A13 Processor. It also takes care of HP-IB protocol to bus management.

A13-34 Bus Handshake, Drivers and Receivers

A13-35 The Instrument bus D0 to D7 and the Keyboard bus KBD0 to KBD7 and Memory Bus XMD0 to XMD7are all connected to the Processor via the tri-state Data Bus Drivers and Receivers U62, U52 and U72.

A13-36 Instrument and Keyboard Handshake Protocol

A13-37 The Instrument and Keyboard Bus Handshake Protocol for writing to or reading from the Input/Output Ports is illustrated in Figure A13-4.

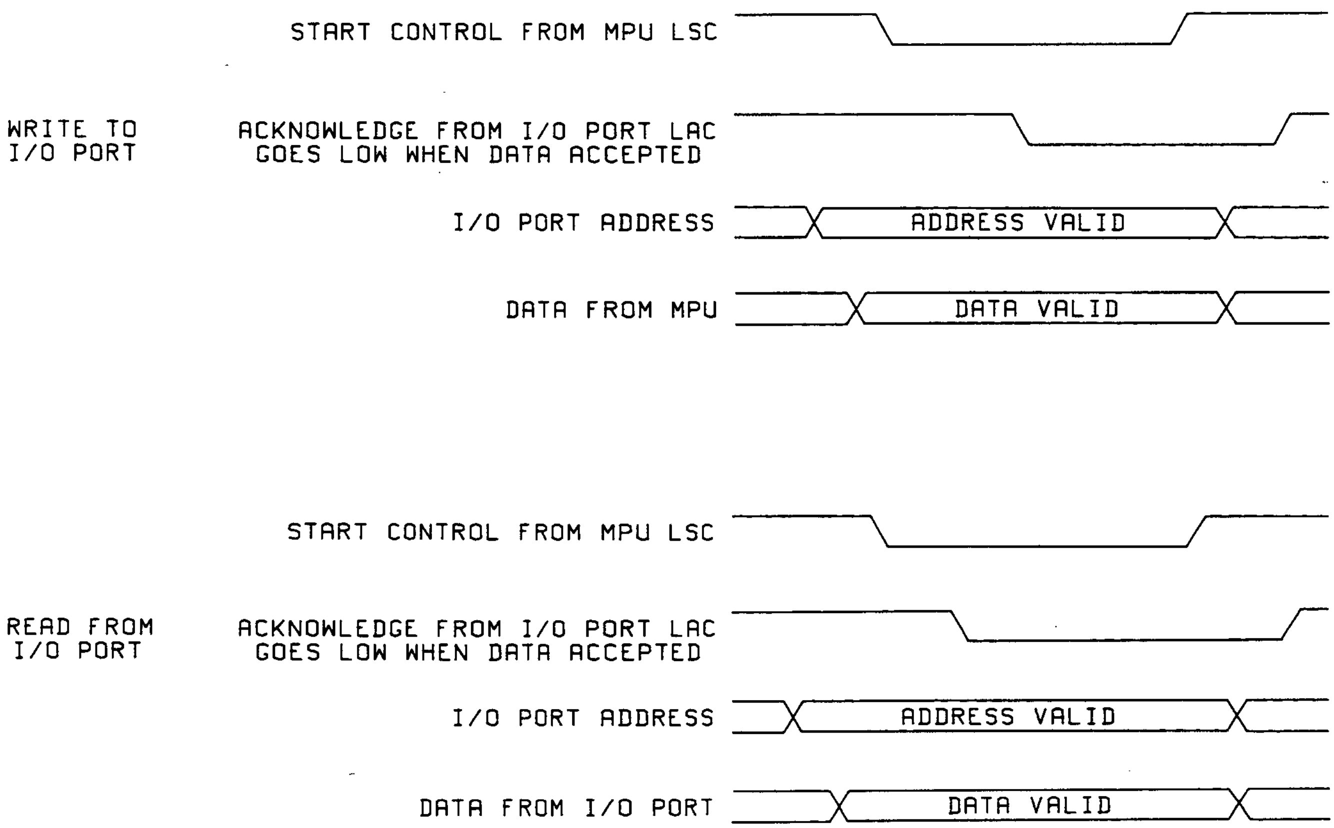
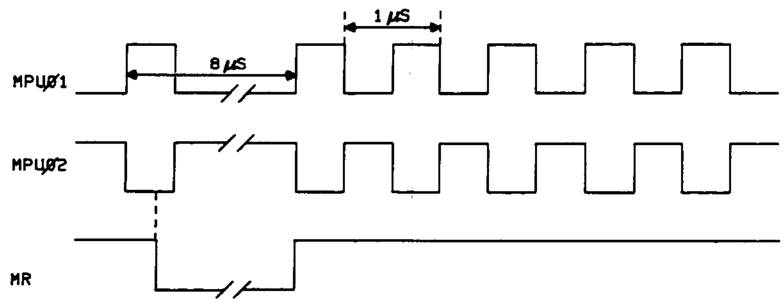


Figure A13-4 Handshake Protocol

A13-38 Keyboard & Instrument Bus Time-outs

A13-39 If the handshake from either the keyboard or instrument bus is not acknowledged (no LAC) the MPU may be delayed by up to 8us. If LAC has not been returned after 8us a time-out is generated which is latched into the PIA. The PIA produces LNMI which interrupts the MPU.

A13-40 Delaying the MPU or slow memory access is performed by stretching the MPU 01 and MPU 02 clocks signals. This stretching action is controlled by the memory ready signal MR from the Address Decoder (see Figure A13-5).



A13-5 Stretching MPU Clocks

A13-41 Address Decoder

A13-42 The MA0 to MA15 address lines from the MPU are decoded to control the various circuit elements illustrated in the mapping diagrams of Figure A13-6.

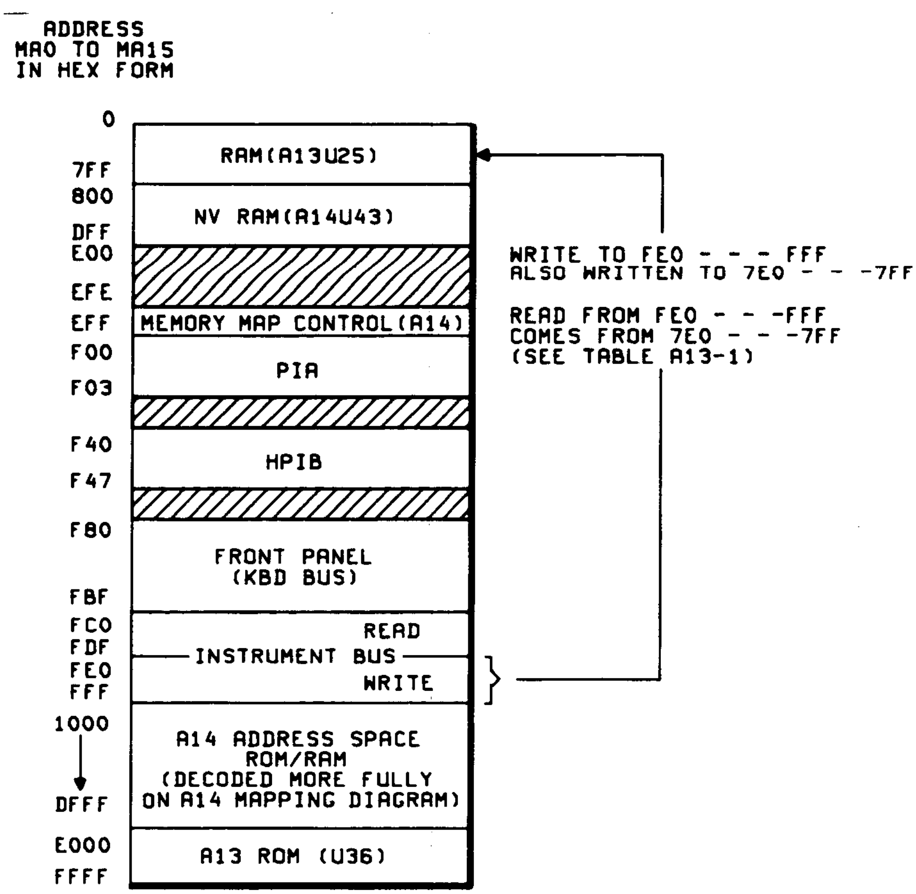


Figure A13-6 Mapping Diagram for A13

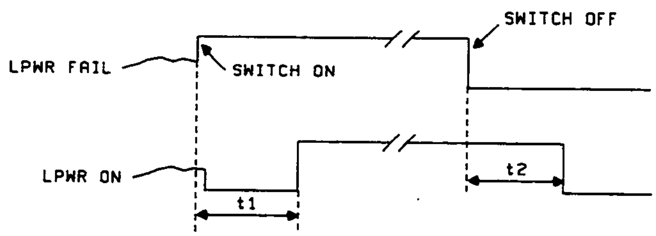
A13-43 Power-on/off Sequence

A13-44 When the 3776 is powered ON and OFF, two signals L PWR ON and L PWR FAIL are generated on the Power Supply Assembly A15. These two signals when applied to the processor ensure:

1 the processor is ready to run at switch ON,

2 the processor has enough time to store data in NVM (non-volatile memory) at switch OFF.

Figure A13-7 describes the Power on/off sequence.



t1 = Processor reset (Processor starts the power on sequence when L PWR ON goes high). Delay t1 is present to ensure the +5V rail is up and stable. This is determined by Monostable A15 U52.

t2 = Time allocated for Processor to store data in NVM before supply shut-down. Delay t2 is determined by the Mains Power Detection on A15 and is >20ms.

NOTES: L PWR FAIL used primarily to instruct Processor that the power is about to fail, so start "Power fail routine".

L PWR ON is used to reset the processor. Processor starts running when L PWR ON goes high.

Figure A13-7 Power on/off Sequence

A13-45 PIA (Peripheral Interface Adapter)

A13-46 The PIA device in conjunction with the test switch S2 is used to select specialised self test/diagnostic test routines. It can also be configured to interrupt the MPU when a bus time-out occurs (ie when KBD TO or BUS TO go true)) or when there is an instrument power failure (ie L PWR FAIL is true). The PIA also drives the LEDs CR1 through CR8.

A1-47 Signature Analysis (see GENERAL SERVICE SHEET G3)

A13-48 Since signature analysis is used in the troubleshooting of the A13 Assembly, only the following circuit elements are described in detail:

1 Keyboard Bus & Instrument Bus Handshake Control,
2 Address Decoder.

A13-49 Keyboard Bus & Instrument Bus Handshake Control

A13-50 The Keyboard Bus & Instrument Bus Handshake Control, made up of two identical sets of logic gates, produce the initiating handshake signals L KBD SC and LSC for the Keyboard and Instrument buses respectively. When the data accepted signals (LKBD AC or LAC) which complete the handshake protocol are NOT received, time-out signals (KBD TO or BUS TO) are produced.

A13-51 Since the Keyboard and Instrument buses are accessed in a similar manner only the Instrument bus access is described in the following paragraphs and in Figure A13-8.

A13-52 The Instrument bus access cycle starts when an instrument bus address is present, the memory clock MPU 02 is low and the data bus enable signal DBE changes low to high (↑). The DBE signal changes only when the address lines MA0 to MA15 have settled.

A13-53 When DBE changes low to high the Address Decoder produces L BUS EN. This signal produces LIO and enables the Instrument tranceiver U62.

A13-54 When the signal LIO goes low the Address Buffer U71 is enabled, triggering the time-out monostable U13A which enables the address lines A0 to A5. When U13A is triggered a memory not ready signal (low MR) is produced. When MR goes high MPU 02 is stretched.

A13-55 Only if L BUS EN and L MCLK are low is the initiating handshake signal LSC produced. This signal then goes to Assemblies A1 to A12. When LSC is low the address lines A0 to A5 are stable as are the data lines if writing from the MPU to the I/O Port.

A13-56 When the data accepted signal LAC goes low U13A is reset, MR goes high which allows MCLK to go low. This allows LSC to go high to terminate the handshake.

A13-57 If a low LAC is NOT received then U13A time-outs after 8us (ie resets). This action releases MR and produces a high time-out signal BUS TO which is latched by the PIA.

A13-58 P/O Address Decoder

A13-59 RAM U25 may read from or write to the Instrument Bus. The logic gates around U64 and U44A allow the reading or writing to be implemented (see Table A13-1).

Table A13-1 RAM Read from/Write to Instrument Bus

U64(7)	MA5	L READ	L KBD EN	L RAM	action
0	0*	0	0	1	read from bus, no ram access
0	0*	1	1	1	no bus access, no ram access
0	1+	0	1	0	no bus access, read from ram
0	1+	1	0	0	write to bue, write to ram

0 = low   * corresponds to addresses FC0......FDF   see Figure
1 = HIGH   + corresponds to addresses FE0......FFF   A13-6

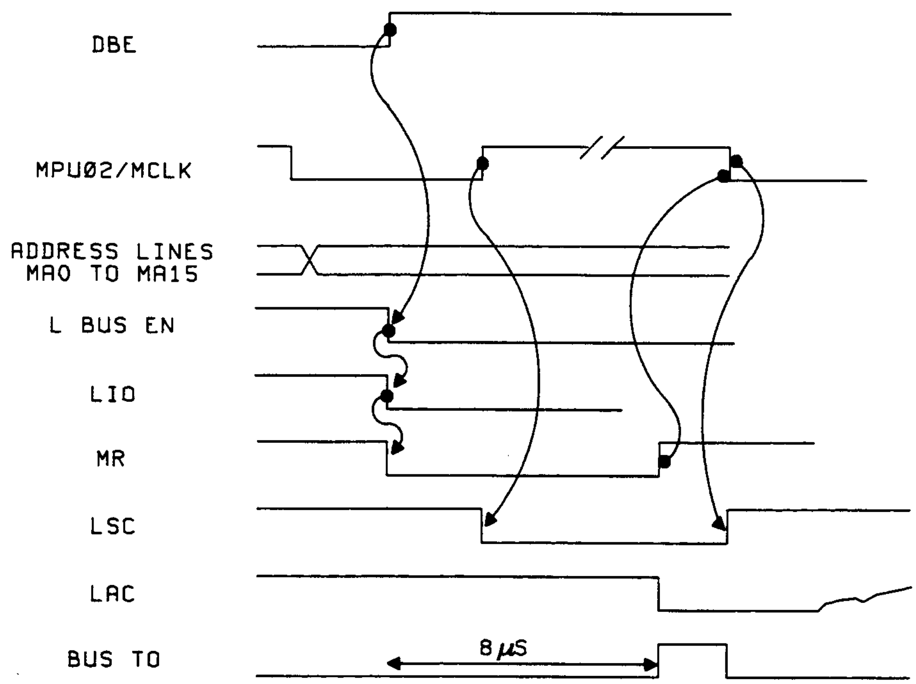


Figure A13-8 Timing Diagram

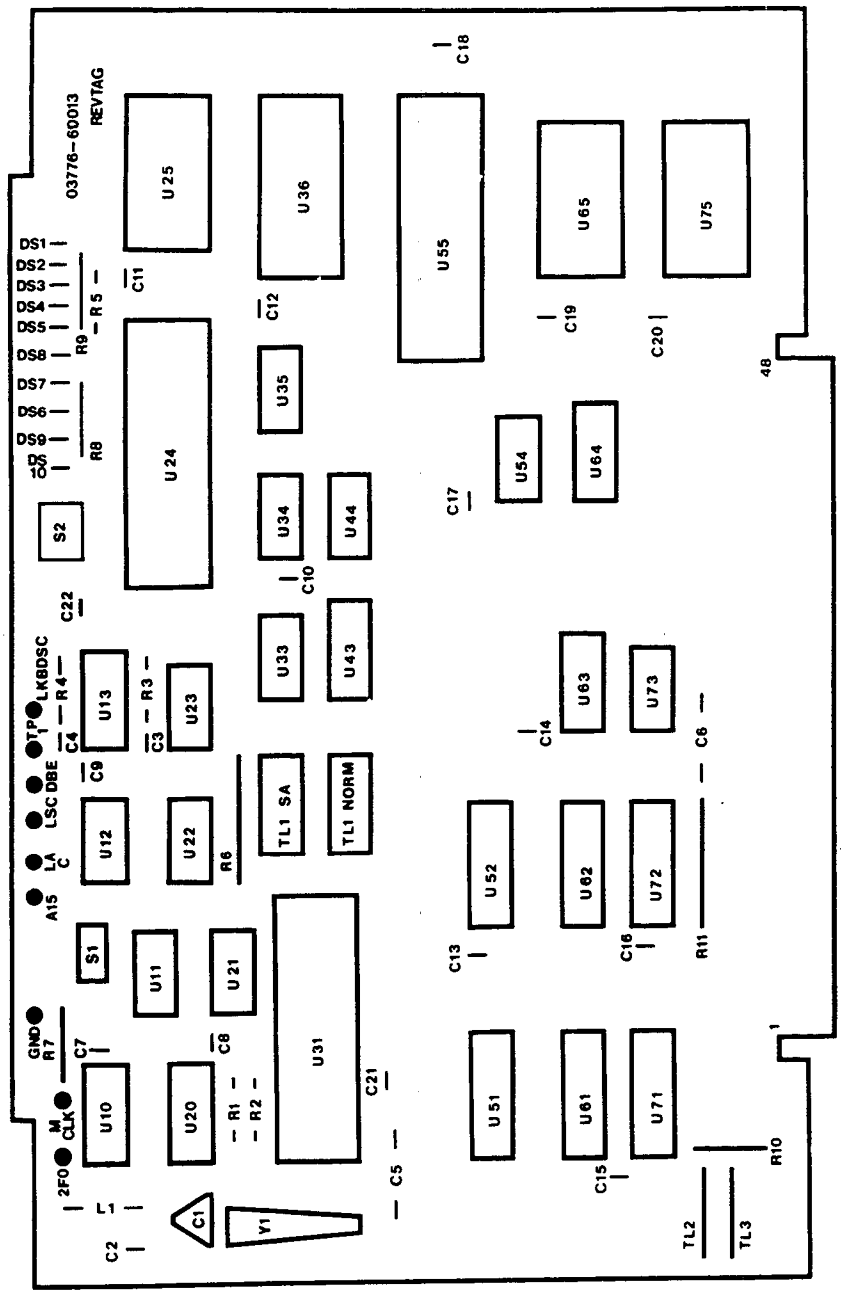


Figure A13-9 A13/A113 Component Location

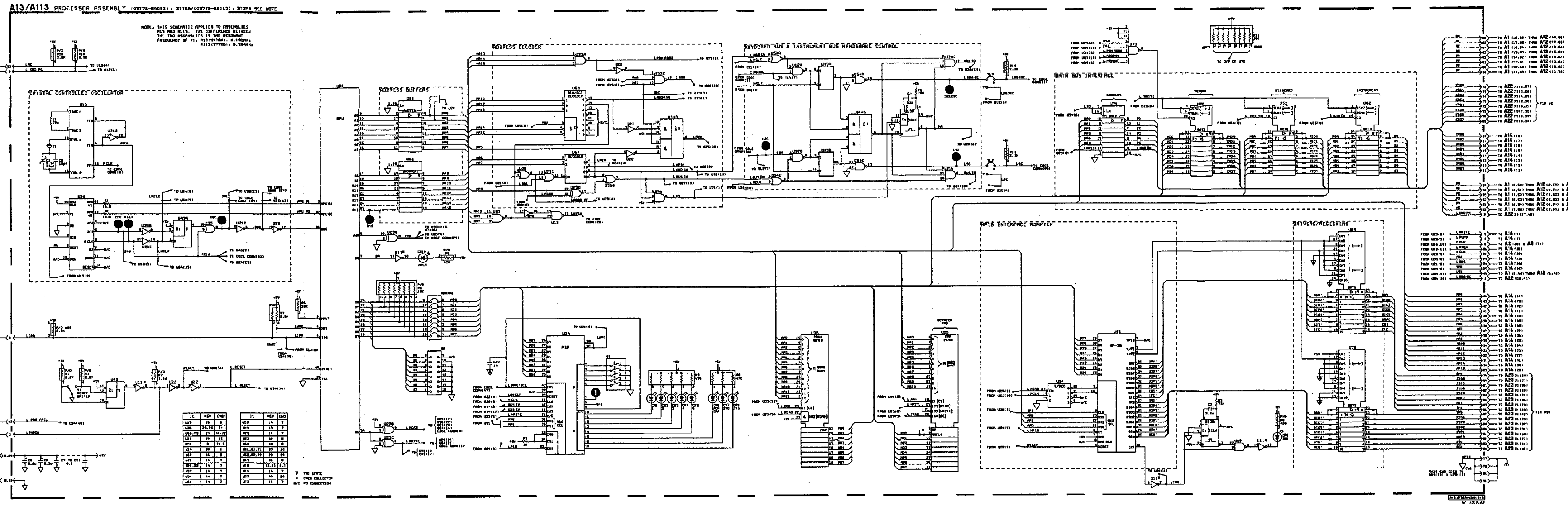


Figure A13-10 A13/A113 Schematic

ASSEMBLY SERVICE SHEET A14/A114
A14(3776A)/A114(3776B)
MEMORY

A14-1 INTRODUCTION

A14-2 The A14 Assembly is the main memory section of the 3776 (see Figure A13-1), it stores instructions and routines performed by A13. Figure A13-2 shows the main circuit elements on A14.

A14-3 Assembly A14 can hold up to 10 X 8k bytes of ROM (although only 8 X 8k bytes are used) and 3.5k bytes of RAM (1.5k bytes of RAM is non-volatile-memory [NVM]).

A14-4 CIRCUIT DESCRIPTION

A14-5 The RAMs and ROMs on A14 are addressed by the MA0 to MA15 lines from the MPU on A13. A mapping diagram illustrating the addresses in HEX form and the RAMs and ROMs they address are shown in Figure A14-1. The mapping information is also shown next to the appropriate memory device on the A14 schematic.

A14-6 The 2000 -> 3FFF area of Figure A14-1 (ROM -2) and 1000 -> 1FFF area (ROM -1) is bank switchable.

A14-7 One of four 8k ROMs (ROM -20, ROM -21, ROM -22 and ROM -23) or the U33 2k RAM can be mapped into the 2000 -> 3FFF area. The required device is selected by the lower three bits of the memory mapping register U45.

A14-8 ROM -1 (an 8k ROM) can have its upper or lower half mapped into 1000 -> 1FFF. This is determined by bit 3 of U45.

A14-9 RAM Standby Power Supply

WARNING

DO NOT INCINERATE OR MUTILATE THE BATTERY. IT MIGHT BURST OR RELEASE TOXIC MATERIALS CAUSING PERSONAL INJURY.

A14-10 When there is a power failure the RAM standby Power Supply is the power source for the NVM RAM U43. When a power supply failure is detected the MPU on A13 goes into a power failure routine and all data to be retained is stored in U43.

A14-11 ROM Address Decoder

A14-12 This circuit comprising three 3 to 8 line decoders, U54, U55 and U35 and latch U45 decodes the address lines MA 8, 9, 10 and MA 13, 14, 15 to produce the ROM enable signals RA1 to RA10. The decoder also produces the RAM enable signals L RAM for U43 and L GD RAM EN for U33.

A14-13 Troubleshooting information for the A14 Assembly is contained in GENERAL SERVICE SHEET G3.

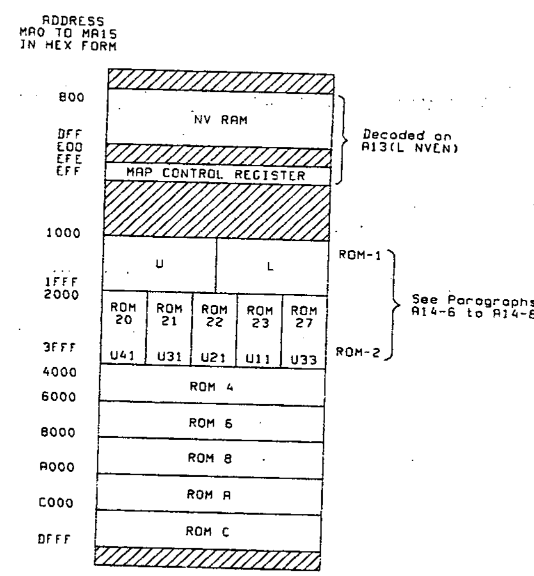


Figure A14-1 Mapping Diagram

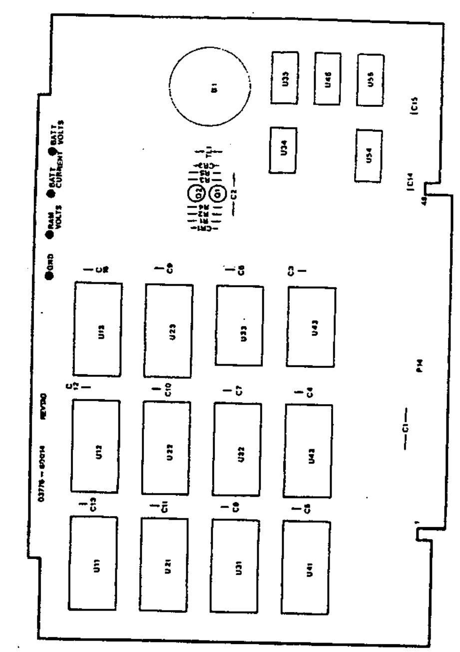


Figure A14-2 A14/A114 Component Location

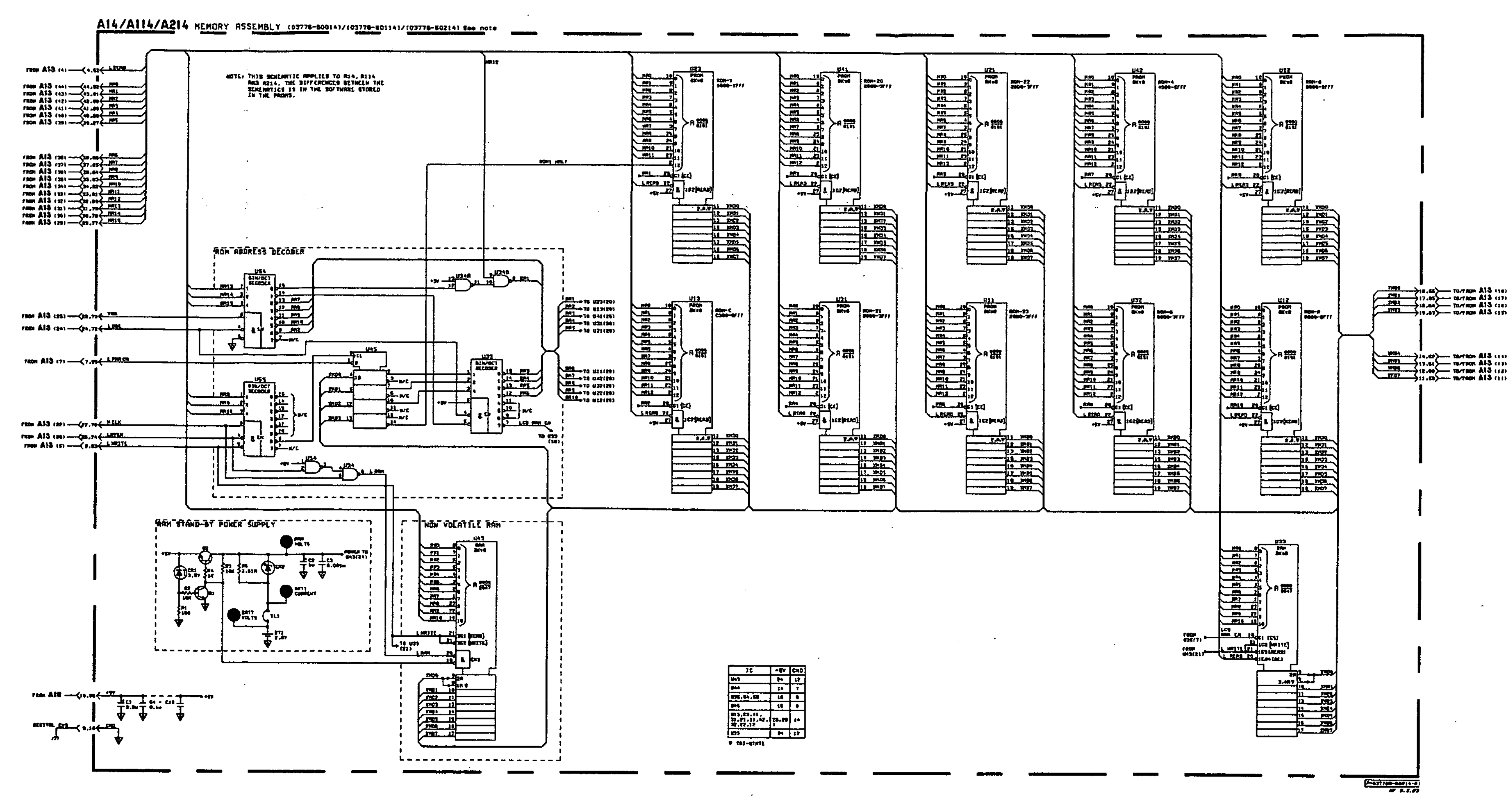


Figure A14-3 A14/A114 Schematic

ASSEMBLY SERVICE SHEET A15
POWER SUPPLY CONTROLLER

A15-1 INTRODUCTION

A15-2 The power supply circuits are contained on assemblies A15, A16 and A24. Due to the interconnection between the assemblies, they are described collectively in this introduction (see Figure A15-1).

A15-3 This instrument uses a switching power supply to produce the regulated +5V, +15V and -15V lines. The switched operation avoids the use of large mains transformers and also allows small smoothing capacitors.

A15-4 Assembly A24 rectifies either the 115Vac or 230Vac mains voltage to provide approximately 340Vdc between the HT+ and HT- lines. Mains over-voltage protection is also contained on this assembly.

A15-5 The A16 assembly uses a transformer switching circuit to convert the 340Vdc from A24 to the regulated +5V, +15V and -15V lines at the output of A16. Transformer switching is controlled by the A15 Assembly.

A15-6 The Variable Pulse Generator on A15 controls the +5V, +15V and -15V lines by providing drive to the transformer switching circuit. Regulation of the +5V line is achieved by changing the width of the drive pulses to Q1 and Q2 on A16. The pulse width is a function of the feedback from the unsmoothed +5V line.

A15-7 Assembly A15 contains four detectors. The mains Power Detection initialises the instrument power "turn on/off" sequence and also protects the instrument processing data against mains dropouts. When mains dropout occurs the detector produces L PWR FAIL which instructs the processor (A13) that it has 20ms to store information before the supply lines go down.

A15-8 Three other detectors protect the instrument against high temperature, over-current and over-voltage conditions.

A15-9 The Overload Protection and Reset Control on A15 does three things at initial switch-on:

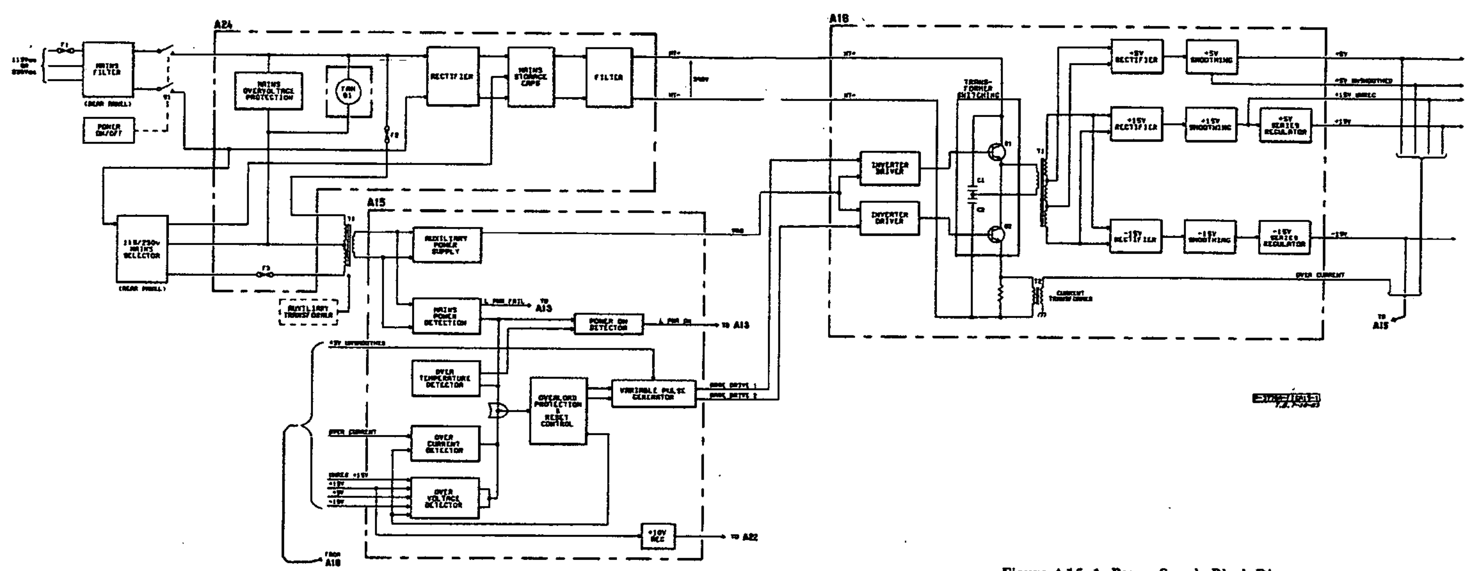


Figure A15-1 Power Supply Block Diagram

1 ensures the Variable Pulse Generator stays inactive ie no +5V +15V and -15V

2 informs the processor (A13) that the instrument is now mains powered - L PWR ON goes low

3 resets (high) the outputs of the Over Current and Over Voltage Detectors

After a short period of time (set by a delay in the Mains Power Detector) the Overload Protection & Reset Control activates the Variable Pulse Generator and disables the Reset Control. After further delay, LPWR ON goes high to inform processor that the power supply has settled.

A15-10 Assembly A15 functions using its own Auxiliary Power Supply.

A15-11 CIRCUIT DESCRIPTION

A15-12 Auxiliary Power Supply

A15-13 This power supply comprises full-wave bridge rectifier CR4 and regulators U13 and Q1/CR6. It provides A15 with power lines +5V(A) and V_{AUX} and also provides a bias voltage V_{BD} (8.5V) to the Inverter Drivers on A16.

A15-14 Mains Power Detector & Overload Protection and Reset Control

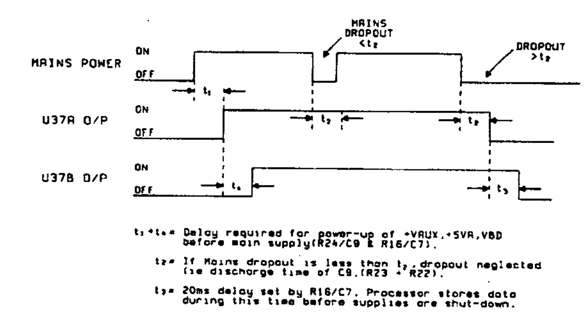


Figure A15-2 Timing Diagram

A15-15 The Mains Power Detection circuit comprises diode bridge CR5 and associated components R24 through R22 and schmitt triggers U37A and U37B.

A15-16 At switch-on diode bridge CR5 triggers U37A when it detects the mains voltage (via auxiliary transformer T1). However triggering is delayed by R24/C9 and R16/C7 long enough for the Auxiliary Power Supply to provide the +5V(A) and V_{AUX} lines on A15 ($t_1 + t_4$ in Figure A15-2). During this delay the Overload Protection & Reset Control performs the functions described in Paragraph A15-9.

A15-17 U37B is triggered after U37A, the time delay between the triggering of these devices is determined by R16 and C7 (t_1 in Figure A15-2). The high now at the input of the Overload Protection & Reset Control allows the Variable Pulse Generator to operate by applying a high to U33(2) and a low to the bases of Q2 and Q3. The low at the output of U37D also de-activates the Reset Control device U36.

A15-18 When the instrument mains power is switched off or interrupted (mains dropout) the output of U37A is reset low after a delay (t_2 in Figure A15-2) determined by R23/R22/C9. This causes L PWR FAIL to go low instructing the processor on A13 that it has 20ms (t_3 in Figure A15-2) to store data before there is total power loss. However, if the mains voltage is interrupted for <20ms (at nominal mains voltage) this dropout is ignored by the Mains Power Detection and the supplies are maintained.

A15-19 The low at U37A(14) also resets U37B but only after a 20ms delay set by R16 and C7. (This 20ms is the time allocated to store data in the processor). The low at U37B instructs the Overload Protection & Reset Control to close-down the power supplies by de-activating the Variable Pulse Generator.

A15-20 The Overload Protection & Reset Control also switches off the power supplies when the output of either the Over-temperature, Over-current or Over-voltage Detectors goes low.

A15-21 Over-temperature Detector

A15-22 This detector uses a schmitt trigger and thermister to monitor the ambient temperature within the instrument. When the temperature exceeds 75 degrees Centigrade U56A triggers the Overload Protection and Reset Control which switches off the power supplies.

A15-23 Over-current Detector

A15-24 This detector comprises schmitt trigger U56B and flip-flop U35A. Over-current transformer A16 T2 monitors overload current in the supplies (due to shorts). When an overload current condition occurs the OVERLOAD CURRENT signal triggers U56B and U35A, which switch off the power supplies - CR3 illuminates.

A15-25 The Over-voltage Detector

A15-26 This detector comprises 4 zener diodes, two schmitt triggers U56C and U56D and flip-flop U35B. When either the +5V, +15V or UNREG +15V goes over-voltage, and >1V appears at U56(4), the output of U56B is triggered low. The low at the input to U55 sets the inverted output of U35B low and CR2 is illuminated. In the case of the -15V line going over-voltage, U56D triggers when <1V appears at U56(7).

A15-27 Variable Pulse Generator

A15-28 Device U33 is a Variable Pulse Generator. It oscillates at 20kHz and its pulse width varies as the UNSMOOTHED +5V varies in relation to the +5V(A) from U13. When the power supplies are switched off Q2 and Q3 ensure that the output of U33 is clamped to GND.

A15-29 Power On Detector

A15-30 At initial switch on L PWR ON is set low (see Paragraph A15-9).

A15-31 10V Regulator

A15-32 A 10V regulated supply is provided at the output of U57. This power line is used on the A21/A22 front panel assemblies.

A15-33 Troubleshooting information for the power supplies is contained on GENERAL SERVICE SHEET G2.

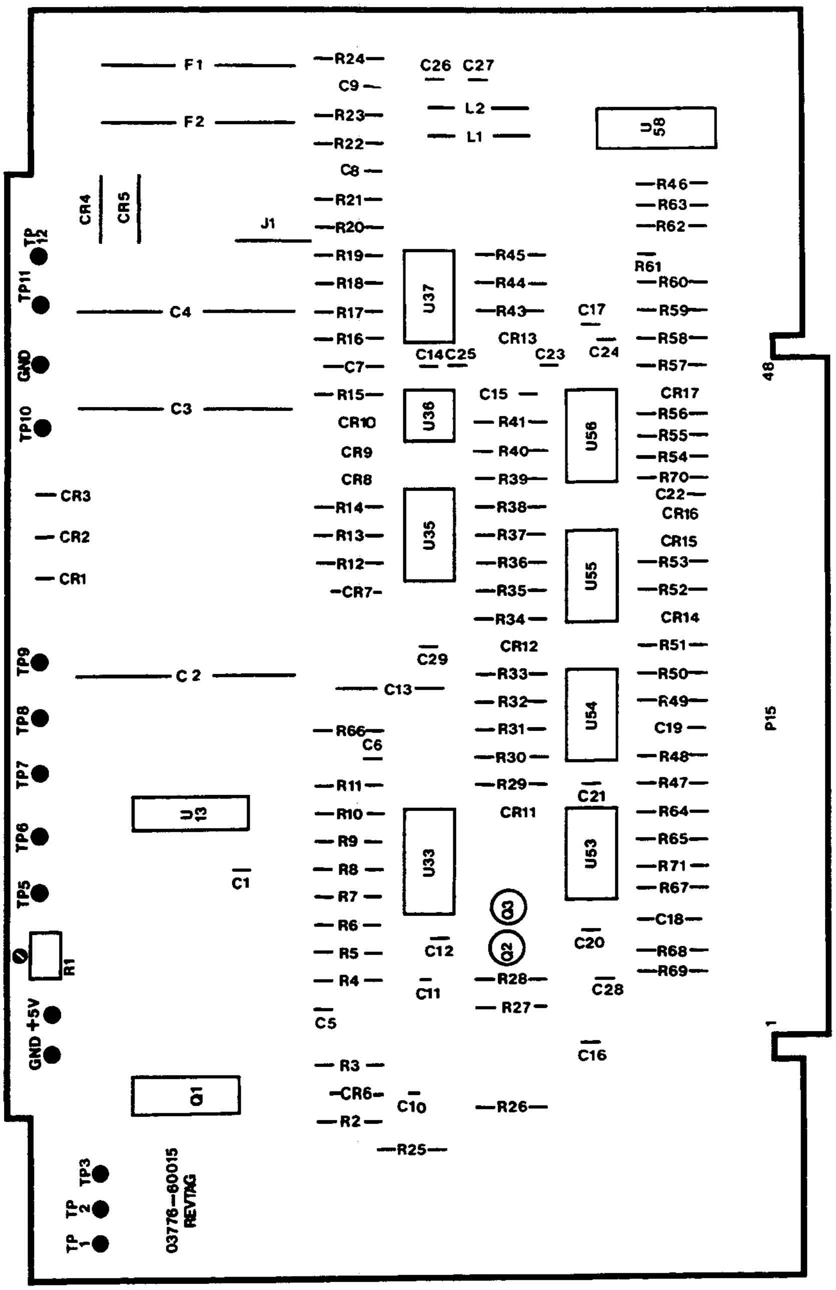


Figure A15-3 A15 Component Location

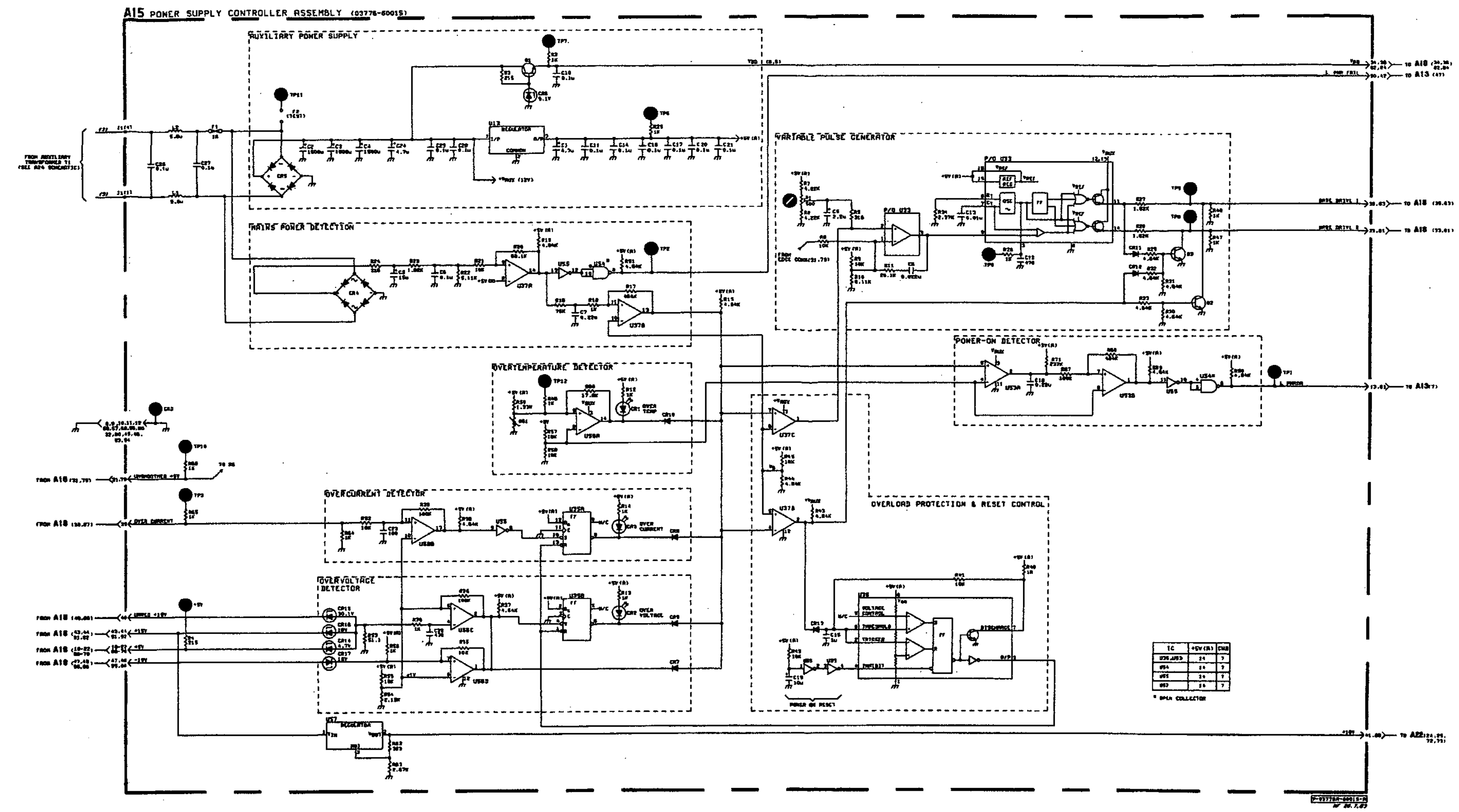


Figure A15-4 A15 Schematic

ASSEMBLY SERVICE SHEET A16
POWER SUPPLY CONVERTER

A16-1 INTRODUCTION

A16-2 A general description of the A15, A16 and A24 power supply circuits is contained on Assembly Service Sheet A15 together with a block diagram.

A16-3 CIRCUIT DESCRIPTION

A16-4 Inverter Drivers

A16-5 The Inverter Drivers for switching transistors Q1 and Q2 are identical, only the circuitry for Q1 will be described.

A16-6 The pulse train BASE DRIVE 1 from A15 is applied to Q7 where it switches current through the primary of T3. The resulting output pulses from the secondary (8 and 7) of T3 are fed to Q1 via CR11 and R21 to provide "turn on" drive. "Turn off" drive is provided by switching Q1 base negative by means of Q3/Q5. The negative voltage provided from the winding (6, 5) of T3 is rectified by CR12 and C13.

A16-7 Transformer Switching

A16-8 Transistors Q1 and Q2 are driven on and off in a push-pull manner, alternately switching the positive and negative unregulated supplies HT+ and HT- through Switching Transformer T1. The primary of T1 is damped by R4 and C3. Figure A16-1 shows the waveform across the secondary of T1.

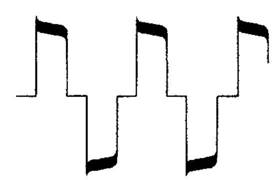


Figure A16-1 Waveform at T1 Secondary

A16-9 Rectifiers and Smoothing

A16-10 The centre-tapped secondary of T1 is full-wave rectified by CR3/CR4 for +5V; CR6/CR8 for +15V and CR5/CR7 for -15V.

A16-11 The +5V supply is obtained by full-wave rectification by hot carrier diodes CR3 and CR4. These diodes have a low forward voltage drop which minimises heat dissipation.

A16-12 The +5V, -15V and +15V supplies are all smoothed by conventional L/C networks.

A16-13 The +15V and -15V supplies are regulated by U1 and U2 respectively.

A16-14 Current Transformer

A16-15 Current transformer T2 monitors the current in the primary of T1 for overload conditions.

A16-16 Power Supply troubleshooting is contained on GENERAL SERVICE SHEET G2.

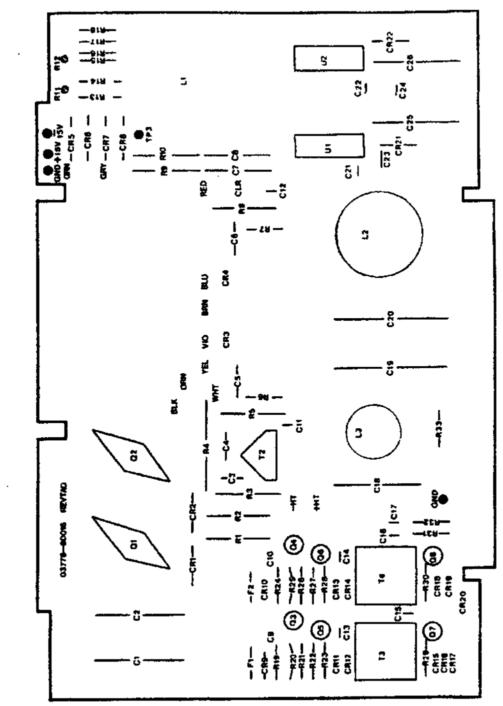


Figure A16-2 A16 Component Location

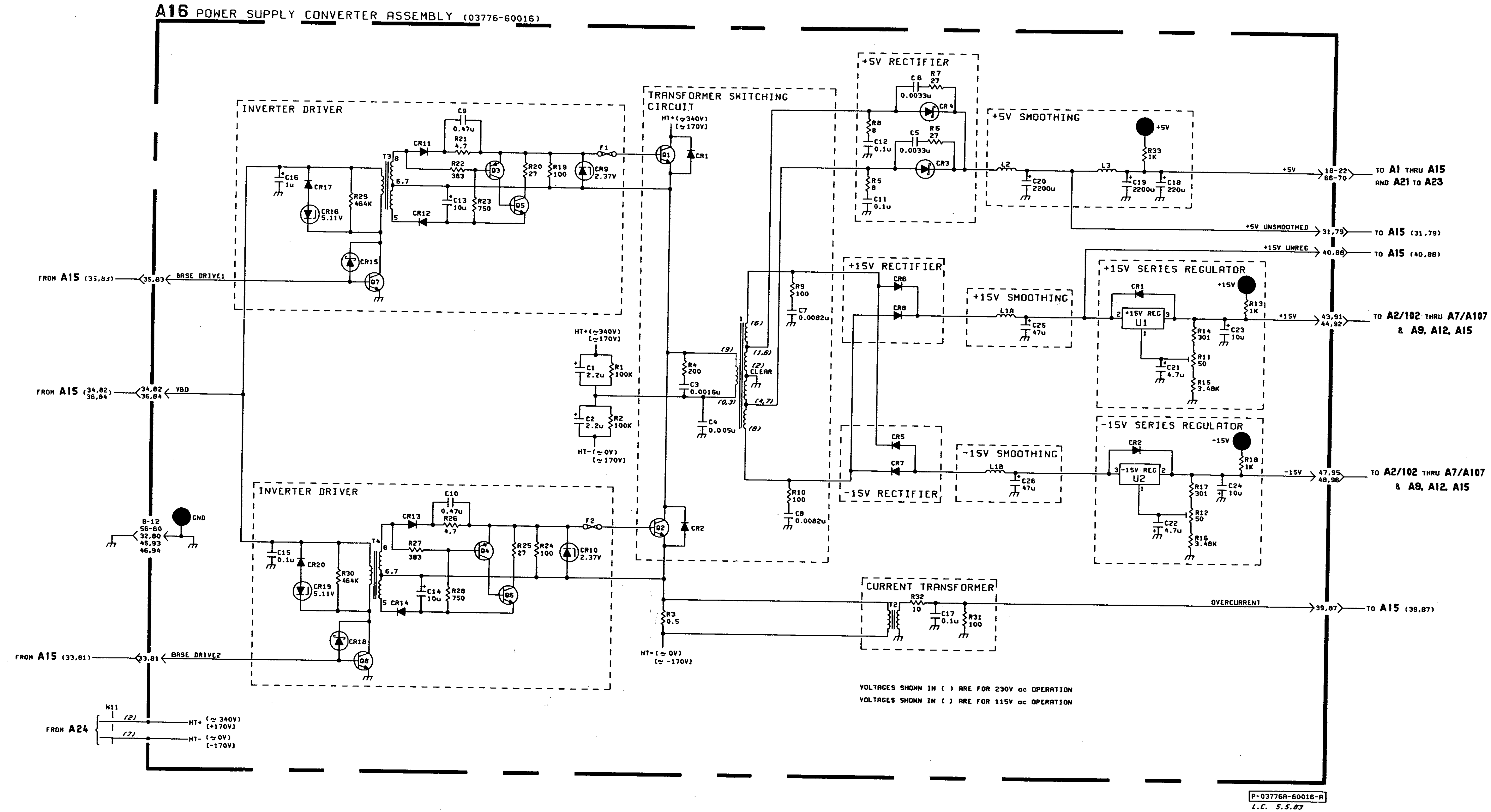


Figure A16-3 A16 Schematic

ASSEMBLY SERVICE SHEET A20
MOTHERBOARD

A20-1 INTRODUCTION

A20-2 All 3776 board assemblies with the exception of the A21, A22, A23 and A24 are housed on the Motherboard assembly.

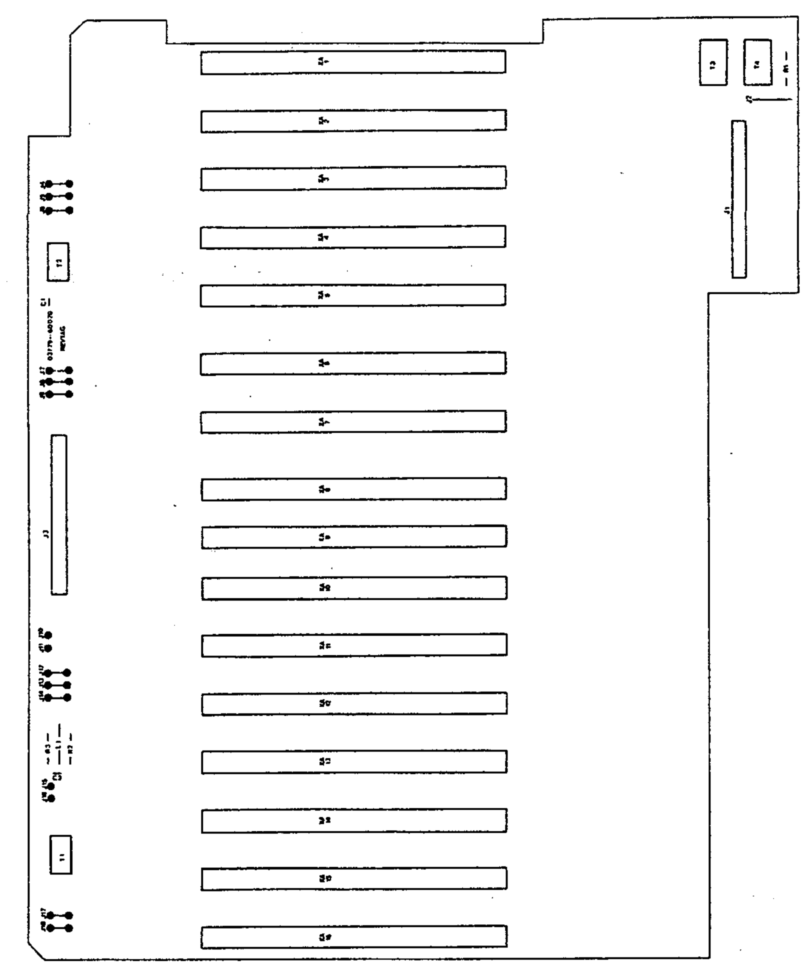


Figure A20-1 A20 Component Location

Circuitry applicable to Assembly A20 is included in appropriate places on relevant Assembly Service Sheets. A separate Schematic of A20 is not provided.

SWITCH FUNCTIONS – MODEL 3776B

SWITCH REF	FUNCTION
S10	NOTCHED NOISE
S12	Tx TLP/T-SLOT
S25	Rx TLP/T-SLOT
S31	I/MOD DIST
S32	QUAD DIST
S34	OTHER MEAS

ALL OTHER FUNCTIONS AS MODEL 3776A

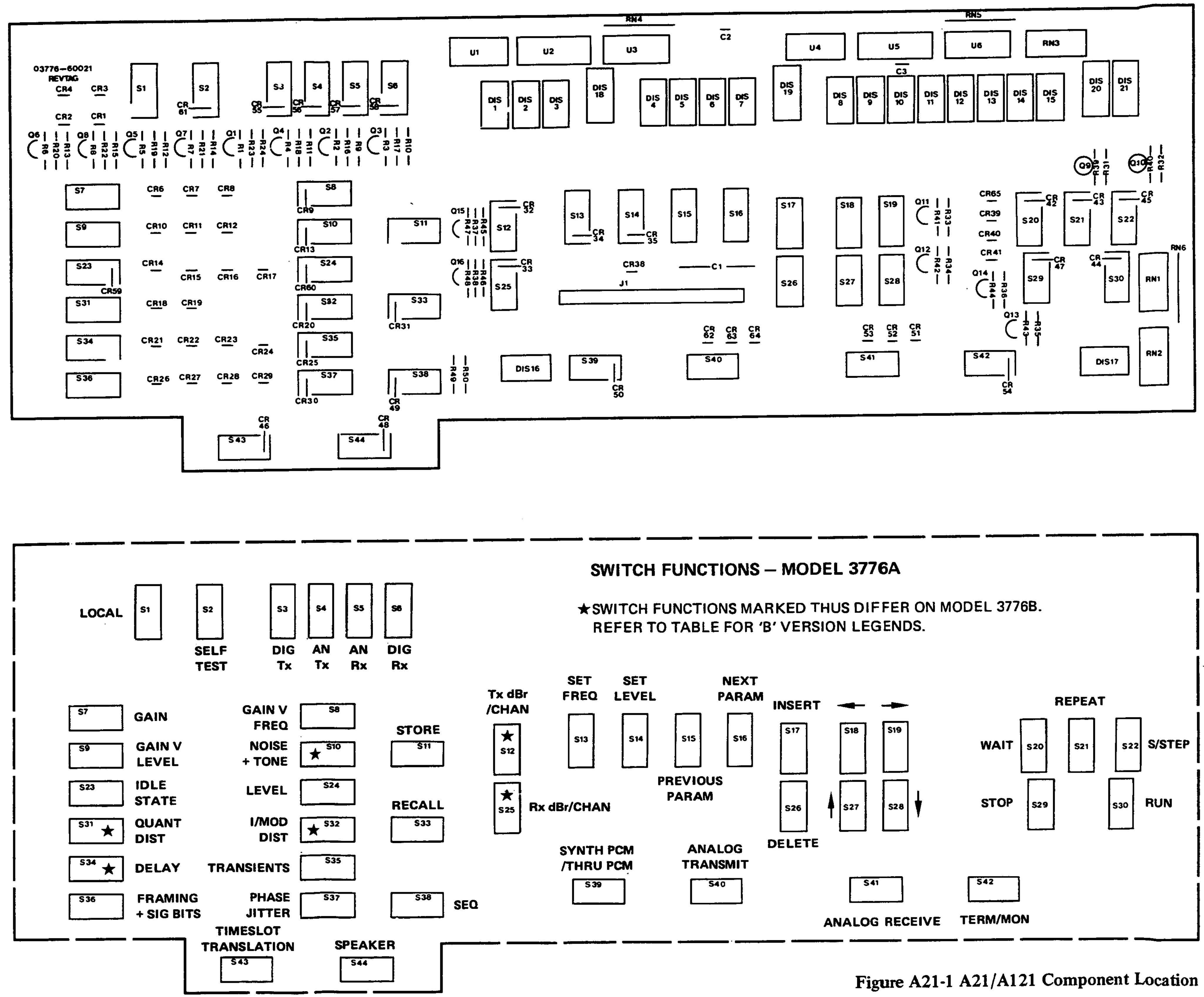


Figure A21-1 A21/A121 Component Location

ASSEMBLY SERVICE SHEET A21/A121
A21(3776A)/A121(3776B)
KEYBOARD ASSEMBLY

A21-1 INTRODUCTION

A21-2 The A21 and A22 assemblies are described collectively in the INTRODUCTION in Assembly Service Sheet A22.

A21-3 CIRCUIT DESCRIPTION

A21-4 7-Segment Displays and LEDs

A21-5 For ease of identification the 7-segment displays and LEDs on this schematic have been arranged in the same order as they appear on the instrument front panel.

A21-6 Character Strobe Generator

A21-7 The Character Strobe Generator is made up of two decoders U1 and U4; two buffers U2 and U5 and two drivers U3/U6. The address data RAMA 0 to 3 from A22 is decoded by the Character Strobe Generator to produce the strobing data L CHAR 0 to 15, which is used to strobe the LEDs and displays on A21. H BLANK ensures that there is no ghosting of the front panel displays by disabling the Character Strobe Generator prior to new address data being applied to U1 and U4. When the new data is applied H BLANK goes low and U1 and U4 decode the new data.

A21-8 Keyboard troubleshooting information is contained in GENERAL SERVICE SHEET G4.

8-A21-2 LOCATED INSIDE FOLD – **Figure A21-1 A21/A121 Component Location**

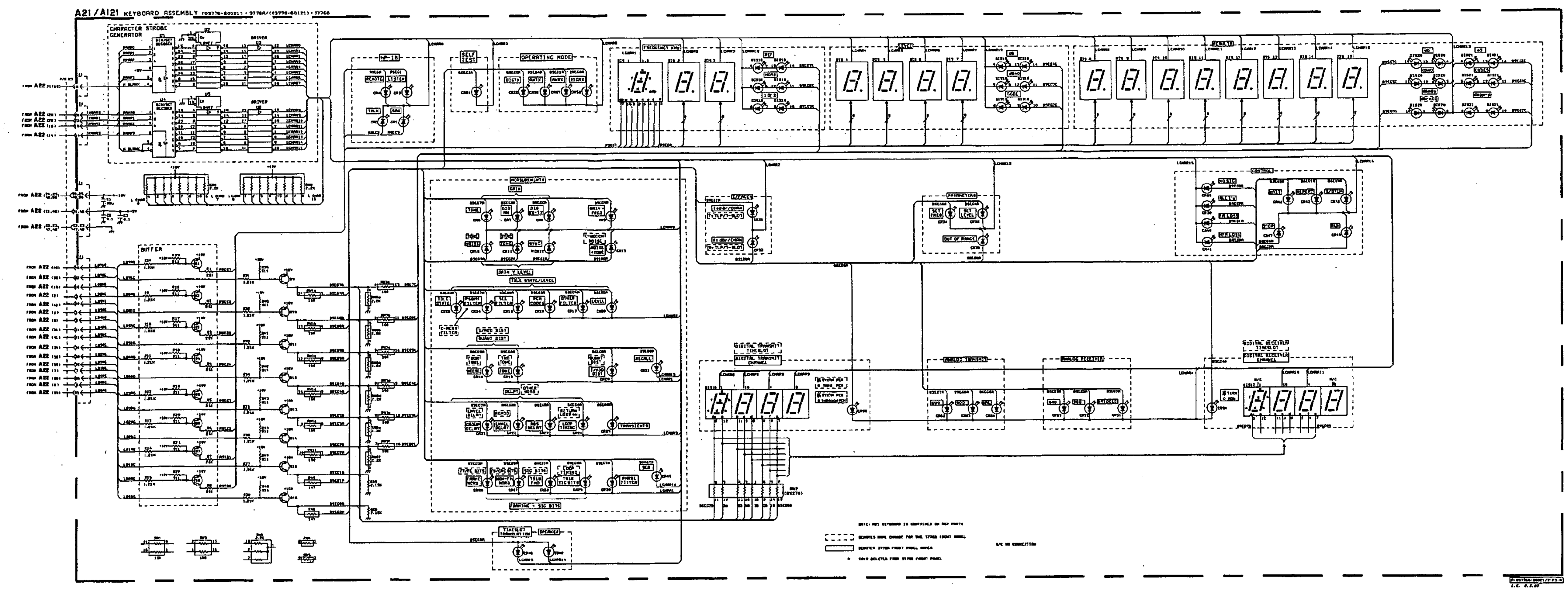


Figure A21-2 A21/A121 Schematic

ASSEMBLY SERVICE SHEET A22
KEYBOARD AND DISPLAY CONTROLLER

A22-1 INTRODUCTION

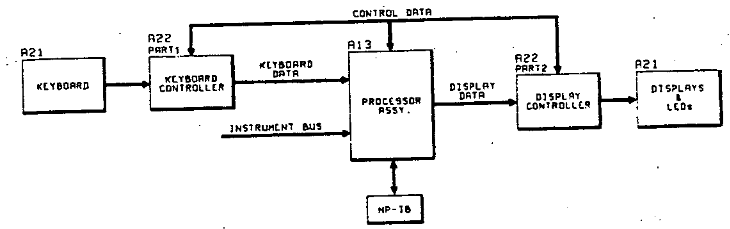


Figure A22-1 Keyboard and Display Block Diagram

A22-2 The keyboard and display section of this instrument is illustrated in Figure A22-1. Due to the interconnection between the Keyboard Assembly A21 and the Keyboard and Display Controller Assembly A22, they are collectively described in this section.

A22-3 The keyboard, on A21, enables the operator to manually control the instrument. Assembly A21 also contains the front panel 7-segment displays and LEDs.

A22-4 The A22 assembly interacts with the Processor Assembly A13 to control the flow of KEYBOARD DATA to A13 and also to control the DISPLAY DATA to the 7-segment displays and LEDs on A21. The KEYBOARD and DISPLAY DATA buses shown in Figure A22-1 are in reality one bi-directional bus (KBD0 to 7, see Figure A22-2).

A22-5 Keyboard

A22-6 Each of the front panel keys when pressed is identified by the Processor Assembly A13. The circuits on A22 which make identification possible are illustrated in Figure A22-3.

A22-7 The front panel keyboard is arranged in the form of a grid. When a key at the point of intersection is pressed, a connection is made between a pair of X and Y lines (see Figure A22-3).

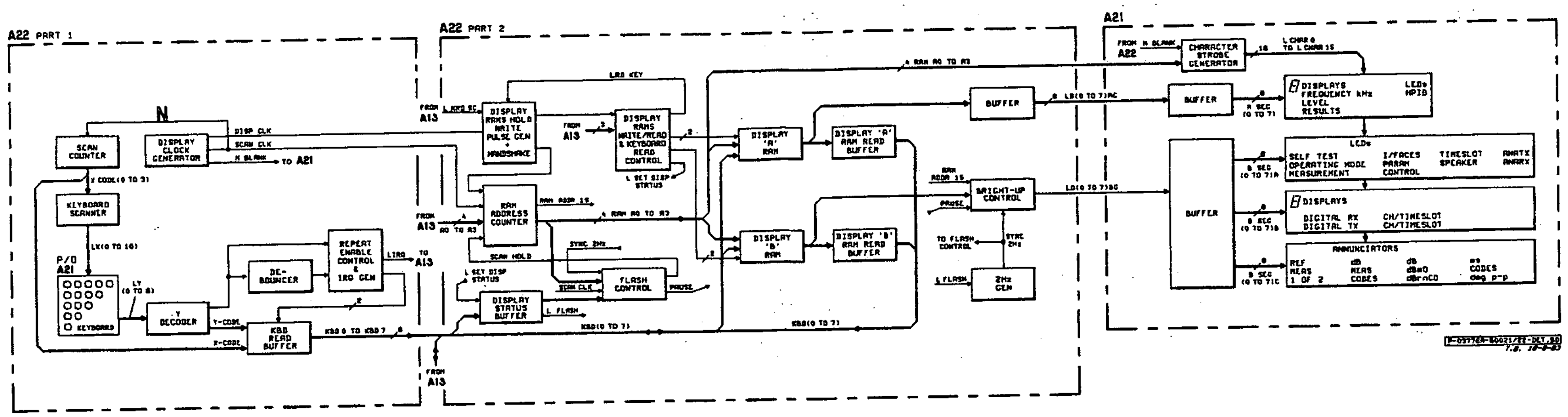


Figure A22-2 Detailed Block Diagram

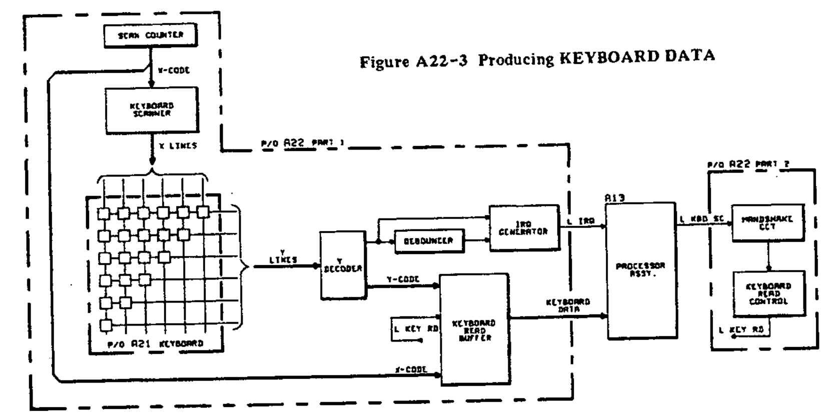


Figure A22-3 Producing KEYBOARD DATA

A22-8 The Scan Counter and Keyboard Scanner ensure that the X lines to the keyboard are strobed at a 16kHz rate. This high strobing rate ensures that the key being pressed is identified by the processor. The Scan Counter also supplies X-CODE data to the Keyboard Read Buffer.

A22-9 The Y Decoder monitors the Y lines of the keyboard. When a key is pressed the Y Decoder provides trigger signals for the Debouncer and IRQ (interrupt request) Generator circuits. Y-CODE data is also generated and applied to the Keyboard Read Buffer.

A22-10 The Debouncer circuit ensures that a single pressing of a key is sensed only once.

A22-11 When a key has been pressed the processor is alerted by an interrupt request signal (LIRQ) from the IRQ Generator. The processor, when ready to identify the pressed key, then produces the Keyboard Send Control signal (L KBD SC). This signal is applied to the handshake logic to produce a trigger signal for the Keyboard Read Control circuit which in turn generates a low L KEY RD. When L KEY RD goes low, the Keyboard Read Buffer latches the X and Y code data and this becomes the KEYBOARD DATA. This data is used by the processor to identify the pressed key.

A22-12 7-Segment Displays and LEDs

A22-13 All front panel 7-segment and LED information, DISPLAY DATA, is produced on the Processor Assembly A13 and stored in RAM in the Display Control Logic on A22. The Display Control, when instructed by A13, provides the drive for the 7-segment displays and LEDs on A21. To optimise the power consumption, the displays are scanned by a Character Strobe Generator on A21.

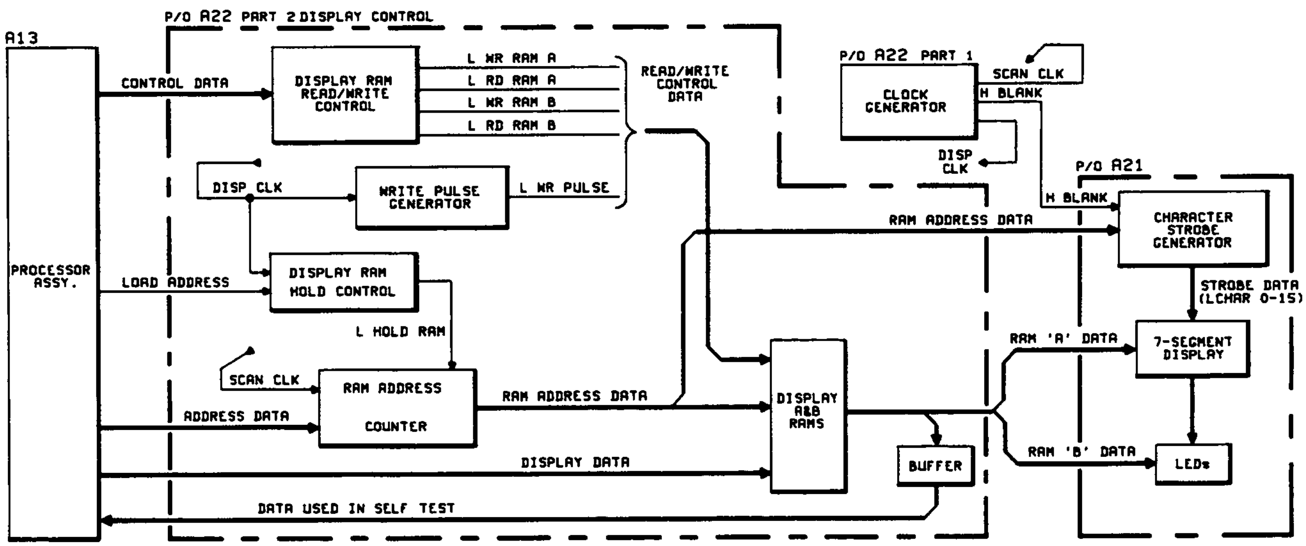


Figure A22-4 Strobing of the Front Panel Displays and Storage of Display Data

A22-14 Figure A22-4 illustrates the circuit elements required to,

1 strobe the front panel displays,
2 store display data into RAM,
3 read display data from RAM.

A22-15 Strobing the Front Panel Displays

A22-16 The front panel 7-segment displays and LEDs are strobed under the control of the Processor Assembly A13 and the Display Control on A22. Strobing is almost continuous, being interrupted only when DISPLAY DATA is to be stored in/read from RAM (see Figure A22-4).

A22-17 The front panel displays are arranged into 16 groups, or characters. Each character is allocated one of the strobing L CHAR 0 to 15 signals. Data to illuminate 7-segment display or group of LEDs is stored in RAM.

A22-18 SCAN CLK clocks the RAM Address Counter through its 16 RAM addresses. These in turn are applied to both the Character Strobe Generator and the Display A & B RAMs. The Character Strobe Generator enables each of the 16 groups of displays in turn while the Display A & B RAM output data selects the 7-segment display or LEDs to be illuminated within each group.

A22-19 Storing DISPLAY DATA in RAM

A22-20 Assembly A13 controls the storage of display information into RAM, by allocating the address into which the display information is to be stored and by deciding when to store.

A22-21 Data is stored in RAM by interrupting the front panel display strobing sequence. When display information is to be stored, the A13 assembly applies the DISPLAY DATA to the inputs of the Display A & B RAMs and applies the DISPLAY ADDRESS to the input of the RAM Address Counter. The ADDRESS is then loaded into the RAM Address Counter. With the RAM ADDRESS and DISPLAY DATA now at the inputs of the Display A&B RAMs the appropriate RAM WRITE signal is produce which together with the LWR PULSE signal from the Write Pulse Generator stores the display information in RAM. While the display information is being written into RAM, the front panel 7-segment displays and LEDs are blanked by H BLANK.

A22-22 The outputs of the Display A and B RAM may be fed back to the A13 Assembly during self test.

A22-23 Interaction between the Keyboard and the Front Panel Display

A22-24 An example is given here which illustrates the interaction between the pressing of a front panel key(s) and the updating of a front panel 7-segment display(s) and LED(s), ie UPDATING FREQUENCY VIA THE FRONT PANEL KEYS. This example comprises two steps;

1 Select mode of operation by pressing the SET FREQ key.
2 Update front panel FREQ display by pressing ← or → and the INCR or DECR keys.

A22-25 Mode of Operation

A22-26 When the SET FREQ key is pressed, the key is identified by the processor on A13 which then updates the display RAMs to illuminate the SET FREQ LED. The processor on A13 is now waiting to initiate the updating of the FREQ display.

A22-27 Update of FREQ display

A22-28 When the SET FREQ key is pressed, the furthest right of the FREQ 7-segment displays is lit more brightly (Bright-up) than all the others and flashes at a 2Hz rate. "Bright-up" acts as a cursor for the front panel 7-segment displays and is shifted to the right by the → key and left by ← key. The INCR and DECR keys alter the value of the selected digit. Figure 22-5 illustrates the circuits used for "Bright-up".

A22-29 When bright-up is required the Processor Assembly supplies the RAM address of the display to be brightly lit. The address is latched into the Keyboard Display Status Register by L SET DISP STATUS. The Flash Control compares the RAM ADDRESS with the address from the A13 assembly. When they are the same, two signals are produced, SCAN HOLD and PAUSE. SCAN HOLD prevents changes in the RAM Address Counter output for several SCAN CLK pulses. This causes the Character Strobe Generator on A21 to "hold-on" to the selected display. This holding causes the bright-up.

A22-30 Bright-up occurs only on data from the Display "A" RAM (data for the fifteen 7-segment displays). The PAUSE signal prevents bright-up on the Display "B" RAM output data by switching off the signal path, to the LEDs at the Bright-up Control.

A22-31 The 2Hz flashing of three LEDs (SET LEVEL, SET FREQ and OUT OF RANGE) is controlled by the A13 assembly, Keyboard Data Input Buffer and the 2Hz Generator. When 2Hz flashing is required, the A13 assembly has L FLASH latched into the Display Status Register, which in turn produces SYNC 2Hz.

a) SYNC 2Hz is applied to the Timeslot Contents Test Control to flash the 7-segment displays, ie PAUSE flashes at 2Hz.

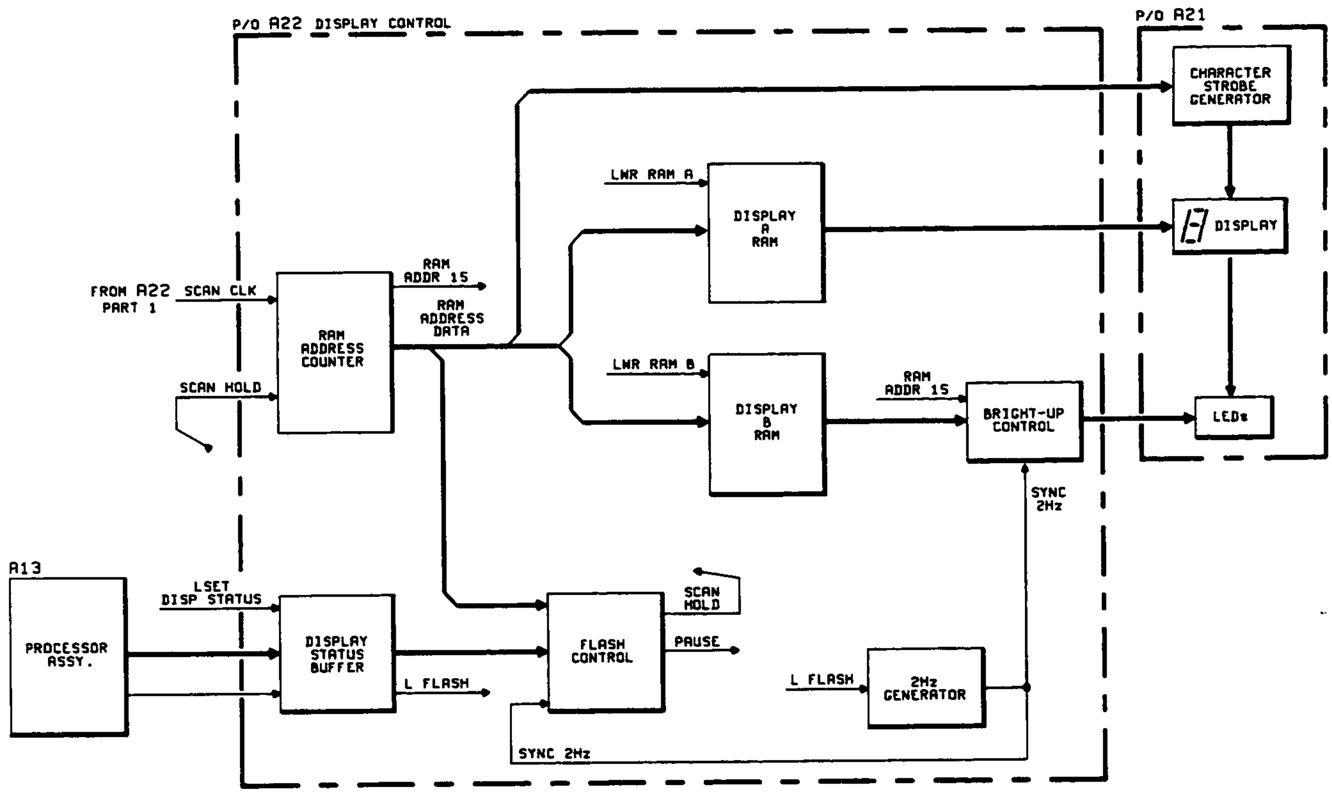


Figure A22-5 Bright-up and 2Hz Flashing

b) SYNC 2Hz is applied to the Flash Control to control the flashing of the three LEDs. RAM ADDR 15 must be true (ie address 15) for the LEDs to flash.

A22-32 CIRCUIT DESCRIPTION

A22-33 Scan Counter, Keyboard Scanner, Scan Inhibit Logic

A22-34 The Scan Counter U20 is a binary up counter. It is clocked through its sixteen output states by SCAN CLK. The output data from U20 is decoded by U21 and U22, the 3 to 8 line (Bin to Oct) decoders of the Keyboard Scanner. When a key is pressed the X lines of the keyboard are scanned for a further 5ms (determined by U11) before the scanning is inhibited by L KEY INT. When a low L KEY INT is applied to U20 the counter is inhibited and its output data along with data from the Y Decoder is applied to the processor A13 via the Keyboard Read Buffer for key identification.

A22-35 Y Decoder U34 is an octal to binary highest priority decoder. When a key is pressed, the Y line of the key is strobed by the X line once every 16 SCAN CLK pulses. This produces a train of pulses at U34(15) which activate the Debouncer circuit. The next pulse after the 5ms delay produces L KEY INT at the output of the Scan Inhibit Logic which stops the scan (see Figure A22-6). The binary output data from the Y Decoder is used by the processor to identify the key.

A22-36 The gated KEYINT signal clocks the keyboard co-ordinates into the Keyboard Read Buffer U46 when LRD KEY goes low. Once in the buffer the keyboard data can be read by the processor.

A22-37 Debouncer

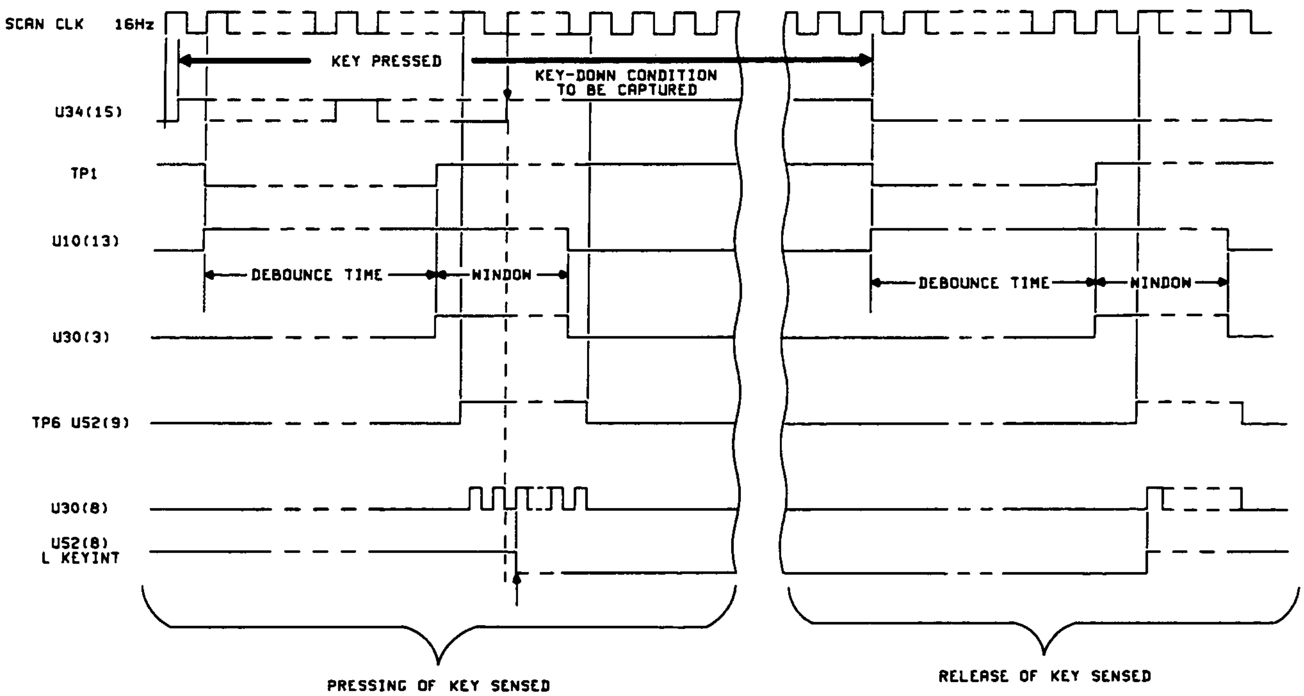


Figure A22-6 Debouncer Timing Diagram

A22-38 Two monostables U10 and U11, two AND gates and a flip-flop make up the Debouncer circuit. This circuit ensures that only a single pressing of a key is sensed, by utilising the 5 and 7ms time constants of U10 and U11. The circuit is described using timing diagram Figure A22-6.

A22-39 Repeat Enable Control Logic & IRQ Generator

A22-40 When a key is pressed and after a 5ms delay, KEYINT goes high at TP6 causing a low to high transition at U30(6) which triggers U12A. The high at U12(9) is inverted by U57A, producing an instrument request LIRQ for the processor.

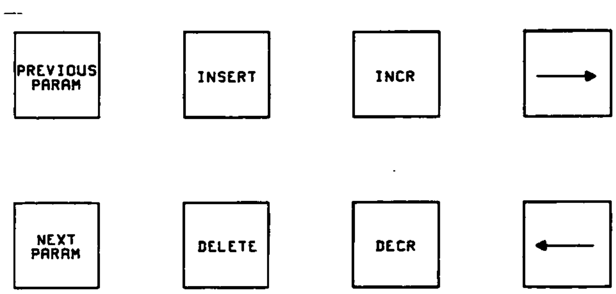


Figure A22-7 Repeat LIRQ Keys

A22-41 Certain keys, see Figure A22-7, when continuously pressed produce a continuous train of LIRQ pulses. The Repeat Enable Control Logic at TP2 repeatedly pulses the input of U30A. The first pulse is delayed by 750ms thereafter the pulses repeat every 250ms.

A22-42 When the X CODE 0 to 2 lines are decoded by U41A and U43A a low to high transition is obtained at U41(11), U10 triggers with an initial time constant of 750ms determined by R6/C8, C9. After 750ms TP2 goes high triggering U12B. This action forward biases CR1 which in turn changes the time constant of U10 to 250ms, determined by R3, R6/C8, C9.

A22-43 Keyboard Read Buffer

A22-44 When KEYINT goes low to high, U46 latches the X and Y data but only when LRD KEY is low.

A22-45 Display RAMs Read/Write Control & Keyboard Read Control

A22-46 The decoder U54 decodes data from the processor to provide control signals for A22.

A22-47 Display RAMs Hold Control & Write Pulse Generator + Handshake

A22-48 This circuit, made up of U56 and associate gates and controlled by the processor, performs three functions (see Paragraphs A22-12, A22-19 and A22-22). It provides the timing data which allows the various routines performed on this assembly to occur at the appropriate time. The Handshake protocol is illustrated in Figure A13-4.

A22-49 RAM Address Counter

A22-50 Binary up counter U33 either clocks through each of the 16 RAM addresses or is preloaded with an address sent from the processor. The carry output RAM ADDR 15 is used when flashing LEDs are required.

A22-51 Keyboard Data Input Buffer & Timeslot Contents Test Control

A22-52 When bright up is required the processor sends the appropriate information on the KBD (0to7) bus. This information is stored in U51 when L SET DISP STATUS goes high. The outputs of U51 and U33 are applied to 4 exclusives OR gates and an AND gate to produce SCAN HOLD at U41(8) and PAUSE at TP5 (see Paragraph A22-30 to 32).

A22-53 Display "A" and "B" RAM

A22-54 Each RAM contains sixteen 4 bit words which are controlled by L WR PULSE, L WR RAMA and L WR RAMB.

A22-55 Display RAMs "A" and "B" Read Buffer

A22-56 The buffers U36 and U37 pass the contents of RAM "A" or "B" when either L RD RAMA or L RD RAMB is true.

A22-57 Bright-up Control

A22-58 When flashing (bright-up) is required the Bright-up Control circuit ensures that only data from the Display "A" RAM reaches the displays on A21 by inhibiting data from the Display "B" RAMs U17 and U27.

A22-59 Further Keyboard and Display troubleshooting is contained on GENERAL SERVICE SHEET G4.

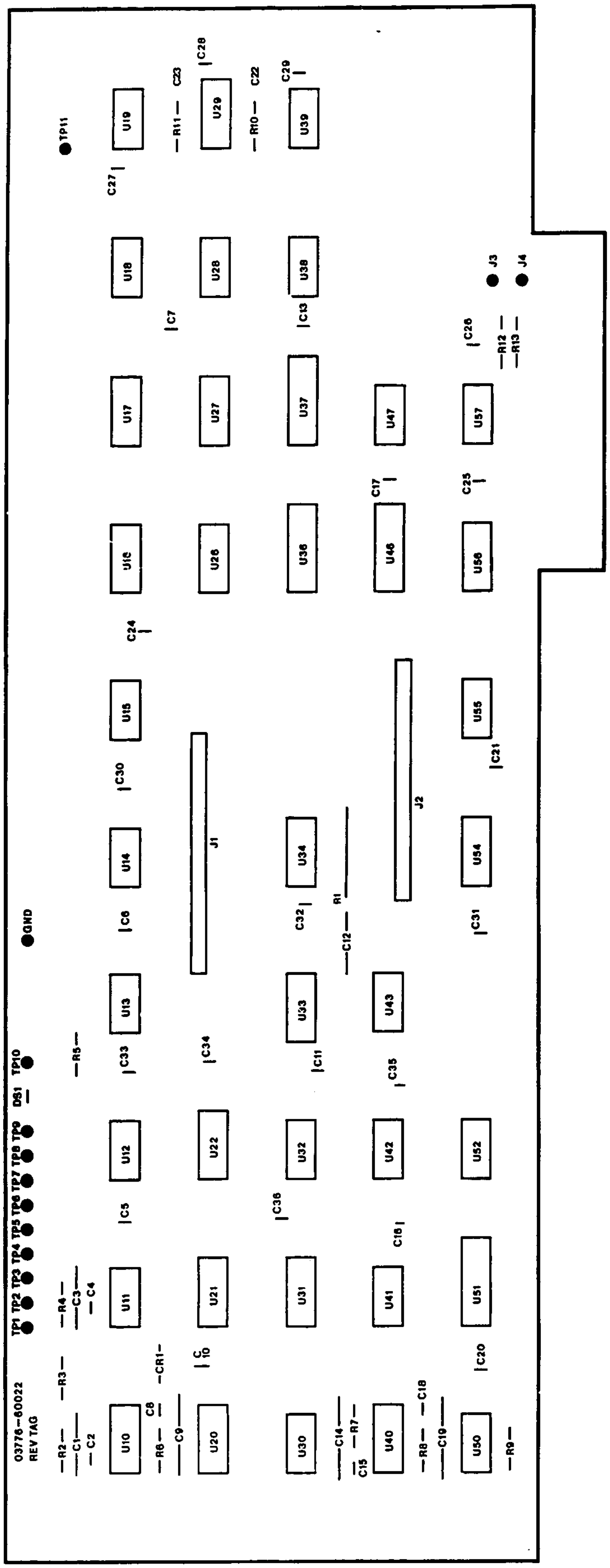


Figure A22-8 A22 Component Location

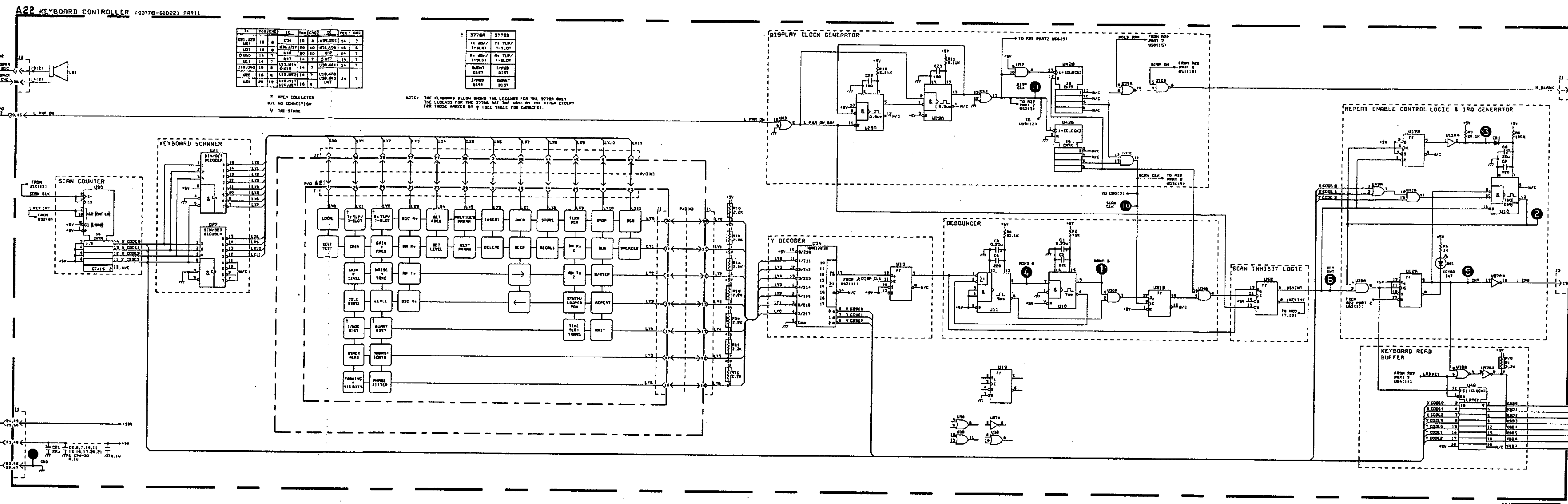


Figure A22-9 A22 Schematic – Part 1

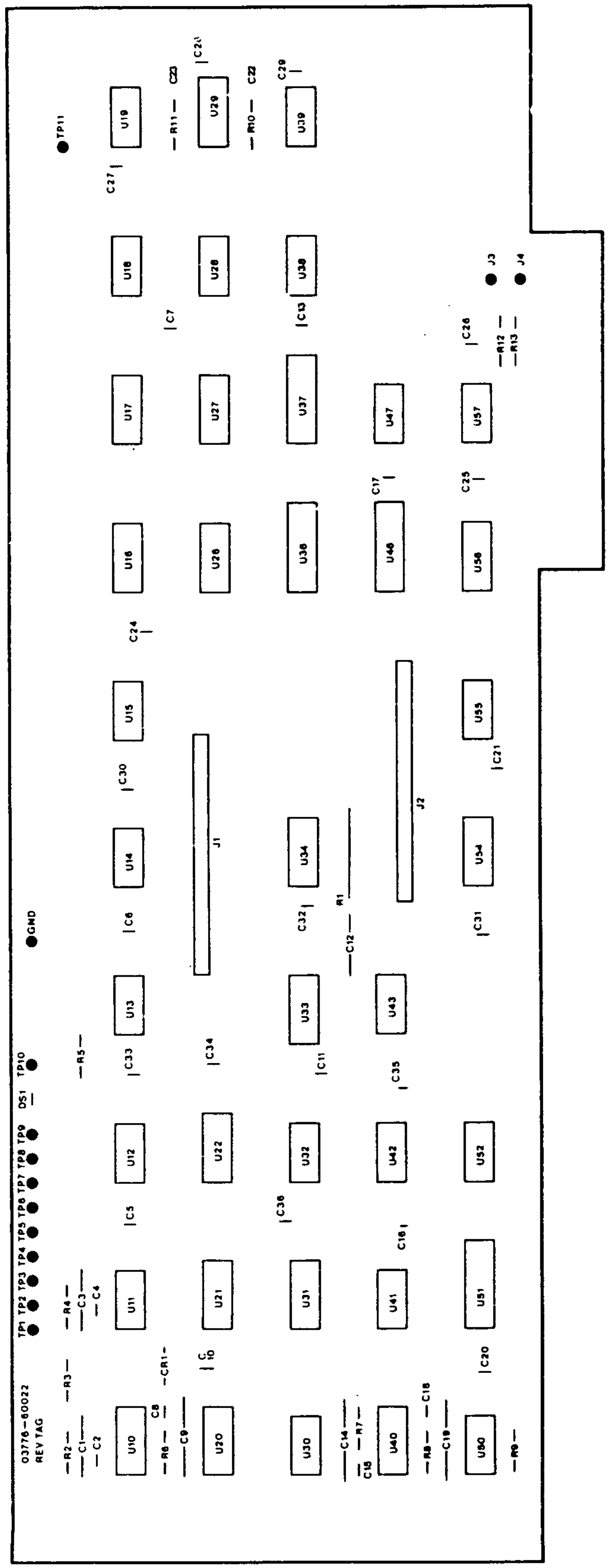


Figure A22-8 A22 Component Location

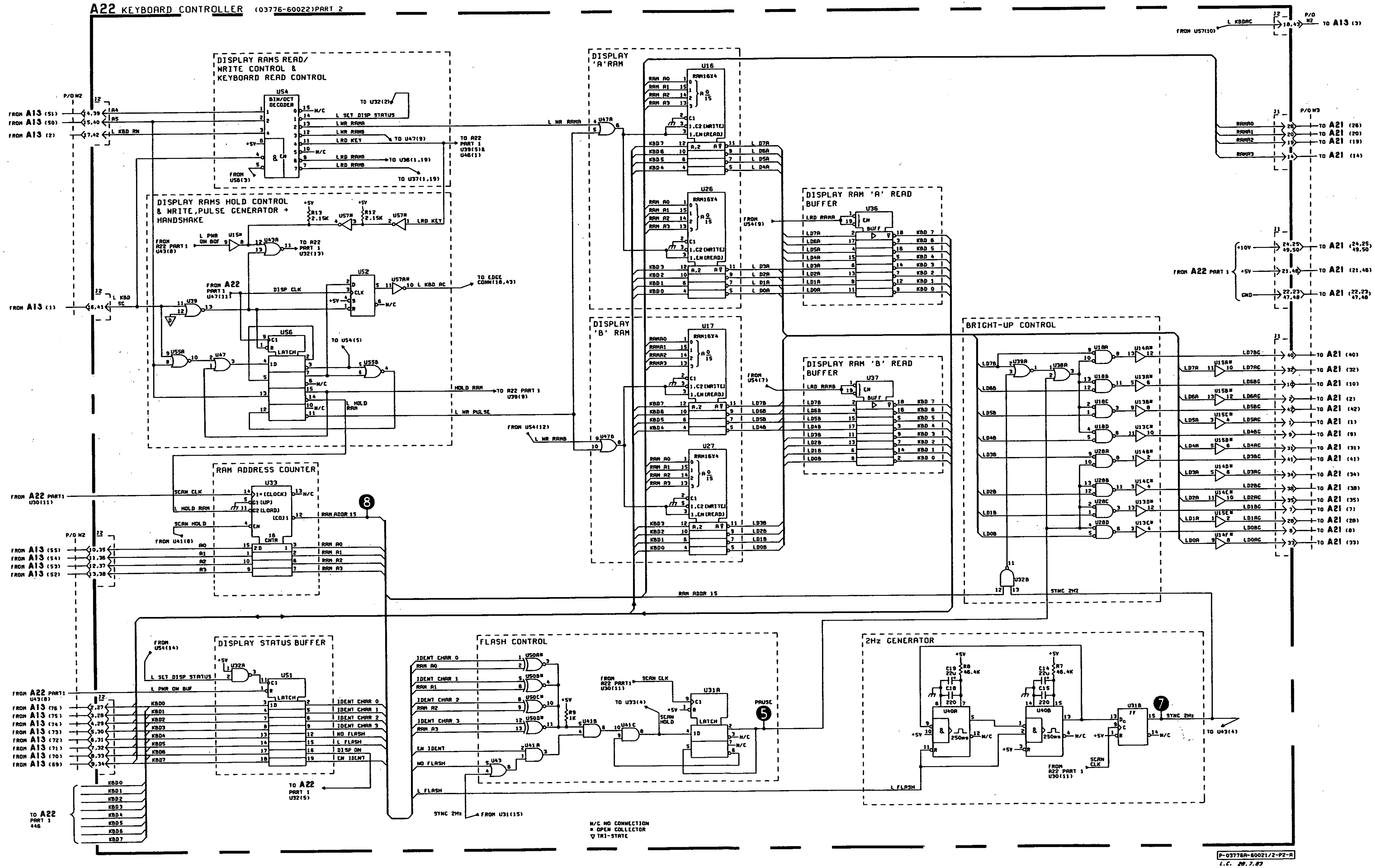


Figure A22-10 A22 Schematic – Part 2

ASSEMBLY SERVICE SHEET A23
REAR PANEL CONTROL

A23-1 INTRODUCTION

A23-2 Figure A23-1 illustrates the contents of the A23 assembly. Whenever the mode of operation of the instrument is changed, by changing one of the rear panel switches, the A23 assembly produces an interrupt request signal (LIRQ). This signal informs the Processor Assembly A13 that a rear panel switch has been changed.

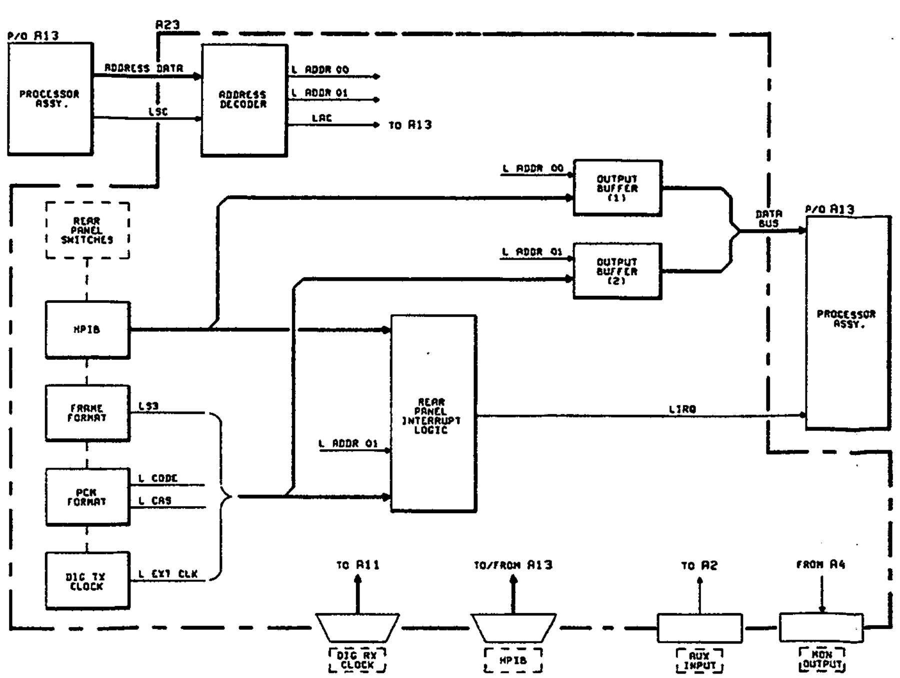


Figure A23-1 Rear Panel Control Block Diagram

A23-3 When assembly A13 is ready to identify the switch, it sends ADDRESS DATA and a handshake start control signal LSC to the Address Decoder on A23. Two addresses in turn are decoded, producing L ADDR00 and L ADDR01 which enable Output Buffers 1 and 2 respectively. An "accept-data" handshake signal LAC, derived from ADDR00 and ADDR01, is also produced which instructs the A13 assembly that the "switch data" is on the DATA BUS ready for identification. LAC is part of the handshake protocol - see Assembly Service Sheet A13.

A23-4 The A23 assembly also contains the input and output ports as illustrated in Figure A23-1.

A23-5 CIRCUIT DESCRIPTION

A23-6 The Address Decoder U7 decodes data from A13 to produce the buffer enable signals L ADDR00 and L ADDR01 for Output Buffers U5 and U4 respectively. Exclusive OR gates U19A and U19B decode L ADDR00 or L ADDR01 to produce the "accept data" handshake signal LAC for the A13 assembly.

A23-7 The Rear Panel Interrupt Logic comprises two parity encoders U1 and U6; two flip-flops U3A and U3B; two monostables U2A and U2B and associated gates. The outputs of U1 change whenever a rear panel switch is changed. Exclusive OR gate U9C senses this change and triggers debouncer monostable U3A. After 45ms, U3A triggers U2A and U2B. The input and output of U2A are now at the same level - as are the inputs to U9C. This causes the output of U9C to go low - U3A is ready to be retriggered. Flip-flop U2B, when triggered, produces the LIRQ signal via exclusive OR gate U9D.

A23-8 After applying L ADDR01 to the Output Buffer U4, it is necessary to reset the interrupt request signal, ie set LIRQ high. This is achieved by triggering monostable U3B using L ADDR01. When U3B triggers its inverting output is set high for 4us, thereafter it goes low to reset the outputs of U2B. This action causes a high LIRQ at U9(6).

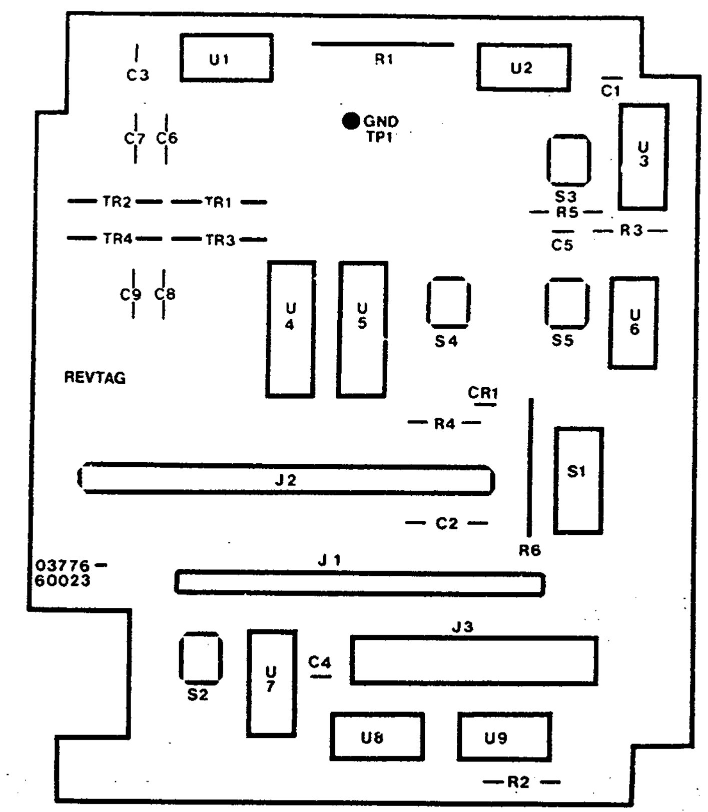


Figure A23-2 A23 Component Location

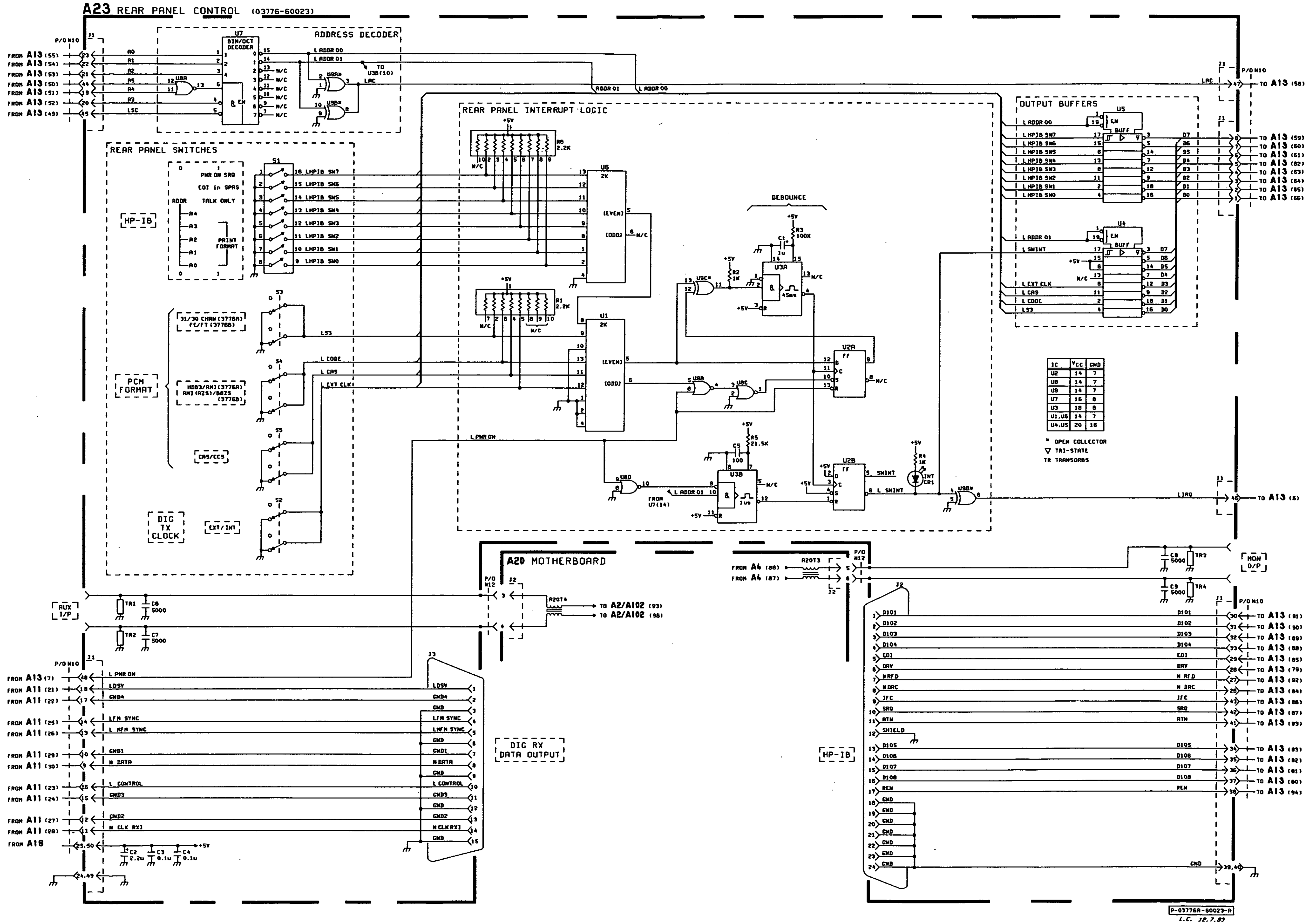


Figure A23-3 A23 Schematic

ASSEMBLY SERVICE SHEET A24
MAINS INPUT

A24-1 INTRODUCTION

A24-2 A general description of the A15, A16 and A24 power supply circuits is contained on Assembly Service Sheet A15 together with a block diagram.

A24-3 CIRCUIT DESCRIPTION

A24-4 Mains Over-voltage Protection

A24-5 The instrument is protected against mains over-voltage by a crowbar circuit. When the mains voltage exceeds 150Vac in the 115Vac operation or 300Vac in the 230Vac operation the crowbar circuit (CR7) blows fuse F1.

A24-6 Rectifier and Storage Capacitors

A24-7 When the instrument is connected for 115Vac operation the junction of C1/C3 is connected to neutral and CR3 and CR4 are reverse biased. The circuit operates as a voltage doubler (see Figure A24-1).

A24-8 When the instrument is connected for 230Vac operation the circuit operates as a standard full wave bridge rectifier (see Figure A24-2).

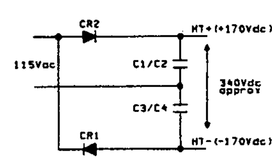


Figure A24-1 Voltage Doubler

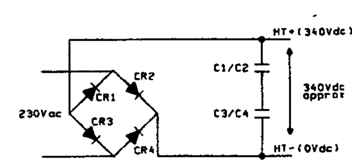


Figure A24-2 Full-wave Bridge Rectifier

A24-9 Filter

A24-10 The Filter isolates the switching power supply noise from the mains supply.

A24-11 Auxilliary Tranformer (T1)

A24-12 T1 has two primary windings. In the 230Vac mode of operation, both windings are used. In the 115Vac mode, the winding fused by F3 is switched out of circuit.

A24-13 The secondary of T1 provides the same drive to the auxilliary supply on A15 in both the 115Vac and 230Vac operating modes.

A24-14 Fan B1 is driven by the primary winding of T1 (fused by F2) in both the 115Vac and 230Vac operating modes.

A24-15 Power supply troubleshooting information is contained on GENERAL SERVICE SHEET G2.

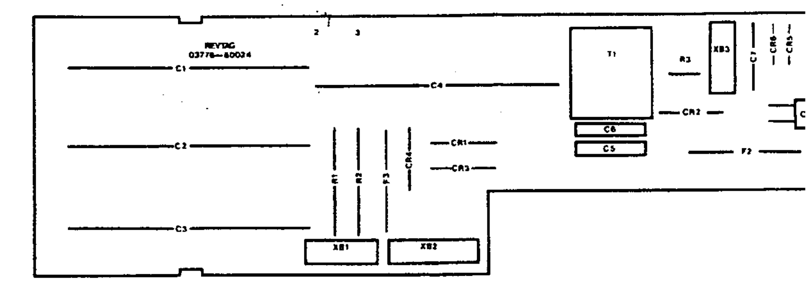


Figure A24-3 A24 Component Location

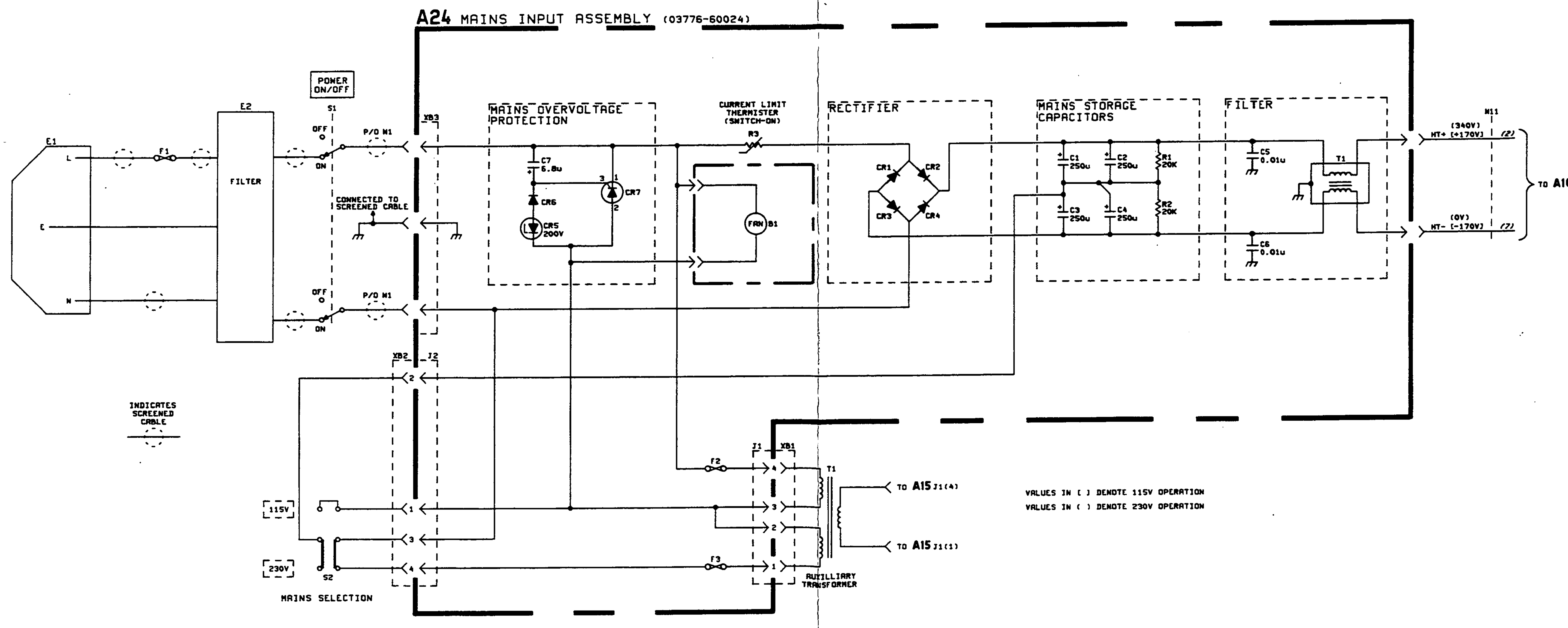
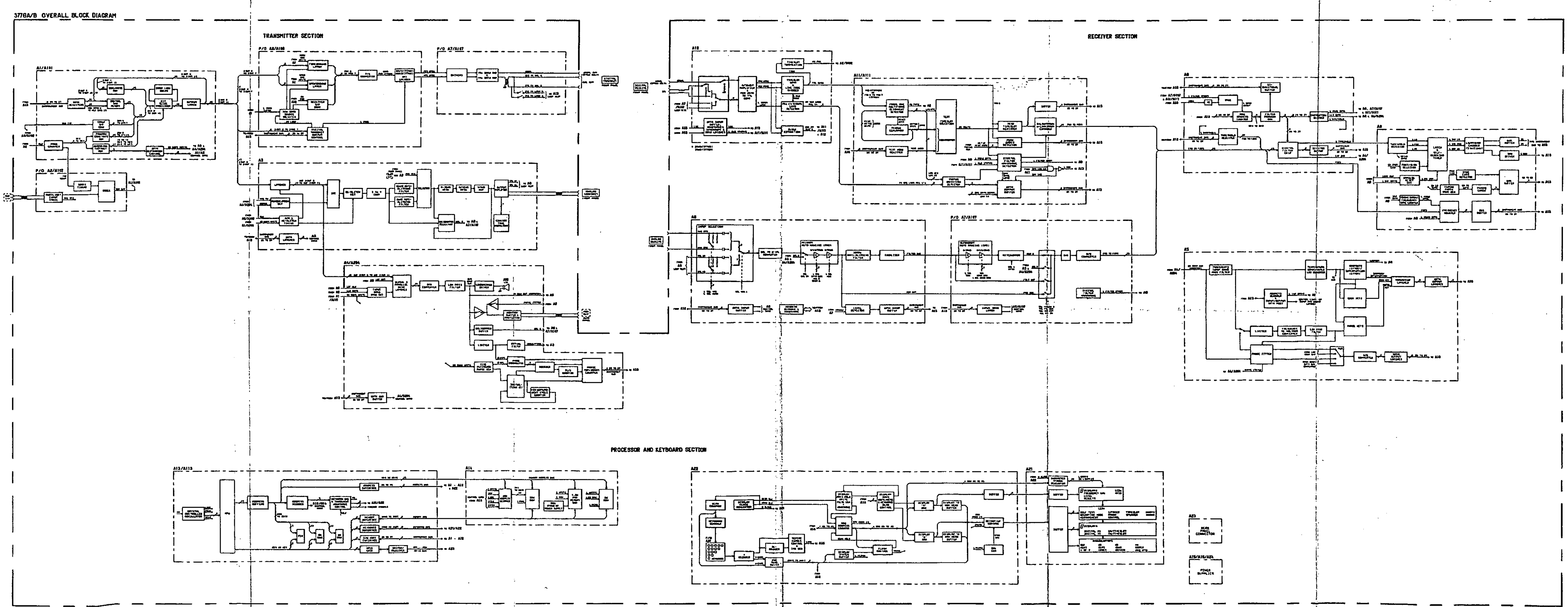


Figure A24-4 A24 Schematic

APPENDICES


3776A/B OVERALL BLOCK DIAGRAM
TRANSMITTER SECTION
RECEIVER SECTION
PROCESSOR AND KEYBOARD SECTION
A1/A101
P/O A2/A102
P/O A2/A102
P/O A7/A107
A3
A4/A204
A12
A11/A111
A6
P/O A7/A107
A8
A9
A5
A13/A113
A14
A22
A21
A23
A15/A16/A24

APPENDIX A
PCM FRAME STRUCTURES

APPENDIX B
ALIASING SIGNALS

APPENDIX C
CALIBRATION

Appendices A, B & C not available at time of printing.

To be issued later.

APPENDIX D

SERVICE ACCESSORIES

This Appendix provides the information required to build and test the three simple test circuits SA1, SA2 and SA3 called up in the Performance Tests for the 3776.

Complete circuit schematics, component location diagrams and component lists are given, together with performance test procedures to establish correct operation of the completed accessories. The specifications listed for each are the minimum acceptable and should be easily achieved using the recommended parts and layout.

The part number of the blank printed circuit board for each accessory is included in the appropriate component list.

IMPORTANT

PERFORMANCE TESTING OF SA2 MUST BE CARRIED OUT BEFORE TESTING SA1.

Service Accessory 1 (SA1) – Balanced/Unbalanced Converter

PERFORMANCE TEST

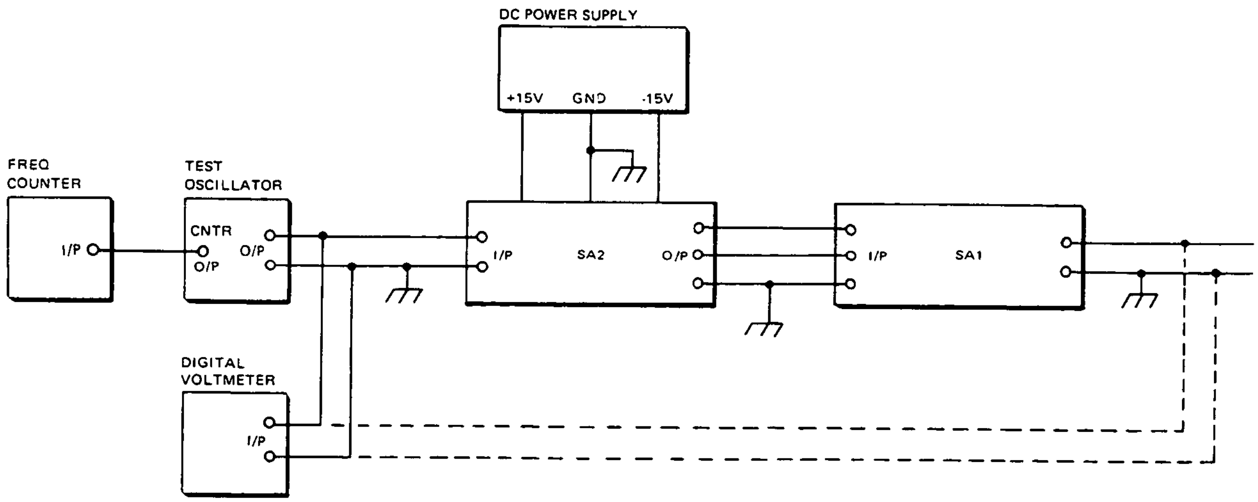
MINIMUM SPECIFICATION
Input Impedance: 600Ω or 900Ω balanced.
Output Impedance: <1Ω unbalanced.
Gain: ± 0.005dB, 40Hz – 4kHz.
± 0.05dB, 4kHz – 40kHz.

EQUIPMENT REQUIRED

Dual DC Power Supply	HP 6205B
Test Oscillator	HP 654A
Digital Voltmeter	HP 3455A
Frequency Counter	HP 5328A
600/900Ω, Unbal/Bal Converter	SA2
Resistor 600Ω ± 0.01%	HP 0811-3502
Resistor 900Ω ± 0.01%	HP 0811-3504

PROCEDURE

1. Connect the test circuit as shown below (it is assumed that SA2 performs within specification).



2. Set SA1 input impedance and SA2 output impedance to 600Ω.

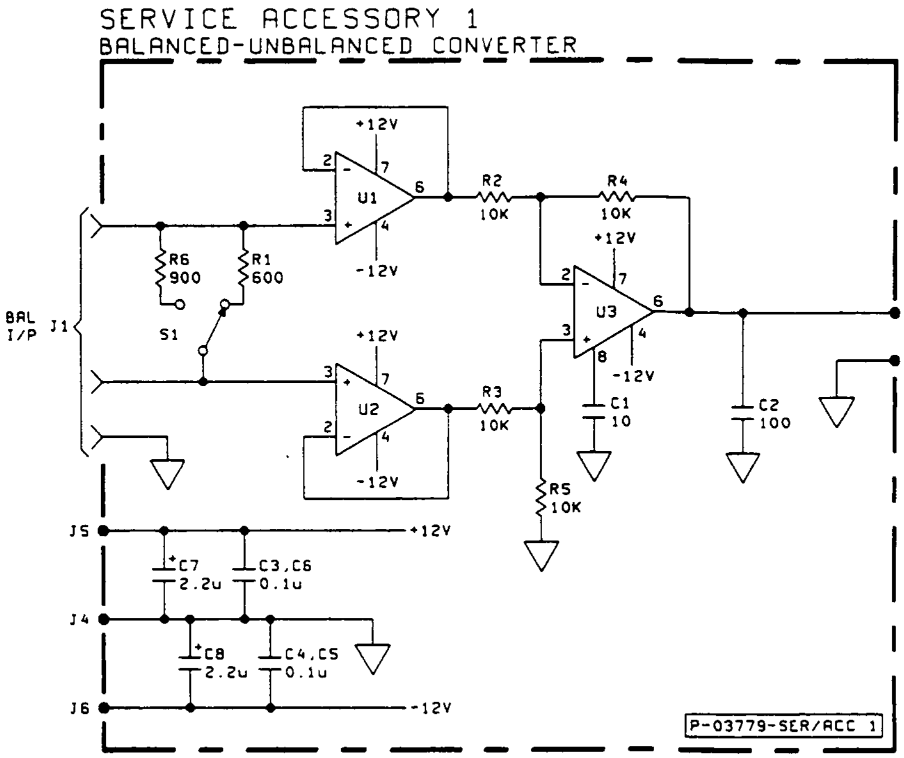
3. Set the Test Oscillator FREQUENCY to 40Hz and adjust its OUTPUT LEVEL to give a reference voltage on the Digital Voltmeter of 1.000V. Press the STORE Y pushbutton on the Digital Voltmeter.

4. Connect the Digital Voltmeter to SA1 output. Press the Digital Voltmeter % ERROR pushbutton and check that the % Error is within ± 0.115%. This tolerance corresponds to ± 0.01dB.

5. Set SA2 output impedance to 900Ω and SA1 input impedance to 900Ω. Check that the % Error is within ±0.115%.

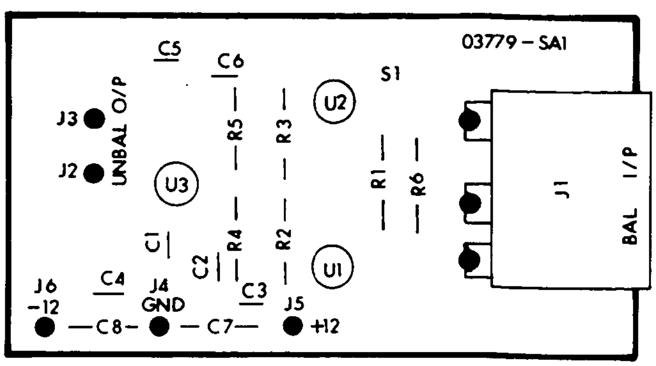
6. Repeat Steps 2 to 5 at 4kHz. The same measurement tolerances apply.

7. Repeat Steps 2 to 5 at 40kHz. Check that the % Error in Step 5 is within ± 1.16%. This tolerance corresponds to ±0.1dB.



Replaceable Parts

U1 TO U3	IC OP-AMP HA2-2605-5	1826-0413
R1	R FXD 600Ω 0.01% .25W	0811-3502
R2 TO R5	R FXD 10K 0.01% 0.05W	0811-1185
R6	R FXD 900Ω 0.01% 0.25W	0811-3504
C1	C FXD 10PF 1% 63V CER	0160-3874
C2	C FXD 100PF 5% 200V CER	0160-4389
C3 TO C6	C FXD 0.1μF 20% 50V CER	0160-0576
C7, C8	C FXD 2.2μF 10% 20V TA	0180-0155
J1	CONN, 3-PIN	1251-2533
S1	SWITCH DPDT	3101-0407
MSC (QTY: 8)	CONN, SGL	1251-0600
MSC (QTY: 1)	BLANK P.C. BOARD	03779-20043



Service Accessory 2 (SA2) – Unbalanced/Balanced Converter

PERFORMANCE TEST

MINIMUM SPECIFICATION

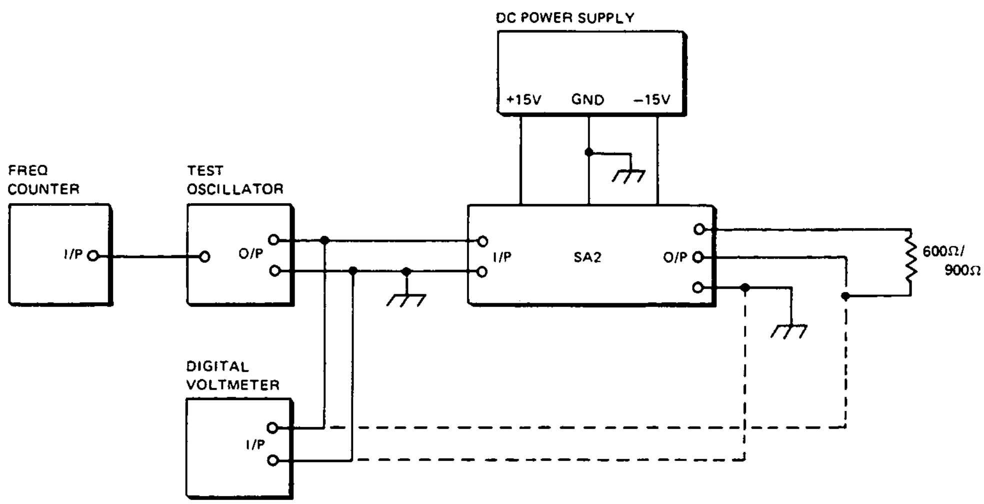
Input Impedance:	> 10kΩ , unbalanced.
Output Impedance:	600Ω or 900Ω, balanced.
Gain:	± 0.005dB, 40Hz – 4kHz ± 0.05dB, 4kHz – 40kHz

EQUIPMENT REQUIRED

Frequency Counter	HP 5328A
Dual DC Power Supply	HP 6205B
Test Oscillator	HP 654A
Digital Voltmeter	HP 3455A
Resistor 600Ω ± 0.01%	HP 0811-3502
Resistor 900Ω ± 0.01%	HP 0811-3504

PROCEDURE

1. Connect the test circuit as shown below:



2. Set SA2 output impedance to 600Ω.

3. Set the Power Supply voltages to +15V and −15V and connect to the appropriate pins on SA2. Ensure that a good ground connection is made between the Power Supply and SA2.

4. Set the Digital Voltmeter to ACV and the Test oscillator frequency to 40Hz displayed on the Frequency Counter.

5. Adjust the Test Oscillator amplitude to give a reference voltage of 1.0000V displayed on the Digital Voltmeter. Press the STORE Y pushbutton on the Digital Voltmeter.

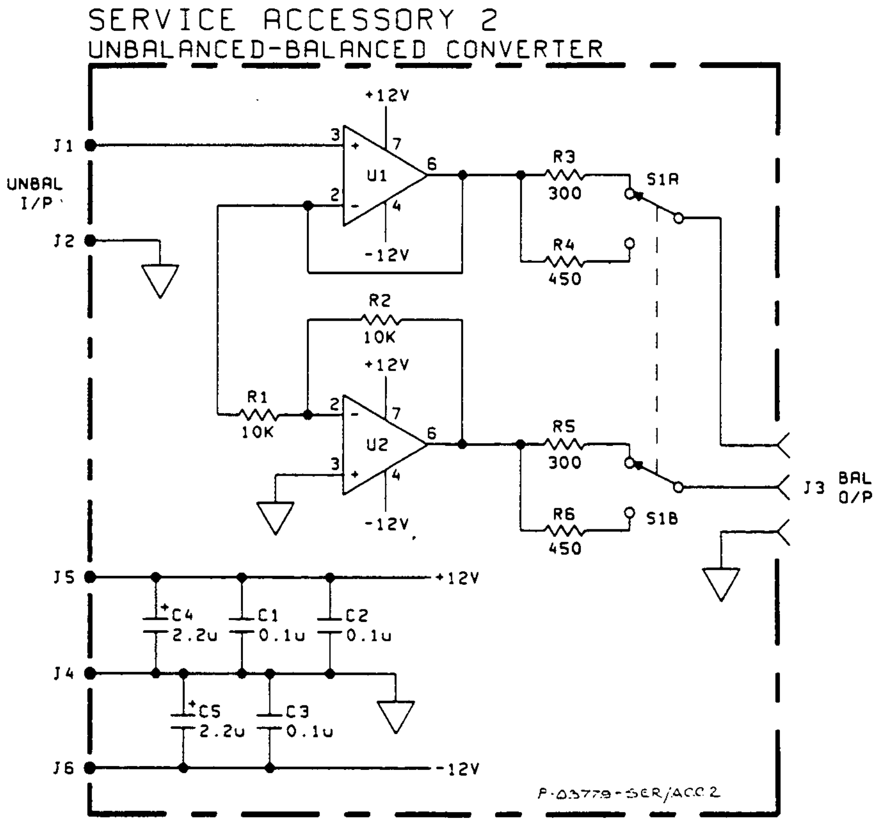
6. Connect the Digital Voltmeter between one of SA2 output terminals and ground. Press the % ERROR push-button on the Digital Voltmeter and check that the percentage error displayed is 50 ± 0.057% (± 0.057% corresponds to ± 0.005dB).

7. Set SA2 output impedance to 900Ω and connect the 900Ω resistor across SA2 output terminal.

8. Repeat Steps 5 and 6.

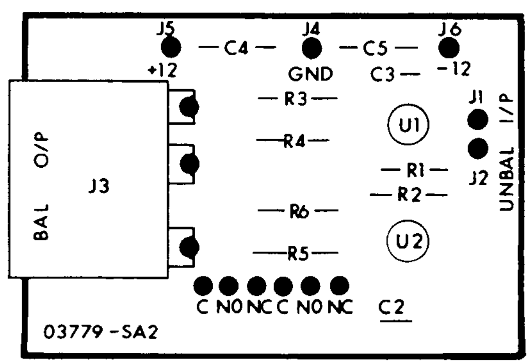
9. Repeat Steps 1 to 8 with the Test Oscillator Frequency set to 4kHz. Measurement tolerances remain the same.

10. Repeat steps 1 to 8 with the Test Oscillator Frequency set to 40kHz. In this case, the measurement tolerance is ± 0.577% (± 0.577% corresponds to ± 0.05dB).



Replaceable Parts

U1 and U2	IC OP-AMP HA2-2605-5	1826-0413
R1, R2	R FXD 10K 0.01% 0.05W	0811-1185
R3, R5	R FXD 300Ω 0.01% 0.25W	0811-3500
R4, R6	R FXD 450Ω 0.01% 0.25W	0811-3501
C1 TO C3	C FXD 0.1uF 20% 50V CER	0160-0576
C4, C5	C FXD 2.2uF 10% 20V TA	0180-0155
J3	CONN, 3-PIN	1251-2533
S1	SWITCH DPDT	3101-0407
MSC (QTY: 5)	CONN, SGL	1251-0600
MSC (QTY: 1)	BLANK P.C. BOARD	03779-20044



Service Accessory 3 (SA3) – Power Splitter/Adder

PERFORMANCE TEST

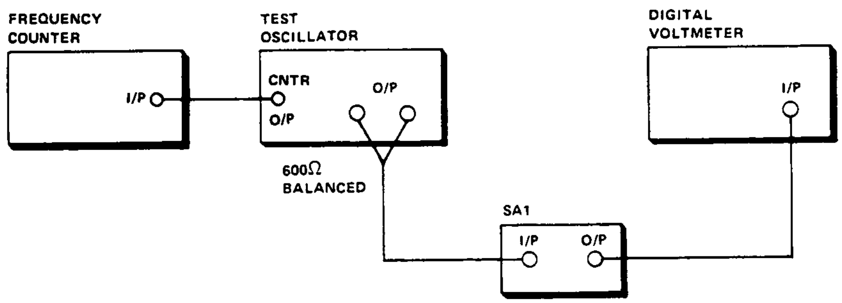
MINIMUM SPECIFICATION
Characteristic Impedance: 600Ω
Attenuation between any two ports: 6.02dB ±0.05dB, 40Hz to 40kHz.

EQUIPMENT REQUIRED

Balanced/Unbalanced Converter	HP Service Accessory 1
Frequency Counter	HP 5328A
Test Oscillator	HP 654A
Dual Dc Power Supply	HP 6205B
Digital Voltmeter	HP 3455A
Resistor 600Ω ±0.01%	HP 0811-3502

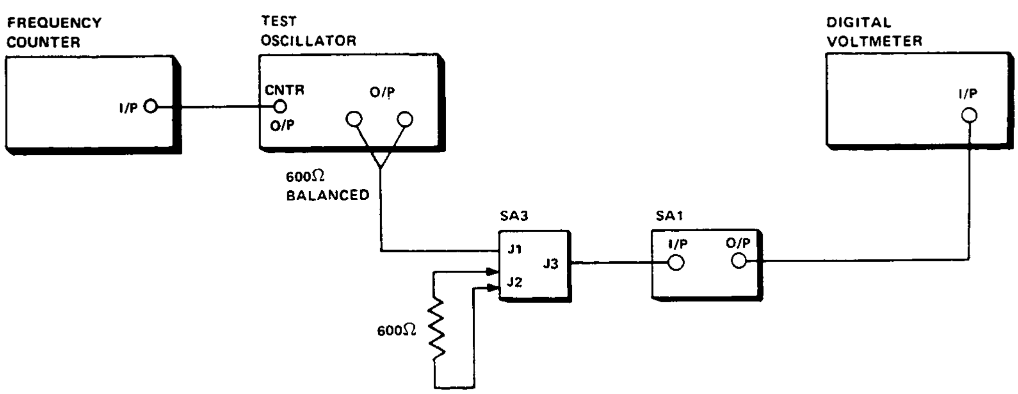
PROCEDURE

1. Connect the equipment as shown below:



Test circuit 1

2. Set SA1 input impedance to 600Ω.
3. Set the Test Oscillator FREQUENCY to 40Hz and the Digital Voltmeter to measure ACV.
4. Adjust the Test Oscillator OUTPUT LEVEL to give a reference voltage of 1.000V on the Digital Voltmeter. Press the STORE Y pushbutton on the Digital Voltmeter.
5. Connect the equipment as shown below, taking care not to disturb the Test Oscillator settings.

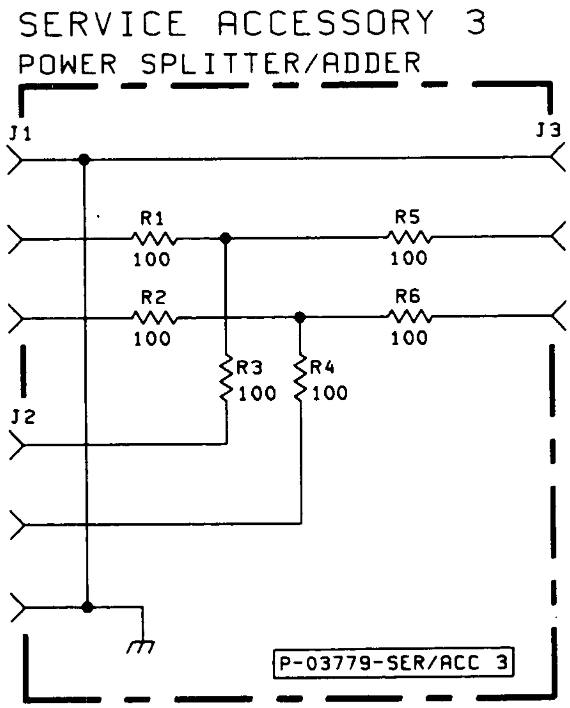


Test circuit 2

6. Press the Digital Voltmeter % ERROR pushbutton and check that the % Error displayed is within 50% ±0.58%, (±0.58% corresponds to ±0.05dB).

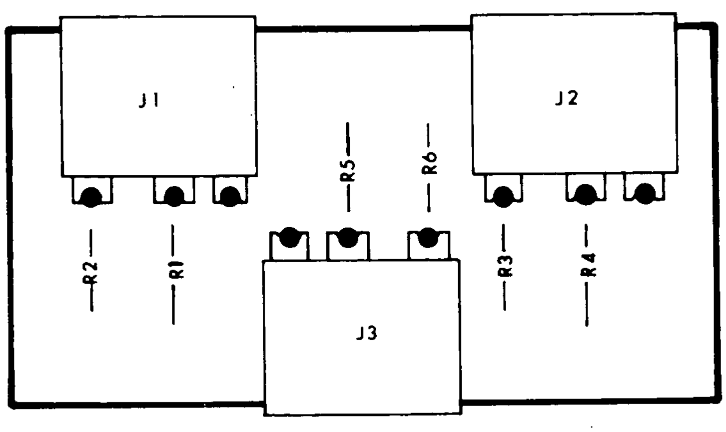
7. Repeat Step 6 with the Test Oscillator output connected to SA3J2 and SA3J1 terminated in 600Ω.

8. Repeat Steps 1 to 7 at 40kHz (same tolerances apply).



Replaceable Parts

R1 to R6	R FXD 100Ω 0.1% 1/8W	0698-6323
J1 to J3	CONN, 3-PIN	1251-2533
MSC (QTY: 9)	CONN, SGL	1251-0600
MSC (QTY: 1)	BLANK P.C. BOARD	03779-20045



SERVICE NOTE

SUPERSEDES: 3776A-34

HP 3776A PCM Terminal Test Set

Serial Numbers: 2613U00457 / 9999U99999
See text for other applicable serial numbers.

Duplicate Service Notes:

3776B-41A
4947A-09A

A13 Processor Assembly (03776-60122)

Preferred Replacement of A13U48

Table of affected Serial Numbers

3776B	2616U01152 / 9999U99999
4947A	0000U00000 / 9999U99999

Situation:

RAM HP P/N 1818-4120 has been replaced due to difficulties experienced in obtaining supplies.

Solution/Action:

In the event of a field replacement of A13U48 then replace it with RAM HP P/N 1818-3185.

Update your Service Manual to show this change.

DATE: 02 November 1990

ADMINISTRATIVE INFORMATION

SERVICE NOTE CLASSIFICATION:

INFORMATION ONLY

AUTHOR:	ENTITY:	ADDITIONAL INFORMATION:
ER	1400	For instruments below serial number 2613U00457: This Service Note applies where the instrument has had Service Note 3776A-26 implemented.

HEWLETT PACKARD

SERVICE NOTE

SUPERSEDES None

HP 3776A PCM Terminal Test Set
HP 3776B PCM Terminal Test Set
HP 4947A Transmission Impairment Measuring Set

Duplicate Service Notes:
3776B-43
4947A-10

Serial Numbers: 0000U00000/9999U99999
See text for other applicable serial numbers

A5 Transients Assembly (03776-60005)

Preferred Replacement of A5C107

Table of affected Serial Numbers

3776B	0000U00000/9999U99999
4947A	0000U00000/9999U99999

Situation

Capacitor, HP part number 0160-0576 has been replaced in current production instruments.

Solution/Action

In the event of a field replacement of HP part number 0160-0576 (C107 on assembly A5) then replace it with capacitor HP part number 0180-3463.

DATE 30 January 1989

ADMINISTRATIVE INFORMATION

SERVICE NOTE CLASSIFICATION:	INFORMATION ONLY	
AUTHOR ER	ENTITY 1400	ADDITIONAL INFORMATION:

HEWLETT PACKARD

S E R V I C E N O T E

SUPERSEDES None

HP 3776A PCM Terminal Test Set

Serial Numbers: 0000U00000/9999U99999

A7 A/D Converter & Digital Output Assy (03776-60007)

Preferred Replacement of A7Q21, 22

Situation

Transistors Q21, 22 have been replaced in current production instruments.

Solution/Action

In the event of a field replacement of A7Q21, 22 then replace with HP part number 1853-0314.

DATE **12 February 1990**

ADMINISTRATIVE INFORMATION

SERVICE NOTE CLASSIFICATION:

INFORMATION ONLY

AUTHOR:	ENTITY:	ADDITIONAL INFORMATION:
ER	1400	

HEWLETT PACKARD

S E R V I C E N O T E

SUPERSEDES None

3776A PCM Terminal Test Set (Std & Opt 001)

Serial Numbers: 0000U00000/9999U99999
See text for other applicable serial numbers.

Duplicate Service Notes:

3776B-44
4947A-12

A3 Analog Transmitter Assembly (03776-60003) and A204 Analog Monitor Assembly Opt 001 (03776-60204).

Preferred Replacement of A3U33 and A204U47

Table of affected Serial Numbers

Model No.	Serial Nos.
3776B	0000U00000/9999U99999
4947A	0000U00000/9999U99999

continued

DATE 05 February 1990

ADMINISTRATIVE INFORMATION

SERVICE NOTE CLASSIFICATION:

INFORMATION ONLY

AUTHOR:	ENTITY:	ADDITIONAL INFORMATION:
ER	1400	

HEWLETT PACKARD

Situation

IC HP Part Number 1826-0726 is being obsoleted by the suppliers.

Solution/Action

In the event of a field replacement of HP Part Number 1826-0726 (U33 on assembly A3 or U47 on assembly A204) then replace it with IC HP Part Number 1826-1013.

S E R V I C E N O T E

SUPERSEDES None

3776A PCM Terminal Test Set

Serial Numbers: 0000U00000/9999U99999

A6 Analog Receiver Assembly (03776-60006)

Duplicate Service Note: 3776B-45

Preferred Replacement of A6 CR3-6

Situation

The current diode is being obsoleted by the supplier.

Solution/Action

In the event of a field replacement of HP P/N 1901-0376 (CR3-6 on assembly 03776-60006) then replace it with HP P/N 1901-0033.

DATE 29 May 1990

ADMINISTRATIVE INFORMATION

SERVICE NOTE CLASSIFICATION:		
INFORMATION ONLY		
AUTHOR:	ENTITY:	ADDITIONAL INFORMATION:
ER	1400	

HEWLETT PACKARD

S E R V I C E N O T E

SUPERSEDES: 3776B-41

HP 3776B PCM Terminal Test Set

Serial Numbers: 2616U01152 / 9999U99999
See text for other applicable serial numbers.

Duplicate Service Notes:

3776A-34A
4947A-09A

A113 Processor Assembly (03776-60123/4)

Preferred Replacement of A113U48

Table of affected Serial Numbers:

3776A	2613U00457 / 9999U99999
4947A	0000U00000 / 9999U99999

Situation:

RAM HP P/N 1818-4120 has been replaced due to difficulties experienced in obtaining supplies.

Solution/Action:

In the event of a field replacement of A113U48 then replace it with RAM HP P/N 1818-3185.

Update your Service Manual to show this change.

DATE: 02 November 1990

ADMINISTRATIVE INFORMATION

SERVICE NOTE CLASSIFICATION:

INFORMATION ONLY

AUTHOR:	ENTITY:	ADDITIONAL INFORMATION:
ER	1400	For instruments below serial number 2616U01152: This Service Note applies where the instrument has had Service Note 3776B-28 implemented.

HEWLETT PACKARD

S E R V I C E N O T E

SUPERSEDES None

HP 3776B PCM Terminal Test Set

Serial Numbers: 0000U00000/9999U99999

A102 Digital PCM Transmitter Assembly

Preferred replacement of A102U309, 404, 405 & 406

Situation

IC HP part number 1820-1997. has been replaced in current production instruments.

Solution/Action

IN the event of a field replacement of HP part number 1820-1997 (U309, 404, 405 & 406 on assembly A102) then replace it with HP part number 1820-2701.

Update your Service Manual to show this change.

DATE **02 February 1989**

ADMINISTRATIVE INFORMATION

SERVICE NOTE CLASSIFICATION:	**INFORMATION ONLY**	
AUTHOR ER	ENTITY 1400	ADDITIONAL INFORMATION:

HEWLETT PACKARD

S E R V I C E N O T E

SUPERSEDES None

HP 3776B PCM Terminal Test Set
HP 3776A PCM Terminal Test Set
HP 4947A Transmission Impairment Measuring Set

Duplicate Service Notes:
3776A-35
4947A-10

Serial Numbers: 0000U00000/9999U99999
See text for other applicable serial numbers

A5 Transients Assembly (03776-60005)

Preferred Replacement of A5C107

Table of affected Serial Numbers

3776A	0000U00000/9999U99999
4947A	0000U00000/9999U99999

Situation

Capacitor. HP part number 0160-0576 has been replaced in current production instruments.

Solution/Action

In the event of a field replacement of HP part number 0160-0576 (C107 on assembly A5) then replace it with capacitor HP part number 0180-3463.

DATE **30 January 1989**

ADMINISTRATIVE INFORMATION

SERVICE NOTE CLASSIFICATION:	**INFORMATION ONLY**	
AUTHOR: **ER**	ENTITY: **1400**	ADDITIONAL INFORMATION:

HEWLETT PACKARD

SERVICE NOTE

SUPERSEDES None

3776B PCM Terminal Test Set (Std & Opt 001)

Serial Numbers: 0000U00000/9999U99999
See text for other applicable serial numbers.

Duplicate Service Notes:

3776A-37
4947A-12

A3 Analog Transmitter Assembly (03776-60003) and A204 Analog Monitor Assemb ly Opt 001 (03776-60204).

Preferred Replacement of A3U33 and A204U47

Table of affected Serial Numbers

Model No.	Serial Nos.
3776A	0000U00000/9999U99999
4947A	0000U00000/9999U99999

DATE 05 February 1990

ADMINISTRATIVE INFORMATION

SERVICE NOTE CLASSIFICATION:		
INFORMATION ONLY		
AUTHOR:	ENTITY:	ADDITIONAL INFORMATION:
ER	1400	

HEWLETT PACKARD

Situation

IC HP Part Number 1826-0726 is being obsoleted by the suppliers.

Solution/Action

In the event of a field replacement of HP Part Number 1826-0726 (U33 on assembly A3 or U47 on assembly A204) then replace it with IC HP Part Number 1826-1013.

S E R V I C E N O T E

SUPERSEDES None

3776B PCM Terminal Test Set

Serial Numbers: 0000U00000/9999U99999

A6 Analog Receiver Assembly (03776-60006)

Duplicate Service Note: 3776A-38

Preferred Replacement of A6 CR3-6

Situation

The current diode is being obsoleted by the supplier.

Solution/Action

In the event of a field replacement of HP P/N 1901-0376 (CR3-6 on assembly 03776-60006) then replace it with HP P/N 1901-0033.

DATE 29 May 1990

ADMINISTRATIVE INFORMATION

SERVICE NOTE CLASSIFICATION:		
INFORMATION ONLY		
AUTHOR:	ENTITY:	ADDITIONAL INFORMATION:
ER	1400	

HEWLETT PACKARD