Instruction Manual

Model 6040
Universal Pulse Generator

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WARRANTY

Berkeley Nucleonics Corporation warrants all instruments, including component parts, to be free from defects in material and workmanship, under normal use and service for a period of one year. If repairs are required during the warranty period, contact the factory for component replacement or shipping instructions. Include serial number of the instrument. This warranty is void if the unit is repaired or altered by others than those authorized by Berkeley Nucleonics Corporation.

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SAFETY PRECAUTIONS

The following warnings, which appear both here and in the main body of the test, are to alert the user of potential safety hazards and to encourage safe operating practices.

WARNING: To avoid possible electric shock, observe the following:

Do not operate with the cover removed. Exposed ac power is present even with the power switch off.

Be sure the ground conductor of the ac power cord connects the instrument to a solid earth ground.

WARNING: *To remove all ac power from the unit, the line cord must be unplugged.*

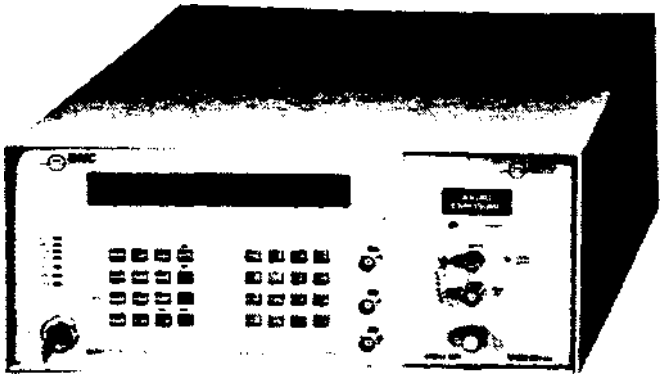
WARNING: *To avoid accidental shock, unplug the line cord and turn the power off before checking or replacing the fuse. For protection against fire, use only the specified fuse value. Do not attempt to bypass or repair the fuse.*

The following cautions, which appear both here and in the main body of the text, are to prevent equipment damage that could result from improper operation.

CAUTION: *The module must be installed with mainframe power off. A module can be damaged or have its memory corrupted if inserted or removed from the mainframe with the power on.*

CAUTION: *Before plugging the instrument into a 234 V ac line, be sure the 115 V/230 V selection switch is set to 230 V and a fuse of proper value is in place. Do not move this switch while the power is on.*

UNIVERSAL PULSE GENERATOR
MODEL 6040



The Model 6040 System consists of a crystal-controlled programmable pulse/digital delay generator mainframe and a family of optional plug-in modules. The 6040 itself generates TTL and ECL outputs at rates to 100 MHz with 1 ns or less rise times and a 1 nanosecond resolution for pulse width, delay and double pulse timing.

The interchangeable modules provide the instrument with additional capabilities such as faster transition times, higher pulse amplitudes, and generating optical pulses.

SECTION 1

SPECIFICATIONS

MODEL 6040 MAINFRAME CHARACTERISTICS

Timing Characteristics

INTERNAL REP RATE

Range:	0.01 Hz – 100 MHz
Resolution:	4 digits
Accuracy:	0.01%

DELAY

Range:	0 – 640 s.
Resolution:	1 ns or 5 digits, whichever is greater.
Jitter (rms):	25 ps or 0.01% of Delay, whichever is greater.
Accuracy:	0 to 9 ns. 1 ns; 10 ns to 640 s, 0.5 ns or 0.2% of Delay, whichever is greater.

WIDTH

Range:	3 ns – 640 s.
Resolution:	1 ns or 5 digits, whichever is greater.
Jitter (rms):	25 ps or 0.01% of Width, whichever is greater.
Accuracy:	Width, whichever is greater.

PULSE SPACING

Minimum Pulse Separation:	For Widths < 160 ns: 5 ns For Widths ≥ 160 ns: 150 ns. Trailing to leading edges.
Maximum Delay:	For Delays < 160 ns: Delay ≤ (trig, period)- 5 ns. For Delays ≥ 160 ns: Delay ≤ (trig, period) - 150 ns. (For Double Pulses, see also Minimum Pulse Separation.)

SINGLE CYCLE Depression of the ENTER or EXEC key will initiate a single delay and width sequence.

SPECIFICATIONS

Input Characteristics

TRIG IN — External trigger to initiate delay and width sequences.

Range:	0-100 MHz.
Input Impedance:	50 ohms.
Slope:	Selectable pos/neg.
Minimum Pulse Width:	3 ns.
Minimum Signal Amplitude:	100 mV.
Maximum Signal Amplitude:	± 7 V.
Threshold Range:	± 2.5 V.
Threshold Resolution:	10 mV.
Trigger Jitter:	20 ps rms (between TRIG IN and TRIG OUT).

MODULE DISABLE — Allows the outputs on some modules to be remotely disabled.

Disable:	4 V - 5 V. 5 mA sourcing current (into the 6040) or contact opening.
Enable:	0 - 300 mV, 5 mA sinking current (from the 6040) contact closure, or plug removed from jack.

Output Characteristics

PULSE OUT — Provides the signal selected by the rep rate, delay, width, and single/ double pulse settings. Corresponds in timing to ECL OUT and to module outputs.

Amplitude:	+5 V into 50 ohms.
Transition Times:	1 ns rise time, 1.5 fall time.
Insertion Delay:	50 ns typical (between TRIG IN and PULSE OUT; see Figure 1-1).

ECL OUT — Provides an ECL version of PULSE OUT.

Amplitude:	-0.8 V to -1.8 V into 50 ohms ("low true" pulses).
Transition Times:	700 ps.
Insertion Delay:	50 ns typical (between TRIG IN and ECL OUT; see Figure 1-1).

SPECIFICATIONS

TRIG OUT — Denotes the start of a liming cycle.

Amplitude:	+2 V into 50 ohms. +4 V into 100 ohms.
Transition Times:	3 ns.
Pulse Width:	3 ns.
Trigger Delay:	20 ns typical (between TRIG IN and TRIG OUT).

MODES — With a module installed, four main operating modes are available. The Mode selection is module dependent.

PULSE

Single Pulse:	Conventional pulse generator with rate, delay and width controlled by the 6040 mainframe (see Figure 1-1).
Double Pulse:	A pair of identical pulses of the selected width with leading edges separated by the selected delay.
External Drive:	Produces pulses corresponding in rate and duty cycle to an external pulse train. Available with some modules.

EXTERNAL MODULATION — Converts digital and analog electrical signals into their optical equivalent.

IMPULSE

Single Impulse:	A subnanosecond pulse of fixed width and amplitude, with rate and delay controlled by the 6040 mainframe.
Double Impulse:	A pair of Identical impulses separated by the selected delay.

CW — Provides a steady-state, adjustable power level.

SPECIFICATIONS

Programming

GPIB IEEE-488	Remote interface with all functions and parameters programmable and bus triggerable. Interface Functions: SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0.
RS-232	Remote interface with all functions and parameters programmable in full or half-duplex to 1200 baud and bus triggerable.
LOCAL	Pushbutton manual entry with panel LCD display.

General

DIMENSIONS	12.75" W x 5.25" H x 16" D (324 mm x 133 mm x 406 mm). Rack Mount: 19" W x 6.97" H x 16" D (483 mm x 177 mm x 406 mm).
WEIGHT	16 lbs net (7.3 kg): 23 lbs shipping (10.4 kg). Rack Mount: 5 lbs net (2.3 kg): 10 lbs shipping (4.5 kg).
POWER	115/230 V ± 10 %. 50/60 Hz. 80 W.
AMBIENT TEMPERATURE	Operating Range: 0° - 50° C (32° -122° F). Specifications apply: 10° - 40° C (50° - 104° F).

Module Characteristics

PERMANENT MEMORY	A ROM in the module determines the instrument's allowable operating conditions and display units.
STORE	Ten complete instrument settings can be stored in the module's nonvolatile RAM. The module may be removed without loss of these settings.

SPECIFICATIONS

RECALL — Stored settings can be manually recalled or bus transferred to the mainframe. The setting in memory 0 is activated automatically upon power-up or reset.

General

DIMENSIONS — 3.75" W x 4.9 " H x 10" D (95 mm x 124 mm x 254 mm).

WEIGHT — 2 lbs net (0.9 kg): 7 lbs shipping (3.2 kg).

Status Byte Summaries

Table 1-2. Instrument Status Byte

Bit	Description
7	Always zero
6	Always zero
5	Always zero
4	Always zero
3	Trigger has occurred
2	Overlap
1	PLL out of lock
0	Timing cycle in progress

Table 1-3. Error Status Byte

Bit	**Description**
7	Always zero
6	Always zero
5	Always zero
4	Always zero
3	Always zero
2	Always zero
1	Overrange
0	Unrecognized command

Module Status Byte

The Module Status byte is module dependent. Refer to the module's instruction manual.

SECTION 2

OPERATING INFORMATION

General

POWER UP

When power is first applied, the mainframe performs a test to determine if a module is installed. If a module is present, the limits for each module dependent parameter are transferred to the mainframe. The memory is checked for any errors and the parameters in memory 0 are loaded into the mainframe.

If a module is not present, the parameters are set as indicated in Table 2-1.

Table 1-4. 6040 Mainframe Default Settings

MODE:	Pulse
TRIG:	Single Cycle (with other values set as follows) Internal Trigger Rate = 1 kHz External Trigger Threshold = 0 V External Trigger Slope: +
TIMING:	Width = 1 µs Delay = 1 µs Single Pulse
GPIB/RS-232:	IEEE-488 Address = 6 Baud Rate = 1200 Full Duplex Remote Enabled

LCD Power On Sequence

When the 6040 is first turned on, the display will show the software version number. If a module is present, the LCD will then momentarily display "MEMORY CHECK," followed by the module I.D. display. Without a module, the display will read "6040 No Plug-In."

OPERATING INFORMATION

Module Installation

CAUTION: The module must be installed with mainframe power off. *A module can be damaged or have its memory corrupted if inserted or removed from the mainframe with the power on.*

To install a module, turn the power off, slide the module in and tighten the mount screw knob.

Warm Up Requirements

The instrument should be allowed to warm up for 30 minutes before high precision measurements are made. Less critical tests can be performed immediately after turn-on. Please refer to the module's manual to determine if it requires an additional warm up period.

Safety Precautions

The safety warnings and cautions that appear in this manual are listed at the end of the table of contents. Some modules have high voltage or laser outputs and additional safety precautions should be taken. See the module manual for details.

WARNING: To avoid possible electric shock, observe the following-

Do not operate with the cover removed. Exposed ac power is present even with the power switch off.

Be sure the ground conductor of the ac power cord connects the instrument to a solid earth ground.

Electrical Cables, Attenuators and Oscilloscopes

The electrical signal inputs and outputs have fast rise and fall times containing frequency-components far in excess of 100 MHz. All signal handling components such as loads, cables, attenuators, connectors and oscilloscopes should have a response exceeding 100 MHz and preferably 350 MHz. Cable and load impedance mismatch will cause signal reflections and result in distorted waveforms and measurement errors. Some sampling oscilloscopes will require attenuators to protect their inputs.

OPERATING INFORMATION

TROUBLESHOOTING

To start, make sure that the line cord is plugged in all the way, and that the power-on key switch is in the ON position. Verify that the 115 V/230 V selection switch is properly set for your area. (If it is not, unplug the line cord and move the switch. Make sure the proper fuse in in place before plugging the cord back in.)

With the line cord unplugged check the fuse. Make sure that it has not blown and that it is of the correct value for the line voltage being used.

When ac power is applied, you should be able to hear the fan. The unit will not operate properly if the side vents are blocked.

A thermal cutoff switch will shut off the power to everything but the fan should the temperature exceed 50^{o} C. Power will be restored when the unit has cooled sufficiently. Make sure that the fan and the side vents are not blocked, and that the fan is operating properly.

With the power off, make sure that the module is seated correctly in the mainframe.

LCD Contrast

If there are no characters on the LCD or the contrast is poor, a simple internal adjustment may solve the problem (see the calibration procedure for details).

Cold Boot

If the instrument turns on, but is completely unresponsive to the keyboard or displays the error message "Invalid Function." then the module's memory may have been corrupted causing the instrument to "hang up." To correct for this, turn the unit off, then hold down the ENTER key and turn the power back on. This will initialize the module's memory to its default settings (see the module's manual for the specific values).

Quick Test

Since the 6040 uses a modular approach, operating problems can arise from either the mainframe unit or the installed module: the problem must be localized to one or the other. To test the mainframe, turn the power off, remove the module, and switch the power back on. Press the TRIG key until the internal trigger parameter is displayed ("Trig Int: 1.000 kHz"). Press the 11} key, the {10^{x}} key, the {5} key, and the ENTER key in sequence. The display will read "Trg Int: 100.0 kHz."

Connect the TRIG OUT and PULSE OUT to channels A and B of an oscilloscope. Trigger the oscilloscope on the leading edge of TRIG OUT. Set the oscilloscope for 1 us per division. Display the PULSE OUT. A pulse of +5 V amplitude and 1 us duration should occur 1 µs into the sweep.

Press the TIMING key to display the Delay parameter ("Delay: 1.000 µs"). Move the cursor (using the {◄} key) to underline the 1 us decade. Now use the increment key {▲} to increase the Delay noting that the incidence of PULSE OUT moves in 1 µs steps. Repeat this with the Width parameter to change the duration of PULSE OUT.

For quick testing of the module, repeal the above using the module output (an optical detector may be necessary). Since some modules may have rep rate and width limitations, the specific values above may have to be modified, but the general procedure is the same.

GPIB and RS-232 Problems

For remote operation from either GPIB or RS-232. the {GPIB/RS-232} key menu must be set to display "Remote Enabled."

When using the GPIB, make sure that the GPIB cable is properly attached and that the address is specified correctly. The default address is 6. but may be set between 1 and 30.

The 6040 will respond to remote commands only if the Remote Enable line (REM) is asserted. When this happens the LCD will display "GPIB Remote Mode," and all keys except LOCAL will be disabled.

The LOCAL key allows the user to return to manual operation (unless the GPIB command LLO has disabled it).

For the RS-232. again check the cable, but also verify that Baud Rate and Duplex are set correctly.

OPERATING INFORMATION

FRONT PANEL DESCRIPTION

Power Switch

The power switch, located in the lower left comer of the front panel, is keyed to prevent unauthorized use. The key can be removed only when the switch is turned to the off position.

> **WARNING:** *To remove all ac power from the unit, the line cord must be unplugged.*

LCD Display

The 6040 has a 20-character liquid crystal display (LCD). This displays all menus and data while the unit is being programmed from the front panel. In the following descriptions the display for each menu is given.

LED Annunciator

The front panel has a set of seven LED indicators on the left side of the panel. The upper four LEDs. labeled PULSE, IMPLS (Impulse), CW (Continuous Wave) and MOD (External Modulation), reflect the current Mode setting. This allows continuous monitoring of the Mode setting.

The next two LEDs, labeled TRIG'D (triggered) and OVRLP (overlap), are used to indicate the status of triggering in the Pulse and Impulse Modes. The TRIG'D LED is illuminated if there is a signal present at the front panel TRIG IN jack that exceeds the threshold setting for an external trigger. The OVRLP LED indicates that a potential triggering error exists. It blinks when the combination of rep rate. Width and Delay results in some pulses not being generated. This occurs when the Minimum Pulse Separation and Maximum Delay conditions are not met (see the Specifications section).

Finally, the bottom LED is labeled REM (remote) and indicates that the 6040 is under remote computer control (via GPIB or RS-232).

Keypads

The 6040 has two keypads. The left keypad is used to control the operating state (Trigger, Timing, Mode, etc.) and to modify existing parameters (increment/decrement value). The right keypad is used primarlily to enter numeric data for new parameters. It is also used to toggle the states of certain parameters (e.g. Single Pulse/Double Pulse) and to trigger the instrument under Single Cycle operation.

OPERATING INFORMATION

Control Keypad

Some of these keys are dependent on the presence of a plug-in module. For example, the LEVEL, STORE and RECALL keys function only with a module installed. The keys on the control keypad can be divided into the following subsets: menu key, memory keys, function keys, and scan keys, as well as the LOCAL and UNITS keys.

The five menu keys. MODE, TRIG. TIMING, LEVEL, and GPIB/RS-232, step through a number of possible states or parameter displays, allowing the user to configure the instrument's operating characteristics. The memory keys, STORE and RECALL, allow storage and retrieval of ten complete instrument settings. The function keys are reserved for use with future modules. The scan keys, {◄} {►}, {▲}and (▼) are used to modify parameters that have been previously entered.
The two remaining keys do not fall into any of the above categories. The LOCAL key returns instrument control to the front panel from either GPIB or RS-232. The UNITS key allows the user to select between different display units for the level parameter (an optical unit, for example, may allow the display of the level settings in units of either Watts or dBm).

Numeric Keypad

The right keypad is similar to a calculator. It has keys for the decimal digits (0-9), the decimal point (.), sign change (+/-), exponent (10^x), backspace (BK SPC), enter (ENTER), and execute (EXEC). ENTER and EXEC are used to terminate data entry and also to trigger a Single Cycle timing sequence. The {+/-, SGL/DBL} key is used both to indicate negative values and to toggle between Single Pulse and Double Pulse operation.

Connectors

There are three BNC connectors on the front panel. These are used in the Pulse and Impulse Modes to monitor or trigger the pulse generator.

PULSE OUT provides waveform synchronized to TRIG OUT. The time position (with respect to TRIG OUT) and duration of this output are set by the Delay and Width, respectively. PULSE OUT produces pulses of a fixed +5 V amplitude (into 50 ohms) with 1 ns rise times and an 1.5 ns fall times.

PULSE OUT is nominally coincident with the plug-in module's output. The "module delay" (the fixed time between the mainframe PULSE OUT and the module output) depends on the module being used and is given in the module manual. In Impulse Mode, PULSE OUT has a fixed width of 5 ns (the Width setting has no effect in Impulse Mode).

TRIG IN is the input for external triggers. It has a 50 ohm input impedance, can take input voltages up to ±7 V dc or 7 V ac pk, and accepts frequencies up to 100 MHz.

TRIG OUT is the lime marker for the beginning of a timing cycle. TRIG OUT has fixed +3 V amplitude (into 50 ohms), a 3 ns width, and transition times of 3 ns. In External Trigger operation, TRIG OUT will occur 20 ns after the TRIG IN signal.

Plug-In Module Receptacle

The plug-in module receptacle is on the right side of the front panel, and accepts a single BNC 6040 plug-in module. The receptacle consists of an alignment guide, one 40-pin edge connector, and one ConheX coaxial connector.

The 40-pin edge connector allows the 6040 mainframe to control and communicate with the module and also supplies the power to the module.

The ConheX connector delivers the high speed pulse generator DRIVE signal to the module. This signal is an ECL version of the mainframe's front panel PULSE OUT.

REAR PANEL DESCRIPTION

Located on the rear panel are the GPIB and RS-232 bus interface connectors, the ECL OUT jack, MODULE DISABLE jack, RESET pushbutton, line voltage selection switch and fuse. There is also a heat sink for the power supply regulators, a line cord receptacle and the cooling fan.

GPIB Connector

In the upper left corner is the connector for interfacing with an IEEE-488 GPIB bus. This allows full control of the unit via a remote controller. All front panel settings can be controlled and any parameter can be read.

RS-232 Connector

In the upper center-left corner is the RS-232 connector. As with the GPIB bus, all front panel settings can be controlled and all parameters read.

ECL OUT Connector

This SMA connector provides an Ed version of the PULSE OUT output. Negative pulses, switching from -0.8 V to -1.8 V (standard ECL "low true" levels) with transition times of 700 ps, are produced nominally coincident with the positive pulses generated from the PULSE OUT jack.

MODULE DISABLE Jack

The MODULE DISABLE jack is used in conjunction with optical plug-in modules. This allows the user to disable the module output from a remote location. The connector is an audio phone jack that is normally closed (grounded). When a phone plug is inserted, the jack leads are opened so a plug with a two conductor cord and a switch can be used for control. Whenever the switch is open, the module output will be disabled.

OPERATING INFORMATION

RESET Button

The RESET pushbutton initiates a power-on sequence. This resets the microprocessor board which in turn resets all hardware to its power-on settings.

115 V/ 230 V SELECTION SWITCH AND FUSE

This switch allows operation on either 117 V ac (U.S.) or 234 V ac (European), as well as giving the fuse value for that line setting (1.5 A 3AG Slo-Blo for 117 V, 0.75 A 3AG Slo-Blo for 234 V). Below this switch are the line cord and fuse receptacles. The switch is factory preset and should not be moved unless a new line voltage is used. Note that a new fuse value is required as well for a new line voltage.

WARNING: *To avoid accidental shock, unplug the line cord and turn the power off before checking or replacing the fuse. For protection against fire, use only the specified fuse value. Do not attempt to bypass or repair the fuse.*

CAUTION: *Before plugging the instrument into a 234 V ac line, be sure the selection switch is set to 230 V and a fuse of proper value is in place. Do not move this switch while the power is on.*

FRONT PANEL PROGRAMMING

General

Menus and Parameter Selection

The front panel control of the 6040 has been optimized for ease of use and understanding. The control and modification of the operating Mode, states and parameters are realized by a set of control keys. Some of these keys have a single parameter or state associated with them (such as the STORE key), while others have a menu of selections (for example, the MODE key).

For menu keys, the user can sequence through the selections by successively asserting the given key. A menu item is chosen simply by stopping at that item. So that the user may see what selection is in effect on another key without altering the setting, sequencing - is done only on repeated assertions of a key. So, for example, the first time the MODE key is pressed, it will simply display the active Mode. Only when it is pressed a second time (without pressing another key) will it cycle to the next Mode selection.

OPERATING INFORMATION

The MODE and TRIG menu keys change the operating state of the 6040 directly. As the user sequences through the Mode menu, the state of the module's output is modified in accordance with the displayed Mode (Pulse, CW, etc.). Similarly, as the user sequences through the Trigger menu, the Trigger source for the pulse generator is set in accordance with the display (Internal, External, Single Cycle).

The TIMING. LEVEL and GPIB/RS-232 keys simply display parameter values and do not change the operating characteristics unless these parameters are modified. The TIMING key, for example, allows the user to examine the Width, Delay and Single/Double Pulse parameters. Only if the user modifies the displayed setting will the operating state of the machine change.

Each plug-in module has its own set of available menu selections. Electrical modules, for example, do not have a CW option in the Mode menu. Manuals for each module describes the menus and range of parameter values that correspond to the module.

Although the user has access to all the parameters and menu items (for a given module) at all times, their action is Mode dependent. Table 2-2 gives a general chart of the menu keys, showing which menu selections have control in each Mode. An x in the column for a given Mode indicates that a menu selection (or parameter modification) has an effect in that Mode.

Note that modifying a given parameter will only change the current operating state of the machine if the parameter is valid for the current Mode setting. For example, in the CW Mode, the parameters associated with the TRIG (Trigger) and TIMING keys will not affect the current operating state (but they will become valid when the Mode is subsequently set to Pulse). Another example is the LEVEL key. For the Pulse Mode, the External Modulation Level parameter will not affect the module's output Again, only after setting the Mode to External Modulation will this setting become pertinent.

Modifying Parameters

A parameter can be altered by two methods: by entering a totally new number using the numeric keypad or by altering the present value incrementally using the scan keys.

OPERATING INFORMATION

Numeric Data Entry

To enter an entirely new value, simply type in the desired value using the digit, decimal point, sign (where appropriate), and exponent keys, and then use either the EXEC (execute) or ENTER key to terminate the data entry. During the entry of values any errors can be corrected using the BK SPC (backspace) key. If the user decides midstream not to modify the parameter, pressing any menu key will nullify the data entry. If the menu key is the one associated with the given parameter, the parameter will be redisplayed with its previous value.

EXAMPLE: To set the repetition rate to 1 kHz, the following sequence is possible:

1) Assert TRIG and the display reads:
<Ext Drv: 1.00 V >

This means that the last sequencing of the TRIG key selected for External Drive (available with certain modules).

2) Assert TRIG again and the display reads:
<Trg Int: 900.0 Hz>

We have now sequenced the TRIG menu to the Internal Trigger section and are ready to modify the parameter.

3) Any of the following will achieve the goal:
1000 {ENTER}
1.00 {l0^x} 3 {EXEC}
2 {BK SPC} 0.1 {10*} 4 {ENTER} (here we used the backspace key)

The display will now read:
<Trg Int: 1.000 kHz>

The method for other parameters is the same as above. The decimal point {.} and exponent {l0^x} keys, however, are not recognized for parameters such as bus address. Also, for parameters that are not signed, the {+/-} key is not recognized.

Note that when used to change Delay or Width parameters, the ENTER and EXEC key differ slightly. EXEC terminates the current timing cycle and will turn off a pulse if one is in progress. ENTER allows the current timing cycle to complete but prevents the keyboard from responding to new input until the timing cycle has finished.

If a value is entered that is outside the range of acceptable values, the display will momentarily display "Range Error," after which the original value is redisplayed.

OPERATING INFORMATION

Parameter Scanning

The second method of altering a parameter is incremental. First display the desired parameter. Then choose the desired digit with the cursor using the left {◄} and right {►} keys. Once the digit is selected, the increment {▲} and decrement {▼} keys allow the incremental modification of the existing value.

In addition, the value will be multiplied (or divided) by ten if the left (or right) key is pressed when the cursor is located at the most (or least) significant digit. This simulates the vemiered tuning and range switch associated with analog pulse generators.

If an attempt is made to scan a parameter outside the range of acceptable values, a display of "Range Error" will remain until the scan key is released, at which time the parameter's value is again displayed.

EXAMPLE: The user could modify the Delay parameter as follows.

Key Hit:	**Display:**	**Comments:**
{TIMING}	<Delay: 1.2340 ms >	Display previous Delay parameter
{▲}	<Delay: 2.2340 ms >	Increment Delay
{◄}	<Delay: 22.340 ms >	Multiply Delay by 10
{◄}	<Delay: 223.40 ms >	Multiply Delay by 10
{►} x 4	<Delay: 223.40 ms >	Move cursor right (asserting {►} 4 times)
{▼}	<Delay: 223.32 ms >	Decrement Delay
{►}	<Delay: 22.332 ms >	Divide Delay by 10

Saving the Panel Setting in Memory

All plug-in modules are equipped with a nonvolatile memory. This allows the user to store ten complete instrument settings. Included in each of these are all the parameter values (whether active or not) for the Mode, Trigger, Timing and Level menus as well as which menu selections are currently in effect. These memories are accessed by the STORE and RECALL keys.

To save the present panel state, press STORE followed by the digit key for the memory location desired. To retrieve a previously saved panel stale, press RECALL, followed by the digit key of the desired memory. (Note that the ENTER and EXEC keys are not used.)

The GPIB/RS-232 menu parameters are not accessed or retrieved by STORE and RECALL. Instead, the most recent setting for each selection on the GPIB/RS-232 menu is automatically stored in the module. These go into effect as soon as the instrument is turned on (with the module plugged in).

OPERATING INFORMATION

Control Key Descriptions

The following is a detailed description of each key on the control keypad. The discussion follows the grouping given in the Keypads section. The operation of each key is provided along with the dependence that key may have on the presence of a plug-in module. The display associated with each state of the key's operation is shown.

In the diagrams for the display, the character x denotes a digit, and an asterisk (*) denotes an exponential unit (e.g. u for micro-, k for kilo-, M for mega-).

For the menu keys, an overall chart, showing which menu selections have control in each Mode, is given in Table 2-2. An x in the column for a given Mode indicates that the menu selection operates in that Mode. Note that not all Modes and not all menu selections apply to each module (the appropriate module manuals provide details on this).
Table 2-3 gives a list of the menu selections available for the 6040 when used as a stand alone instrument (without a module installed).

Table 1-5. Menu Keys

	MODE Menu			
	Pulse	**Impulse**	**CW**	**External Modulation**
TRIG Menu				
Single Cycle	x	x		
Internal Trigger (and Rate)	x	x		
External Trigger (and Threshold)	x	x		
External Trigger Slope	x	x		
External Drive (and Threshold)	x			
TIMING Menu				
Delay	x	x		
Width	x			
Single/Double Pulse	x	x		
LEVEL Menu				
Peak	x			
Baseline	x			
CW			x	
External Modulation				x
GPIB/RS-232 Menu	x	x	x	x
IEEE-488 Address	x	x	x	x
Baud Rate	x	x	x	x
Full/Half Duplex	x	x	x	x
Remote Enable/Disable	x	x	x	x

Table 1-6. Menu Keys For Stand Alone Operation

MODE Menu	Pulse
TRIG Menu	Single Cycle Internal Trigger (and Rate) External Trigger (and Threshold) External Trigger Slope
TIMING Menu	Delay Width Single/Double Pulse
LEVEL Menu	(not used)
GPIB/RS-232 Menu	IEEE-488 Address Baud Rate Full/Half Duplex Remote Enable/Disable

OPERATING INFORMATION

Menu Keys

{MODE} Sequences through the Mode menu and determines the type of output waveform produced. The selections are Pulse, Impulse. CW. and External Modulation. These are all module dependent. With no plug-in module. Mode defaults to Pulse.

Pulse Mode provides flat topped pulses from the mainframe outputs (PULSE OUT and ECL OUT) and the module output jacks(s). All of these outputs follow the timing menu settings (adjustable Delay, adjustable pulse Width and Single or Double Pulse). The Level menu controls Peak and Baseline amplitudes for the module output. The mainframe PULSE OUT and ECL OUT output levels are fixed (zero to +5 V and -0.8 V to -1.8 V respectively). The trigger source is selected with the Trigger menu.

External Drive (on the Trigger menu) is available in this Mode for certain high-speed modules. This allows the module to be digitally modulated (in some cases at rates exceeding 100 MHz) via a connector on the front panel of the module. The mainframe's PULSE OUT and ECL OUT are disabled in this slate of operation.

Impulse causes the module to produce a pulse output of a fixed (narrow) width and fixed amplitude. A corresponding pulse (of 5 ns duration) is produced from the mainframe PULSE OUT and ECL OUT jacks. The Delay setting and Single or Double Pulse selection can be made with the Timing menu (Width is inoperative). The Level menu settings have no effect in this Mode. The trigger source is selected with the Trigger menu, but External Drive operation cannot be used. Impulse is not available with all modules.

CW causes the module to put out a continuous steady-state level as set by the CW setting on the Level menu. The Trigger and Timing menus have no effect in this Mode. CW is not available with all modules.

External Modulation allows the output of the plug-in module to be linearly modulated about the level as set by External Modulation on the Level menu. The modulation input is a connector on the front of the plug-in module. In this Mode, the Trigger and Timing menu settings have no effect. This is not available with all modules.

Front Panel Display:

```
< Mode:   Pulse     >
< Mode:  Impulse    >
< Mode:    C.W.     >
< Mode:  Ext Mod    >
```

{TRIG} Sequences through the trigger source and parameter menu. This is used in the Pulse and Impulse Modes.

The selections are Internal Trigger, External Trigger (threshold and slope). External Drive, and Single Cycle. With no plug-in module, this is set to Single Cycle at power-on.

Internal Trigger selects the internal rep-rate generator as the source of triggers for timing cycles and allows the user to set this rate.

External Trigger selects the front panel TRIG IN connector as the source of triggers for liming cycles and allows the setting of the discriminator threshold.

External Trigger Slope selects which edge of a TRIG IN pulse will initiate a timing cycle. This setting is toggled using the {+/-, SGL/DBL} key.

External Drive switches the source of the digital drive from the internal DRIVE waveform (coincident with the mainframe's front panel PULSE OUT) to the module's EXTERNAL DRIVE coaxial connector. This also allows the setting of the module external drive discriminator threshold. In External Drive operation, the module output goes to the Peak level when the External Drive input is above the threshold voltage and returns to the Baseline level when the input is below the threshold. Timing menu settings are ignored and mainframe TRIG OUT, PULSE OUT and ECL OUT jacks are disabled. External Drive is only available with certain plug-in modules.

Single Cycle causes a timing cycle to be generated once every time the EXEC or ENTER key is pressed.

Front Panel Display:

```
<Trg Int:          x.xxx *Hz>
<Trg Ext:          x.xx *V>
<Trigger Slope:    +>          or   <Trigger Slope:- >
<Single Cycle>
<Ext Drv:          x.xx *V>
```

{TIMING} Sequences through the pulse timing parameter menu. This is used in the Pulse and Impulse Modes (but has no effect on External Drive operation). The selections are Delay, Width, and Single/Double Pulse. These are not plug-in module dependent.

Delay controls the time interval from the TRIG OUT pulse to the mainframe (PULSE OUT and ECL OUT) or module outputs. In Single Pulse operation, Delay specifies the interval between the leading edge of the TRIG OUT signal and the leading edge of the output pulse or impulse (plus a fixed delay—see Figure 1-1).

In Double Pulse operation, Delay determines the leading edge separation between the pair of output pulses or impulses as well as the interval between TRIG OUT and the second of the two pulses or impulses.

Width controls the pulse duration of PULSE OUT and ECL OUT (and of the module output) in Pulse mode. In Impulse Mode, the width is fixed and this setting has no effect.

Single Pulse/Double Pulse determines the number of output pulses or impulses produced for each trigger. In Single Pulse operation, one delayed pulse or impulse is generated for each TRIG OUT pulse. In Double Pulse operation, an initial pulse or impulse is produced at zero Delay as well as a delayed pulse or impulse. The selection of Single or Double Pulse is made with the {+/-, SGL/DBL} key, which toggles between the two.

Front Panel Display:

<Delay: x.xxx **s* >
<Width: x.xxx *s >
< Single Pulse > or < Double Pulse >

{LEVEL} Sequences through the Level parameter menu. The selections are Peak, Baseline, CW, and External Modulation. All of these are plug-in module dependent. With no plug-in module these are not available.

Peak Level is used in Pulse Mode. This controls the level of the module output when PULSE OUT is true (or, for External Drive operation, when the EXTERNAL DRIVE input is above the External Drive threshold setting).

Baseline Level is the complement of Peak and is also used in Pulse Mode. It controls the module output level when PULSE OUT is false. For some modules this setting is not adjustable, and Baseline is set to zero.

External Modulation Level determines the level about which the module output is modulated in the External Modulation Mode.

CW Level determines the level of the module output in CW Mode.

Front Panel Display (for an optical plug-in module with 3 digit resolution):

```
< Lv Peak:    x.xx *W >
< Lv Bsln:    x.xx *W >
< Lv ExMd:    x.xx *W >
< Lv C.W.:    x.xx *W >
```

{GPIB/RS-232} Sequences through the GPIB/RS-232 enable and bus parameters. The selections are IEEE-488 Address, Baud Rate, Full/Half Duplex, and Remote Enable/Disable. These are not plug-in module dependent.

IEEE-488 Address determines the listen/talk address of the GPIB This value can be set to any nonconflicting address between 0 and 30.

Baud Rate determines the baud rate for the RS-232. It can be set to 300, 600, 900 or 1200.

Full Duplex/Half Duplex determines whether characters will be echoed back through the RS-232. With Full Duplex, each character sent to the 6040 will be echoed back; for Half Duplex no echoing takes place. The selection of full or half is made with the {+/-, SGL/DBL) key, which toggles between the two.

Remote Enable/Remote Disable determines whether the instrument may be operated through the RS-232 or GPIB interface. Remote Enable allows full control of the unit via RS-232/GPIB. Remote Disable only allows the unit to be queried for parameter and Mode settings. The selection of Enable or Disable is made with the {+/-, SGL/DBL) key, which toggles between the two.

Front Panel Display:

```
<   Remote Enable   >   or   < Remote Disable  >
<   488 Add:  xx    >
<   Bd Rate: xxxx   >
<   Full Duplex     >   or   < Half Duplex  >
```

Memory Keys

These keys allow the storage (retrieval) of a complete panel setting to (from) the "ith" memory in the module. To store (retrieve) a panel setting, press STORE (RECALL) followed by the "ilh" digit. This causes the immediate transfer to (from) memory: the ENTER and EXEC keys are not used to terminate the memory transfer.

{STORE} Allows the storage of the present machine state in one of ten (nonvolatile) memory locations in the module. This is operable only with a plug-in module installed.

Front Panel Display:
< Store Set (0-9): i >
< Stored as Set i >

{RECALL} Allows the retrieval of one of ten previously stored machine stales. This is operable only with a plug-in module installed.

Front Panel Display:
< Recall Set (0-9): i >
< Recalled Set i >

Scan Keys

{▲} Increments the digit that is underlined by the cursor.

{▼} Decrements the digit that is underlined by the cursor.

{◄} Moves the cursor one digit to the left. If the cursor is at the most significant digit, the value will be multiplied by ten.

{►} Moves the cursor one digit to the right. If the cursor is at the least significant digit, the value will be divided by ten.

Function Keys

{A}, {B}, {C} These keys are reserved for use with future modules.

Front Panel Display:
< Function A >
< Function B >
< Function C >

Miscellaneous Keys

{UNITS} Used to select between parameter display units. This is plug-in module dependent.

{LOCAL} Returns control to front panel from either GPIB or RS-232 remote operation. This is not plug-in module dependent.

Front Panel Display:
< LOCAL >

Note: *This display appears only on the return to local from remote operation.*

Also, under GPIB operation, the bus command LLO can disable this key.

Numeric Key Descriptions

The following is a detailed description of each key on the numeric keypad.

{0}...{9} The digits zero through nine.

{.} The decimal point.

{+/-, SGL/DBL} Changes the sign of a parameter entered using the digit keys (or of an exponent when pressed after the {10^x} key). This key is also used to toggle between positive and negative Trigger Slope, between Single or Double Pulse, between Full or Half Duplex and between Remote Enable and Remote Disable (when the appropriate menu selection appears on the display).

{10^x} The exponent key. Digits entered after UO*} has been pressed will be exponents of ten.

{BK SPC} Deletes the last digit entered and moves the cursor one position to the left. The backspace key is only active while data entry is taking place with the numeric keypad.

{ENTER} Terminates data entry from the numeric keypad. When used for entering Delay and Width parameters, ENTER leaves the current timing cycle unaffected, but prevents the keyboard from responding to new input until the timing cycle has completed. This key is also used to manually trigger the instrument under Single Cycle operation.

{EXEC} Terminates data entry from the numeric keypad. When used for entering Delay and Width parameters, EXEC turns off pulses for the remainder of the current timing cycle. This key is also used to manually trigger the instrument under Single Cycle operation.

REMOTE PROGRAMMING

Remote programming can be accomplished via either the RS-232 serial interface or the IEEE-488 GPIB. The command sets for the two buses are identical. Commands sent to the 6040 are case sensitive. Multiple commands, which must be separated by blanks or commas, maybe sent in a single transfer. The command string, including blanks, cannot exceed 255 characters. Strings, or single commands, must be terminated with a carriage return. Extra blank spaces are ignored. Error messages, sent back by the 6040 in response to invalid commands or data, are listed in Table 2-4.

In all of the commands listed here, i represents an integer value, f, v, and x may be in integer, floating point, or exponential notation, and c represents an ASCII character string. Optional parameters are enclosed in curly brackets.

In general, if optional parameters are omitted then the current value of those parameters will be sent back (immediately with RS-232 or upon request with GPIB). Responses sent back from the 6040 (other than error messages) are 20 characters long and correspond to the LCD display that would appear under manual operation. They are terminated with a carriage return. With GPIB programming, EOI is asserted with the carriage return.

Command errors are reported in the Error Status Byte. The controller should verify that the Error Status Byte is zero after each command string is sent: a zero value indicates no errors have been detected.

Table 1-7. GPIB/RS-232 Error Messages

Primary PCC	Error Message	Meaning
XX	"Invalid Command"	Primary PCC not recognized.
MO	"Invalid Mode"	Mode not available for the module type, or secondary PCC not recognized.
TR	"Invalid Trigger Command or Data" "Invalid Module Command" Trigger Range Error"	Secondary PCC or data not recognized. Trigger choice not available for the module type. Invalid trigger value.
TI	"Invalid Timing Command or Data" "Invalid Module Command" "Timing Range Error"	Secondary PCC or data not recognized. Timing choice not available for the module type. Invalid timing value.
LV	"Invalid Level Command or Data" "Invalid Module Command" "Level Range Error"	Secondary PCC or data not recognized. Level choice not available for the module type. Invalid level value
RE, ST	"Memory Range Error" "No Memory Present"	Invalid or unrecognized memory number, No plug-in module installed.
DS	"Invalid Display Command"	Secondary PCC not recognized.

The transfer from mainframe memory into hardware of a new parameter can be suppressed by following the value with a semicolon. This can be used for loading an entire front panel state into mainframe memory and saving it in module memory, without disrupting the current hardware settings. As an example, the string **TR IN 1E3** sets the rep rate generator to 1.000 kHz, whereas the string **TR IN 1E3;** does not affect the current setting of the repetition rate.

Initial Bus Parameter Selection

The {GPIB/RS-232} menu key has a number of items that affect the GPIB and RS-232 operation.

The Remote Enable/Disable setting determines whether full remote control is allowed. To allow remote control, select Remote Enable. To prevent remote control, select Remote Disable. In both cases, the instrument can be queried for parameter settings and the Mode setting.

Specific to the RS-232 are the Baud Rate and the Full/Half Duplex setting. These can be set according to the user's needs. Note that Cntrl-Z (ASCII 26) must be received by the 6040 to enable RS-232 operation. Cntrl-C (ASCII 3) disables RS-232 operation.

For GPIB operation, the IEEE-488 Address (listen/talk) should be set to a unique address so that no bus conflicts arise.

Command Set

The commands are grouped into four sets: status, panel control, display, and supplemental control commands. The panel control commands have counterparts in the keypad commands used during front panel programming. The other commands are unique to remote operation.

Status Commands

The status commands are used to query the status of command transactions, and the state of the mainframe and plug-in module.

ES Error Status. This returns a single byte that flags any errors that have occurred since the previous **ES** command. All bits are set to zero following this instruction. The bit definitions are as follows.

Error Status Byte:

Bit	**Description**
7	Always zero
6	Always zero
5	Always zero
4	Always zero
3	Always zero
2	Always zero
1	Overrange
0	Unrecognized command

Bits 2-7: These bits are always zero and are reserved for future use.

Bit 1: This is set if a parameter was set to a value outside its allowable boundary. For example, if the command **TR** IN -5 is sent (set internal rep-rate generator for -5 Hz), the value would be discarded and bit 1 would be set.

Bit 0: This bit is set if the command is unrecognized.

IS Instrument Status. This returns the instrument status byte.

Instrument Status Byte:

Bit	**Description**
7	Always zero
6	Always zero
5	Always zero
4	Always zero
3	External Trigger has been recognized
2	Overlap
1	PLL out of lock
0	Timing cycle in progress

Bits 4-7: These bits are always zero and are reserved for future use.

Bit 3: This bit is set if a trigger has occurred that generated a timing cycle.

Bit 2: This bit is set if a trigger has occurred and no timing cycle has been generated.

Bit 1: This bit is set if the PLL for the internal rep rate generator is unlocked.

Bit 0: This bit is set if a timing cycle is in progress.

PS Module Status. This returns the module status byte, which is module dependent. For definitions, refer to the module's manual.

Panel Control Comands (PCCs)

In the Front Panel Programming description, there are a group of keys denoted as menu keys. They have associated with them a sequence of menu items that allow the user to select a particular Mode or state of operation or to modify a specific parameter. The panel control commands (PCCs) are set up in a similar fashion, except that sequencing is replaced by a second PCC that selects the specific menu item.

Each front panel menu key has a corresponding PCC. These are the primary PCCs. Each of these primary PCCs is used in conjunction with a set of secondary PCCs to select a specific sequenced menu item. There are roughly the same number of secondary PCCs for a given primary PCC as there are menu items associated with a similar menu key. This allows the direct selection of Mode, operating state or parameter via a two instruction command string. Finally, if a parameter is associated with the primary-secondary PCC command string, the desired value can be appended to the command string, or, if no value is appended, the present value of the parameter can be read back by the controller.

The general format for a command string is:

primary PCC {secondary PCC (value x)} , where x is either an integer or floating point value.

There are four primary PCCs, equivalent to the menu keys MODE. TRIG, TIMING, and LEVEL. These are described in the following. The GPIB/RS-232 key cannot be controlled remotely.

MO {PCC} Mode Control, where the secondary PCC is one of the following:

PL	Pulse
IM	Impulse
CW	CW
EM	External Modulation

If the secondary PCC is omitted, the current Mode setting will be returned. For example, sending the string **MO PL** would set the operating mode to Pulse operation. If the string **MO** were subsequently sent, the 20 character string "Mode: Pulse" would be returned.

TR PCC {x} Trigger Control, where the secondary PCC is one of the following:

ED {v}	External Drive (threshold set for v volts)
EP	External Trigger Slope, positive
EN	External Trigger Slope, negative
ET {v}	External Trigger {threshold set for v volts}
IN {f}	Internal Trigger {rep rate set to f Hertz}
SC	Single Cycle

If the value {x} is omitted, the current value is returned. If the string **TR IN 1E3** were sent, the internal rep-rate generator would be set for a frequency of 1.000 kHz. A subsequent string **TR IN** would cause the return of the 20 character string Trg Int: 1.000 kHz."

Once Single Cycle operation has been selected, the 6040 can be triggered with the EX command (see the Supplemental Control Commands section).

TI PCC {x} Timing Control, where the secondary PCC is one of the following:

DL {t}	Delay {set for t seconds}
WD {t}	Width {set for t seconds)
SP	Single Pulse
DP	Double Pulse

Width and Delay commands terminate the current liming cycle when received by the 6040 (just as the EXEC key does under manual operation).

If the value {x} is omitted, the current value is returned. If the siring **TI WD 1.23E-3** were sent, the delay would be set for 1.2300 ms. A subsequent string **TI DL** would cause the return of the 20 character siring "Width 1.2300 ms."

LV PCC {x} Level Control, where the secondary PCC is one of the following:

AV {x}	CW level {set for x units}
BL {x}	Baseline level {set for x units)
EM {x}	External Modulation level {set for x units)
PK {x}	Peak level {set for x units}

If the value (x) is omitted, ihe currenl value is relumed. If ihe siring **LV PK 1.23E-3** were sent, the peak level would be set to 1.23 mW (for an optical module). A subsequent siring **LV PK** would cause the return of the 20 character string "Lv Peak: 1.23 mW." The unit used is dependent on the module.

There are no secondary PCCs used with the mention' commands. The formal is simple, the memory PCC followed by a single integer.

RE i Recall the panel settings from the "ith" memory, where ***i*** is an integer between and including 0 and 9.

The string **RE 2** would recall the panel settings in memory 2.

ST i Store the present panel settings in the "ith" memory, where ***i*** is an integer, between and including 0 and 9.

The string **ST 2** would store the instrument setting in memory 2.

The following commands control the function keys (reserved for future use).

FA Execute function key A.

FB Execute function key B.

FC Execute function key C.

The last four PCCs operate identically to the four scan keys ({◄}, {►}, {▲}, {▼}). When followed by an integer **i** the commands are equivalent to pressing the corresponding scan key i times.

LF {i} Move the cursor one digit (or i digits) to the left.

RT {i} Move the cursor one digit (or i digits) to the right.

UP {i} Increment (i times) the digit at the cursor.

DN {i} Decrement (i times) the digit at the cursor.

Display Commands

The display commands allow the user to control the LCD readout from the GPIB/RS-232 bus. They have no other effect on the operation of the 6040.

DS ON This command causes the response from the 6040 to a parameter query to be displayed on the LCD.

DS OFF This returns the instrument to the default stale, in which queried parameters are not displayed on the LCD. The 6040 is always in this state following power up.

DS ST c Displays the string **c** on the LCD, where c consists of up to 20 ASCII characters.

Supplemental Control Commands

These commands provide additional methods for controlling the instrument. They do not directly correspond to the keys on the 6040 front panel.

CL Clear Instrument. This command recalls the settings in module memory zero if a module is installed (equivalent to **RE O**). With no module installed, the mainframe is set for Single Cycle triggering (and no other parameters are changed).

; The semicolon is used to suppress the loading of parameters into hardware. When added to the end of a panel control command, that command is temporarily stored in mainframe memory (not to be confused with the module memory accessed by STORE and RECALL), but not put into effect.

The command can be activated later in a number of ways. It can be activated by immediately following it with an **EX** command or by querying that menu item some time later and then immediately following that with **EX.** For example, either the sequence **TR IN 1234; EX or TR IN 1234;...**[other commands]...**TR IN EX** will put 1.234 kHz Internal Triggering into effect. Additionally, a complete set of instrument parameter can be held in mainframe memory using ; repeatedly. These could be activated in hardware as a group with the **RL** command or they could be stored in module memory (using the **ST i** command) and recalled as a group when needed (using **RE i**).

EX Execute. This command activates parameters into hardware and initiates Single Cycle triggers. Under Single Cycle operation. **EX** triggers the instrument, causing the pulse of specified Width and Delay to be produced. If the most recent command received by the 6040 was a parameter query (a panel control command with the argument omitted) or a command terminated by a semicolon (to load into temporary memory but not activate a parameter), then EX activates the menu parameter just queried about or the parameter just loaded into memory. (In this case, if the instrument is in Single Cycle operation, a trigger is not produced.) For example, both the command sequences **TR IN EX** and **TR IN 2E3; EX** select Internal Trigger operation. The second also changes the rep rate to 2 kHz.

RL Reload. The RL command loads the complete set of instrument parameters from temporary mainframe memory into hardware (see **;**).

SECTION 3

THEORY OF OPERATION

General

PULSE GENERATOR

Figure 3-1 shows a simplified block diagram of the timing circuits. There are four main functional groupings: Rep-Rate Generator. External Trigger Circuit, Delay Circuit and Width Circuit. A high speed multiplexer selects either the output of the External Trigger Circuit or one of frequencies available from the Rep Rate Generator. The selected signal generates a TRIG OUT pulse and triggers the Delay and width are digitally programmable with 1 ns resolution. The entire signal path from either circuits involves approximately 20 IC gates. Excellent time coherence (-25 ps rms) is advanced through careful layout and the use of high speed ECL devices.

The top rows of blocks represent a frequency synthesizer employing a phase locked loop (PLL) to insure that crystal accuracy is maintained for all rep rates. The dashes (blocks) indicate CMOS counters that are located on the Microprocessor board. By programming the 16-bit divides in the PLL feedback path as well as the 4-bit and two 16-bit dividers outside the loop, all of the required frequencies are obtained.

When the external Trigger Circuit is used, the multiplexer sselects the line from the fast comparator. The x2 attenuator at the input provides a wideband low VSWR termination for the external triggers. An 8-bit DAC plus a polarity bit provides 0.2% resolution (20 mV/step) for the trigger threshold level. When solid triggering occurs, an LED indicator lights.

The two remaining circuits (Delay and Width) are essentially identical. An input pulse starts a 100 MHz oscillator running. The 4-bit (÷16) counter begins to count the oscillator pulses. When the programmed Width is reached, the trailing edge of the (previously started) output pulse returns to ground and the entire cycle can be repeated almost immediately. DRIVE, an ECL version of the PULSE OUT output is sent to the plug-in module.

SOFTWARE AND MICROPROCESOR

The model 6040 is based on the Intel 80C31 family of microprocessors (see Figure 3-2). This microprocessor, optimized for imbedded controller applications such as the BNC 6040, is very efficient at bit control, has a built-in serial I/O and baud rate control, and supports a six-level interrupt system.

Programs developed for the 6040 are written in the C language using a cross-assembler. Some low level routines are coded in assembly for speed and efficiency.

The software has a timer interrupt for the keypad interface, as well as interrupt driven GPIB and RS-232 routines. The timer interrupt occurs at intervals of 50ms. This allows optimal keypad detection while minimizing interruptions of other software tasks.

THEORY OF OPERATION

When power is first applied the software determines if a plug-in module is present and configures the front panel user interface as necessary. This includes enabling or disabling the selection of certain parameters. Modes, and Timing States, and the limiting of parameters to boundaries as specified by the module.

The microprocessor has 64K bytes of code memory, and a separate 64 K bytes of data memory. Code is accessed when the CODE SELECT line (PSEN) is asserted. In the 6040, the hardware control is realized by “memory mapping” the interface ICs into the data memory space.

The microprocessor is mapped into 8K bytes of RAM which is used for temporary values and the stack.

The module is mapped into 8K bytes of memory. There is a special bus interface designed to minimize bus induced noise in the module.

The CMOS timers are mapped into a 2K byte segment of memory. There are total of four LSI counters, Each having three 16-bit timers, for a total of 12 timers. These are used to augment the range of the ECL circuitry and interface via the 20-pin connector 19.

The ECL I/O is mapped into a 512-byte segment of memory. This allows 32 bits to control circuitry and four bits to monitor the timing hardware. These interface to the timing board via the 40-pin connector, J6.

The front panel control is mapped into a 256-byte segment. This notifies (interrupts) the processor when the 6040 has been addressed (as set by the GPIB key parameter, 488 Add) via the GPIB.

The RS-232 takes advantage of he 80C31’s internal serial port. The processor’s circuitry interrupts the processor when the RS-232 port is active.

CIRCUIT DESCRIPTION

Simplified Interconnection Diagram

This diagram depicts the signal flow between circuit boards in the 6040, as well as inputs and outputs to and from the front panel, rear panel and plug-in module. The printed circuit boards are shown with their assigned number. Such as PCB 6040-1 for the Power Supply Board. The schematic number for each board is also shown.

Timing Board (Schematic 6040-32)

Rep-Rate Generator and External Trigger Circuit (Schematic 6040-32, Sheet 1)

The rep-rate generator schematic consists of Z1, Z2 and Z5, Z8 buffers the signal from Z5 and drives Z14 (a binary divider) and Z15 (a multiplexer). The external trigger circuit also supplies a signal to the multiplexer.

THEORY OF OPERATION

The external trigger circuit consists of Z4, Z7, Z13, Z22 and Q3, Z4 (a DAC) is supplied data from the microprocessor board and with the aid of Z7 sets the input trigger level. Q3 when activated inverts the level polarity. Z13 is a high speed comparator and is used as the input sensing device. Three sections of Z22 are used to select the slope of the incoming signal.

The fourth section of Z22 is used to detect the presence of a successful input trigger. lengthen the pulse (if necessary) and flash the trigger indicator.

Z8-3 is used to lock out a signal from Z15 and thus prevent triggering of the 6040 when required. The upper portion of Z23 is used to shorten (typically 3 ns) any pulse on its clock input for timing purposes. Z30-4 is used to stretch the pulse for use by the CMOS circuits on the microprocessor board.

Delay Circuit (Schematic 6040-32 Sheet 2)

The delay trigger from sheet 1 starts the delay cycle when Z25 is enabled Z25 pin 10 is the trigger input and pin 11 is a disable from the CMOS circuitry that prevents additional triggers while the CMOS circuitry is being loaded with data. The input on pin 9 performs a similar function until coincidence is reached (the end of the delay cycle.)

Z16-15 is a delay line oscillator that runs at 100 MHz and is enabled by Z18-14. When Z18-12 is set by Z25 the oscillator is enabled and supplies clock pulses to Z18-11 and Z6 (a binary counter) until both CMOS and ECL coincidence are present at the same time. When this condition is met there is one more clock pulse which loads the counter returns Z18 to its original state and disables the oscillator.

Z25-7 is used to proved two signals: one to the TRIG OUT amplifies and the other to the width circuit at the beginning of delay in the Double pulse mode only. The Z18-14 output in addition to controlling the oscillator, also provides a signal to the 1 ns delay circuit (Z9 and Z17). Z17 determines the 0 to 1 ns increments.

Z9 determines the 2, 4, 6 or 8 ns delay as selected by Z10. The output of Z10 buffered and inverted by Z17-15 and the trailing edge of the delay pulse is detected by Z18-6 which then generates a short pulse (3 ns typical). This pulse is the trigger for the width circuit. Z27 is used to detect the presence of a trigger during a cycle and fire the overlap indicator via the microprocessor

Width Circuit (Schematic 6040-32, Sheet 3)

The width trigger is inverted by Z26 (when enabled) and sets Z28 starting the width timing cycle Z26-10 disables the gate when data is being loaded into the CMOS circuits. Z26-11 disables the gate when a trigger signal sets Z28 and prevents the acceptance of any additional triggers until the width timing cycle is completed.

When set by the trigger the Z28-3 output enables the 100 MHz delay line oscillator (Z31-15). The output of Z31 drives both Z28 and Z32 (a binary counter) with clock pulses. The carry output of Z32 supplies the CMOS circuits with clock pulses via Z29-2 and Z11-13. Z32 continues to count until both CMOS and ECL coincidence is reached. The next clock pulse returns Z28 to its original state. In addition this extra clock pulse reloads data into Z32.

THEORY OF OPERATION

At the start of the width timing cycle Z6-15 transmits a rising edge to the clock input of Z28 via DL2. This initiates the width output. The electrical length of DL2 is equivalent to the sum of the propagation time through Z19, Z20, Z21 and Z29 when the data set in the 1 ns decade is zero. At the end of the width timing cycle. Z26 transmits this edge through the 1 ns circuits (Z29 and Z20) the multiplexer (Z21) and the pulse shaper (Z29-14) to Z28-12 to end the width cycle. The outputs of Z28 supply both the plug-in and the output amplifier with a width signal.

Microprocessor Board (Schematic 6040-33)

CPU and Interface (Schematic 6040-33, Sheet 1)

Z8, is an Intel 80C31 Microprocessor. Since it has no internal program memory, all program memory is contained in an external EPROM. The output of Zll, a 10 MHz crystal oscillator (described later), is buffered by Z13C and drives Z8-19. It also drives the CMOS counter circuits.

Port 0 on Z8 is used as both a bidirectional data bus and lower bit address latch control. The bidirectional data buffer Z14, points away from the microprocessor except during a data or I/O read.

Port 0 is also connected to Z15. an 8-bit latch used for demultiplexing AD0-AD7. The lower eight bits of the address are always placed on the bus during the first portion of an external memory read or write cycle. Latching of the address bits occurs when ALE (Address Latch Enable) on Z8-30 (on its trailing edge) goes from high to low. Also during this first cycle A8-A15 are presented to an output buffer for the upper eight address lines.

External 4.7 k pull-up resistors are required on the PO port. Note that the buffered DATA bus actually contains the both the multiplexed address and data information though only the data is recovered by other chips on the logic board. The special "quiet bus", however, re-decodes the multiplexed address/data bus. This is discussed in greater detail in the Module Interface description (sheet 9).

An internal serial port for communication to a three-wire DCE device is provided via the CMOS to RS-232C translation devices. Z3 and Z5 are the RS-232C bus driver and receiver. Note that Z3 is the only device requiring -12 V and +12 V. This is necessary to produce the proper voltage swing for the RS-232C standard. Baud rates of 300-1200 are supported, and data is fixed at eight bits, no parity.

Bus and External Memory Control Lines:

Memory is divided into two sections identified as Code and Data. Hardware I/O is mapped in the Data space.

Code (program memory as opposed to data memory) is read by the microcomputer when PSEN*, Z8-29, goes low (true). This signal, combined with A0-A15, allows 2^{16} or 65,536 directly addressable program memory locations. Program memory is stored in Z17 (sheet 2).

Data (Read/Write memory or RAM) is read and latched by the microprocessor when RD*, Z8-17, goes from low (true) to high (false). While the microprocessor can theoretically address 65,536 data spaces, only 8192 locations (8K) are used for the RAM. I/O (hardware used to control or sense the 6040) is also mapped into the Data space. This includes the module and timing board control circuits.

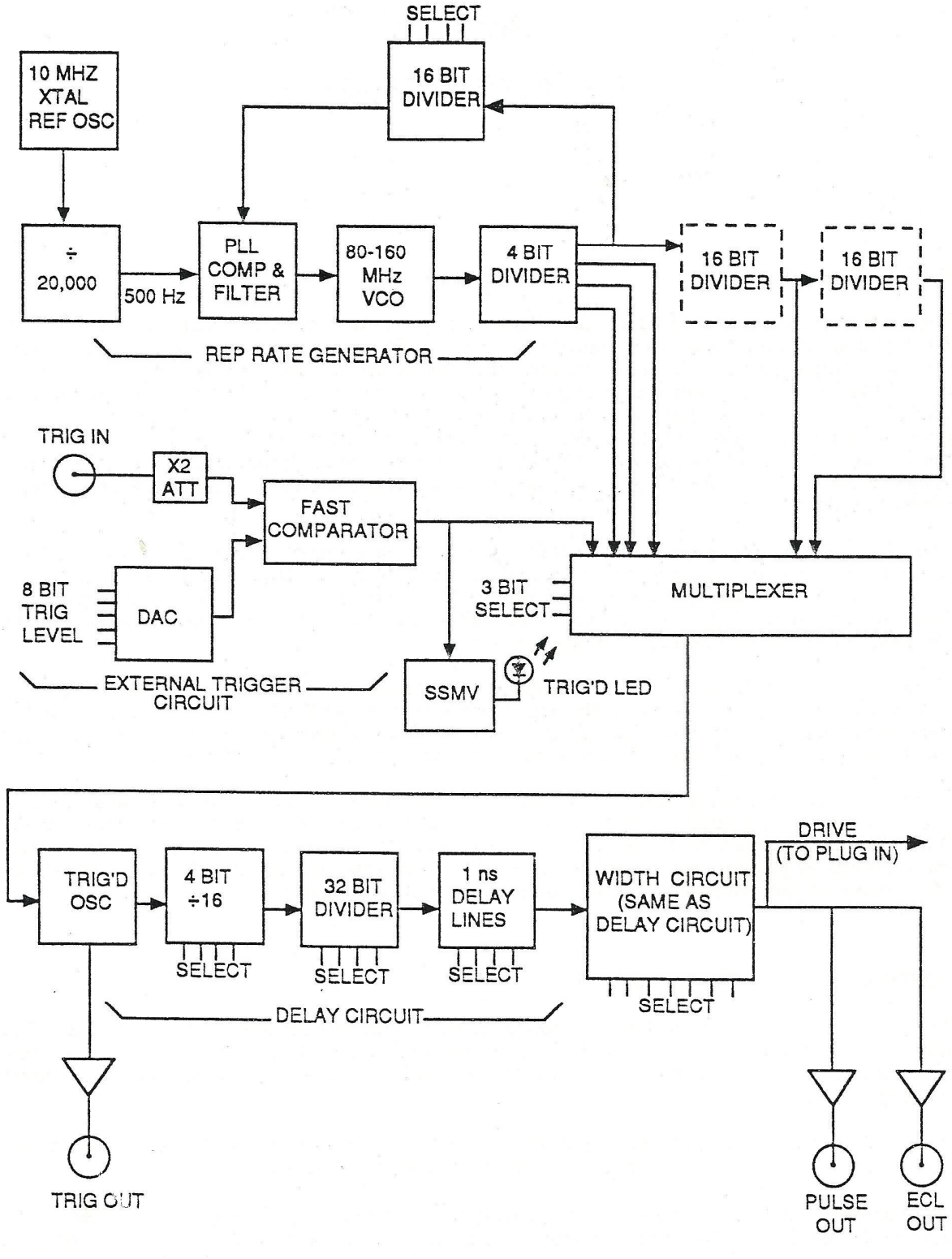


Figure 3-1. 6040 Timing Circuits

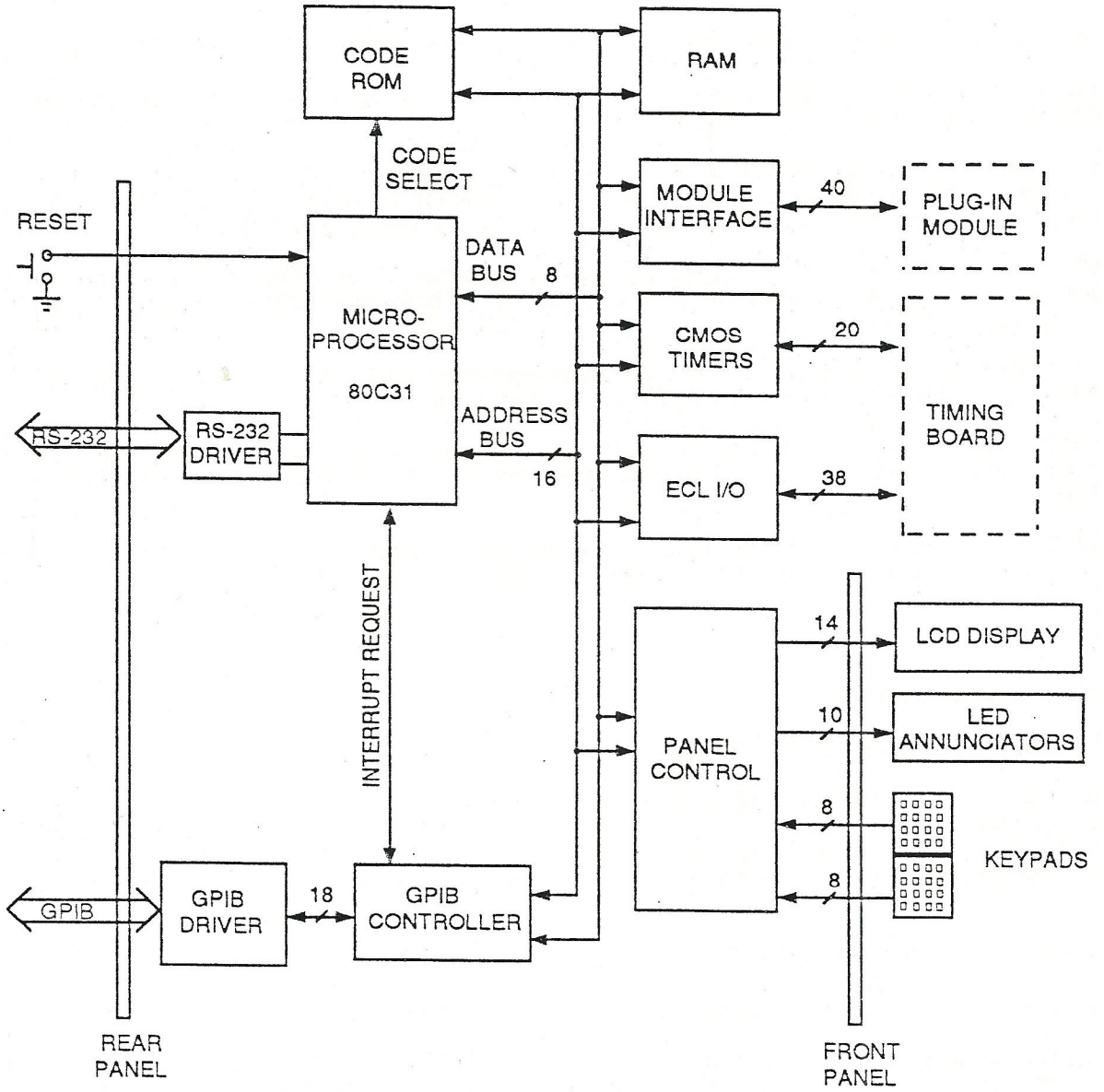


Figure 3-2. Microprocessor Block Diagram

THEORY OF OPERATION

Memory and I/O Decoding (Schematic 6040-33, Sheet 2)

Program Memory – ROM:

Z.17, the EPROM, encompasses the full 64K code space. During a program code fetch instruction, PSEN* will cause the internal output buffer of the EPROM to be placed on the data bus. The internal output buffer is enabled when OE*, Z17-22, goes low (at the same time Z14 will momentarily point inward, permitting the data to be transferred into the microprocessor).
RAM and Memory Mapped I/O:

Z25, a decoder, divides the 64K data memory space into eighi 8K seclions. YO selects the RAM (Z24), Y6 selects the plug-in module, and Y7 selects the 8K allotted for other memory mapped hardware I/O.

Data Memory – RAM:

Read/write data memory or RAM is stored in Z24. a 6264 8K by 8 static RAM. It contains the current operating parameters and other software variables.

Timer and I/O Decoding (Schematic 6040-33, Sheet 3)

Hardware I/O Data Space:

I/O control, selected by Z25-7 (sheet 2), is realized by mapping all hardware into the memory space EOOO to FFFF. Selections of specific hardware within this area (such as the 82C54 timers and 82C55 parallel I/O chips) is done by Z35, another decoder.

The first four chip selects (CSO-CS3) go to the 82C54 timers. CS4 selects Z33 (front panel control), CS5 and CS6 select the ECL timing board interface, and CS7 selects the GPIB interface.

CMOS Counters:

The four 82C54 counter timer chips (Z16, Z20. Z23, Z27) each contain three 16-bit timers that can generate four independent time delays. The logic connected to the clocks, gales and outputs of these 12 timers are shown on schematic sheets 6, 7, and 10. Sheet 3 shows only the microprocessor interfacing.

Front Panel Interface (Schematic 6040-33, Sheet 4)

Z33 is an 82C55 Parallel Peripheral Interface device with three programmable 8-bit input/output ports. Z33 is selected by CS4 from Z13 (on sheet 3).

Keypad Decoding:

Port A outputs the keyboard scan pattern to the two 4-bit wide columns in the keypad matrix. The four rows on the 8x4 keypad map are input on the lower four bits on port C. Key decoding works as follows.

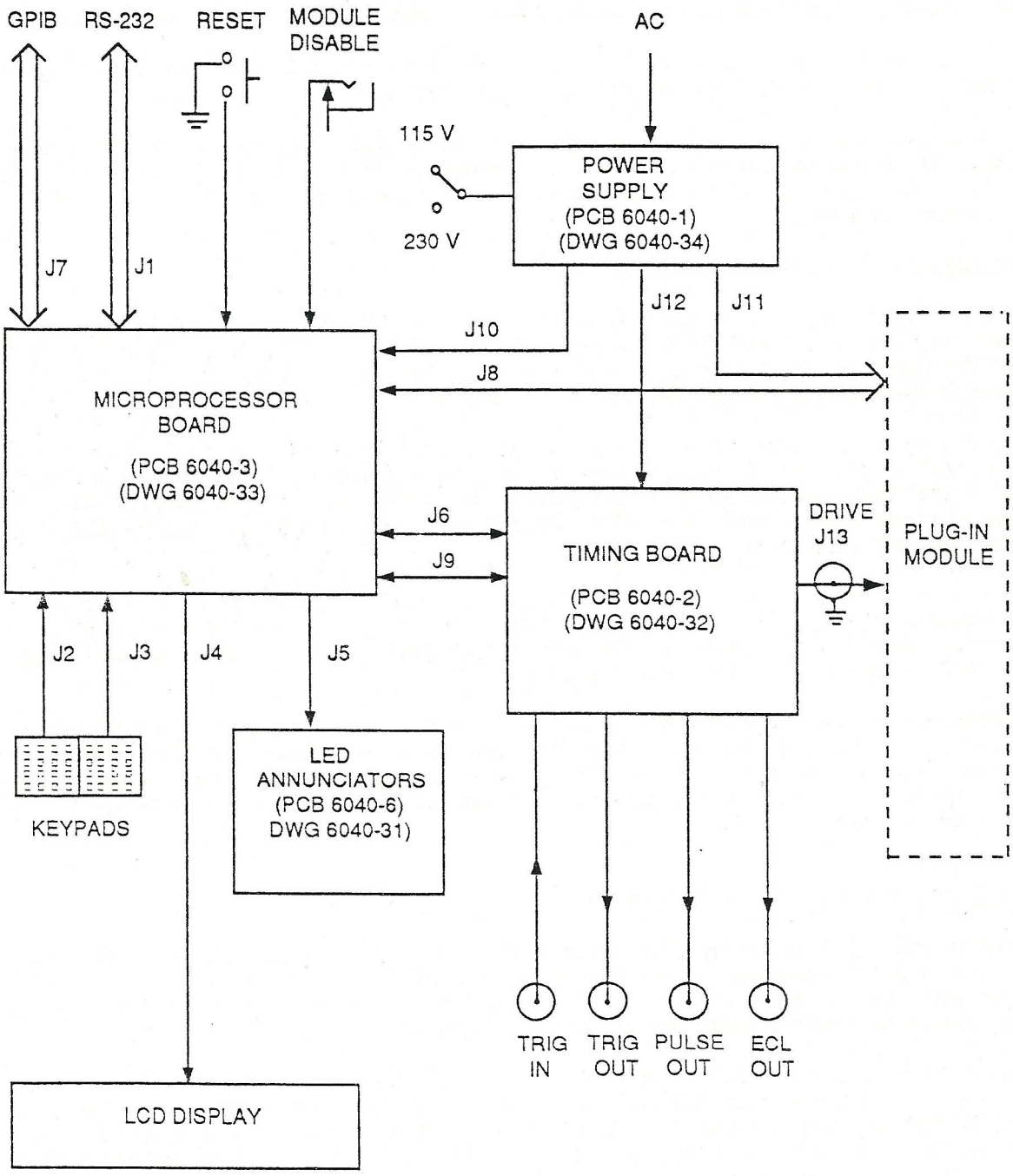


Figure 3-3. Simplified Interconnection Diagram

Software normally sets port A to all zeroes. During the primary 50 ms operating system timer tick interrupt, the lower half of port C is tested to see if any bits are low. A bit will be low if any key is pressed because the 4.7 k row resistor is pulled low by a connection through the keypad switch. Once a key is pressed, software selectively scans through the columns one by one testing until the unique combination of a row and column is identified.

LED and LCD Display Interface:

Port B of Z33 is connected to both the data bus of the LCD display and Z30 an octal latch and port driver for the eight LEDs. Strobing of data to control the LEDs is accomplished by bit 4 on Port C. Strobing of data to control the LCD is by strobing bits 5. 6. and 7 of this same port.

ECL Interface (Schematic 6040-33, Sheet 5)

The microprocessor uses a pair of 82C55 Programmable Peripheral Interfaces (PPIs) to control the timing board (PCB 6040-2). The PPIs, Z19 and Z22, control the timing board via the 40-pin connector J6. Each PPI has three I/O ports which are one byte wide. All of the ports are for output control except Z22, port C's lower four bits.

Z19 controls the 1 ns and 10 ns timing decades. Port A controls the delay, while port B controls the width. Port C is used for resetting the CMOS counters and to reset the overlap detector on the timing board.

Z22 controls the trigger circuits, enables the CMOS Timing counters, and monitors the status of hardware on the Timing board. Port A has the SEL A,B, and C lines, that are used in the rep-rate generator. FRQEN, RALMT, and DBLPLS enable the trigger generator, the rate limit circuitry, and allow double pulses. TRGSL and TRGPOL determine the slope and polarity for the External Trigger circuitry. Port B sets the External Trigger threshold DAC. The lower four bits of port C allows the microprocessor to monitor when a timing cycle is in progress (DWPROG), if the PLL is out of lock (PLLK), if a timing cycle error has occurred (OVRLAP). and if an external trigger has been recognized by the discriminator (TGR'D). Port C's upper four bits is used to enable the CMOS timing count chain.

CMOS Delay Circuit (Schematic 6040-33. Sheet 6)

This circuit augments the high speed ECL delay circuitry. It extends the delay from 159 ns to more than 100 s. This is done by utilizing a single LSI counter and four SSI ICs.
Z16 contains three user configurable 16-bit counters, configured as two programable counters and a fixed prescaler. The CMOS count can be up to four bytes wide. The Z16-A counter is loaded with two least significant bytes and is clocked from the DTTLCK signal, at a frequency of 6.25 MHz (a period of 160 ns).

The Z16-B counter is loaded with the remaining two high order bytes and is clocked by the output of the prescaler, Z16-C. The prescaler devides the 6.25 MHz DTTLCK signal by 65536 (2 to the 16) producing a frequency of 95.367 Hz.

THEORY OF OPERATION

The presettable counters, Z16-A and Z16-B, are enabled by the signals, DCNT24 and DCNT220, respectively. These come from port C of the PPI Z22. They are set by the microprocessor according to the Delay setting.

The LDCLK signal is used when the counters are loaded with a new value. This comes from port C of the PPI, Z22.

The DHLDOFF signal is used to prevent the ECL delay circuitry from initiating a new delay cycle during the reloading of Z16 at the end of a delay cycle.

The DTTLEN signal allows the ECL circuitry to generate the DTTLCK signal.

The DTTLCOIN signal indicates that the CMOS count chain has reached 0 (counted down).
CMOS Width Circuit (Schematic 6040-33, Sheet 7)

The width counter circuitry is essentially identical to the description of the delay counters.

The CMOS width circuit is similar to the delay circuit. In the width circuitry Z20 is the LSI counter, and signals that began with a 'D' begin with a ‘W’.
Z20 is a 82C54 that contains three user configurable 16-bit counters. These are configured as two programable counters, and a fixed prescaler. The CMOS count can be up to four bytes wide. The Z20-A counter is loaded with two least significant bytes and is clocked from the WTTLCK signal, at a frequency of 6.25 MHz (a period of 160 ns).

The Z20-B counter is loaded with the remaining two high order bytes and is clocked by the output of the prescaler Z20-C. The prescaler divides the 6.25 MHz WTTLCK signal by 65536
(2^{16}) producing a frequency of 95.367 Hz.

The presettable counters, Z20-A and Z20-B, are enabled by the signals, WCNT24 and WCNT220. respectively. These come from port C of the PPI Z22 and are set by the microprocessor according to the Width setting.

The LWCLK signal is used when the counters are loaded with a new value from port C of the PPI Z22.

The WHLWOFF signal is used to prevent the ECL width circuitry from initiating a new width cycle during the reloading of Z20 at the end of a width cycle.

The WTTLEN signal allows the ECL circuitry to generate the WTTLCK signal.

The WTTLCOIN signal indicates that the CMOS count chain has reached 0 (counted down).

GPIB Interface (Schematic 6040-33, Sheet 8)

Z35's CS7 (chip select 7) enters Z4 on pin 3 and in conjunction with AO-A3 select internal registers on the TMS9914 bus controller. The RD* must be inverted to accommodate the unusual positive-true DBIN (data bus in) signal.

Z6 is used to divide the 10 MHz logic board oscillator which is output to Z4's clock input.

Z1 and Z2 are standard 75161 and 75160 interface driver chips normally used with the 9914. They go to the 26-pin connector which in turn is connected to the 24-pin GPIB connector mounted on the back of the 6040.

Module Interface (Schematic 6040-33, Sheet 9)

The quiet bus, J8, is a specially designed bus to minimize interference caused by normal CPU bus noise. J8 provides the communication path to the plug-in modules. (See Table 3-1.)

The microprocessor controls the plug-in module via the 40-pin connector, J8. There are four interface control lines QRD, QWR, QALE, PLUGIN. QRD and QWR are used to control the direction of data (read from or write to the module). QALE is used for demultiplexing the QAD multiplexed data/address lines. PLUGIN enables the module data transaction.

The data/address bus consists of five address lines and eight multiplexed data/address lines. This allows an access of 8K bytes of memory or I/O in the module.

The power for the module is also supplied via J8, but the cable is cut and fitted with a second 16-pin DIP connector which is routed to the power supply (PCB 6040-1).

PLL and Rate Limiter (Schematic 6040-33, Sheet 10)
The 20-pin connector, J9, is used for all dynamic signals between the microprocessor board (PCB 6040-3) and the timing board (PCB 6040-2). (See Table 3-2.)

Table 1-8. J8, Microprocessor to Module Interface Signals

Signal(s)	Pin Number	Description
QAD0-QAD7	8-1	8 multiplexed data/address lines
QA8-QA12	16-12	5 address lines
QRD	11	Module read
QWR	10	Module write
QALE	9	Address Latch Enable (demux QAD0-QAD07)
PLUGIN	18	Enables Module interface circuits
RESET	17	System reset
MOD DIS	19	Disables Module
+5	26, 28	+5 V supply
-5.2 V	34, 36	-5.2 V supply
+12 V	37, 39	12 V supply
-12 v	38, 40	-12 V supply
THE	27	+3 V supply
GND	35, 29-33	Ground
	20-25	Unused

PLL Synthesizer:

The 6040's internal trigger generator is made of two subsections. The VCO. loop fillers, and range selection circuits are located on the timing board (PCB 6040-2). The 82C54 CMOS dividers are located on the microprocessor board (PCB 6040-3).

Table 1-9. J9, Microprocessor to ECL Interface Signals

Signal	Pin Number	Description
PLLVAR	14	PLL variable frequency
FTTL1	16	Output of first CMOS frequency divider
FTTL2	17	Output of second CMOS frequency divider
PLLIN	15	VCO input
PLLREF	20	PLL reference frequency
RTLMTTR	19	Rate Limit trigger
RLMTHD	18	Rate Limit Hold signal
ELDCLK	1	ECL Timing count chain, load clock
ELDEN	3	ECL Timing count chain, enable load
DTTLCK	7	Delay time base
DHLDOFF	9	Disables triggering of ECL Delay
DTTLEN	4	Enables ECL Delay to generate DTTLCK
DTTLCOIN	10	CMOS Delay count is at zero
WTTLCK	5	Width time base
WHLWOFF	6	Disables triggering of ECL Width
WTTLEN	2	Enables ECL Width to generate WTTLCK
WTTLCOIN	8	CMOS Width count is at zero
	11, 12, 13	Unused

The VCO is operated over the frequency range of 80 to 160 MHz. This is divided by 16 and level shifted to produce the signal PLLIN (a CMOS signal with a frequency between 5 and 10 MHz). The PLLIN feeds two counters, Z23-A and Z23-B. Z23-A generates the PLLVAR signal. Z23-B produces the FTTL1 signal and also clocks Z23-C, which generates the FTTL2 signal. The counter Z27-A, is clocked from the 10 MHz crystal oscillator, and produces the PLLREF signal, a fixed frequency of 500 Hz. This is used by the PLL for the reference frequency, and the PLL adjusts the VCO to force the PLLVAR signal to the same frequency.

Rate Limit:

Z27-B is used to prevent external triggering above certain frequencies. The counter is triggered by the signal RTLMTTR, and triggers are ignored until the output RLMTHD returns low. This is used with certain plug-in modules that have upper frequency limits below 100 MHz.

Loading ECL Count Chain:

The signals ELDEN and ELDCLK are used to enable and load new data into the ECL Timing counters, Z6 and Z28, (PCS 6040-3, schematic 6040-32, sheets 2 and 3).

CMOS to ECL Timing Interface signals:

Please refer to the CMOS Width and Delay Circuits for a description of these signals.

Table 1-10. Mainframe Memory Map

Memory Range	Description
CODE:	
0000 – FFFF	64K EPROM, Z17, 27C512
DATA I/O	
0000 – 1FFF	8K RAM, Z24, 6264
C000 – DFFF	Plug-In Module (see module manual)
E800 – EFFF	Memory Mapped I/O
E800 – E8FF	Z16, 82C54; DELAY
E800	LSW Counter
E801	MSW Counter
E802	Prescaler
E803	Control Register
E900 – E9FF	Z20, 82C54, WIDTH
E900	LSW Counter
E901	MSW Counter
E902	Prescaler
E903	Control Register
EA00 – EAFF	Z23, 82C54, PLL1
EA00	Divides PLLIN to produce PLLVA
EA02	Divides FTTL1 to produce FTTL2
EA03	Control Register
EB00 – EBFF	Z27, 82C54; PLL2, RATE LIMIT
EB00	Divides Crystal to 500.0 Hz PLLREF
EB01	Outputs RLMTHD
EB02	Unused
EB03	Control Register
EC00 – ECFF	Z33, 82C55; FRONT PANEL CONTROL
EC00	Port A, Keypad column scan output
EC01	Port B, LCD and LED data BUS
EC02	Port C, Keypad row scan input
EC03	Control Register
ED00 – EDFF	Z22, 82C55; ECL TRIGGER CONTROL
ED00	Port A, Trigger Control
ED01	Port B, External Trigger DAC
ED02	Port C, Error Input, CMOS Enable
ED03	Control Register
EE00 – EEFF	Z19, 82C55; ECL TIMING CONTROL
EE00	Port A, Delay 1 and 10 ns
EE01	Port B, Width 1 and 10 ns
EE02	Port C, Load Timing
EE03	Control Register
EF00 – EFFF	Z4, TMS9914; IEEE-488 INTERFACE
EF00	Interrupt 0 status/mask
EF01	Interrupt 1 status/mask
EF02	Address Status
EF03	Bus Status / Auxiliary Command
EF04	Address
EF05	Serial Poll
EF06	Command Pass Through / Parallel Poll
EF07	Data In/Out

THEORY OF OPERATION

Power Supply Board (Schematic 6040-34)

There are four regulated voltages generated by the power supply: ±12 V. +5.0 V and -5.2 V. In addition there are three unregulated dc voltages: ±18 V and +3 V. These last three are labeled + UNREG. - UNREG and TEH (used for a thermoelectric heater-cooler).

The operation of the ±12 and +5 V supplies is identical. These are straightforward 1C regulators with internal references. An external voltage divider (such as R5, R6 and R4 in the +5 V supply) permits setting the voltages precisely.

The -12 V and -5.2 V supplies are implemented with an op-amp and a power FET. Their operation is identical except for small details in the reference and voltage sensing, networks. The -5.2 V circuit will be described first.

A sample equal to 50% of the output voltage is applied to Z2-2 by R7 and R11. A reference voltage of 2.6 V relative to the output is applied to Z2-3. The polarities are such that the voltage across R11 is forced to be 2.6 V relative to the output. This requires the output itself to -5.2 V. Q2 senses the current in RIO and provides overcurrent protection.

The -12 V supply operates in a similar manner to the -5.2 V supply. In this case, the entire zener voltage of CR16 (approximately 6.2 volt, relative to the output) is applied to Zl-3. R1 permits adjustment of the sensing voltage divider so that an output of -12 V is obtained.

The transformer primary can be configured for either 117 V ac or 234 V ac operation via S901. S903 is a thermal cutout that opens if the air temperature entering the unit exceeds 50° C.

SECTION 4

MAINTENANCE AND CALIBRATION

CALIBRATION

General

It is recommended that calibration of the 6040 mainframe be verified every 12 months. The instrument should be allowed to warm up for 30 minutes before beginning the calibration procedure.

Equipment Required

- HP Model 5370 Time Interval Counter (referred to in the text as TIC) or equivalent.
- Tektronix Model 485 Oscilloscope (1 ns rise time) or equivalent.
- Low capacity, high bandwidth probe (Tektronix Model 6160A).
- Two high quality 50-ohm coaxial cables approximately 3 feet to 4 feet in length and terminated in BNC connectors on each end.
- 3-1/2 digit (or better) DVM.
- Variable dc voltage source capable of ±3 V into 50 ohms.

PROCEDURE

NOTE: *This calibration should be carried out in the order presented.*

Power Supply

The first step in calibrating the instrument is to check each of the power supply voltages to insure correct setting and minimal ripple. Set the +5 V and -5.2 V supplied to within 0.05 V and the ±12 V supplied to within 0.1 V. The 120 Hz ripple should not exceed 5 mV p-p. There are test points and adjustment potentiometers on the power supply board and each one is labeled with the appropriate voltage. The test points are located in front of the fan.

LCD Contrast

If no characters appear on the LCD display or the contrast is poor, adjust potentiometer R5 on the Microprocessor board (PCB 6040-3). R5 is located near die key switch, under the ribbon cable for the LED annunciator board.

MAINTENANCE AND CALIBRATION

Rep Rate Check

Remove any plug-in module. Connect the TRIG OUT to channel B of the Time Interval Counter (TIC). Select the Internal Trigger parameter with the {TRIG} key. Set the rep rate for 5.000 MHz. Now set the rep rate for 4.999 MHz and check that the frequency is between 4.9990 and 4.9992 MHz.

External Trigger Circuit

The external trigger circuit requires calibration of the DAC (Z4) and its associated amplifier (Z7).

Refer to Schematic 6040-32. The first step measures the attenuation factor (approximately x 2) of the trigger input termination network R78. 79. 80 and 81. Apply approximately 1.9 V dc to the TRIG IN connector and record both this voltage (Vin) and the voltage at Z13-3 (Vs). Calculate Vin/2Vs = A. Record A (typically 0.97-1.03). Disconnect the dc voltage from the instrument.

The next step calibrates the DAC including the actual value of A. With the front panel pushbuttons, set the external trigger level to *+2.5* V. Calculate 1.35 x A - B and record (typically B = 1.35 V). With R4, set the voltage at Z7-7 to equal B. Change the display to -2.5 V and with R7 set Z7-7 to B. This completes the calibration of the external trigger circuit.

Pulse Out Amplifier

As the performance of this unit is in part dependent on the correct adjustment of the PULSE OUT amplifier this should be performed next, as follows.
Set the 6040 to generate pulses at approximately 1 MHz in the Single Pulse setting. Set the Width to 100 ns. Connect a 50-ohm cable between TRIG OUT and the scope EXT TRIG input and also from PULSE OUT to the scope vertical input. Check to be sure that the 50-ohm input impedance (not 1 Meg) is used.

1. Set R17 and R23 at midrange.
2. Observe PULSE OUT and set R17 for minimal ringing and edge distortions.
3. Set R23 for an amplitude of 5 V ±0.2 V.

Delay Oscillator

Connect the TIC (HP 5370) as follows: Start input to TRIG OUT and Stop input to PULSE OUT (both inputs terminated in 50 ohms and both slopes to +). Set the TIC for "TIM" and 100 samples and adjust the trigger levels for best triggering (set attenuator to XI for Start and XI0 for Stop). Set the 6040, using the front panel controls, for internal trigger rate of 90 Hz, a delay of zero and a width of 30 ns. Press the Set Reference button of the TIC. Reset the delay to 10 ms and adjust RIO for 10 ms.

MAINTENANCE AND CALIBRATION

1 ns Delay

Connect the TIC as above. Set the 6040, with the front panel controls, for 30 ns width and 100 ns delay. Press the Set Reference button on the TIC. Cycle through 100 ns plus 2, 4. 6 and 8 ns delay and adjust R6 for best compromise of delays. Next cycle through 100 ns plus 2 versus 3 ns, 100 ns plus 4 versus 5 ns, and 100 ns plus 6 versus 7 ns and adjust C1 for the best 1 ns change compromise.

Width Oscillator

Connect the TIC as follows: Start input to TRIG OUT and Stop input to PULSE OUT (both inputs terminated in 50 ohms, the Start slope to + and the Stop slope to -). Set the TIM for 100 samples and adjust trigger levels for best triggering (set attenuation to X1 for Start and X10 for Stop). Set the 6040, with front panel controls, for a delay of zero and a width of 30 ns. Press the Set Reference button and reset the width to 10 ms. Adjust R25 for a 10 ms reading on the TIC.

1 ns Width

Connect the TIC as in the Width Oscillator procedure. Set the 6040, with front panel controls, for zero delay and 100 ns width. Press the Set Reference button. Cycle through 100 ns plus 2, 4, 6 and 8 ns widths and adjust R11 for the best compromise of delays. Next cycle through 100 ns plus 2 versus 3 ns, 100 ns plus 4 versus 5 ns, and 100 ns plus 6 versus 7 ns and adjust C2 for the best 1 ns change compromise.

10 ns Width

Connect the scope to PULSE OUT and trigger the scope with the TRIG OUT of the 6040. Set the delay and width to zero, using the front panel controls. Adjust C3 for a half amplitude pulse. Reset the width to 10 ns and readjust C3, if necessary, to obtain a 10 ns pulse width.

SECTION 5

PARTS LIST

Abbreviations

CER	Ceramic	**PF**	Picofarad
COMP	COMPOSITION	**SIP**	Single Inline Package
DIP	Dual Inline Package	**TAN**	TANTALUM
ELEC	Eelectrolytic	**UH**	Microhenry
FAC SEL	Value Set at Factory	**UF**	Microfarad
K	Kilohm	**V**	Working Volts
M	Megohm	**VAR**	Variable
MF	Metal Film	**W**	Watts
MIC	Mica	**WW**	Wirewound
MONO	Monolythic Ceramic		

---------- NOTE ----------
*The number in the **second column** is the*
BERKELEY NUCLEONICS re-order number

TIMING BOARD 6040-2

C1	130-001 2-20 PF PC MOUNT	**C24**	**110-033 0.1Mf 20% 50 V CER MONO**
C2	130-001 2-20 PF PC MOUNT	**C25**	**112-015 8 PF 5% 500 V MIC**
C3	130-001 2-20 PF PC MOUNT	**C26**	**NOT USED**
C4	110-019 0.05 µF 25% 25 V CER	**C27**	**112-016 10 PF 5% 600 V MIC**
C5	122-013 3.3 µF 10% 15 V TAN	**C28**	**112-004 100 PF 5% 500 V MIC**
C6	122-013 3.3 µF 10% 15 V TAN	**C29**	**112-021 5PF 5% 500 V MIC**
C7	110-021 0.01 µF 20% 16 V CER	**C30**	**110-033 0.1 µF 20% 50 V CER MONO**
C8	110-011 0.001 µF 10% 1 KV CER	**C31**	**112-016 10 PF 5% 500 V MIC**
C9	110-021 0.001 µF 20% 16 V CER	**C32**	**110-033 0.1 µF 20% 60 V CER MONO**
C10	112-016 10PF 5% 500 V MIC	**C33**	**112-016 8 PF 5% 600 V MIC**
C11	110-033 0.1 µF 20% 50 V CER MONO	**C34**	**112-031 12 PF 5% 500 V MICC35**
C12	112-010 390 PF 5% 600 V MIC	**C35**	**110-033 0.1 µF 20% 50V CER MONO**
C13	110-033 0.1 µF 20% 50 V CER MONO	**C36**	**112-004 100 PF 5% 500 V MIC**
C14	112-016 10 PF 5% 500 V MIC	**C37**	**112-016 10 PF 5% 500 V MIC**
C15	112-004 100 PF 5% 500 V MIC	**C38**	**110-033 0.1 µF 20% 50 V CER MONO**
C16	122-014 33 µF 10% 6 V TAN	**C39**	**110-033 0.1 µF 20% 50 V CER MONO**
C17	112-003 47 PF 5% 500 V MIC	**C40**	**110-033 0.1 µF 20% 50 V CER MONO**
C18	110-033 0.1 µF 20% 50 V CER MONO	**C41**	**110-033 0.1 µF 20% 50 V CER MONO**
C19	112-016 10 PF 5% 500 V MIC	**C42**	**110-033 0.1 µF 20% 50 V CER MONO**
		C43	**110-033 0.1 µF 20% 50 V CER MONO**

PARTS LIST

C20 110-033 0.1 µF 20% 50 V CER MONO
C21 112-018 8 PF 5% 500 V MIC
C22 112-031 12 PF 5% 500 V MIC
C23 110-033 0.1 µF 20% 50 V CER MONO
C47 NOT USED
C48 NOT USED
C49 NOT USED
C50-C87 110-0330.1 µF 20 % 50 V CER MONO

C88 122-014 33 µF 10% 6 V TAN
C89 122-014 33 µF 10% 6 V TAN
C90 122-015 33 µF 10% 25 V TAN
C91 110-033 33 µF 10% 25 V TAN
C92 110-033 0.1 µF 20 % 50 V CER MONO

C93 110-033 0.1 µF 20 % 50 V CER MONO
C94 112-016 10 PF 5% 500 V MICA
C95 112-016 10 PF 5% 500 V MICA
C96 112-019 15 PF 5% 500 V MICA
C97 110-033 0.1 µF 20 % 50 V CER MONO

CR1 411-009 IN3595
CR2 411-009 IN3595
CR3 411-004 1N4152
CR4 411-004 1N4152
CR5 411-004 1N4152

CR6 411-004 1N4152
CR7 417-005 MV1404
CR8 417-005 MV1404
CR9 411-004 1N4152
CR10 411-004 1N4152

CR11 415-004 HP5082-2835
CR12 411-004 1N4152
CR13 415-004 HP5082-2835
CR14 415-004 HP5082-2835
CR15 417-004 MV209

CR16 411-004 1N4152
CR17 411-004 1N4152
CR18 415-004 HP5082-2835
CR19 415-004 HP5082-2835
CR20 417-004 MV209

CR21 411-004 1N4152
CR22 412-017 1N4100
CR23 412-017 1N4100
CR24 410-003 1N4005

Q1 430-026 MP53640
Q2 430-026 MP53640
Q3 431-006 SD210

C44 110-019 0.05 µF 220% 25 VCERMONO
C45 112-004 100 PF 5% 500 V MIC
C46 110-033 0.1 µF 20 % 50 V CER MONO
Q11 430-049 2N5583
Q12 430-027 MPS3646
Q13 430-025 2N5179

Q14 430-025 2N5179
Q15 430-049 2N5583
Q16 430-049 2N5583

R1 223-010 1K×5 SIP RES NETWORK
R2 223-010 1K×5 SIP RES NETWORK
R3 223-010 1K×5 SIP RES NETWORK
R4 244-011 1K PC MT MULTITURN
R5 223-010 1K×5 SIP RES NETWORK

R6 244-036 10 K PC MT MUTLITURN
R7 244-010 500 OHM PCMTMULTITURN
R8 223-007 390OHM×5SIPRESNETWORK
R9 223-010 1K × 5 SIP RES NETWORK
R10 244-032 50 OHM PC MT 20- TURN

R11 244-036 10 K PC MT MULTITURN
R12 223-007 390 OHM×5SIPRESNETORK
R13 NOT USED
R14 223-007 390OHM×5SIPRESNETWORK
R15 223-007 390OHM×5SIPRESNETWORK

R16 223-010 1K × 5 SIP RES NETWORK
R17 244-034 200 OHMPCMT MULTITURN
R18 223-0101K × 5 SIP RES NETWORK
R19 223-010 1K × 5 SIP RES NETWORK
R20 223-007 390OHM×5SIPRESNETWORK

R21 223-007390OHM×5SIPRESNETWORK
R22 223-007390OHM×5SIPRESNETWORK
R23 244-032 50 OHM × PC MT 20- TURN
R24 223-007 390OHM×5SIPRESNETWORK
R25 244-032 50 OHM PC MT 20-TURN

R26 223-010 1K × 5 SIP RES NETWORK
R27 NOT USED
R28 NOT USED
R29 NOT USED
R30 213-102 1K 5% ¼ W COMP

R31 213-221 220 OHM 5% ¼ W COMP
R32 213-2215.1 K 5% ¼ W COMP
R33 213-562 5.6 K 5% ¼ W COMP
R34 213-512 5.1 K 5% ¼ W COMP

PARTS LIST

Q4	430-055 2N5836
Q5	430-055 2N5836
Q6	430-049 2N5583
Q7	430-049 2N5583
Q8	430-049 2N5583
Q9	430-049 2N5583
Q10	430-049 2N5583
R42	213-102 1K 5% ¼ W COMP
R43	213-102 1K 5% ¼ W COMP
R44	213-102 1K 5% ¼ W COMP
R45	213-102 1K 5% ¼ W COMP
R46	213-391 390 OHM 5% ¼ W COMP
R47	213-102 1K 5% ¼ W COMP
R48	213-102 1K 5% ¼ W COMP
R49	213-271 270 OHM 5% ¼ W COMP
R50	213-391 390 OHM 5% ¼ W COMP
R51	213-221 220 OHM 5% ¼ W COMP
R52	213-560 56 OHM 5% ¼ W COMP
R53	213-102 1K 5% ¼ W COMP
R54	213-102 1K 5% ¼ W COMP
R55	213-102 1K 5% ¼ W COMP
R56	213-102 1K 5% ¼ W COMP
R57	213-102 1K 5% ¼ W COMP
R58	213-102 1K 5% 12/4 W COMP
R59	213-102 1K 5% ¼ W COMP
R60	222-041 1.51 K 1% ¼ W COMP
R61	222-018 2.49 K 1% 1.4 W MF
R62	222-014 499 OHM 1% ¼ W MF
R63	222-018 2.49 K 1% W MF
R64	213-223 22 K 5% ¼ W COMP
R65	213-103 10 K 5% ¼ W COMP
R66	222-018 2.49 K 1% ¼ MF
R67	222-080 332 OHM 1% ¼ W MF
R68	222-091 18.2 K 1% ¼ W MF
R69	213-223 22 K 5% ¼ W COMP
R70	222-051 10 K 1% ¼ W MF
R71	222-051 10 K 1% ¼ W MF
R72	213-391 390 OHM 5% ¼ W COMP
R73	213-151 150 OHM 5% ¼ W COMP
R74	213-472 4.7 K 5% ¼ W COMP
R75	213-051 10 K 1% ¼ W MF
R76	213-391 390 OHM 5% ¼ W COMP
R77	213-391 390 OHM 5% ¼ W COMP
R78	221-006 102 OHM 1% ½ W MF

R35	**213-512 5.1 K 5% ¼ W COMP**
R36	**213-103 10 K 5% ¼ W COMP**
R37	**213-103 10 K 5% ¼ W COMP**
R38	**213-103 10 K 5% ¼ W COMP**
R39	**213-223 22 K 5% ¼ W COMP**
R40	**213-103 10 K 5% ¼ W COMP**
R41	**213-103 10 K 5% ¼ W COMP**
R90	**213-121 120 OHM 5% ¼ W COMP**
R91	**213-122 1.2 K 5% ¼ W COMP**
R92	**213-391 390 OHM 5% ¼ W COMP**
R93	**213-101 100 OHM 5% ¼ W COMP**
R94	**213-391 390 OHM 5% ¼ W COMP**
R95	**213-103 10 K 5% ¼ W COMP**
R96	**213-561 560 OHM 5% ¼ W COMP**
R97	**213-122 1.2 K 5% ¼ W COMP**
R98	**213-102 1K 5% ¼ W COMP**
R99	**213-102 1K 5% ¼ W COMP**
R100	**213-102 1K 5% ¼ W COMP**
R101	**213-271 270 OHM 5% ¼ W COMP**
R102	**NOT USED**
R103	**213-391 390 OHM 5% ¼ W COMP**
R104	**213-102 1K 5% ¼ W COMP**
R105	**213-102 1K 5% ¼ W COMP**
R106	**213-102 1K 5% ¼ W COMP**
R107	**213-102 1K 5% ¼ W COMP**
R108	**213-102 1K 5% ¼ W COMP**
R109	**213-102 1K 5% ¼ W COMP**
R110	**212-271 270 OHM 5% ¼ W COMP**
R111	**213-102 1K 5% ¼ W COMP**
R112	**213-391 390 OHM 5% ¼ W COMP**
R113	**213-101 100 OHM 5% ¼ W COMP**
R114	**213-391 390 OHM 5% ¼ W COMP**
R115	**213-391 390 OHM 5% ¼ W COMP**
R116	**213-391 390 OHM 5% ¼ W COMP**
R117	**222-061 20 OHM 1% ¼ W MF**
R118	**213-820 82 OHM 5% ¼ W COMP**
R119	**213-131 130 OHM 5% ¼ W COMP**
R120	**213-223 22 K 5% ¼ W COMP**
R121	**222-059 29.4 K 1% ¼ W COMP**
R122	**225-061 100 K @25 C± 2.C**
R123	**213-121 120 OHM 5% ¼ W COMP**
R124	**213-151 150 OHM 5% ¼ W COMP**
R125	**213-560 56 OHM 5% ¼ W COMP**
R126	**213-102 1K 5% ¼ W COMP**

PARTS LIST

R79	222-003 49.9 OHM 1% ¼ W MF
R80	222-003 49.9 OHM 1% ¼ W MF
R81	213-102 1K 5% ¼ W COMP
R82	213-102 1K 5% ¼ W COMP
R83	213-102 1K 5% ¼ W COMP
R84	213-102 1K 5% ¼ W COMP
R85	213-102 1K 5% ¼ W COMP
R86	213-102 1K 5% ¼ W COMP
R87	213-102 1K 5% ¼ W COMP
R88	213-102 1K 5% ¼ W COMP
R89	213-102 1K 5% ¼ W COMP
R137	213-102 1K 5% ¼ W COMP
R138	213-102 1K 5% ¼ W COMP
R139	213-102 1K 5% ¼ W COMP
R140	213-102 120 OHM 5% ¼ W COMP
R141	213-150 15 OHM 5% ¼ W COMP
R142	213-122 1.2 K 5% ¼ W COMP
R143	213-561 560 OHM 5% ¼ W COMP
R144	213-101 100 OHM 5% ¼ W COMP
R145	213-391 390 OHM 5% ¼ W COMP
R146	213-103 10 K 5% ¼ W COMP
R147	213-102 1K 5% ¼ W COMP
R148	213-122 1.2 K 5% ¼ W COMP
R149	213-820 82 OHM 5% ¼ W COMP
R150	213-131 130 OHM 5% ¼ W COMP
R151	213-271 270 OHM 5% ¼ W COMP
R152	213-391 390 OHM 5% ¼ W COMP
R153	213-102 1K 5% ¼ W COMP
R154	213-391 390 OHM 5% ¼ W COMP
R155	22206120 OHM 1% ¼ 2 MF
R156	213-820 82 OHM 5% ¼ W COMP
R157	213-131 130 OHM 5% ¼ W COMP
R158	213-223 22 K 5% ¼ W COMP
R159	225-017 100 K @25 C ± 2C
R160	222-059 29.4 K 1% ¼ W MF
R161	213-102 1K 5% ¼ W COMP
R162	213-102 1K 5% ¼ W COMP
R163	213-102 1K 5% ¼ W COMP
R164	213-102 1K 5% ¼ W COMP
R165	213-271 270 OHM 5% ¼ W COMP
R166	213-271 270 OHM 5% ¼ W COMP
R166	213-102 1K 5% ¼ W COMP
R167	213-101 100 OHM 5% ¼ W COMP
R168	213-121 120 OHM 5% ¼ W COMP
R169	213-560 56 OHM 5% ¼ W COMP
R170	213-151 150 OHM 5% ¼ W COMP

R127	**213-271 270 OHM 5% ¼ W COMP**
R128	**213-391 390 OHM 5% ¼ W COMP**
R129	**213-391 390 OHM 5% ¼ W COMP**
R130	**213-510 51 OHM 5% ¼ W COMP**
R131	**213-510 51 OHM 5% ¼ W COMP**
R132	**213-221 220 OHM 5% ¼ W COMP**
R133	**213-221 220 OHM 5% ¼ W COMP**
R134	**213-221 220 OHM 5% ¼ COMP**
R135	**213-102 1K 5% ¼ W COMP**
R136	**213-102 1K 5% ¼ W COMP**
R184	**213-681 680 OHM 5% ¼ W COMP**
R185	**213-131 130 OHM 5% ¼ W COMP**
R186	**212-680 68 OHM 5% ½ W COMP**
R187	**212-680 68 OHM 5% ½ W COMP**
R188	**213-471 470 OHM 5% ¼ W COMP**
R189	**213-102 1K 5% ¼ W COMP**
R190	**213-271 270 OHM 5% ¼ W COMP**
R191	**213-820 82 OHM 5% ¼ W COMP**
R192	**212-271 270 OHM 5% ½ W COMP**
R193	**213-391 390 OHM 5% ¼ W COMP**
R194	**213-391 390 OHM 5% ¼ W COMP**
R195	**213-103 10 K 5% ¼ W COMP**
R196	**213-820 82 OHM 5% ¼ W COMP**
R197	**213-131 130 OHM 5% ¼ W COMP**
R198	**213-131 130 OHM 5% ¼ W COMP**
R199	**213-820 82 OHM 5% ¼ W COMP**
R200	**213-391 390 OHM 5% ¼ W COMP**
R201	**213-331 330 OHM 5% ¼ W COMP**
R202	**213-154 150 K 5% ¼ W COMP**
R203	**213-820 82 OHM 5% ¼ W COMP**
R204	**213-391 390 OHM 5% ¼ W COMP**
R205	**213-510 51 OHM 5% ¼ W COMP**
R206	**213-154 150 K 5% ¼ W COMP**
R207	**213-510 51 OHM 5% ¼ W COMP**
R208	**213-131 130 OHM 5% ¼ W COMP**
R209	**213-820 82 OHM 5% ¼ W COMP**
Z1	**440-076 MC4044**
Z2	**440-068 LM348N**
Z3	**440-134 10H 102**
Z4	**440-064 1408-PB**
Z5	**440-198 MC1648P**
Z6	**440-199 10H136P**
Z7	**440-168 LF412**
Z8	**440-134 10H102**

R171	221-001 49.9 OHM 1% ½ W MF
R172	221-001 49.9 OHM 1% ½ W FM
R173	213-270 27 OHM 5% ¼ W COMP
R174	213-101 100 OHM 5% ¼ W COMP
R175	213-270 27 OHM 5% ¼ W COMP
R176	213-100 10 OHM 5% ¼ W COMP
R177	213-101 100 OHM 5% ¼ W COMP
R178	222-005 61.9 OHM 1% ¼ W MF
R179	222-005 61.9 OHM 1% ¼ W MF
R180	213-681 680 OHM 5% ¼ W COMP
R181	213-131 130 OHM 5% ¼ W COMP
R182	213-820 82 OHM 5% ¼ W COMP
R183	213-131 130 OHM 5% ¼ W COMP
Z23	440-136 10H131
Z24	440-138 10H105
Z25	440-138 10H105
Z26	440-138 10H105
Z27	440-136 10H131
Z28	440-134 10H131
Z29	440-134 10H102
Z30	440-041 MC10125
Z31	440-134 10H102
Z32	440-199 10H136P

MICROPROCESSOR BOARD 6040-3

MALE

C1	122-016 10 µF 10% 15 V TAN
C2	122-016 10 µF 10% 15 V TAN
C3	122-016 10 µF 10% 15 V TAN
C4	122-016 10 µF 10% 15 V TAN
C5	110-033 0.1 µF 20% 50 V CER
C6	110-033 0.1 µF 20% 50 V CER
C7	110-033 0.1 µF 20% 50 V CER
C8	110-033 0.1 µF 20% 50 V CER
C9	110-033 0.1 µF 20% 50 V CER
C10	110-033 0.1 µF 20% 50 V CER
C11	110-033 0.1 µF 20% 50 V CER
C12	110-033 0.1 µF 20% 50 V CER
C13	110-033 0.1 µF 20% 50 V CER

Z9	**440-079 MC10116**
Z10	**440-200 10H164P**
Z11	**440-041 MC10125**
Z12	**440-138 10H105**
Z13	**440-185 AM885DL**
Z14	**440-199 10H136P**
Z15	**440-200 10H164P**
Z16	**440-134 10H102**
Z17	**441-002SEPROM**
Z18	**440-136 10H131**
Z19	**440-214 PB265A-5**
Z20	**440-079 MC10115**
Z21	**440-200 10H164P**
Z22	**440-214 PB255A-5**
C34	**110-033 0.1 µF 20% 50 V CER**
C35	**110-033 0.1 µF 20% 50 V CER**
C36	**110-033 0.1 µF 20% 50 V CER**
C37	**110-033 0.1 µF 20% 50 V CER**
C38	**110-033 0.1 µF 20% 50 V CER**
C39	**110-033 0.1 µF 20% 50 V CER**
C40	**110-033 0.1 µF 20% 50 V CER**
CR1	**411-004 1N4152**
J1	**621-017 SOCKET 16-PIN DIP**
J2	**620-022 HEADER 10-PIN MALE**
J3	**620-022 HEADER, 10-PIN MALE**
J4	**620-025 HEADER, 14-PIN MALE**
J5	**620-022 HEADER 10-PIN**
J6	**626-065 CABLE ASSY 40-PIN**
J7	**620-023 HEADER 24-PIN MALE**
J8	**620-027 HEADER 40-PIN MALE**
J9	**626-054 CABLE ASSY 20-PIN**
J10	**621-017 SOCKET 16-PIN DIP**
J11	**NOT USED**
J12	**NOT USED**
J13	**NOT USED**
J14	**NOT USED**
J15	**620-028 HEADER 3-PIN MALE**
LSI	**633-001 BEEPER 3-20 V DC**
R1	**213-479 47K 5% ¼ W COMP**

C14	110-033 0.1 µF 20% 50 V CER
C15	110-033 0.1 µF 20% 50 V CER
C16	110-033 0.1 µF 20% 50 V CER
C17	110-033 0.1 µF 20% 50 V CER
C18	110-033 0.1 µF 20% 50 V CER
C19	110-033 0.1 µF 20% 50 V CER
C20	110-033 0.1 µF 20% 50 V CER
C21	110-033 0.1 µF 20% 50 V CER
C22	110-033 0.1 µF 20% 50 V CER
C23	110-033 0.1 µF 20% 50 V CER
C24	110-033 0.1 µF 20% 50 V CER
C25	110-033 0.1 µF 20% 50 V CER
C26	110-033 0.1 µF 20% 50 V CER
C27	110-033 0.1 µF 20% 50 V CER
C28	110-033 0.1 µF 20% 50 V CER
C29	110-033 0.1 µF 20% 50 V CER
C30	110-033 0.1 µF 20% 50 V CER
C31	110-033 0.1 µF 20% 50 V CER
C32	110-033 0.1 µF 20% 50 V CER
C33	110-033 0.1 µF 20% 50 V CER
Z11	322-011 OSC 10 MHZ HYBRID
Z12	440-204 74HC245
Z13	440-202 74HC14
Z14	440-204 74HC245
Z15	440-176 74HC373
Z16	440-194 PB2C54-2
Z17	440-0025EPROM
Z18	440-204 74HC246
Z19	440-214 P8255A-5
Z20	440-194 P82C54-2
Z21	NOT USED
Z22	440-214 P8255A-5
Z23	440-194 P82C54-2
Z24	440-191 COM62643
Z25	440-203 74HC138
Z26	440-162 74HC08
Z27	440-194 P82C64-2
Z28	NOT USED
Z29	440-151 74HC02
Z30	440-175 74HC373
Z31	440-155 74HC32
Z32	440-162 74HC08
Z33	440-214 PB255A-5

R2	**223-016 4.7K X 9SIP RES NETWORK**
R3	**223-016 4.7K X 9 SIP RES. NETWORK**
R4	**213-27327 K 5% ¼ W COMP**
R5	**244-038 6K CERMET MT**
R6	**223-016 4.7K X 9 SIP RES NETWORK**
R7	**213-472 4.7 K 5% ¼ W COMP**
R8	**223-020 22K X 9 SIP RES NETWORK**
TP1	**620-007 TERMINAL BIFURCATED**
TP2	**620-007 TERMINAL BIFURCATED**
TP3	**620-007 TERMINAL BIFURCATED**
Z1	**440-188 SN76161 BN**
Z2	**440-187 SN75160 BN**
Z3	**440-196 MC1489P**
Z4	**440-189 TMS9914 ANL**
Z5	**440-197 MC1489P**
Z6	**440-156 74HC74**
Z7	**440-204 74HC245**
Z8	**440-192 DBOC31BH**
Z9	**440-206 74HC367**
Z10	**440-162 74HC08**
CR7	**410-006 MR750**
CR8	**410-006 MR760**
CR9	**410-007 1N6401**
CR10	**410-007 1N6401**
CR11	**410-003 1N4005**
CR12	**410-003 1N4005**
CR13	**412-001 1N821**
CR14	**410-003 1N4005**
CR15	**410-003 1N4005**
CR16	**412-001 1N821**
J10	**621-017 16-PIN DIP**
J11	**621-017 16-PIN DIP**
J12	**621-017 16-PIN DIP**
Q1	**430-027 MPS3646**
Q2	**430-027 MPS3646**
R1	**244-035 2K PC MT MULTITURN**
R2	**244-011 1K PC MT MULTITURN**
R3	**244-010 500OHM PC MTMULTITURN**
R4	**244-034 200OHM PC MTMULTITURN**
R5	**222-011 249 OHM 1% ¼ W MF**
R6	**222-087 604 OHM 1% ¼ W MF**
R7	**222-042 2K 1% ¼ W MF**
R8	**213-103 10K 5% ¼ W COMP**

Z34	440-152 74HC10
Z35	440-203 74HC138
Z36	440-181 74HC04
Z37	440-160 74HC00

POWER SUPPLY BOARD 6040-1

C1	120-026 20000 µF 25 V ELEC
C2	120-025 10000 µF 25 V ELEC
C3	120-025 10000 µF 25 V ELEC
C4	120-025 10000 µF 25 V ELEC
C5	120-025 10000 µF 25 V ELEC
C6	110-033 0.1 µF 20% 50 V CER
C7	110-011 0.001 µF 10% 1 K CER
C8	110-033 0.1 µF 20% 50 V CER
C9	112-004 100 PF 5% 500 V MIC
CR1	410-006 MR750
CR2	410-006 MR750
CR3	410-006 MR750
CR4	410-006 MR750
CR5	410-006 MR750
CR6	410-006 MR750
D52	416-007 LED YELLOW
D53	416-007 LED YELLOW
D54	416-007 LED YELLOW
D55	416-007 LED YELLOW
D56	416-066 LED RED
D57	416-006 LED RED
J5	620-022 HEADER 10-PIN MALE
R1	223-019 390 OHM X 9 SIP NETWORK

MISC. FRONT PANEL ASSEMBLY 640-033

	409-005 LCD 1 UNE X 20 CHARACTERS
	616-006 KEYPAD 16 PUSH BUTTON, GREY
5813	616-005 KEY SWITCH
J801	624-018 BNC CONNECTOR 50 OHM
J803	624-018 BNC CONNECTOR 50 OHM

NOTE: *Contact Factory for Instrument Schematics*

R9	**213-511 510 OHM 5% ¼ W COMP**
R10	**225-019 0.15 OHM 5% 2 W MF**
R11	**222-042 2K 1% ¼ W MF**
R12	**222-050 8.66K 1% ¼ W MF**
R13	**222-039 1K 1% ¼ W MF**
R14	**222-047 6.19K 1% W MF**
R15	**222-011 249 OHM 1% ¼ W MF**
R16	**222-042 2K 1% ¼ W MF**
R17	**222-050 11.6K 1% ¼ W MF**
R18	**213-103 10K 5% ¼ W COMP**
R19	**213-511 510 OHM 5% ¼ W COMP**
R20	**225-020 0.27 OHM 5% 2 W MF**
R21	**222-063 768 OHM 1% ¼ W MF**
R22	**222-053 12.1K 1% ¼ W MF**
Z1	**440-139 CA3140**
Z2	**440-139 CA3140**

ANNUNCIATOR BOARD 6040-6

D51	**416-007 LED YELLOW**

MISC. TOP ASSEMBLY 801-097

1701	**320-014 TRANSFORMER.4-15132**
	631-022 FAN
S901	**621-002 PB SWITCH**
S902	**613-002 SLIDE SWITCH**
S903	**616-004 THERMO SWITCH**
F801	**634-010 FUSE, 3AG 1.5A, SLOBLO (155VAC)**
	634-008 FUSE, 3AG 0.75A, SLOBLO (230 VAC)
	623-003 SOCKET, LINE CORD. 15A 250 V
	623-004 CORD SET, 10 A
Q901	**431-012 FET. MTP10N05**
Q902	**431-012 FET, MTP10N05**
Z901	**440-209 IC LM 350T**
Z902	**440-209 IC LM 350T**
J901	**626-051 CABLEASSY, JEEE CONN**
J902	**626-040 CABLE ASSY RS-232**
J903	**626-018 PHONE JACK. NC**
J904	**624-021 SMA CONNECTOR 50 OHM**
J802	**624-018 BNC CONNECTOR 50 OHM**