OPERATING AND SERVICE MANUAL

8112A
PULSE GENERATOR
50 MHz

SERIAL NUMBERS

This manual applies directly to instruments with serial number 2136G00931 and higher. Any changes made in instruments having serial numbers higher than the above number will be found in a "Manual Changes" supplement supplied with this manual. Be sure to examine this supplement for changes which apply to your instrument and record these changes in your manual. Backdating information for instruments with lower serial numbers can be found in Section 7 (yellow pages).

HERRENBERGER STR. 110, D-7030 BOBLINGEN
FEDERAL REPUBLIC OF GERMANY

MANUAL PART NO. 08112-90002
MICROFICHE PART NO. 08112-90002

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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrume
Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of desi
manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure
comply with these requirements.

GENERAL – This is a Safety Class I instrument (provided with terminal for protective earthing) and has been manufactured and tested according to international safety standards.

OPERATION – BEFORE APPLYING POWER
comply with the installation section. Additionally, the following shall be observed.

Do not remove instrument covers when operating.

Before the instrument is switched on, all protective earth terminals, extension cords, auto-transformers and devices connected to it should be connected to a protective earth via a ground socket. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in serious personal injury. Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

Make sure that only fuses with the required rated current and of the specified type (normal blow, time delay, etc.) are used for replacement. The use of repaired fuses and the short-circuiting of fuseholders must be avoided.

Adjustments described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

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. Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation is present. Do not replace components with power cable connected.

Do not operate the instrument in the presence of flammable gases or fumes. Operation of an electrical instrument in such an environment constitutes a definite safety hazard.

Do not install substitute parts or perform any unauthorized modification to the instrument.

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

SAFETY SYMBOLS

The apparatus will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect the apparatus against damage.

Indicates dangerous voltages.

Earth terminal.

WARNING

The WARNING sign denotes a hazard. 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.

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the equipment. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

WARNING

Dangerous voltages, capable of causing serious personal injury, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

5955–0713

HEWLETT PACKARD

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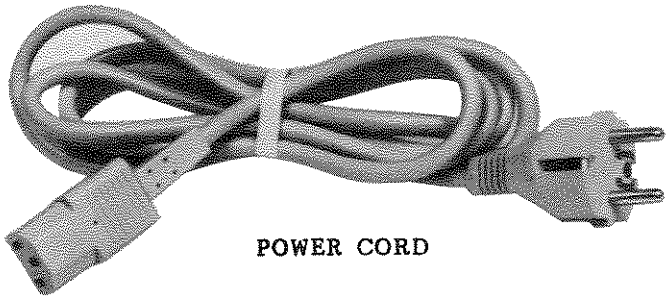
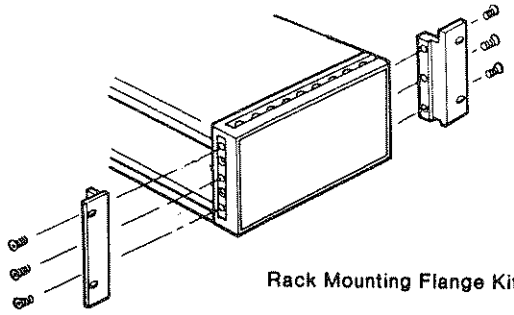
8112A

FUSE

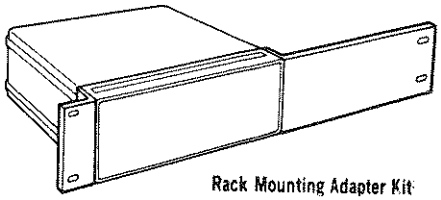


POWER CORD

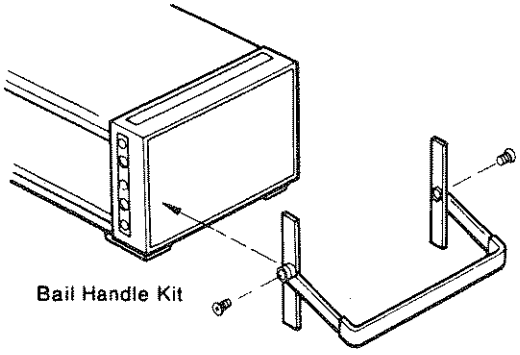
Figure 1-1. 8112A and supplied accessories.



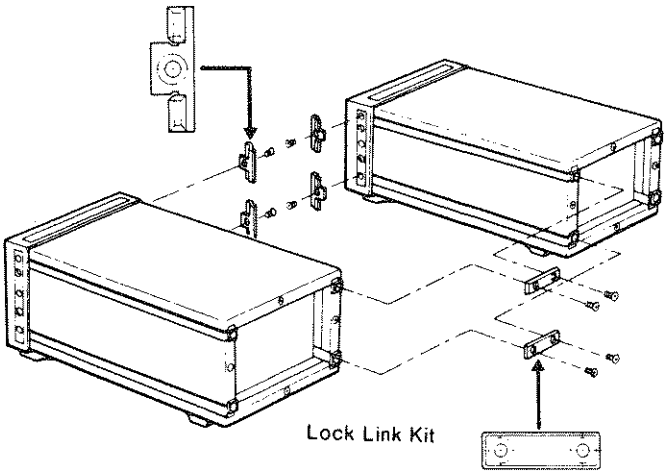
Rack Mounting Flange Kit



Rack Mounting Adapter Kit



Bail Handle Kit



Lock Link Kit

Figure 1-2. Available rack mounting accessories.

SECTION 1
GENERAL INFORMATION

1-1 INTRODUCTION

1-2 This manual contains all the information required to install, operate, test, adjust and service the Hewlett-Packard Model 8112A. This section covers instrument identification, description, accessories, specifications and other basic information. Figure 1-1 shows the mainframe and supplied accessories.

1-3 SPECIFICATIONS

1-4 A Microfiche version of this manual is available on 4 x 6 inch microfilm transparencies (order number on title page). Each microfilm contains up to 60 photoduplicates of the manual pages. The microfiche package also includes the latest Manual Changes supplement as well as all pertinent Service Notes.

1-5 Instrument specifications are listed in Table 1-2. These specifications are the performance standards or limits against which the instrument is tested.

1-6 SAFETY CONSIDERATIONS

1-7 The 8112A is a safety Class 1 instrument (it has an exposed metal chassis that is directly connected to earth via the power supply cable). Before operation, the instrument and manual, including the red safety page, should be reviewed for safety markings and instructions. These must then be adhered to in order to ensure safe operation and to maintain the instrument in a safe condition.

1-8 INSTRUMENTS COVERED BY THIS MANUAL

1-9 Attached to the rear of this instrument is a serial number plate (Figure 1-3). The first four digits of the serial number only change when there is a significant change to the instrument. The last five digits are assigned to instruments sequentially. The contents of this manual apply directly to the instrument serial number quoted on the title page. For instruments with lower serial numbers, refer to the back-dating information in Section VII of this manual. For instruments with higher serial numbers, refer to the Manual Change sheets at the end of this manual. In addition to change information, the Manual Change sheets may contain information for correcting errors in the manual. To keep this manual as up-to-date and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Change supplement. The supplement for this manual is identified with the manual's print date and part number, both of which appear on this manual's title page. Complimentary copies of the supplement are available from Hewlett-Packard.

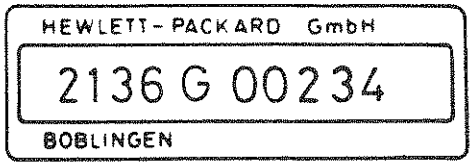


Figure 1-3. Serial Number Plate

1-10 DESCRIPTION

1-11 The HP 8112A Programmable Pulse Generator operates over the frequency range 1 Hz to 50 MHz, with a maximum 32V peak-to-peak output delivered into a high impedance load.
Instrument capabilities include:

- Fixed 5ns transition times.
- 6.5ns to 95ms variable rise and fall times.
- Variable delay in all modes.
- High and Low Level Limit for device under test (DUT) protection.
- Full HP-IB programmability.
- Easily accessible memory for up to 9 sets of mode and parameter selections.

1-12 Correct functionability is assured by the automatic self-test and error recognition capabilities. Self-test and fault diagnosis are performed each time the instrument is switched on. Error recognition helps the operator recover from an incorrect frontpanel or programming operation.

1-13 ACCESSORIES SUPPLIED

1-14 The 8112A is supplied complete with the following items:

ITEM	HP PART NUMBER
750mA fuse for 220/240V operation, or;	2110-0063
1.5A fuse for 110/120V operation	2110-0043
Power cable	see figure 2-2

1-15 ACCESSORIES AVAILABLE

ITEM	HP PART NUMBER
Carrying handle-Bail handle kit.	5061-2001
Rack mounting adaptors: Rack mounting flange and filler panel for mounting a single 8112A.	5061-0072
Rack mounting flange and Lock link kit for mounting two 8112As.	5061-0074 5061-0094

1-13 RECOMMENDED TEST EQUIPMENT

1-14 Equipment required to maintain the 8112A is given in Table 1-1. Alternative equipment may be substituted, provided that it meets or exceeds the critical specifications listed in the table.

INSTRUMENT	RECOMMENDED MODEL	REQUIRED CHARACTERISTICS	ADEQUATE SUBSTITUTE	USE *
Counter	HP5335A	50MHz start/stop T1, Ato B	HP5345A	P,A
D.V.M.	HP3456A	d.c. 0.01V - 50V Pulse amplitude facility	HP3455A	P,A,T
Time Interval Probe	HP5363B	Dynamic range +9.99V to -9.99V	HP5363A	P,A
Sampling scope	TEK 7603 + 7T11/7S11 & S-3A	1GHz		P,A
Realtime scope	HP1740A	100MHz	HP1722A	P,A,T
Pulse/Function Generator	HP8116A	50MHz		P,A
Signature Analyser	HP5005A		HP5004A	T
Power supply	HP6237B	0 - 10V	HP6205B	P
Logic Probe	HP10525E	ECL		T
Logic Probe	HP545A	TTL		T
BNC Cables		30cm, 60cm.		
BNC Tees				
50 Ohm loads				

Table 1-1. Recommended Test Equipment

* P= Performance Test; A= Adjustment; T= Troubleshooting.

Table 1-2. Specifications

SPECIFICATIONS

(Specifications describe the instrument's warranted performance). The following specifications apply with 50 Ohm load resistance from 0 C to 55 C. Output levels double when driving into open circuit (up to 32 Vpp).

PULSE PARAMETERS

Period (PER)

Range: 20ns to 950ms.
Resolution: 3 digits. min 100ps
Accuracy: +/- 5% of progr. value +/- 2ns.
Repeatability: Factor 4 better than accuracy.
Max Jitter: 0.2% of progr. value + 100ps.

Delay, Double Pulse, Width (Specifications apply for minimum transition times, measured at 50% of amplitude. Delay is measured from trigger output to main output).

Delay (DEL)

Range: 75ns to 950ms.
Accuracy: +/- 5% of progr. value +/-5ns.
Max Delay: 1 period plus 55ns.
Repeatability: Factor 4 better than accuracy.
Resolution: 3 digits.
Max Jitter: 0.2% of progr. value + 100ps.

Double Pulse (DBL)

Range: 20ns to 950ms.
Accuracy: +/- 5% of progr. value +/- 2ns.
Repeatability: Factor 4 better than accuracy.
Resolution: 3 digits.
Max Jitter: 0.2% of progr. value + 100ps.

Width (WID)

Range: 10ns to 950ms.
Accuracy: +/- 5% of progr. value +/- 2ns.
Max Width: Actual period minus 10ns.
Repeatability: Factor 4 better than accuracy.
Resolution: 3 digits.
Max Jitter: 0.2% of progr. value + 100ps.

Constant Duty Cycle (DTY)

Range: 1% to 99%, width at least 10ns.
Max: Actual period minus 10ns.
Resolution: 1%.
Accuracy: 10% of progr. value.
Repeatability: Factor 4 better than accuracy.

Output Levels (Value in parenthesis into open circuit).

High Level (HIL) Range: -7.90 V to 8.00 V (-15.8 V to 16.0 V).
Low Level (LOL) Range: -8.00 V to 7.90 (-16.0V to 15.8 V).
Amplitude: 0.1 V to 16 V (0.2 V to 32 V).
Resolution: 3 digits. min 10mV.
Accuracy: +/- 40mV, +/- 1% of progr. value, +/- 3% of amplitude.
Repeatability: Factor 4 better than accuracy.
Settling Time: 100 ns + transition time.

Transition Times (10-90% of amplitude; leading and trailing edge transition times are independently programmable within a common range, max ratio 1:20).

Fixed Transition (⌐¬): typ. 5ns for leading and trailing edge.

Linear Transition (⌐/¬):
Leading Edge (LEE): 6.5ns to 95ms.
Trailing Edge (TRE): 6.5ns to 95ms.
Resolution: 3 digits (best case 100ps).
Accuracy: +/- 5% of progr. value +/- 2ns.
Repeatability: Factor 4 better than accuracy.
Linearity: +/- 3% (10% to 90% of amplitude) for transition times > 100ns.

Pulse Performance

Preshoot, Overshoot, Ringing: +/- 5% of amplitude +/- 10mV for linear and sinusoidal transitions; 10% of amplitude +/- 10mV for fixed transitions.

Reflections: < 10%.
Source Impedance: 50 Ohm +/- 5%.

SUPPLEMENTARY PERFORMANCE CHARACTERISTICS

(describing non-warranted typical performance parameters)

OPERATING MODES

Normal (NORM): Continuous pulse stream.

Trigger (TRIG): Each active input transition generates a single output pulse.

Gate (GATE): External signal enables period generator. First output pulse sync with leading edge. Last pulse always completed.

Table 1-2 cont. Specifications

External Width (E.WID): Restoration of external signal with selectable transition times and output levels.

External Burst (E.BUR): Each active input transition generates a pre-programmed number of pulses (1 to 1999). Min time between two bursts is 100ns.

AUXILIARY OPERATING MODES

Manual (MAN): Simulates an external input.
1 Pulse: Provides one pulse in TRIG, GATE and E.BUR.

Limit: Maximum high and low levels into 50 Ohm can be limited to protect the device under test. Pushing the LIMIT key will set the limits to the actual levels, which then can not be exceeded as long as the mode is active.

Compl: Switch-selectable normal/complement output.

Disable: Relay disconnects all output circuitry.

Sto/Rcl (STO/RCL): 9 programmable locations, 1 location with fixed mode/parameter set, 1 location for active operating state. Capacity is one complete mode/ parameter set per location.

CONTROL MODES

(external voltage controls the output signal, display shows the max. available value in the selected range or HIL).

Period Control (PERC)

Pulse Period Ratio: 1:10.
Control Voltage: 1V to 10V.
Period Ranges: 20ns to 1s in eight non-overlapping decade ranges.
Bandwidth: 20kHz.

Delay Control (DELC)

Pulse Delay Ratio: 1:10.
Control Voltage: 1V to 10V.
Delay Ranges: 10ns to 1s in eight non-overlapping decade ranges (55 ns fixed delay not included).
Bandwidth: 20kHz.

Width Control (WIDC)

Pulse Width Ratio: 1:10.
Control Voltage: 1V to 10V.
Width Ranges: 10ns to 1s in eight non-overlapping decade ranges.
Bandwidth: 20kHz.

High Level Control (HILC)

Control Voltage: -8V to +8V.
High Level Output Window: -8V to +8V into 50 Ohm independent of actual low level, which is programmable between -8.00V and +7.90V in 50mV steps.
Settling time: 200us to settle within 5% of the final level.

AUXILIARY INPUTS AND OUTPUTS

Ext. Input

Threshold level: +/- 10V adjustable.
Max input voltage: +/- 20V.
Sensitivity: 500mVpp.
Min pulse width: 10ns.
Input impedance: 10kOhm.
Trigger slope pos/neg and trigger off, in TRIG and E.BUR both slopes simultaneously available.

Control Input

Max input voltage: +/- 20V.
Input impedance: 10kOhm.

Trigger Output

Output levels: 0/2.4V into 50 Ohm, 0/4.8V into open circuit.
Output impedance: 50 Ohm.
Delay from trigger input to trigger output: 25ns.
Max external voltage: 0V to +5V.

Main Output

Output levels: -8.0V/+8.0V into 50 Ohm, -16.0V/+16.0V into open circuit.
Output impedance: 50 Ohm.
Max external voltage: -5.0V to +5.0V.

GENERAL

Recalibration Period: 1 year.
Warm-up Time: 15 min to meet all specifications.

Table 1-2 cont. Specifications

HP-IB CAPABILITY

All modes except external input threshold level can be programmed.

Data transmission times:

Note: Values in parentheses indicate excessive slope calculation is not active (SR0).

Listen (time for 8112A to receive and verify a message)

PARAMETER	TIME TO INTERPRET
DISABLE, COMPL, LIMIT, TRANSITION MODES, TRIGGER SLOPES, EXT INPUT MODES	< 4ms
CONTROL MODES	< 50ms
SET mode ON	< 90ms(< 62ms)
SET mode OFF	< 4ms
HIL, LOL	< 90ms

PARAMETER	TIME TO INTERPRET
BUR	< 12ms
PER, DEL, WID, TRE, LEE, DBL	< 50ms
DTY, PER in DTY mode	< 80ms(< 50ms)
STO	6ms
RCL	180ms(150ms)

Settling (time to execute message) : 5ms

Talk (time for 8112A to transmit a message) :1ms per character
Learn mode, error recognition
Status : 15ms

Example

"M1 PER1MS DTY20% HIL3V LOL1V D1"

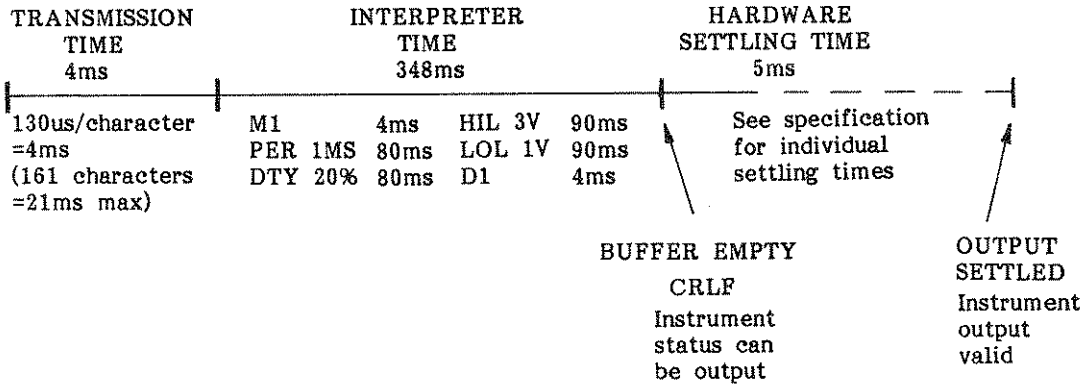


Table 1-2 cont. Specifications

Environmental

Storage Temperature: -40 C to 70 C.
Operating Temperature: 0 C to 55 C.
Accuracy Specifications apply from 0 C to 55 C.
Humidity Range: < 95% R.H. > 0 C to 40 C.

Power-off-storage.

After eight hours of operation, battery is fully charged and maintains all current mode and parameter information up to 2 weeks with instrument switched off.

Power

100/120/200/240 Vrms +5%, -10%, 48-440 Hz;
120 VA max.

Weight

Net 5.9 kg (13 lbs), Shipping 8.0 kg (18 lbs).

Dimensions

89mm high, 213mm wide, 450mm deep
(3.5 x 8.4 x 17.7 inch).

Options

910 Additional Operating and Service Manual
(part no: 08112-90001).

SECTION 2
INSTALLATION

2-1 INTRODUCTION

2-2 This section provides installation instructions for the instrument and its accessories. It also includes information about initial inspection and damage claims, preparation for use, packaging, storage and shipment.

2-3 Initial Inspection

2-4 Inspect the shipping container for damage. If the container or cushioning is damaged, it snould be kept until the contents of the shipment have been checked for completeness, and the instrument has been verified mechanically and electrically. The contents of the shipment should be as shown in Figure 1-1, plus any accessories that were ordered with the instrument. Procedures for checking the electrical operation are given in Section 3. If the contents are incomplete, mechanical damage or defect is apparent, or if the instrument does not pass the operator's checks, notify the nearest Hewlett-Packard Office. Keep the shipping materials for carrier's inspection. The HP office will arrange for repair or replacement without waiting for settlement.

2-5 Preparation for use

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, connectors etc).

2-6 Power Requirements

2-7 The instrument requires a power source of 100/120/220 or 240V rms (+5%, -10%) at a frequency of 48 - 440Hz single phase. The maximum power consumption is 120VA.

2-8 ⚠ Line Voltage Selection

CAUTION

BEFORE SWITCHING ON THIS INSTRUMENT, make sure that it has been set to local line voltage. The line voltage selector switches can be seen through the lefthand side of the instrument cover to the rear. The correct setting for the country of destination will have been made at the factory. The instrument power fuse is located on the rear panel. To access the line selector switches, first DISCONNECT the power cord, then remove the 8112A top cover by releasing the captive securing screw at the rear, and sliding the cover off.

CAUTION

DO NOT CHANGE THE LINE SELECTOR SWITCH SETTINGS WITH THE INSTRUMENT ON, OR WITH POWER CONNECTED TO THE REAR PANEL.

2-9 Figure 2-1 provides information for line voltage and fuse selection.

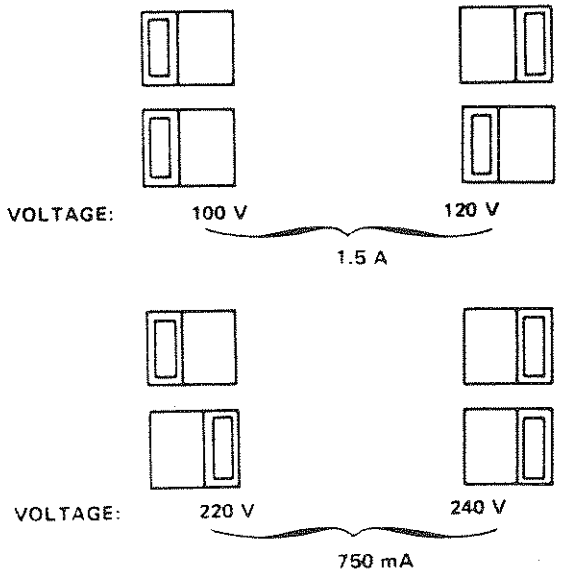


Figure 2-1. Line voltage slide switch positions

2-10 Power Cable

WARNING

To avoid the possibility of injury or death, the following precautions must be followed before the instrument is switched on.

a) If this instrument is to be energised via an autotransformer for voltage reduction, ensure that the Common terminal is connected to the grounded pole of the power source.

b) The power cable plug shall only be inserted into a socket outlet provided with a protective ground contact. The protective action must not

be negated by the use of an extension cord without a protective conductor.

c) Before switching on the instrument, the protective ground terminal of the instrument must be connected to the protective conductor of the power cable. This is verified by checking that the resistance between the instrument chassis and the frontpanel and the ground pin of the power cable is zero Ohms.

2-11 In accordance with International safety standards, this instrument is equipped with a three-wire power cable. When connected to an appropriate a.c. power receptacle, this cable grounds the instrument cabinet. The type of power cable shipped with each instrument depends upon the country of destination. Refer to Figure 2-2 for the part number of the power cords available.

2-12 The following work should be carried out by a qualified electrician - all local electrical codes being strictly observed. If the plug on the cable does not fit the power outlet, or the cable is to be attached to a terminal block, cut the cable at the plug end and re-wire it. The colour coding used in the cable will depend on the cable supplied (see Figure 2-2). If a new plug is to be connected, it should meet local safety requirements and include the following features:

Adequate load-carrying capacity (see table of specifications in Section 1).

Ground connection.

Cable clamp.

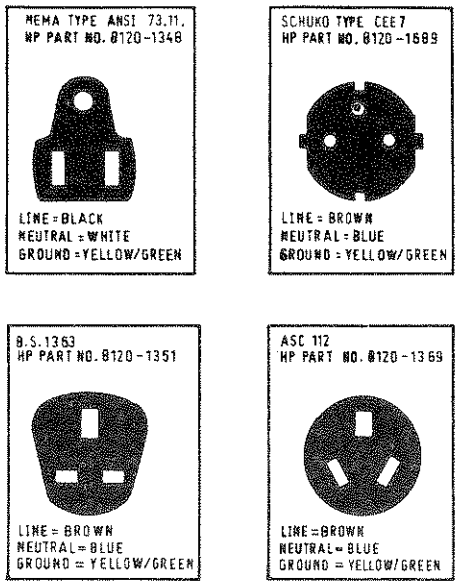


Figure 2-2. Power cables available: Plug identification

2-13 HP-IB Connector

2-14 The rear panel HP-IB connector (Fig 2-3), is compatible with the connector on Cable Assemblies 10833A,B,C and D. If a cable is to be locally manufactured, use connector male, HP part number 1251-0293.

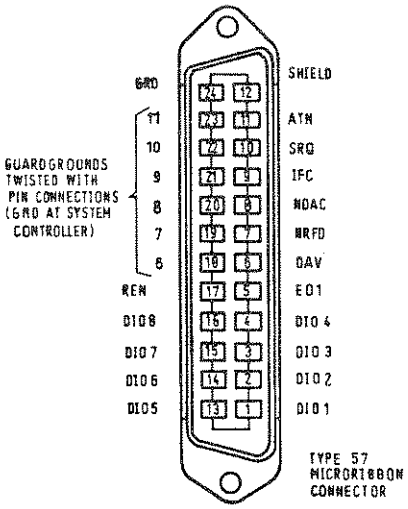


Figure 2-3. HP-IB Connector

2-15 HP-IB Logic Levels

2-16 The 8112A HP-IB lines use standard TTL logic, the levels being as follows:

True = Low = digital ground or 0V dc to 0.4V dc,

False = High = open or 2.5V dc to 5V dc.

All HP-IB lines have LOW assertion states. High states are held at 3.0V d.c. by pull-ups within the instrument. When a line functions as an input, approximately 3.2mA of current is required to pull it low through a closure to digital ground. When a line functions as an output, it will sink up to 48mA in the low state and approximately 0.6mA in the high state.

CAUTION

ISOLATION: The HP-IB line screens are not isolated from ground.

2-17 Operating Environment

The operating temperature limits are 0 deg C to 55 deg C. The specifications also apply over this range.

2-18 CLAIMS AND REPACKAGING

2-19 If physical damage is evident or if the instrument does not meet specification when received, notify the carrier and the nearest Hewlett-Packard Sales/ Service Office. The Sales/Service Office will arrange for repair or replacement of the unit without waiting for settlement of the claim against the carrier.

2-20 Storage and Shipment

2-21 The instrument can be stored or shipped at temperatures between minus 40 deg C and plus 75 deg C. The instrument should be protected from temperature extremes which may cause condensation within it.

2-22 If the instrument is to be shipped to a Hewlett-Packard Sales/Service Office, attach a tag showing owner, return address, model number and full serial number and the type of service required. The original shipping carton and packing material may be reusable, but the Hewlett-Packard Sales/Service Office will also provide information and recommendations on materials to be used if the original packing is no longer available or reusable. General instructions for repacking are as follows:

1. Wrap instrument in heavy paper or plastic.

2. Use strong shipping container. A double wall carton made of 350-pound test material is adequate.

3. Use enough shock-absorbing material (3 to 4 inch layer) around all sides of the instrument to provide a firm cushion and prevent movement inside container. Protect control panel with cardboard.

4. Seal shipping container securely.

5. Mark shipping container FRAGILE to encourage careful handling.

6. In any correspondence, refer to instrument by model number and serial number.

SECTION 3
OPERATING AND PROGRAMMING

3-1 INTRODUCTION

3-2 The following operating information explains the functions of the controls and indicators of the Model 8112A Pulse Generator. Front and rear panel controls indicators and connectors are identified and briefly described in Figure 3-1, which should be read before continuing with the following description. Programming information is available at the end of this section.

3-3 SPECIAL OPERATING POINTS

3-4 The following points should be read before applying power to the Model 8112A:

1. Read the Safety Summary at the beginning of this manual.

2. Ensure the power selector switches are correctly set for the intended source, to avoid instrument damage. This can be achieved by checking the line selection label on the rear panel.

CAUTION

CAUTION: Do not alter the line selector switch setting with power connected to the rear panel.

3. Ensure that the load cannot be overdriven by the 8112A output (16Vp-p into 50 Ohm, 32Vp-p into High Impedance).

3-5 OPERATING CHECKS

3-6 The 8112A performs a "self-test" at power switch on. During this series of tests, all LED's shall be momentarily lit. In the event of a fault being detected, an error code will present itself on the frontpanel digital display. The error codes are as follows :

☐. Frontpanel mode, control, parameter or vernier key jammed in.

E01. Fail RAM Test.

E11. Fail Period Timing Test.

E12. Fail Delay Timing Test.

E13. Fail Width Timing Test.

E14. Fail Slope Generation Test.

E21. Fail Output Amp +ve Offset Test.

E22. Fail Output Amp -ve Offset Test.

E31 to E39. Fail Overall Tests.

E41 and E42. Fail DAC Amplitude Tests.

E51 and E52. Fail Burst Counter Tests.

3-7 OPERATING INSTRUCTIONS.

3-8 Operating modes may be local (frontpanel) or programmed, using the HP-IB. The current operating mode is indicated by an illuminated LED in the MODE column on the frontpanel. Parameter selection for the 8112A is indicated by an illuminated pushbutton LED and the digital display. Similarly, current Transition mode, Control mode (if in use), and Output information is indicated by illuminated LED's.

3-9 At power switch-on, the 8112A performs a self-test routine, then assumes the set of operating modes and parameters prevailing at switch-off. The output is disabled (DISABLE pushbutton LED illuminated), at this time to protect externally connected devices. The operator should then select the required mode operation and output signal. Upon selection, the 8112A automatically displays the parameters available in this mode mnemonically.

3-10 Pressing a parameter pushbutton will enable the value of that parameter to be displayed digitally, and a new value may be set using the RANGE/VERNIER keys. When all parameters have been set to the required values, the DISABLE pushbutton should be pressed to enable the OUTPUT (pushbutton LED no longer illuminated).

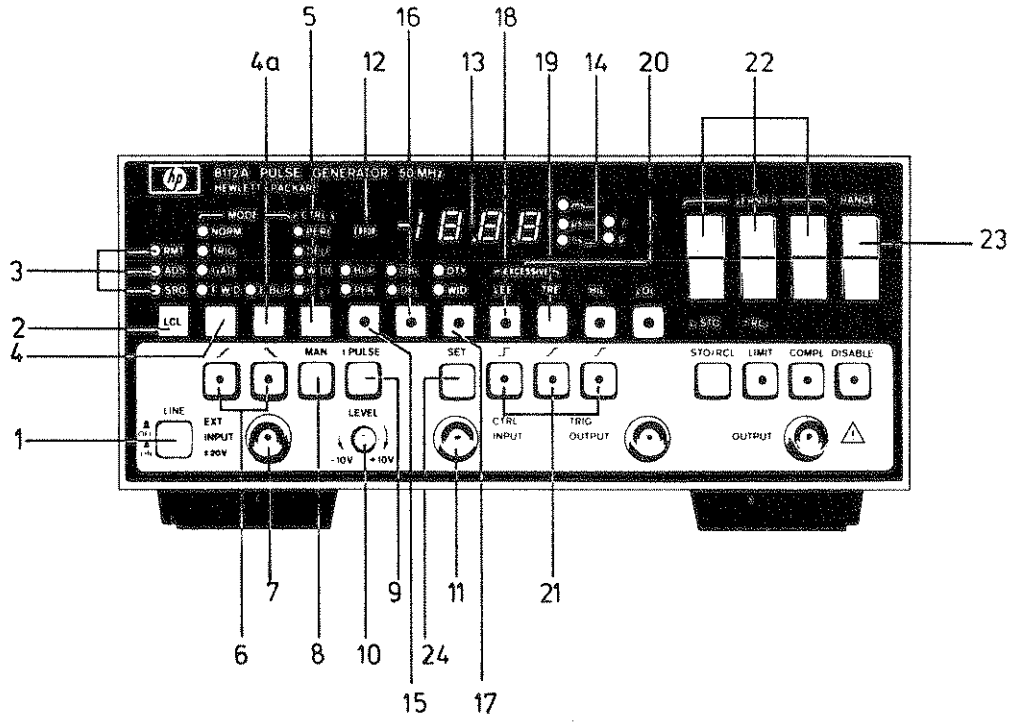
3-11 In addition to the operating modes, the 8112A offers four Control (CTRL) modes, which allow the operator to vary PERIOD, DELAY, WIDTH and HIGH LEVEL by means of an external voltage applied to the CTRL INPUT. Note that when the DBL facility is currently active, the DELAY Control facility becomes DOUBLE Control. Table 3-1 indicates the various permissible combinations of Control and Operating modes. In the event of an erroneous combination, e.g. EWID and DELC, the EWID and DELC LEDs will blink. When the operator selects incompatible timing settings, (e.g. WID greater than PER) in NORM mode, the 8112A displays ERROR, and the incompatible parameter LEDs will blink.

3-12 VERNIER / RANGE OPERATION

3-13 The VERNIER control comprises three rocker-switches, each of which correspond to a display digit. Incrementing a display is

(continued on page 3-5)

Figure 3-1 8112A Controls



OPERATING AND CONTROL MODE SELECTION

1. Line switch: Power ON/OFF pushbutton.

2.LCL: This pushbutton returns the 8112A to local manual operation. (Note: Pushbutton ineffective when LOCAL LOCKOUT command is sent by the controller to the 8112A). In local mode, pressing this pushbutton causes the currently selected HP-IB address to be displayed, whereupon the instrument will respond to a change in its bus address.

3. Program status LED's. When illuminated, they indicate the following:

RMT: Indicates remote control; all pushbuttons being inoperative (except LCL).

ADS: Indicates that the 8112A is under program control, although frontpanel pushbuttons may be operated depending on the status of the RMT LED.

SRQ: Indicates that the SERVICE REQUEST signal has been sent to the controller.

4. Standard mode selection pushbutton and associated LED's. Repetitive operation of this pushbutton steps through the modes in the sequence indicated by the LED column. Standard modes are as follows:

NORM: Internal rate generator free running.

TRIG: A trigger signal, either at the EXT INPUT connector or via the MAN pushbutton, initiates one output pulse.

GATE: A gate signal, either at the EXT INPUT connector or via the MAN pushbutton generates an output for the duration of the gate signal.

E.WID: External signal at the EXT INPUT connector is shaped to determine the output pulse width and period.

E.BUR: (4a)A burst trigger, either at the EXT INPUT connector or via the MAN push-button, generates a preselected number of pulses (1 to 1999).

5. Control mode selection pushbutton and associated LED's. Repetitive operation steps through the modes in the same sequence as the LED column. The modes are as follows:

PERC: Period Control. The 8112A output signal may have its Period varied by applying an external voltage to the frontpanel CTRL INPUT connector.

DELC: Delay Control. The 8112A output signal may have its Delay varied (time between TRIG OUTPUT and Main OUTPUT leading edges measured at 50% amplitude), by applying an external voltage to the CTRL INPUT connector.

Figure 3-1 (continued) 8112A Controls

WIDC: Width Control. The 8112A output may have its Width varied by applying an external voltage to the CTRL INPUT connector.

HILC: High-Level Control. The 8112A output signal may have its High Level varied by applying an external voltage to the CTRL INPUT connector. NOTE: When in this mode, HIL LIMIT becomes inoperative and Low Level (LOL) is unaffected.

6. Trigger slope pushbuttons. In external triggering modes, the slope of the signal applied to the EXT INPUT connector from which the 8112A will trigger, is selected via these pushbuttons. The currently selected trigger(s) slope is indicated by an illuminated pushbutton LED.

7. EXT INPUT connector: BNC connector for trigger signals.

8. MAN pushbutton: Used to simulate an external trigger.

9. 1 PULSE pushbutton: Provides a single pulse in TRIG, GATE and EBUR modes.

10. LEVEL adjust: Enables the external input trigger threshold level to be adjusted in the range -10V to +10V.

11. CTRL INPUT connector: BNC connector for external control signals.

PARAMETER / TRANSITION MODE SELECTION

12. ERROR LED: When lit, indicates hardware recognised fault in Normal mode.

13. Digital display: Indicates numerical value of currently displayed parameter.

14. Units LEDs: An indication of the currently displayed parameters' reference of measurement.

15 to 19. Timing parameter selection pushbuttons and their associated mnemonics.

When a pushbutton is selected, the built-in LED illuminates and the current value of the selected parameter is displayed. The selected parameter is indicated by an illuminated mnemonic. Once selected, the parameter value may be varied via the RANGE and VERNIER keys. Individual information for each of the pushbuttons is given in the following:

15. Parameter selection. Mnemonics are:

PER- illuminated to indicate that "Period" is currently selectable; or

BUR- illuminated to indicate that "Burst Number" is currently selectable.

16. Selected mode determines mnemonic illumination, hence parameter selection. Mnemonics are:

DBL- illuminated to indicate that a "Double Pulse" is currently selectable; or

DEL- illuminated to indicate that "Pulse Delay" is currently selectable.

17. Selected mode determines mnemonic illumination, hence parameter selection. Mnemonics are:

DTY- illuminated to indicate that "Duty Cycle" is currently selectable. (This is a percentage parameter and therefore left hand VERNIER and RANGE keys are inactive); or

WID- illuminated to indicate that "Pulse Width" is currently selectable.

18.LEE- LED in pushbutton is illuminated to indicate "Leading Edge" rise time is currently selectable.

19.TRE- LED in pushbutton is illuminated to indicate "Trailing Edge" fall time is currently selectable.

20.EXCESSIVE- mnemonic is illuminated when either leading or trailing edge has become incompatible with period, or pulse width, causing levels to become inconsistent with the selected value(s).

21. Transition Mode pushbuttons. LEDs illuminate to indicate current setting of Transition Mode (Fixed, Linear or Gauss).

22. VERNIER rocker keys: Used to vary parameter values.

23. RANGE rocker key: Used to change the range of the currently selected parameter by a factor of 10.

24. SET Pushbutton: When selected, sets the 8112A to the following: NORM, (PER remains at initial value). WID becomes 50% of PER. DEL is reduced to 65ns (minimum), LEE and TRE assume 10% of PER in Linear and Gauss modes. In Fixed mode, rise and fall times will become 5ns.

Select any of the mode, control or timing parameter keys to clear the SET mode, or press the SET key again.

Figure 3-1 (continued) 8112A Controls

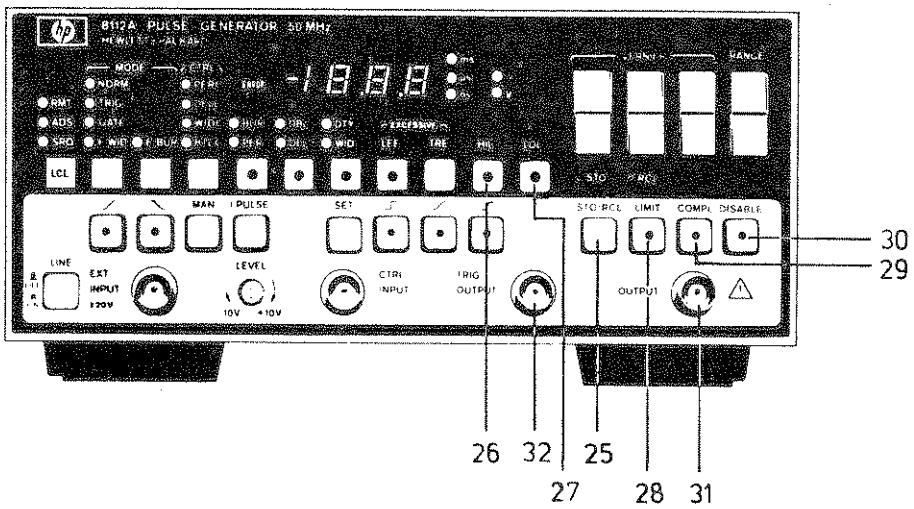


Figure 3-1 (continued) 8112A Controls

OUTPUT CONTROL SELECTION

25. STO/RCL: This pushbutton used in conjunction with the Vernier rocker switches to store or recall 9 complete parameter sets.

26. HIL: High Level pushbutton. LED illuminated to indicate selectability of this parameter.

27. LOL: Low Level pushbutton. LED illuminated to indicate selectability of this parameter.

28. LIMIT: Pushbutton LED illuminated to indicate selectability of this function.

29. COMPL pushbutton: Provides selectability of normal or complementary output. When pushbutton LED is illuminated, the complementary output has been selected.

30. DISABLE: When pressed, this pushbutton withdraws the preprogrammed signal from the OUTPUT connector. Pushbutton LED indicates DISABLE. (Note: instrument output is disabled at switch-on).

31. OUTPUT connector: BNC connector providing the 8112A Output signal.

32. TRIG OUTPUT connector: BNC connector providing the 8112A Trigger Output signal.

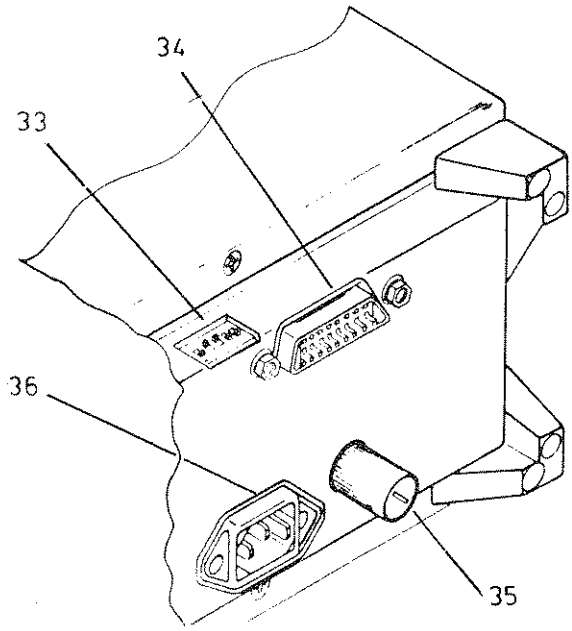
REAR PANEL CONTROLS/CONNECTORS

33. HP-IB address switch (5 bits A1 to A5)

34. HP-IB connector

35. FUSE. Accepts standard fuses to provide instrument protection in case of current overload. A 750mA slow-blow fuse must be used when operating from a 220/240V power source. A 1.5A fuse is used when operating from a 120V power source.

36. LINE. A three terminal plug to provide a chassis ground connection via the power cable for operator protection .



CTRL	MODE				
	NORM	TRIG	GATE	EWID	EBUR
PERC	●		●		●
DELC/DBLC	●	●	●		●
WIDC	●	●	●		●
HILC	●	●	●	●	●

Table 3-1. Operating/Control mode combinations.

NOTE 1: THE DBL facility is available in all of the above combinations.

NOTE 2: When DBL is active on the frontpanel, DELC becomes DBLC.

accomplished by pressing the upper switch section. Similarly, decrementing a display digit is accomplished by pressing the lower switch section. Continuous operation of a VERNIER key results in the respective display being incremented or decremented continuously.

3-14 The RANGE rocker-switch is used for incrementing or decrementing the displayed value by a factor of ten.

3-15 LIMIT OPERATION

3-16 LIMIT operation is available on the 8112A to provide protection for the Device Under Test. When HIL and LOL have been set, pressing the LIMIT pushbutton (LED illuminates) will ensure that the 8112A output does not exceed the selected values. Pressing the key again disables LIMIT operation.

3-17 EXTERNAL TRIGGERING

3-18 The 8112A may be triggered from an external source via the EXT INPUT connector in any one of four operating modes (TRIG, GATE, EWID or EBUR). The instrument can be set to trigger from the positive edge AND/OR the negative edge of the input signal - depending upon the operation mode selected - the threshold being adjustable in the range -10V to +10V using the LEVEL control. The function of the individual pushbuttons in combination with Operating modes is described in the following:

3-19 Trigger Slopes

3-20 Positive and/or negative slope is selectable for triggering. The level at which the instrument triggers is determined by adjustment of the LEVEL control. Trigger sensitivity, although specified at 500mV, is normally in the order of 50mV. With both Trigger slopes deselected (both pushbutton LEDs off), the EXT INPUT is inhibited.

3-21 TRIG mode. A signal at the EXT INPUT connector initiates one output pulse - the parameters depending upon the values set via the parameter pushbuttons and RANGE/VERNIER rocker switches.

3-22 In the GATE mode, a signal at the EXT INPUT connector will generate an output from the 8112A for the duration of the GATE signal. The last output pulse will always be completed.

3-23 EWID mode. A signal at the EXT INPUT connector is shaped to determine the width of that signal, with reference to the trigger threshold.

3-24 EBUR mode. A signal at the EXT INPUT connector is used to initiate a burst of pulses - the number and parameters of which are determined by the parameter values set at the parameter pushbuttons and RANGE/VERNIER rocker switches.

3-25 MANUAL

3-26 In external trigger modes, the 8112A may be triggered manually via the MAN pushbutton - the external input and trigger slope LED's being switched off.

TRIG mode: Each operation of MAN generates one output cycle - the parameters of which are determined by the values set via parameter pushbuttons and RANGE/VERNIER rocker switches.

GATE mode: The 8112A outputs continuously for as long as MAN is depressed. The output is determined by the values set via parameter pushbuttons and RANGE/VERNIER rocker switches.

EBUR mode: The 8112A will output a burst with each operation of MAN. The burst number and parameters are determined by the values set via parameter pushbuttons and RANGE/VERNIER rocker switches.

3-27 1 PULSE

3-28 In TRIG, GATE and EBUR modes, each operation of this pushbutton generates a single cycle at the 8112A output.

3-29 CONTROL MODES

3-30 The 8112A output signal may be either Period, Delay, Width, or High Level controlled by an external voltage applied to the CTRL INPUT, depending upon the Control mode selected. The external input may take any waveshape in the range +/-20V. A signal applied to the CTRL INPUT outside this range may cause damage to the instrument. The range within which the

instrument actually responds to a Control signal, however, is 1.0V to 10.0V. Figures 3-2 to 3-7 show the variable Pulse Parameters available under the CONTROL MODES menu. For details of Mode specifications, see Table 1-2.

3-31 Period Control (PERC)

3-32 The Period of the 8112A signal output may be varied by an external voltage applied to the CTRL INPUT. The CTRL INPUT sensitivity is +1.0V to +10.0V (+2.0V to +10.0V in the 20ns to 100ns range), and period ranges from 20ns to 1s in eight non-overlapping decades. See Figures 3-2 and 3-6.

3-33 Delay Control (DELC)

3-34 The Delay between the 8112A signal output and trigger outputs may be varied by an external voltage applied to the CTRL INPUT. Minimum delay is 75ns (see Section 1) and a maximum delay of 1s is obtainable. NOTE: In DBL mode, the time between pulses will be varied as a result of DELC being selected. See Figures 3-3 and 3-6.

3-35 Width Control (WIDC)

3-36 The Width of the pulse(s) at the 8112A output may be varied by an external voltage applied to the CTRL INPUT, sensitivity range being +1.0V to +10.0V and width range 10ns to 1s in eight non-overlapping decades. See Figures 3-4 and 3-6.

3-37 High Level Control (HILC)

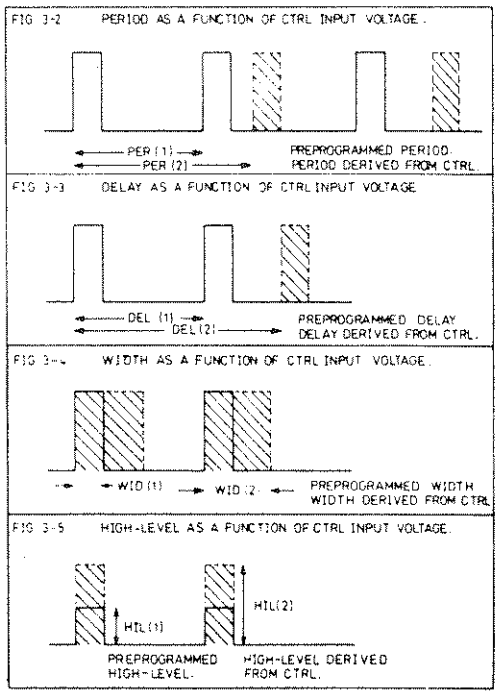
3-38 High Level Control is available in the range -8.0V to +8.0V. It is important to note that while the Low Level (LOL) value can be set to a maximum of +7.95V in 50mV steps, the LIMIT facility becomes non-operational in this Control mode, and the pushbutton LED will blink. See Figures 3-5 and 3-7.

3-39 PARAMETER SETTING

3-40 Period/Burst Key

PER: When selected, the period of the 8112A output signal may be adjusted using the VERNIER and RANGE keys, the value being displayed digitally and mnemonically.

BUR: In EBUR mode, this key is used to set the number of pulses (between 1 and 1999) which will comprise the Burst.



Figures 3-2 to 3-5. Control Input functions

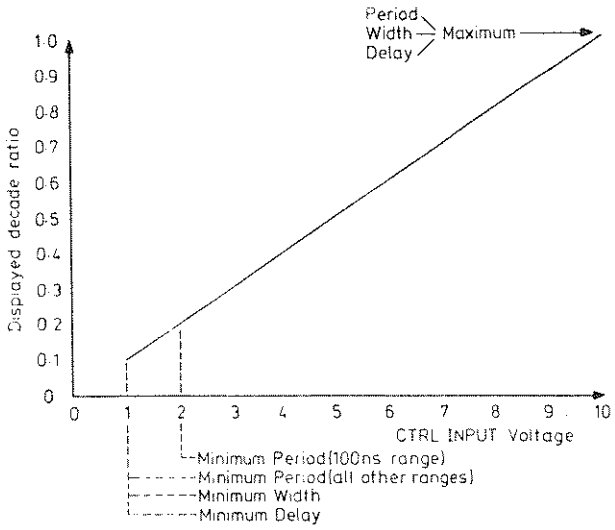


Figure 3-6. Relationship between CTRL INPUT voltage and controlled parameter

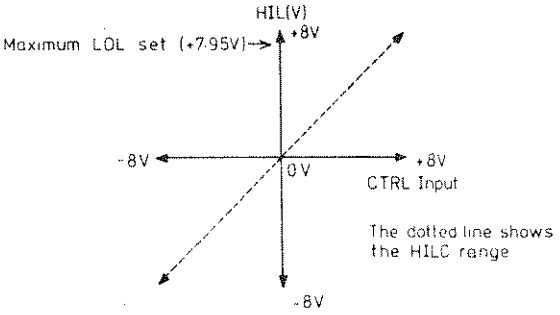


Figure 3-7. High Level control capabilities

3-41 Double/Delay Key

DEL: Selection of this parameter enables the operator to set the desired delay between TRIG OUTPUT pulse and 8112A OUTPUT pulse, using the VERNIER and RANGE keys. The value will be displayed digitally and mnemonically.

DBL: When selected, double pulses may be output, their characteristics being defined by the set 8112A parameter values. The width of each pulse is either equal to the WID setting or half of the DTY setting and the delay between the two pulses may be varied using the RANGE and VERNIER keys. Range - 20ns to 950ms.

3-42 Duty/Width Key

DTY: Pulse Duty Cycle is variable from 1% to 99% using the VERNIER keys. Percentage values will be displayed digitally and mnemonically when this parameter has been selected. (See specifications for Duty Cycle and Pulse Width).

WID: When selected, Pulse Width may be set between 10ns and 950ms using VERNIER and RANGE keys. The Pulse Width value will be displayed both digitally and mnemonically.

3-43 Leading and Trailing Edge Keys

LEE,TRE: Used in conjunction with TRANSITION MODE keys, it is possible to increase or decrease rise and fall times of output pulses. Should the operator select a rise or fall time which degrades HIL or LOL settings, the EXCESSIVE message and incompatible parameter key LED will flash.

3-44 High and Low Level Keys

HIL,LOL: When either of these keys are selected, the corresponding level may be set using the VERNIER keys. The value will be displayed digitally and mnemonically. Note: The selected HIL value is inoperative in the HILC mode.

3-45 SET Key

SET: Selection of this key causes the 8112A to assume a factory-programmed Parameter Set. Namely: NORM, PER active, WID= 50% PER, LEE and TRE assume 10% of PER. SET will automatically be eliminated by selection of any other Mode or Parameter key, or pushing the SET key again.

3-46 Complementary Output

COMPL: Selection of this key will invert the 8112A output. The OUTPUT signal will be normal while the LED is unlit.

3-47 Store and Recall.

STO/RCL: The 8112A has the capability to store nine complete sets of mode and parameter information in its memory.To store; Press STO/RCL key. Press the left VERNIER key. The digital display shall read ⌴⌐X, where X= file number (1 to 9). The right Vernier key is used to determine which file the parameter set will occupy. To recall; Press STO/RCL key. Press the the centre VERNIER key. The digital display shall read ⌴⌐X, where X = file number (0 to 9). The right Vernier key is used to determine which file the operator wishes to recall.

3-48 RCL 0 reverts the 8112A to the Standard Parameter Set, namely:

PER = 1.00ms	BUR = 0001 #
DEL = 65 ns	HIL = 1.00 V
DBL = 200 us	LOL = 0.00 V
WID = 100us	DTY = 50%
LEE = 10ns	TRE = 10ns
EXT INPUT: POS SLOPE	TRANSITION: LINEAR
CTRL: OFF	OUTPUT DISABLED

NORM, PER - active (displayed).

WID, DEL, LED's illuminated.

3-49 If no file has been allocated an operational parameter data set, selecting RCL for any file number will automatically revert the 8112A to the Standard Parameter Set (RCL 0).

3-50 TRANSITION MODES

3-51 FIXED mode. The transition value of 4.5ns is preset, and therefore any VERNIER or RANGE key operation is ineffective.

3-52 LINEAR mode, when selected, permits both the leading and trailing edges of the 8112A to be programmed independently of each other in the range 6.5ns to 95ms, and maximum ratio of 1:20.

3-53 GAUSS mode. As for LINEAR mode, except that edges become cosinusoidal in shape. It is important to note that the actual rise and fall times of the transitions will be up to 25% faster than the selected and displayed value for slopes of greater than 50ns duration. For slopes of less than 50ns duration, the transition times tend increasingly toward the displayed value. The reason for this being that selected values are based only upon times between 10% and 90% of total trigonometric transition. Values between 0 to 10% and 90% to 100% are not taken into account by the instrument.

3-54 Transition Ranging

3-55 There are seven ranges for linear and gauss transitions, and it is important to note the following:

When the currently active slope is selected in a higher or lower range than the non-active slope, the latter will automatically be pulled into the same range. The maximum ratio of the leading edge transition time to the trailing edge transition time in any range is 1:20. The ranges are illustrated in the following diagram.

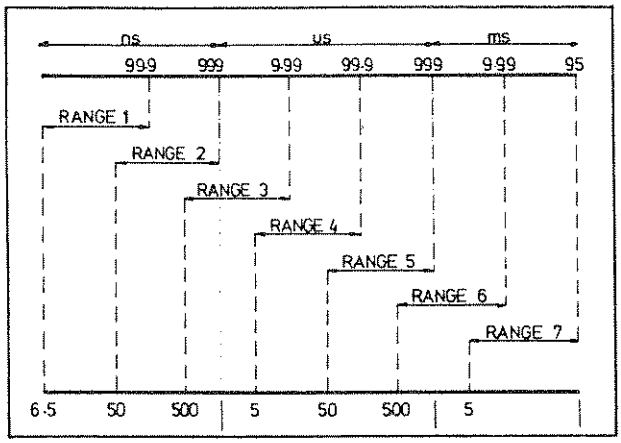


Figure 3-8. LEE and TRE ranges

3-56 Up-Ranging using the VERNIER keys.

Note that there is an overlap between all ranges. When the currently active slope is increased a range above the non-active slope, the value of the latter will automatically increase in value by a factor of 100 if originally in an overlap area with a lower range, or a factor of 10 if in an exposed range position.

3-57 Down-Ranging using the VERNIER keys.

When moving the active slope down a range, the non-active slope will assume a value which is a factor of 10 below its original value.

The following diagram illustrates the technique of passing Range "Break Points".

Should the active slope be moved into the Y1 area, the non-active slopes X1, X2 and X3 values will all be decreased by a factor of 10. If the active slope is moved into the Y2 area, the non-active slope X1 value will be incremented by a factor of 100, and X2 and X3 values by a factor of 10.

3-58 Up and Down-Ranging using the RANGE key.

When moving the currently active slope up or down a range using the RANGE key, the non-active slope will automatically be pulled into the SAME DECADE as the active slope setting. This effect is particularly useful for fast ranging between decades.

3-59 OPERATING MODES

Each of the five operating modes is described briefly in Figures 3-10 to 3-14. Control modes, parameter selection and timing diagrams for the various operating modes are also described.

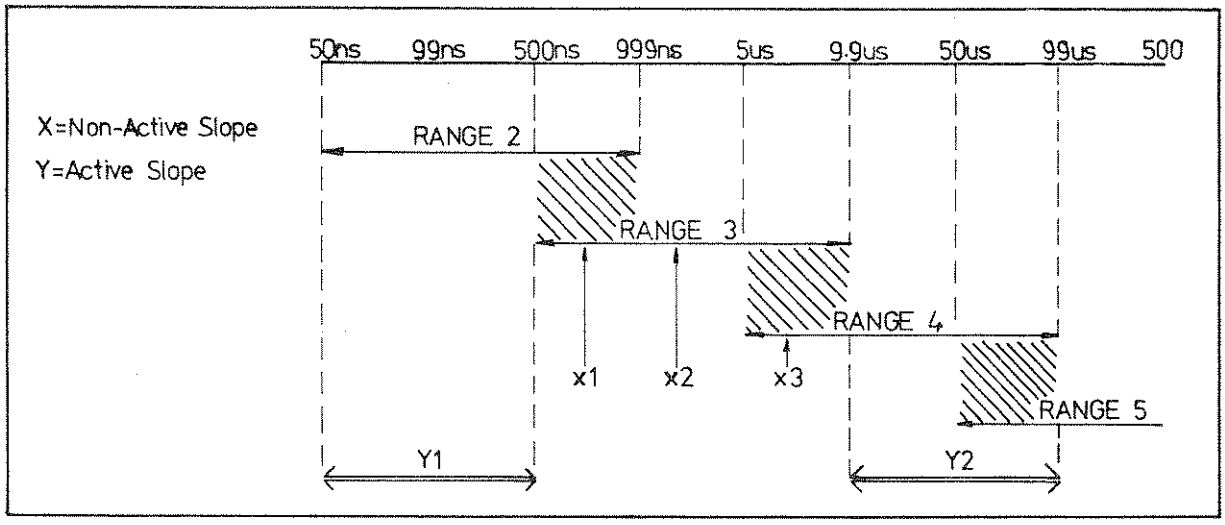
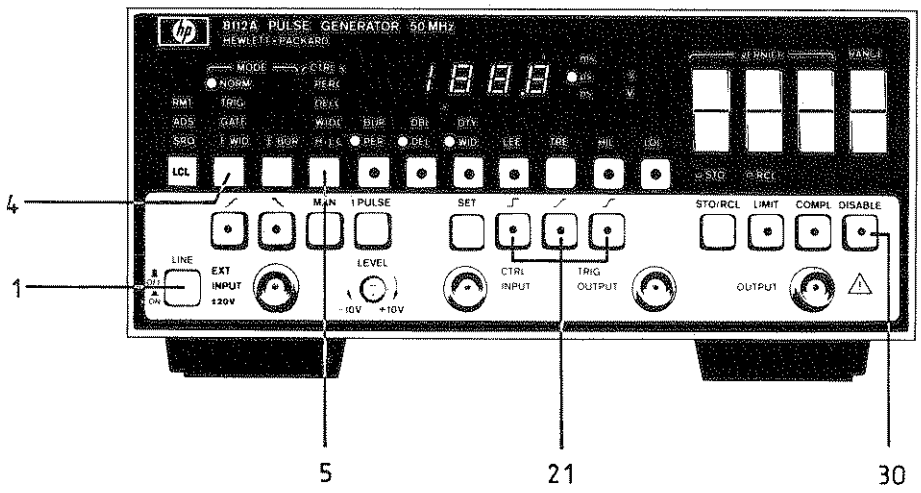


Figure 3-9. Ranging examples



NORM MODE

1. Switch instrument ON at LINE (1).

2. Select NORM mode via key (4). Standard modes are stepped-through by repetitive operation of this key.

3. Select TRANSITION mode at row (21). The parameter menu will be automatically illuminated.

4. Select each parameter in turn, and set it to the desired value using the RANGE/VERNIER keys and the digital display.

5. If a Control function is required, select the mode at key (5) and apply the Control signal to the CRTL INPUT connector. Table 3-1 shows permissible combinations of Operating and Control modes.

6. Select LIMIT and/or COMPL if required. The key LEDs will become illuminated upon selection.

7. Press key (30) to enable the 8112A OUTPUT. The key LED will now be extinguished. The following timing diagram illustrates outputs in the NORM mode.

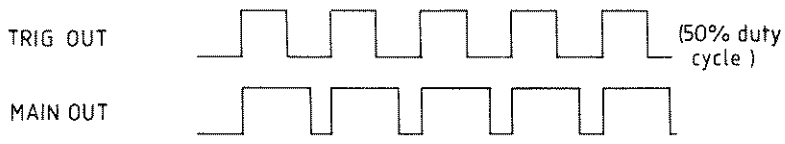
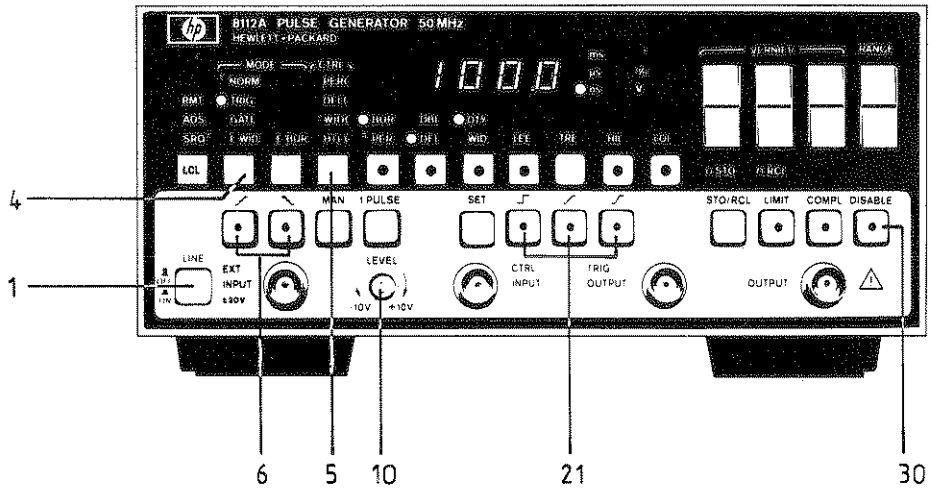


Figure 3-10. NORM mode



TRIG MODE

1. Switch instrument ON at LINE (1).

2. Select TRIG mode via key (4). Standard modes are stepped-through by repetitive operation of this key.

3. Apply the TRIG signal to the EXT INPUT connector. Select Trigger Slope(s) at (6) and threshold at (10). Triggering may be from leading and/or trailing edges may be simulated by pressing the MAN key, in which case, the EXT INPUT is disabled.

4. Select TRANSITION mode at row (21). The parameter menu will be automatically illuminated.

5. Select each parameter in turn and set it to the desired value using the RANGE and VERNIER keys and the digital display.

6. If a Control function is required, select the mode at key (5) and apply the Control signal to the CRTL INPUT connector. Table 3-1 shows permissible combinations of Operating and Control modes.

7. Select LIMIT and/or COMPL if required. The key LEDs will become illuminated upon selection.

8. Press key (30) to enable the 8112A output. The key LED will now be extinguished. The following timing diagram illustrates outputs in the TRIG mode.

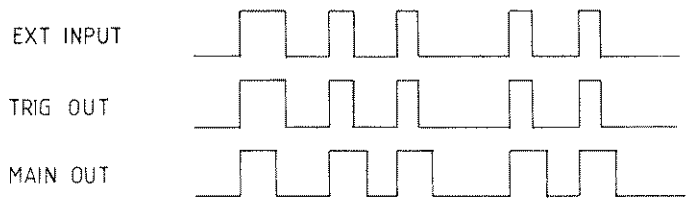
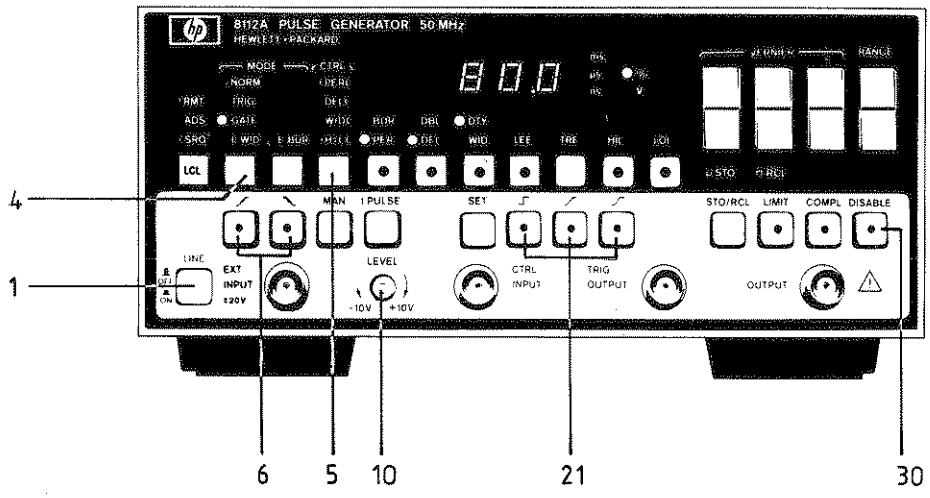


Figure 3-11. TRIG MODE



GATE MODE

1. Switch instrument ON at LINE (1)

2. Select GATE mode via key (4). Standard modes are stepped-through by repetitive operation of this key.

3. Apply the GATE signal to the EXT INPUT connector. Select Trigger Slope at (6) and threshold at (10).

4. Select Transition mode at row (21). The parameter menu will be automatically illuminated.

5. Select each parameter in turn and set it to the desired value using the RANGE /VERNIER keys and the digital display.

6. If a Control function is required, select the mode at key (5) and apply the Control signal to the CRTL INPUT connector. Table 3-1 shows permissible combinations of Operating and Control modes.

7. Select LIMIT and/or COMPL if required. The key LEDs will become illuminated upon selection.

8. Press key (30) to enable the 8112A output. The key LED will now be extinguished. The following timing diagram illustrates outputs in the GATE mode.

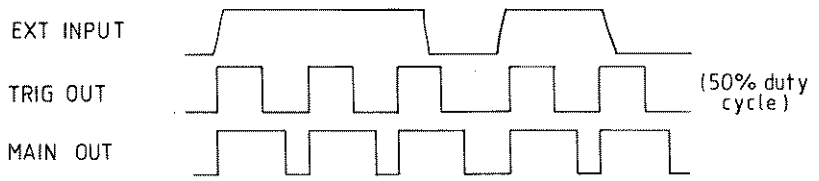
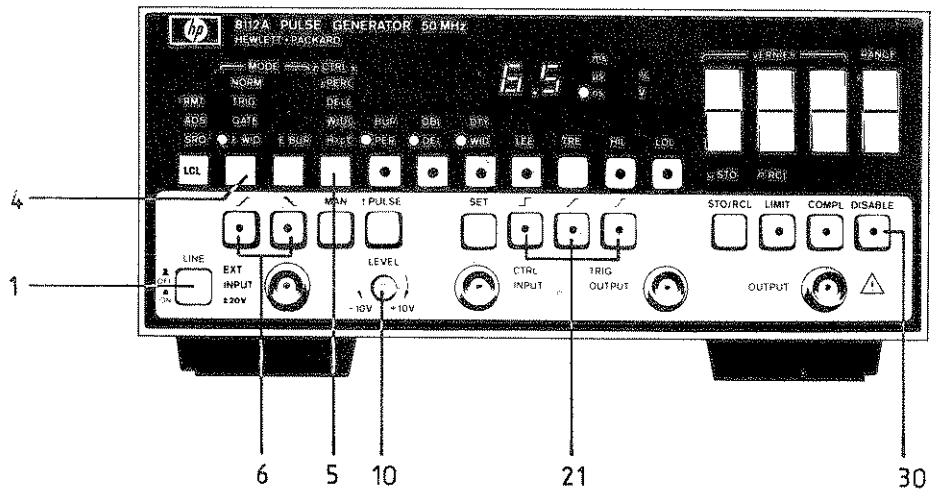


Figure 3-12. GATE MODE



E.WID MODE

1. Switch instrument ON at LINE (1).

2. Select E WID mode via key (4). Standard modes are stepped-through by repetitive operation of this key.

3. Apply the E.WID signal to the EXT INPUT connector. Select Trigger Slope at (6) and threshold at (10).

4. Select Transition mode at row (21). The parameter menu will be automatically illuminated.

5. Select each parameter in turn and set it to the desired value using the RANGE/VERNIER keys and the digital display.

6. If a Control function is required, select the mode at key (5) and apply the Control signal to the CRTL INPUT connector. Table 3-1 shows permissible combinations of Operating and Control modes.

7. Select LIMIT and/or COMPL if required. The key LEDs will become illuminated upon selection.

8. Press key (30) to enable the 8112A output. The key LED will now be extinguished. The following timing diagram illustrates outputs in the E.WID mode.

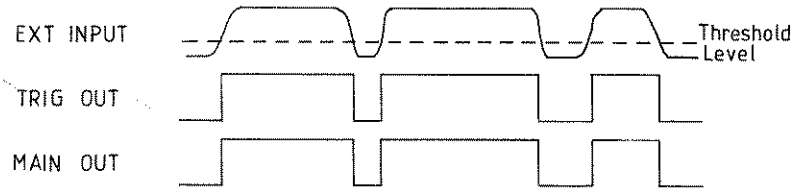
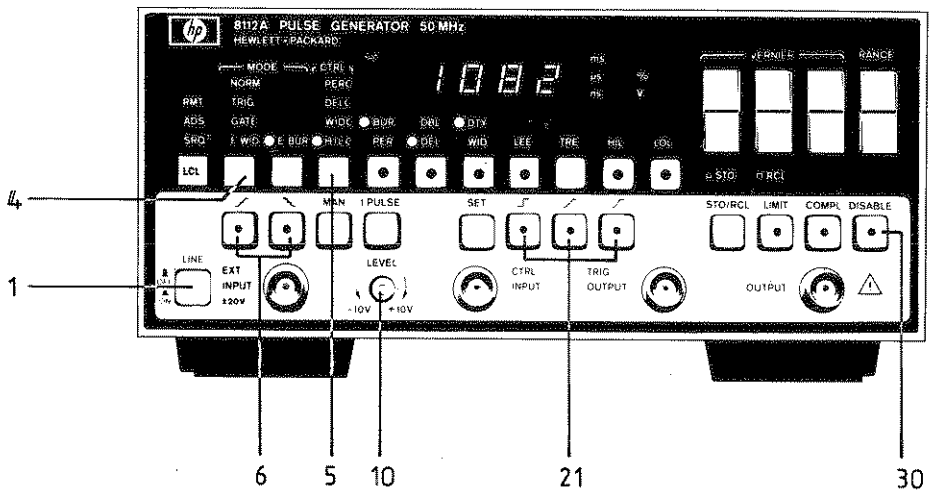


Figure 3-13. E.WID MODE



E.BUR MODE

1. Switch instrument on at line (1).

2. Select E BUR mode via key (4a). Standard modes are stepped-through by repetitive operation of this key.

3. Apply the E BUR signal to the EXT INPUT connector. Select Trigger Slope(s) at (6) and threshold at (10).

4. Select Transistion mode at row (21). The parameter menu will be automatically illuminated.

5. Select each parameter in turn and set it to the desired value using the RANGE/VERNIER keys and the digital display.

6. If a Control function is required, select the mode at the key (5) and apply the Control signal to the CTRL INPUT connector. Table 3-1 shows permissible combinations of Operating and Control modes.

7. SELECT LIMIT and/or COMPL if required. The key LED's will become illuminated upon selection.

8. Press key (30) to enable the 8112A output. The key LED will now be extinguished. The following timing diagram illustrates outputs in the E.BUR mode.

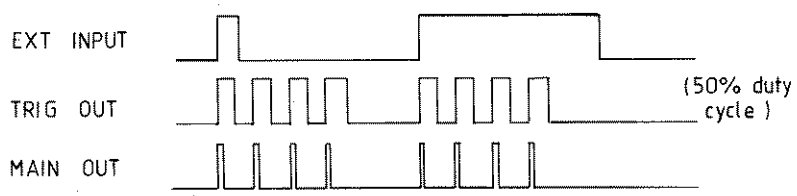


Figure 3-14. E. BUR MODE

MANUAL OPERATING EXAMPLES

The following examples are designed to demonstrate instrument capabilities to the first-time user.

All instructions are based upon front panel operation only. Operating examples for the instrument when under software (HP-IB) control are given in the Programming instructions.

1. Switch the 8112A on at LINE (1).

2. Select the following Mode and Parameter values:

EXAMPLE 1

```
SET      (24) - ON
NORM     (4)  - ON
PER      (15) - 1us
DEL      (16) - 65ns
WID      (17) - 100ns
DBL      (16) - 200ns
LIMIT    (28) - OFF
HIL      (26) - 3.00V
LOL      (27) - -2.00V
FIXED    (21) - ON
LIMIT    (28) - ON
uSTO     (25) - FILE 1
```

```
SET      (24) - ON
TRIG     (4)  - ON
PER      (15) -  10ms
DEL      (16) - 1ms
WID      (17) - 250us
LIMIT    (28) - OFF
HIL      (26) - 5.00V
LOL      (27) - 0.00V
LIMIT    (28) - ON
LINEAR   (21) - ON
LEE      (18) - 50us
TRE      (19) - 50us
POS      (6)  - ON
uSTO     (25) - FILE 2

EXT INPUT(7):
     PERIOD - 1ms
     WIDTH  - 500us
```

EXAMPLE 3

```
SET      (24) - ON
GATE     (4)  - ON
PER      (15) - 10us
DEL      (16) - 100us
WID      (17) - 5us
LIMIT    (28) - OFF
HIL      (26) - 2.00V
LOL      (27) - 0.00V
LIMIT    (28) - ON
GAUSS    (21) - ON
LEE      (18) - 500ns
TRE      (19) - 500ns
POS      (6)  - ON
uSTO     (25) - FILE 3

EXT INPUT(7):
     PERIOD - 10ms
     WIDTH  - 100us
```

EXAMPLE 4

```
SET      (24) - ON
EWID     (4 ) - ON
DEL      (16) - 1us
LIMIT    (28) - OFF
HIL      (26) - 2.00V
LOL      (27) - -3.00V
LIMIT    (28) - ON
LEE      (18) - 250ns
TRE      (19) - 250ns
NEG      (6 ) - ON
uSTO     (25) - FILE 4

EXT INPUT:
     PERIOD - 1ms
     WIDTH  - 1us
     AMPL   - 2.5V
```

EXAMPLE 5

```
SET      (24) - ON
EBUR     (4a) - ON
BUR      (15) - 7#
PER      (15) - 1us
DEL      (16) - 200ns
WID      (17) - 100ns
LIMIT    (28) - OFF
HIL      (26) - 5.00V
LOL      (27) - 0.00V
LIMIT    (28) - ON
FIXED    (21) - ON
COMPL    (6 ) - ON
uSTO     (25) - FILE 5

EXT INPUT:(7)
     PERIOD - 1ms
     WIDTH  - 10us
```

EXAMPLE 6

```
SET      (24) - ON
NORM     (4 ) - ON
WIDC     (5 ) - ON
PER      (15) - 2us
DEL      (16) - 250ns
WID      (17) - 1us
LIMIT    (28) - OFF
HIL      (26) - 3.00V
LOL      (27) - -1.00V
LIMIT    (28) - ON
LINEAR   (20) - ON
LEE      (18) - 30ns
TRE      (19) - 30ns
COMPL    (29) - ON
uSTO     (25) - FILE 6
```

EXAMPLE 6 (continued)

```
CTRL INPUT(11):
     PERIOD - 1s
     DTY    - 50%
     AMPL   - 4.0V
     OFFSET - 0.00V
              SINE
```

EXAMPLE 7

```
SET      (24) - ON
EBUR     (4a) - ON
HILC     (5 ) - ON
BUR      (15) - 3#
PER      (15) - 1us
DEL      (16) - 500ns
DTY      (17) - 25%
LIMIT    (28) - OFF
LOL      (27) - 0.00V
POS      (6 ) - ON
uSTO     (25) - FILE 7

EXT INPUT(7):
     PERIOD - 10us
     WIDTH  - 2us

CTRL INPUT(11): SINE
     PERIOD - 0.5s
     DTY    - 50%
     AMPL   - 4.00V
     OFFSET - 0.00V
```

EXAMPLE 8

```
SET      (24) - ON
TRIG     (4 ) - ON
DELC     (5 ) - ON
PER      (15) -  1ms
DBL      (16) - 100us
WID      (16) - 5us
LIMIT    (28) - OFF
HIL      (26) - 5.00V
LOL      (27) - 1.00V
LIMIT    (28) - ON
FIXED    (21) - ON
LEE      (18) - 1us
TRE      (19) - 1us
POS      (6 ) - ON
uSTO     (25) - FILE 8

EXT INPUT(7):
     PERIOD - 1ms
     WIDTH  - 2us

CTRL INPUT(11):
     PERIOD - 2s
     DTY    - 50%
     AMPL   - 6.00V
     OFFSET - +2.00V
```

PROGRAMMING

3-61 GENERAL

3-62 The 8112A operates on the HP-IB as follows:

Listens: To messages from the HP-IB system controller. In this state, all modes and parameters - except External Trigger LEVEL Adjust are fully programmable. Also available are special HP-IB-only functions to aid the programmer.

Talks: Provides error messages and reports operating parameters.

3-63 The bus lines are as follows (see Figure 3-15), all using negative logic:

8-bit data bus. (lines DI01 to DI08).

Handshake lines. DAV (data valid), NRFD (not ready for data), NDAC (data not accepted).

Control lines. IFC (interface clear), ATN (attention),REN (remote enable), EOI (end or identify), SRQ (service request).

The 8112A uses all lines on the bus; terminations, logic levels and pinouts described in Section 3. For the purposes of this manual, bus information will be restricted to 8112A specifics. For this reason, handshake lines are not discussed and control lines are mentioned only in connection with specific 8112A activity. Permissible codes are presented in Table 3-13. For detailed bus information, refer to any of the following publications:

IEEE	INTERFACE STANDARD	488-1975
ANSI	INTERFACE STANDARD	MC1.1
HP	PUBLICATION	59401-90030
HP	PUBLICATION	5952 -0058

3-64 Address Assignment

3-65 The 8112A HP-IB address is determined by the contents of an internal storage register. This address is initialised at power switch-on by reading the address bits A1 through A5 from the HP-IB Address on the rear panel. Note that this switch is factory preset to decimal 12. To change this address, change the bit settings on the rear panel switch, then press the LCL key to read the new address into the register. Table 3-2 lists all possible addresses on the bus.

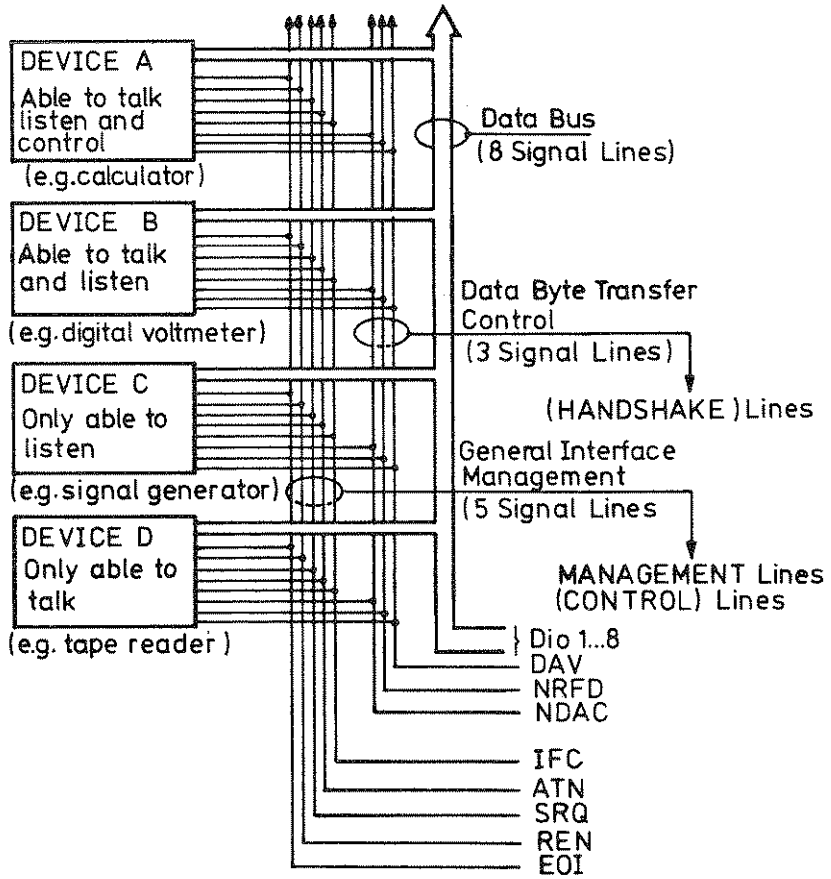


Figure 3-15. HP-IB bus configuration

3-66 The current 8112A HP-IB address can be checked by pressing the LCL key. The address is then displayed in decimal form.

3-67 Talk and Listen addresses are sent along the bus by the system controller with the ATN line true. When an instrument recognises its address, it will respond accordingly i.e. Listen if Listen address has been sent, Talk if the Talk address has been sent. When allocating addresses, ensure that no two instruments have the same address. To program an address, set ATN true and arrange that the ASCII character derived from Table 3-2 appears on the bus. For de-addressing, use UNL, UNT commands (or address another device).

3-68 Remote Operator's Checks

A quick check of the 8112A Talk/Listen functions is provided in Figure 3-16. The program example assumes the 8112A address is set to the factory value (Decimal 12).

Available Addresses (ATN true)									
Data bus (D IO lines)								Address in ASCII	
Fixed			Selectable						
8	7	6	5	4	3	2	1	DEC	Talk / Listen
O	T	L	0	0	0	0	0	0	@ SPACE
O	T	L	0	0	0	0	1	1	A !
O	T	L	0	0	0	1	0	2	B "
O	T	L	0	0	0	1	1	3	C #
O	T	L	0	0	1	0	0	4	D $
O	T	L	0	0	1	0	1	5	E %
O	T	L	0	0	1	1	0	6	F &
O	T	L	0	0	1	1	1	7	G '
O	T	L	0	1	0	0	0	8	H (
O	T	L	0	1	0	0	1	9	I)
O	T	L	0	1	0	1	0	10	J *
O	T	L	0	1	0	1	1	11	K +
O	T	L	0	1	1	0	0	12	L , ←8112A set to this address
O	T	L	0	1	1	0	1	13	M - at factory
O	T	L	0	1	1	1	0	14	N .
O	T	L	0	1	1	1	1	15	O /
O	T	L	1	0	0	0	0	16	P 0
O	T	L	1	0	0	0	1	17	Q 1
O	T	L	1	0	0	1	0	18	R 2
O	T	L	1	0	0	1	1	19	S 3
O	T	L	1	0	1	0	0	20	T 4
O	T	L	1	0	1	0	1	21	U 5 ←Usually controller address
O	T	L	1	0	1	1	0	22	V 6
O	T	L	1	0	1	1	1	23	W 7
O	T	L	1	1	0	0	0	24	X 8
O	T	L	1	1	0	0	1	25	Y 9
O	T	L	1	1	0	1	0	26	Z :
O	T	L	1	1	0	1	1	27	[;
O	T	L	1	1	1	0	0	28	\ <
O	T	L	1	1	1	0	1	29	] =
O	T	L	1	1	1	1	0	30	^ >
O	T	L	1	1	1	1	1	31	_ ? ←Forbidden settings. UNT, UNL commands.

Selector on 8112A rear panel (factory setting)

L = 1 for listen address, 0 for talk address

T = 1 for talk address, 0 for listen address

Table 3-2. Available addresses (ATN true)

3-70 Also implemented in the 8112A is a RAM/hardware self-test routine initialized via HP-IB command "EST"- see Figure 3-17. Tested hardware functions include:

PERIOD GENERATOR
DELAY GENERATOR
SLOPE GENERATOR
WIDTH GENERATOR
OUTPUT AMPLIFIER
BURST COUNTER

3-71 In the event of an error being detected, the 8112A will set any of bits 1 to 6 (which give the error number), and bit 7 - Service Request, (SRQ) of its HP-IB Status Byte to 1. More information on this status byte is given later under "Error Reporting".

3-72 Mode and Parameter Settings (Listener Function)

3-73 When the 8112A is in the Remote (RMT) mode, and has been Listen addressed, it accepts commands which change parameter and/or mode settings. Each mode and parameter-setting command comprises either a number of ASCII data bytes sent serially along the data lines with ATN false or an HP-IB Universal Command. The coding for the bytes is given in Table 3-3, which summarises all mode/parameter setting commands. Note: The HP-IB program code syntax for parameters is identical to front panel mnemonics e.g. PER for Period. Table 3-13 shows the conversion of ASCII bytes to bit patterns on the data bus.

3-74 The 8112A responds to program codes in the data sent in the order in which they are received. Any incompatible parameter settings will be identified when the 8112A has processed all data in the string, and performed a compatibility check at the end of the process. More information on parameter programming sequence is given under "Error Reporting".

3-75 End of String Message (EOS). This must take the form of ASCII character sequence CR,LF,(decimal 13,10), or the bus END command (EOI and ATN true).

Figure 3-17. Talk/Listen Function Check

Flowchart	HPL statement (HP9826 Desk-top Computer)	BASIC statement (HP85 Desktop Computer)	Visual Indicators
START			
Set REN line true to ensure 8112A is in Remote Enable state.	rem 712	REMOTE 712	RMT LED on
Program 8112A Period to 1ms.	wrt 712,"PER 1MS"	OUTPUT 712; "PER 1MS"	RMT and ADS LEDs on. PER key LED on. "1ms" displayed
Interrogate 8112A Period setting.	wrt 712,"IPER" dim A$ 12 red 712, A$	output 712; "IPER" DIM A$ 12 ENTER 712; A$	
Print 8112A Period.	prt A$	PRINT A$	Printout "PER 1 ms"
END			

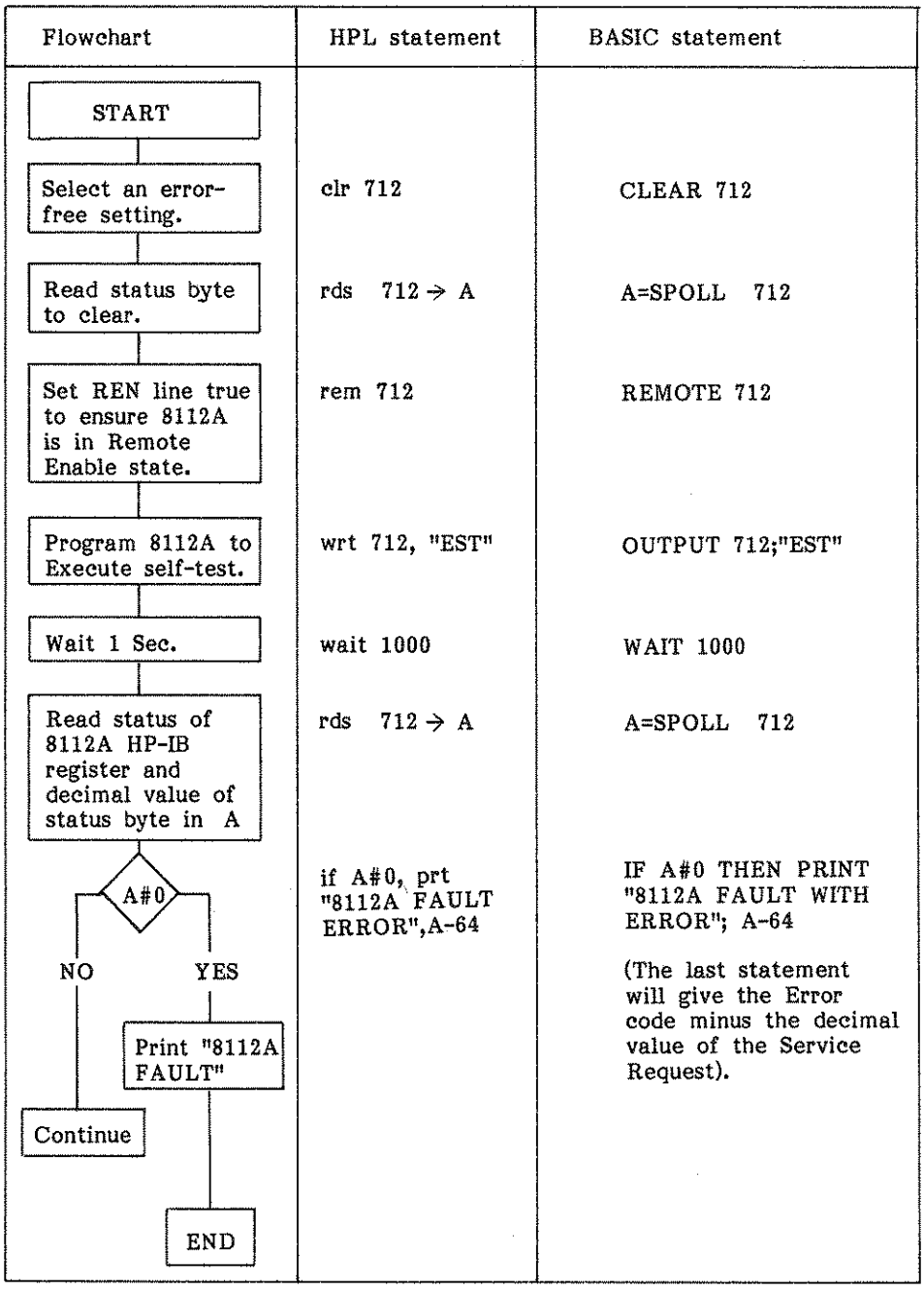


Figure 3-17. RAM/Hardware Check

Table 3-3. 8112A Parameter commands. (listener Function)

Parameter or Operation	Mnemonics ASCII code	Data	ASCII code delimiters	sample statements
OPERATING MODES	M1 M2 M3 M4 M5	NORM TRIG GATE E.WID E.BUR		
CONTROL MODES	CTO CT1 CT2 CT3 CT4	OFF PERC DELC WIDC HILC		
EXT TRIG SLOPE	TO T1 T2 T3	OFF POS NEG BOTH		HPL wrt 712, "HIL 1.00V, LOL-2.54V, L1, C0, D0"
WAVEFORM	W1 W2 W3	FIXED LINEAR GAUSS		BASIC OUTPUT 712: "HIL 1.00V, LOL-2.54V, L1,C0, D0"
PERIOD	PER		NS=nanosecs US=microsecs MS=millisecs	
DELAY	DEL		NS=nanosecs US=microsecs MS=millisecs	
DOUBLE PULSE	DBL		NS=nanosecs US=microsecs MS=millisecs	Sets High Level to 1.00V, Low Level to -2.54V LIMIT 'ON',COMP and DISABLE 'OFF'
DUTY CYCLE	DTY		%	
WIDTH	WID		NS=nanosecs US=microsecs MS=millisecs	
LEADING EDGE	LEE		NS=nanosecs US=microsecs MS=millisecs	
TRAILING EDGE	TRE		NS=nanosecs US=microsecs MS=millisecs	
HIGH LEVEL	HIL		V = VOLT	
LOW LEVEL	LOL		V = VOLT	
BURST	BUR		#	

NOTE: ALL PARAMETER DATA MUST BE ACCOMPANIED BY A DELIMITER.

TABLE 3-3(continued) 8112A Parameter commands (listener Function).

Parameter or Operation	Mnemonics ASCII Code	Data	ASCII code delimiters	Sample statements
LIMIT	L0 L1		OFF ON	
COMPLEMENT	C0 C1		OFF ON	
DISABLE	D0 D1		OFF ON	HPL wrt 712, "HIL
VERNIER KEYS				1.00V, LOL -2.54V L1, C0, D0, PER
MSD UP	MU			10US, DEL 80NS
SSD UP	SU			WID 2.5 US,M1,W1"
LSD UP	LU			
MSD DOWN	MD			
SSD DOWN	SD			
LSD DOWN	LD			
RANGE UP DOWN	RU RD			BASIC OUTPUT 712; "HIL 1.00V, LOL -2.54V L1,C0,D0, PER
SET MODE PARAMETER	SM0 SM1		OFF ON	10 US,DEL 80NS, WID 2.5 US.M1.W1"
EXCESSIVE SLOPE CALCULATION	SR0 SR1		OFF ON	
SELFTEST	EST			Selects NORM mode, Fixed transition mode,HIL=1.00V
STORE PARAMETER SET	STO		1..9	LOL= -2.54V PER=10us DEL=80ns, WID=2.5us
RECALL PARAMETER SET	RCL		0=Standard 1..9 Stored set	LIMIT 'ON',COMPL 'ON' and DISABLE 'OFF'

HP-IB Universal Commands		
GROUP EXECUTE TRIGGER (GET)	BS	Initialise manual trigger0 in TRIG and EBUR mode.
DEVICE CLEAR (DCL)	DC4	Loads Standard Parameter Set stored in 8112A in 8112A ROMs 8112A does not go into addressed mode
SELECTED DEVICE CLEAR	EOT	Loads Standard Parameter Set stored in 8112A ROMS. 8112A goes into addressed mode.

NOTE: ALL PARAMETER DATA MUST BE ACCOMPANIED BY A DELIMITER.

3-76 Mode and Parameter Settings (Talker Function)

3-77 The 8112A can send data messages concerning its mode/parameter settings when in remote and addressed to talk. The available output modes are:

LEARN STRING
INTERROGATE FUNCTION
STATUS

Table 3-4 lists the ASCII commands associated with each of these modes.

3-78 The Learn String consists of a 153 character ASCII string representing the 8112A current settings. The Interrogate Function sends a data message consisting of a 14 character ASCII string representing the current setting of the interrogated parameter.

3-79 The Status Function sends an 8-bit byte in response to a Serial Poll. Bit 8 set to "1" (decimal 128), indicates "Buffer Not Empty". The Buffer described is the HP-IB buffer. If the "Buffer Not Empty" message is sent, it means that there is data still being processed from the last parameter string.

3-80 ERROR REPORTING

3-81 In general, whenever a program or instruction attempts to put the 8112A into an error condition, the instrument responds by making a Service Request i.e. SRQ line set true. Under these circumstances, the system controller can be used to address the 8112A as Talker using a Serial Poll command (SPE). The 8112A will then respond by outputting an error message onto the data bus. This message consists of a single 8-bit byte in which SRQ (bit 7) is set true ("1"), and bits 1 to 6 comprise the error code. The contents of this byte are shown in detail in Table 3-5.

3-82 As can be seen from Table 3-5, bits 1 to 6 are each allocated to an error type. i.e. TIMING, SLOPE and SYNTAX. In each case the bit is set to "1" for error information.

3-83 Should a more detailed description of the error be required (e.g. delay error or width error when TIMING ERROR is indicated by the Status Byte), the "Interrogate Error" (IERR) command can be implemented. Table 3-6 shows the relationship between the various status byte errors and ASCII error strings. Tables 3-7 to 3-11 list the 8112A responses to the IERR command for TIMING, SLOPE, LIMIT, DUTY-CYCLE and INPUT ERRORS respectively.

Table 3-4. Talker Function Commands

Command	ASCII Command	Sample Statements	
		HPL	BASIC
CURRENT SETTING	CST	(HP9826) dim A$(142) wrt 712,"CST" red 712, A$	(HP 85) DIM A$ (153) OUTPUT 712;"CST" ENTER 712: A$
INTERROGATE PARAMETER	IPER IDEL IDBL IDTY IWID ILEE ITRE IHIL ILOL IBUR	dim A$ (14) wrt 712, "IPER" red 712, A$	DIM A$ (14) OUTPUT 712;"IPER" ENTER 712; A$
INTERROGATE ERROR	IERR	dim A$ (24) wrt 712;"IERR" red 712, A$	DIM A$ (24) OUTPUT 712; "IERR" ENTER 712; A$
INTERROGATE PARAMETER SET	IRCL0 (Standard) IRCL1...9 (stored set)	dim A$ (148) wrt 712; "IRCL2" red 712,A$	DIM A$ (153) OUTPUT 712; "IRCL2" ENTER 712; A$

3-84 Service Request. Bit 7 of the HP-IB Status Byte is usually set in conjunction with any of bits 1 to 6 (error indicators).

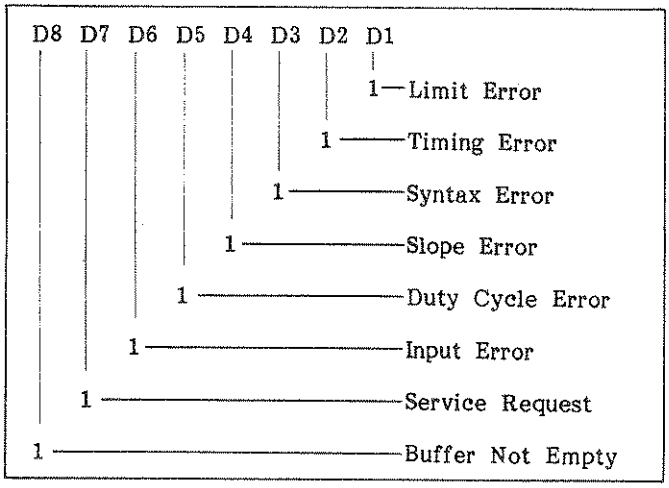


Table 3-5. HP-IB Status Error.

Status Byte	ASCII Error String
Limit Error	Limit Error Limit-HILC
Timing Error	Delay Error Width Error
Syntax Error	Value error may be "no error"*
Slope Error	Excessive Slope
Duty Cycle Error	Duty-PERC Duty-WIDC Duty-Trigger
Input Error	EWID-PERC EWID-DELC EWID-WIDC Trigger-PERC Gate-both Trigger slopes EWID-both Trigger slopes
No Error Occurred	No Error

* This "no error" indication may be as a result of unrecognised input data. e.g. DDY 50% instead of DTY 50%.

Table 3-6. Interrogate Error Mode

ASCII string	Remarks
DELAY ERROR (12 characters)	1. Delay value is greater than Period value. i.e. PER 1ms, DEL 1.1ms. 2. Frontpanel LEDs blink to indicate Error. 3. ERROR LED on.
WIDTH ERROR (12 characters)	1. Width value is greater than Period value. i.e. PER 1ms, WID 1.1ms. 2. Frontpanel LEDs blink to indicate Error. 3. ERROR LED on.

Table 3-7. Timing Error (shown in NORM mode only).

ASCII string	Remarks
EXCESSIVE SLOPE (16 characters)	1. No valid waveform at the output. a) LEE > WID*0.8 or (PER*DTY/100)*0.8 b) TRE > (PER-WID)*0.8 or (PER-(PER*DTY/100))*0.8 c) TRE ≥ (DBL-WID)*0.8 or (DBL-PER*DTY/200)*0.8 d) TRE > (PER-DBL-WID)*0.8 or (PER-DBL-(PER*DTY/200))*0.8 2. No calculation with "SR1".

Table 3-8. Slope Error. (Linear and Gauss modes).

ASCII string	Remarks
LIMIT ERROR (12 characters)	This error appears only when LIMIT is on and; a) the programmed High Level is greater than the limited High Level. b) the programmed Low Level is lower than the limited Low Level.
LIMIT-HILC	This error occurs only when LIMIT is on and; a) High Level Control has been selected. b) No High Level limit is possible as HILC is an external Control voltage.

Table 3-9. Limit Error.

3-85 SLOPE ERROR indication (bit4). The "EXCESSIVE SLOPE" message and calculation can be suppressed via the command "SRO" e.g.

(HPL) wrt 712, "SRO"
(BASIC) OUTPUT 712; "SRO"

This is particularly useful for character strings where a multiple of the same timing parameter is programmed. For example:

for "A" = 1 to 100
by 1
PER "A" ms

Immediately upon receiving the new PERIOD value, the 8112A would calculate the excessive slope error for each period time interval. By suppressing "EXCESSIVE SLOPE", new settings for Period are accepted by the 8112A without any calculation, and a reduction in programming time of typically 30mS may be achieved.

ASCII string	Remarks
DTY-PERC (9 characters)	Duty Cycle not available in PERC. An external voltage controls the Period and NOT the Duty Cycle.
DTY-WIDC (9 characters)	As above. External voltage controls the Width and NOT the Duty Cycle.
DTY-TRIG (12 characters)	An external trigger signal generates the Period. The displayed Duty Cycle is calculated from the internal Period. DTY is not confirmed with the external period.

Table 3-10. Duty Cycle Error

ASCII string	Remarks
EWID-PERC -DELC -WIDC (11 characters)	The external trigger input signal is passed through to the output. A Control input cannot alter Period, Delay or Width.
TRIG-PERC (15 characters)	Both inputs will attempt to control the Period. This is not possible.
GATE-TRIG slope (16 characters)	Both EXT INPUT slopes selected. EITHER leading edge OR trailing edge may be selected - NOT both.
EWID-TRIG slope (16 characters)	As above. EITHER leading edge OR trailing edge may be selected - NOT both.

Table 3-11. Input Error.

Note: In the permanently stored Mode/Parameter settings in the 8112A ROMs, "SR" is set to "0". In the event of these settings being recalled as current settings the Service Request function can be re-activated by programming "SR" to "1". e.g:

(HPL) wrt 712, "SR1"
(BASIC) OUTPUT 712; "SR1".

The LCL key re-activates the Excessive Slope Error.

3-86 Remote Capability. In Remote Mode, all 8112A frontpanel controls are disabled except for LINE, LCL and EXT TRIG LEVEL adjust. When addressed to Listen, the 8112A will respond to the following bus messages; Data, Local Lockout, Clear Lockout/Set Local and Abort. When addressed to Talk, the 8112A will send one of the following messages; Data, Require Service or Status Byte.

3-87 The RMT LED is on when the 8112A is in Remote Mode. The ADS LED is on when the 8112A has been addressed to Talk or Listen. The frontpanel digital display shows the value of the last parameter to be programmed - except for Fixed Transition mode, when 4.5 ns will be displayed.

Local-to-Remote Change. The 8112A switches to Remote when the two-part Remote message has been received. Namely; Remote Enable (REN).

Addressed to Listen or Talk (MLA or MTA). The 8112A output signal and all Control settings remain unchanged with the Local -to-Remote transition.

3-88 Remote-to-Local Change. The 8112A returns to Local Control when the Local or Clear Lockout/Set message has been received. It can also be set to Local by pressing the front panel LCL key (assuming that Local Lockout is not in effect). The Output signal and all Control settings remain unchanged with the Remote to Local transition.

3-89 Local Lockout. When a data transmission is interrupted (perhaps by returning the 8112A to Local via the LCL key), there is a possibility of data being lost. This could render the 8112A to an unknown state. To prevent this occurence it is recommended that a Local Lockout command be sent from the Controller to disable the LCL key. Local Lockout remains in effect until the 8112A is returned to the Local state by turning the LINE switch OFF/ON, or programming the Local message.

Note: When a "LCL 7" command has been sent - returning all devices on the bus to Local (frontpanel) control, an "RMT 7" command is required before any devices can be brought back under HP-IB control. "7" is a general bus address, and unless specific device addresses are programmed, ALL devices on the bus will be affected. The address in the case of the 8112A will always be "712" (unless the address switch on the 8112A rear panel is altered). When "LCL 712" has been sent however, an "OUTPUT 712" (BASIC), or "wrt 712;" (HPL) command will be sufficient to return the 8112A to HP-IB control.

3-90 UNIVERSAL HP-IB CODES

3-91 The 8112A will respond to the Universal Commands listed in Table 3-12 which are sent in the Command Mode (ATN true).

Table 3-12. Universal Commands and additional HP-IB capabilities

Mnemonic	Command	ASCII code
DCL	Device Clear	DC4
LLO	Local Lockout	DC1
MLA	My Listen Address	(selectable)
MTA	My Talk Address	(selectable)
SPD	Serial Poll Disable	EM
SPE	Serial Poll Enable	CAN
UNL	Unlisten	?
UNT	Untalk	-
GET	Group Execute Trigger	BS
GTL	Go To Local	SOH
SDC	Selected Device Clear	EOT

Code	Function
SH1	Source Handshake capability.
AH1	Acceptor Handshake capability.
T6	Talker (basic talker, serial poll), deaddressed to talk if addressed to listen.
L4	Listener (basic listener), deaddressed as listener when addressed to talk.
SR1	Service request capability.
RL1	Remote/local capability (including local lockout to prevent interference with a running program.
PP0	No parallel poll capability.
DC1	Device clear capability.
DT1	Device trigger capability (Trig, Burst modes).modes).

Table 3-13. ASCII code assignments

Apply only in Command Mode (ATN true).

These characters cause SRQ.

These characters are ignored.

HP-IB DATA LINES. 7 6 5 / 4 3 2 1	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
0 0 0 0 0	NUL	DLE	SP	0	@	P	`	p
0 0 0 1 1	SOH GTL	DC1 LLO	!	1	A	Q	a	q
0 0 1 0 2	STX	DC2	"	2	B	R	b	r
0 0 1 1 3	ETX	DC3	#	3	C	S	c	s
0 1 0 0 4	EOT SDC	DC4 DCL	$	4	D	T	d	t
0 1 0 1 5	ENQ	NAK	%	5	E	U	e	u
0 1 1 0 6	ACK	SYN	&	6	F	V	f	v
0 1 1 1 7	BEL	ETB	'	7	G	W	g	w
1 0 0 0 8	BS GET	CAN SPE	(	8	H	X	h	x
1 0 0 1 9	HT	EM SPD	)	9	I	Y	i	y
1 0 1 0 10	LF	SUB	*	:	J	Z	j	z
1 0 1 1 11	VT	ESC	+	;	K	[	k	{
1 1 0 0 12	FF	FS	,	<	L	\	l	|
1 1 0 1 13	CR	GS	-	=	M	]	m	}
1 1 1 0 14	SO	RS	.	>	N	^	n	~
1 1 1 1 15	SI	US	/	? UNL	O	_ UNT	o	DEL

ASSIGNED LISTEN ADDRESS

ASSIGNED LISTEN ADDRESS

ASSIGNED TALK ADDRESS

ASSIGNED TALK ADDRESS