User Manual
8023/8024
50/100 MHz
Arbitrary Waveform/Function Generator

Serial Prefix: 82

Tabor Electronics Ltd.

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REVISION: D

Warranty

Tabor Electronics' products are warranted against defects in material and workmanship, when used under normal operating conditions, for a period of one year after delivery. Tabor Electronics will repair or replace without charge any product which proves defective during this period. Repair necessitated by misuse of the product is not covered by this warranty. No other warranties are expressed or implied, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. Tabor Electronics is not liable for consequential damage.

REPAIR AND CALIBRATION

Prior authorization is required from Tabor Electronics before products are returned for service. All service must be performed by Tabor Electronics' factory or an authorized service center. Please contact the factory directly for repair and re-calibration:

Tabor Electronics, Ltd.
9 Hatasia Street
Tel Hanan, Israel 20302
Tel: (972) 4 821-3393
Fax: (972) 4 821-3388

REPAIR AND CALIBRATION REQUEST FORM

To allow us to better understand your repair requests, we suggest you use the following outline when calling and include a copy with your instrument to be sent to the Tabor Repair Facility.

Model_____Serial No._____Date_____

Company Name_____Purchase Order #_____

Billing Address_____
                                          City

_____
        State/Province   Zip/Postal Code   Country

Shipping Address_____
                                          City

_____
        State/Province   Zip/Postal Code   Country

Technical Contact_____Phone Number (   )_____
Purchasing Contact _____Phone Number (   )_____

1. Describe, in detail, the problem and symptoms you are having. Please include all set up details, such as input/output levels, frequencies, waveform details, etc.

_____

_____

_____

_____

2. If problem is occurring when unit is in remote, please list the program strings used and the controller type.

_____

_____

_____

3. Please give any additional information you feel would be beneficial in facilitating a faster repair time (i.e., modifications, etc.)

_____

_____

_____

4. Is calibration data required?   Yes   No   (please circle one)

Call before shipping   Ship instruments to nearest support office
Note: We do not accept   listed on back.
"collect" shipments.

Safety Precautions

The following safety precautions should be observed before using this product and associated computer. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present. This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product. Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cables, connector jacks, or test fixtures.

The American National Standard Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60 VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before touching or disconnecting the line cord. Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables and test leads for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other of the instrument parts while power is applied to the circuit under test. ALWAYS remove power from the entire test system before connecting cables or jumpers, installing or removing cards from the computer, or making internal changes, such as changing card address. Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always keep dry hands while handling the instrument. If you are using test fixtures, keep the lid closed while power is applied to the device under test. Safe operation requires that the computer lid be closed at all times during operation.

Carefully read the Safety Precautions instructions that are supplied with your computer. Instruments, cables, leads or cords should not be connected to humans. Before performing any maintenance, disconnect the line cord and all test cables. Finally, maintenance should be performed by qualified service personnel only. If you have no past experience in instrument servicing, we strongly recommend that installation and initial tests on the instrument be done by your dealer or by the factory itself.

Declaration of Conformity

We:

Tabor Electronics, Ltd.

P.O. Box 404

Tel Hanan, Israel 20302

declare, that the Arbitrary Waveform/Function Generator

Model 8023 and model 8024

meets the intent of Directive 89/336/EEC for Electromagnetic Compatibility and complies with the requirements of the Low Voltage Directive 73/23/EEC. Compliance was demonstrated to the following specifications as listed in the official Journal of the European Communities:

Safety:

EN 61010-1

   IEC 1010-1 (1990) + Amendment 1 (1992)

EMC:

EN 50081-1 Emissions:

   EN 55022 - Radiated, Class B

   EN 55022 - Conducted, Class B

EN 50082-1 Immunity:

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1

General Information

1-1. Introduction

This manual provides operating and maintenance information for the Models 8023 and 8024 - Arbitrary Waveform Generator. Section 1 is a general description of the instrument. Sections 2 and 3 contain installation and operation instructions. IEEE-488.2 (GPIB) programming is explained in Section 4. Maintenance and performance checks are provided in section 5. The theory of operation is described in section 6. Section 7 outlines calibration and trouble shooting procedure. Section 8 contain tables of replaceable parts and recommended spare parts. Appendix D, at the end of this manual, contains schematic and component location diagrams.

NOTE

This manual provides complete description of all features and options that are common to Model 8023 and Model 8024. Model 8023 is limited in its sampling clock to 50MHz. Sinewave and square-wave frequency in Model 8023 is limited to 25MHz. Throughout the whole manual, substitute these values where applicable.

1-2. Description

Model 8024 is an extremely high-performance programmable arbitrary waveform generator. Model 8024 combines two powerful instruments in one small package: function generator, and arbitrary waveform generator. It provides a variety of standard waveforms, to be used as test stimuli for different electronic devices. Model 8024 is capable of generating arbitrary waveforms with sampling rates to 100 MHz and with 12 bits of vertical resolution. Microprocessor-based, Model 8024 is easy to set up for manual use. It is also simple to program in a GPIB system environments.

The instrument is built in metal case for improved RFI and EMI shielding. It is housed in a size to fit half-rack enclosures. Despite its small size, Model 8024 offers many features and functions, such as counted burst, internal trigger-generator, full implementation of the new IEEE-488.2 standard, SCPI language compatibility, and more. Model 8024 guarantees high quality waveforms throughout the specified frequency range, amplitude span, and operating temperature.

Model 8024 covers a frequency range from 10 μHz to 100 MHz and an amplitude span from 10 mV to 20 Vp-p. Such broad coverage warrants a variety of complex applications. Rapid, repeatable testing every time is assured by a non volatile memory. Up to 10 front panel setups can be stored and recalled for later use; ensuring exact duplication of previous tests and status. Its performance, programmability and economy make it equally at home in every laboratory.

Besides its normal continuous mode, Model 8024 offers a variety of interrupted modes. The output waveform may be gated, triggered, or may generate a counted burst of waveforms. A built-in trigger generator, which

has a programmable period, can replace an external trigger stimulant. The MANUAL trigger is just an additional convenience for front panel operation.

Model 8024 provides an output level from 20 mV to 20 Vp-p into open circuit or 10 mV to 10 Vp-p into 50 Ω. DC offset plus amplitude are independently variable within three level windows: ±10 V, ±1 V and ±100 mV. This special characteristic allows generation of extremely small signals, at elevated DC levels.

Model 8024 is capable of generating arbitrary waveforms with 12 bits of resolution. There are a few standard waveforms which are memory-resident. Other waveforms may be generated either manually, or downloaded from computers to the instrument using the GPIB link. Waveforms may also be generated using the Wave-CAD program. The wave generation software package - WaveCAD, is available from Tabor, contact your local representative for details.

The arbitrary memory may store waveforms up to 64 long. If smaller size portions are needed, the memory may be divided to 99 smaller segments. A built-in circuit controls the sequence and the number of times that each segment is replayed. The sequencing circuit, operating at a sampling rate of 100 MHz can generate extremely long waveforms which, otherwise, require much larger memory depth.

1-3. Instrument & Manual

Identification

The serial number of the instrument is located on the rear panel of the instrument. The two most significant digits identify instrument modifications. If this prefix differs from that listed on the title page of this manual, there are differences between this manual and your instrument.

Technical corrections to this manual (if any) are listed in the back of this manual on an enclosed MANUAL CHANGES sheet.

1-4. Options

Model 8024 does not offer any options. It comes complete and ready to operate with GPIB interface. Model 8024 includes WaveCAD - Waveform Generation Pro-

gram that lets you create and edit waveforms on any personal coputer. If you did not receive WaveCAD with your instrument, please contact Tabor Electronics or your nearest representative and ask for the free Wave-CAD software package.

1-5. Safety Considerations

Model 8024 has been manufactured according to international safety standards. The instrument meets VDE 0411/03.81 and UL 1244 standards for safety of commercial electronic measuring and test equipment for instruments with an exposed metal chassis that is directly connected to earth via the power supply cable. Before the instrument is switched on, make sure that protective earth terminal is connected to a protective earth via the power cord. Do not remove instrument covers when operating or when power cord is connected to mains.

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

1-6. Supplied Accessories

Model 8024 is supplied with a power cord, instructions manual. WaveCAD software and WaveCAD manual are also included.

1-7. Specifications

Instrument specifications are listed in Tables 1-1. These specifications are the performance standards or limits against which the instrument is tested. For model 8023, substitute maximum sampling rate with 50 MHz.Sinewave and squarewave frequency is limited to 25MHz on Model 8023.

NOTE

All specifications in the following table apply under the following conditions: Output terminated into 50 Ω, after 30 minutes of warm-up time, and within a temperature range of 20°C to 30°C.

Table 1-1. Model 8024 - Specifications.

OUTPUT CHARACTERISTICS

Output:	Via front panel OUTPUT BNC terminal.
Stand-by:	Output Normal or Minimum signal.
Impedance:	50 Ω, ±2%.
Protection:	Protected against continuous short to case ground.
Glitch Energy:	1 nV-s at 10 Vp-p
Amplitude:	20 mV to 20 Vp-p, into open circuit;
	10 mV to 10 Vp-p, into 50 Ω.
Resolution:	3 digits.
Accuracy (1 KHz):	±(2%+20 mV), from 1 V to 10 V;
	±(3%+4 mV), from 100 mV to 1 V;
	±(4%+2 mV), from 10 mV to 100 mV.
Offset	
Dependency:	Offset and Amplitude are independently adjustable within level windows:
	±5 V, ±500 mV, and ±50 mV.
Range:	0 to ±4.50 V, within ±5 V window;
	0 to ±450 mV, within ±500 mV window;
	0 to ±45.0 mV, within ±50 mV window.
Resolution:	3 digits
Accuracy:	±(2% +1% of amplitude +20 mV), within 5 V window;
	±(3% +1% of amplitude +5 mV), within 500 mV window;
	±(4% +1% of amplitude +2 mV), within 50 mV window.
Filters:	50 MHz 7-pole elliptic;
	25 MHz 7-pole elliptic;
	20 MHz 7-pole Gaussian.
Square Wave, Pulse	
Rise/Fall time:	6 ns typical, 10% to 90% of amplitude.
Aberration:	<5%.
SYNC Output:	Via front panel SYNC OUT BNC terminal.
Level:	TTL.

TRIGGERING CHARACTERISTICS

Trigger Input:	Via rear panel TRIG IN BNC terminal.
Impedance:	1 KΩ, ±5%.
Level:	TTL
Max Input Voltage:	±10 V.
Min Pulse Width:	15 ns.
Slope:	Positive going leading edges.
Source:	Manual (front panel button), internal, or external stimulant.
Modes	
Normal:	Continuous waveform is generated.
Triggered:	Each input cycle generates a single output cycle.
Internal Trigger:	An internal timer repeatedly generates a single output cycle

Table 1-1. Model 8024 - Specifications (continued).

Gated:	External signal enables generator. First output cycle synchronous with the active slope of the triggering signal. Last cycle of output waveform always completed.
External Burst:	Preset number of cycles stimulated by an internal, external, or manual trigger.
Internal Burst:	An internal timer repeatedly generates a burst of counted output cycles
Trigger Frequency	
External:	To 10 MHz, or GPIB trigger.
Internal:	From 20 µs to 999 s;
Manual:	Simulates an external trigger signal.

STANDARD WAVEFORMS

Frequency Range:	Waveform dependent.
Source:	Internal synthesizer
Resolution:	4 digits
Accuracy:	±0.01% of reading
Stability:	100 ppm
Sine	
Frequency Range:	10 µHz to 50 MHz.
Distortion:	<0.1%, below 100 KHz.
Harmonics:	<30dB below carrier, 100 KHz to 50 MHz.
Band Flatness:	1%, to 1 MHz; 5% to 10 MHz; 15%, to 50 MHz.
Adjustable Parameters	
Start Phase:	0 to 360°.
Power (sine^x):	1 to 9.
Triangle	
Frequency Range:	10 µHz to 10 MHz.
Adjustable Parameters	
Start Phase:	0 to 360°.
Power (sine^x):	1 to 9.
Square	
Frequency Range:	10 µHz to 50 MHz.
Adjustable Parameters	
Duty Cycle:	1% to 50%
Pulse/Ramp	
Frequency Range:	10 µHz to 1 MHz.
Adjustable Parameters	
Delay:	0% to 99.9% of period
Rise Time:	0% to 99.9% of period
High Time:	0% to 99.9% of period
Fall Time:	0% to 99.9% of period
Sinc (Sine(x)/x)	
Frequency Range:	10 µHz to 1 MHz.
Adjustable Parameters	
Cycles:	4 to 999 cycles.

Table 1-1. Model 8024 Specifications (continued).

Gaussian Pulse	
Frequency Range:	10 µHz to 1 MHz.
Adjustable Parameters	
Time Constant:	1000 to 65,535.
Exponential Decaying/	
Rising Pulse	
Frequency Range:	10 µHz to 1 MHz.
Adjustable Parameters	
Time Constant:	0 to 20.
DC	
Range:	1% to 100% of amplitude.

ARBITRARY WAVEFORMS

Waveform Memory:	64 K points.
Memory Segmentation	
Number of Segments:	1 to 99
Min Segment Size:	10 point
Vertical Resolution:	12 bits (4096 points).
Sinewave	
Total Harmonic Distortion (at 4096 vertical points and sampling rate of 100 MHz):	
	<0.1%, below 100 KHz.
Harmonic Signals Below the Carrier Level (at 4096 vertical points, below Nyquist frequency):	
	>50dB, 100KHz to 1MHz;
	>45dB, 1MHz to 3.125MHz
Sampling Clock	
Source:	Internal synthesizer, external clock, internal reference.
Range:	
Internal:	10 mHz to 100 MHz,
External:	To 100 MHz.
Internal Reference:	10 MHz, fixed internal crystal clock frequency.
Resolution:	4 digits
Accuracy:	±0.01% of reading,
Stability:	100 ppm.
Built-In Utilities:	Permit global operations on memory segments.
Clear:	Clears a selected memory segment.
Fill:	Fills a selected memory segment with constant data.
Invert:	Inverts contents of active segment..
Offset:	Offsets a waveform in a selected memory segment.
AM:	Modulates segment's contents with a sine waveform.

SEQUENCED WAVEFORMS

Operation:	Permits division of the main memory into smaller segments. The segments may be linked and repeated to generate extremely long waveforms.
Number of Sequences:	From 0 to 9, front panel selection.
Number of Steps:	From 0 to 99 steps, each sequence.
Repeated Segments:	From 0 to 32767 loops, each segment.

Table 1-3. Model 8024 - Specifications (continued).

Segment Duration:	Minimum 100 ns for more than one loop.
Sampling Clock	
Source:	Internal synthesizer, external clock, 10 MHz internal reference.
Range:	
Internal:	10 mHz to 100 MHz,
External:	To 100 MHz.
Internal Reference:	10 MHz, fixed internal crystal clock frequency.
Resolution:	4 digits
Accuracy:	±0.01% of reading,
Stability:	100 ppm.

ENVIRONMENTAL

Operating Temperature:	0° to +40°C, ambient.
Specified Accuracy:	Within +25°C ±5°C.
Storage Temperature:	−40°C to +70°C.
Humidity range:	80% R.H.

GENERAL

Display:	2 lines, 16 characters, back-lit LCD.
Power:	115/230 Vac, 50 or 60 Hz, 60 VA max.
Stored Set-ups:	Stores 10 complete front panel set-ups.
Dimensions:	3.5" x 8.3" x 15.4" (H x W x L).
Rack Mount Dimensions:	3.5" x 19" (H x W).
Weight:	Approximately 12 Lbs.

GPIB INTERFACE (IEEE-488.2)

Interface Functions:	Complies with IEEE-488.2 standard.
Programmable controls:	All front panel controls except POWER switch.
Subsets:	SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP2, DC1, DT1, C0.
Program Message Format:	Program Message Header, Program Data (floating point and/or suffix program data), Program Message Terminator.
Response Message Format:	Variable length response format consisting of Response Header, Response Data (NR1, NR2, or NR3 format), and Response Message Terminator.
Common Commands and Queries:	*CLS, *ESE, *ESE?, *ESR, *IDN?, *OPC, *OPC?, *RCL, *RST, *SAV, *SRE, *SRE?, *STB, *TRG, *TST?, *WAI.
Status Reporting:	*ESR?, *STB?, and RQS - read by Serial Poll.

2

Installation

2-1. Introduction

This section contains information and instructions necessary for the installation and shipping of the Arbitrary/Waveform generators - 8024. Details are provided for initial inspection, power connection, grounding safety requirements, installation information, and re-packing instructions for storage or shipment.

2-2. Unpacking & Initial Inspection

Unpacking and handling of the generator requires only the normal precautions and procedures applicable to the handling of sensitive electronic equipment. The contents of all shipping containers should be checked for included accessories and certified against the packing slip to ascertain that the shipment is complete.

2-3. Safety Precautions

The following safety precautions should be observed before using this product and associated computer. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cables, connector jacks, or test fixtures. The American National

Standard Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before touching or disconnecting the line cord.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables and test leads for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other of the instrument parts while power is applied to the circuit under test. ALWAYS remove power from the entire test system before connecting cables or jumpers, installing or removing cards from the computer, or making internal changes, such as changing card address.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always keep dry hands while handling the instrument.

If you are using test fixtures, keep the lid closed while power is applied to the device under test. Safe operation requires that the computer lid be closed at all times during operation. Carefully read the Safety Precautions instructions that are supplied with your computer.

Instruments, cables, leads or cords should not be connected to humans. Before performing any maintenance, disconnect the line cord and all test cables.

Finally, maintenance should be performed by qualified service personnel only. If you have no past experience in computer servicing, we strongly recommend that installation and initial tests on the instrument be done by your computer dealer or by the factory itself. Use the enclosed Service Form when you return the instrument for service.

2-4. Performance Checks

The instrument was carefully inspected for mechanical and electrical performance before shipment from the factory. It should be free of physical defects and in perfect electrical order upon receipt. Check the instrument for damage in transit and perform the electrical procedures outlined in Section 5. If there is indication of damage or deficiency, see the warranty in this manual and notify Tabor Electronics.

CAUTION

It is recommended that the operator be fully familiar with the specifications and all sections of this manual. Failure to do so may compromise the warranty and the accuracy which Taboe Electronics has engineered into your instrument.

2-5. Power Requirements

The function generator may be operated from any one of the following sources: a. 103.5 to 126.5 Volts (115 Volts, NOMINAL) b. 207 to 253 Volts (230 Volts, NOMINAL).

The instrument operates over the power mains frequency range of 48 to 63Hz. Always verify that the operating power mains voltage is the same as that specified on the rear panel voltage selector switch.

CAUTION

Failure to switch the instrument to match the operating line voltage will damage the instrument and may void the warranty.

The Model 8024 should be operated from a power source with its neutral at or near ground (earth potential). The instrument is not intended for operation from two phases of a multi-phase ac system or across the legs of a single-phase, three-wire ac power system. Crest factor (ratio of peak voltage to rms) should be

typically within the range of 1.3 to 1.6 at 10% of the nominal rms mains voltage.

2-6. Grounding Requirements

To insure the safety of operating personnel, the U.S. O.S.H.A. (Occupational Safety and Health) requirement and good engineering practice mandate that the instrument panel and enclosure be "earth" grounded. All of Tabor's instruments are provided with an Underwriters Laboratories (U.L. and V.D.E) listed three-conductor power cable, which when plugged into an appropriate power receptacle, grounds the instrument. The long offset pin on the male end of the power cable carries the ground wire to the long pin of the Euro connector (DIN standard) receptacle on the rear panel of the instrument.

To preserve the safety protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green lead on the adapter to an "earth" ground.

CAUTION

To avoid operator shock hazard do not exceed the power mains voltage frequency rating which limits the leakage current between case and power mains. Never expose the instrument to rain, excessive moisture, or condensation.

2-7. Installation and Mounting

The instrument is fully solid state and dissipates only a small amount of power. No special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 40°C, when the relative humidity exceeds 80% or condensation appears anywhere on the instrument. Avoid operating the instrument close to strong magnetic fields which may be found near high power equipment such as motors, pumps, solenoids, or high power cables. Use care when rack mounting to locate the instrument away from sources of excessive heat or magnetic fields. Always leave 4 cm (1.5 inches) of ventilation space on all sides of the instrument.

2-8. Bench Operation

The Model 8024 is shipped with plastic feet, tilt stand in place and ready for use as a bench or portable instrument. See outline drawing Figure 2-1 for outline dimensions.

2-9. Rack Mounting

The instrument may be rack mounted in a standard 19 inch rack. The instrument may be rack mounted in Rack Mount Kit option -002.

2-10. Portable Use

The instrument may be used in applications requiring portability. A tilt stand consisting of two retractable legs is provided with each unit.

2-11. Short Term Storage

If the instrument is to be stored for a short period of time (less than three months), place cardboard over the panel and cover the instrument with suitable protective covering such as a plastic bag or strong craft paper. Place power cable and other accessories with the instrument. Store the covered generator in a clean dry area that is not subject to extreme temperature variations or conditions which may cause moisture to condense on the instrument.

2-12. Long Term Storage or Re-Packaging For Shipment

If the instrument is to be stored for a long period or shipped to the factory for repair, proceed as directed below. If you have any questions contact your local Tabor representative or the Tabor Service Department at the factory.

If the original Tabor supplied packaging is to be used proceed as follows:

1. If the original wrappings, packing material, and container have been saved, re-pack the instrument and accessories originally shipped to you. If the original container is not available, one may be purchased through the Tabor Service Department at the factory.
2. Be sure the carton is well sealed with strong tape or metal straps.
3. Mark the carton with the model number and serial number with indelible marking. If it is to be shipped, show sending address and return address on two sides of the box; cover all previous shipping labels.

If the original container is not available, proceed as follows:
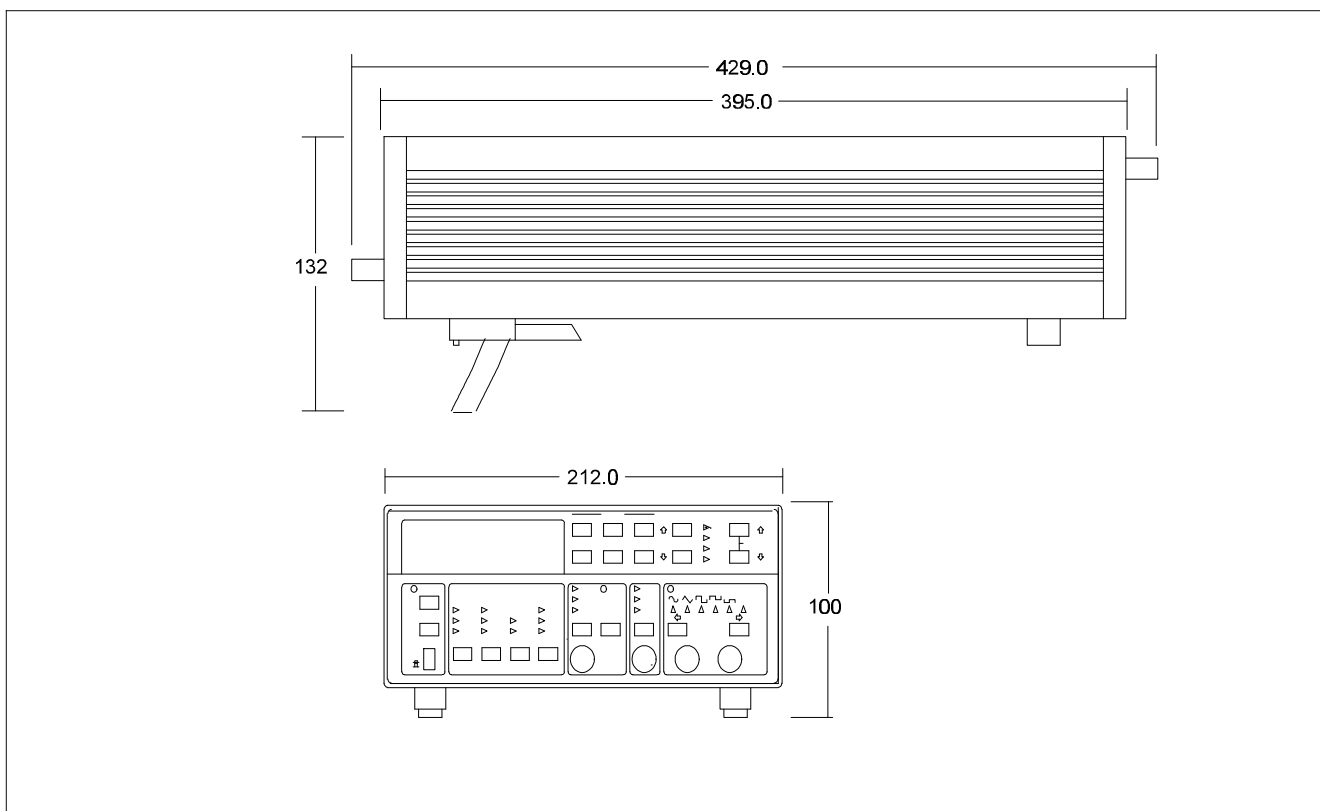
Figure 2-1. Model 8024 - Outline Dimensions.

1. Before packing the unit, place all accessories into a plastic bag and seal the bag.

2. For extended storage or long distance shipping only, use U.S. government packing method II C and tape a two-unit bag of desiccant (per MIL-D-3464) on the rear cover.

3. Place a 13 cm (5 inch) by 30 cm (12 inch) piece of sturdy cardboard over the front panel for protection.

4. Place the generator into a plastic bag and seal the bag.

5. Wrap the bagged instrument and accessories in one inch thick flexible cellular plastic film cushioning material (per PPP-C-795) and place in a barrier bag (per MIL-B-131). Extract the air from bag and heat seal.

6. Place bagged instrument and accessories into an oversized card-board box (per PPP-B-636 type CF, class WR, variety SW, grade V3C). Fill additional spaces with rubberized hair or cellular plastic cushioning material. Close box in accordance with container specifications. Seal with sturdy water resistant tape or metal straps.

7. Mark container "DELICATE INSTRUMENT", "FRAGILE", etc. Mark instrument model and serial number and date of packaging. Affix shipping labels as required or mark according to MIL-STD-129.

NOTE

If the instrument is to be shipped to Tabor for calibration or repair, attach a tag to the instrument identifying the owner. Note the problem, the symptoms, and service or repair desired. Record the model and serial number of the instrument. Show the work authorization order as well as the date and method of shipment. ALWAYS OBTAIN A RETURN AUTHORIZATION NUMBER FROM THE FACTORY BEFORE SHIPPING THE INSTRUMENT TO TABOR.

3

Operating Instructions

3-1. Introduction

Model 8024 operation is divided into two general categories: basic bench operation, and GPIB operation. Basic bench operation, which is covered in this section, explains how to use the model 8024 for generating the required waveform characteristics. GPIB programming can also be used to greatly enhance the capability of the instrument in applications such as automatic test

equipment. This aspect of operation is covered in Section 4.

3-2. Front Panel Familiarization

The front panel is generally divided into four sections: buttons, connectors, display and indicators. The following paragraphs describe the purpose of each of these items in details. Refer to the Model 8024 front panel layout throughout the following descriptions.
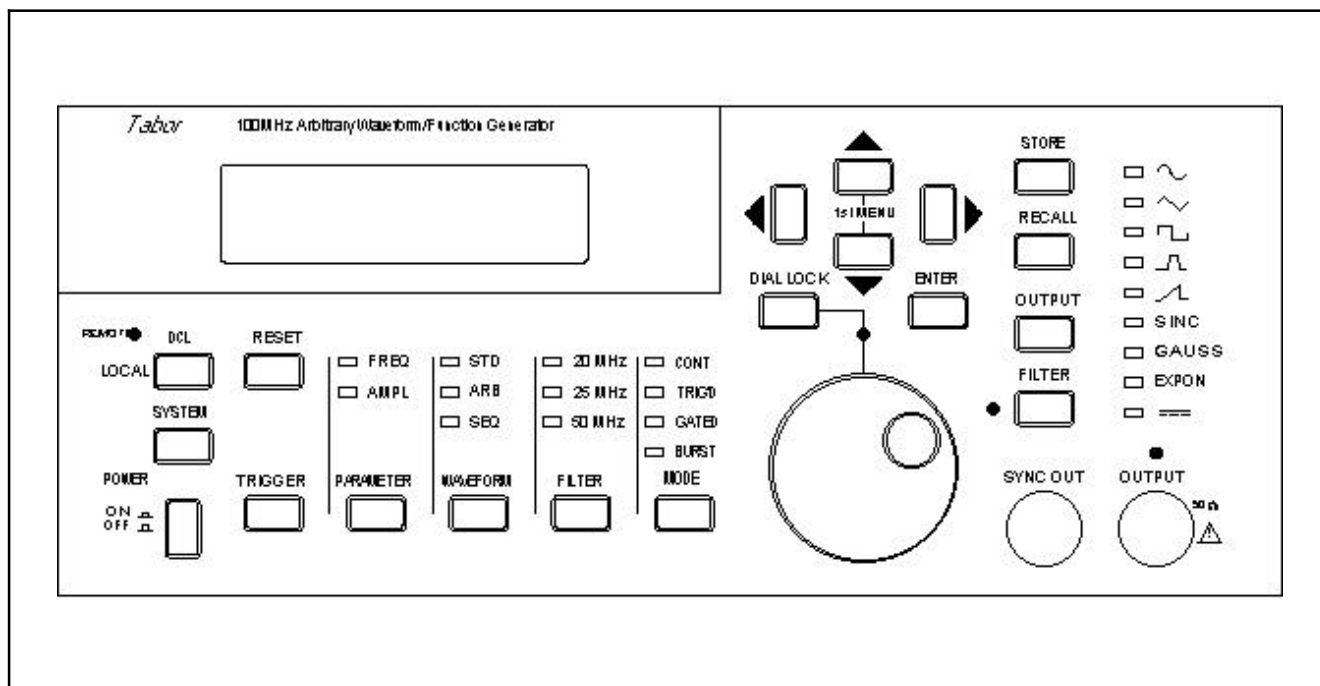
Figure 3-1. *Model 8024 - Front Panel Layout.*

3-3. Buttons

All front panel buttons except the POWER switch and the dial are momentary contact switches. Most buttons include an associated annunciator light for indication of the selected parameter and/or operating mode. Some buttons do not have an associated annunciator light. Exercising these buttons generates an immediate response on the display.

Front panel buttons may be divided into five functional groups: Instrument state, Parameters, Cursor control, Output control, and Memory control. These controls are described in the following paragraphs.

3-3-1. Instrument State Buttons

Five buttons in this group control the state of the Model 8024. They are marked: Power, System, DCL, Reset, and Trigger.

POWER - The POWER switch controls the AC power to the instrument. Pressing and releasing the switch once turns the power on. Pressing and releasing the switch a second time turns the power off.

SYSTEM - The SYSTEM button when pressed modifies the LCD display to read the current GPIB address setting. Press any other button to resume normal operating conditions.

LOCAL/DCL - The LOCAL/DCL button when pressed, and the instrument is in remote mode (but not in remote lockout condition - LLO), will cause the instrument to go to local operating mode. When the generator is already in local operating mode, this button may be used to clear the instrument to its factory default settings. The function of DCL (Device Clear) is described later in this Section.

RESET - The RESET button modifies individual parameter setting to its factory default. This button effects the displayed parameter only.

TRIGGER - The TRIGGER button may be used as a manual trigger stimuli, when the instrument is operating in one of its external trigger modes.

3-3-2. Parameter Buttons

There are four buttons in this group. They are marked PARAMETERS, WAVEFORMS, FILTER, and MODE. These buttons control which parameter will be displayed on the LCD display. The function of each button is described in the following.

PARAMETER - The PARAMETER button when pressed toggles between the FREQ and AMPL menus. Selection and modification of various parameters is discussed later in this section.

WAVEFORM - The WAVEFORM button controls which of three types of waveforms will be placed at the output connector. There are three types of waveforms that the Model 8024 can output: standard waveforms, arbitrary waveforms, and sequenced waveforms. The various waveform options are described later in this manual.

FILTER - The FILTER button selects between filter options that may be applied to the output signal. The generator offers three low-pass filters: 20 MHz Gaussian, 25 MHz Elliptical, and 50 MHz Elliptical. Each filter has a different frequency response and is used in different application. The filters and their operation is described later in this manual.

MODE - The MODE button when pressed modifies the instrument's operating mode to one of four options. It also modifies the LCD reading to display trigger parameters. The various operating modes are described later in this manual.

3-3-3. Cursor Control Buttons

There are six buttons and a dial in the cursor control group. These buttons control the cursor position within the menus. These buttons are described in the following.

CURSOR/MENU CONTROL - There are four buttons that control the position of the cursor within each menu. These buttons are marked with arrows; pointing to four different direction. The buttons which are marked with the up and down arrows are used for scrolling through the various parameters within a specific menu. The buttons which are marked with the left and right arrows are used for placing the cursor on the data or digit which has to be modified.

DIAL - The Dial is a mechanical rotary-encoder that simulates a digital potentiometer. It is used for editing the displayed parameter. The dial may rotate clockwise to increment reading or counterclockwise to decrement reading.

ENTER - This button is used for executing a specific function which requires complete operators' attention. It is normally used in conjunction with front panel settings of arbitrary parameters which, once modified, change front panel settings permanently.

DIAL LOCK - This button when pressed locks the dial to prevent accidental data modification. It toggles between lock and unlock while its associated LED turns on and off to indicate its status.

3-3-4. Output Control Buttons

OUTPUT - The output button enables or disables the signal at the main output connector. The light above the OUTPUT connector is associated with this button.

FILTER - The FILTER button applies or removes filters from the output signal. The light left to the FILTER button is associated with this control.

3-3-5. Instrument Setups Buttons

STORE - The STORE button when pressed allows storage of front panel setups. Using this function is described later in this manual.

RECALL - The RECALL button when pressed initiates recalling process of previously stored front panel setups. Using this function is described later in this manual.

3-4. Connectors

The connectors are used for connecting the Model 8024 to the unit under test.

1. SYNC OUT - The SYNC OUT connector outputs fixed amplitude pulses. In most cases, the leading edge of the SYNC output is synchronous with the leading edge at the main output connector.

2. OUTPUT - The OUTPUT connector is used as the main output for the function generator. Output is driven from a 50Ω source. Special care should be taken when these outputs are connected to the device under test because these outputs are capable of delivering amplitudes up to 20Vp-p.

3-5. Display and Indicators

1. DISPLAY - The function of the numeric display is to indicate the value of the various parameters. The 8024 is using of a 2-line, 16-character LCD display. The display is back-lit to enhance the LCD readout. The display is also used to indicate other information such as messages, errors, and more.

2. INDICATORS - 25 indicators are located on the front panel. These indicators are used as pointers to a selected menu, operating modes, etc.

3-6. Rear Panel Familiarization

There are a number of connectors and switches on the rear panel. Their function is described in the following.

AC RECEPTACLE - Power is applied through the power cord to the 3-terminal AC receptacle. Note that the selected ac line voltage is marked on the line voltage selector switch.

LINE SELECT SWITCH - The LINE SELECT switch selects one of the primary voltages which are marked on both sides of the switch.

LINE FUSE - The line fuse provides protection for the AC power line input. For information on replacing this fuse, refer to Section 5.

IEEE-488.2 CONNECTOR - This connector is used for connecting the instrument to the IEEE-488.2 bus.

TRIG IN - The TRIG IN connector is used for applying an external triggering source to the function generator. This input accepts TTL signals only.

CLOCK IN - The CLOCK IN is used as an input to receive a reference signal for synchronizing the Model 8024 to other instruments.

3-7. Power-Up Procedure

The basic procedure of powering up the Model 8024 is described below.

1. Connect the female end of the power cord to the AC mains receptacle on the rear panel. Connect the other end of the power cord to a grounded AC outlet.

WARNING

Be sure the power line voltage agrees with the indicated value on the rear panel of the instrument. Failure to heed this warning may result in instrument damage. The instrument is equipped with a 3-wire power cord designed to be used with grounded outlets. When the proper connections are made, the instrument chassis is connected to the power line ground. **Failure to use a properly grounded outlet may result in personal shock hazard.**

2. Turn on the mains power by pressing and releasing the POWER switch on the front panel.

3. The instrument then begins operation by performing a display and indicator test which takes approximately one second. All front panel indicators illuminate.

4. After all the indicators are tested, the instrument performs internal ROM and RAM tests. Successful execution of these tests is followed by a one second readout of the installed software revision, similar to the example below:

```
Software Rev 1.03
Last update 11/94
```

5. The model 8024 then checks which of its options are installed and displays consequent message. The installed option message will look like the following:

```
     GPIB option
      installed
```

6. If the instrument detects that the GPIB option is installed and displays the above message, the instrument proceeds with displaying its GPIB primary address. The GPIB address is set by front panel programming and is stored in the non-volatile memory. For example, with the generator programmed to address 19, the display shows:

```
   GPIB address 19
    Commands SCPI
```

7. Following these display messages, the instrument commences its normal operating mode and generates waveforms. Note that the instrument is equipped with a non-volatile memory. This memory automatically monitors front panel traffic and retains its last set-up for events such as accidental power loss. In case of power loss, or after normal power-up procedure, the instrument resumes operation with its previously programmed front panel set-up.

NOTE

One who does not wish to observe the power-up procedure every time that the generator is turned on, can easily remove the sequence of displayed messages. Depressing the left-pointing and the right-pointing arrows in the cursor control group, simultaneously writes a special code to the non-volatile memory. The next time the generator will be powered-

up, the instrument will skip the power-up procedure and will immediately commence with displaying the front panel set-up. Repeating the sequence as above, restores normal power up procedure. Note that there are no front panel markings that indicate power-up sequence removal. Therefore, unless the instrument is being used by one person only, and to remove confusion, it is recommended that power-up sequence remains unchanged.

3-8. Software Reset

An operator who is not yet fully familiar with front panel operation of the function generator, may find himself locked into a "dead-end" situation where nothing operates the way it should. The fastest way of restoring the generator to a known state is by resetting its software. This may be done by pressing the [DCL] button and then acknowledging the question on the display by pressing the [ENTER] button. The instrument then resets to its factory selected defaults. Table 3-1 summarizes these defaults.

3-8-1. Parameter Reset

As discussed in paragraph 3-9, software reset restores all front panel parameters to their factory selected values. It may, however, be required to reset one or two parameters and leave the rest intact. In that case the instrument provides additional capability besides the DCL function. Pressing the [RESET] button modifies the displayed parameter, at the cursor position, to its default value. Default values are summarized in Table 3-1.

NOTE

Software reset has no effect on the stored front panel set-ups and on the programmed GPIB address.

3-9. Display Messages

Model 8024 has several display messages pertaining to its operation. The generator also displays an error indication when a front panel programming error is detected. These messages and error indications are discussed in the following. Note that the instrument has a number of additional display messages associated with IEEE-488.2 programming. These messages are discussed in section 4 of this manual.

Table 3-1. *Default State After Front Panel Reset.*

FUNCTION	DESCRIPTION	DEFAULT STATE
FREQ	Frequency	100.0KHz
AMPL	Amplitude	1.00V
OFFS	Offset	+000mV
FILTER	Analog filter	Auto (sine filter)
TRIG_COUN	Trigger counts (Burst)	00001
INT_PER	Internal trigger period	1.00s
SOURCE	Trigger source	External
SCLK	Sampling clock	10.00Msps
Reference Clock	Arbitrary clock source	Internal
SEG01=	Segment size	0
STEP01=	Segment size	SEG01*0
General Status		
DISPLAY	Main menu parameters	FREQ
MODE	Operating mode selection	Continuous
STATE	GPIB status	Local state
WAVEFORM	Output waveform	Sinewave (standard)
ST-BY	Output stand-by mode	Off

3-10. Front Panel Error Indication

In general, whenever a front panel or GPIB programming attempts to place the 8024 in an error condition, the Model 8024 responds by front panel error indication or by addressing the IEEE-488.2 service request register.

Errors are categorized in four main groups:

1. General errors
2. Limit errors
3. IEEE errors

3-10-1. General Errors

Errors in this group are caused by improper usage of the instrument. Such errors occur while attempting to place the instrument in an illegal mode. For example, depressing simultaneously two buttons (except [1st MENU]) has no valid definition or by depressing the MANUAL button while the instrument is in its continuous operating mode. In such cases, the instrument simply ignores this error and continues with its normal operation.

3-10-2. Limit Errors

Errors in this group are caused by an attempt to program values outside the legal limits of the instrument. For

example, trying to program frequency value of 50 MHz for the standard triangle waveform. In this case, the LED above the OUTPUT connector starts blinking, indicating that the output waveform may not look as expected. Table 3-2 summarizes all front panel entry limits.

3-10-3. IEEE-488.2 Errors

In general, whenever a GPIB programming attempts to put the Model 8024 into an error condition, the function generator responds in two ways. First by displaying a front panel message and than, if programmed so, by raising an SRQ flag in its Status Byte Register. Using the Serial Poll command, the controller may then address the generator and request its status byte.

The generator incorporates a number of display messages which are associated with errors involving GPIB interface programming. These messages are discussed in detail in Section 4 of this manual.

There is one message however, which should be explained at this point because it may interfere with front panel operation. A remote enable or a device dependent command, sent to the instrument through the bus, turns the REMOTE light on. In this case, all front panel buttons except [LOCAL] are disabled. Pressing any button generates the following message:

```
press LOCAL to
remove from RMT!
```

This message indicates that the instrument expects that the [LOCAL] button be first depressed otherwise front panel operations are ignored. After the [LOCAL] button is depressed, the REMOTE light turns off and the instrument is ready to accept additional front panel programming sequences.

3-11. Selecting and Modifying Parameters

Parameters may be selected and modified by pressing one of four buttons: [TRIGGER], [PARAMETER], [FILTER], and [MODE]. Pressing one of these buttons enables access to a number of menus which are associated with it. Each time a button is depressed a different menu is displayed. The selected menu is indicated by an LED. Selection of the required parameter within a specific menu is done with the Cursor Control and Dial buttons. The menus are divided into functional groups; these groups are discussed in the following paragraphs.

3-11-1. The Menu Concept

An instrument, as complex as model 8024, would have been extremely difficult to program if the parameters would not be grouped and placed in menus. The menu concept cuts down the number of buttons which are necessary to access parameters and simplifies understanding of front panel programming.

The various parameters which are required to program Model 8024 are grouped in four logical menus. The Parameter Menus include general parameters which effect the output of the generator, regardless of its selected mode of operation. The Waveform menus control the shape of the wavefrom which will be placed at the output connector. The Filter menu permits selection of a specific filter range which may be applied to an output waveform. The Mode menu controls the operating mode of the Model 8024.

A specific menu is selected and displayed on the front panel readout when the light at the left of the menu name illuminates. Menus may have a minimum of one line and may have as many as 10 sub-sequent lines; each line representing a different parameter. The menus are selected by pressing one of four buttons as described before. One may then scroll through the various parameters within the selected menu by using the

dial and cursor control buttons as described in the following.

The right character position on any displayed parameter is always reserved for an indication if there are additional parameters above or below the displayed parameter. This indication is done with an arrow; pointing up when more parameters are available above, or an arrow pointing down when more parameters are available below. It is possible for both arrows to show; indicating that parameters are available below and above the displayed parameter.

3-11-2. The Cursor & Dial Concept

The cursor can be move within menu layers and from a data character to an adjacent data character, using the cursor buttons. Press the [⇑] or [⇓] buttons to move within menu layers. The [⇐] and [⇒] buttons control the cursor position on the displayed value. When both [⇑] and [⇓] cursor keys are pressed simultaneously, the cursor jumps to the top menu. Pressing the [RESET] button forces the displayed parameter to its factory default value.

The dial modifies characters at the cursor location. For instance, with an offset reading of +123mV, if the cursor is placed on 3, this digit will increment or decrement; depending on the direction that you rotate the dial. If the cursor is placed on the sign, the dial, when rotated, modifies the sign only. Placing the cursor on a suffix and then rotating the dial, increments or decrements the range. The dial may be locked to prevent accidental change of parameters by pressing the [DIAL LOCK] button.

3-11-3. The Displayed Readout Concept

Any parameter which is displayed on the front panel has two or three parts: Header, Data, and most times Suffix . For example, the frequency parameter is displayed as follows: FREQ 100.0MHz.

The **Header** describes the function of the parameter, for example, FREQ, AMPL, and SCLK. The header, in most cases is not spelled in-full, but abbreviated in such a way that will make sense to the operator. The headers follow SCPI (Standard Commands for Programmable Instruments) convention.

The **Data** is separated from the header by space(s) and may contain integer numbers, floating decimal point, and a leading plus or minus sign. The data rep-

resents the value for the displayed header. Each header has different limits for its associated data. These limits are given in Table 3-2.

The **Suffix** associates units and multipliers that modify how the data is interpreted by the device. Some headers, like BURST do not require suffix.

3-11-4. Modifying Parameters

There are various parameters, such as frequency, amplitude, offset, sampling rate, and others, which control the shape of the waveform at the output connector.

Modification of a specific parameter is simply done by selecting the required parameter as discussed before, placing the cursor on the required digit for modification, and then rotating the dial until the correct value is displayed. Some modifications cause immediate change at the output connector. Some modification require that [ENTER] button be first pressed to acknowledge the change. The various parameters which can be displayed and modified are listed in the following.

Parameters were assigned definite boundaries. The instrument was design in such a way that front panel programming, under no circumstances, may lead to an error situation by exceeding the specified limits. GPIB parameter programming errors are discussed in section 4. Front panel programming permits modification of parameters within the limits shown in Table 3-2.

3-12. Generating Std. Waveforms

There are 8 standard waveforms built into the Model 8024. The standard waveforms are active when the STD light is on. To select one of the available waveforms press the WAVEFORM button and observe that the display reads as follows:

```
Output Waveform
      Sine
```
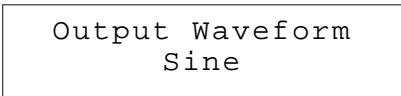
Also note that the sine LED above the OUTPUT connector is on. Rotate the dial to select the required waveform. There are a number of programmable ancillary functions which are associated with the standard waveforms. These functions are available on lower menu layers. Table 3-3 lists the standard waveforms with their associated ancillary functions.

3-13. Changing Output Frequency

The output frequency range depends on the waveform currently selected. Note that the frequency setting for standard waveforms is not the same as for arbitrary waveforms. Table 3-3 lists the upper frequency limit for each of the standard waveforms. If you try to exceed the specified limit, the instrument responds by blinking its OUTPUT LED at a constant rate. The default frequency setting is 100 KHz for all standard waveforms.

To change output frequency select the FREQ menu, place the cursor on the required data and use the dial and the cursor control buttons until you set the required frequency. You may also set the output period. To change output period select the PERIOD sub-menu, place the cursor on the required data and use the dial and the cursor control buttons until you set the period.

3-14. Changing Output Amplitude and Offset

The output amplitude and offset are the same for all standard output waveforms. The default amplitude setting is +5 V. The default offset setting is 0 V. Select

PARAMETER	LOW LIMIT	HIGH LIMIT	DEFAULT VALUE	REMARKS
FREQ	10 mHz	50 MHz	100 KHz	Std Waveforms Frequency
PERIOD	20.00 ns	100.0 Ks	10.00 μs	Std. waveforms period
AMPL	10.0 mV	10.0 V	5.00 V	Amplitude, offset dependent
OFFS	0.00 V	±4.50 V	+0.00 V	Offset, amplitude level dependent
INT PER	20 μs	999 s	1.00 s	Internal trigger source period
BURST	1	32767	1	Counted burst
STORE	0	9	0	Save setups
RECALL	0	9	0	Recall setups

Table 3-2. *Front Panel Parameter Entry Limits*

Table 3-3. *Standard Waveforms and Their Ancillary Functions*

FUNCTION	ANCILLARY FUNCTION	RANGE & RESOLUTION	DEFAULT VALUE	FREQUENCY HIGH LIMITS
Sine	Start Phase	0° to 360°	000°	50 MHz
	Power	1 to 9	1	
Triangle	Start Phase	0° to 360°	000°	10 MHz
	Power	1 to 9	1	
Square	Duty Cycle	1% to 99%	50%	50 MHz
Pulse	Delay Time	0.1% to 99.9%	0%	1 MHz
	Rise Time	0.1% to 99.9%	10%	
	High Time	0.1% to 99.9%	10%	
	Fall Time	0.1% to 99.9%	10%	
Ramp	Delay Time	0.1% to 99.9%	10%	1 MHz
	Rise Time	0.1% to 99.9%	10%	
	Fall Time	0.1% to 99.9%	10%	
Sine(x)/x	Cycles	4 to 999	10	1 MHz
Gaussian	Time Constant	1 to 65535	1000	1 MHz
Exponential	Time Constant	±0.01 to ±20.00	−1.00	1 MHz
DC	Amplitude	0% to ±100%	0%	

amplitude and offset in the AMPL menu. Note that amplitude and offset are inter-related parameters which can be selected in three level windows as specified in Section 1 of this manual.

3-15. Generating Arb. Waveforms

In general, whenever the ARB LED above the [WAVE-FORM] button is lit, the model 8024 generates arbitrary waveforms at the output connector.

3-15-1. What Are Arb. Waveforms

An arbitrary waveform is generated from digital data points which are stored in a special memory. Each data point has vertical resolution of 12 bits (4094 points). So, each sample is placed on the vertical axis with precision of 1/4096.

The arbitrary memory has a capacity to store up to 64K horizontal of data points . Each horizontal point has a unique address; the first being 00000 and the last 64535. In cases where smaller wavelengths are required. Model 8024 makes it possible to divide the entire length to smaller segments and then to select which segment is sampled, how many times, and in what sequence.

When the instrument is programmed to output arbitrary waveforms, a clock samples the data points, one at a time, from address 0 to the last address. The rate of which each sample is replayed is defined by the sampling rate parameter. Model 8024 provides programmable sampling rates from 10 mHz to 50 MHz.

If the Model 8024 operates in continuous mode, the sampling cycle repeats automatically. If the Model 8024 is placed in triggered mode, the cycle stops at the end address. In burst mode, the cycle is repeated as many times as programmed to do so.

Unlike the built-in standard waveforms, the required arbitrary waveforms are not always resident in the instrument's memory. The reason for not always keeping the complete library resident is because of the size limitation of the arbitrary memory. Some waveforms have small length of 1K words or less, but some require much more. In cases where the arbitrary waveform is not resident, the instrument provides drivers to several communication links from which the waveform may be loaded.

3-15-2. Arb. Memory Management

The arbitrary memory has a fixed length of 64,535 words. 1K is always reserved for the built-in standard waveforms. So, the maximum size waveform which the Model 8024 can generate is 63,536 point long. It is, however, not always necessary to utilize the com-

plete length of this memory. The Model 8024 permits partition of the arbitrary memory to smaller memory segments. It is possible to divide the memory from 1 to 99 memory segments and assign different size to each segment. Minimum segment size is 10 points.

3-15-3. Partitioning The Memory

As discussed above, the arbitrary memory may be divided into smaller segments. So, up to 99 different arbitrary waveforms can be generated with the Model 8024. The length of each segment is left totally to the user's discretion. The arbitrary waveforms are active when the ARB light is on. To partition the arbitrary memory press the [WAVEFORM] button and observe that the display reads as follows:

```
Output Segment
  01 (Empty)
```

Segment remains empty until you assign it a size. Press the cursor button to move one menu down and observe that the display reads as follows:

Move the cursor under the fourth digit and rotate the dial clockwise to increment the reading to 01000. Before you proceed, compare the display reading and make sure that it looks exactly as follows:

```
SEG01=01000Pts
64536 Pts left
```

To complete the segment size modification process press the [ENTER] button. The instrument will prompt you with the following message:

```
Change SEG Size?
  ENTER=yes
```

If you press [ENTER], the size which you have selected will lock-in permanently and the above reading will change as follows (the same question will be asked if you'll try to leave this menu without finalizing the process):

```
SEG01=01000Pts
63536 Pts left
```

You may continue partitioning the memory using the same procedure to assign sizes to other segments. You may do so by incrementing SEG01.

3-15-4. Loading Arb. Waveforms

Model 8024, when supplied first, does not have any arbitrary waveforms loaded into its memory. The loading process can be done either from the front panel or from a GPIB station. Front panel loading of arbitrary waveforms will be discussed now, while GPIB operation is discussed in Section 4 of this manual.

Assuming that you have already assigned size to at least one segment, you may proceed to load the segment with one of the standard functions that are available from the front panel. From the menu shown before, press the cursor button to go down one menu layer. The display reading will change as follows:

```
LOAD Sine
into SEG01 /ENT
```

The cursor is placed under the Sine function indicating that this is the only parameter that may be changed. Rotate the dial to select another function, then press [ENTER] to load the selected function into the arbitrary memory.

3-15-5. Modifying Arb. Functions

The Model 8024 does not provide front panel editing capabilities, besides a few built-in modifiers. If you select to load, for instance, the Sine function, it will be loaded exactly as it was set up in the standard waveforms menu. Therefore, if you want to load this function with one of its ancillary function changed, do so first in the standard waveforms menu, then load it into the arbitrary memory.

There are a number of modifiers built-in the ARB menu. They are: Clear, Fill, Offset, Invert, and AM. These modifiers operate globally on the entire segment. To access the modify menu, press the cursor control button to go one menu layer down. The display will change to read as follows:

```
SEG01 MODIFY
   Clear
```

The cursor is positioned under the Copy function indicating that this function can be changed. Use the dial to select one of the modifier function, then move

menu layers down to complete the modifier operation. The final modification requires that [ENTER] button be pressed.

3-15-5-1. Generating Amplitude Modulated Functions

The following is an example how to generate a modulated function using the arbitrary waveforms and the AM modifier menu.

1. Start this procedure from a known state by pressing [DCL] and then [ENTER]. The Model 8024 is now set to its default state.

2. Press [WAVEFORM] button twice to access the ARB menu, then, press the cursor control button down to go down one menu layer.

3. Change SEG01 size to 1000 points and press [ENTER] twice to confirm segment size change to 1000 points, then, press the cursor control button down to go down one menu layer.

4. Press [ENTER] twice to confirm sine data load. If you followed the step correctly, you should have a sine waveform at the output connector.

5. Press the cursor control button down to go down one menu layer. Now, rotate dial until AM appears on the LCD display.

6. Press the cursor control button down to go down one menu layer.

7. The display shows LENGTH 0100 Pts. Since you assigned 1000 points to this segment, carrier frequency of 100 Pts corresponds to 1/10th of segment length. You may change this reading, but for this example leave this parameter as is.

8. Press the cursor control button down to go down one menu layer. The display shows DEPTH 050%. leave this reading for now and press the cursor control button down again to go down one more menu layer.

9. Press [ENTER]. The output modulates a sine carrier waveform to 100%.

At this point you may push the up and down cursor control buttons, simultaneously, to jump to the first menu layer. Repeat the above steps to modulate to 100% and 200% depth and observe the results.

3-16. Changing Sampling Clock Frequency

As explained before, arbitrary waveforms are made of digital data points which are equally spaced on the horizontal scale. The "spacing" between the points are defined by the sampling clock frequency. The sampling clock, divided by the number of points, determine the

waveform frequency at the output connector. To program the sampling clock place the Model 8024 in ARB waveform mode. Then, press the [PARAMETER] button. The display should read as follows:

```
SCLK 100.0MHz
FREQ  off
```

SCLK designates sampling clock frequency. The sampling clock may be programmed within the range of 10 mHz to 100 MHz. Preset value is set to 100.0 MHz.

FREQ designates repetition rate at the output connector. It depends on many parameters: The sampling rate, the wavelength, and the number of times that the wave is repeated by the sequencer. The FREQ reading is set to **off** as long as memory remains un-partitioned. Also note that the FREQ indication is available for reference only and could not be changed.

To change the sampling clock, first partition the memory and load it with data. Then, press the [PARAMETER] button and use the cursor control buttons and the dial to program the required sampling clock.

3-16-1. Selecting SCLK Source

The arbitrary waveform clock can be driven from three different clock sources: 1) From its internal synthesized clock, 2) From an internal and fixed 10 MHz crystal, and 3) From an external clock source.

INT - Internal synthesized clock is the clock you normally use. Its range and accuracy equals to the frequency parameter for the standard waveforms.

EXT - External clock may be applied to the generator for synchronizing it to a centralized clock system. Make sure to remove the Model 8024 from this mode whenever you are done with this mode of operation, because when you remove the external clock the Model 8024 stops generating arbitrary waveforms.

10 MHz Xtal - Where required, a pure 10 MHz signal which comes directly from an internal crystal clock may be used as the primary clock. This clock is especially useful in applications requiring low phase noise on the output waveform. Note that the 10 MHz signal in this case is fixed at one frequency only. So, the waveform frequency depends on the number of horizontal points which were assigned to the segment.

To select the sampling clock source, from the above LCD display reading press the cursor control button to move down one menu layer. The display reading should look as follows:

```
┌─────────────────────────────┐
│      Reference Clock        │
│            INT              │
└─────────────────────────────┘
```

Rotate the dial to select between the available clock options.

3-17. Generating Sequenced Waveforms

In general, whenever the SEQ LED above the [WAVE-FORM] button is lit, the model 8024 outputs a sequence of waveforms.

3-17-1. What Are Seq. Waveforms

In paragraph 3-16 we explained to you what are arbitrary waveforms. You may want to go back and refresh your memory on this topic. Sequenced waveforms are made of a number of arbitrary waveforms which can be linked and repeated in various manners.

Sequenced waveforms can be generated from waveforms which are stored in different segments of the arbitrary memory. Before you can use output a sequence of waveforms, you must first load your arbitrary memory with the required waveforms. Waveforms can be loaded either from the front panel or through GPIB programming. Information how to partition the memory and load front panel functions is given in paragraph 3-16-3 and 3-16-4. Information how to load your memory from the GPIB is given in section 4 of this manual.
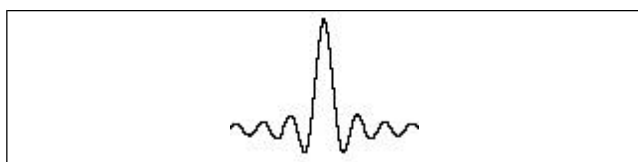
Figure 3-2. *Waveform in Segment 1.*
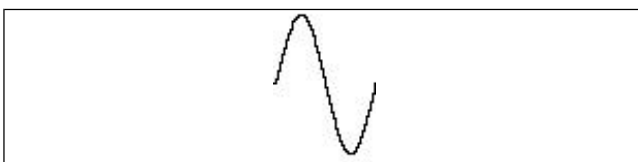
Figure 3-3. *Waveform in Segment 2.*

An example how sequenced waveforms work is demonstrated in the following figures. Figure 3-2 shows a sine(x)/x waveform which was loaded in segment 1.
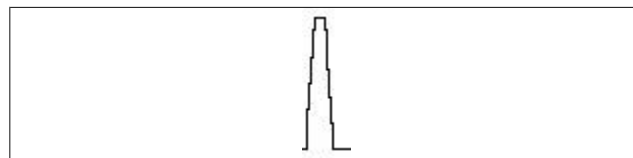
Figure 3-4. *Waveform in Segment 3.*
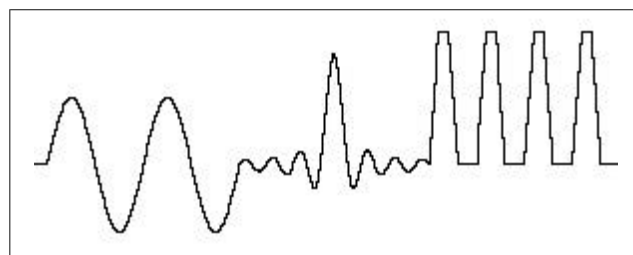
Figure 3-5. *Sequenced Waveforms.*

Figure 3-3 shows a sine waveform which was loaded into segment 2, and Figure 3-3 shows a pulse waveform which was loaded into segment 3. The sequence generator lets you link segments in user defined order and repeat each segment as many times as needed.

Figure 3-4 shows a sequence of waveforms which was made of the waveforms that were stored in three different memory segments. You may notice that segment number 2 is generated first and repeated twice, segment 3 follows once, then segment 1 is repeated four times.

3-17-2. Generating a sequence

Assuming that you already loaded waveforms into memory segments, proceed to generate a sequence as explained in the following.

Press the [WAVEFORM] button until the SEQ light turns on. Observe that the display reads as follows:

```
┌─────────────────────────────┐
│      Output sequence        │
│        1   (Empty)          │
└─────────────────────────────┘
```

The "(Empty)" reading will remain until you program the first sequence. The "(Empty)" reading is associated with the sequence number - "1" which is shown on the left. It will change to "(Loaded)" after programming a sequence.

Nine different sequences can be programmed from the front panel. The sequences are selected by rotating the dial. If a selected sequence is "(Empty)" the output will generate 0 V dc level. To program the first sequence

3-11

press the cursor button to move one menu down and observe that the display reads as follows:

```
STEP01 = SEG01
REPEAT * 00000
```

STEP01 = SEG01 shows that the waveform is segment one will be output at the beginning of the sequence. If you have more than one segment loaded, you may move the cursor under SEG01 and select the required segment number by rotating the dial. Up to 99 steps are available in this menu. Selection can be made from 99 different segments.

REPEAT * 00000 shows how many times the segment in step 1 will be repeated. The output remains at 0 V dc level as long as the REPEAT number is 0.

As an exercise, load the first three segments with waveforms as shown in Figures 3-3 through 3-5. Then, program a sequence which will output a waveform as shown in Figure 3-6.

3-18. Disabling The Output

The Model 8024 features an output disable mode which reduces the amplitude of the output waveform to minimum. The stand-by function is especially useful in automatic test systems where the output is constantly connected to a device under test and where modification of waveform parameters may endanger this device.

To place the instrument in its stand-by mode press the [OUTPUT] button. The light above the output connector turns off, indicating that the amplitude level of the output signal is lowered to its minimum level.

The [OUTPUT] button toggles between output on and off. Press the [OUTPUT] button to resume normal operation.

3-19. Selecting an Operating Mode

Model 8024 offers four operating modes: Continuous, Triggered, Gated, and Burst. The selected waveform is repeated continuously when the instrument is set to operate in continuous mode. The continuous operating mode is selected when the CONT light above the [MODE] button illuminates. In this mode of operation, the model 8024 does not require an external source to stimulate its output cycles. Triggered, gated, and burst modes require an external source to initiate output cycles. Information how to trigger, gate, and how to output a burst of waveforms is given in the following.

3-19-1. Triggered Mode

Model 8024 is set to operate in trigger mode when the TRIG light above the [MODE] button is lit. The output remains at 0 V dc level as long as the TRIG IN connector on the rear panel remains disconnected. A TTL level signals can be used to stimulate the TRIG input. The generator is sensitive to the rising edge only. So, every time that a positive transition occurs at the trigger input, the model 8024 generates one complete output waveform at the output connector. At the end of the output cycle, the output goes back to 0 V dc level.

The triggered mode of operation operates equally on standard waveform, arbitrary waveform, and sequenced waveform. You should observe the limitations of the trigger signal as specified in Table 1-1. When you first select the trigger mode, the display shows the following reading:

```
SOURCE EXT
```

This reading indicated that the generator is ready to accept external signals at the TRIG IN connector to stimulate its output. In this mode, the model 8024 responds to a rear panel signal, to a front panel [TRIGGER] button press, and to GPIB trigger commands. The last two options will be discussed later in this manual.

3-19-1-1. Internal Trigger

When an external source is not available, the operator has an option to use the built-in trigger generator. The internal trigger generator is a free running generator, asynchronous to the main output generator. The period of the internal trigger generator can be programmed from 20 µs to 999 s. When the internal trigger source is selected the TRIG IN connector is disconnected, so external signals do not effect the generator. The internal trigger generator is also available in burst mode. It has no effect in gated mode. To place the model 8024 in internal trigger mode and to program an internal trigger period rotate the dial in the above shown menu. The menu will change as follows:

```
SOURCE INT
INT PER 1.00s
```

Now you can select the bottom menu and program the period of the internal trigger stimuli.

3-19-1-2. Manual Trigger

The [TRIGGER] button simulates an external signal. When the generator is set to trigger on an external source, each time the [TRIGGER] button is pressed a single output waveform is generated. The [TRIGGER] button has no effect in continuous mode of operation or when the instrument is set to internal trigger mode.

3-19-2. Gated Mode

Model 8024 is set to operate in gated mode when the GATED light above the [MODE] button is lit. The output remains at 0 V dc level as long as the TRIG IN connector on the rear panel remains disconnected. A TTL level signal can be used to stimulate the TRIG input. The generator is sensitive to the rising edge only. So, the first positive going transition at the TRIG IN connector enables the generator output. The second positive going transition disables the generator output. At the end of the output cycle, the output goes back to 0 V dc level.

3-19-2-1. Manual Gate

The [TRIGGER] button simulates an external gating signal. When the generator is set to gated mode, output waveforms are generated as long the the [TRIGGER] button is pressed.

3-19-3. Burst Mode

Model 8024 is set to operate in burst mode when the BURST light above the [MODE] button is lit. The output remains at 0 V dc level as long as the TRIG IN connector on the rear panel is not connected. A TTL level signal can be used to stimulate the TRIG input. The generator is sensitive to the rising edge only. So, every time that a positive transition occurs at the trigger input, the model 8024 generates one burst of output waveforms at the output connector. At the end of the burst output cycle, the output goes back to 0 V dc level. The number of complete output waveforms which will be generated can be programmed from 1 to 32767.

The counted burst mode of operation operates equally on standard waveform and arbitrary waveform. This mode can not work in conjunction with sequenced waveforms. To eliminate confusion, the model 8024 does not allow you to go into burst mode if you selected SEQ waveforms. Likewise, it will also not allow you to go into burst mode if you are already generating sequenced waveforms.

When you first select the burst mode, the display shows the following reading:

```
┌─────────────────────────────┐
│      BURST  00001           │
│      SOURCE  EXT            │
└─────────────────────────────┘
```

This reading indicates that the generator is ready to accept external signals at the TRIG IN connector to stimulate its output. In this mode, the model 8024 responds to a rear panel signal, to a front panel [TRIGGER] button press, and to GPIB trigger commands. The last two options will be discussed later in this manual.

3-19-3-1. Internal Burst

When an external source is not available, the operator has an option to use the built-in trigger generator. The internal trigger generator is a free running generator, asynchronous to the main output generator. The period of the internal trigger generator can be programmed from 20 μs to 999 s. When the internal trigger source is selected the TRIG IN connector is disconnected, so external signals do not effect the generator. To place the model 8024 in internal trigger mode and to program an internal trigger period rotate the dial in the above shown menu. The menu will change as follows:

```
┌─────────────────────────────┐
│      BURST  00001           │
│      SOURCE  INT            │
└─────────────────────────────┘
```

Press the cursor control down button one to move one menu layer and adjust the internal burst period as explained in paragraph 3-19-1-1.

3-20. Using The Offset

The function generator employs three level windows; allowing amplitude and offset to be independently selected within these levels. When setting up the offset parameter, one must keep in mind that the offset is attenuated with the signal. The user has no control over the selected internal amplitude range. This may cause some confusion since, not knowing this fact, one may produce an offset error at an amplitude-offset combination that seems to be reasonable. It is therefore suggested to first set up the amplitude parameter and only then set the required offset level. An attempt to modify the offset parameter beyond the capability of the instrument will generate an error indication. Offsets and amplitudes are independently selectable within the level windows given in Table 1-1.

3-21. Using Front Panel Setups

Setting up all parameters in a versatile instrument such as the Model 8024 takes some time. Setup time is longer when a number of tests are performed and more than one setup is required. The function generator incorporates a non-volatile memory that preserves several front panel states for a long time. The size of the non-volatile memory permits storage of up to 10 complete front panel setups. Front panel setups can be recalled one at a time.

3-21-1. Saving Setups

First modify front panel parameters as necessary to perform the required test. When all parameters are programmed and verified for accuracy, proceed with storing front panel state as follows:

1. Press the [STORE] button and observe that the display is modified to indicate the following:

```
STORE SETUP n
Push ENT to save
```

"n" indicates active storage cell number. Number may range from 0 to 9. Pressing any other button, besides {ENTER] removes the generator from this mode and leaves front panel settings intact.

2. Rotate the dial to select the required memory cell number and press [ENTER] to complete the process. The instrument then resumes normal operation.

3. Repeat the above procedure for as many setups that are required.

3-21-2. Recalling Setups

The model 8024 employs a non-volatile memory (RAM). The computer circuit continuously monitors front panel traffic and saves it in a special location within the RAM. This location is separated from the stored front panel setups. After turning mains power off or in case of accidental power failure, the generator updates front panel indicators with the last state before power shut-down. To recall other stored front panel setups proceed as follows:

1. Press the [RECALL] and observe that the display is modified to indicate the following:

```
RECALL SETUP n
Push ENT to rcl
```

"n" indicates active storage cell number. Number may range from 0 to 9. Pressing any other button, besides {ENTER] removes the generator from this mode and leaves front panel settings intact.

2. Rotate the dial to select the required memory cell number and press [ENTER] to complete the process. The instrument then resumes normal operation.

3. Repeat the above procedure for as many setups that are required.

3-22. Changing GPIB Address

GPIB address is modified using front panel programming. The GPIB address is stored in non-volatile memory. To change the GPIB address press the [SYSTEM] button. The display reading will change as follows:

```
GPIB address 19
Commands SCPI
```

At this point, if you want to change the GPIB address rotate the dial until the display reads the required address. To resume normal operation press any key on the front panel. The Commands menu determines the shape of the GPIB commands. The Model 8024 can accept two options: command set which is SCPI compatible or another set of short commands which make the instrument compatible with WaveCAD software. Information how to change command set is given in Section 4 of this manual.

3-23. Loading Waveforms Using the GPIB Interface

In general, there are no special preparations to be made before waveforms can be loaded from GPIB controllers. Model 8024 is completely programmable, therefore, a computer can place it in listen mode, download all of the required parameters to set up Model 8024, and download waveforms to a selected segment. Information on how to program Model 8024 using the GPIB interface is given in Section 4 of this manual - Remote Programming.

4

Remote Interface

4-1. Introduction

This section contains programming information for the Model 8024. Commands to program the instrument over the IEEE-488 interface bus are very similar to those defined by the IEEE-488.2 standard and the SCPI 1993 (Standard Commands for Programmable Instruments) standard.

IEEE-488.2 defines a syntax for sending data to and from instruments, how an instrument interprets this data, and what registers should exist to record the state of the instrument. The subset of commands (common commands) is used to perform basic operations, such as registers, triggering the output, and resetting the instrument.

The SCPI standard defines a common language protocol. It goes one step farther than IEEE-488.2 and defines a standard set of commands to control every programmable aspect of the instrument. It also defines the format of command parameters and the format for values returned by the instrument.

4-2. Introduction to SCPI Language

SCPI (Standard Commands for Programmable Instruments) is an ASCII-based instrument command language designed for test and measurement instruments. SCPI commands are based on a hierarchical structure, also known as a tree system. In this system, associated commands are grouped together under a common node or root, thus forming subsystems.

Throughout this manual, the following conventions are used for SCPI command syntax.

- Square brackets ([ ]) indicates optional keywords or parameters.
- Braces ({ }) enclose parameters within a command string.
- Triangle brackets (< >) indicate that you must substitute a value for the enclosed parameter.
- A vertical bar (|) separates multiple parameter choices.
- Bold typeface letters designate factory default values.

The OUTPUT subsystem is shown below to illustrate the tree system.

```
OUTPut
  :FILTer
    [:LPASs]
      :FREQuency {20MHz|25MHz|50MHz}
      [:STATe] OFF|ON
  [:STATe] OFF|ON
```

OUTPut is the root keyword of the command, FILTer and STATe are second-level keywords, and FREQuency and STATe are third-level keywords. A colon (:) separates a command keyword from a lower-level keyword.

4-3. Command Format

The format used to show commands in this manual is shown below:

FREQuency {<frequency>|MINimum|MAXimum}
The command syntax shows most commands (and some parameters) as a mixture of upper- and lower-case letters. The upper-case letters indicate the abbreviated spelling for the command. For shorter program lines, send the abbreviated form. For better program readability, send the long form.

For example, in the above syntax statement, FREQ and FREQUENCY are both acceptable forms. You can use the upper- or lower-case letters. Therefore, FREQ, FREQUENCY, freq, and Freq are all acceptable. Other forms, such as FRE and FREQUEN, will generate an error.

The above syntax statement shows the frequency parameter enclosed in triangle brackets. The brackets are not sent with the command string. You must specify a value for the parameter (such as "FREQ 50e+6Hz).

Some parameters are enclosed in square brackets ([]). The brackets indicate that the parameter is optional and can be omitted. The brackets are not sent with the command string. If you do not specify a value for an optional parameter, the generator chooses a default value.

4-4. Command Separators

A colon (:) is used to separate a command keyword from a lower-level keyword as shown below:

"SOUR:FUNC:SHAP SIN"

A semicolon (;) is used to separate commands within the same subsystem, and can also minimize typing. For example, sending the following command string:

"TRIG:SOUR INT;STAT ON;INT:RATE 5e-3s"

...is the same as sending the following three commands:

"TRIG:SOUR INT"
"TRIG:STAT ON"
"TRIG:INT:RATE 5e-3s"

You may use the colon and semicolon to link commands from different subsystems. For example, in the following command string, an error is generated if you do not use both the colon and the semicolon:

"OUTP:STATE ON;:TRIG:STAT ON"

4-5. The MIN and MAX Parameters

One may substitute MINimum or MAXimum in place of a parameter for some commands. For example, consider the following command:

FREQuency {<frequency>|MINimum|MAXimum}

Instead of selecting a specific frequency, you can substitute MIN to set the frequency to its minimum value or MAX to set the frequency to its maximum value.

4-6. Querying Parameter Settings

You can query the current value of most parameters by adding a question mark (?) to the command. For example, the following command sets the output function to square:

"SOUR:FUNC:SHAP SQR"

You can query the output function by executing:

"SOUR:FUNC:SHAP?"

4-6-1. Query Response Formats

The response to a query depends of the command which is sent to the instrument to generate the query response. In general, response to a query do not contain header information, but current values or setting of the generator. Commands that set values can be queried about their current value of the setting. Commands that set modes of operation can be queried about their current mode setting. IEEE-488.2 defined set of common queries generate a response which is common to all instruments that are connected to the GPIB interface.

4-7. SCPI Command Terminators

A command string sent to the function generator must terminate with a <new line> character. The IEEE-488 EOI (end-or-identify) message is interpreted as a <new line> character. A <carriage return> followed by a <new line> is also accepted. Command string termination will always reset the current SCPI command path to the root level.

4-8. IEEE-488.2 Common Commands

The IEEE-488.2 standard defines a set of common commands that perform functions like reset, trigger, and status operations. Common commands always begin with an asterisk (*), are four to five characters in length, and may include one or more parameters. The command keyword is separated from the first parameter by a blank space. Use a semicolon (;) to separate multiple commands as shown below:

"*RST; *STB?; *IDN?

4-9. SCPI Parameter Types

The SCPI language defines several different data formats to be used in program messages and response messages.

4-9-1. Numeric Parameters

Commands that require numeric parameters will accept all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation. Special values for numeric parameters like MINimum and MAXimum are also accepted.

You can also send engineering unit suffixes with numeric parameters (e.g., Mhz or Khz). If only specific numeric values are accepted, the function generator will ignore values which are not accepted and will generate an error message. The following command is an example of a command that uses a numeric parameter:

"VOLT:AMPL {<amplitude> | MIN | MAX}"

4-9-2. Discrete Parameters

Discrete parameters are used to program settings that have a limited number of values (like FIXed, USER, and SEQuence). They have a short form and a long form just like command keywords. You can mix upper- and lower-case letter. Query responses will always return short form in all upper-case letters. The following command uses discrete parameters:

SOUR:FUNC:MODE {FIXed | USER | SEQuence}

4-9-3. Boolean Parameters

Boolean parameters represent a single binary condition that is either true or false. For a false condition, the generator will accept "OFF" or "0". For a true condition, the generator will accept "ON" or "1". When you query a boolean setting, the instrument will always return "0" or "1". The following command uses a boolean parameter:

OUTP:FILT { OFF | ON }

The same command could be written as follows:

OUTP:FILT {0 | 1 }

4-9-4. Arbitrary Block Parameters

Arbitrary block parameters are used for loading waveforms to the generator's memory. The Model 8024 can accept binary blocks of data, files that contain binary data, and files that contain ASCII data. The following command uses an arbitrary block parameter that is loaded as binary data:

TRAC:DATA <binary_block>

4-10. Setting the GPIB Address

GPIB address is modified using front panel programming. The GPIB address is stored in the non-volatile memory. To change the address press the [SYSTEM] button. The display reading will change as follows:

```
GPIB address 19
commands SCPI
```

At this point, if you want to change the GPIB address, rotate the dial until the display reads the required address. To resume normal operation, press any front panel key.

4-11. Selecting a Command Set

The Model 8024 can accept two sets of commands: SCPI commands and short-form commands. The SCPI set of commands is the default setting of the generator. The short-form commands set is available for those programmers who do not want to use the lengthy programming code that SCPI requires.

The short-form command set speeds bus communications and is also required in conjunction with WaveCAD operation. Appendix C lists the short-form command set. Selection of which command set is used as GPIB protocol is done from the front panel. To change the GPIB command set press the [SYSTEM] button, then press the cursor button to move the cursor one menu down. Rotate the dial. The display toggles between "SCPI" and "std.". Select the required command set and press any front panel key to resume normal operation. If you select to use the "std". set of commands make sure that the generator displays the following:

```
GPIB address 19
commands std.
```

4-12. SCPI Command Summary

Table 4-1 summarizes the complete SCPI command tree available to program the generator over the GPIB. Tables 4-2 through Table 4-5 categorize these commands. Refer to later sections in this manual for more complete details on each command.

Table 4-1. *Model 8024 - SCPI Command Summary.*

```
:FORMat
  :BORDer {NORMal | SWAPped}

:OUTPut
  :FILTer
    [:LPASs]
      :FREQuency <filter_frequency>
      [:STATe] {OFF | ON}
  [:STATe] {OFF | ON}

[:SOURce]
  :APPLy
    :SINusoid {[<frequency> [,<amplitude> [,<offset> [,<phase> [,<power>] ]]]]}
    :TRIangle {[<frequency> [,<amplitude> [,<offset> [,<phase> [,<power>] ]]]]}
    :SQUare {[<frequency> [,<amplitude> [,<offset> [,<duty_cycle>] ]]]}
    :PULSe {[<frequency>[,<amplitude>[,<offset>[,<delay>[,<rise_time>[,<high_time>[,<fall_time>]]]]]]]}
    :RAMP {[<frequency> [,<amplitude> [,<offset> [,<delay> [,<rise_time> [,<fall_time>] ]]]]]}
    :SINC {[<frequency> [,<amplitude> [,<offset> [,<number_cycles>] ]]]}
    :EXPonential {[<frequency> [,<amplitude> [,<offset> [,<exponent>] ]]]}
    :GAUSsian {[<frequency> [,<amplitude> [,<offset> [,<exponent>] ]]]}
    :DC [<amplitude>]
    :USER{[<sampling_clock> [,<amplitude> [,<offset> [,<exponent>] ]]]}
    :SEQuence{[<sampling_clock> [,<amplitude> [,<offset> [,<exponent>] ]]]}

  :FREQuency
    [:CW] {<frequency> | MINimum | MAXimum}
    :RASTer {<frequency> | MINimum | MAXimum}
      :SOURce {EXT | INT | XTAL}

  :VOLTage
    [:LEVel]
      [:IMMediate]
        [:AMPLitude] {<amplitude> | MINimum | MAXimum}
        :OFFSet {<offset | MINimum | MAXimum}

  :FUNCtion
    :MODE {FIXed | USER | SEQuence}
    :SHAPe {SINusoid | TRIangle|SQUare|PULSe|RAMP|SINC|EXPonential|GAUSsian|DC
      :USER <segment_number>
      :SEQuece <sequence_number>

  :SINusoid
    :PHASe <value>
    :POWer <value>
  :TRIangle
    :PHASe <value>
    :POWer <value>
  :SQUare
    :DCYCle <value>
  :PULSe
    :DELay <value>
    :WIDTh <value>
```

Table 4-1. *SCPI Command Summary (continued).*

```
[:SOURce] (continued)
    :TRANsition
        [:LEADing] <value>
        :TRAiling <value>
  :RAMP
    :DELay <value>
    :TRANsition
        [:LEADing] <value>
        :TRAiling <value>
  :SINC
    :NCYCle <value>
  :GAUSsian
    :EXPonent <value>
  :EXPonential
        :EXPonent <value>
  :DC
    :VOLTage
        [:AMPLitude] <%_amplitude>

  :AM
    [:DEPTh] <value>
    :INTernal
        :FREQuency <value>
    :EXECute

  :BM
    :NCYCles <value>
    :INTernal
        :RATE <value>
    :SOURce {EXTernal | INTernal | BUS}
    [:STATe] {OFF | ON}
    :IMMediate

  :GM
    :STATe {OFF | ON}

  :SEQuence
    :DEFine <step_number>, <segment_number>, <#_repeat>
    :DELete
        [:NAME] <sequence_number>
        :ALL
    :SELect <sequence_number>


 :SYSTem
   :ERRor?
   :VERSion?
   :LOCal
   :REMote
```

Table 4-1. *SCPI Command Summary (continued).*

```
:TRACe
  [:DATA] #<binary_block>
  :DEFine {<segment_number/name>, <length>}
  :DELete
    [:NAME] <segment_number>
    :ALL
  :SELect <segment_number>

:TRIGger
  :SOURce {EXTernal | INTernal | BUS}
  :INTernal
    :RATE <value>
  :STATe {OFF | ON}
  :IMMediate




Common Commands

*CLS      Clear status command
*ESE      Standard event status enable command
*OPC      Operation complete command
*RCL      Recall front panel set-up command
*RST      Reset command
*SAV      Save front panel set-up command
*SRE      Service request enable command
*TRG      Trigger command
*WAI      Wait-to-continue command

*ESE?     Standard event status enable query
*ESR?     Standard event status register query
*IDN?     Identification query
*OPC?     Operation complete query
*SRE?     Service request enable query
*STB?     Read status byte query
```

4-13. Output Configuration Command Summary

The Output Configuration Commands control the output function, shape, frequency, amplitude, filter, and state. The commands are presented exactly as they should be typed in your program. Optional nodes were omitted from these commands. Factory defaults after *RST or front panel reset are shown in bold typeface. Parameter low and high limits are given where applicable. Use the Standard Waveforms parameters in paragraph 4-13 for the APPLy command.

Command and Parameters	*Low Limit*	*High Limit*	*Default*

[SOURce:]
  APPLy:SINusoid {[<frequency> [,<amplitude> [,<offset> [,<phase> [,<power>]]]]]}
  APPLy:TRIangle {[<frequency> [,<amplitude> [,<offset> [,<phase> [,<power>]]]]]}
  APPLy:SQUare {[<frequency> [,<amplitude> [,<offset> [,<duty_cycle>]]]]}
  APPLy:PULSe {[<frequency> [,<amplitude> [,<offset> [,<delay> [,<rise_time> [,<high_time>,

  [<fall_time>]]]]]]]}
  APPLy:RAMP {[<frequency> [,<amplitude> [,<offset> [,<delay> [,<rise_time> [,<fall_time>]]]]]]}
  APPLy:SINC {[<frequency> [,<amplitude> [,<offset> [,<number_cycles>]]]]}
  APPLy:EXPonential [<frequency> [,<amplitude> [,<offset> [,<exponent>]]]]}
  APPLy:GAUSsian {[<frequency> [,<amplitude> [,<offset> [,<exponent>]]]]}
  APPLy:DC {[<percent_amplitude>]}
  APPLy:USER {[<segment_number> [,<sampling_clock> [,<amplitude>, [,<offset>]]]]}
  APPLy:SEQuenc {[<sequence_number> [,<sampling_clock> [,<amplitude> [,<offset>]]]]}
  APPLy:<function_shape>?
  APPLy?

  FUNCTion:MODE {FIXed | USER | SEQuence}
  FUNCTion:MODE?
  FUNCtion:SHAPe {SINusoid | TRIangle | SQUare | PULSe | RAMP | SINC | EXPonential |

    GAUSsian | DC }
  FUNCtion:SHAPe?
  FUNCtion:SHAPe:USER <segment_number>
  FUNCtion:SHAPe:USER?
  FUNCtion:SHAPe:SEQuence <sequence_number>
  FUNCtion:SHAPe:SEQuence?

FREQuency {<frequency>	MINimum	MAXimum}...........	10e-6hz	50e6hz	100e3hz
FREQuency?			
FREQuency:RASTer {<frequency>	MINimum	MAXimum}...	10e-3hz	100e6hz	100e6hz
FREQuency:RASTer?			
FREQuency:RASter:SOURce {EXT	INT	XTAL}			
FREQuency:RASTer:SOURce?			
VOLTage {<amplitude>	MINimum	MAXimum}	10e-3v	9.99v	5.00v
VOLTage?			
VOLTage:OFFSet <offset>	0v	4.5v	0v
VOLTage:OFFSet?			

OUTPut:
  FILTer:FREQuency {20MHz | 25MHz | 50MHz}
  FILTer:FREQuency?
  FILTer {OFF | ON}
  FILTer?

4-14. Standard Waveform Command Summary

The Standard Waveform Commands control the various parameters of the standard output functions. The commands are presented exactly as they should be typed in your program. Optional nodes were omitted from these commands. Factory defaults after *RST or front panel reset are shown in bold typeface. Parameter low and high limits are given where applicable. The Standard Waveforms parameters could be used for the APPLy command.

Command and Parameters	*Low Limit*	*High Limit*	*Default*
[SOURce:]			
SINusoid:PHASe <value> 0		360	**0**
SINusoid:PHASe?			
SINusoid:POWer <value> 1		9	**1**
SINusoid:POWer?			
TRIangle:PHASe <value> 0		360	**0**
TRIangle:PHASe?			
TRIangle:POWer <value> 1		9	**1**
TRIangle:POWer?			
SQUare:DCYCle <value>..................................... 1		99	**50**
SQUare:DCYCle?			
PULSe:DELay <value>.. 0%		99.9%	**10.0%**
PULSe:DELay?			
PULSe:WIDTh <value> 0%		99.9%	**10.0%**
PULSe:WIDTh			
PULSe:TRANsition <value> 0%		99.9%	**10.0%**
PULSe:TRANsition?			
PULSe:TRANsition:TRAiling <value> 0%		99.9%	**10.0%**
PULSe:TRANsition:TRAiling?			
RAMP:DELay <value>.. 0%		99.9%	**10.0%**
RAMP:DELay?			
RAMP:TRANsition <value> 0%		99.9%	**10.0%**
RAMP:TRANsition?			
RAMP:TRANsition:TRAiling <value> 0%		99.9%	**10.0%**
RAMP:TRANsition:TRAiling?			
SINC:NCYCle <value>....................................... 4		999	**10**
SINC:NCYCle?			
GAUSsian:EXPonent <value>................................ 1		65535	**1000**
GAUSsian:EXPonent?			
EXPonential:EXPonent <value> 0.01		20.00	**1.00**
EXPonential:EXPonent?			
DC <%_amplitude>... 0%		100%	**100%**
DC?			

4-15. Arbitrary Waveform and Sequence Command Summary

The Arbitrary Waveform Commands control the segmentation of the arbitrary memory, the waveform shape, and the various bits each memory segment. The sequence commands control the segments which are linked and the number of times each segment is repeated in this loop. The commands are presented exactly as they should be typed in your program. Optional nodes were omitted from these commands.

Command and Parameters

TRACe #<binary_block>
TRACe:DEFine {<segment_number>, <length>}
TRACe:DELete <segment_number>
TRACe:DELete:ALL
TRACe:SELect <segment_number>

FORMat:BORDer {**NORMal** | SWAPped}
FORMat:BORDer?

SEQuence:DEFine <step_number>, <segment_number>, <#_repeat>
SEQuence:DELete <sequence_number>
SEQuence:DELete:ALL
SEQuence:SELect <sequence_number>

4-16. Modulation Command Summary

The Modulation Commands control the various modulation modes that the generator is capable of handling. The Model 8024 can be amplitude, gate, and burst modulated from an internal or an external source. The commands are presented exactly as they should be typed in your program. Optional nodes were omitted from these commands. Factory defaults after *RST or front panel reset are shown in bold typeface. Parameter low and high limits are given where applicable.

Command and Parameters	*Low Limit*	*High Limit*	*Default*
[SOURce:]			
AM <value> 0%	200%	**50%**
AM?			
AM:INTernal:FREQuency <value> 10	65535	**100**
AM:INTernal:FREQuency?			
AM:EXECute			
BM:NCYCles {<value>	MINimum	MAXimum} 1	32767	**1**
BM:NCYCles?			
BM:INTernal:RATE <value>. 20e-6s	999s	**1s**
BM:INTernal:RATE?			
BM:SOURce {**EXTernal**	INTernal	BUS}			
BM:SOURce?			
BM {**OFF**	ON}			
BM?			
BM:IMMediate			
GM {**OFF**	ON}			
GM?			

4-17. Trigger Command Summary

The Trigger Commands control the trigger modes that the generator is capable of handling. The commands are presented exactly as they should be typed in your program. Optional nodes were omitted from these commands. Factory defaults after *RST or front panel reset are shown in bold typeface. Parameter low and high limits are given where applicable.

Command and Parameters	Low Limit	High Limit	**Default**
TRIGger:SOURce {**EXTernal**	INTernal	BUS}			
TRIGger:SOURce?			
TRIGger:INTernal:RATE <value> 20e-6s	999s	**1s**
TRIGger:INTernal:RATE?			
TRIGger:STATe {**OFF**	ON}			
TRIGger:STATe?			
TRIGger:IMMediate			
*TRG			

4-18. System-Related Command Summary

The system-Related commands are not related directly to waveform generation but is an important part of operating the Model 8024. These commands control the display, error conditions, bus state, etc. The commands are presented exactly as they should be typed in your program. Optional nodes (if any) were omitted from these commands. Factory defaults after *RST or front panel reset are shown in bold typeface. Parameter low and high limits are given where applicable.

Command and Parameters	Low Limit	High Limit	**Default**
SYSTem:ERRor?			
SYSTem:VERSion?			
SYSTem:LOCal			
SYSTem:REMote			
*IDN?			
*RST			
*SAV <memory_cell> 0	9	**0**
*RCL <memory_cell> 0	9	**0**

4-19. IEEE-488.2 Common Commands and Queries

Since most instruments and devices in an ATE system use similar commands which perform identical functions, the IEEE-488.2 document has specified a common set of commands and queries which all device must use. This avoids the problem in which devices from various manufacturers used a different set of commands to enable functions and report status. The IEEE-488.2 treats the common commands and queries as device dependent commands. For example, *TRG is sent over the bus to trigger the instrument. Some common commands and queries, however, are optional; most of them are mandatory. The following is a complete listing of all common commands and queries which are used in the Model 8024.

*CLS - Clear the Status Byte summary register and all event registers.

*ESE <enable_value> - Enable bits in the Standard Event enable register. The selected bits are then reported to the status byte.

*ESE? - Query the Standard Event enable register. The generator returns a decimal value which corresponds to the binary-weighted sum of all bits set in the register.

*ESR? - Query the Standard Event register. The generator returns a decimal value which corresponds to the binary-weighted sum of all bits set in the register.

*IDN? - Query the generator identity. The returned data is organized into four fields, separated by commas. The generator responds with its manufacturer and model number in the first two fields and may also report its serial number and options in field three and four. If the later information is not available, the device must return an ASCII 0 for each. For example, model 8024 response to *IDN? is TABOR,8024,0,REV1.08.

*OPC - Set the "operation complete" bit (bit 0) in the Standard Event register after the previous commands have been executed.

*OPC? - Returns "1" to the output buffer after the previous commands have been executed. Used for synchronization between a controller and the instrument using the MAV bit in the Status Byte or a read of the Output Queue. The *OPC? query does not in any way affect the OPC Event bit in the Standard Event Status Register (ESR). Reading the response to the *OPC? query has the advantage of removing the complication of dealing with service requests and serial polls. However, it has the penalty that both the system bus and the controller handshake are in temporary holdoff state while the controller is waiting to read the *OPC? query response.

*RCL - Recall a previously stored state. To recall a stored state, you must use the same memory cell location used previously to store the state. Note that only front panel states are stored.

*RST - Reset the generator to its default state. Default values are listed in paragraphs 4-12 through 4-17.

*SAV - Stores instrument configurations. Ten memory cell locations (numbered 0 to 9) are available to store instrument configurations. The generator stores front panel states and configurations only. It does not store arbitrary waveforms and sequences. To recall a stored

state, you must use the same memory cell location used previously to store the state.

*SRE <enable_value> - Enables bits in the Status Byte enable register.

*SRE? - Query the Status Byte enable register. The generator returns a decimal value in the range of 0 to 63 or 128 to 191, since bit 6 (RSQ) cannot be set. The binary_weighted sum of the number represents the value of the bits of the Service Request Enable Register.

*STB? - Query the Status Byte summary register. The *STB? command is similar to a serial poll but it is processed like any other instrument command. The *STB? command returns the same result as a serial poll but the "request service" bit (bit 6) is not cleared if a serial poll has occurred.

*TRG - Trigger the generator from the remote interface. This command effects the generator if it is first placed in trigger or burst mode of operation and the trigger source is set to "BUS".

*WAI - Wait for all pending operations to complete before executing any additional commands over the interface.

4-20. The SCPI Status Registers

The Model 8024 uses the Status Byte register group and the Standard Event register group to record various instrument conditions. Figure 4-1 shows the SCPI status system.

An Event Register is a read only register that reports defined conditions within the generator. Bits in an event register are latched. When an event bit is set, subsequent state changes are ignored. Bits in an event register are automatically cleared by a query of that register or by sending the *CLS command. The *RST command or device clear will not clear bits in an event register. Querying an event register returns a decimal value which corresponds to the binary-weighted sum of all bits set in the register.

An Event Register defines which bits in the corresponding event register are logically ORed together to form a single summary bit. You can read from, and write, to an enable register. Querying an enable register will not clear it. The *CLS command does not clear enable registers but it does clear the bits in the event registers. To enable bits in an enable register, you must write a decimal value which corresponds to the binary_weighted sum of the bits you wish to enable in the register.
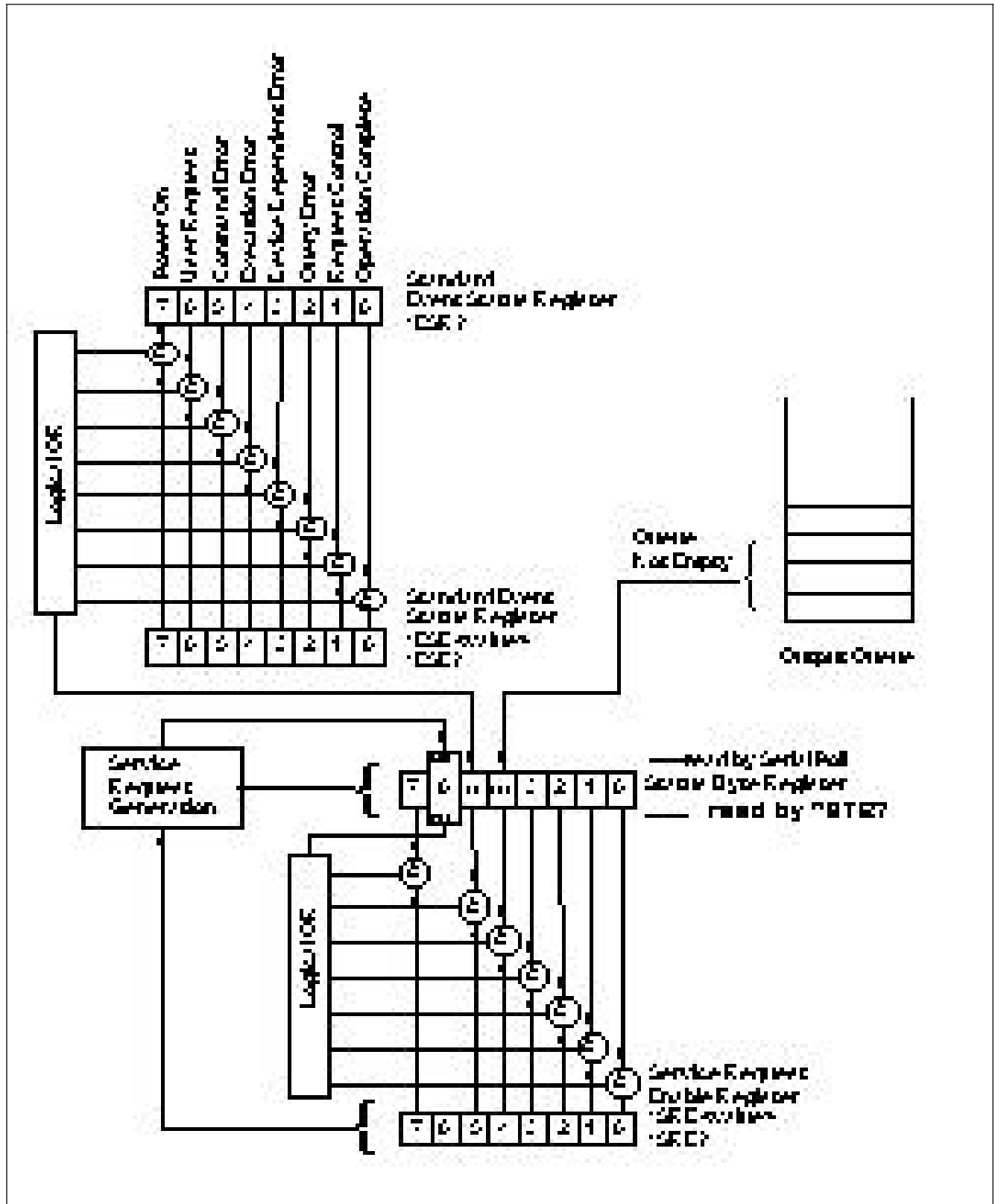
Figure 4-1. *IEEE-488.2 Status Reporting Model*

4-20-1. The Status Byte Register (STB)

The Status Byte summary Register contains conditions from the other registers. Query data that is waiting in the generator's output buffer is immediately reported through the Message Available bit (bit 4). Bits in the summary register are not latched. Clearing an event register will clear the corresponding bits in the Status Byte summary Register. Description of the various bits within the Status Byte summary Register is given in the following.

Bit 0 - Decimal value 1. Not used, always set to 0.
Bit 1 - Decimal value 2. Not used, always set to 0.
Bit 2 - Decimal value 4. Not used, always set to 0.
Bit 3 - Decimal value 8. Not used, always set to 0.

Bit 4 - Decimal value 16. Message Available Queue Summary Message (MAV). The state of this bit indicates whether or not the output queue is empty. The MAV summary-message is true when the output queue is not empty. This message is used to synchronize information exchange with the controller. The controller can, for example, send a query command to the device and then wait for MAV to become true. If an application program begins a read operation of the output queue without first checking for MAV, all system bus activity is held up until the device responds.

Bit 5 - Decimal value 32. Standard Event Status Bit (ESB) Summary Message. Its state indicates whether or not one or more of the enabled ESB events have occurred since the last reading or clearing of the Standard Event Status Register.

Bit 6 - Decimal value 64. Master Summary Status (MSS)/Request Service (RQS) Bit. Its state indicate if the device has at least one condition to request service. The MSS bit is not part of the IEEE-488.1 status byte and will not be sent in response to a serial poll. The RQS bit, however, if set, will be sent in response to a serial poll.

Bit 7 - Decimal value 128. Not used, always set to 0.

4-20-1-1. Reading the Status Byte Register

The Status Byte summary Register can be read with either a serial poll or the *STB? common query. Both of these methods read the STB message. The value sent for the bit 6 position is, however, dependent upon the method used.

4-20-1-2. Reading with a Serial Poll

When serial polled, the generator returns the 7-bit status byte plus the single bit RQS message. The status bye and RQS message are returned to the controller as a single data byte. The RQS message is sent on line D107 (bit 6). RQS TRUE means that bit 6 line is asserted (pulled to a low voltage) when the status byte is sent. The response represents the sum of the binary-weighted values of the Status Byte Register.

Reading the Status Byte Register with a serial poll sets the RQS message FALSE until a new reason for service has occurred. The STB portion of the Status Byte Register is read non-destructively. The value of the status byte is not altered by a serial poll. Once the generator has generated an RQS, its status byte should be read to clear the SRQ line so the controller can detect an SRQ from another device. Otherwise the instrument will continuously assert the SRQ line.

4-20-1-3. Reading With the *STB?

The *STB? common query causes the generator to send the contents of the Status Byte Register and the MSS (Master Summary Status) summary message as a single <NR1 Numeric Response Message> element. The response represents the sum of the binary-weighted values of the Status Byte Register. The *STB? common query does not alter the status byte.

4-20-1-4. Clearing the Status Byte Register

The entire Status Byte Register can be cleared by removing the reasons for service from Auxiliary Status Registers. Sending the *CLS command to the device after a SCPI command terminator and before a Query, clears the Standard Event Status Register and clears the output queue of any unread messages. With the output queue empty, the MAV summary message is set to FALSE. Methods of clearing other auxiliary status registers are discussed in the following.

4-20-2. Service Request Enable Register (SRE)

The Service Request Enable Register is an 8-bit register that enables corresponding summary messages in the Status Byte Register. Thus, the application programmer can select reasons for the generator to issue a service request by altering the contents of the Service Request Enable Register.

The Service Request Enable Register is read with the *SRE? common query. The response to this query is an number that represents the sum of the binary-weighted value of the Service Request Enable Register. The value of the unused bit 6 is always zero.

The Service Request Enable Register is written using the *SRE command followed by a decimal value representing the bit values of the Register. A bit value one indicates an enabled condition. Consequently, a bit value of zero indicates a disabled condition. The Service Request Enable Register is cleared by sending *SRE0. The generator always ignores the value of bit 6. Summary of *SRE commands is given in the following.

    *SRE0 -   Clears all bits in the register.
    *SRE1 -   Not used.
    *SRE2 -   Not used.
    *SRE4 -   Not used.
    *SRE8 -   Not used.
    *SRE16 -   Service request on MAV.
    *SRE32 -   Service request on ESB summary bit.
    *SRE128 - Not used.

4-20-3. Standard Event Status Register (ESR)

The Standard Event Status Register is a special application of the status reporting. The 8 bits of the ESR have been defined by the IEEE-488.2 as specific conditions which can be monitored and reported back to the user upon request. The Standard Event Status Register is destructively read with the *ESR? common query. The Standard Event Status Register is cleared by a *CLS common command, on power-on, and when read by *ESR?.

The arrangement of the various bits within the register is firm and is required by all GPIB instruments that implement the IEEE-488.2. Description of the various bits is given in the following.

Bit 0 - Operation Complete. Generated in response to the *OPC command. It indicates that the device has completed all selected and pending operations and is ready for a new command.

Bit 1 - Request Control. This bit operation is disabled on the Model 8024.

Bit 2 - Query Error. This bit indicates that an attempt is being made to read data from the output queue when no output is either present or pending.

Bit 3 - Device Dependent Error. This bit is set when an error in a device function occurs. For example, the following command will cause DDE error:

    VOLTage 7.25V;OFFSet 4.1V

Both of the above parameters are legal and within the specified limits, however, generator is unable to generate such an amplitude and offset combination.

Bit 4 - Execution Error. This bit is generated if the parameter following the command is outside of the legal input range of the generator.

Bit 5 - Command Error. This bit indicates the generator received a command that was a syntax error, or a command that the device does not implement. A GET receive inside a command string will also cause a Command Error.

Bit 6 - User Request. This event bit indicates that one of a set of local controls, had been activated. This event bit occurs regardless of the remote or local state of the device.

Bit 7 - Power On. This bit indicates that the device's power source was turned off, then on, since the last time that the register was read.

4-20-3-1. Standard Event Status Enable Register (ESE)

The Standard Event Status Enable Register allows one or more events in the Standard Event Status Register to be reflected in the ESB summary-message bit. The Standard Event Status Enable Register is an 8-bit register that enables corresponding summary messages in the Standard Event Status Register. Thus, the application programmer can select reasons for the generator to issue an ESB summary-message bit by altering the contents of the ESE Register.

The Standard Event Status Enable Register is read with the *ESE? common query. The response to this query is an number that represents the sum of the binary-weighted value of the Standard Event Status Enable Register.

The Standard Event Status Enable Register is written using the *ESE command followed by a decimal value representing the bit values of the Register. A bit value one indicates an enabled condition. Consequently, a bit value of zero indicates a disabled condition. The Standard Event Status Enable Register is cleared by sending *ESE0. Summary of *ESE messages is given in the following.

*ESE0 -   No mask. Clears all bits in the register.
*ESE1 -   ESB on Operation Complete.
*ESE2 -   ESB on Request Control.
*ESE4 -   ESB on Query Error.
*ESE8 -   ESB on Device Dependent Error.
*ESE16 -   ESB on Execution Error.
*ESE32 -   ESB on Command Error.
*ESE64 -   ESB on User Request.
*ESE128 - ESB Power on.

4-21. Error Messages

In general, whenever the generator receives an invalid SCPI command, it automatically generates an error. The error number is displayed on the LCD readout for about one second and the instrument resumes normal operation. Errors are stored in a special error queue and may be retrieved from this buffer one-at-a-time. Errors are retrieved in first-in-first-out (FIFO) order. The first order returned is the first error that was stored. When you have read all errors from the queue, the generator responds with a +0,"No error" message.

If more than 30 errors have occurred, the last error stored in the queue is replaced with -350, Too many errors". No additional errors are stored until you remove errors from the queue. If no errors have occurred when you read the error queue, the generator responds with +0,"No error".

The error queue is cleared when power has been shut off or after a *CLS command has been executed. The *RST command does not clear the error queue. Use the following command to read the error queue:

SYSTem:ERRor?

Errors have the following format (the error string may contain up to 80 characters):

-102,"Syntax error"

A complete listing of the errors that can be detected by the generator is given in the following.

-100,"Command error". When the generator can not detect more specific errors, this is the generic syntax error used.

-102,"Syntax error". Invalid syntax found in the command string.

-103,"invalid separator". An invalid separator was found in the command string. You may have used a comma instead of a colon or a semicolon. In some cases where the generator can not detect a specific separator, it may return error -100 instead of this error.

-109,"Missing parameter". Fewer parameters were received for the command. You omitted one or more parameters that are required for the command.

-113."Undefined header". A command was received that is not valid for the generator. You may have misspelled the command or it may not be a valid command.

-131,"Invalid suffix". A suffix was incorrectly specified for a numeric parameter. You may also have misspelled the suffix.

-161,"Invalid block data". Applies only to the TRACe command. For a definite block, the number of bytes of data sent does not match the number of bytes that you specified in the block header. For an indefinite-length block, an EOI was received without an accompanying "new line" character.

-221,"Setting conflict". Two conflicting parameters were received which can not be executed without generating an error. You may have sent an offset value which is outside the amplitude level window.

-222,"Data out of range". Parameter data which followed a specific header could not be used because its value is outside the valid range defined by the generator.

-224,"Illegal parameter value". A discrete parameter was received which was not a valid choice for the command. You may have used an invalid parameter choice.

-350,"Too many errors". The error queue is full because more than 30 errors have occurred. No additional errors are stored until you remove from the queue. The error queue is cleared when power has been off, or after a *CLS command has been executed.

-410,"Query INTERRUPTED". A command was received which sends data to the output buffer, but the output buffer contained data from a previous command (the previous data is not overwritten). The output buffer is cleared when power has been off, or after a device clear has been executed.

4-22. Device-Specific Commands

The Model 8024 conforms to the 1993.0 version of the SCPI standard. Some of the commands used are not included in the 1993.0 version of the SCPI standard. However, these commands are designed with the SCPI standard in mind and they follow all of the command syntax rules defined by the standard. Appendix B lists all device-specific commands that were designed specifically for the Model 8024.

4-23. Output Configuration Commands

This paragraph describes the low-level commands used to program the generator. Although the APPLy command provides the most straightforward method to program the generator, the low-level commands give you more flexibility to change individual parameters.

    `FUNCtion:MODE  {FIXed|USER|SEQuence}`

Select the output function type. The selected function type outputs one of the previously selected function shape. If you select "FIXed", the generator outputs the standard waveform currently selected by the FUNC:SHAP command. If you select "USER", the generator outputs the arbitrary waveform currently selected by the FUNC:SHAP:USER command. If you select "SEQuence", the generator outputs the sequence currently selected by the FUNC:SHAP:SEQ command.

    `FUNCtion:MODE?`

Query the output function type. Returns FIX, USER, or SEQ.

    `FUNCtion:SHAPe  {SINusoid|TRIangle|SQUare|PULSe|  RAMP  |SINC`
    `|EXPonential|GAUSsian  |DC}`

Select a standard output function. The selected waveform is output using the previously selected frequency, amplitude, offset, and other relevant settings. The standard waveform will be output only after the FUNC:MODE:FIX commands has been selected.

    `FUNCtion:SHAPe?`

Query the standard function shape. Returns SIN,TRI,SQU,PULS,RAMP,SINC,EXP, GAUS, or DC.

    `FUNCtion:SHAPe:USER  <segment_number>`

Select an arbitrary waveform. The selected arbitrary waveform is output using the previously selected sampling clock, segment size, amplitude, and dc offset. The <segment_number> should be programmed using the TRACe commands before it can output a waveform. The arbitrary waveform will be output only after the FUNC:SHAP:USER command has been selected.

    `FUNCtion:SHAPe:USER?`

Query the active arbitrary segment number. Returns a value.

    `FUNCtion:SHAPe:SEQuence  <sequence_number>`

Select a sequence of waveforms. The selected sequence is output using previously selected segments, sampling clock, amplitude, and dc offset. The <sequence_number> should be programmed using the SEQuence commands before it can output a sequence. The sequence will be output only after the FUNC:SHAP:SEQ command has been selected.

    `FUNCtion:SHAPe:SEQuence?`

Query the active sequence number. Returns a value.

    `FREQuency  {<frequency>|MINimum|MAXimum}`

Set the output frequency for the standard functions. MIN selects the lowest frequency allowed for the currently active function. MAX selects the highest frequency allowed for the currently active function. The default frequency setting is 100KHz for all functions.

    `FREQuency?`

Query the frequency setting for the standard function currently active. Returns a value in hertz.

`FREQuency:RASTer  {<frequency>|MINimum|MAXimum}`

Set the sampling clock frequency for the user and sequenced functions. MIN selects the lowest frequency allowed for the currently active segment or sequence. MAX selects the highest frequency allowed for the currently active segment or sequence. The default sampling clock frequency setting is 100MHz for all functions. Note that the output frequency depends on the number of points specified in the waveform. The output frequency can be computed using the following formula: Output Frequency = Sampling Clock / Segment Points. The frequency parameter is automatically computed and displayed on the LCD display. If a segment or a sequenced have not been defined, the LCD will display "FREQ off".

`FREQuency:RASTer?`

Query the sampling clock frequency setting for the arbitrary segment or sequence currently active. Returns a value in hertz.

`FREQuency:RASter:SOURce  {EXT|INT|XTAL}`

Set the sampling clock source for the user and sequenced functions. EXT selects an external clock source. The external source is applied to the rear panel CLOCK IN terminal. INT selects the internal synthesized clock generator. XTAL selects a fixed source directly from the 10 MHz crystal. The default setting is INT.

`FREQuency:RASTer:SOURce?`

Query the sampling clock source setting. Returns EXT, INT, or XTAL

`VOLTage  {<amplitude>|MINimum|MAXimum}`

Set the peak-to-peak amplitude for the currently active function. MIN selects the smallest amplitude. MAX selects the largest amplitude. The default amplitude is 5.00 V (into 50Ω).

`VOLTage?`

Query the output amplitude for the currently selected function. Returns a value in volts.

`VOLTage:OFFSet  <offset>`

Set the dc offset voltage for the currently active function. The default offset is 0 V (into 50Ω).

`VOLTage:OFFSet?`

Query the output offset for the currently selected function. Returns a value in volts.

`OUTPut:FILTer:FREQuency  {<20MHz|25MHz|50MHz>}`

Set the filter frequency for the currently active function. Note that the filters can not be changed if the generator is set to output sine waveform from its standard waveform library. The filters will be activated only after the OUTP:FILT ON command. The default filter setting is 20MHz.

`OUTPut:FILTer:FREQuency?`

Query the currently selected filter setting. Returns 20MHz, 25MHz, or 50MHz.

`OUTPut:FILTer  {OFF|ON}`

Turn the previously selected output filter on or off. The active filter is selected with the OUTP:FILT:FREQ command. The default filter state setting is OFF.

`OUTPut:FILTer?`

Query the output filter state. Returns "0" (OFF) or "1" (ON).

```
OUTPut:[STATe]  {OFF|ON}
```

Disable or enable output from the OUTPUT terminal. The default value is ON. When the output signal is disabled, the output level on the OUTPUT terminal is set to the minimum amplitude level (10 mVp-p into 50Ω).

```
OUTPut:[STATe]?
```

Query the state of the OUTPUT terminal. Returns "0" (OFF) or "1" (ON).

4-23-1. Using the APPLy Commands

The APPLy command provides a high level language method to program the generator over the remote interface. You can select the function, frequency, amplitude, offset, and other parameters which are associated with the selected function. For example, the following statement outputs a 2 Vp-p square wave at 1 MHz with a 0 V offset and 10% duty cycle using APPLy:

```
APPL:SQU  1e6Hz,  2V,  0V,  10%
```

You can also query all parameters which are associated with a standard function using the APPL: <function_shape>? query. For example, if you programmed the generator using the above APPLy:SQU command you can query the square wave parameters using the following query:

```
APPL:SQU?
```

The generator returns a string that contains all the parameters that are associated with the square function similar to the following string: "1.000e+6,2,0,10".

```
APPLy:SINusoid  {[<frequency>[,<amplitude>[,<off-
set>[,<phase>[,<power>]]]]]}
```

Program the generator to output sine waveform with frequency, amplitude, offset, start phase, and power parameters. Parameters are optional, However, if you want to use the APPLy command as above and change just the amplitude, you must include the frequency parameter in your command. The parameters that follow could be omitted. The default setting for this function are: 100 KHz, 5 Vp-p, 0 V, 0, and 1.

```
APPLy:TRIangle  {[<frequency>[,<amplitude>[,<off-
set>[,<phase>[,<power>]]]]]}
```

Program the generator to output triangle waveform with frequency, amplitude, offset, start phase, and power parameters. The default setting for this function are: 100 KHz, 5 Vp-p, 0 V, 0, and 1.

```
APPLy:SQUare  {[<frequency>[,<amplitude>[,<offset>[,<duty_cy-
cle>]]]]}
```

Program the generator to output square waveform with frequency, amplitude, offset, and duty cycle parameters. The default setting for this function are: 100 KHz, 5 Vp-p, 0 V, and 50%.

```
APPLy:PULSe  {[<frequency>[,<amplitude>[,<offset>[,<de-
lay>[,<rise_time>
                [,<high_time>,[<fall_time>]]]]]]]}
```

Program the generator to output pulse waveform with frequency, amplitude, offset, delay, rise time, high time, and fall time parameters. The default setting for this function are: 100 KHz, 5 Vp-p, 0 V, 0%, 10%, 10%, 10%, and 10%.

```
APPLy:RAMP  {[<frequency>[,<amplitude>[,<offset>[,<de-
lay>[,<rise_time
                [,<fall_time>]]]]]]}
```

Program the generator to output sine(x)/x waveform with frequency, amplitude, offset, and number of cycles parameters. The default setting for this function are: 100 KHz, 5 Vp-p, 0 V, and 10.

```
APPLy:EXPonential    [<frequency>[,<amplitude>[,<offset>[,<expo-
nent>]]]]}
```

Program the generator to output exponential waveform with frequency, amplitude, offset, and exponent parameters. The default setting for this function are: 100 KHz, 5 Vp-p, 0 V, and 1.00.

```
APPLy:GAUSsian  {[<frequency>[,<amplitude>[,<offset>[,<expo-
nent>]]]]}
```

Program the generator to output gaussian waveform with frequency, amplitude, offset, and exponent parameters. The default setting for this function are: 100 KHz, 5 Vp-p, 0 V, and 1000.

```
APPLy:DC  {[<percent_amplitude>]}
```

Program the generator to output dc level. The dc level is set as percent of programmed amplitude. The default setting for this function are: 100 %.

```
APPLy:USER  {[<segment_number>[,<sampling_clock>[,<amplitude>,
            [,<offset>]]]]}
```

Program the generator to output an arbitrary waveform. The specified segment number must be loaded with an arbitrary waveform before the generator can execute this command successfully. This command lets you specify segment number, sampling clock rate, amplitude and offset. The default setting for this function are: 1, 100 MHz, 5 Vp-p, and 0 V.

```
APPLy:SEQuence  {[<sequence_number>[,<sampling_clock>[,<ampli-
tude>
            [,<offset>]]]]}
```

Program the generator to output a sequence of waveforms. The specified sequence number must be programmed with a sequence before the generator can execute this command successfully. This command lets you specify segment number, sampling clock rate, amplitude and offset. The default setting for this function are: 1, 100 MHz, 5 Vp-p, and 0 V.

```
APPLy:<function_shape>?
```

Query parameters that are associated with the specified function shape. Returns a string of values, depending on the parameters that are available for the selected function shape.

```
APPLy?
```

4-24. Standard Waveform Commands

The Standard Waveform Commands control the various parameters for the active output function. The standard function output will be available at the OUTPUT terminal only after FUNC:MODE FIX, and FUNC:SHAP PULS commands have been executed. Parameters for the selected function shape can be modified now and will cause an effect on the output waveform.. Note that changes to a specific function do not have any effect on other functions.

```
PULSe:DELay  <value>
```

Set pulse delay in percent of pulse period. For example, if your pulse period is 100 ms, 10% will delay the first transition of the pulse by 10 ms. Delay is measured from trigger to the first turning point.

`PULSe:DELay?`

Query pulse delay setting. Returns a value in percent.

`PULSe:TRANsition  <value>`

Set pulse rise time in percent of pulse period. For example, if your pulse period is 100 ms, 5% rise time equals 5 ms. Pulse rise time is measured between the two turning points of the first transition.

`PULSe:TRANsition?`

Query pulse rise time setting. Returns a value in percent.

`PULSe:WIDTh  <value>`

Set pulse width in percent of pulse period. For example, if your pulse period is 100 ms, 20% pulse width equals 20 ms. Pulse width is measured between the two turning points on the top of the pulse.

`PULSe:WIDTh?`

Query pulse width setting. Returns a value in percent.

`PULSe:TRANsition:TRAiling  <value>`

Set pulse fall time in percent of pulse period. For example, if your pulse period is 100 ms, 15% fall time equals 15 ms. Pulse fall time is measured between the two turning points of the second transition.

`PULSe:TRANsition:TRAiling?`

Query pulse fall time setting. Returns a value in percent.

4-25. Arbitrary Waveform Commands

The following is an overview of the arbitrary waveform commands, how to define memory segments, how to download data to the selected memory segment and how to output an arbitrary waveform over the remote interface.

`TRACe:DEFine  {<segment_number>, <length>}`

Assign length to a specific memory segment. The 64K non-volatile memory can be divided to 99 smaller segments. Minimum segment length is 10 points. Maximum segment length is 64,536 points. Note that total size of the non-volatile memory is 65,535 points however, 1000 points are reserved for the built-in standard waveform library. The TRAC:DEF command does not change the FUNC:MODE setting. Therefore, unless you use the FUNC:MODE USER command, TRAC:DEF will have no immediate effect on the output waveform or function.

`TRACe:DELete  <segment_number>`

Delete contents of a specific memory segment. This command destructively modifies segment length to 0. Re-sizing a deleted segment to its previously set length does not recover its data.

`TRACe:DELete:ALL`

Delete contents of the entire non-volatile memory at once. This command destructively modifies all segment's length to 0. Re-sizing deleted segments to their previously set length does not recover their data. Use the TRAC:DEL command to delete stored waveforms one at a time.

`TRACe:SELect  <segment_number>`

Select a specific memory segment to be placed at the OUTPUT terminal. The generator will output the selected memory segment only after executing the FUNC:MODE USER command.

4-25-1. High Speed Binary Waveform Transfer

The high speed binary transfer allows any 8-bit bytes (including extended ASCII codes) to be transmitted in a message. This command is particularly useful for sending large quantities of data. Model 8024 uses this element to transmit its waveform data to the controller.

There are two possible methods of using high speed binary waveform transfer commands: as part of a string of commands, regardless of the location of this command within the complete string, or at the end of a string of commands, where with the second option, the command must terminate the transmission sequence by sending NL+^END. The following command shows an example how to use the high speed binary waveform transfer command as part of a string.

```
TRACe  #42000<binary_block>
```

This command will begin the transfer of 2000 bytes of data (1000) points to the active memory segment. The ASCII "#" ($23) is the start of the data block. "4" designates the number of digits that follow. "2000" is an even number of byte to follow. The generator represents binary data as 12-bit integers, which is sent as two bytes. Therefore, the total number of bytes is always twice the number of data points in the waveform. For example, 2000 bytes are required to download a waveform with 1000 points. You may use the FORM:BORD command to select the byte order for binary transfers.

NOTE

> The Model 8024 operates in interlaced mode where two memory cells generate one byte of data.. Segment size can be programmed in even number only. Therefore, the generator can accept binary blocks of data that divide by 4 only. For example, 2000 bytes will be an acceptable binary block; 2002 does not divide by 4, therefore, the generator will automatically adjust the size to 1002 points and generate an error message.

There is another method of sending high speed binary waveform data without specifying the number of byte in the block. This format is especially useful when the length of the transmission is unknown or when transmission speed or other considerations prevent segmentation into definite length blocks. The use of this command require NL+^END and forces immediate termination of the command string. The following command shows an example how to use the high speed binary waveform transfer command without specifying the number of byte in the block.

```
TRACe  #<binary_block>NL+^END
```

This command will begin the transfer of data to the active memory segment. The ASCII "#" ($23) is the start of the data block. The total number of bytes sent is always twice the number of data points in the waveform. For example, 2000 bytes are required to download a waveform with 1000 points. You may use the FORM:BORD command to select the byte order for binary transfers.

```
FORMat:BORDer  {NORMal|SWAPped}
```

Select the byte order for binary transfers in the block mode using FORM command. The default is NORM. This command is used only for binary block transfers.

```
FORMat:BORDer?
```

Query the byte order configuration. Returns "NORM" or "SWAP".

4-26. Arbitrary Waveform Sequence Commands

The following is an overview of the arbitrary waveform sequence commands, how to define a sequence and how to output a sequence of arbitrary waveforms over the remote interface.

    SEQuence:DEFine {<step_number>,<segment_number>,<#_repeat>}

Define the links between segments and the number of repeats for each segment in a specific sequence. You can program 99 links between 99 waveforms and repeat each of the 99 waveforms 32767 times. The sequence generator steps through the steps numbers in descending order. In continuous operating mode, after the last step has been completed, the sequence is repeated automatically. When the generator is set to operate in trigger mode, the output stops at the last point of the last waveform in the sequence. In gated mode, the sequence is always completed after the gate stop signal.

The SEQ:DEF command does not change the FUNC:MODE setting. Therefore, unless you use the FUNC:MODE SEQ command, SEQ:DEF will have no immediate effect on the output waveform or function.

    SEQuence:DELete <sequence_number>

Delete contents of a specified sequence. This command destructively modifies the selected sequence to "Empty". Re-selecting a deleted sequence does not recover its data.

    SEQuence:DELete:ALL

Delete contents of all sequences at once. This command destructively modifies all sequences to "Empty". Re-selecting deleted sequence does not recover its data. Use the SEQ:DEL command to delete sequences one at a time.

    SEQuence:SELect <sequence_number>

Select a specific sequence to be placed at the OUTPUT terminal. The generator will output the selected sequence only after executing the FUNC:MODE SEQ command.

4-27. Modulation Commands

The Modulation Commands control the various modulation modes that the generator is capable of handling. The Model 8024 can be amplitude, gate, and burst modulated from an internal or an external source.

4-27-1. Amplitude Modulation Commands

The arbitrary waveforms which are stored in memory segments are used as modulating envelop. The modulated carrier is always a sine wave with its frequency set in points. The first step in modulating a waveform is to generate an arbitrary waveform either from the internal standard functions library or download a waveform using the GPIB. The following is an overview of amplitude modulation commands.

    AM <value>

Set the internal modulation depth in percent. Select from 0% to 200%. The default setting for AM depth is 50%.

    AM?

Query the modulation depth. Returns a value in percent.

    AM:INTernal:FREQuency <value>

Set the frequency of the carrier sine waveform. The frequency of the carrier wave is programmed in points. Select from 10 to 64535 points. The default setting for the carrier frequency is 100 points. The frequency of the carrier wave can be computed from the sampling clock frequency divided by the number of points in the active segment.

    AM:INTernal:FREQuency?

Query the carrier frequency. Returns a value in points.

    AM:EXECute

Enable amplitude modulation. To ensure proper operation, you should enable amplitude modulation after you have set up the other modulation parameters. Amplitude modulation can not be turned toggled on and off. Therefore, make sure that you have the original arbitrary waveform available in another memory segment for back-up.

4-27-2. Gate Modulation Commands

The following is an overview of the gate modulation commands. The gate modulation commands toggle the gated mode on and off.

    GM {OFF|ON}

Enable gate modulation. The default state for the gate modulation is off. Turning gate modulation on, automatically turns trigger and burst modes off.

    GM?

Query the gate modulation state. Returns "0" (off) or "1" (on).

4-27-3. Burst Modulation Commands

When the generator is placed in burst mode, the output is idle at a voltage level from -V p-p max to + Vp-p max. Following the first burst of waveforms, the output will idle at the last point on the output waveform. The generator outputs a burst of counted waveforms after receiving a trigger signal. The trigger could come from a number of sources: from an external signal, from an internal trigger generator, and from an SCPI command. The following is an overview of the burst modulation commands.

    BM:NCYCles <value>

Set the number of output cycles to be output per burst. Select from 1 cycle to 32767 cycles, in 1 cycle increments. The default is 1 cycle.

    BM:NCYCles?

Query the burst count. Returns an integer.

    BM:INTernal:RATE <value>

Set the burst rate for internally triggered bursts. The burst rate period defines the interval between bursts. Select from 20e-6s to 999s. The default is 1 s. The burst rate setting is used only when BM:SOUR is set to INT. The burst rate is ignored when single triggering, external, or bus source is enabled.

    BM:INTernal:RATE?

Query the burst rate. Returns a value in seconds.

`BM:SOURce {EXTernal|INTernal|BUS}`

Select the burst modulation source. When the INT burst source is selected, the other source modes are disabled. The internal rate controls the interval between the bursts. Selecting EXT source disables the internal trigger generator and does not allow bus triggers. The BUS source allows triggering from using GPIB commands only. The default burst modulation source is EXT.

`BM:SOURce?`

Query the present burst modulation source. Returns "EXT", "INT", or "BUS".

`BM {OFF|ON}`

Disable or enable burst modulation. To ensure proper operation, you should enable the burst mode after you have set up the burst parameters. Only one modulation mode can be enabled at a time. When you enable the burst mode, the previous modulation or trigger mode turn automatically off.

`BM?`

Query the state off burst modulation. Returns "0" (OFF) or "1" (ON).

`BM:IMMediate`

Initiate one burst cycle immediately after this command. The generator will respond to this command after you select BM:SOUR BUS. If you select BM:SOUR EXT or BM:SOUR INT, the generator will ignore this command.

4-28. Trigger Commands

The Trigger Commands control the trigger modes that the generator is capable of handling. The following is an overview of the trigger commands.

`TRIGger:INTernal:RATE <value>`

Set the rate for internally triggered mode. The trigger period defines the interval between triggers. Select from 20e-6s to 999s. The default is 1 s. The trigger rate setting is used only when TRIG:SOUR is set to INT. The trigger rate is ignore when external or bus source is enabled.

`TRIGger:INTernal:RATE?`

Query the trigger rate. Returns a value in seconds.

`TRIGger:SOURce {EXTernal|INTernal|BUS}`

Select the trigger source. When the INT trigger source is selected, the other source modes are disabled. The internal rate controls the interval between the bursts. Selecting EXT source disables the internal trigger generator and does not allow bus triggers. The BUS source allows triggering from using GPIB commands only. The default trigger source is EXT.

`TRIGger:SOURce?`

Query the present trigger source. Returns "EXT", "INT", or "BUS".

`TRIGger:STATe {OFF|ON}`

Disable or enable trigger mode. To ensure proper operation, you should enable the trigger mode after you have set up the trigger parameters. Only one trigger mode can be enabled at a time. When you enable the trigger mode, the previous trigger mode turn automatically off.

`TRIGger:STATe?`

Query the state off burst modulation. Returns "0" (OFF) or "1" (ON).

```
TRIGger:IMMediate
```

Initiate one trigger cycle immediately after this command. The generator will respond to this command after you select TRIG:SOUR BUS. If you select TRIG:SOUR INT, the generator will ignore this command.

```
*TRG
```

Trigger the generator from the remote interface. This command is equivalent to the TRIG:IMM command. The generator will respond to this command after you select TRIG:SOUR BUS. If you select TRIG:SOUR EXT or TRIG:SOUR INT, the generator will ignore this command.

4-29. System-Related Commands

System-related commands are used to place the instrument in a specific state, clear the instrument to its defaults, query the generator on errors and its identity. Use these commands to save and recall front panel setups. The following is an overview of the system-related commands.

```
SYSTem:ERRor?
```

Read one error from the error queue. A record of up to 30 errors can be stored in the generator's error queue. Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. When you have read all errors from the queue, the generator returns +0, "No error".

If more than 30 errors have occurred, the last error stored in the queue (the most current error) is replaced with -350,"Too many errors". No additional errors are stored until you remove errors from the queue. The error queue is cleared when power has been off or after a *CLS command has been executed. The *RST command does not clear the error queue.

SYST:ERR? returns a string with following format: -102,"Syntax error"

```
SYSTem:VERSion?
```

Query the generator to determine the present SCPI revision. Returns a string similar to "1993.0"

```
SYSTem:LOCal
```

Turns the remote LED off and changes generator state to local operation. All key on the front panel are fully functional.

```
SYSTem:REMote
```

Turns the remote LED on and changes generator state to remote operation. All keys on the front panel, except the LOCAL key, are disabled.

```
*IDN?
```

Read the generator's identification string. The generator returns four field separated by commas. The first field is the manufacturer's name, the second field is the model number, the third field is not used (always "0"), and the fourth field is the firmware version number. The command returns "Tabor,8024,0,1.08".

```
*RST
```
Reset the generator to its default state. The *RST command has no effect on status registers, GPIB bus states, GPIB address, and GPIB command set.

`*SAV  <memory_cell>`

10 memory locations (numbered 0 to 9) are available to store instrument configurations. The state storage feature remembers a complete front panel configuration. To recall a stored state, you must use the same memory location used previously to store the state. Arbitrary waveforms downloaded to the generator *are not* remembered. The default memory cell location is "0".

When power is turned off, the generator automatically stores its state to a separate memory cell that is not one of the cells used to store front panel states. When power is restored, the instrument updates its front panel to the last state before the power turned off. In this case, the arbitrary waveforms that were downloaded to the generator are remembered.

`*RCL  <memory_cell>`

Recall a previously stored state. To recall a state, you must use the same memory location used previously to store the state. The default memory cell location is "0".

5

Maintenance and Performance Tests

5-1. Introduction

This section provides maintenance, service information, and performance tests for the Model 8024. Fuse replacement procedure, line voltage selection and disassembly procedure are also included.

WARNING

The procedures described in this section are for use only by qualified service personnel. Do not perform these procedures unless qualified to do so. Many of the steps covered in this section may expose the individual to potentially lethal voltages that could result in personal injury or death, if normal safety precautions are not observed.

5-2. Line Voltage Selection

The Model 8024 may be operated from either 115 Vac or 230 Vac, nominal, 50 - 60 Hz power sources. A special transformer may be installed for 100 Vac and 200 Vac ranges. Unless otherwise specified, the instrument was shipped from the factory set for an operating voltage of 230 Vac. To change the line voltage, proceed as follows:

WARNING

Disconnect the Model 8024 from the power cord and all other sources before changing the line voltage setting.

1. Using a flat-blade screwdriver, place the line voltage selection switch in the desired position. The selected voltage is marked on the selection switch.
2. Install a power line fuse consistent with the operating voltage. See paragraph 5.3

CAUTION

The correct fuse type must be used to maintain proper instrument protection.

5-3. Fuse Replacement

The Model 8024 has a line fuse to protect the instrument from excessive current. This fuse may be replaced by using the procedure described in the following:

WARNING

Disconnect the instrument from the power line and from other equipment before replacing the fuse.

1. Place the end of a flat-blade screwdriver into the slot in the LINE FUSE holder on the rear panel. Push in and rotate the fuse carrier. The holder and its internal spring will push the fuse and the carrier out of the holder.

POWER LINE	VOLTAGE	FUSE TYPE
90 - 125 V	0.4 A, 250 V	5 x 20 mm
195 - 250 V	0.8 A, 250 V	5 x 20 mm

Table 5-1. *Line Fuse Selection*

2. Remove the fuse and replace it with the proper type using Table 5-1 as a guide.

CAUTION

Do not use a fuse with a rating higher than specified, or instrument damage may occur. If the instrument persistently blows fuses, a problem may exist within the instrument. If so, the problem must be rectified before continuing operation.

5-4. Disassembly Instructions

If it is necessary to troubleshoot the instrument or replace a component, use the following disassembly procedure to remove the top cover:

1. Remove the four screws that secure the top cover to the side bars.
2. Grasp the top cover at its sides and carefully lift it off the instrument.
3. When replacing the top cover, reverse the above procedure.

5-5. Special Handling of Static Sensitive Devices

MOS devices are designed to operate at a very high impedance levels for low power consumption. As a result, any normal static charge that builds up on your person or clothing may be sufficient to destroy these devices if they are not handled properly. When handling such devices, use precautions which are described in the following to avoid damaging them.

1. The MOS ICs should be transported and handled only in special containers designed to prevent static build-up. Typically, these parts will be received in static-protected containers of plastic or foam. Keep these devices in their original containers until ready for installation.
2. Remove the devices from the protective containers only at a properly grounded work station. Also ground yourself with a suitable wrist strap.
3. Remove the devices only by the body; do not touch the pins.
4. Any printed circuit board into which the device is to be inserted must also be grounded to the bench or table.
5. Use only anti-static type solder sucker.
6. Use only grounded soldering irons.
7. Once the device is installed on the PC board, the device is normally adequately protected, and normal handling may resume.

5-6. Cleaning

Model 8024 should be cleaned as often as operating conditions require. Thoroughly clean the inside and the outside of the instrument. Remove dust from inaccessible areas with low pressure compressed air or vacuum cleaner. Use alcohol applied with a cleaning brush to remove accumulation of dirt or grease from connector contacts and component terminals.

Clean the exterior of the instrument and the front panel with a mild detergent mixed with water, applying the solution with a soft, lint-free cloth

5-7. Repair and Replacement

Repair and replacement of electrical and mechanical parts must be accomplished with great care and caution. Printed circuit boards can become warped, cracked or burnt from excessive heat or mechanical stress. The following repair techniques are suggested to avoid inadvertent destruction or degradation of parts and assemblies.

Use ordinary 60/40 solder and temperature controlled 35 to 40 watt pencil type soldering iron on the circuit board. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the circuit from the base material. Keep the soldering iron in contact with the PC board for a minimum time to avoid damage to the components or printed conductors.

To de-solder components use a commercial "solder sipper", or better, solder removing SOLDER - WICK, size 3. Always replace a component with its exact duplicate as specified in the parts list.

5-8. Performance Checks

The following performance checks verify proper operation of the instrument, and should normally be used:

1. As part of incoming inspection of instrument specifications;
2. As part of troubleshooting procedure;
3. After any repair or adjustment, before returning instrument to regular service.

5-8-1. Environmental Conditions

Tests should be performed under laboratory conditions having an ambient temperature of 25⌈ ⌈5⌈C and a relative humidity of less than 80%. If the instrument has been subjected to conditions outside these ranges, allow at least one additional hour for the instrument to stabilize before beginning the adjustment procedure.

5-8-2. Warm-Up Period

Most equipment is subject to at least a small amount of drift when it is first turned on. To ensure accuracy, turn on the power to the Model 8024 and allow it to warm-up for at least 30 minutes before beginning the performance tests procedure.

5-8-3. Front Panel Settings

To avoid confusion as to front panel settings, it is required that front panel set-up be reset to factory default values at the beginning of each of the performance tests. To reset front panel to factory default values press **[DCL]** and then **[ENTER]** buttons.

5-8-4. Recommended Test Equipment

Recommended test equipment for troubleshooting, calibration and performance checking is listed in table 5-2. Test instruments other than those listed may be used only if their specifications equal or exceed the required characteristics.

5-9. Performance Checks Procedure

5-9-1. Frequency Accuracy

Accuracy specifications: $($0.01% of reading to 50.00 MHz; .

Equipment: Counter

1. Set 8024 as follows:

CONTROL	POSITION
OUTPUT	Square
PARAMETER	FREQ

2. Set counter to frequency measurement.
3. Connect 8024 output to counter input. Set 8024 frequency and verify frequency reading on the counter display as follows:

8024 SETTING	COUNTER READING
10.00 Hz	9.999 Hz - 10.001 Hz
100.0 Hz	99.99 Hz - 100.01 Hz
1.000 KHz	999.9 Hz - 1.0001 KHz
10.00 KHz	9.999 KHz - 10.001 KHz
100.0 KHz	99.99 KHz - 100.01 KHz
1.000 MHz	999.9 KHz - 1.0001 MHz
10.00 MHz	9.999 MHz - 10.001 MHz
50.00 MHz	49.995 MHz - 50.005 MHz

5-9-2. Amplitude Accuracy

Accuracy specifications (1KHz):
$($4% of reading +2 mV), to 100 mV;
$($3% of reading +4 mV), to 1 V;
$($2% of reading +20 mV), to 10 V.
Equipment: DMM, 50Ω feedthrough termination.

Instrument	Recommended Model	Specifications	Use (*)
Counter	Tabor 6010/6020	100 MHz Universal	P,A,T
DMM	Tabor 4121	0.1 V - 100 Vac, DC	P,A,T
Pulse/Function Generator	Tabor 8021	1 mHz - 20 MHz	P
Synthesizer	Marconi 2019	80 KHz - 1040 MHz	P,A
DC power supply	Fluke 341A	0 V - 30 V 0.1%	P,A
Oscilloscope	Tek 2465B	400 MHz band width	P,A,T
Distortion analyzer	K-H 6900	100 Hz - 1 MHz	P,A
Spectrum analyzer	HP 182T/8557A	10 KHz - 350 MHz	P
Feedthrough Termination	Tek 011-0129-00	50Ω, 2W, 0.1%	P,A
20dB feedthrough Attenuator	Tek 011-0086-00	50Ω, 2W, 2%	P

(*) P= Performance Test, A= Adjustments, T= Troubleshooting

Table 5-2. *Required Test Equipment.*

1. Set 8024 as follows:

CONTROL	POSITION
OUTPUT	Sine
FREQ	1.000 KHz
PARAMETER	AMPL

2. Set DMM to ACV measurements (RMS).
3. Connect 8024 output to DMM input. Terminate the output with a 50Ω feedthrough termination. Set amplitude and verify DMM reading as follows:

8024 SETTING	DMM READING
9.99 V	3.441 V - 3.621 V
5.00 V	1.822 V - 1.712 V
1.00 V	407.5 mV - 326.5 mV
500 mV	185.7 mV - 167.7 mV
50.0 mV	20.37 mV - 14.97 mV

5-9-3. DC Characteristics

Accuracy specifications:
$($(4% of reading +1% of amplitude +2mV), to .045V;
$($(3% of reading +1% of amplitude +5mV), to .45V;
$($(2% of reading +1% of amplitude +20mV), to 4.5V.
Equipment: DMM, 50Ω feedthrough termination.
1. Set 8024 as follows:

CONTROL	POSITION
AMPL	1 V
MODE	TRIG'D
PARAMETER	OFFS

2. Set DMM to DCV measurements.
3. Connect 8024 output to DMM input. Terminate the output with a 50Ω feedthrough termination. Set 8024 offset and verify DMM reading as follows:

OFFS SETTING	DMM READING
$($4.50 V	$($4.39 V to $($4.61 V
$($3.00 V	$($2.92 V to $($3.08 V
$($1.00 V	$($0.96 V to $($1.04 V

4. Change 8024 AMPL setting to 100 mV. Set OFFS and verify DMM reading as follows:

OFFS SETTING	DMM READING
$($450 mV	$($432 mV to $($468 mV

5. Change 8024 AMPL setting to 10.0 mV. Set OFFS and verify DMM reading as follows:

OFFS SETTING	DMM READING
$($45.0 mV	$($41.2 mV to $($48.8 mV

5-9-4. Squarewave Characteristics

Specified transition time: 5 ns typical (10% to 90% of amplitude).
Specified aberration: <5% of amplitude.
Equipment: Oscilloscope, 20dB attenuator.

1. Set 8024 as follows:

CONTROL	POSITION
FREQ	1.000 MHz
AMPL	5.00 V
OUTPUT	Squarewave

2. Connect 8024 output to the oscilloscope input. Use the 20 dB attenuator and set oscilloscope input impedance to 50Ω.

3. Set oscilloscope and verify that the rise and fall times are 5 ns (typically). Verify that overshoot and ringing are less than 5% of amplitude.

5-9-5. Sine Characteristics

Specified total harmonic distortion: <0.1% from 10.00 mHz to 100.0 KHz.
Specified harmonic signals: >30 dB below the carrier level from 100.0 KHz to 50.00 MHz.
Equipment: Distortion Analyzer, Spectrum Analyzer, 50Ω feedthrough termination, 20dB attenuator.

1. Connect 8024 output to distortion analyzer input.
2. Set distortion analyzer to % distortion measurements, set 8024 frequency setting, and verify distortion reading as follows:

8024 SETTING	DISTORTION READING
10.00 Hz	<0.1%
100.0 Hz	<0.1%
1.000 KHz	<0.1%
10.00 KHz	<0.1%
100.0 KHz	<0.1%

3. Tune spectrum analyzer to carrier frequency, and adjust gain so that the fundamental corresponds to 0 dB.
4. Connect 8024 output to spectrum analyzer input through a 20dB feedthrough attenuator.
5. Set 8024 FREQ setting and verify harmonic distortions levels as follows:

FREQ SETTING	HARMONICS LEVEL
5.000 MHz	<30 dB
50.00 MHz	<30 dB

5-9-6. Sine Flatness

Level Flatness: ⌠1% to 1.000 MHz; ⌠5% to 10.00 MHz; ⌠15% to 50.00 MHz.
Equipment: Oscilloscope (2465B).

1. Set 8024 as follows:

CONTROL	POSITION
AMPL	6.00 V
OUTPUT	Sinewave
FREQ	1 KHz

2. Connect 8024 OUTPUT to the oscilloscope, set oscilloscope input impedance to 50Ω, and set oscilloscope to display the sinewave within exactly 6 vertical divisions.
3. Change 8024 FREQ setting to 1.000 MHz. Verify that peak to peak of the displayed sinewave is within 5.9 to 6.1 divisions.
4. Change 8024 FREQ setting to 10.00 MHz. Verify that peak to peak of the displayed sinewave is within 5.7 to 6.3 divisions.
5. Change 8024 FREQ setting to 50.00 MHz. Verify that peak to peak of the displayed sinewave is within 5.1 to 6.9 divisions.

5-9-7. External Trig, Gate, Burst Characteristics

Specifications: Triggered - Each transition at the front panel TRIG IN connector stimulates the 8024 to generate one complete output waveform;
Gated - External signal at the TRIG IN connector enables the 8024 output. Last cycle of output waveform always completed;
Burst - Each transition at the front panel TRIG IN connector stimulates the 8024 to generate a burst of pre-selected number of cycles.
Equipment: Pulse/function generator (8021), oscilloscope.

5-9-7-1. External Trigger

1. Set 8024 as follows:

CONTROL	POSITION
FREQ	1.000 MHz
MODE	TRIG
SOURCE	EXT

2. Set external pulse/function generator frequency to 10 KHz and connect its SYNC output to the 8024 TRIG IN connector. Set oscilloscope and verify on the oscilloscope that 8024 outputs a triggered signal. Leave external pulse generator connected to the 8024 for the next test.

5-9-7-2. External Gate

1. Set 8024 as follows:

CONTROL	POSITION
FREQ	1.000 MHz
MODE	GATED

2. Set oscilloscope and verify on the oscilloscope that 8024 outputs a gated signal. Leave external pulse generator connected to the 8024 for the next test.

5-9-7-3. External Burst

1. Set 8024 as follows:

CONTROL	POSITION
FREQ	1.000 MHz
MODE	BURST
SOURCE	EXT
BURST	10

2. Set oscilloscope and verify on the oscilloscope that 8024 outputs a burst of 10 complete output waveforms. Remove external pulse generator connection from the 8024 for the next test.

5-9-8. Internal Trigger, Burst Characteristics

Specifications: Triggered - An internal timer repeatedly generates a single output waveform. **Burst** - An internal timer repeatedly generates a burst of pre-selected number of cycles.
Equipment: Oscilloscope.

5-9-8-1. Internal Trigger

1. Set 8024 as follows:

CONTROL	POSITION
FREQ	10.00 KHz
MODE	TRIG
SOURCE	INT
INT PER	1 ms

2. Set oscilloscope and verify on the oscilloscope that 8024 outputs repetitive triggered waveform.

5-9-8-2. Internal Burst

1. Set 8024 as follows:

CONTROL	POSITION
FREQ	10.00 KHz
MODE	BURST
SOURCE	INT
INT PER	10 ms
BURST	10

2. Set oscilloscope and verify on the oscilloscope that 8024 outputs repetitive bursts of 10 complete output waveforms.

5-9-9. Manual Trig, Gate, Burst Characteristics

Specifications: [TRIGGER] button simulates external stimulant.
Equipment: Oscilloscope, universal counter/timer (6020).

5-9-9-1. Manual Trigger

1. Set 8024 as follows:

CONTROL	POSITION
FREQ	10.00 Hz
MODE	TRIG
SOURCE	EXT

2. Connect 8024 output to the oscilloscope input. Set oscilloscope time base to 1 ms.
3. Press the **[TRIGGER]** button a few times and verify that you get a single sinewave waveform on the oscilloscope every time that the **[TRIGGER]** button is depressed. Leave 8024 output connected to the oscilloscope for the next test.

5-9-9-2. Manual Gate

1. Set 8024 as follows:

CONTROL	POSITION
FREQ	10.00 KHz
MODE	GATED

2. Press the **[TRIGGER]** button a few times and verify that you get a gated sinewave waveform on the oscilloscope every time that the **[TRIGGER]** button is depressed. Remove 8024 output from the oscilloscope for the next test.

5-9-9-3. Manual Burst

1. Set 8024 as follows:

CONTROL	POSITION
FREQ	10.00 MHz
MODE	BURST
SOURCE	EXT
BURST	32767

2. Connect 8024 output to the universal counter/timer input. Set counter to Totaling measurement mode. Reset counter.
3. Press the **[TRIGGER]** button once and verify that counter reading is exactly 32767 counts.

5-9-10. Arbitrary Memory Check

Specifications: Memory length 64535 points. Memory can be divided to 99 smaller segments.
Equipment: Distortion Analyzer, 50Ω feedthrough termination.
1. Connect 8024 output to distortion analyzer input.
2. Set 8024 waveform to ARB. Program 6 segments to have 10,000 points each and load sine waveform to each of the six segments. Program segment number 7 to have 4536 points and load sine waveform to segment 7.
3. Set distortion analyzer to % distortion measurements and verify distortion reading of less than 0.1% for each of the seven segments.

5-9-11. Sequencer Characteristics

Specifications: Number of steps - 99. Each step repeated 32767 times.
Equipment: Oscilloscope.

1. Set 8024 as follows:

CONTROL	POSITION
WAVEFORM	SEQ

1. Program three segments, each with 1000 points. Load sine, triangle, and square in segment 1, 2, and 3, respectively.
2. Change STEP01 to repeat SEG01 x 1 time, change STEP02 to repeat SEG02 x 1 time, and then change STEP03 to repeat SEG03 x 1 time.
3. Connect 8024 output to the oscilloscope input. Set oscilloscope and verify that Model 8024 outputs a periodical waveform that contains sine, triangle, and square waveforms.
4. Change the number of repeats and observe that the selected segment is multiplied accordingly.

6

Theory of Operation

6-1 What in This Chapter

This chapter contains an overall functional description of the instrument, as well as, detailed theory of operation of the Model 8024. Information is arranged in a logical order that guides you through the various circuits of the 8024. It also provides functional description of individual circuit block. As an aid to understanding, the descriptions are keyed to a block diagram. Detailed schematics and component layout drawings can be found at the end of this manual. It is suggested that you read previous chapters first to make yourself familiar with the instrument's functions, features and capabilities.

6-2. Overall Functional Description

Figure 6-1 is a general block diagram of the Model 8024. Refer to this figure throughout the following description.

The Model 8024 is a bench-type waveform generator. It is an extremely high-performance waveform generator that combines two powerful instruments in one small package: function generator, and arbitrary waveform generator. The instrument provides a variety of standard waveforms, to be used as test stimuli for different electronic devices. Model 8024 is also capable of generating arbitrary waveforms with sampling rates to 100 MHz at 12 bits of vertical resolution.

Despite its small size, Model 8024 offers many features and functions, such as counted burst, internal trigger-generator, sequence generator and more. The instrument

generates high quality, high accuracy waveforms throughout the specified frequency range, amplitude span, and operating temperature.

The Model 8024 generates standard waveforms at frequencies ranging from 10 mHz to 50 MHz. Arbitrary waveforms are generated with clock rates ranging from 10 µHz to 100 MHz. Output amplitude may be programmed within the range of 20 mV to 20 Vp-p into open circuit and 10 mV to 10V into 50Ω. Its wide ranges, high performance, programmability and economy make the Model 8024 at home in every laboratory.

Besides normal continuous mode, Model 8024 offers a variety of interrupted modes. The output waveform may be gated, triggered, or generate a counted burst of waveforms. A built-in trigger generator, having a programmable period, can replace an external trigger stimulant.

The Model 8024 generates arbitrary waveforms with 12 bits of resolution. There are a few standard waveforms which are memory-resident. Other waveforms may be generated either manually, or downloaded from slot 0 to the instrument using shared memory or standard data bus transfer. Waveforms may also be generated using the WaveCAD program. The wave generation software package - WaveCAD, is available from Tabor Electronics. Contact your local representative for details.

The Model 8024 waveform generator is a digital instrument. Besides its standard waveforms, any waveform that it generates, must be first loaded into its arbitrary
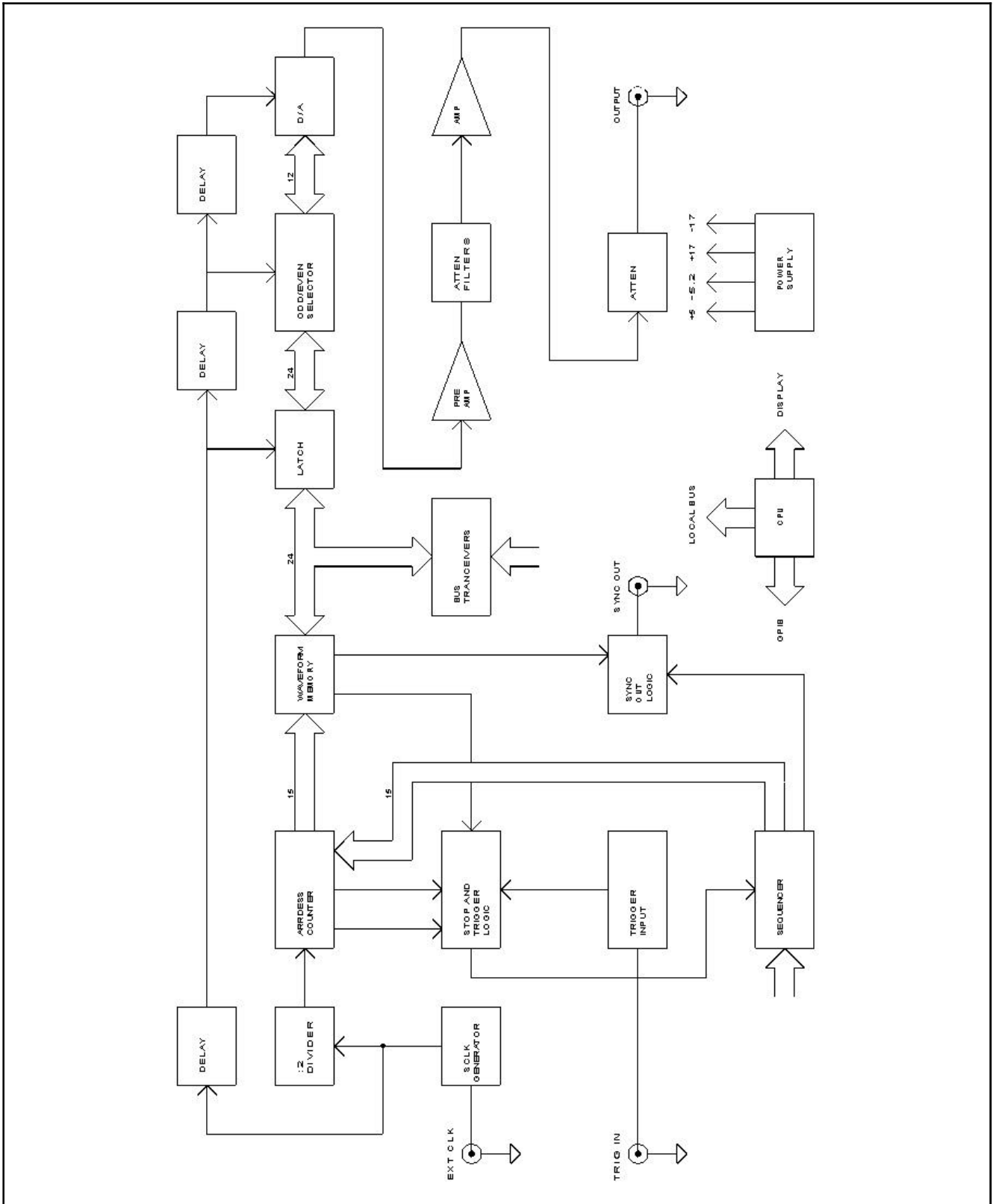
Figure 6-1. *Model 8024 - Block Diagram.*

waveform memory. The arbitrary waveform memory is a bank of 12-bit words. Each word represents a point on the waveform. Each word has an horizontal address that can range from 0 to 64535 and a vertical address that can range from -2047 to +2048 (12 bits). Using an high-speed clocking circuit, the digital contents of the arbitrary waveform memory is extracted and routed to the D/A converter. The D/A converts the digital data to an analog signal and the output amplifier completes the task by amplifying or attenuating the signal at the output connector.

Arbitrary waveform addresses are advanced by the address counter. In normal operating mode, the address counter sweeps the waveform memory addresses between start and stop addresses continuously. In triggered mode, the address counter sweeps the waveform memory addresses once. In gated mode, this operation is repeated until the end of the gating signal. In burst mode, the operation is repeated for a number of times that is set by the burst count parameter.

The Model 8024 can be set to operate in sequence mode. In this mode, memory segments are linked and looped in user programmable fashion. In this case, the address counter sweeps from start address to stop address according to the programmable link and loop sequence. This procedure is explained in details in the following paragraphs.

6-3. Waveform Memory and D/A Circuits

Addresses for the waveform memory are generated by the address counter. The address counter is a synchronous counter and is made of U65, U66, U70, and U71. Fifteen lines are routed from the sequence generator and are connected to the preset inputs of the counter IC's. These 15 lines set the start address for the arbitrary waveform. A sampling clock (SCLK) signal is applied to the input of the address counter. This clock causes the address counter to increment from start address (first waveform point) to stop address (last waveform point).

The SCLK is routed to the address counter through a divide by 2 circuit - U113a, ECL-to-TTL converter U68a, and U69a gate.

The output bits of the waveform memory contain 3 bits which are used as control signals and 24 bits form the digital data for the arbitrary waveform; the remaining 5 bits are not used. The STP2 bit is routed to a synchronizer circuit which is comprised of "D" flip-flops U64a, and U64b. The synchronizer circuit function is to synchronize the control bit with the sampling clock signal.

The three control bits are used as follows:

- The STP2 bit detects the last point of the waveform and sets true the preset enable inputs of the address counters. When the preset enable inputs are set true, the next clock transition presets the address counters to their original start address. This is done by applying STP2 signal to the D input of U64a. STP2 bit is also applied to the D input of U64b. In continuous mode, U64b is reset, preventing STP2 from doing any action. In all other modes, the reset input of U64b is set false. As the address counter increments, and this bit is sensed "1", the next clock sets the complement output of U64b to "0", blocking the gate - U69a which, in turn, blocks the sampling clock from accessing the address counter.

- The Sync bit (TRG) is used for external synchronization to the main output waveform. This signal can be qualified with other signals to generate the required sync output signal at the SYNC output BNC.

- The MRK bit is used as a MARKER output.

The outputs of the address counter are applied to the address inputs of the waveform memory IC's. Every waveform memory address contains data for 2 waveform points (24 bits). One point (12 bits) forms the odd part of the word, the other point (remaining 12 bits) forms the even part of the word. The odd and even bits are latched by U49, U50, and U51. The latched outputs are applied to a 12-bit selector which is made of U108, U109, and U110. The output of the 12-bit selector alternates between the odd and even bits which were applied to its inputs. The outputs of the selector are converted from TTL to ECL logic levels by U39, U42, and U46 and then are applied to the D/A converter - U45.

The current output of the D/A is converted to voltage using a differential amplifier made of U41 and its associated components. The various control signals that are used for the latches and selectors are derived from a delayed sampling clock signal. The sampling clock is delayed by U37, U38, U112, U114, and DL1 through DL4.

6-4. Trigger Circuits

The following paragraphs will explain the function of circuits in trigger mode of operation.

6-4-1. Triggered Mode

In triggered mode of operation the reset input of U64b is set to "1". At this time, as was explained before, the address counter will stop when STP2 will be sensed "1".

Upon a trigger event, the trigger circuit generates a short negative going pulse that resets U64b. The complement output of U64b then opens the gate in U69a, allowing the sampling clocks to reach the address counter. This action will advance the address counter until STP2 turns "1" again. At this point the address counter will stop.

6-4-2. Gated Mode

In gated mode of operation the trigger circuit generates a negative going pulse, having the same duration as the external gating signal, at the reset input of U64b. When the gating pulse is applied, U64b is reset, hence allowing the sampling clock signal to reach the address counter. When the gating pulse returns to "1", the address counter stops, however, only when the STP2 bit turns "1".

6-5. Trigger Input Circuit

The trigger input circuit accepts TTL level, positive-going transitions at the TRIG IN rear panel connector. Rear panel trigger signals are routed through R15 to the gate U92a. The gates U92c and U92d form a differentiation circuit for the trigger signal, before it is applied to the Clear input of U64b. When placed in internal trigger mode, the CPU generates the trigger signals from one of its ports.

6-6. Sample Clock Generator

The heart of the sample clock generator is a phase locked loop. The loop is closed around a VCO circuit that oscillates in the range of 50 MHz to 100 MHz. The oscillator is made of U96, varicap diode - CR13, L15 and associated components. The PLL circuit sets the voltage level on the diode as a function of the programmed sample clock.

U95 is a monolithic synthesizer which contains two internal programmable dividers (one, for the reference frequency, and the other for the VCO frequency which is divided by 4 by U101), and phase detector. The phase detector senses the difference between the two frequencies and generates a signal with a proportional amplitude. This signal is then amplified and filtered by U91 and its associated components. The output of U91 is fed to the varicap diode - CR13 which corrects the VCO frequency. The VCO frequency is divided by U101 and the chain of x2 dividers - U104, U105, and U106.

The output frequency is selected by the selectors U97 through U100, and U102. This selector is also used for selecting between three sample clock options: Internal

clock generator, External reference input and 10 MHz crystal oscillator.

Reference frequency for the Model 8024 is internally generated by the synthesizer U95 and the crystal oscillator Y1. U100 outputs the clock generator signal through a TTL-to-ECL converter - U115.

6-7. Sequence Generator

The sequence generator circuit lets you link and repeat memory segments in user definable fashion, thereby generating extremely long waveform which otherwise would have required very long memory bank. In continuous mode, the sequence of waveform is repeated continuously from start to stop as long as this function is selected. In triggered mode, and after the 8024 has been triggered, the sequence is generated once and the generator will stop at the last point of the last step.

A sequence is made of one or more steps. The sequence advances automatically from one step to the next step. Block diagram of the sequence generator is given in Figure 6-2. Refer to this block diagram and to the schematic drawings in the back of this manual throughout the following descriptions.

The start address is written in the start address memory which is made of U73 and U77. The number of repeats is written in the repeat memory - U81 and U85. Sequence memory address is advanced by a counter circuit which is comprised of U89 and U90. This counter receives clocks which are derived from the preset input of the memory address counter. Note that this preset signal (TARB) is generated every time that the address counter reaches the last point on the waveform.

When the last step sequence is reached, the control bit in the start address memory - STSQ turns "0". This signal is applied to the D input of U74b. The next clock to the sequence address counter which is applied through the gate U62d to the clock input of U74b produces a short positive going pulse at the complement output of U74b. This pulse resets the sequence address counter which, in turn, resets the sequence address to its first address (0). The sequence address counter then resumes a new cycle from address 0.

When one of the sequence steps is to be repeated, the repeat memory is programmed with the REP bit set to "1" at the address that contains the start address of the segment to be repeated. This bit is applied to the D input of U74a. The clock that is applied to the clock input of U74a sets U74a which together with U63d block the clocks to the sequence address counter, keeping the

Figure 6-2. *Model 8024 - Sequencer Block Diagram.*
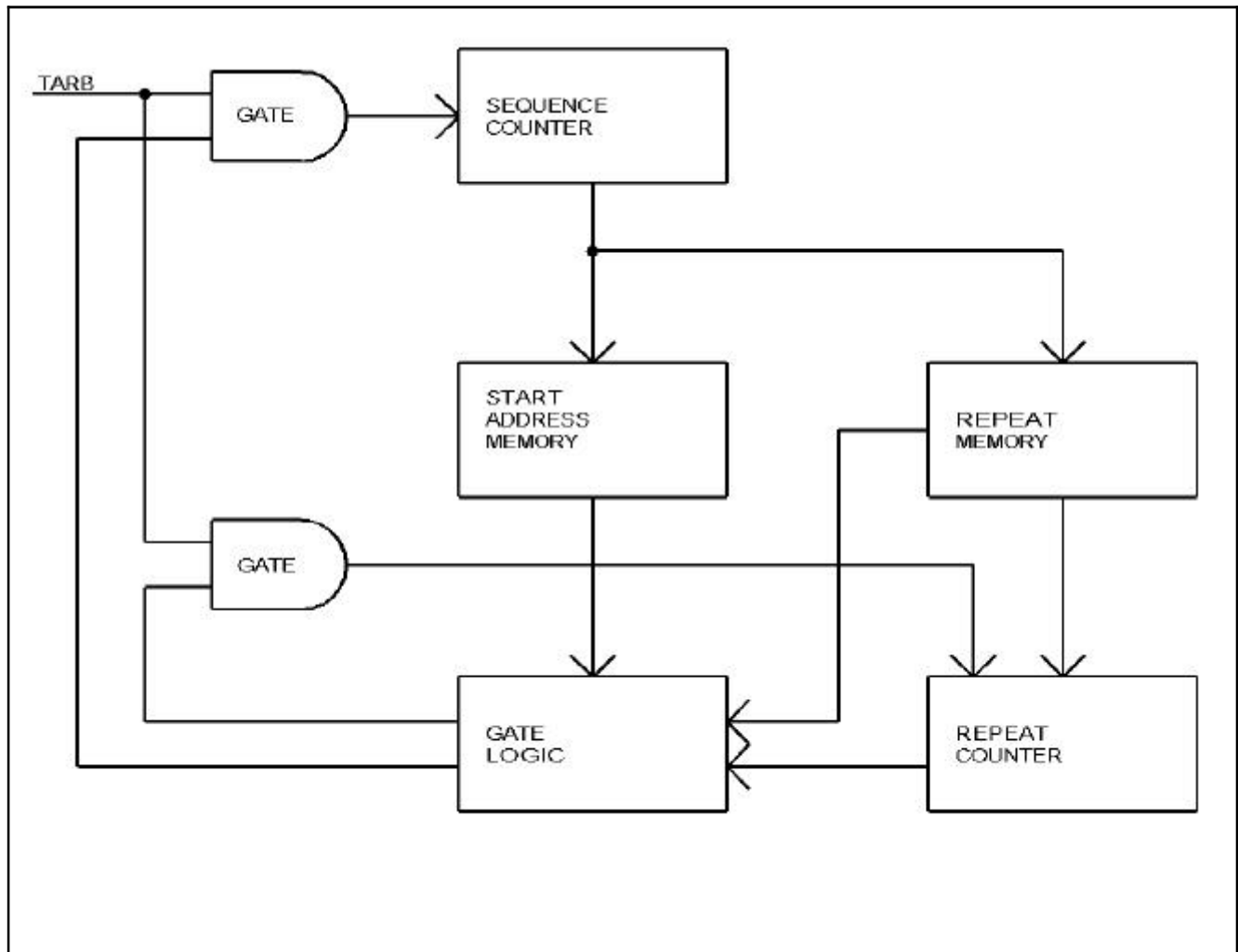
sequence address counter intact while in repeat mode. U74a enables the gates U63a and U63b to apply the clocks to the repeat counter which is made of U82, U83, U86, and U87. When the repeat counter has reached its terminal count (sensed by U79a), U78b is reset. The complement output of U78b is differentiated by U75a and U75b and applied to the reset input of U74a, thereby enabling clocks throughput to the sequence address counter and blocking the clock inputs to the repeat counter.

6-8. Local CPU Circuit

The Model 8024 operation is supervised by an internal microprocessor (CPU). The CPU controls parameter selection, GPIB traffic, memory download and upload operation, internal trigger generation front panel switching, and more. All of these tasks are performed under software supervision. This section briefly describes the operation of the various sections of the microprocessor and its associated digital circuitry. For more complete circuit details refer to the schematics at the end of this manual.

Circuit operation centers around the microprocessor unit (CPU) U6. The CPU is an 8-bit microprocessor capable of directly addressing up to 64K bytes of program memory (ROM) and up to another 64K bytes of data memory (RAM). 10 MHz clock for the microprocessor is derived from a crystal oscillator Y1. Temporary storage is provided by RAM U10 which can store up to 128K bytes.

Software for the CPU is programmed into one EPROM - U9 containing 128K bytes of memory space. Since the CPU is capable of directly addressing only 64K bytes,

the Model 8024 is using memory banks of 32K each. The banks are switched in and out automatically to address the correct address in the memory. Bank switching is done with CPU ports.

6-8-1. Display / Keyboard Interface

Interfacing between the CPU, the keyboard and the display is performed by the Keyboard/Display interface U2. U1 multiplex the LED's and drive the high current transistors Q1 through Q4 which, in turn, drive the anodes of the appropriate LED. The sense lines S0, S1, and S2 determine which of the front panel push-buttons were depressed. The information for the 16 character x 2 line LCD module is buffer by U14.

DE1 (front panel assy.) is a digital encoder that converts rotary movement to incremental parameter steps. Since DE1 is a mechanical switch, its bounces are being de-bounced by U4. U2 and U3 detect the direction that DE1 is being rotated to. The direction signal is routed to one of the CPU ports. The pulses from the digital encoder DE1 are applied to the timer input of the CPU.

6-8-2. GPIB Interface

The instrument has a built in GPIB interface bus (complies with IEEE-488.2) that permits remote control through a system controller. The GPIB interface is made of U15, (General Purpose Interface Adapter), U17 and U18 interface bus drivers. On the CPU side of the GPIB, data transmission is handled much like any other bus transaction. The output of the U15 is standard GPIB format and is buffered by the two GPIB drivers U17 and U18. The bus drivers are necessary for enhancing the drive capability of the interface. Up to 15 devices may be connected in parallel to the 8024.

6-9. Output Amplifier

The signal to the input of the output amplifier is fed from through the pre-amplifier U41. Before this signal is applied to the output amplifier, it can be pre-attenuated by K3 and its associated components and filtered by K1, K2, and K6 and their associated components. K3 switches a 10 dB attenuator. K6 selects a 20 MHz Gaussian response filter. K2 and K1 select elliptical filters, 50 MHz and 25 MHz respectively.

The output amplifier circuit operates in current mode feedback that provides an extremely wide bandwidth at high slew rates (approximately 3000V/(s). The signal from the pre-amplifier is applied through R13 and R18 to the emitters of Q12 and Q13. Their collector signals

are buffered by Q14 and Q15 and are fed to a gain stage which is made of Q16 and Q19. The output of this gain stage is buffered all the way through to the output of the output amplifier by Q16, Q17, Q19, Q20, and their associated components. Q22 with R40, R41, and R42 provide the bias for the buffer class AB stage.

The amplifier's offset voltage is compensated by a low frequency loop which is comprised of U29. R62 equalizes the low frequency gain with the high frequency gain. Operational amplifier - U30 compensates for the offset current at the input stage.

The amplified signal at the output can be attenuated by two 20 dB attenuators that are switched with K4 and K5. Note that all relays that are mentioned in this description are set to their off position during power up.

6-10. Power Supply Circuit

Refer to the power supply schematic at the end of this manual for the following discussions. The power supply consists of a main power transformer, two bridge rectifiers, two integrated regulators, +5 V, and −5.2 V linear power supply. The LINE fuse and the Line Selector are accessible from the rear panel. The LINE VOLTAGE SELECT switch select 115V or 230V operation.

CR9 is used as a full-wave rectifier to provide a sufficient DC voltage for the −17 V and +17 V regulators U23 and U24 respectively. CR14 is used as a full-wave rectifier to provide a sufficient DC voltage for the −5 V and +5 V supplies. The +5 V linear power supply is made of power transistor Q10, control amplifier U25b, Q8, and overload protection Q7 and R103. The −5 V linear supply is made of power transistor Q11, control amplifier U25a, Q6, and overload protection Q5 and R102.

6-10-1. Battery Back-up Circuit

Model 8024 contains battery back-up circuit that is comprised of two NI-CAD batteries BT1, BT2, and associated components. The battery serves two purposes: 1) Back-up the RAM's during power off, and 2) Charge the batteries during power on.

When the instrument is powered from the mains line, the RAM's receive their power from the +5V supply through CR3. At power OFF, CR3 is revered-biased and CR1 provides a path from the battery back-up to the RAM's. The battery charging circuit consists of an operational amplifier U19, Q4 and their associated components.

7

Adjustments & Troubleshooting

7-1. INTRODUCTION

This section contains information necessary to adjust and troubleshoot the Model 8024 waveform generator.

WARNING

The procedures described in this section are for use only by qualified service personnel. Do not perform these procedures unless qualified to do so. Many of the steps covered in this section may expose the individual to potentially lethal voltages that could result in personal injury or death if normal safety precautions are not observed.

7-2. ADJUSTMENTS

7-2-1. Environmental Conditions

Adjustments should be performed under laboratory conditions having an ambient temperature of 24 ∍5C and a relative humidity of less than 70%. If the instrument has been subjected to conditions outside these ranges, allow at least one additional hour for the instrument to stabilize before beginning the adjustment procedure. Between adjustments, Always leave top cover on the unit to keep internal temperature as stable as possible.

7-2-2. Warm-Up Period

Most equipment is subject to at least a small amount of drift when it is first turned on. To ensure long-term calibration accuracy, turn on the power to the Model 8024 and allow it to warm-up for at least 30 minutes before beginning the adjustment procedure.

7-2-3. Recommended Test Equipment

Recommended test equipment for calibration is listed in Chapter 5. Test instruments other than those listed may be used only if their specifications equal or exceed the required characteristics.

7-2-4. Adjustment Procedures

All adjustments are performed with the POWER switch ON. The top cover should be removed to allow access to test points and adjustments.

WARNING

Take special care to prevent contact with live circuits or power line area which could cause electrical shock resulting in serious injury or death. Use an isolated tool when making adjustments.

When necessary, refer to the component layouts for determining adjustment points. Follow the procedure in

the sequence indicated because some of the adjustments are interrelated and dependent on the proceeding steps.

Verify that the waveform generator is functioning according to the performance checks. Make sure that all results are within, or close to, the range of the required specifications, otherwise refer to the troubleshooting procedures given later in this section.

Perform the following adjustment procedure. If an adjustment can not be made to obtain a specific result, refer to the troubleshooting procedures in this Chapter.

NOTE

If not otherwise specified, set Model 8024 parameters to factory defaults before every adjustment, by depressing [DCL] and [ENT] in sequence. Always connect the output BNC connector through a 50Ω feedthrough termination.

7-3. ADJUSTMENT PROCEDURE

7-3-1. Pulse Response

Equipment: Oscilloscope (2465B), 20dB Attenuator

1. Change 8024 Frequency setting to 1.000 MHz, amplitude setting to 10.0 V, and output waveform to squarewave.
2. Connect the 8024 output through 20dB attenuator to the oscilloscope input. Set oscilloscope input impedance to 50Ω.
3. Set oscilloscope vertical gain and time base, and adjust output board trimmer R38 and C39 for best pulse response.
4. Change 8024 frequency setting to 10.00 KHz, amplitude setting to 10.0 V, and output waveform to squarewave.
5. Set oscilloscope vertical gain and time base, and adjust R52 for best pulse flatness.
6. Change 8024 frequency setting to 1.000 KHz and re-touch R52 for best flatness in this range.
7. Repeat steps 8 and 9 until best result is obtained in both steps.

7-3-2. Amplitude Adjustment

Equipment: DMM, 50 Ω Feedthrough termination

1. Change 8024 Frequency setting to 1.000 KHz, amplitude setting to 10.0 V, and output waveform to Sine.

2. Connect 8024 output to DMM input through the 50Ω Feedthrough termination. Set DMM to ACV measurements and 20 V range.
3. Adjust R47 until DMM reading is 3.535 V ∍40 mV.

7-3-3. Offset Adjustment

Equipment: DMM, 50 Ω Feedthrough termination

1. Change 8024 Offset setting to +4.5 V and amplitude setting to 1.00 V.
2. Connect 8024 output to DMM input through the 50Ω Feedthrough termination. Set DMM to DCV measurements and 20 V range.
3. Adjust R44 until DMM reading is 4.500 V ∍45 mV.

7-4. Troubleshooting

Troubleshooting procedure should be initiated whenever the generator fails to perform either completely or partially. It is also required to troubleshoot Model 8024 whenever the instrument fails to fully comply with its published specifications. The information given in the following do not intend to replace full scale troubleshooting, but merely to direct the service engineer to the area were the source of the trouble is located.

The troubleshooting instructions contained in this section are intended for qualified personnel having basic understanding of analog and digital circuitry. The individual should also be experienced at using typical test equipment as well as ordinary troubleshooting procedures. The information presented here has been written to assist in isolating a defective circuit, or circuit section; isolation of the specified component is left to the technician.

7-4-1. Recommended Test Equipment

The success or failure in troubleshooting a complex piece of equipment, like the Model 8024, depends not only on the skills of the technician, but also relies heavily on accurate, reliable test equipment. Recommended test equipment for troubleshooting and adjustment of the Model 8024 are listed in Chapter 5. Other equipment such as logic analyzer, and in-circuit emulator etc., could also be helpful in difficult situation.

7-4-2. Power-Up Tests

Upon power-up the Model 8024 performs a set of tests. If the instrument locks up after power on you should proceed with the troubleshooting procedure as given in the following.

7-5. Power Supply Checks

It is highly suggested that the first step in troubleshooting the Model 8024, would be to check the power supply. If the various supply voltages within the instrument are not within the required limits, troubleshooting the remaining circuits can be very difficult. Table 7-1 shows several checks that can be made to the power supplies.

In addition to the normal voltage checks, it is also a good idea to check the various supplies with an oscilloscope to make sure that no noise, ripple, or ringing are present. In case of a "dead short" between one of the supplies to the common ground, it would be best to disconnect the entire supply section from the remaining of the circuits, and then determine whether the problem is in the power supply or elsewhere. Model 8024 is equipped with such quick-disconnect points, which are located at the bottom side of the main PC board. To access these points, it is necessary to remove the bottom cover, and then to remove the solder layer from these points.

Table 7-1. *Power Supply Checks.*

Test Point	Expected Result
+5V	+5V, ±0.1V
-5.2V	-5.2V, ±0.1V
+17V	+17V, ±0.3V
-17V	-17V, ±0.3V
-2V	-2V, ±0.05V

7-6. Digital Circuits and Display Checks

The most important section, to be verified after the power supply checks, is the digital section with its various clocks. Problems with the digital circuitry could cause erratic operation or erroneous display readings.

Problems in the clock generator for the C.P.U. and the digital circuit may cause a complete malfunction of the entire instrument. The C.P.U. would not even start generating the control lines. This makes it impossible to troubleshoot the remaining of the circuits. Check the various components which are associated with the digital circuitry, clocks, and the IEEE-488.2 interface, using the information given in Table 7-2.

7-7. Clock Synthesizer Checks

Problems with the clock synthesizer circuits can be detected if the 8024 accepts front panel commands and responds correctly to GPIB queries, however, fails to output the correct waveform frequency. If you suspect that you have a problem with the clock synthesizer circuit proceed with the checks given in Table 7-3.

Make sure you reset the 8024 to its factory defaults before you start with the following procedure.

7-8. Arbitrary Generator Checks

Problems with the arbitrary generator circuit may cause generation of distorted waveforms. The arbitrary generator is comprised of fast memory chips, addressing and controlling circuits that closely operate together. Each part has to be tested and its operation verified to make sure that there are no inter-related problems between the various circuits on the board. If your generator fails to generate arbitrary waveforms correctly, proceed by checking the test points in Table 7-4. Before you start your tests, set-up 8024 to factory defaults and change frequency setting to 1 KHz.

7-9. Sequence Generator Checks

Problems with the sequence generator circuits can be detected if the 8024 accepts front panel commands and responds correctly to GPIB queries, however, fails to output sequences or bursts. If you suspect that you have

Table 7-2. *Digital Circuits and Display Checks.*

Test Point	Description	Expected Result
U6 (18)	CPU Clock	10 MHz TTL level signal
U6 (30)	ALE	TTL, Positive going pulses; period 6 μs, pulse width 2 μs
U6 (29)	PSEN	TTL, Square wave; period 6 μs
U6 (16,17)	RD, WR Signals	TTL, Negative going pulses; pulse width o.6 μs
U2 (3)	Display Clock	TTL, Square wave; frequency 1.25 MHz
U16 (3)	GPIB Clock	TTL, Square wave; frequency 5 MHz
U2 (24,27,28,29,31)	Display Sweep Lines	TTL, Positive going pulses; period 10 ms, pulse width 0.5 ms

Table 7-3. *Clock Synthesizer Checks.*

Test Point	Description	Expected Result
U98 (3)	100 MHz source	100 MHz ECL level square waveform
U101 (5)	Divided clock	50 MHz TTL level square waveform
U95 (8)	Divided clock	25 MHz TTL level square waveform
U95 (14)	Divided clock	10 MHz TTL level square waveform
U95 (13)	Divided clock	2 KHz TTL, pulse width 0.1 μs
U95 (3)	Divided clock	2 KHz TTL, pulse width 40 ns
U115 (14)	Clock	100 MHz ECL level square waveform
U115 (14)	Change frequency to 10 KHz	10 MHz ECL level square waveform
U115 (14)	Change frequency to 1 KHz	1 MHz ECL level square waveform

Table 7-4. *Arbitrary Generator Checks.*

Test Point	Description	Expected Result
U82,83,86,87 (2)		TTL, Square wave; frequency 0.5 MHz
U82,83,86,87 (9)		TTL, Negative going pulses; period 1 ms, pulse width 2 μs
U49,50,51 (11)		TTL, Square wave; frequency 0.5 MHz
U108,109,110 (1)		TTL, Square wave; frequency 0.5 MHz
U45 (26)		ECL, Negative going pulses; period 1 μs, pulse width 5 ns
U41 (6)		500 mVp-p, sine waveform; frequency 1 KHz
	Change operating mode to triggered	Apply 500 Hz, TTL level signal to the TRIG IN BNC connector
U64 (2,12)		TTL, Positive going pulses; period 2 ms, pulse width 2 μs
U64 (5,8)		TTL, Square wave; frequency 500 Hz
U69 (1)		500 KHz bursts; burst period 2 ms, burst width 1 ms

a problem with the sequence generator circuit proceed with the checks given in Table 7-5.

Make sure you reset the 8024 to its factory defaults before you start with the following procedure. Configure the 8024 to sequenced output mode, and load two different waveforms - 10 points long, to segments and 2 respectively. Program each step to repeat once. Change SCLK setting to 10 MHz.

7-10. Output Amplifier and Amplitude Control Checks

Problems with the output amplifier and amplitude control circuits can be detected if the 8024 accepts front panel settings and responds correctly to GPIB queries, however, fails to output the required waveform, or fails to output the waveform with its correct amplitude and offset levels. If you suspect that you have a problem

Table 7-5. *Sequence Generator Checks.*

Test Point	Description	Expected Result
U89 (5)		TTL, Negative going pulses; period 2 μs, pulse width 200 ns
U74 (12)		500 KHz TTL level square waveform
U89 (14)		TTL, Positive going pulses; period 2 μs, pulse width 50 ns

with the output amplifier proceed with the checks given in Table 7-6. Proceed with Table 7-7 to check the amplitude and offset control circuits.

Before you start with the following procedure, reset the 8024 to its factory defaults and change amplitude setting to 9.99V.

Table 7-6. *Output Amplifier Checks.*

Test Point	Expected Result
Junction of R13 and R18	1.2 Vp-p, 100 KHz sine waveform
Across R22	Approximately 1.5 Vdc
Across R26	Approximately 1.5 Vdc
Q19 Collector	Approximately 11 Vp-p, 100 KHz sine waveform
Q16 Collector	Approximately 11 Vp-p, 100 KHz sine waveform
U29 (6)	0 Vdc ±100 mV
Junction of R60 and R61	Approximately 10 Vp-p, 100 KHz sine waveform

Table 7-7. *Amplifier and Offset Control Checks.*

Test Point	Expected Result
U40 (2)	+1.2 V ±50 mV
U40 (7)	-8.77 V ±100 mV
U40 (1,3)	-1.11 V ±50 mV
U40 (6,8)	+4.40 V ±100 mV
U33 (6)	+360 mV ±20 mV
Change amplitude setting to 1V and offset to +4.50V	
U40 (6,8)	+8.217 V ±100 mV
U32 (6)	-7.6 V ±100 mV

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8

Parts List

8.1 What in This Chapter

This chapter contains information for ordering replacement parts. the replacement parts are available from Tabor Electronics.

8.2 Ordering Information

When ordering replacement parts, always include the following information:

a) Instrument Model number.

b) Instrument Serial number.

c) Tabor part number.

d) Part description.

e) Circuit designation (where applicable)
.

8.3 Parts Description

In the following Parts List Tables, unless otherwise noted, resistance is given in Ω, capacitance is given in μF, inductance is given in μH, resistors tolerance is 5%, capacitor tolerance is 20%, and inductance tolerance is 10%.

Table 8-1. *Model 8024 - Power Supply Circuit Parts List.*

Quantity	Part Reference	Description	Part Number
2	C17,C16	100/25V	1533-0107
2	C15,C14	10000/16V	1532-0109
2	C19,C10	220/16V	1535-0227
1	C20	3300/35V	1534-0338
1	C21	3300/35	1534-0338
2	CR17,CR6	1N4151	0300-0040
2	CR4,CR5	ICTE-5	0400-9040
2	CR9,CR14	KBU-6A	0400-5020
1	Q8	2N2219	0400-4010
1	Q6	2N2905	0400-0150
1	Q5	2N3904	0400-0120
1	Q7	2N3906	0400-0134
1	Q10	MJE2955	0400-4030
1	Q11	MJE3055	0400-4040

Table 8-1. *Model 8024 - Power Supply Circuit Parts List (continued)*

Quantity	Part Reference	Description	Part Number
2	R103,R102	0.27/2W	0103-0R27
2	R104,R105	33	0100-0330
1	R118	121, 1%	0104-1210
1	R116	237, 1%	0104-2370
4	R101,R100,R111,R112	1K	0100-0102
1	R117	1.5k, 1%	0104-1501
1	R115	3.01k, 1%	0104-2011
1	R106	4.64K, 1%	0104-4641
1	R107	4.99K, 1%	0104-4991
1	R108	8.66K, 1%	0104-8661
1	R109	10K, 1%	0104-1002
1	U25	LM1458N	0500-5650
1	U24	LM337T	0500-5350
1	U23	LM317T	0500-5360

Table 8-2. *Model 8024 - CPU Circuit Parts List*

Quantity	Part Reference	Description	Part Number
1	C8	3.3/25V	1540-0335
2	C4,C3	1/25V	1540-0105
11	C1,C2,C5,C6,C7,C9, C10, C11,C12,C13,C121	0.1	1500-0104
2	Q1,Q3	2N3904	0400-0120
1	Q2	2N4401	0400-0181
1	R3	680	0100-0681
1	R2	1K	0100-0102
1	R1	3.3K	0100-0332
1	R5	10K	0100-0103
1	R4	100K	0100-0104
1	RN1	15 x 8	0109-0150
1	U9	27C010	0500-2129
2	U5,U12	74LS00	0510-0010
1	U13	74LS02	0510-0011
1	U3	74LS138	0510-0270
1	U8	74LS373	0510-0365
1	U7	74HC4040	0520-0700
1	U14	74HCT245	0520-0780
1	U18	75160A	0500-2151
1	U17	75161A	0500-2152
1	U1	L204	0500-1160
1	U10	MT5C-2568	0500-2116
1	U6	P80C32	0500-2143
1	U2	P8279	0500-2070
1	U16	P8291A	0500-2130
1	U4	TL7705	0500-5638

Table 8-3. *Model 8024 - Arbitrary Circuit Parts List.*

Quantity	Part Reference	Description	Part Number
1	BT1,BT2	NI-CAD 1.2V	2600-0010
1	C98	18n	1500-0183
3	C87,C83,C90	33p	1500-0330
2	C104,C106	47p	1500-0470
1	C84	100p	1500-0101
1	C49	1n	1500-0102
1	C92	10n	1500-0103
64	C47,C22,C30,C45,C48,C54, C55,C56,C59,C60,C61,C62, C63,C64,C65,C68,C69,C70, C72,C73,C74,C75,C76,C77, C78,C79,C80,C81,C82,C85, C86,C88,C89,C93,C94,C95, C96,C99,C100,C101,C102, C104,C105,C107,C108,C109, C110,C112,C118,C119,C123, C124,C126,C128,C130,C133, C134,C135,C136,C137,C138, C139,C140,	100n	1500-0104
1	C97	180n	1500-0184
7	C91,R6,C66,C113,C127, C129,C151	10	1540-0106
1	C111	68	1540-1686
1	CR11	1N746A	0300-2000
2	CR2,CR10	1N4151	0300-0040
1	CR3	1N5820	0300-9080
1	CR1	5082-2810	0300-1020
1	CR13	MV1404	0301-0015
5	DL1,DL2,DL3,DL4,DL5	4ns	0600-1030
1	L15	0.33	0600-1R33
3	L7,L5,L6	0.1	0600-0R10
2	L13,L14	3.3	0600-0333
2	Q9,Q26	2N3904	0400-0120
1	Q4	2N3906	0400-0134
1	Q25	2N3646	0400-0020
1	R69	22	0100-0220
5	R9,R34,R99,R113,R121	33	0100-0330
1	R15	47	0100-0470
8	R65,R66,R125,R128,R136, R138,R139, R141	49.9,1%	0104-49R9
1	R146	82	0100-0820
3	R83,R119,R120	100	0100-0101
1	R145	130	0100-0131
1	R73	180	0100-0181
2	R67,R68	200,1%	0104-2000
1	R89	220	0100-0221
3	R7,R60,R61	499,1%	0104-4990

Table 8-3. *Model 8024 - Arbitrary Circuit Parts List (continued).*

Quantity	Part Reference	Description	Part Number
3	R77,R130,R142	560	0100-0561
7	R44,R47,R86,R87,R88,		
	R98,R144	1K	0100-0102
1	R135	1.8K	0100-0182
1	R35	2.2K	0100-0272
1	R134	2.7K	0100-4021
1	R8	4.02K,1%	0104-2391
1	R51	2.49K,1%	0104-2491
1	R27	5.11K,1%	0104-5111
1	R72	6.81K,1%	0104-6811
1	R49	4.99K,1%	0104-4991
7	R14,R84, R85,R90,R92,		
	R97,R124,	10K	0100-0103
1	R58	10K,1%	0104-1002
1	R33	15K,1%	0104-1502
1	R94	18K	0100-0183
2	R31,R40	20K,1%	0104-2002
3	R91,R93,R95	22K	0100-0223
1	R57	75K,1%	0104-7502
1	R21	82.5K	0104-8252
2	R55,R56	100K,1%	0104-1003
2	R200,R201	*	
2	U63,U75	74F00	0500-1190
1	U69	74F02	0500-1200
2	U53,U62	74F08	0500-1250
1	U48	74F10	0500-1240
4	U64,U74,U78,U101	74F74	0500-1260
1	U52	74F132	0500-1265
5	U97,U98,U99,U100,U102	74F151	0500-1280
2	U89,U90	74F193	0500-1270
3	U49,U50,U51	74F574	0500-1285
2	U44,U10	74LS00	0510-0010
1	U79	74LS13	0510-0033
1	U47	74LS32	0510-0051
1	U92	74LS132	0510-0260
4	U87,U82,U83,U86	74LS161	0500-0311
3	U108,U109,U110	74FCT157	0506-0010
1	U26	74HCT125	0520-0745
1	U11	74HCT154	0520-0750
4	U54,U55,U56,U59	74HCT245	0520-0780
4	U72,U76,U80,U84	74HCT541	0520-0810
2	U88,U93	74HCT574	0520-0080
4	U65,U66,U70,U71	74FCT2161	0506-0000
3	U104,U105,U106	74HC4040	0520-0700
4	U73,U77,U81,U85	6116	0500-2114
1	U45	AD9712BAN	0500-6040

Table 8-3. *Model 8024 - Arbitrary Circuit Parts List (continued).*

Quantity	Part Reference	Description	Part Number
3	U20,U27,U103	CA4094N	0540-0110
1	U41	CLC404	0560-0030
1	U34	ULN2004N	0500-1160
2	U19,U33	LM741N	0500-5631
1	U91	LM1458N	0500-5650
1	U40	MAX532LCPE	0560-0087
1	U96	MC1648P	0540-0150
4	U37,U38,U112,U114	MC10102P	0500-4094
4	U39,U42,U46,U115	MC10124P	0500-4086
2	U68,U94	MC10H125P	0500-4580
2	U111,U113	MC10231P	0500-4094
1	U95	MC145157-2P	0520-0660
3	U57,U58,U61	MT5C2568-15L	0500-2113
1	U60	MT5C2568-12L	0500-2115
1	U32	OP07CN	0500-5633
1	U43	OP-200GP	0500-5635
1	Y1	10MHz Crystal	0800-0000

Table 8-4. *Model 8024 - Output Amplifier Circuit Parts List.*

Quantity	Part Reference	Description	Part Number
2	C42,C44	100/25	1533-0107
2	C46,C40	10/25	1540-0106
2	C133,C132	0.1,CHIP	1560-0104
1	C39	2-8P	1550-0000
1	C45	47P	1500-0470
2	C37,C31	470P	1500-0471
6	C53,C32,C33,C34,C35,C41		
17	C27,C28,C29,C30,C43, C57,C58,C141,C142,C143, C144,C145,C146,C147, C148,C149,C150	100n	1500-0104
2	C36,C40	10	1540-0106
1	C52	82P	1500-0820
4	CR18,CR19,CR20,CR21	1N4151	0300-0040
10	K1,K2,K3,K4,K5,K6	R4-5W	0900-0070
8	L20,L21,L22,L23,L24,L25, L26,L27	BEAD	4200-0000
1	L1	0.22	0600-R220
2	L2,L3	0.1	0600-R100
2	L11,L12	0.33	0600-R330
2	L13,L14	0.27	0600-R270
2	Q11,Q22	PN3904	0400-0120
1	Q10	PN3906	0400-0134
2	Q12,Q14	MPS3640	0400-0010
2	Q13,Q15	MPSN3646	0400-0020
3	Q16,Q20,Q21	2N3866A	0400-0161
3	Q17,Q18,Q19	2N5160	0400-0080

Table 8-4. *Model 8024 - Output Amplifier Circuit Parts List. (continued)*

Quantity	Part Reference	Description	Part Number
2	R60,R61	10,1%	0104-10R0
2	R39,R43	10,1/2W	0101-0100
1	R29	33	0100-0330
1	R35	47	0100-0470
3	R24,R36,R37	49.9	0104-49R9
4	R59,R71,R73,R75	61.9,1/2W	0104-61R9
1	R10	82.5	0104-82R5
2	R52,R53	95.3	0104-95R3
1	R38	100	0100-0101
2	R64,R63	100,1%,1/2W	0101-1011
4	R13,R18,R70,R74	249,1%	0104-2490
1	R12	270	0100-0271
2	R22,R26	301,1%	0104-3010
1	R41	390	0100-0391
1	R50	499,1%	0104-4990
1	R54	745,1%	0104-7450
4	R28,R30,R32,R42	1K	0100-0102
1	R62	2K	0100-0202
2	R33,R34	2.49K,1%	0104-2491
2	R23,R25	10K	0100-0103
7	R11,R16,R17,R19,R20		
	R45,R46	10K, 1%	0104-1002
1	R48	4.02K,1%	0104-4021
1	R31	2K,1/2W	0101-0202
1	R40	Selected value	
2	U29,U30	OP07	0500-5633

Table 8-5. *Model 8024 - Display Circuit Parts List.*

Quantity	Part Reference	Description	Part Number
1	C1	470/16V	1532-0477
1	C2	560P	1500-0561
3	CR1,CR2,CR3	1N4151	0300-0040
1	DE1	Rotary Encoder	0205-9200
26	DS1-DS26	3mm LED	1000-0100
1	LCD1	16x2 LCD Display	1200-0010
4	Q1,Q2,Q3,Q4	2N4403	0400-0180
4	R2,R3,R4,R5	220	0100-0221
1	R1	680	0100-0681
1	R5	1.5K	0100-0152
18	S1-S18	Key Switch	2000-6160
1	U1	74LS138	0510-0270
1	U2	74LS74	0510-0110
1	U3	74LS00	0510-0010

Appendix A

A-1. Front Panel Menus at a Glance

Front panel menus are organized in a logical way to make it easy to access and modify parameters. Information how to access and modify parameters is given in Section 3 of this manual. The following is a summary of all menus that can be accessed from the front panel.

A-2. FREQ Menus (STD Waveform mode)

```
1:  FREQ [value]  >  2:  PERIOD [value]
```

A-2-1. FREQ Menus (ARB & SEQ Waveform mode)

```
1:  SCLK (option)
```
Options: FREQ off(all memory segment length = 0), FREQ [value]

```
FREQ [value]
```

```
FREQ [value]  >  1:  Reference clock (option)
```
Options: INT, EXT, 10MHz Xtal

A-3. AMPL Menus

```
1:  AMPL [value]  >  2:  OFFS [value]
```

A-4. STD Menus

```
1:  Output waveform (option)
```
Options: Sine, Triangle, Square, Pulse, Ramp Sinc, Gauss, Expon, DC

```
Sine  >  1:  STA PHASE [value]  >  2:  POWER [value]
```

```
Triangle  >  1:  STA PHASE [value]  >  2:  POWER [value]
```

```
Square  >  1:  DUTY CYCLE [value]
```

A-4. STD Menus (continued)

```
1: Output waveform (option)
```
Options: Sine, Triangle, Square, Pulse, Ramp, Sinc, Gauss, Ex-
ponent'l, DC

```
Pulse > 1: DELAY [value] > 2: RISE [value] >>
```

```
>> HIGH [value] > FALL [value]
```

```
Ramp > 1: DELAY [value] > 2: RISE [value]> 3: FALL
[value]
```

```
Sine(x)/x > 1: # CYCLES [value]
```

```
Gauss > 1: T CONST [value]
```

```
Exponent'l > 1: T CONST [value]
```

```
DC > 1: [value]% (of ampl)
```
Values are function dependent. Value limits are given in
Table 3-3.

A-5. ARB Menus

```
1: Output segment (option)
```
Options: Empty, Loaded

```
nn (Empty)
```

```
1: SEG01=[value]
```

```
nn (Loaded)
```

```
1: SEG01= > 2: Load (function) 3: MODIFY (option)
```
Functions: Sine, Triangle, Square, Pulse, Ramp,
Sinc, Guass, Exponent'l, DC (no lower layers below
function selection)
Options: Clear, Fill, Offset, Invert, AM

```
Clear > 1: push ENT to clr
```

```
Fill > 1: with > 2: push ENT to fill
```

```
Offset > 1: offs by > 2: push ENT to offs
```

```
Invert > 1: push ENT to inv
```

```
AM > 1: LENGTH > 2: DEPTH 3: push ENT to modu
```

A-6. SEQ Menus

```
1: Output sequence (option)
```
Options: Empty, Loaded

```
1: STEP01 = SEG01 > 2: REPEAT * [value]
```

A-7. CONT Menus

`1: Continuous Mode`

A-8. TRIG Menus

`1: SOURCE (option)`
`Options: EXT, INT, BUS`

      `EXT`

      `INT > 1: INT PER [value]`

A-9. GATED Menus

`1: Gated Mode`

A-10. BURST Menus

`1: BURST [value] > 2: SOURCE (option)`
`Options: EXT, INT`

      `EXT`

      `INT > 1: INT PER [value]`

A-11. STORE Menus

`1: STORE SETUP [value] > 2: Push ENT to save`

A-12. RECALL Menus

`1: RECALL SETUP [value] > 2: Push ENT to rcl`

A-13. SYSTEM Menus

`1: GPIB address [value] > 2: Commands (option)`
Option: SCPI, Std.

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Appendix B

B-1. Device-Specific SCPI Command Summary

The Model 8024 conforms to the 1993 version of the SCPI standard. Some of the commands used are not included in the 1993 version of the SCPI standard. However, these commands are designed with the SCPI standard in mind and they follow all of the command syntax rules defined by the standard. This Appendix lists all non-SCPI commands only that were designed specifically for the Model 8024. A complete list of SCPI commands is given in Section 4.

```
[SOURce:]
    APPLy:SINusoid {[<frequency> [,<amplitude> [,<offset> [,<phase> [,<power>] ]]]]}
    APPLy:TRIangle {[<frequency> [,<amplitude> [,<offset> [,<phase> [,<power>] ]]]]}
    APPLy:SQUare {[<frequency> [,<amplitude> [,<offset> [,<duty_cycle>] ]]]}
    APPLy:PULSe {[<frequency> [,<amplitude> [,<offset> [,<delay> [,<rise_time> [,<high_time>,

                                                        [<fall_time>] ]]]]]]}
    APPLy:RAMP {[<frequency> [,<amplitude> [,<offset> [,<delay> [,<rise_time> [,<fall_time>] ]]]]]]}
    APPLy:SINC {[<frequency> [,<amplitude> [,<offset> [,<number_cycles>] ]]]}
    APPLy:EXPonential  [<frequency> [,<amplitude> [,<offset> [,<exponent> ] ]]]}
    APPLy:GAUSsian {[<frequency> [,<amplitude> [,<offset> [,<exponent>] ]]]}
    APPLy:DC {[<percent_amplitude>]}
    APPLy:USER {[<segment_number> [,<sampling_clock> [,<amplitude>, [,<offset>] ]]]}
    APPLy:SEQuenc {[<sequence_number> [,<sampling_clock> [,<amplitude> [,<offset>] ]]]}
    APPLy:<function_shape>?
    APPLy?

    FREQuency:RASTer {<frequency> | MINimum | MAXimum}
    FREQuency:RASTer?
    FREQuency:RASter:SOURce {EXT | INT | XTAL}
    FREQuency:RASTer:SOURce?

    SINusoid:PHASe <value>
    SINusoid:PHASe?
    SINusoid:POWer <value>
    SINusoid:POWer?
```

[SOURce:] (continued)
   TRIangle:PHASe <value>
   TRIangle:PHASe?
   TRIangle:POWer <value>
   TRIangle:POWer?

   SQUare:DCYCle <value>
   SQUare:DCYCle?

   RAMP:DELay <value>
   RAMP:DELay?
   RAMP:TRANsition <value>
   RAMP:TRANsition?
   RAMP:TRANsition:TRAiling <value>
   RAMP:TRANsition:TRAiling?

   SINC:NCYCle <value>
   SINC:NCYCle?

   GAUSsian:EXPonent <value>
   GAUSsian:EXPonent?

   EXPonential:EXPonent <value>
   EXPonential:EXPonent?

   DC <%_amplitude>
   DC?

   AM:EXECute

   BM:NCYCles {<value> | MINimum | MAXimum}
   BM:NCYCles?
   BM:INTernal:RATE <value>
   BM:INTernal:RATE?
   BM:SOURce {EXTernal | INTernal | BUS}
   BM:SOURce?
   BM {OFF | ON}
   BM?
   BM:IMMediate

   GM {OFF | ON}
   GM?

   SEQuence:DEFine <step_number>, <segment_number>, <#_repeat>
   SEQuence:DELete[:NAME] <sequence_number>
   SEQuence:DELete:ALL
   SEQuence:SELect <sequence_number>

   SYSTem:LOCal
   SYSTem:REMote

   TRACe:SELect <segment_number>

Appendix C

C-1. Short-Form (std.) GPIB Commands Summary

The Model 8024 can accept two sets of commands: SCPI command set and short-form commands. The SCPI set of commands is the default setting of the generator. The short-form commands set is available for those programmers who do not want to use the lengthy programming code that SCPI requires.

The short-form command set speeds bus communications and is also required in conjunction with WaveCAD operation. This Appendix lists the short-form command set. Selection of which command set is used as GPIB protocol is done from the front panel. To change the GPIB command set press the [SYSTEM] button, then press the cursor button to move the cursor one menu down. Rotate the dial. The display toggles between "SCPI" and "std.". Select the required command set and press any front panel key to resume normal operation.

PROGRAM & QUERY GENERAL MODES

OPERATING MODE

MODE 0	Normal continuous mode
MODE 1	Trigger Mode
MODE 2	Gated Mode
MODE 3	Burst
MODE?	

TRIGGER SOURCE

TRIG_SRC EXT	External source
TRIG_SRC INT	Internal source
TRIG_SRC?	

OUTPUT WAVEFORMS

WAVE 0	Sinewave
WAVE 1	Triangle
WAVE 2	Squarewave
WAVE 3	Pulse
WAVE 4	Ramp
WAVE 5	Sinc

WAVE 6	Gaussian
WAVE 7	Exponential
WAVE 8	DC
WAVE?	

OUTPUT FUNCTION SHAPE

OUT 0	Standard waveforms
OUT 1	Arbitrary waveforms
OUT 2	Sequenced waveforms
OUT?	

STAND-BY MODE

ST_BY 0	Output On
ST_BY 1	Output Off
ST_BY?	

PROGRAM PARAMETERS

FREQ	MHZ, HZ, KHZ, MAHZ
FREQ?	
SCLK	MHZ, HZ, KHZ, MAHZ
SCLK?	
AMPL	MV, V
AMPL?	
OFFS	MV, V
OFFS?	
BURST	Program burst count
BURST?	
INT_PER	NS,US,MS,S
INT_PER?	
FILTER 0	No filter
FILTER 1	20MHz Gaussian
FILTER 2	25MHz Elliptical
FILTER 3	50MHz Elliptical
FILTER?	
RST_FUNC	Reset function generator parameters

PROGRAM ARBITRARY WAVEFORMS AND SEQUENCE

SEG01=d	Assign memory size (d) to segment 01
SEG01?	Interrogate segment size
STEP01=SEG01*d	Assign multiplier (d) to segment 01 in sequencer step 01
STEP01?	Interrogate step
SEG01_DATA#d	Send complete arbitrary waveform string to segment 01,
	as part of <Program Message>
SEG01_DATA#0	Send complete arbitrary waveform string to segment 01, terminated with NL+^END

RESPONSE MESSAGE FORMAT

X0	Response header OFF
X1	Response header ON
Z0	New line (LF), END (EOI) terminator
Z1	New line (LF) terminator
Z2	END (EOI) terminator

COMMON COMMANDS

*CLS	Clear status command
*ESE	Standard event status enable command
*OPC	Operation complete command
*RCL	Recall front panel set-up command
*RST	Reset command
*SAV	Save front panel set-up command
*SRE	Service request enable command
*TRG	Trigger command
*WAI	Wait-to-continue command

COMMON QUERIES

*ESE?	Standard event status enable query
*ESR?	Standard event status register query
*IDN?	Identification query
*OPC?	Operation complete query
*SRE?	Service request enable query
*STB?	Read status byte query

STANDARD EVENT STATUS ENABLE REGISTER MASK

*ESE0	No mask
*ESE1	ESB bit set on operation complete
*ESE2	Not used
*ESE4	ESB bit set on query error
*ESE8	ESB bit set on device dependent error
*ESE16	ESB bit set on execution error
*ESE32	ESB bit set on command error
*ESE64	ESB bit set on user request
*ESE128	SB bit set on power on

SERVICE REQUEST ENABLE REGISTER MASK

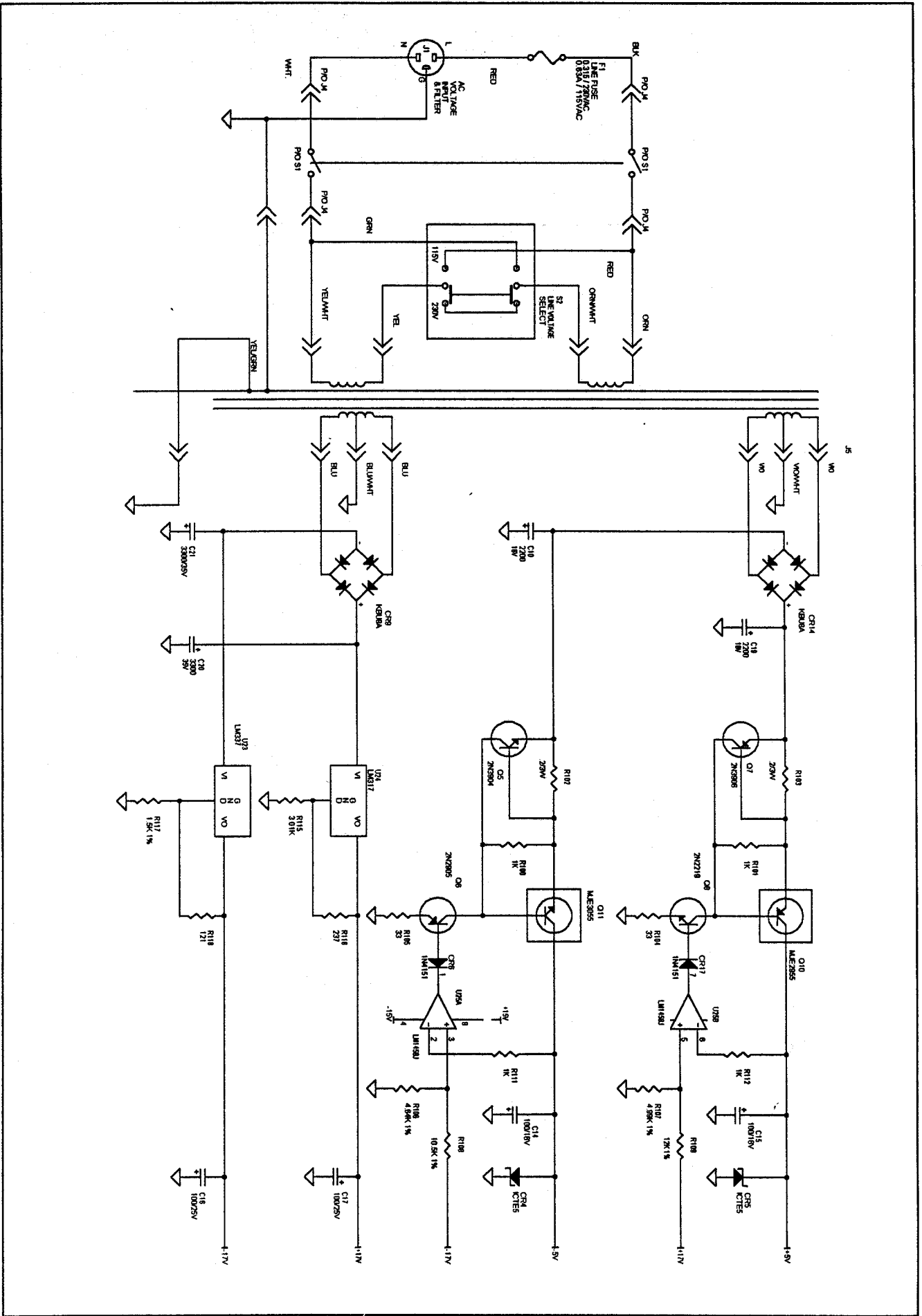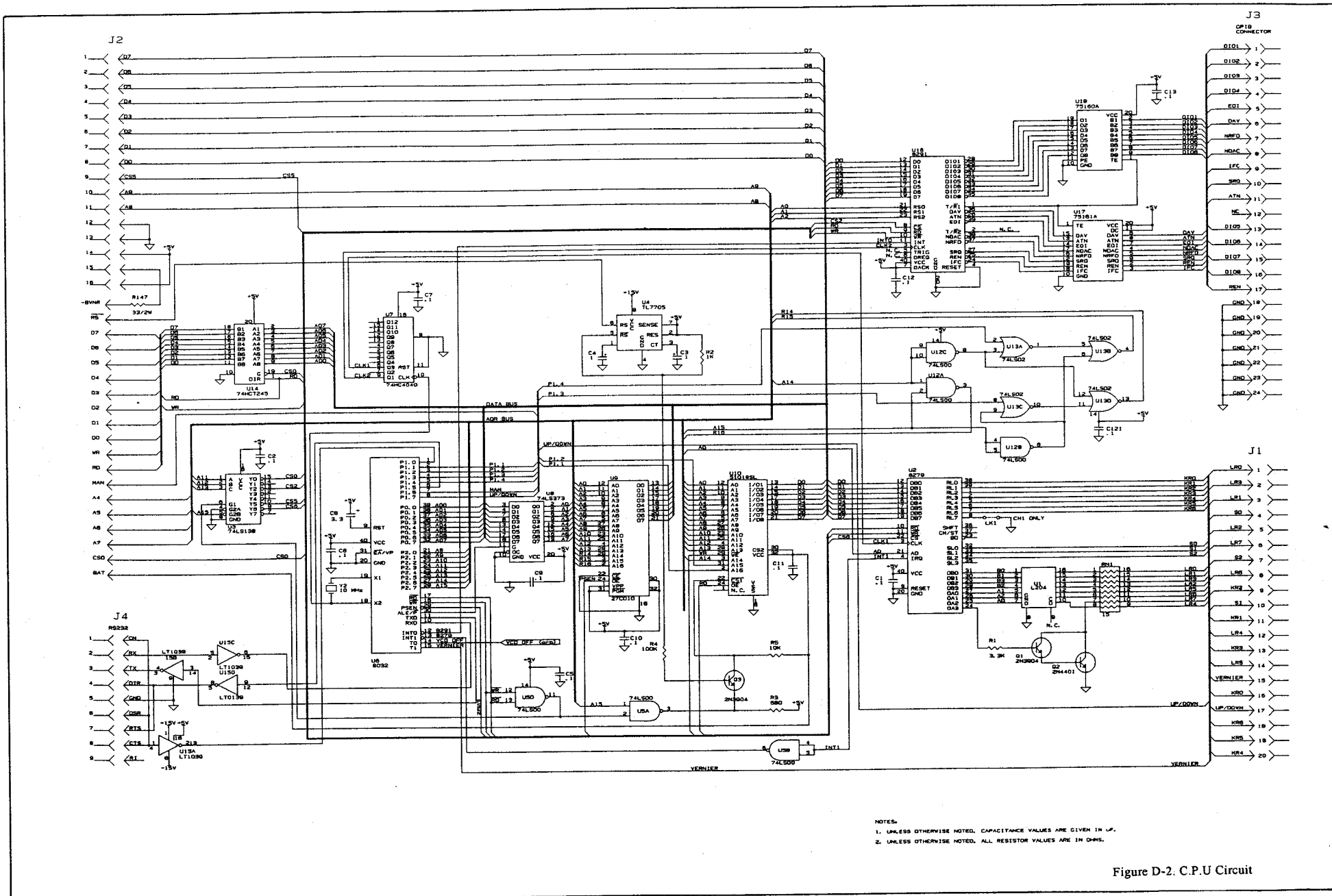|	
*SRE0	No mask
*SRE1	RQS/MSS bit set on ERR bit
*SRE2	No mask
*SRE4	No mask
*SRE8	No mask
*SRE16	RQS/MSS bit set on MAV bit (message available)
*SRE32	RQS/MSS bit set on ESB bit (standard event status register)
*SRE128	Not used

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Appendix D
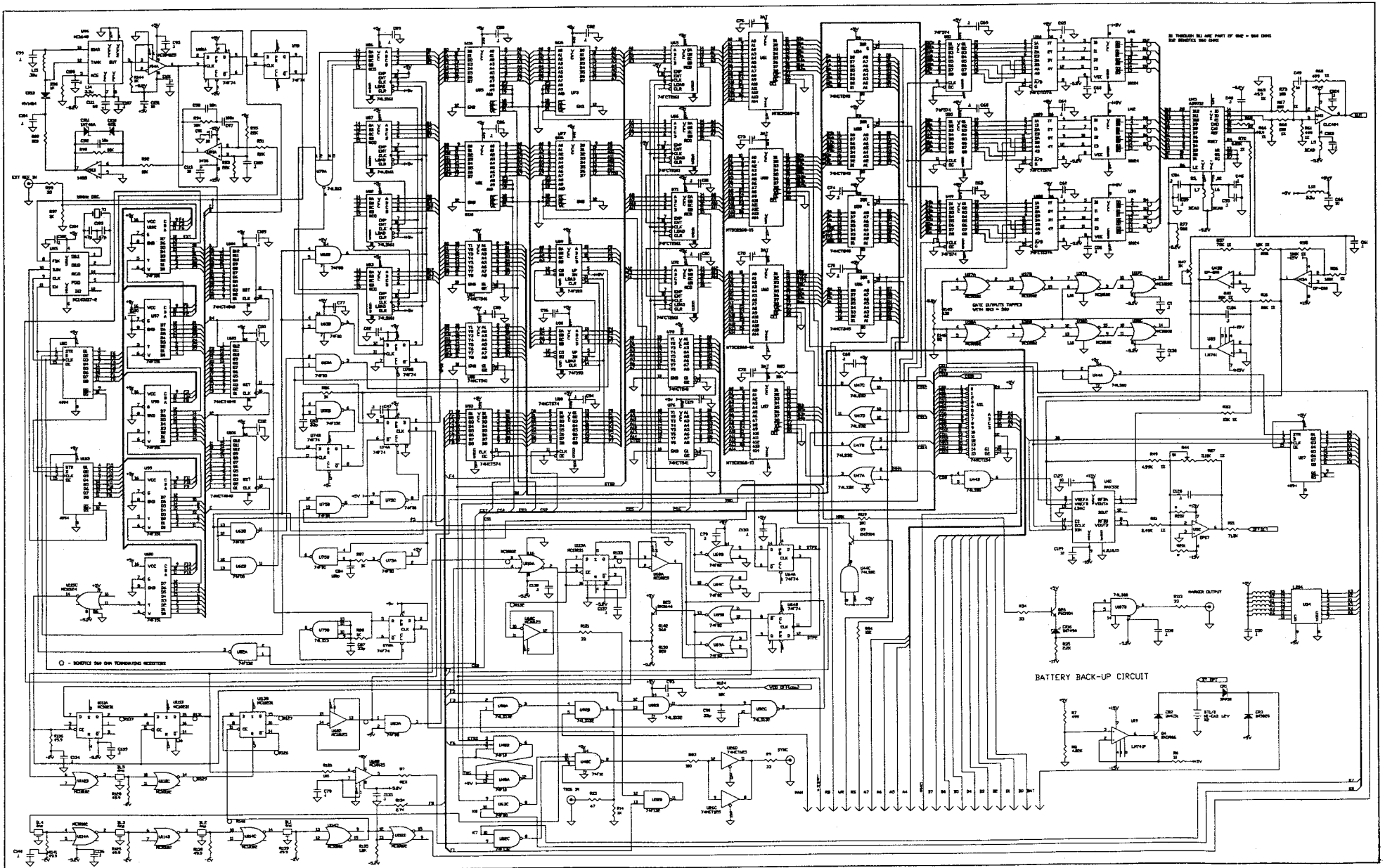
Figure D-1. Power Supply Circuit

Figure D-2. C.P.U Circuit

Figure D-3. Arbitrary Wavefrom Generation Circuit
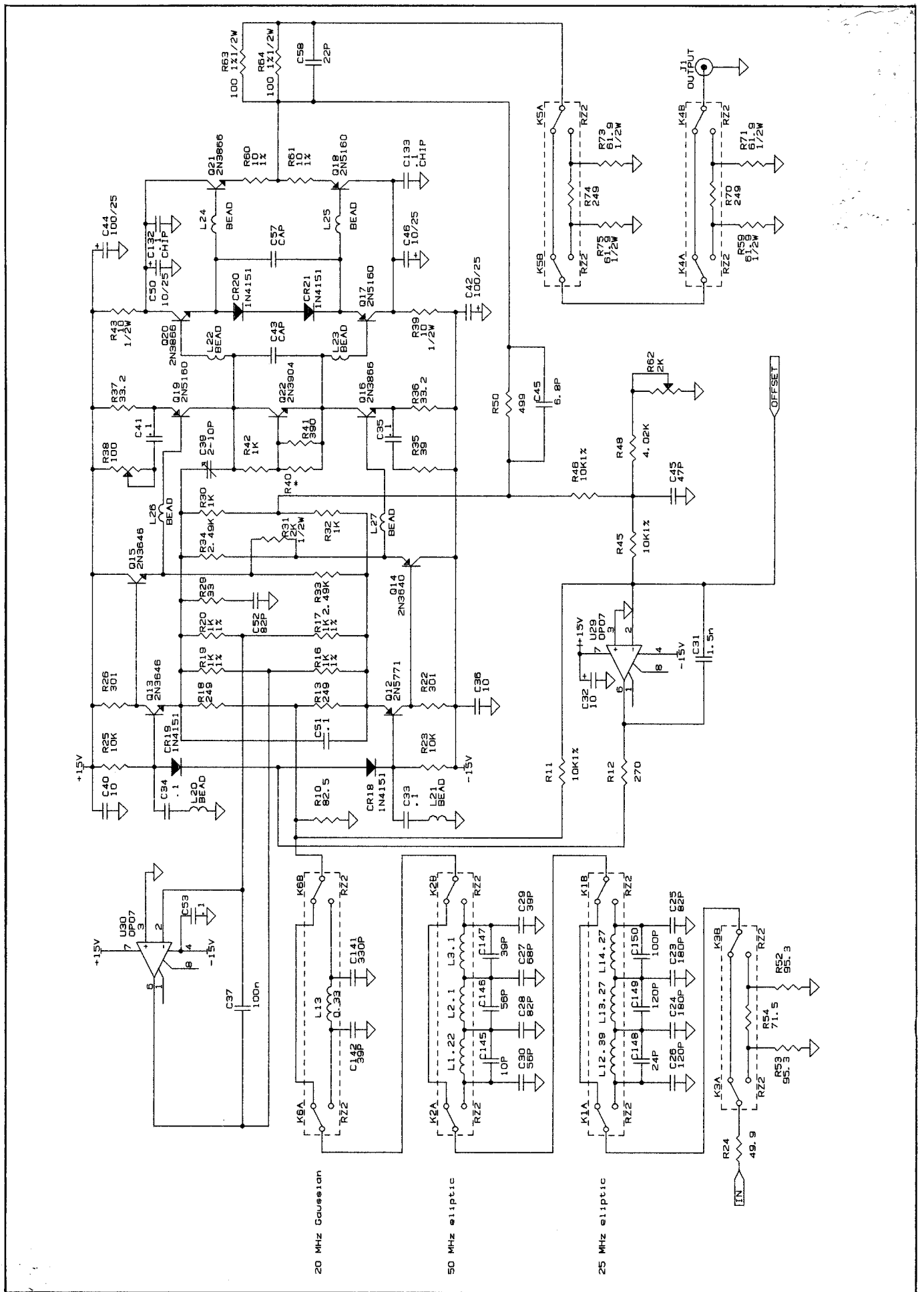
Figure D-4. Output Amplifier Circuit
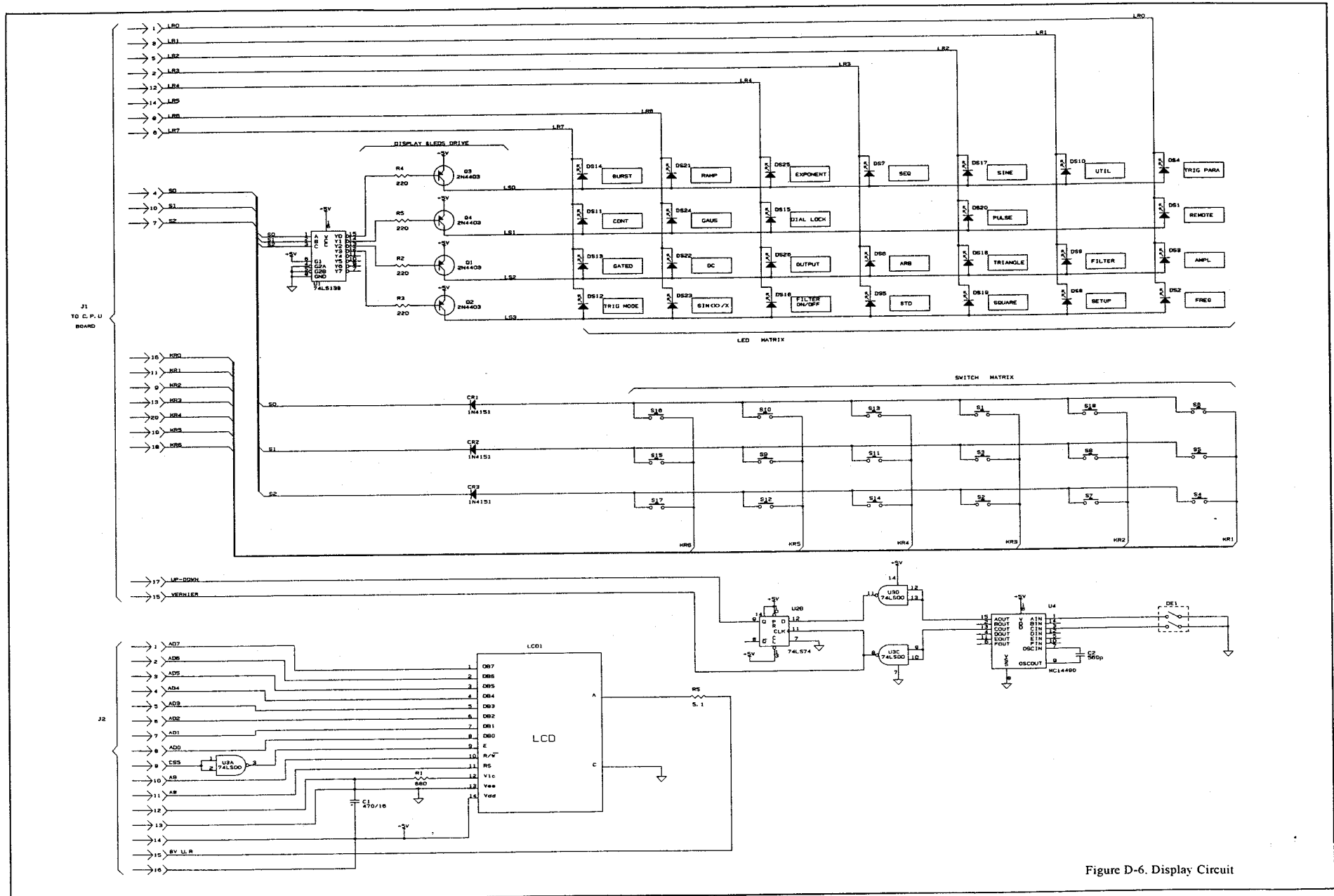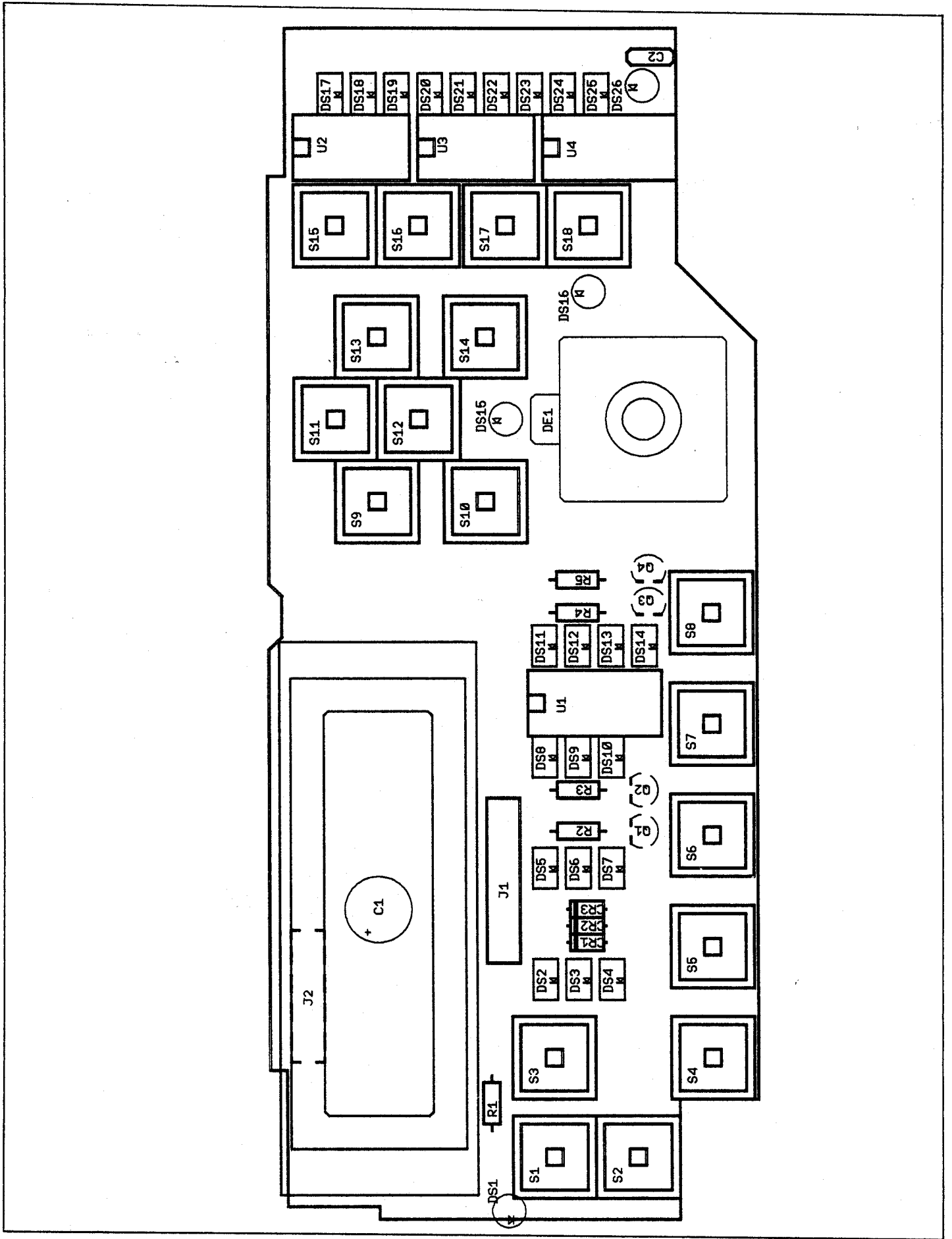
Figure D-5. Main Board Assembly

Figure D-6. Display Circuit

Figure D-7. Display Board Components Location