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Instruction Manual

Model 775A

Programmable Counter / Timer

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Cleveland, Ohio, U.S.A.

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SPECIFICATIONS

INPUT CHARACTERISTICS

Channel A, B; each channel

RANGE: 0 to 120MHz, dc coupled.
30Hz to 120MHz, ac coupled.
SENSITIVITY (x1): 25mV rms, <10MHz.
50mV rms, >10MHz.
DYNAMIC RANGE (x1): 50mV to 5V pk-pk, <20MHz.
140mV to 2.5V pk-pk, >20MHz.
COUPLING: ac or dc, switchable.
IMPEDANCE: 1MΩ nominal, shunted by <60pF.
ATTENUATOR: x1 or x10 nominal, switchable.
LOW PASS FILTER: -10dB at 100kHz nominal, switchable.
SIGNAL OPERATING RANGE (x1): -2.55V dc to +2.55V dc.
TRIGGER LEVEL: -2.55V dc to +2.55V dc, x1.
-25.5V dc to +25.5V dc, x10.
TRIGGER LEVEL RESOLUTION: 10mV, x1.
100mV, x10.
TRIGGER LEVEL SETTING ACCURACY:
±(35mV + 2% of setting), x1.
±(350mV + 2% of setting), x10
TRIGGER LEVEL SETTING OUTPUT: via rear panel BNC, not adjusted for attenuators.
SLOPE: + or - slope, switchable.
DAMAGE LEVEL:

x1:	dc-2kHz	250V dc + peak ac
	2kHz-100kHz	5×10^5V rms•Hz/frequency
	>100kHz	5V rms
x10:	dc-20kHz	250V dc + peak ac
	20kHz-100kHz	5×10^6V rms•Hz/frequency
	>100kHz	50V rms

Channel C (with Model 7751 option)

RANGE: 50MHz to 1.3GHz.
SENSITIVITY: 15mV, 50MHz to 1.0GHz;
25mV, 1.0GHz to 1.2GHz;
75mV, 1.2GHz to 1.3GHz
DYNAMIC RANGE: 25mV rms to 1V rms.
COUPLING: ac.
IMPEDANCE: 50Ω.
DAMAGE LEVEL:

dc-100kHz	15V dc + peak ac
>100kHz	5V rms

FREQUENCY A, B

RANGE: 0.1Hz to 120MHz.
LSD DISPLAYED: (10ns x Frequency)/Gate Time
RESOLUTION:

$$\pm 1 \text{ LSD} \pm \frac{(1.4 \times \text{Trigger Error} + 2\text{ns}) \times \text{Frequency}}{\text{Gate Time}}$$

ACCURACY:
±Resolution ±(Time Base Error x Frequency)
DIGITS DISPLAYED: 8 per second of Gate Time, minimum.

PERIOD A

RANGE: 10ns to 10^4 seconds.
LSD DISPLAYED: 10ns to 0.1ms.
ACCURACY:
±1 LSD ±(Time Base Error x Period) ± Trigger Error.

PERIOD AVERAGE A

RANGE: 10ns to 10sec.
LSD DISPLAYED: (10ns x Period)/Gate Time.
RESOLUTION:

$$\pm 1 \text{ LSD} \pm \frac{(1.4 \times \text{Trigger Error} + 2\text{ns}) \times \text{Period}}{\text{Gate Time}}$$

ACCURACY: ± Resolution ±(Time Base Error x Period)
NUMBER OF PERIODS AVERAGED: Gate Time/Period

TIME INTERVAL A→B

RANGE: 10ns to 10^4 seconds.
LSD DISPLAYED: 10ns to 0.1ms.
ACCURACY: ±1 LSD ±(Time Base Error x Time Interval)
± Trigger Error ± Trigger Timing Error ±2ns.

PULSE WIDTH A (Positive or Negative)

RANGE: 10ns to 10^4 seconds.
LSD DISPLAYED: 10ns to 0.1ms.
ACCURACY: ±1 LSD ±(Time Base Error x Pulse Width)
± Trigger Error ± Trigger Timing Error ±2ns.

TOTALIZE A

MODES: Cumulative or A gated by B
RANGE: 0 to $10^{16}-1$
REPETITION RATE: 120MHz max.
LSD DISPLAYED: 1 count up to $10^{10}-1$, then 9 most significant digits.
ACCURACY: ±1 LSD

GATE/DELAY

INTERNAL GATE TIME: Variable from 100μs to 10sec in 45 increments, or one period of the input, whichever is longer. May be used in Frequency and Period Average measurements.
EXTERNAL GATE TIME: Continuously variable from 100μs to 10sec, or one period of the input, whichever is longer.
EXTERNAL GATE DELAY: 10μs + one period of the input signal, maximum.
INTERNAL DELAY TIME: Variable from 100μs to 10sec in 45 increments. May be used in Period, Time Interval and Pulse Width measurements.
EXTERNAL DELAY TIME: Continuously variable from 100μs to >1 hour.
EXTERNAL GATE/DELAY INPUT: Positive TTL signal via rear panel BNC.

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TIME BASE

FREQUENCY: 10MHz.
AGING RATE: $\leq 5 \times 10^{-7}$/month.
TEMPERATURE: $\pm 5 \times 10^{-6}$, 0° to 40°C, ref 25°C.

TCXO (with Model 7752 option)

FREQUENCY: 10MHz
AGING RATE: $< 1 \times 10^{-7}$/month.
TEMPERATURE: $\pm 1 \times 10^{-6}$, 0 to 40°C, ref 25°C.
LINE VOLTAGE: $< 1 \times 10^{-7}$ for 10% change.

IEEE-488 INTERFACE

MULTILINE COMMANDS: DCL, LLO, SDC, GET, GTL, UNT, UNL, SPE, SPD.
UNILINE COMMANDS: IFC, REN, EOI, SRQ, ATN.
INTERFACE FUNCTIONS: SH1, AH1, T6, TE0, L4, LE0, SR1, PP0, DC1, DT1, C0, E1.
PROGRAMMABLE PARAMETERS: All front panel controls (except POWER) plus Reading Rate, Data Format, Trigger, EOI, Terminator, Service Request, Self Test, Display, Status.
READING RATES: one shot, normal (3/second), fast (25/second), or dump (140/second).

GENERAL

DISPLAY: Nine LED digits with decimal point and exponent.
BENCH READING RATES: One shot, or normal (3/second).
ARMING (TRIGGER): Each channel is armed by it's own signal; or RESET button or EXT ARMING input when in one shot (HOLD) mode.
ARMING DELAY: 30μs in Frequency and Period Average; 10μs in Period, Time Interval and Pulse Width.
EXTERNAL ARMING INPUT: Positive edge TTL signal via rear panel BNC.
EXTERNAL TIME BASE INPUT: 10MHz TTL signal via rear panel BNC
TIME BASE OUT: 2V minimum @ 10MHz, 100Ω output resistance, via rear panel BNC.
GATE: LED indicator lights when gate is open.
WARMUP: 2 hours to rated accuracy and stability.
OPERATING TEMPERATURE: 0° to 40°C, 0% to 80% relative humidity.
STORAGE TEMPERATURE: −25° to 65°C.
POWER: 105–125V or 210–250V (rear panel switch selected), 50–60Hz, 35VA max. 90–110V available.
DIMENSIONS, WEIGHT: 127mm high x 215mm wide x 359mm deep (5"x 8½"x 14⅛").
Net weight 3.5kg (8 lbs).

Specifications subject to change without notice.

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GLOSSARY OF TERMS

Time Base Error—Time base error is the maximum fractional frequency change in the time base frequency due to all errors (e.g. aging, temperature, line voltage).

Trigger Error—

$$\frac{\sqrt{e_j^2 + e_n^2}}{\text{Input Slew Rate at Trigger Point}}$$

Where:

e_j is the RMS noise voltage of the counter's input channel (250μV typical).

e_n is the RMS noise of the input signal for 120MHz bandwidth.

LSD—Unit value of the least significant digit. Calculations should be rounded as follows: 1 to 1.3Hz becomes 1Hz, 1.3nsec to 10nsec becomes 10nsec, etc.

Trigger Timing Error—

$$\frac{35\text{mV}}{\text{Input Slew Rate at Start Trigger Point}} + \frac{35\text{mV}}{\text{Input Slew Rate at Stop Trigger Point}}$$

External Arming (Trigger) Delay—External arming delay is the time from the positive going slope of the arming signal to the internal gate open signal.

External Gate Delay—External gate delay is the time from the positive going slope of the gating signal to the internal gate open signal.

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KEITHLEY INSTRUMENTS

Model 775A Instruction Manual Addendum

Introduction

This addendum to the Model 775A Programmable Counter/Timer Instruction Manual is being supplied in order to give you the latest information in the least possible time. Please incorporate this information into the manual where indicated.

Paragraph 5.4.1, Microcomputer Block Diagram, page 5-13, replace second paragraph with the following:

Software for the MCU is contained in an EPROM (Erasable Programmable Read-Only Memory). U9 is a 27256 EPROM containing 32K bytes of software. Temporary storage is provided by U10 and U11 RAMs which can store up to 1024 bytes of information.

Paragraph 5.4.2, Memory Mapping, page 5-13, replace second paragraph with the following:

The Model 775 uses a total of 32K of program memory stored in the 27256 EPROM U9, and a total of 1K of data memory is stored in U10 and U11. The 8031 MCU uses a memory-mapped I/O scheme, additional memory locations must be allocated for the various I/O functions. All the memory-mapped I/O functions are in the data memory space. Table 5-1 lists the memory locations for the various memory elements.

Table 7-1, Mother Board Parts List, page 7-9:

Change:	U9	Eprom 2764 max 300ms	LSI-52
To:	U9	Eprom Program (27256)	775A-800*

*Order current firmware revision level.

Figure 7-1, Mother Board, Component Location Drawing, page 7-11/7-12:

Change:	U9 (2764)
To:	U9 (27256)

Table 7-3, Model 775 Mechanical Parts List, page 7-35:

Change:	A. Bottom cover	1	30544
To:	A. Bottom cover	1	30541

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SECTION 1
GENERAL INFORMATION

1.1 INTRODUCTION

The Keithley Model 775 Programmable Counter/Timer is a nine digit, microcomputer based, fully programmable, universal counter/timer. The Model 775 measures with high resolution the following parameters:

- Frequency A
- Frequency B
- Frequency C
- Period
- Period Averaged
- Time Intervals A → B
- Pulse Width (positive or negative) A

The Model 775 has an 14mm (0.56 in.) LED display. The display consists of 9 digits with an additional digit for exponent. The built-in interface makes the instrument fully programmable over the IEEE-488 bus.

The Model 775 contains a programmable trigger level that allows additional flexibility in measurements over the bus (e.g. measuring rise and fall time with trigger points other than 10% and 90%). Gate time is programmed in 46 steps from 100μsec to 10sec or external from the front panel or over the bus.

1.2 MODEL 775 FEATURES

Dual Channel Capability—Dual channel capability with two similar channels up to 120MHz.

Full Programmability—Full programmability of all functions and modes including different SRQ masks and channel selection.

High Frequency Option—HF-option adds a third measurement channel for frequencies up to 1GHz.

High Resolution—A 100MHz clock rate, along with the latest technique in frequency counting (reciprocal technique), provides the high resolution of 8 digits/second or 1Hz out of a 100MHz input signal.

Trigger Delay Channel B—This feature is important for some channel A → B time measurements.

True DC Coupling—Allows the Model 775 to do channel A → B time measurements.

Reciprocal Technique—This counting method provides advantages over all traditional counters from DC up to the clock frequency (100MHz). The constant relative resolution (8 digits/second independent of input frequency) makes it even more useful for low frequency applications.

1.3 WARRANTY INFORMATION

Warranty information may be found on the inside front cover of this manual. Should it become necessary to exercise the warranty, contact your Keithley representative or the factory to determine the proper course of action. Keithley Instruments maintains service facilities in the United States, United Kingdom and throughout Europe. Information concerning the application, operation or service of your instrument may be directed to the applications engineer at any of these locations. Check the inside front cover for addresses.

1.4 MANUAL ADDENDA

Information concerning improvements or changes to the instrument which occur after the printing of this manual will be found on an addendum sheet included with this manual. Be sure to review these changes before attempting to operate or service the instrument.

1.5 SAFETY SYMBOLS AND TERMS

The following safety symbols and terms are used in this manual or found on the Model 775.

The ⚠ symbol on the instrument denotes that the user should refer to the operating instructions in this manual.

The **WARNING** used in this manual explains dangers that could result in personal injury or death.

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The **CAUTION** used in this manual explains hazards that could damage the instrument.

1.6 INSPECTION

The Model 775 was inspected both mechanically and electrically before shipment. After unpacking all the items from the shipping carton, check for any obvious signs of physical damage that may have occurred during transit. Report any damage to the shipping agent. Retain and use the original packing materials in case reshipment is necessary. The following items are shipped with every Model 775.

Model 775 Programmable Counter/Timer
Model 775 Instruction Manual
Additional accessories as ordered.

If an additional Instruction Manual is required, order the manual package (Keithley part number 775-901-00). The manual package includes an instruction manual and any applicable addenda.

1.7 USING THE MODEL 775 MANUAL

- Section 1 contains general information about the instrument.
- Section 2 contains detailed operating information on using the front panel controls and rear panel terminals.
- Section 3 contains information necessary to operate the Model 775 over the IEEE-488 bus.
- Section 4 contains performance verification procedures for the instrument. This information is helpful if you wish to verify that the instrument is operating in compliance with stated specifications.
- Section 5 contains a description of operating theory.
- Section 6 contains information for servicing the instrument. This section includes information on line voltage selection, fuse replacement, adjustments and troubleshooting.
- Section 7 contains replacement parts information.

1.8 ACCESSORIES

The following optional accessories are available to enhance the Model 775 capabilities.

Model 1019A Fixed Rack Mount—The Model 1019A is a stationary rack mount kit that allows the Model 775 to be mounted in a standard 19 inch rack.

Model 1019S Slide Rack Mount—The Model 1019S is a sliding rack mount kit that allows the Model 775 to be rack mounted with the added feature of sliding the instrument forward for easy access to the rear panel and top cover.

Model 7007 IEEE-488 Shielded Cables—The Model 7007 connects the Model 775 to the IEEE-488 bus using shielded cables to reduce electromagnetic interference (EMI). The Model 7007-1 is one meter in length and has an EMI shielded IEEE-488 connector at each end. The Model 7007-2 is identical to the Model 7007-1, but is two meters in length.

Model 7008 IEEE-488 Cables—The Model 7008 connects the Model 775 to the IEEE-488 bus. The Model 7008-3 is 0.9m (3 ft.) in length and has a standard IEEE-488 connector at each end. The Model 7008-6 cable is identical to the Model 7008-3, but is 1.8m (6 ft.) in length.

Model 7051 BNC to BNC Cable—The Model 7051 is 1.5m (5 ft.) in length and is terminated on each end with a BNC plug.

Model 7751 1GHz Channel C Option—The Model 7751 is a factory-installed option which provides a third channel (C) for measuring frequencies between 50MHz and 1GHz.

Model 7752 TCXO—High Stability Crystal Oscillator Option-The Model 7752 is a factory-installed TCXO-high stability crystal oscillator that offers improvement over the standard time base, relative to aging and temperature.

Model 7754-3 BNC to Alligator Cable—The Model 7754-3 is 0.9m (3 ft.) in length and is terminated on one end with a BNC plug and on the other with two alligator clips.

Model 7755 50Ω Feedthrough Termination—The Model 7755 is a BNC to BNC adapter for terminating RG 58 cable in its characteristic impedance. VSWR <1.1, DC -250MHz.



BNC PLUG BNC JACK

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SECTION 2
BASIC COUNTER/TIMER OPERATION

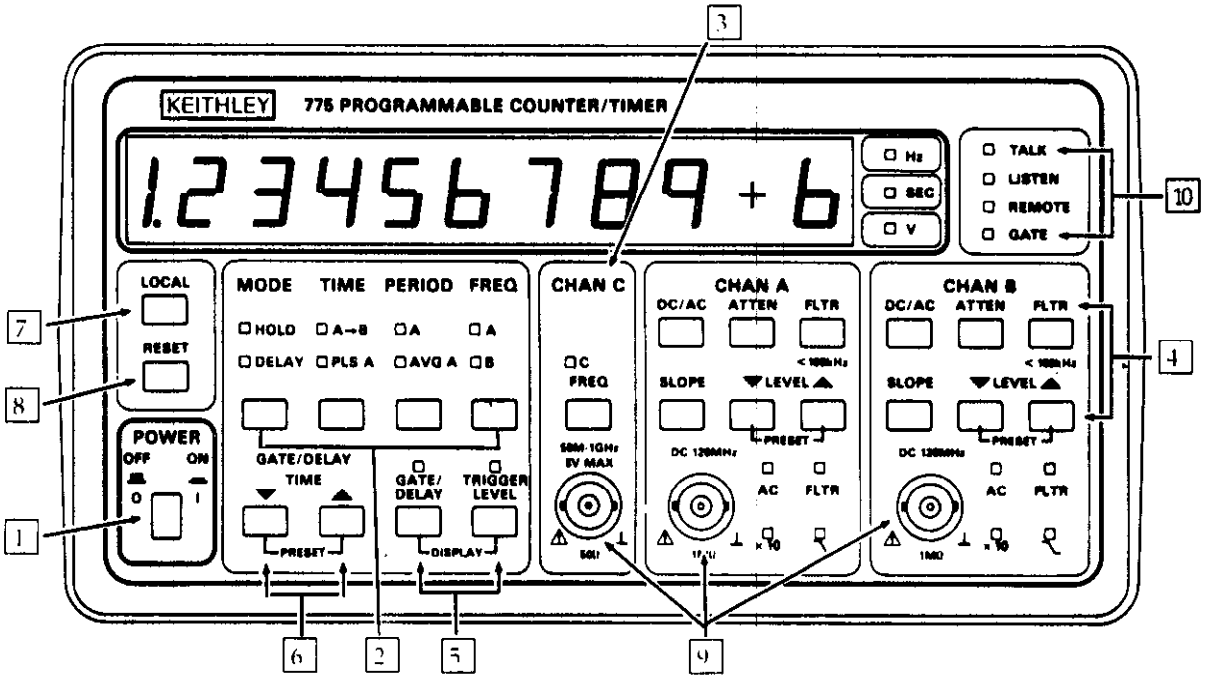
2.1 INTRODUCTION

Model 775 operation is divided into the two general categories: basic bench operation, and IEEE-488 operation. Basic bench operation which is covered in this section, consists of using the Model 775 to perform basic frequency and time measurements. IEEE-488 programming can also be used. These aspects are covered in detail in Sections 3 and 4. A layout of the front and rear panels of the Model 775 are shown in Figures 2-1 and 2-2 respectively, included is a brief description of each control, terminal and indicator.

NOTE

Any front panel button push or IEEE device-dependent command (see Section 3) will cause the measurement to restart, which will affect, for example, a measurement of the time from channels A to B.

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1 **POWER ON/OFF**—Turns the unit on or off.

2 **FUNCTION GROUP**—
- FREQ button toggles measurement between frequency at channel A and frequency at channel B.
- PERIOD button toggles measurement between the period A and period average A.
- TIME button toggles measurement between the time interval A→B and pulse width of A.
- MODE button places instrument in either the hold, delay, both hold and delay, or normal mode.

3 **CHAN C**—Measures frequencies from 50MHz to 1GHz through channel C.

4 **INPUT SETTING GROUP**—
- DC/AC button toggles instrument between AC and DC coupling of the input signal.
- SLOPE button toggles instrument between the positive or negative edge trigger.
- ATTEN button toggles instrument between the x1 and x10 input attenuation.
- FLTR button toggles filter between on and off.
- LEVEL buttons select the threshold point on a signal that the instrument will trigger.

5 **DISPLAY MODIFY GROUP**—
- GATE/DELAY button modifies display from normal frequency (or time reading) to gate time or delay time.
- TRIGGER LEVEL button modifies the display to show trigger level of both channels A and B.

6 **GATE/DELAY TIME GROUP**—
- GATE/DELAY TIME buttons control: time gate is open, delay of gate closure and number of digits displayed.
- These buttons increment or decrement the displayed value by one step.

7 **LOCAL**—Enables front panel operation.

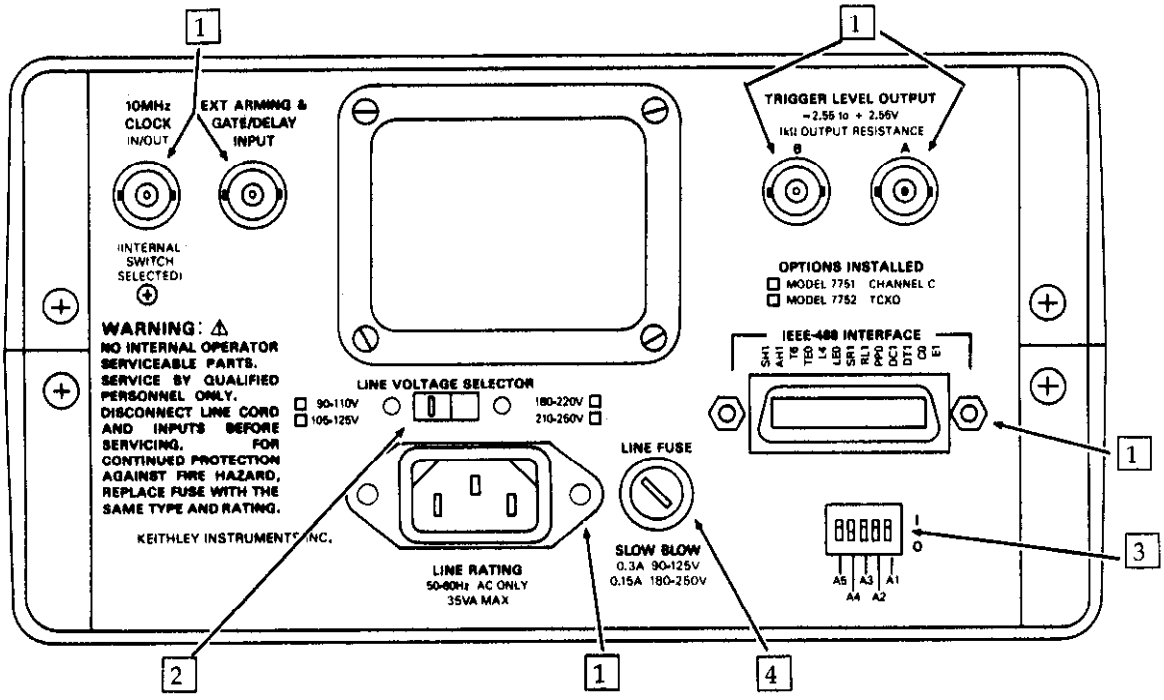
8 **RESET**—Resets display to initiate new measurement cycle during normal or hold mode operation.

9 **TERMINALS**—
- CHAN A used when making frequency and time measurements.
- CHAN B used when making frequency and time A→B measurements.
- CHAN C used when making high frequency measurements up to 1GHz with a 50Ω input impedance (7751 option). The shell is connected to chassis ground as indicated by the ⊥ symbol.

10 **DISPLAY AND INDICATORS**—
- Display consists of a nine digit mantissa and a single digit exponent.
- Range indicator consist of Hz, SEC, V. Hz is on during frequency measurement. SEC is on during time and period measurements. V is on when TRIGGER LEVEL button is pressed.
- GATE indicator blinks at a rate proportional to gate time.
- IEEE status indicators select either remote, talk or listen when programming over IEEE-488 bus.

Figure 2-1. Model 775 Front Panel

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1 **CONNECTORS AND TERMINALS—**

- AC receptacle connects to a three wire line cord which provides connection to the line voltage.
- IEEE-488 connector is used to connect the instrument to the IEEE-488 bus. IEEE interface functions are marked above the connector.
- TRIGGER LEVEL OUTPUT connections are used to connect the DC voltage level from the trigger circuits to an external DMM or oscilloscope. DC output range is marked above the connector.
- CLOCK connector is used to output the internal clock as a reference to another instrument or to use an external clock as the Model 775's time base.
- EXT ARMING & GATE DELAY connector is used to receive one of three signals: arming pulse, external gate signal or external delay pulse.

2 **LINE VOLTAGE SELECTOR** switch selects the line voltage that the unit will operate on.

3 **IEEE-488** address switches set the primary address for IEEE-488 bus operation.

4 **LINE FUSE** provides protection on the AC power line input.

Figure 2-2. Model 775 Rear Panel

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2.2 FRONT PANEL FAMILIARIZATION

The front panel layout of the Model 775 is shown in Figure 2-1. The front panel is generally divided into three sections: controls, terminals, and display and indicators. The following paragraphs describe the purpose of each of these items in detail.

2.2.1 Controls

All front panel controls except POWER are momentary contact switches. Many controls include an annunciator light to indicate the selected configuration. The controls are color coded into functional groups for easier operation.

Front panel controls may be divided into the following functional groups: Function, Input Setting, Display Modify and Gate/Delay Time.

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

Function Group—The four FUNCTION buttons control the type of measurement. Each button is used to select one of two functions.

FREQ—The FREQ button places the instrument in frequency measurement mode. Pressing the FREQ button once turns the A indicator on; indicating the instrument is set for the frequency A mode. Pressing the button a second time, turns the B indicator on; indicating the instrument is set for the frequency B mode. Pressing of the FREQ button toggles the measurement between the frequency at channel A and frequency at channel B modes.

PERIOD—The PERIOD button places the instrument in period measurement mode. Pressing the PERIOD button once turns the A indicator on; indicating the instrument is in the period A mode. Pressing the PERIOD button a second time, turns the AVG A indicator on; indicating the instrument is in the period average A mode. Pressing of the PERIOD button toggles the measurement between the period A and period average A.

TIME—The TIME button sets the Model 775 up to measure the time interval between channel A and B. Pressing the TIME button once turns the A→B indicator on; indicating the instrument is in the time interval A→B mode. Pressing the button a second time, turns the PLS A indicator on; indicating the instrument is in the pulse A mode. Pressing of the TIME button toggles the measurement between the time interval, A→B and pulse width of A.

MODE—Press the MODE button once to place the instrument in the hold mode. Press the RESET button to clear the display and take a reading. The reading will be held on the display until the RESET button is pressed again. Pressing the MODE button a second time, places the Model 775 in the delay mode of operation; the instrument holds off closure of the gate for the selected delay time. Pressing the MODE button a third time places the instrument in both the hold and delay modes. Pressing of the MODE button a fourth time turns the indicators off; and places the instrument in the normal mode of operation.

NOTE

The delay mode is disabled in the frequency and period averaging modes.

FREQ C—The FREQ C button allows the Model 775 to measure frequencies from 50MHz to 1GHz on channel C. Pressing the FREQ C button turns the C indicator on; indicating the instrument is set to make high frequency measurements on channel C. If the Model 7751 Channel C option is not installed, a 'nO C OPt' message will be displayed for two seconds.

Input Setting Group—The six CHAN A pushbuttons control input attenuation, coupling, slope, trigger level and high frequency noise suppression. The six CHAN B pushbuttons are functionaly identical to the CHAN A buttons.

DC/AC—The DC/AC button selects either the AC or DC coupling mode. In default position, the instrument is in the DC coupling mode. Pressing the DC/AC button turns the AC indicator on; indicating the instrument is in the AC coupling mode. Pressing of the DC/AC button toggles the instrument between AC and DC coupling of the input signal.

SLOPE—The SLOPE button selects the slope that the Model 775 will trigger on. In default position, the instrument triggers on a positive going edge. Pressing the SLOPE button turns the " ⌝ " indicator on; indicating the instrument will trigger on a negative going edge. Pressing of the SLOPE button toggles the instrument between the positive or negative edge trigger.

ATTEN—The ATTEN button controls the attenuation of the input signal. In default position, the signal will not be attenuated. Pressing the ATTEN button turns the x10 indicator on; indicating that the instrument will attenuate the signal by 10. Pressing of the ATTEN button toggles the instrument between the x1 and x10 input attenuation. Note that changing attenuation changes the trigger level. (e.g. 1V trigger on x1 goes to 10V on x10).

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FLTR—The FLTR button limits high frequency noise to about 100kHz through a low-pass filter installed at the input terminal. In default position, the low-pass filter is off. Pressing the FLTR button turns the FLTR indicator on; indicating that the low-pass filter is on. Pressing of the FLTR button toggles the filter between on and off.

LEVEL—The LEVEL buttons select the signal voltage level that will trigger the instrument (e.g. start and/or stop the measurement interval). Pressing the ▼ button decrements the level by one step. Pressing the ▲ button increments the level by one step. Each step is 10mV on the x1 attenuator setting or 100mV on the x10 attenuator setting. Holding the LEVEL ▲ or ▼ button in for more than one second, causes the trigger level to continuously move up or down respectively. Holding the LEVEL ▲ and ▼ buttons in at the same time, causes the instrument to jump to the preset position 0.00V (or 00.0V).

Display Modify Group—The two pushbuttons in the display modify group modify the display from normal frequency (or time reading) to another reading such as trigger level, gate time, delay time or displayed number of digits.

GATE/DELAY—The GATE/DELAY pushbutton has two functions: When instrument is in the frequency or period averaged functions, this button modifies the display to display the time that the gate remains open to complete one cycle. When instrument is in the time interval, period A or pulse A function, this button modifies the display to show the time that the closure of the gate is delayed after its opening. Press GATE/DELAY to exit.

TRIGGER LEVEL—The TRIGGER LEVEL button may be used to modify the display to show the trigger level of both channels A and B. Pressing the TRIGGER LEVEL button turns the indicator above the button on, indicating that the instrument is in the trigger level display mode. The display will contain two sets of readings (three digits for each channel). The three digits to the left on the display concern channel A, while the three digits to the right on the display concern channel B. Use CHAN A or CHAN B Level buttons to modify the values. Press TRIGGER LEVEL to exit.

Display Function—The display function allows the user to select the maximum number of most significant digits which are to be displayed. In the normal operating mode, the instrument will display a maximum of nine digits. The minimum number of digits displayed is three. To access the display function press simultaneously the GATE/DELAY and TRIGGER LEVEL buttons. Select the number of digits to be displayed by pressing the GATE/DELAY TIME ▲ or ▼ button to increment or decrement the display. To resume normal operation, simply press any other button on the front panel. The instrument will display its measurements with the preselected number of digits.

GATE/DELAY TIME—The two GATE/DELAY TIME buttons control: the time that the gate is open from 100μsec to 10sec in 46 steps; the delay of the gate closure from 100μsec to 10sec in 46 increments; and the number of digits to be displayed in increments of seven.

GATE/DELAY ▲, ▼—Each time the ▲ button is pressed, the gate or delay increments one step. Each time the ▼ button is pressed, the gate or delay decrements one step. If ▲ or ▼ button is held in for more than one second, the instrument will continuously increment or decrement. If the ▲ and ▼ buttons are held in at the same time, the instrument will jump to a preset position of 1sec delay time or nine digits displayed numbers.

User Gate/Delay Function—Information on accessing this function will be given later in this chapter.

LOCAL—Pressing the LOCAL button when the instrument is in remote operation (but not in remote (local) lockout condition), will place the instrument in local operation. Pressing this button when the instrument is already in local operation will have no effect on the instrument.

RESET—Pressing the RESET button during normal operation will reset the display and initiate a new measurement cycle. When the instrument is in the hold mode of operation, pressing the RESET button clears the display and arms the instrument for the next measurement.

2.2.2 Terminals

The terminals are used to connect the Model 775 to the signal to be measured.

Channel A—The CHAN A terminal is used when making frequency and time measurements.

Channel B—The CHAN B terminal is used when making frequency and time A→B measurements.

Channel C—The CHAN C terminal is used for high frequency measurements up to 1GHz with a 50Ω input impedance. Although this terminal is always installed, the internal circuitry needed to operate this function is optional and may not be installed. BNC shell is connected to chassis ground as indicated by the ⊥ symbol.

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2.2.3 Display and Indicators

The function of the display and indicators is described below.

Display—The display consists of a nine digit mantissa and a single digit exponent. The exponent uses a leading minus to indicate negative values. The sign on the exponent changes to + for zero or positive values. The dimension is determined by the exponent and the Hz, SEC or V indicators.

Units Indicators—The units are shown by three indicators. The Hz indicator is on during frequency measurements and the SEC indicator is on during time and period measurements. When TRIGGER LEVEL button is pressed, the V (volts) indicator turns on.

GATE Indicator—When the instrument takes a measurement, the GATE indicator blinks at a rate which is proportional to the gate time.

IEEE Status Indicators—The REMOTE, TALK and LISTEN indicators are used when programming the instrument over the IEEE-488 bus. Refer to Section 3 for complete IEEE programming information. These status indicators are not operational during front panel instrument operation.

2.2.4 Tilt Bail

The tilt bail, which is located on the bottom cover of the instrument, is useful for elevating the front of the instrument to a convenient viewing height. To extend the bail, first rotate it 90° away from the bottom cover and push up on the leg to lock it into place. To retract the bail, pull the legs away from the bottom cover and then rotate the bail until it is flush with the bottom cover.

2.3 REAR PANEL FAMILIARIZATION

Figure 2-2 shows the rear panel layout of the Model 775.

2.3.1 Connectors and Terminals

AC Receptacle—Power is applied through the supplied power cord to the 3-terminal AC receptacle. Note that the selected power supply voltage is marked on the rear panel above the line voltage selector switch.

IEEE-488 Connector—This connector is used to connect the instrument to the IEEE-488 bus. IEEE interface functions are marked above the connector.

TRIGGER LEVEL OUTPUT Connector—These two BNC connectors are used to connect the DC voltage level from the trigger circuits to an external DMM or oscilloscope. DC output range is marked above the connectors.

CLOCK Connector—This BNC connector is used to output the internal clock as a reference to another instrument. The same input may be connected to an external clock reference. To use an external clock reference, the internal time base must be set for external operation. Refer to Section 6 for this procedure and proper signal levels to apply.

EXT ARMING & GATE/DELAY Connector—A BNC connector which may receive one of three signals: arming pulse, external gate signal or external delay pulse. This input is useful when gate or delay times other than the internal times are required or to take one reading with the Model 775 in synchronized with other equipment.

2.3.2 LINE VOLTAGE SELECTOR Switch

The LINE VOLTAGE SELECTOR switch selects the line voltage that the Model 775 will operate on. For information on voltage selection refer to Section 6.

2.3.3 IEEE-488 Address Switches

The IEEE-488 address switches are used to program the primary address for IEEE-488 interface operation. The address may be set from 0 to 30.

2.3.4 Line Fuse

The LINE FUSE provides protection for the AC power line input. For information on replacing this fuse, refer to Section 6.

2.4 POWER-UP PROCEDURE

The basic procedure of powering up the Model 775 is described below.

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

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CAUTION

Be sure the power line voltage agrees with the indicated value on the rear panel of the instrument. Failure to heed this warning may result in instrument damage. If necessary, the power line voltage may be changed by sliding the recessed LINE VOLTAGE SELECTOR switch to the required voltage position. Refer to Section 6 for details

WARNING

The Model 775 is equipped with a 3-wire power cord designed to be used with grounded outlets. When the proper connections are made, instrument chassis is connected to power line ground. Failure to use a properly grounded outlet may result in personal injury or death because of electric shock.

2. Turn on the power by depressing and releasing the POWER switch on the front panel.
3. The instrument will then begin operation by performing a display and indicator test for about one second. All mode and IEEE indicators will turn on and the display will appear as follows:

   8.8.8.8.8.8.8.8.8±8

   To verify that all display segments are operating, compare the instrument's display during the test with the above figure.
4. Once the test is completed, the instrument will perform ROM and RAM tests. If all these tests are passed, the display will show the software revision level for about one second similar to the example below:

   SoFt A.1

5. Following the software revision level, the instrument will display the default IEEE primary address which is set by the IEEE address switch on the rear panel. For example, with the rear panel switch set to address 23, the display will show:

   IE Adr 23

6. Following these display messages, the instrument will go into the normal operating mode and is ready to take readings. The instrument will be in the following configuration:
   - Freq A
   - Gate/Delay Time = 1Sec
   - Trigger Levels = 0.00V
   - Filters: Off
   - Attenuators: Off
   - DC/AC: DC
   - Slope: Positive
   - Mode: Normal
   - IEEE Status: Local
   - Displayed digits: 9
7. If any of the power tests fail, the instrument will lock up and display an error message as follows:

   FAtAL Err 1

   It is recommended that the power-up procedure be repeated several times to verify that a consistent error occurs; if so, a problem exists in the instrument. See Section 6 for troubleshooting information.

2.5 DISPLAY MESSAGES

The Model 775 has two display messages associated with basic front panel operation. One message indicates that Model 7751 option is not installed, the other that gate time or delay time are user selectable. Note that the instrument has a number of additional display messages associated with IEEE-488 programming.

2.5.1 No Option Message

The Model 7751 option must be installed in the instrument before it can measure frequencies through the channel C input terminal. If the FREQ C button is depressed and the Model 7751 option is not installed, the following message will be displayed:

no C oPt

NOTE

There are no additional software modifications required after the Model 7751 option is installed. After the Model 7751 option is installed, the no option message will no longer be displayed.

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2.6 CONTROL SELECTION

Selecting the various front panel operating modes is simply a matter of depressing, once or twice, the appropriate button as described in the following paragraphs.

2.6.1 Function

The Model 775 must be set up for the proper measuring function with one of the four function buttons.

1. To measure frequency through the channel A input terminal, depress the FREQ button.
2. To measure frequency through the channel B input terminal, depress the FREQ button a second time.
3. To measure the period of a signal through the channel A input terminal, depress the PERIOD button.
4. To measure the period averaged of a signal through the channel A input terminal, depress the PERIOD button a second time.
5. To measure time intervals from events in channel A to events in channel B, depress the TIME button.
6. To measure the pulse width of a pulse at channel A input terminal, depress the TIME button a second time. Use the slope button(s) to select the desired portion of the input signal.
7. To measure frequency through the channel C input terminal, depress the FREQ C button.

2.6.2 Selecting Gate Time

The Model 775 may be operated in the present gate time of one second or in one of 46 gate times which are factory selected. When selecting the gate time, the instrument will move up or down one gate time each time the ▲ or ▼ button is pressed. The present gate time may be noted on the display by pressing the GATE/DELAY button.

Select the gate time as follows:

1. Press the GATE/DELAY button. The GATE/DELAY light will turn on and the instrument will display the following message:

   GAtE DDD±D SEC

2. To change the gate time press the GATE/DELAY TIME ▲ or ▼ button. Pressing the ▲ button will increase the gate time. Conversely, pressing the ▼ button will decrease the gate time. Holding in the ▲ or ▼ button for more than one second, causes the instrument to increment or decrement continuously.
3. Pressing the ▲ and ▼ buttons simultaneously will change the gate time to a preset value of 1sec.
4. To resume normal display operation, depress the GATE/DELAY button. The GATE/DELAY light will turn off and instrument will be ready to perform measurements with the newly selected gate time. Table 2-1 lists the gate/delay times which are available.

It is also possible to change the gate time without observing the actual gate time on the display. To do so, simply press the GATE/DELAY TIME ▲ or ▼ button. Each time the ▲ button is pressed, the instrument will increment one gate time. Each time the ▼ button is pressed, the instrument will decrement one gate time. Holding in the ▲ or ▼ button for more than one second, causes the instrument to increment (or decrement) after each measuring cycle.

Table 2-1. Gate/Delay Determination

100μsec	1msec	10msec	100msec	1sec	10sec
200μsec	2msec	20msec	200msec	2sec	User Gate/
300μSec	3msec	30msec	300msec	3sec	User Delay
400μsec	4msec	40msec	400msec	4sec	
500μsec	5msec	50msec	500msec	5sec	
600μsec	6msec	60msec	600msec	6sec	
700μsec	7msec	70msec	700msec	7sec	
800μsec	8msec	80msec	800msec	8sec	
900μsec	9msec	90msec	900msec	9sec	

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NOTE

To prevent operator error, there is an internal alarm that beeps whenever a limit is reached. (e.g. 100μsec low limit or 10sec high limit). With the GATE/DELAY light on, the alarm will sound when the users gate is displayed and the ▲ button is pressed. Refer to Table 2-2 alarm conditions.

2.6.3 User Gate Function

The user gate function is useful when a gate time other than the predetermined gate times listed in Table 2-1 is required. The limits which must be observed are the minimum limit of 100μsec and the maximum limit of 10sec. The user gate function is accessible in the FREQ A, B and C and Period Averaged functions. To operate the instrument in the user gate mode proceed as follows:

1. Press the GATE/DELAY button and observe that the light turns on and the instrument displays the following message:

   GAtE DDD±D SEC

   This display shows the actual gate time that the instrument is set to operate. DDD±D SEC may be any time from 100E-6 to 10E+0.
2. Press and hold in the GATE/DELAY TIME ▲ button and observe that the display increments. After the 10sec gate time the instrument will enter the user gate mode and the instrument will display the following:

   USEr GATE SEC

   Pressing the ▲ button after the gate is displayed will sound an alarm.
3. Press the GATE/DELAY button. The light will turn off and the instrument will be ready for measurements with an external gate time.
4. Apply a TTL pulse to the rear panel EXT ARMING & GATE/DELAY BNC terminal. The high level of the TTL pulse width determines the length of the gate time.

NOTE

The user gate function may be accessed only when the GATE/DELAY light is on. To exit the user gate function press the GATE/DELAY TIME ▼ button, or both the ▲ and ▼ buttons to preset the gate time to 1sec.

2.6.4 Using Delay

The Model 775 has a delay function which disables the closure of the opened gate for the predetermined periods listed in Table 2-1. This function is very useful in burst measurements, relay open/close time measurements where bounce time should be eliminated or in measurements done on a train of pulses.

NOTE

The delay mode is accessible only when PERIOD A, TIME A→B or PLS A functions are on. The selection of any other function, when the DELAY light is on, will cause the instrument to exit from delay mode.

The delay time may be selected as follows:

1. Press the GATE/DELAY button. The GATE/DELAY light will turn on and the instrument will display the following message:

   dELAY DDD±D SEC

2. To change the delay time, press the GATE/DELAY TIME ▲ or ▼ button. When the ▲ or ▼ button is depressed for more than one second, the instrument will increment or decrement continuously.
3. Pressing the ▲ and ▼ buttons simultaneously will change the delay time to a preset value of 1sec.
4. To resume normal display operation, press the GATE/DELAY button. The GATE/DELAY light will turn off and instrument will be ready to perform measurement with the newly selected delay time. Table 2-1 lists the gate/delay times which are available as preselected values.

It is also possible to change the delay time without observing the actual delay time on the display. To do so, simply press the GATE/DELAY TIME ▲ or ▼ button. Each time the ▲ button is pressed, the instrument will increment one delay time. Each time the ▼ button is pressed, the instrument will decrement one delay time. When ▲ or ▼ button is held in for more than one second, the instrument will increment (or decrement) after each measuring cycle.

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NOTE

To prevent operator error, there is an internal alarm that beeps whenever a limit is reached. (e.g. 100μsec low limit or 10sec high limit). When the GATE/DELAY light is on, the alarm will sound when the user's delay is displayed and the ▲ button is pressed. Refer to Table 2-2.

2.6.5 User Delay Function

The user delay function is useful when a delay time other than the predetermined delay times listed in Table 2-1 is required. The limits which must be observed are the minimum limit of 100μsec and the maximum limit of 10,000sec. The user delay function is accessible in the PERIOD A, TIME A→B or PLS A functions. To operate the instrument in the user delay mode proceed as follows:

1. Press the GATE/DELAY button and observe that the light turns on and the instrument displays the following message:

   dELAY DDD±D SEC

   This display is the actual delay time that the instrument is set to operate. DDD±D SEC may be any time from 100E-6 to 10E+0.
2. Press and hold in the GATE/DELAY TIME UP button and observe that the display increments. After the 10sec delay time the instrument will enter the user delay mode and the instrument will display the following:

   USEr dLAY SEC

   Pressing the ▲ button after the user delay time is displayed will sound an alarm.
3. Press the GATE/DELAY button and observe that the light turns off.
4. Press the MODE button twice. The first time the MODE button is pressed, the HOLD light will turn on. The second time the button is pressed, the DELAY light will turn on and the instrument will be ready for measurements with an external delay.
5. Apply a TTL high level pulse to the rear panel EXT ARMING & GATE/DELAY terminal. Delay would then be enabled as long as this input is kept at a TTL high level. The first negative transition to TTL low at this input will disable the delay. The delay would then be disabled as long as this input is kept at a TTL low level.

NOTE

The user delay function may be accessed only when the GATE/DELAY light is on. To exit the user delay mode simply depress the GATE/DELAY TIME ▼ button, or both the ▲ and ▼ buttons to preset the delay time to 1sec.

2.6.6 Selecting Measurement Rate

There are four measurement rates which are available on the Model 775. Only two measurement rates are accessible from the front panel: normal rate and single cycle (Hold). The other measurement rates are accessible only via the rear panel IEEE-488 bus and will be discussed in further detail in Section 3. To select the measurement rate proceed as follows:

1. Refer to the front panel MODE indicator: The HOLD light determines the rate of measurement. When the indicator is off, the instrument is in the normal measurement rate.
2. Press the HOLD button. The HOLD light will turn on and the instrument will go into the one-shot measurement cycle.
3. Press the RESET button. This action will clear the display and the Model 775 will be ready to take and process the next signal from the input terminal (see paragraph 2.7 for arming).

2.6.7 Selecting the Number of Displayed Digits

A major advantage of the Model 775 is its capability to display a fixed number of digits regardless of the frequency of the signal. For example, with a one second gate time, the Model 775 is capable of displaying a minimum of eight digits. This however, may turn out to a disadvantage when measuring a frequency of a relatively unstable signal in which just the most significant digits are stable and the least significant digits are "jumping around" with no significant meaning. Model 775 is designed in such a way that it truncates the unstable least significant digits while still preserving the full performance of the Model 775. To select the number of displayed digits proceed as follows:

1. Press the GATE/DELAY and TRIGGER LEVEL buttons simultaneously. The respective indicators will light and the following message will appear on the display.

   D dIGIt

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Where: D is any number from 3 to 9. The factory selected default number for D is nine. This means that the maximum number of digits that the Model 775 is capable of displaying 9.

2. To change the number of displayed digits, press the GATE/DELAY TIME ▲ or ▼ button until D is equal to the required number of digits.

NOTE

Selecting five digits to be displayed, instead of nine, will eliminate the four least significant digits and will move the entire display to the right by four places. An example of a normal display reading, and the same display reading with five digits of resolution is given as follows.

Display reading with nine digits:

1.13456789Hz

Display reading with selected five digits:

1.1345Hz

3. To return the Model 775 to the normal mode of operation, simply press any button on the front panel, except the LOCAL button.

NOTE

In certain circumstances, it is possible that the Model 775 will display less than nine digits. This may occur when the selected gate time is very small. In this case, the instrument will override the function of the selected number of digits and will display only as many digits as it can. When gate time is increased, the Model 775 will again limit the number of displayed digits to the selected value.

2.6.8 Input Condition Controls Setting

A proper setup of the input controls will ensure proper operation of the instrument. There are six buttons which control the input. These buttons are identical in both channels A and B.

Changing one of the input setting controls is simply a matter of pressing the required button. There are four lights which are associated with each of the controls which will turn on when a button is pressed.

To change the input setting proceed as follows:

1. To change the slope that the instrument will trigger on, press the SLOPE button. If the ⌝ indicator light is off, the counter will trigger on the positive edge of the input signal. If the ⌝ indicator light is on, the counter will trigger on the negative going edge.
2. To select the required coupling mode, press the AC/DC button. The instrument is in the DC coupling mode when the AC indicator light is off. When the AC indicator light is on, the instrument is in the AC coupling mode.
3. When the signal exceeds the specified dynamic range of the input, attenuation is required. To attenuate the signal, press the ATTEN button. The input signal will be attenuated by a factor of 10 when the light is on. When the light is off, the input signal will not be attenuated.
4. In low frequency measurements where the frequency range is below 100KHz, the use of a filter is recommended to attenuate high frequency signals which may interfere with the measurement. To apply a filter depress FLTR button, the FLTR light will turn on.

2.6.9 Setting Trigger Levels

There are two LEVEL buttons associated with both channels A and B. The LEVEL buttons set the signal voltage level that will trigger the instrument.

To set the trigger levels proceed as follows:

NOTE

The procedure for setting the trigger level is identical for channels A and B.

1. Press the TRIGGER LEVEL button. The TRIGGER LEVEL indicator will turn on and the display will read as follows:

-D.DD -D.DD VOLT

The display segment "-D.DD" may have any value from -2.55 to +2.55 if the "ATTEN" indicator is off. When the ATTEN indicator is on, the value may range from -25.5 to +25.5. Also, note that the left three digits on the display are associated with channel A and the three digits on the right side of the display are associated with channel B.

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2. Simultaneously press the two LEVEL buttons and note that the display section associated with channel A resets to 0. The display will appear as follows:

   0.00 -D.DD VOLTS

3. To set a positive trigger level press the ▲ button. Holding in the ▲ or ▼ button for more than a ½ second, will cause the instrument to increment or decrement continuously.

NOTE

Pressing the LEVEL ▲ or ▼ button, when the limits of +2.55 or -2.55 respectively have been reached, will sound an alarm.

4. Press the TRIGGER LEVEL button. The indicator light will turn off and the instrument will return to the previous measurement state.

NOTE

It is also possible to change the trigger level setting without observing the trigger level setting on the display. To do so, proceed as follows:

1. Select a function and gate time as discussed previously in this section and apply the signal to be measured to the appropriate input terminal.
2. To preset the trigger level, press both LEVEL ▲ and ▼ buttons simultaneously. Observe the display, if the GATE light flashes and the Model 775 displays a steady result, there is no further need to change the trigger level setting. If the GATE light does not flash or the reading is noisy, press and hold in the LEVEL ▲ button. The instrument will increment until the bottom peak of the signal is found. At this point the instrument will beep, signaling to the user that the signal has been found, and the GATE light will flash at a rate equal to the gate time. Pressing and holding in the LEVEL ▲ button after the signal has been found will increment the instrument once after every measurement cycle.

   If the signal cannot be found in the positive range of 0V to 2.55V, the Model 775 will beep continuously until the ▲ button is released. In this instance, continue to search for the signal in the negative range of 0V to -2.55V using the ▼ button.

2.6.10 Selecting Totalize Operation

The totalize mode is used when counting the number of pulses at the Channel A input terminal. Pulses may be repetitive or erratic. When the Model 775A is set to operate with infinite gate time, pulses are counted for as long as they are present at the input terminal. This is called cummulative totalize mode. It is also possible to limit the amount of time that the pulses are counted. This is done by utilizing the totalize A by B mode, where a gating signal on Channel B permits counting of channel A pulses

To operate the Model 775A in totalize A by B, proceed as follows:

1. Simultaneously press the FREQ and PERIOD buttons. Note that all function lights are turned off, indicating that the instrument is set to operate in totalize.

   NOTE: Upon power up, the totalize function defaults to totalize A by B.
2. Connect the signal to be counted to the Channel A input terminal.
3. Connect the gating signal to the Channel B input terminal. The GATE light illuminates whenever the level at Channel B is above the selected trigger level.

   NOTE: Press the RESET key to set counts back to zero.
4. Set Channels A and B to the required trigger level, making sure that the gating signal will cross the threshold level.

   NOTE: Whenever the voltage level at the Channel B input terminal is above the Channel B programmed trigger level, the gate will open and the Model 775A will accumulate the counted pulses at the Channel A input. The gate may also be left open when Channel B is set to a negative trigger level and no cable is connected to its input.

To operate the Model 775A in the cumulative totalize mode, proceed as follows:

1. Simultaneously press the FREQ and PERIOD buttons. Note that all function lights are turned off, indicating that the instrument is set to operate in totalize.
2. Press the GATE/DELAY button. The GATE/DELAY light turns on and the instrument displays the following message:

   tot A by B

   The Model 775A is set to operate in totalize A by B.
3. To operate with infinite gate time, press the GATE/DELAY ▲ button once. The instrument displays the following message:

   tot InF

   The Model 775 is set to operate in totalize mode with an infinite gate time. Repeatedly pressing the button will toggle the unit between the two gating options.

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4. Press the GATE/DELAY button. The GATE/DELAY indicator turns off and the GATE light turns on.
5. Connect the signal to be counted to the Channel A input terminal. The Model 775A will begin accumulating counts.

2.7 ARMING

Arming allows a measurement to be triggered by the input signal. The Model 775 may be armed to take readings in four ways:

1. Continuously armed in the normal mode.
2. With the front panel RESET button when the instrument is in hold mode.
3. Through an arming pulse applied to the rear panel EXT ARMING & GATE/DELAY input when the instrument is in the hold mode.
4. With commands given over the IEEE-488 bus as described in Section 3. This section covers front panel and external arming in detail.

2.7.1 Continuous Arming

When the instrument is not in the hold mode and there is no signal present at the input terminals, the instrument will stay in the idle state and the GATE light will not flash. An input signal with the correct dynamic range and correct input control setting will initiate, a measurement cycle and the GATE light will flash every time the internal gate opens.

2.7.2 Front Panel Arming

Front panel arming is done with the RESET button. This arming mode is very useful in burst measurements where a signal is present only temporarily. To use front panel arming perform the following steps.

1. Enter the hold mode by pressing the MODE button. The HOLD light will turn on and the GATE light will cease flashing; indicating the instrument is in the one-shot arming mode. The display will zero and no new readings are processed until an arming stimulus is applied.
2. To trigger a single reading, press and release the RESET button. The instrument will be ready to take and process the next reading.
3. To arm the instrument for a new measurement, press the RESET button, the display will zero.
4. To remove the instrument from the one-shot arming mode, press the MODE button until the HOLD light turns off.

2.7.3 External Arming

External arming operates much like front panel arming except for the arming stimulus itself. In this case the arming stimulus is applied to the rear panel EXT ARMING & GATE/DELAY terminal (see Figure 2-2). The input arming pulse must conform to TTL levels. To use external arming, proceed as follows:

1. Place the instrument in the hold mode by pressing the MODE button, (refer to paragraph 2.7.2). Note that the GATE light will not flash, indicating that the instrument is in one-shot mode. The instrument will cease processing readings while it is waiting for the arming signal.
2. Connect the external arming source to the rear panel EXT ARMING & GATE/DELAY connector. The first positive going pulse at the input terminal will cause the Model 775 to take and process the next available signal. Note that after each positive going transition of the arming signal, the numeric display will be set to read zero until the next data is processed and displayed.
3. To return the instrument to the continuous mode, press and release the MODE button until the HOLD light turns off.

2.7.4 Alarm Conditions

Table 2-2 lists the front panel conditions that will cause the instrument to sound an audible alarm. Some of these conditions are errors, while others provide information to the user.

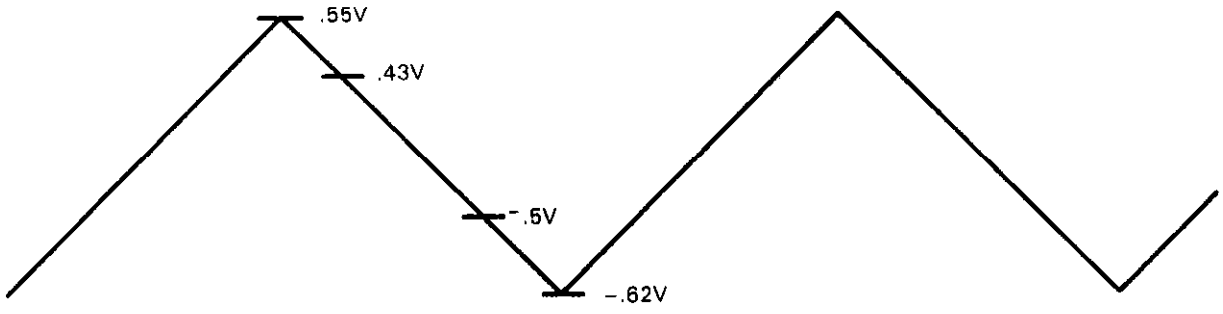
Table 2-2. Alarm Conditions

Item	Description
1	Pressing two buttons other than those specified as legal.
2	Pressing the GATE/DELAY TIME ▲ or ▼ button when high or low limits are reached.
3	Pressing the LEVEL ▲ or ▼ button when upper or lower limits are reached.
4	After selecting the number of digits to be displayed, pressing the LEVEL ▲ or ▼ button after the limits are reached.

2.8 APPLICATIONS

Applications for the Model 775 are many and varied and will depend on the user's needs. Figure 2-3 contains an application concerning fall time measurements; while Figure 2-4 contains an application using delay to measure contact dwell time. For application information on high frequency multiplexed measurements, refer to Figure 2-5.

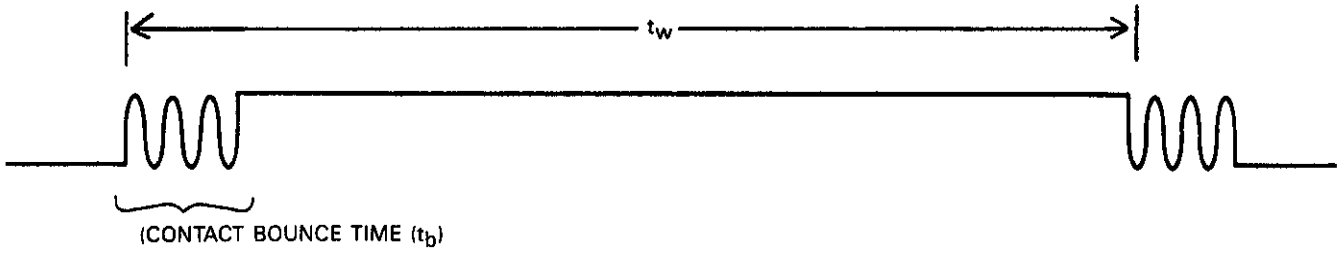
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1. Attach the input to channels A and B. (Use a BNC TEE connector.)
2. Display the trigger levels and adjust level A = 2.55V, level B = −2.55V.
3. Display frequency A and hold the level ▼ button in until a gate occurs.
4. Display frequency B and hold the level ▲ button in until a gate occurs.
5. Display trigger levels to realize the p-p voltage of the input signal. Assuming figure above, trigger A = .55V and trigger B = −.62V.
   NOTE: While displaying frequency and holding a level button, the trigger level changes rapidly until a reading is triggered; after which the level changes slowly (at one step per reading). This feature provides a means to detect the peaks of an input signal.
6. Set trigger A and trigger B levels to the 90% and 10% points (i.e. A = .43V and B = −.5V).
7. Set CHAN A and CHAN B to negative slope.
8. Display fall time by displaying time A→B.
   NOTE: To verify the above procedure, measure the trigger level output voltage at the rear panel of the Model 775.
9. To use this procedure over the bus, trigger levels must be sent by the controller, while monitoring the serial poll byte for "reading done". See Section 3 of this instruction manual.

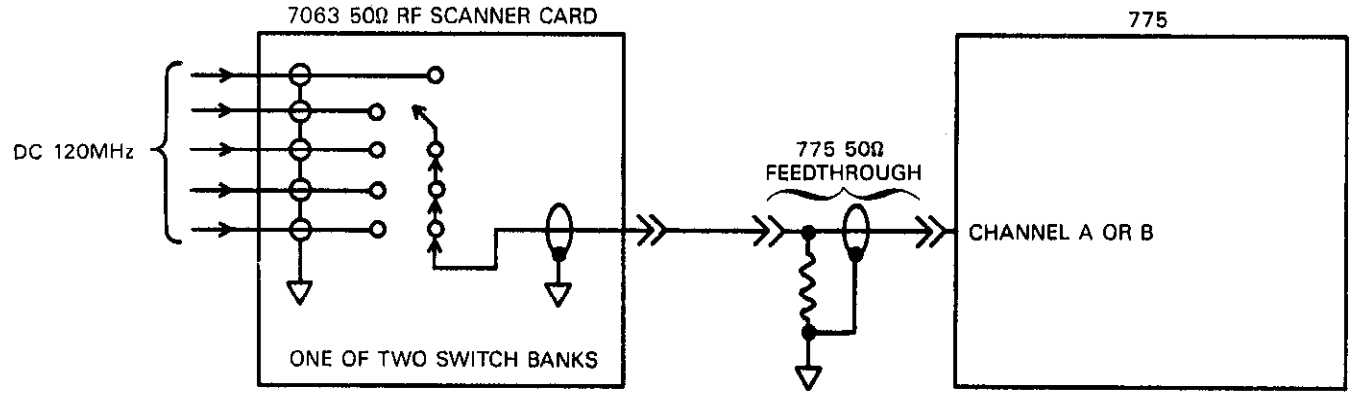
Figure 2-3. Fall Time Measurement

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1. Connect a signal to channel A input and select TIME PLS A.
2. Set the slope at channel A to trigger on the rising or the falling edge, for high time or low time measurements.
3. Set the delay time to a value between the bounce time (t_b) and the pulse width (t_w) so that the bouncing is ignored.
4. The counter is now reading t_w time. The delay in gate closing prevented the initial bounce time from prematurely closing the gate.

Figure 2-4. Using Delay to Measure Contact Dwell Time



1. Use a 50Ω feedthrough terminator (Model 7755) to balance line at inputs of channel A or B.

Figure 2-5. High Frequency Multiplexed Mesurements

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SECTION 3
IEEE-488 OPERATION

3.1 INTRODUCTION

The IEEE-488 bus is an instrumentation data bus with standards adopted by the IEEE (Institute of Electrical and Electronic Engineers) in 1975 and given the IEEE-488 designation. The most recent revision of bus standards was made in 1978; hence the complete description for current bus standards is the IEEE-488-1978 designation. The Model 775 conforms to 1978 standards.

This section contains general bus information as well as detailed programming information and is divided as follows:

1. General introductory information pertaining to the IEEE-488 bus may be found primarily in paragraphs 3.2 through 3.6.
2. Information necessary to connect the Model 775 to the bus is contained in paragraph 3.7 and 3.8.
3. General bus command programming is covered in paragraph 3.9.
4. Device-dependent command programming is described in detail in paragraph 3.10. The commands outlined in this section can be considered to be the most important since they control virtually all instrument functions.
5. Additional information pertaining to front panel error messages and controller programs can be found in paragraphs 3.11 and 3.12.

3.2 BUS DESCRIPTION

The IEEE-488 bus as designed as a parallel data transfer medium to optimize data transfer without using an excessive number of bus lines. In keeping with this goal, the bus has only eight data lines that are used for both data and most commands. Five bus management lines and three handshake lines round out the complement of signal lines. Since the bus is of parallel design, all devices connected to the bus have the same information available simultaneously. Exactly what is done with the information by each device depends on many factors, including device capabilities.

A typical bus configuration for controlled operation is shown in Figure 3-1. The typical system will have one controller and one or more instruments to which commands are given and, in most cases, from which data is received. Generally, there are three categories that describe device operation. These designations include: controller; talker; listener.

The controller does what its name implies: it controls other devices on the bus. A talker sends data, while a listener receives data. Depending on the instrument, a particular device may be a talker only, a listener only, or both a talker and listener.

Any given system can have only one controller (control may be passed to an appropriate device through a special command), but any number of talkers or listeners may be present up to the hardware constraints of the bus. Generally, the bus is limited to 15 devices, but this number may be reduced if higher than normal data transfer rates are required or if longer than normal cables are used.

Several devices may be commanded to listen at once, but only one device may be a talker at any given time. Otherwise, communications would be scrambled.

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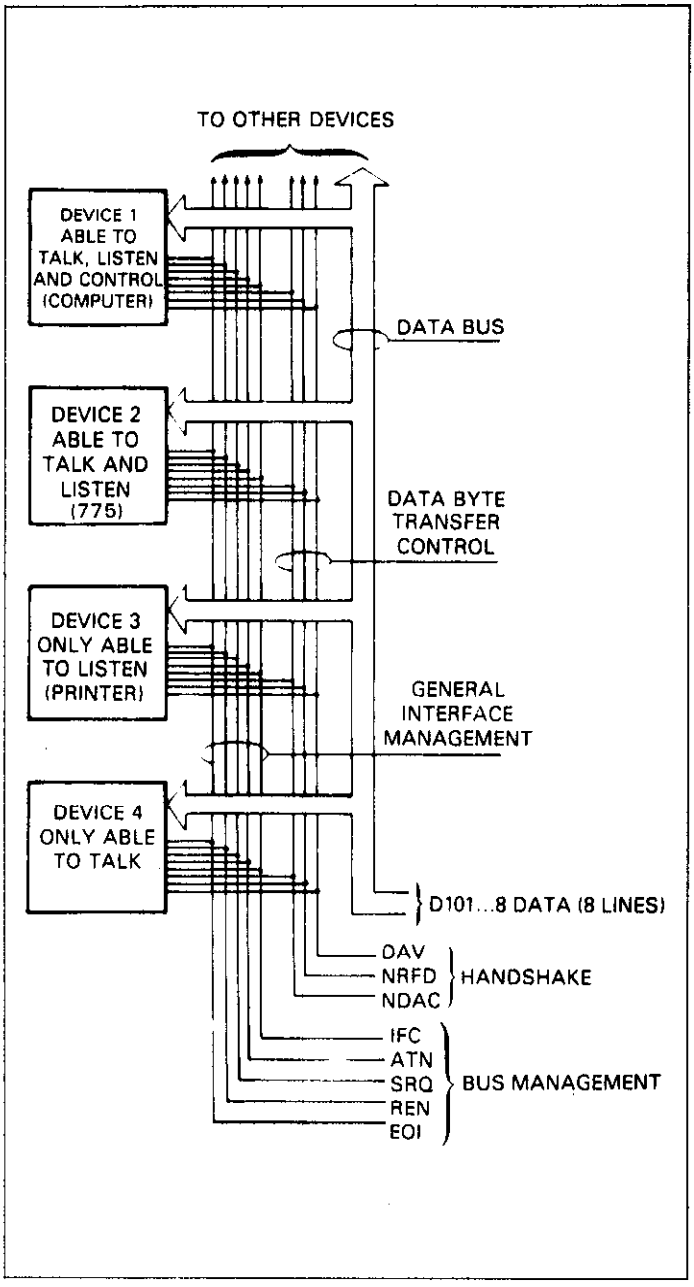


Figure 3-1. IEEE Bus Configuration

Before a device can talk or listen, it must be appropriately addressed. Devices are selected on the basis of their primary address; the addressed device is sent a talk or listen command derived from its primary address. Normally, each device on the bus has a unique primary address so that each may be addressed individually. The bus also has another addressing mode called secondary addressing, but not all devices use this addressing mode.

Once the device is addressed to talk or listen, appropriate bus transactions are set to take place. For example, if an instrument is addressed to talk, it will usually place its data on the bus one byte at a time. The listening device will then read this information, and the appropriate software can then be used to channel the information to the desired location.

3.3 IEEE-488 BUS LINES

The signal lines on the IEEE-488 bus are grouped into three general categories. The data lines handle bus information, while the handshake and bus management lines ensure that proper data transfer and bus operation takes place. Each of the bus lines is active low so that approximately zero volts is a logic one. The following paragraphs describe the purpose of these lines, which are shown in Figure 3-1.

3.3.1 Bus Management Lines

The bus management group is made up of five signal lines that help ensure an orderly transfer of data. These lines are used to send the uniline commands described in paragraph 3.4.1.

ATN (Attention)—The ATN line is one of the more important management lines. The state of the ATN line determines whether controller information on the data bus is to be considered data or a multiline command as described in paragraph 3.4.

IFC (Interface Clear)—Setting the IFC line true (low) causes the bus to go to a known state.

REN (Remote Enable)—Setting the REN line low sends the REN command. This sets up instruments on the bus for remote operation.

EOI (End Or Identify)—The EOI line is used to send the EOI command that usually terminates a multi-byte transfer sequence.

SRQ (Service Request)—The SRQ line is set low by a device when it requires service from the controller.

3.3.2 Handshake Lines

The bus uses three handshake lines that operate in an interlocked sequence. This method ensures reliable data transfer regardless of the transfer rate. Generally, data

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transfer will occur at a rate determined by the slowest active device on the bus.

One of the handshake lines is controlled by the data source, while the remaining two lines are controlled by accepting devices. The three bus handshake lines are:

DAV (Data Valid)—The source controls the state of the DAV line.

NRFD (Not Ready For Data)—The acceptor controls the state of the NRFD line.

NDAC (Not Data Accepted)—The acceptor also controls the NDAC line.

The complete handshake sequence for one data byte is shown in Figure 3-2. Once data is on the bus, the source checks to see that NRFD is high, indicating that all devices on the bus are ready for data. At the same time NDAC should be low from the previous byte transfer. If these conditions are not met, the source must then wait until the NRFD and NDAC lines have the correct status. If the source is a controller, NRFD and NDAC must remain stable for at least 100nsec after ATN is set low. Because of the possibility of bus hang up, some controllers have time-out routines to display error messages if the handshake sequence stops for any reason.

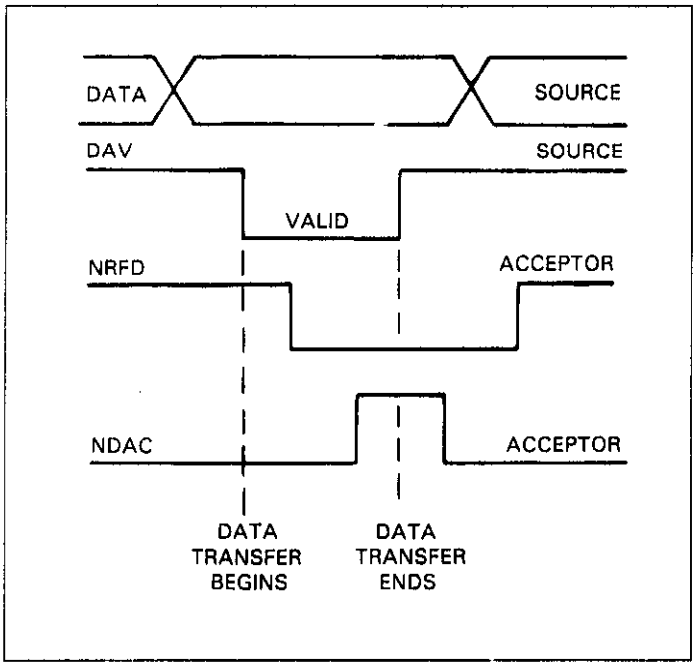


Figure 3-2. IEEE Handshake Sequence

Once the NRFD and NDAC lines are properly set, the source sets the DAV line low, indicating that data on the bus is now valid. The NRFD line then goes low; the NDAC line goes high once all devices on the bus have accepted the data. Each device will release the NDAC line at its own rate, but the NDAC line will not go high until the slowest device has accepted the data byte.

After the NDAC line goes high, the source then sets the DAV line high to indicate that the data on the bus is no longer valid. At this point, the NDAC line returns to its low state. Finally, the NRFD line is released by each of the devices at their own rates, until the NRFD line finally goes high when the slowest device is ready, and the bus is set to repeat the sequence with the next data byte.

The sequence just described is used to transfer both data and multiline commands. The state of the ATN line determines whether the data bus contains data or commands as described in paragraph 3.4.

3.3.3 Data Lines

The IEEE-488 bus uses the eight data lines that allow data to be transmitted and received in a bit-parallel, byte-serial manner. These eight lines use the convention DIO1 through DIO8 instead of the more common D0 through D7 binary terminology. The data lines are bidirectional and, as with the remaining bus signal lines, low is true.

3.4 BUS COMMANDS

While the hardware aspect of the bus is essential, the interface would be essentially worthless without appropriate commands to control communications between the various instruments on the bus. This paragraph briefly describes the purpose of the bus commands, which are grouped into the following three general categories:

Uniline commands—Sent by setting the associated bus line low.

Multiline commands—General bus commands which are sent over the data lines with the ATN line low (true).

Device-dependent commands—Special commands that depend on device configuration; sent over the data lines with ATN high (false).

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Table 3-1. IEEE-488 Bus Command Summary

Command Type	Command	State of ATN Line*	Comments
Uniline	REN (Remote Enable)	X	Set up for remote operation.
	EOI	X	Sent by setting EOI low.
	IFC (Interface Clear)	X	Clears Interface
	ATN (Attention)	Low	Defines data bus contents.
	SRQ (Service Request)	X	Controlled by external device.
Multiline			
Universal	LLO (Local Lockout)	Low	Locks out front panel controls.
	DCL (Device Clear)	Low	Returns device to default conditions.
	SPE (Serial Poll Enable)	Low	Enables serial polling.
	SPD (Serial Poll Disable)	Low	Disables serial polling.
Addressed	SDC (Selective Device Clear)	Low	Returns unit to default conditions.
	GTL (Go To Local)	Low	Returns to local control.
	GET (Group Execute Trigger)	Low	Triggers device for reading.
Unaddress	UNL (Unlisten)	Low	Removes all listeners from bus.
	UNT (Untalk)	Low	Removes all talkers from bus.
Device-dependent**		High	Programs Model 775 for various modes.

*X = Don't Care
**See paragraph 3.10 for complete description

3.4.1 Uniline Commands

Uniline commands are sent by setting the associated bus line low. The ATN, IFC and REN commands are asserted only by the system controller. The SRQ command is sent by an external device. The EOI command may be sent by either the controller or an external device depending on the direction of data transfer. The following is a brief description of each command.

REN (Remote Enable)—When the controller sends the REN command, the instrument will be set up for remote operation. Generally, the REN command should be sent before attempting to program instruments over the bus.

EOI (End Or Identify)—The EOI command is sent to positively identify the last byte in a multi-byte transfer sequence. This allows variable length data words to be transmitted easily.

IFC (Interface Clear)—The IFC command is sent to clear the bus and set device to a known state. Although device configurations differ, the IFC command usually places instruments in the talk and listen idle states.

ATN (Attention)—The controller sends ATN while transmitting addresses or multiline commands. Device-dependent commands are sent with the ATN line high (false).

SRQ (Service Request)—The SRQ command is asserted by an external device when it requires service from the controller. If more than one device is present, a serial polling sequence, as described in paragraph 3.9.8, must be used to determine which device has requested service.

3.4.2 Universal Commands

Universal commands are multiline commands that require no addressing. All instrumentation equipped to implement the command will do so simultaneously when the command is transmitted over the bus. As with all multiline commands, the universal commands are sent over the data lines with ATN low.

LLO (Local Lockout)—The LLO command is used to lock out front panel controls on devices so equipped.

DCL (Device Clear)—After a DCL is sent, instrumentation equipped to implement the command will revert to a known state. Usually, instruments return to their power-up conditions.

SPE (Serial Poll Enable)—The SPE command is the first step in the serial polling sequence, which is used to determine which instrument has requested service with the SRQ command.

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SPD (Serial Poll Disable)—The SPD command is sent by the controller to remove all instrumentation on the bus from the serial poll mode.

3.4.3 Addressed Commands

Addressed commands are multiline commands that must be preceded by a listen command derived from the device's primary address before the instrument will respond. Only the addressed device will respond to each of these commands:

SDC (Selective Device Clear)—The SDC command performs essentially the same function as the DCL command except that only the addressed device will respond. Instruments usually return to their default conditions when the SDC command is sent.

GTL (Go To Local)—The GTL command is used to remove instruments from the remote mode of operation. Also, front panel control operation will usually be restored if the LLO command was previously sent.

GET (Group Execute Trigger)—The GET command is used to trigger devices to perform a specific action that depends on device configuration. Although GET is considered to be an addressed command, many devices respond to GET without being addressed.

3.4.4 Unaddressed Commands

The two unaddressed commands are used by the controller to remove all talkers and listeners from the bus simultaneously. ATN is lov. when these multiline commands are asserted.

UNL (Unlisten)—All listeners are removed from the bus at once when the UNL command is placed on the bus.

UNT (Untalk)—The controller sends the UNT command to clear the bus of any talkers.

3.4.5 Device-Dependent Commands

The meaning of the device-dependent commands is determined by instrument configuration. Generally, these commands are sent as one or more ASCII characters that tell the device to perform a specific function. For example, F0 is sent to the Model 775 to place the instrument in the frequency A mode. The IEEE-488 bus treats device-dependent commands as data in that ATN is high (false) when the commands are transmitted.

3.5 COMMAND CODES

Each multiline command is given a unique code that is transmitted over the data bus as 7-bit ASCII data. This section briefly explains the code groups which are summarized in Figure 3-3. Every command is sent with ATN low.

Addressed Command Group (ACG)—Addressed commands are listed in column 0(B) in Figure 3-3. Column 0(A) lists the corresponding ASCII codes.

Universal Commad Group (UCG)—Columns 1(A) and 1(B) list the universal commands and the corresponding ASCII codes.

Listen Address Group (LAG)—Columns 2(A) and 3(A) list the ASCII codes corresponding to the primary address listed in columns 2(B) and 3(B). For example, if the primary address of the instrument is set to 16, the LAG byte will correspond to an ASCII zero.

Talk Address Group (TAG)—TAG primary address values and the corresponding ASCII characters are listed in columns 4(A) through 5(B).

The preceding address groups are combined together to form the Primary Command Group (PCG). The bus also has another group of commands, called the Secondary Command Group (SCG). These are listed in Figure 3-3 for informational purposes only; the Model 775 does respond to these commands, but other devices may have secondary addressing capability.

NOTE

Commands are normally transmitted with the 7-bit code listed in Figure 3-3. For most devices, the condition of D7 (DIO8) is unimportant, as shown by the "Don't Care" indication in the table. Some devices, however, may require that D7 assumes a specific logic state before the commands are recognized.

Hexadecimal and decimal values for each of the commands or command groups are listed in Table 3-2. Each value in the table assumes that D7 is set to 0.

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Table 3-2. Hexadecimal and Decimal Command Codes

Command	Hex Value*	Decimal Value
GTL	01	1
SDC	04	4
GET	08	8
LLO	11	17
DCL	14	20
SPE	18	24
SPD	19	25
LAG	20-3F	32-63
TAG	40-5F	64-95
UNL	3F	63
UNT	5F	95

*Values shown with D_7=0

3.6 COMMAND SEQUENCES

The proper command sequence must be sent by the controller before an instrument will respond as intended. The universal commands, such as LLO and DCL, require only that ATN be set low before the command is sent. Other commands require that the device be addressed to listen first. This section briefly describes the bus sequence for several types of commands.

3.6.1 Addressed Command Sequence

Before a device will respond to one of these commands, it must receive a LAG command derived from its primary address. Table 3-3 shows a typical sequence for the SDC command. The LAG command assumes that the instrument is set at a primary address of 23.

Note that an UNL command is transmitted before the LAG, SDC sequence. This is generally done to remove all other listeners from the bus first so that only the addressed device responds.

Table 3-3. Typical Addressed Command Sequence

Step	Command	ATN State	Data Bus		
			ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	7	37	55
3	SDC	Stays low	EOT	04	4
4		Returns high			

*Assumes primary address=23

3.6.2 Universal Command Sequence

The universal commands are sent by setting ATN low and then placing the command byte on the bus. For example, the following gives the LLO command:

ATN•LLO

Note that both the ATN and LLO commands are on the bus simultaneously. Also, addressing is not necessary.

3.6.3 Device-Dependent Command Sequence

Device-dependent commands are transmitted with ATN high. However, the device must be addressed to listen first before the commands are transmitted. Table 3-4 shows the sequence for the following command:

F0X

This command, which sets the Model 775 to the frequency A mode, is described in detail in paragraph 3.10.2.

Table 3-4. Typical Device-Dependent Command Sequence

Step	Command	ATN State	Data Bus		
			ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	7	37	55
3	Data	Set high	F	46	70
4	Data	Stays high	0	30	48
5	Data	Stays high	X	58	88

*Assumes primary address=23

3.7 HARDWARE CONSIDERATIONS

Before the Model 775 can be used with the IEEE-488 bus, the instrument must be connected to the bus with a suitable connector. Also, the primary address must be properly programmed as described in this section.

3.7.1 Typical Controlled Systems

The IEEE-488 bus is a parallel interface system. As a result, adding more devices is simply a matter of using more cables to make the desired connections. Because of this flexibility, system complexity can range from the very simple to extremely complex.

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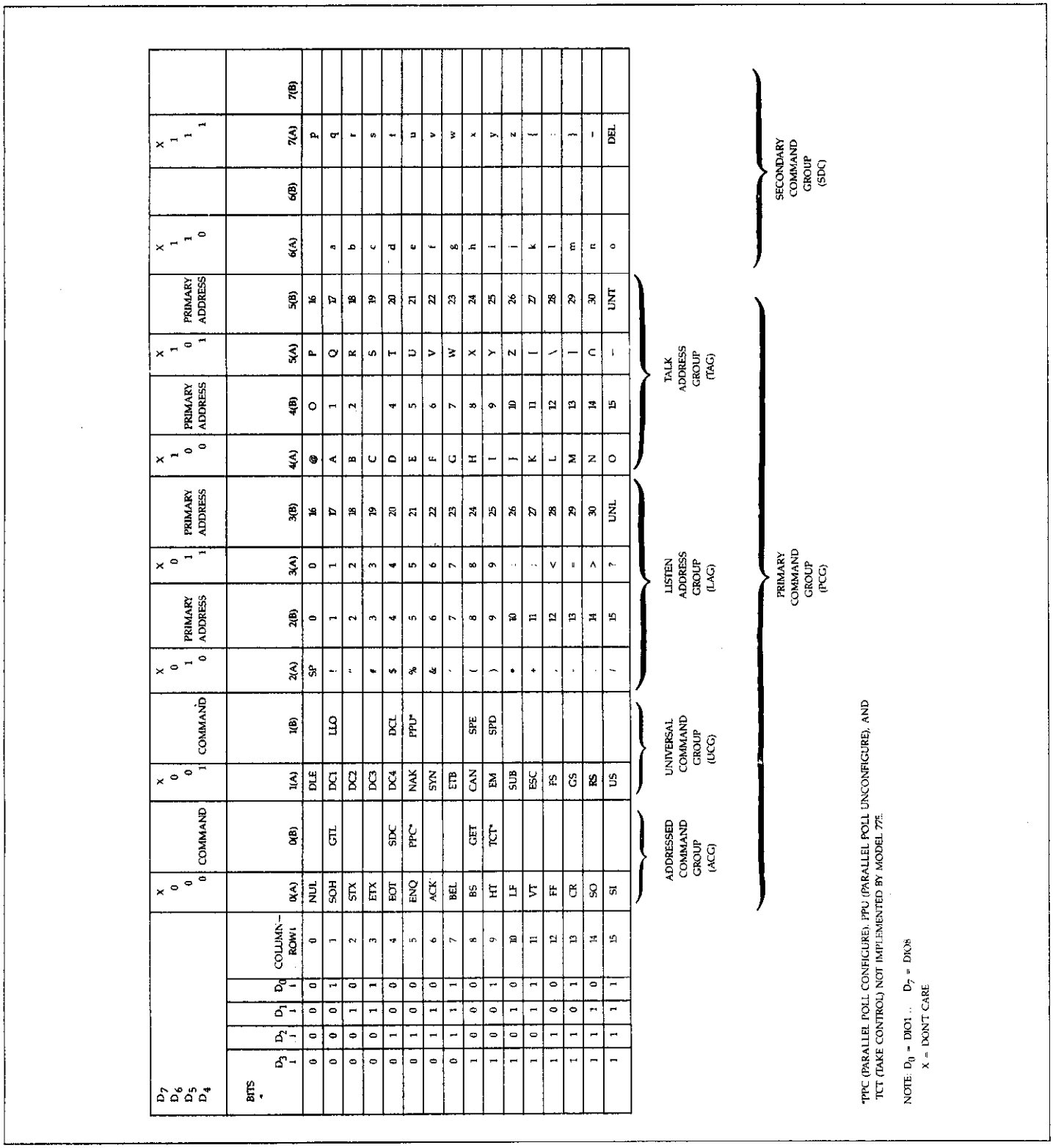


Figure 3-3. Command Codes

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Figure 3-4 shows two typical system configurations. Figure 3-4(A) shows the simplest possible controlled system. The controller is used to send commands to the instrument, which sends data back to the controller.

The system becomes more complex in Figure 3-4(B), where additional instrumentation is added. Depending on programming, all data may be routed through the controller, or it may be transmitted directly from one instrument to another.

For very complex applications, a much larger computer can be used. Tape drives or disks can then be used to store data.

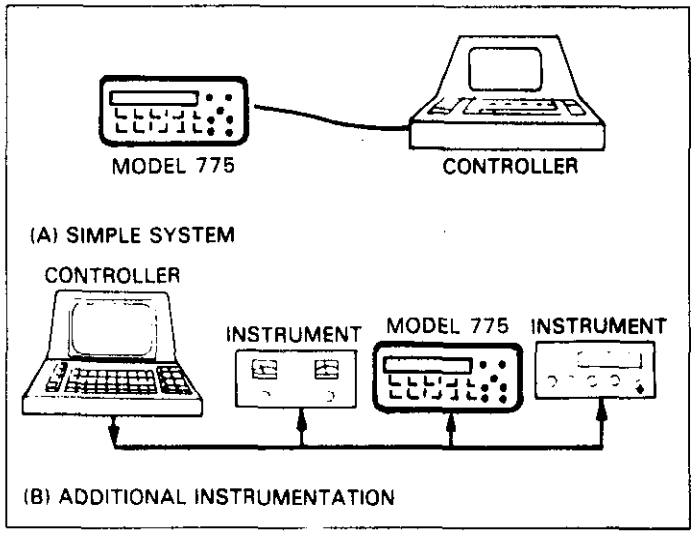


Figure 3-4. System Types

3.7.2 Bus Connections

The Model 775 is connected to the bus through an IEEE-488 connector which is shown in Figure 3-5. This connector is designed to be stacked to allow a number of parallel connections on one instrument.

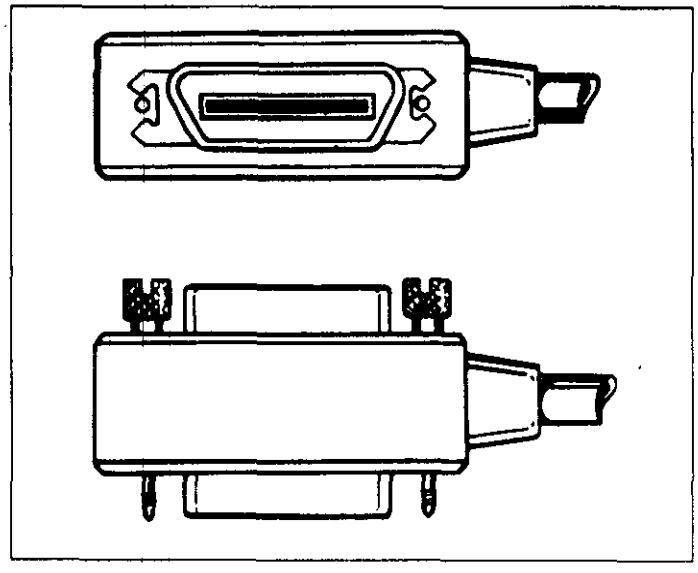


Figure 3-5. IEEE-488 Connector

NOTE
To avoid possible mechanical damage, it is recommended that no more than three connectors be stacked on any one instrument. Otherwise, the resulting strain may cause internal damage.

A typical connecting scheme for the bus is shown in Figure 3-6. Each cable normally has the standard IEEE connector on each end. The Keithley Model 7007 cable is ideal for this purpose. Once the connections are made, the screws should be tightened securely. For the location of the connector on the rear panel of the Model 775, refer to Figure 3-7.

NOTE
The IEEE-488 bus is limited to a maximum of 15 devices, including the controller. Also, the maximum cable length is 20 meters. Failure to observe these limits will probably result in erratic bus operation.

NOTE
For control of possible radio frequency interference, a shielded IEEE-488 cable (such as the Keithley Model 7007-1) must be used.

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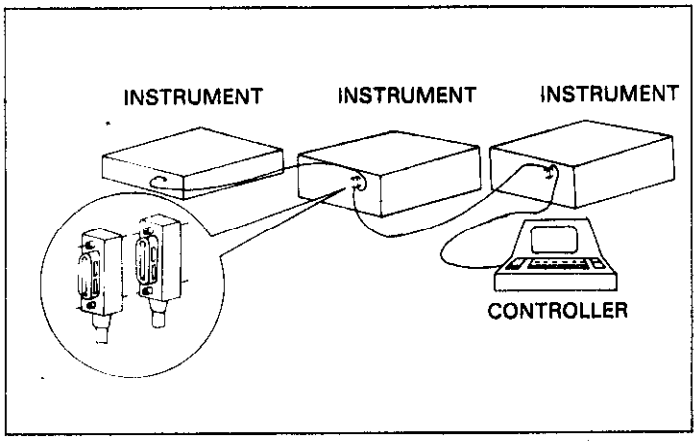


Figure 3-6. IEEE-488 Connections

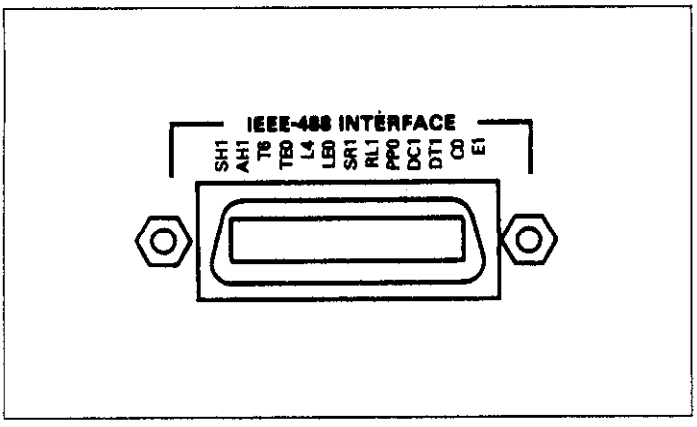


Figure 3-7. Rear Panel of Model 775 Showing IEEE Connector

Custom cables may be constructed using the information in Table 3-5 and Figure 3-6. Table 3-5 lists the contact assignments for the various bus lines, while Figure 3-8 shows contact designations. Contacts 18 through 24 are return lines for the indicated signal lines, and the cable shield is connected to contact 12 and the connector shell. Each ground line is connected to digital common in the Model 775.

Table 3-5. IEEE Contact Designations

Contact Number	IEEE-488 Designation	Type
1	DIO1	Data
2	DIO2	Data
3	DIO3	Data
4	DIO4	Data
5	EOI (24)*	Management
6	DAV	Handshake
7	NRFD	Handshake
8	NDAC	Handshake
9	IFC	Management
10	SRQ	Management
11	ATN	Management
12	SHIELD	Ground
13	DIO5	Data
14	DIO6	Data
15	DIO7	Data
16	DIO8	Data
17	REN (24)*	Management
18	Gnd, (6)*	Ground
19	Gnd, (7)*	Ground
20	Gnd, (8)*	Ground
21	Gnd, (9)*	Ground
22	Gnd, (10)*	Ground
23	Gnd, (11)*	Ground
24	Gnd, LOGIC	Ground

*Numbers in parentheses refer to signal ground return of referenced contact number. EOI and REN signal lines return on contact 24.

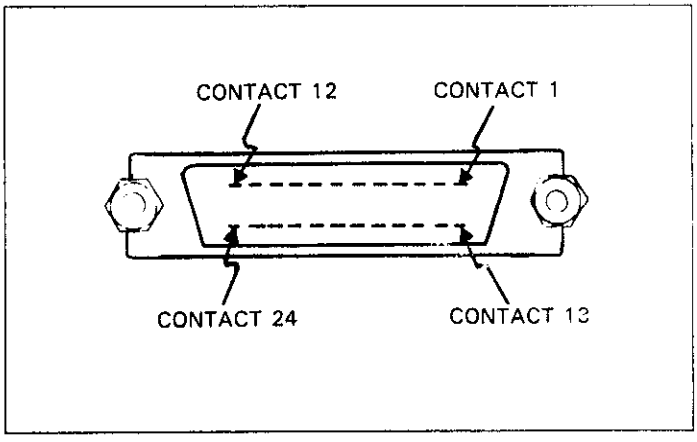


Figure 3-8. Contact Assignments

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CAUTION

The voltage between IEEE common and ground must not exceed 30V or damage to the instrument may occur.

A typical signal line bus driver is shown in Figure 3-9. With the configuration shown, the driver has bidirectional capability. When the I/O control line is high, the line is configured as an output line. When the control line is low, the driver is set up for input operation. Note that not all signal lines have bidirectional capability. Some lines, such as ATN, will always be configured as an output line in the controller and as an input line for all other devices on the bus.

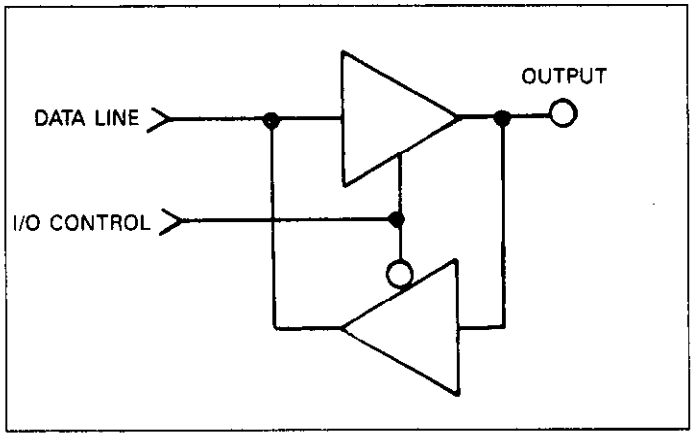


Figure 3-9. Typical IEEE-488 Bus Driver (One of 16)

3.7.3 Primary Address Programming

The Model 775 must receive a listen command before it will respond to addressed commands. Similarly, the instrument must receive a talk command before it will transmit its data string, status word, or status byte. These listen and talk commands are derived from the instrument's primary address. The Model 775 is shipped from the factory with primary address of 23. The primary address may be set to any value between 0 ad 30 as long as address conflicts with other bus instruments are avoided. This may be done by setting the address switch on the rear panel. Note that the primary address of the instrument must agree with the address specified in the controller's programming language.

NOTE

The programmed primary address is briefly displayed as part of the power-up cycle.

To check the present primary address:

1. Turn on the instrument.
2. The Model 775 will display the present primary address. For example, with the factory set value, the display will show the following:

IE Adr 23

This message will show on the display after a lamp test is complete and the version of the software has been displayed.

NOTES:

1. If a new address is set with the address switch on the rear panel, the instrument should be turned off and then on to activate the new address.
2. Each device on the bus must have a unique primary address. Failure to observe this precaution may result in erratic bus operation.

3.8 SOFTWARE CONSIDERATIONS

The most sophisticated computer in the world would be useless without the necessary software. This basic requirement is also true of the IEEE-488 bus, which requires the use of handler routines as described in this paragraph.

3.8.1 Controller Interface Routines

Before a controller can be used with the IEEE-488 interface, the user must make certain that appropriate handler software is present within the controller. With the HP-85 computer, for example, the HP-85 interface card must be used with an additional I/O ROM, which contains the necessary handler software.

Other small computers that can be used as controllers have limited IEEE command capability. The PET/CBM computers, for example, are incapable of sending multiline commands from BASIC, although these commands can be sent through machine language routines. The capabilities of other small computers depends on the particular interface being used. Often, little software "tricks" are required to achieve the desired results.

From the preceding discussion, the message is clear: make sure the proper software is being used with the instru-

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ment. Often, the user may incorrectly suspect that a hardware problem is causing fault, when it was the software that was causing the problem all along.

3.8.2 HP-85 BASIC Statements

Many of the programming instructions covered in this section use examples written in Hewlett-Packard Model 85 BASIC. The HP-85 was chosen for these examples because it has a large number of BASIC statements that control IEEE-488 operation. This section covers those HP-85 BASIC statements that are essential to Model 775 operation.

A complete list of HP-85 IEEE-488 BASIC statements is shown in Table 3-6. All the statements in the table have one or three digit arguments that must be specified. The first digit is the HP-85 interface select code, which is set to 7 at the factory. The last two digits of those statements that require a three digit argument specify the primary address. Generally, only those commands that actually require an address to be sent over the bus require that the primary address be specified in the BASIC statement.

Those statements in the table with three digit arguments assume that the primary address of the device is set at 23. Other primary addresses require that the last two digits be set to the corresponding value. For example, to send a GTL command to device 22, the following BASIC statement would be used: LOCAL 722.

Some of the statements in the table have two forms; the exact configuration used depends on the desired command. For example, CLEAR 7 will cause a DCL to be sent, while CLEAR 723 causes an SDC to be transmitted to device 23.

The third column of Table 3-6 lists the mnemonics for the command sequences. While most of these are covered elsewhere, a couple of points should be noted. As described earlier, the ATN line is set low by the controller if the data bus contains a multiline command. This is indicated in the table by ANDing the ATN mnemonic with the first command on the bus. For example, ATN•GET means that ATN and GET are sent simultaneously.

Table 3-6. HP-85 IEEE-488 BASIC Statements

Statement	Action	Bus Command Sequence
ABORTIO 7	Send IFC.	IFC
CLEAR 7	Send DCL.	ATN•DCL
CLEAR 723	Send SDC to device 23.	ATN•UNL;MTA;LAG;$\overline{\text{SDC}}$
ENTER 723;A$	Device 23 addressed to talk. Data placed in A$.	ATN•UNL;MLA;TAG;$\overline{\text{ATN}}$;data
LOCAL 723	Send GTL to device 23.	ATN•UNL;MTA;LAG;GTL
LOCAL LOCKOUT 7	Send LLO.	ATN•LLO
OUTPUT 723;A$	Device 23 addressed to listen. Transmit A$.	ATN•MTA;UNL;LAG;$\overline{\text{ATN}}$;data
REMOTE 7	Set REN true.	REN
REMOTE 723	Set REN true. Address device 23 to listen.	REN;ATN•UNL;MTA;LAG
RESET 7	Send IFC, cancel REN.	IFC;REN;$\overline{\text{REN}}$
SPOLL(723)	Address device 23 to talk. Conduct serial poll.	ATN•UNL;MLA;TAG;SPE;$\overline{\text{ATN}}$ status byte;ATN•SPD;UNT
TRIGGER 7	Send GET	ATN•GET
TRIGGER 723	Address device 23 to listen. Send GET.	ATN•UNL;MTA;LAG;GET

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Two commands not previously covered are MLA (My Listen Address) and MTA (My Talk Address). These are ordinary PCG (Primary Command Group) addresses sent by the HP-85 to facilitate bus operation.

NOTE

The HP-85 address is set to 21 at the factory. Since each device on the bus must have a unique primary address, do not program the Model 775 for the controller's address to avoid possible conflicts.

3.8.3 Interface Function Codes

The interface function codes are part of the IEEE-488-1978 standards. These codes define an instrument's ability to support various interface functions and should not be confused with programming commands found elsewhere in this manual.

Table 3-7 lists the codes for the Model 775. These codes are also listed for convenience on the rear panel of the instrument immediately above the IEEE connector. The numeric value following each one or two letter code defines Model 775 capabilities as follows:

SH (Source Handshake Function)—The ability for the Model 775 to initiate the transfer of message/data on the data bus is provided by the SH function.

AH (Acceptor Handshake Function)—The ability for the Model 775 to guarantee proper reception of message/data on the data bus is provided by the AH function.

T (Talker Function)—The ability for the Model 775 to send device-dependent data over the bus (to other devices) is provided by the T function. Model 775 talker capabilities exist only after the instrument has been addressed to talk.

L (Listener Function)—The ability for the Model 775 to receive device-dependent data over the bus (from other devices) is provided by the L function. Listener function capabilities of the Model 775 exist only after it has been addressed to listen.

SR (Service Request Function)—The ability for the Model 775 to request service from the controller is provided by the SR function.

RL (Remote-Local Function)—The ability for the Model 775 to be placed in the remote or local modes is provided by the RL function.

PP (Parallel Poll Function)—The Model 775 does not have parallel polling capabilities.

DC (Device Clear Function)—The ability for the Model 775 to be cleared (initialized) is provided by the DC function.

DT (Device Trigger Function)—The ability for the Model 775 to have its readings triggered is provided by the DT function.

C (Controller Function)—The Model 775 does not have controller capabilities.

TE (Extended Talker Capabilities)—The Model 775 does not have extended talker capabilities.

LE (Extended Listener Capabilities)—The Model 775 does not have extended listener capabilities.

Table 3-7. Model 775 Interface Function Codes

Code	Interface Function
SH1	Source Handshake Capability
AH1	Acceptor Handshake Capability
T6	Talker (Basic Talker, Serial Poll, Unaddressed To Talk On LAG)
L4	Listener (Basic Listener, Unaddressed To Listen On TAG)
SR1	Service Request Capability
RL1	Remote/Local Capability
PP0	No Parallel Poll Capability
DC1	Device Clear Capability
DT1	Device Trigger Capability
C0	No Controller Capability
E1	Open Collector Bus Drivers
TE0	No Extended Talker Capabilities
LE0	No Extended Listener Capabilities

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3.8.4 Model 775 Interface Commands

Interface commands controlling Model 775 operation are listed in Table 3-8. Not included in the table are device-dependent commands, which are covered in detail in paragraph 3.10.

Table 3-8. IEEE Command Groups

```
HANDSHAKE COMMAND GROUP
        DAC=DATA ACCEPTED
        RFD=READY FOR DATA
        DAV=DATA VALID
UNIVERSAL COMMAND GROUP
        ATN=ATTENTION
        DCL=DEVICE CLEAR
        IFC=INTERFACE CLEAR
        LLO=LOCAL LOCKOUT
        REN=REMOTE ENABLE
        SPD=SERIAL POLL DISABLE
        SPE=SERIAL POLL ENABLE
ADDRESS COMMAND GROUP
  LISTEN: LAG=LISTEN ADDRESS GROUP
        MLA=MY LISTEN ADDRESS
        UNL=UNLISTEN
   TALK: TAG=TALK ADDRESS GROUP
        MTA=MY TALK ADDRESS
        UNT=UNTALK
        OTA=OTHER TALK ADDRESS
ADDRESSED COMMAND GROUP
        ACG=ADDRESSED COMMAND
        GROUP
        GET=GROUP EXECUTE TRIGGER
        GTL=GO TO LOCAL
        SDC=SELECTIVE CLEAR
STATUS COMMAND GROUP
        RQS=REQUEST SERVICE
        SRQ=SERIAL POLL REQUEST
        STB=STATUS BYTE
        END=EOI
```

3.9 GENERAL BUS COMMAND PROGRAMMING

General bus commands are those commands which have the same general meaning regardless of instrument configuration. These commands are grouped into two categories:

Addressed Commands—These commands require that the primary address of the instrument agrees with the primary address in the controller's programming language.

Unaddressed Commands—No primary address is required for these commands. All devices equipment to implement these commands will do so simultaneously when the command is sent.

General bus commands are summarized in Table 3-9, which also lists the HP-85 BASIC statement that sends each command. Each addressed command statement assumes a primary address of 23.

NOTE

The Model 775 rear panel address switches must be set for a primary address of 23 to work with addressed command examples.

Table 3-9. General Bus Commands

Command	Addressing Required ?	HP-85 BASIC Statements
REN	Yes	REMOTE 723
IFC	No	ABORTIO 7
LLO	No	LOCAL LOCKOUT 7
GTL	Yes	LOCAL 723
DCL	No	CLEAR 7
SDC	Yes	CLEAR 723
GET*	Yes	TRIGGER 723
GET*	No	TRIGGER 7

*GET may be sent with or without addressing.

3.9.1 REN (Remote Enable)

The remote enable command is sent to the Model 775 by the controller to set the instrument up for remote operation. Generally, this should be done before attempting to program the instrument over the bus. The Model 775 will indicate that it is in the remote mode by illuminating its front panel REMOTE indicator.

To place the Model 775 in the remote mode, the controller must perform the following steps:

1. Set the REN line true.
2. Address the Model 775 to listen.

NOTE

Setting REN true without addressing will not cause the REMOTE indicator to turn on; however, once REN is true, the REMOTE light will turn on the next time an addressed command is received.

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Programming Example—This sequence is automatically sent by the HP-85 when the following is typed into the keyboard.

```
REMOTE 723
```

After the END LINE key is pressed, the Model 775 REMOTE indicator light should come on. If not, check to see that the instrument is set for the proper primary address. Also, check to see that all bus connections are tight.

3.9.2 IFC (Interface Clear)

The IFC command is sent by the controller to set the Model 775 to the talk and listen idle states.

To send the IFC command, the controller need only set the IFC line true.

```
ABORTIO 7
```

After the END LINE key is pressed, the Model 775 is in the talk and listen idle states.

3.9.3 LLO (Local Lockout)

The LLO command is sent by the controller to remove the Model 775 from the local operating mode. Once the unit receives the LLO command, all its front panel controls (except POWER) will be inoperative.

NOTE

The REN bus line must be true before the instrument will respond to an LLO command.

To lock out the front panel controls of the Model 775, the controller must perform the following steps:

1. Set ATN true.
2. Send the LLO command to the instrument.

Programming Example—This sequence is automatically performed by the HP-85 when the following statement sequence is typed into the keyboard:

```
LOCAL LOCKOUT 7
```

3.9.4 GTL (Go To Local)

The GTL command is used to take the instrument out of the remote mode. To send the GTL command, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 775 to listen.
3. Place the GTL command on the bus.

NOTE

The GTL command does not remove the local lockout state. With the local lockout condition previously set, the GTL command will enable front panel control operation until the next time a listener address command is received. This places the Model 775 in the local lockout state again.

Programming Example—If the instrument is not in the remote and lockout modes, enter the following statements into the HP-85 computer:

```
REMOTE 723
LOCAL LOCKOUT
```

Check to see that the REMOTE indicator is on and that the front panel controls are locked out. The GTL command sequence is automatically sent by the HP-85 with the following statement.

```
LOCAL 723
```

Note that the REMOTE Light on the front panel turns off.

Front panel control operation can be restored by setting the REN line false with the following HP-85 statement:

```
LOCAL 7
```

After executing this statement, the front panel controls will again operate.

NOTE

Setting REN false with the LOCAL 7 statement will also take the instrument out of the remote mode.

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3.9.5 DCL (Device Clear)

The DCL command may be used to clear the Model 775, setting it to a known state. Note that all devices on the bus equipped to respond to a DCL will do so simultaneously. When the Model 775 receives a DCL command, it will return to the default, conditions listed in Table 3-10.

To send a DCL command, the controller must perform the following steps:

1. Set ATN true.
2. Place the DCL command on the bus.

Table 3-10. Default Conditions (Status Upon Power Up or After SDC or DCL)

Mode	Value	Status
Function	F0	Frequency on channel A.
Coupling	AC0	DC coupled on channel A.
Attenuator	AA0	x1 attenuator on channel A.
Filter	AF0	Filter off on channel A.
Slope	AS0	Positive slope on channel A.
Coupling	BC0	DC coupled on channel B.
Attenuator	BA0	x1 attenuator on channel B.
Filter	BF0	Filter off on channel B.
Slope	BS0	Positive slope on channel B.
Delay	I0	Delay disabled.
Display Mode	D0	Display the measurement.
Data Format	P0	Reading with prefix, without reading zero.
Displayed Digits	N9	Set maximim displayed digits to 9.
EOI	K0	EOI enabled.
SRQ Mask	M00	SRQ disabled.
Rate	S1	Normal 3rdgs per second.
Terminator	Y0	CR LF
Gate Time	G0	One second gate time.
Delay Time	W0	One second delay time.
Trigger Level	AL0	0V
Trigger Level	BL0	0V
Totalize	TO0	Totalize A by B

Programming Example—Place the instrument in the frequency B measurement mode using the front panel controls. Also, enable the AC and filter modes. Now enter the following statement into the HP-85:

```
CLEAR 7
```

When the END LINE key is pressed, the instrument returns to power-up status.

3.9.6 SDC (Selective Device Clear)

The SDC command performs the same function as the DCL command except that only the addressed device responds. This command is useful for clearing only a selected instrument instead of all devices simultaneously. The Model 775 will return to the default conditions listed in Table 3-10 when responding to an SDC command.

To transmit the SDC command, the controller must perform the following steps:

1. Set ATN true.
2. Address the Model 775 to listen.
3. Place the SDC command on the data bus.

Programming Example—Using the front panel controls, place the instrument in the frequency B measurement mode and enable the AC and filter modes. Now enter the following statement into the HP-85:

```
CLEAR 712
```

Note that the instrument did not respond because the SDC command was sent with a primary address of 12. Now enter the following statement into the HP-85 keyboard:

```
CLEAR 723
```

This time the instrument returns to the default conditions listed in Table 3-10.

3.9.7 GET (Group Execute Trigger)

The GET command is sent to the Model 775 to arm the instrument. Using the GET command is only one of several methods that can be used to initiate readings. More detailed information on triggering including GET can be found in paragraph 3.10.18.

To send GET command over the bus, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 775 to listen.
3. Place the GET command on the data.

GET can also be sent without addressing by omitting step 2.

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Programming Example—Type in the following statement into the HP-85 keyboard:

```
REMOTE 723
```

Place the instrument in the one-shot on GET trigger mode with the following statement:

```
OUTPUT 723;''S0X''
```

When the END LINE key is pressed, the GATE LED will stop flashing and the HOLD LED will light indicating the instrument is waiting for a trigger.

The instrument may be triggered to take a single reading with the following statement:

```
TRIGGER 723
```

The GATE LED will flash once, indicating that one reading has been processed.

NOTE

The Model 775 will also respond to GET without addressing. This command is sent with the following HP-85 statement: `TRIGGER 7`.

NOTE

The Model 775 will open the gate and complete a reading, only if a signal is applied to the input and a proper trigger level has been set.

The preceding examples use device-dependent commands to place the instrument in the appropriate trigger modes. These commands are covered in detail in paragraph 3.10.

3.9.8 Serial Polling (SPE, SPD)

The serial polling sequence is used to obtain the Model 775 status byte. Usually, the serial polling sequence is used to determine which of several devices has requested service over the SRQ line. However, the serial polling sequence may be used at any time to obtain the status byte from the Model 775 for more information on status byte format, refer to paragraph 3.10.15.

The serial polling sequence is conducted as follows:

1. The controller sets the ATN line true.
2. The SPE (Serial Poll Enable) command is placed on the bus by the controller.
3. The Model 775 is addressed to talk.
4. The controller sets ATN false.
5. The instrument then places its status byte on the bus to be read by the controller.
6. The controller then sets the ATN line low and places SPD (Serial Poll Disable) on the bus to end the serial polling sequence.

Steps 3 through 5 may be repeated for other instruments on the bus by using the correct talk address for each instrument. ATN must be true when the talk address is transmitted and false when the status byte is read.

Programming Example—The HP-85 SPOLL statement automatically performs the serial polling sequence. To demonstrate serial polling, momentarily power down the Model 775 and enter the following statements into the HP-85 keyboard:

```
REMOTE 723
S=SPOLL 723
DISP S
```

When END LINE is pressed the second time, the computer performs the serial polling sequence. When END LINE is pressed the last time, the status byte value is displayed on the CRT. Paragraph 3.10.15 covers the status byte format in detail.

3.10 DEVICE-DEPENDENT COMMAND PROGRAMMING

IEEE-488 device-dependent commands are sent to the Model 775 to control various operating modes such as function, trigger levels, gate time, filter and data format. Each command is made up of an ASCII alpha character followed by one of more numbers designating specific parameters. For example, a function is programmed by sending an ASCII "F" followed by numbers representing the function. The IEEE bus treats device-dependent commands as data in that ATN is high when the commands are transmitted.

A number of commands may be grouped together in one string. The Model 775 will ignore all nonprintable ASCII characters (00 HEX through 1F HEX) and space character (20 HEX) will be ignored. A command string is terminated by an ASCII "X" character which tells the instrument to execute the command string.

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If an illegal command or command parameter is present within a command string, the instrument will:

1. Ignore the entire command string.
2. Display appropriate front panel error messages.
3. Set certain bits in its status byte.
4. Generate an SRQ if programmed to do so.

These programming aspects are covered in paragraphs 3.10.15 and 3.11.

HP-85 examples are included throughout this section to clarify programming.

NOTE

Before performing a programming example, it is recommended that the instrument be set to its default values by sending an SDC over the bus. See paragraph 3.9.6 for information on using the SDC command.

If the HP-85 should become "hung up" at any point, operation may be restored by holding the SHIFT key down and then pressing RESET on the keyboard.

In order to send a device-dependent command, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 775 to listen.
3. Set ATN false.
4. Send the command string over the data bus one byte at a time.

Programming Example—Device-dependent commands are sent by the HP-85 using the following statement:

```
OUTPUT 723; A$
```

A$ in this case contains the ASCII characters that form the command string.

NOTE

REN must be true when attempting to program the Model 775.

Commands that affect the Model 775 are listed in Table 3-11. All the commands listed in the Table 3-11 are covered in detail in the following paragraphs.

NOTE

Programming Examples that follow assume that the Model 775 primary address is at its factory setting 23.

Table 3-11. Device-Dependent Command Summary

Mode	Command	Description
Function	F0	Frequency on Channel A
	F1	Frequency on Channel B
	F2	Period on Channel A
	F3	Period average on Channel A
	F4	Time interval from A to B
	F5	Pulse on Channel A
	F6	Frequency on Channel C
	F7	Totalize on Channel A
Coupling	AC0	DC coupled on Channel A
	AC1	AC coupled on Channel A
	BC0	DC coupled on Channel B
	BC1	AC coupled on Channel B
Attenuator	AA0	X1 attenuator on Channel A
	AA1	X10 attenuator on Channel A
	BA0	X1 attenuator on Channel B
	BA1	X10 attenuator on Channel B
Filter	AF0	Filter Off on Channel A
	AF1	Filter On on Channel A
	BF0	Filter Off on Channel B
	BF1	Filter On on Channel B

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Table 3-11. Device-Dependent Command Summary (Cont.)

Mode	Command	Description
Slope	AS0	Positive Slope on Channel A
	AS1	Negative Slope on Channel A
	BS0	Positive Slope on Channel B
	BS1	Negative Slope on Channel B
Trigger Level	ALn	Set Trigger Level for Channel A
	BLn	Set Trigger Level for Channel B
		n=(sign)d.ddE(sign)d
		d=digit
Rate	S0	One-shot on T, GET or external timing.
	S1	Normal. 3 readings per second.
	S2	Fast. 25 readings per second.
	S3	Dump. 140 readings per second, BCD format.
Gate Time	Gn	Set the gate time in seconds.
		n=dE(sign)d
		d=digit
	GU	Set gate time to user gate.
Delay Time	Wn	Set the delay time in seconds.
		n=dE(sign)d
		d=digit
	WU	Set delay time to user delay.
Delay	I0	Delay disabled
	I1	Delay enabled
Displayed Digits	Nn	Set the maximum displayed digits (n=3 to 9)
Trigger	T	One-shot in S0 mode
EOI	K0	EOI enabled
	K1	EOI disabled
SRQ Mask	M0	SRQ disabled
	M1	SRQ on overflow
	M2	SRQ on self-test done
	M8	SRQ on reading done
	M16	SRQ on ready
	M32	SRQ on error
Terminator	Y0	CR LF
	Y1	LF CR
	Y2	CR
	Y3	LF
	Y4	No Terminator
Display Mode	D0	Display the Measurement
	D1	Display the Gate Time
	D2	Display the Delay Time
	D3	Display the Trigger Levels
	D4	Display the Totalize gate option
	D5	Display the ASCII message
Data Format	P0	Reading with prefix, without leading zero.
	P1	Reading without prefix, without leading zero.
	P2	Reading with prefix, with leading zero.
	P3	Reading without prefix, with leading zero.
Totalize	TO0	Totalize A by B
	TO1	Cumulative Totalize

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Table 3-11. Device-Dependent Command Summary (Cont.)

Mode	Command	Description
Self Test	J	Test ROM, RAM
Data Control	B0 B1 B2 B3 B4	Send measuring data string. Send gate time data string. Send delay time data string. Send trigger level A data string. Send trigger level B data string.
Status Word	U0 U1	Send operating mode status. Send error status.
Execute	X	Execute other device-dependent commands.

3.10.1 Execute (X)

The execute command is implemented by sending an ASCII "X" over the bus. Its purpose is to tell the Model 775 to execute other device-dependent commands. Generally, the "X" character is the last byte in the command string.

NOTE

A command string sent without an execute character will not be executed at that time, but will be stored in the command buffer. The next time an execute character command is received, the stored commands will be executed, assuming all commands in the previous string were valid.

Programming Example—Enter the following statements into the HP-85 keyboard:

```
REMOTE 723
OUTPUT 723;"X"
```

When END LINE key is pressed the second time, the front panel LISTEN LED flashes on then off, showing that the instrument received the command. No other changes will occur with this example because no other commands were given.

3.10.2 Function (F)

The function commands select the type of measurement made by the Model 775A. The eight parameters associated with the function command set the instrument to measure FREQ A, FREQ B, PERIOD A, PERIOD AVG A, TIME A→B, PLS A and Totalize, and with Model 7751 option installed, FREQ C. The function may be programmed by sending one of the following commands:

F0=FREQ A
F1=FREQ B
F2=PERIOD A
F3=PERIOD AVG A
F4=TIME A→B
F5=PLS A
F6=FREQ C
F7=Totalize

Upon power-up, or after the instrument receives a DCL or SDC command, the F0 mode will be enabled.

Programming Example—Place the Model 775 in the frequency A function from the front panel and enter the following statements into the HP-85 keyboard:

```
REMOTE 723
OUTPUT 723;"F2X"
```

After the END LINE KEY is pressed the second time, the Model 775 will change to the period A function as shown by the PERIOD A indicator light.

3.10.3 Channels A, B Coupling (AC, BC)

The coupling command gives the user control over the input coupling of the channel A and B inputs for the Model 775. The coupling may be programmed by sending one of the following commands:

AC0=DC coupling CHAN A
AC1=AC coupling CHAN A
BC0=DC coupling CHAN B
BC1=AC coupling CHAN B

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Upon power-up, or after receiving a DCL or SDC, the instrument will be in the AC0 and BC0.

Programming Example—Select AC coupling with the front panel DC/AC button. Enter the following statements into HP-85:

```
REMOTE 723
OUTPUT 723;"AC0X"
```

When END LINE is pressed the second time, the AC LED indicator turns off and the instrument switches to DC coupling.

3.10.4 Channels A, B Attenuator (AA, BA)

The attenuator command gives the user control over the input attenuator mode of the channels A and B inputs for the Model 775. The attenuator may be programmed by sending one of the following commands:

AA0=x1 attenuator
AA1=x10 attenuator
BA0=x1 attenuator
BA1=x10 attenuator

Upon power-up, or after receiving a DCL or SDC, the instrument will be in AA0 and BA0.

Programming Example—Select the X10 attenuator with the front panel ATTEN button. Enter the following statements into HP-85:

```
REMOTE 723
OUTPUT 723;"AA0X"
```

When END LINE is pressed the second time, the X10 LED indicator turns off and the instrument switches to X1 attenuation.

3.10.5 Channels A, B Filter (AF, BF)

The filter on/off command gives the user control over the input filter of the channels A and B inputs for the Model 775. The filter may be programmed by sending one of the following commands:

AF0=Filter off
AF1=Flter on
BF0=Filter off
BF1=Filter on

Upon power-up, or after receiving a DCL or SDC, the instrument will be in AF0 and BF0.

Programming Example—Select the filter off with the front panel FLTR button. Enter the following statements into HP-85:

```
REMOTE 723
OUTPUT 723;"AF1X"
```

When END LINE is pressed the second time, the FLTR LED indicator turns on and the instrument switches the filter on.

3.10.6 Channels A, B Slope (AS, BS)

The slope selection command gives the user control over the input slope mode of the channels A and B inputs for the Model 775. The slope may be programmed by sending one of the following commands:

AS0=Positive slope
AS1=Negative slope
BS0=Positive Slope
BS1=Negative Slope

Upon power-up, or after receiving a DCL or SDC, the instrument will be in the AS0 and BS0.

Programming Example—Select the positive slope with the front panel SLOPE button. Enter the following statements into HP-85:

```
REMOTE 723
OUTPUT 723;"AS1X"
```

When END LINE is pressed the second time, the negative slope LED indicator turns on and the instrument switches to negative slope.

3.10.7 Channels A, B Trigger Level (AL, BL)

The trigger level selection command gives the user control over the input threshold point on the signal applied to the channels A and B inputs of the Model 775. The trigger mode may be programmed by sending a command using the following format:

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ALn
BLn

Where n is the trigger level in volts in engineering format e.g. (<sign>D.DDE<sign>D). The sign and the exponent are optional. The trigger level may range from -2.55 to +2.55V in 10mV steps or from -25.5 to +25.5V in 100mV steps. Selecting a trigger level in the range of -2.55V to +2.55V will automatically set up the x1 attenuator. Selecting a trigger level in the range of -25.5V to +25.5V will change the attenuator setting internally to the x10 attenuator mode.

Upon power-up, or after receiving a DCL or SDC, the instrument will be in AL0 and BL0 (trigger levels at 0.00V).

Programming Example—Select the trigger level 0.00V by pressing simultaneously the LEVEL ▲ and ▼ buttons. Select x1 attenuator mode. Enter the following statements into HP-85:

```
REMOTE 723
OUTPUT 723;''D3X''
OUTPUT 723;''AL+10.0X''
```

When END LINE is pressed the second time the Model 775 enters the trigger level display mode (More detailed information on all display modes, including D3 can be found in paragraph 3.10.16). Observe that the trigger level on channel A is 0.00V.

When END LINE is pressed the third time, the x10 indicator turns on and the trigger level for channel A is set to +10.0V.

NOTE

To increase flexibility, the Model 775 was designed in such a way to allow free format in programming the trigger level. In the previous example therefore, the last line may be replaced with one of the following lines:

```
OUTPUT 723;''AL10X''
OUTPUT 723;''AL+1E1X''
OUTPUT 723;''AL0001.00E+1X''
OUTPUT 723;''AL+100000.000E-4X''
```

3.10.8 Rate (S)

The rate command gives the user control over the measuring rate of the Model 775. Rate command parameters are summarized in Table 3-12.

The instrument will be in the S1 mode upon power-up, or after receiving a DCL or SDC command.

NOTES

1. The rate of transfer of information from the Model 775, depends to a great extent on the gate time. Table 3-12 lists the measuring rates, with the shortest gate time selected.
2. The data output format for the S3 mode is different from the data output format for all the other modes (More detailed information on data output format for the dump mode (S3), can be found in paragraph 3.11.5).
3. It may appear that GATE light does not flash when the fast rate mode (S2) is selected. This is because the microcomputer is busy performing the fast rate measurements and therefore cannot update the GATE light.

Table 3-12. Rate Commands

Command	Mode	Measuring Rate	Process Time Between Measurements
S0	Hold	One-shot on T, GET or external arming input.	
S1	Normal	3 readings per sec.	275smec max
S2	Fast*	25 readings per sec.	27smec max
S3	Dump*	140 readings per sec.	5.5msec max

*Can not be selected through front panel programming.

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Programming Example—Observe that the HOLD LED is off. If the indicator is on, press the MODE button on the front panel of Model 775 to turn the HOLD LED off. Enter the following statements into HP-85:

```
REMOTE 723
OUTPUT 723;''S0X''
```

When END LINE is pressed the second time, the front panel HOLD LED will turn on, indicating that the one-shot mode is enabled.

3.10.9 Gate Time (G)

The gate time command controls the time that the gate remains open. The gate time may be programmed by sending a command using the following format:

Gn

Where n is the gate time in seconds in engineering format e.g. (DE<sign>D). The sign and the exponent are optional. The allowable values for gate time are listed in Table 3-13.

Upon power-up, or after receiving a DCL or SDC, the instrument will be in the G1 mode, with a gate time of one second.

The gate time may be programmed to the external user gate time by sending a command using the following format: GU.

Programming Example—Select the frequency A function, then select the gate time of one second by pressing simultaneously the GATE/DELAY TIME ▲ and ▼ buttons on the front panel. Enter the following statements into HP-85:

```
REMOTE 723
OUTPUT 723;''D1X''
OUTPUT 723;''G0.5X''
```

When END LINE is pressed the second time the Model 775 enters the gate time display mode. (More detailed information on all display modes; including D1, can be found in paragraph 3.10.16.) Observe that the gate time is one second. When END LINE is pressed the third time, the gate time is set to 500msec.

NOTE

To increase flexibility, the Model 775 was designed in such a way to allow free format in programming the gate time. In the previous example therefore, the last line may be replaced with one of the following lines:

```
OUTPUT 723;''G500E-3X''
OUTPUT 723;''G5E-1X''
OUTPUT 723;''G.5X''
OUTPUT 723;''G000000.0005E+3X''
```

3.10.10 Delay Time (W)

The delay time command controls the amount of delay in closing the gate after the gate was open. The delay time mode may be programmed using a command with the following format:

Wn

Where n is the delay time is seconds in engineering format e.g (DE<sign>D). The sign and the exponent are optional. The allowed values for delay time are listed in Table 3-13.

Upon power-up, or after receiving a DCL or SDC, the instrument will be in the W1 mode (delay time of one second).

The delay time may be programmed to external delay by sending a command using the following format: WU

Programming Example—Select TIME A→B function, then select a delay time of one second by pressing simultaneously the GATE/DELAY TIME ▲ and ▼ buttons on the front panel of the Model 775. Enter the following statements into the HP-85:

```
REMOTE 723
OUTPUT 723;''D2X''
OUTPUT 723;''G0.03X''
```

When END LINE is pressed the second time the Model 775 enters in delay time display mode. (More detailed information on all display modes; including D2, can be found in paragraph 3.10.16). Observe that the delay time is one second. When END LINE is pressed the third time, the delay time is set to 30msec.

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NOTE

To increase flexibility, the Model 775 was designed in such a way to allow free format in programming the delay time. In the previous example therfore, the last line may be replaced with one of the following lines:

```
OUTPUT 723;''W30E-3X''
OUTPUT 723;''W3E-2X''
OUTPUT 723;''W000000.00003E3X''
```

Table 3-13. Gate/Delay Time Predetermined Values

100μsec	1msec	10msec	100msec	1sec	10sec
200μsec	2msec	20msec	200msec	2sec	
300μsec	3msec	30msec	300msec	3sec	
400μsec	4msec	40msec	400msec	4sec	
500μsec	5msec	50msec	500msec	5sec	
600μsec	6msec	60msec	600msec	6sec	
700μsec	7msec	70msec	700msec	7sec	
800μsec	8msec	80msec	800msec	8sec	
900μsec	9msec	90msec	900msec	9sec	

3.10.11 Delay (I)

The delay command gives the user control over the delay mode. The delay mode may be programmed by sending one of the following commands:

I0=Delay off
I1=Delay on

Upon power-up, or after receiving a DCL or SDC, the instrument will be in the I0 mode.

Programming Example—Select TIME A→B function, then select the delay off mode with the front panel MODE button. Enter the following statemen*s into the HP-85:

```
REMOTE 723
OUTPUT 723;''I1X''
```

When END LINE is pressed the second time, the DELAY LED indicator turns on and the instrument switches to the delay on mode.

3.10.12 Displayed Digits (N)

The displayed digits function sets the maximum number of digits that the Model 775 will display. To program the number of digits send the following command:

Nn

Where n may have any value fom 3 to 9.

Upon power-up, or after receiving a DCL or SDC, the instrument will be set to N9.

Programming Example—Select the frequency A function, then select the gate time of one second by pressing simultaneously the GATE/DELAY TIME ▲ and ▼ buttons.

Press simultaneously the GATE/DELAY and TRIGGER LEVEL DISPLAY buttons and then, press simultaneously the GATE/DELAY TIME ▲ and ▼ buttons. This will set up the Model 775 to display nine digits. Press any pushbutton on the front panel of the Model 775 to return to the normal display mode. Apply a signal to the channel A input of Model 775 and observe that the frequency of the signal will be displayed with at least eight digits. Enter the following statements into the HP-85:

```
REMOTE 723
OUTPUT 723;''N4X''
```

When END LINE is pressed the second time the measured frequency will be displayed with maximum four digits.

3.10.13 Triggering (T)

The "T" and GET commands are used to trigger the Model 775 over the IEEE bus (see GET 3.9.7). Triggering arms a measurement cycle. In the continuous mode, the Model 775 is always armed. In the one-shot mode (S0), a separate trigger stimulus is required to arm each measurement cycle.

Programming Example—Place the Model 775 into the hold mode. Using the MODE button on the front panel of the Model 775, apply a signal to the channel A input of Model 775 and observe that the GATE LED indicator is not flashing, indicating the instrument is waiting for a trigger. Enter the following statements into the HP-85:

```
REMOTE 723
OUTPUT 723;''TX''
```

When END LINE is pressed the second time the GATE indicator flashes once, indicating one reading has been processed. To continue taking readings in this mode, a trigger is needed for each measurement cycle.

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3.10.14 EOI (K)

The EOI line on the bus is usually set low by the device during the last byte of its data transfer sequence. In this way, the last byte is properly identified, allowing variable length data words to be transmitted. The Model 775 will normally send EOI during the last byte of its data string or status word. The EOI response of the instrument may be sent with one of the following commands:

K0=Send EOI during last byte.
K1=Send no EOI.

Upon power-up, the K0 mode is enabled.

Programming Example—The Model 775 EOI response will be suppressed with the following HP-85 statement sequence:

```
REMOTE 723
OUTPUT 723;"K1X"
```

NOTE

HP-85 does not rely on EOI to mark the last byte of data transfer. Some controllers, however, may require that EOI be present at the end of transmitting.

3.10.15 SRQ Mode (M) and Serial Poll Status Byte Format

The SRQ command controls which of a number of conditions within the Model 775 will cause the instrument to request service from the controller with the SRQ line command. Once a SRQ is generated, the Model 775 status byte can be checked, via serial polling (see paragraph 3.9.8), to determine if it was the Model 775 that requested service. Other bits in the status byte could also be set depending on certain data or error conditions.

The Model 775 can be programmed to generate SRQ under one or more of the following conditions.

1. If a reading has been completed.
2. If an overflow condition occurs.
3. If an error condition occurs.
4. If a self test has been completed.
5. If the Model 775 is ready to receive device-dependent commands.

Upon power-up, or after a DCL or SDC command, SRQ is disabled.

SRQ Mask—In order to facilitate SRQ programming, the Model 775 uses an internal mask to generate the SRQ. When a particular mask bit is set, the Model 775 will send a SRQ when those conditions occur. Bits within the mask can be controlled by sending the ASCII letter "M" followed by a decimal number to set the appropriate bits. Table 3-14 lists the commands to set the various mask bits, while Table 3-15 lists all legal SRQ mask commands.

Table 3-14. SRQ Mask Commands

Command	Condition to Sets Bit Number	Generate SRQ
M1	B0 (LSB)	Overflow
M2	B1	Self-test done
M8	B3	Reading done
M16	B4	Ready
M32	B5	Error

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Table 3-15. SRQ Mask Legal Commands

Bit Number	B5	B4	B3	B2	B1	B0 (LSB)
Command	Error	Ready	Reading Done	0	Self-Test Done	Overflow
M0	No	No	No		No	No
M1	No	No	No		No	Yes
M2	No	No	No		Yes	No
M3	No	No	No		Yes	Yes
M8	No	No	Yes		No	No
M9	No	No	Yes		No	Yes
M10	No	No	Yes		Yes	No
M11	No	No	Yes		Yes	Yes
M16	No	Yes	No		No	No
M17	No	Yes	No		No	Yes
M18	No	Yes	No		Yes	No
M19	No	Yes	No		Yes	Yes
M24	No	Yes	Yes		No	No
M25	No	Yes	Yes		No	Yes
M26	No	Yes	Yes		Yes	No
M27	No	Yes	Yes		Yes	Yes
M32	Yes	No	No		No	No
M33	Yes	No	No		No	Yes
M34	Yes	No	No		Yes	No
M35	Yes	No	No		Yes	Yes
M40	Yes	No	Yes		No	No
M41	Yes	No	Yes		No	Yes
M42	Yes	No	Yes		Yes	No
M43	Yes	No	Yes		Yes	Yes
M48	Yes	Yes	No		No	No
M49	Yes	Yes	No		No	Yes
M50	Yes	Yes	No		Yes	No
M51	Yes	Yes	No		Yes	Yes
M56	Yes	Yes	Yes		No	No
M57	Yes	Yes	Yes		No	Yes
M58	Yes	Yes	Yes		Yes	No
M59	Yes	Yes	Yes		Yes	Yes

NOTE

There are 32 legal SRQ mask commands that are possible with the Model 775. Table 3-15 lists all combinations. (e.g. selecting M10, Model 775 will request service after one reading is complete or a self-test occurs.)

Status Byte Format—The status byte contains information relating to data and error conditions within the instrument. Table 3-16 lists the meaning of the various bits. The status byte is obtained by using the SPE, SPD polling sequence described in paragraph 3.9.8.

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Table 3-16. Status Byte Interpretation

Bit Number	B7 (MSB)	B6	B5	B4	B3	B2	B1	B0 (LSB)
Interpretation	0	RQS	Error	Ready	Reading Done	0	Self-Test Done	Overflow

The various bits in the status byte are described below:

1. Overflow—When measuring a time interval larger than 10000sec in S0, S1 and S2 modes, the overflow bit will be set. In S3 mode, the overflow bit will be set when measuring a time interval larger than 9msec or measuring frequency and PERIOD AVG A with a gate time larger than 9msec. This bit is cleared after the Model 775 is addressed to talk in the B0 mode.
2. Self-Test Done—Set after power-up self test completion or after executing the self test (J) command. This bit is cleared by reading the error status word (U1).
3. Reading Done—Set after completion of a measurement cycle. The reading done bit is cleared after the Model 775 is addressed to talk in the B0 mode.
4. Ready—Set after power-up. This bit is cleared when the Model 775 receives an execute command (X) and is reset after the instrument completes the command (Model 775 is ready for the next command string).
5. Error-Set if an illegal command has been received or gate error has occurred in the last measurement cycle. This bit is cleared by reading the error status word (U1).
6. RQS—Model 775 will set this bit if one or more conditions for service request occur, and the SRQ mask, for at least one of these service request conditions is enabled. This bit is cleared by reading the status byte using the SPE, SPD polling sequence.

NOTES

1. Once the Model 775 has generated an SRQ, its status byte should be read to clear the SRQ line. Otherwise the instrument will continuously assert the SRQ line.
2. The Model 775 may be programmed to generate an SRQ for more than one condition simultaneously. For example, to set SRQ mask bits for an SRQ if an error occurs and when an overflow condition occurs, the following command would be sent: M33X. All possible mask combinations are listed in Table 3-15.
3. If the instrument is programmed to generate an SRQ when a reading is done, it will generate the SRQ only once when the reading is complete; the SRQ may be cleared by reading the status byte. The reading done bit in the status byte may then be cleared by requesting a normal reading from the instrument.

Programming Example—Enter the following program into the HP-85:

PROGRAM	COMMENTS
`10 REMOTE 723`	Set up remote operation.
`20 OUTPUT 723; ''M32X''`	Program for SRQ on error.
`30 OUTPUT 723; ''F7X''`	Attempt to program illegal command option.
`40 S=SPOLL (723)`	Perform serial poll.
`50 DISP ''B7 B6 B5 B4 B3 B2 B1 B0''`	
`60 FOR I=7 TO 0 STEP -1`	Loop eight times.
`70 DISP BIT (S,I);`	
`80 NEXT I`	
`90 DISP`	
`100 END`	

Press the HP-85 RUN key. The computer conducts a serial poll and displays the status byte bits in order on the CRT. The SRQ (B6) and the Error (B5) bits are set because line 30 of the program attempts to program the instrument with an illegal command option (F7). The Model 775 will then respond with an IddCo Err message which will be diplayed for about one second.

3.10.16 Display Modes (D)

The display command controls what the Model 775A places on the display. The six parameters associated with the measurement, gate time, delay time, trigger levels, totalize gate option or an ASCII message. The display mode may be programmed by sending one of the following commands:

D0=Measurement
D1=Gate Time
D2=Delay Time
D3=Trigger Levels
D4=Totalize gate option
D5=ASCII message

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In the D5 display mode, the ASCII message that can be placed on the Model 775A display is limited by the capabilities of the seven segment readout, but; even with those limitations, considerable versatility is possible.

NOTES

1. The maximum number of characters that can be sent with the D5 command is 10. Any additional characters will be ignored.
2. Display position 10 (the second position from the right on the display) is not used in this mode because of its limited possibilities.
3. Any undisplayed character will appear as an underline segment.
4. Decimal points are set on the current display position, if possible, and do not advance the display to the next position.
5. Sending a "D5X" command will blank out the display.
6. The "D0X" command restores the display to normal (measurement) operation.

Programming Example—Enter the following statements into the HP-85 keyboard:

```
REMOTE 723
OUTPUT 723;''D5HELLO-775X''
```

When END LINE is pressed the second time, the "HELLO-775" message will be displayed.

3.10.17 Self-Test (J)

The J command causes the instrument to perform ROM and RAM tests similar to the power-up procedure tests. When the self-test command is given, the Model 775 performs the following tests:

1. RAM test
2. ROM test

The J command has no parameters. When the test is complete the SELF TEST DONE bit in the status byte is set, and if the SRQ mask bit for self test done is set, the Model 775 will request service. If the self-test is successful, the SELF TEST bit in the U1 error status word (see paragraph 3.11.2) will be a 0. Otherwise, this bit will be a 1.

Programming Example—Enter the following statements into the HP-85:

```
REMOTE 723
OUTPUT 723;''JX''
```

When the END LINE is pressed the second time, the instrument performs the self-test. The result of the self-test may be checked by reading the U1 error status word. A detailed description on the U1 error status word and how to read it is given in paragraph 3.11.2.

3.10.18 Totalize (TO)

The totalize command allows the user to select between two gating options: Totalize A by B and cumulative totalize. Totalize A by B allows the user to limit the amount of time that pulses are counted; where as, the cumulative totalize command allows an infinite gate time. The totalize gate option may be programmed by sending one of the following commands.

TO0=Totalize A by B
TO1=Cumulative totalize

NOTE: The TO command only selects the gate option. The F7 command must also be used to select the totalize function.

Upon power up, or after receiving a DCL or SDC, the instrument defaults to TO0.

Programming Example—With the Model 775A in the Totalize A by B mode, enter the following statements into the HP-85 keyboard.

```
REMOTE 723
OUTPUT 723;''F7T01X''
```

After the END LINE key is pressed a second time, the Model 775A will change to the cumulative totalize mode.

3.11 READING FROM THE MODEL 775

The reading sequence is used to obtain from Model 775 various information strings such as measurement, gate time, delay time and trigger levels. Each information string is made up of ASCII alpha and alphanumeric characters. For more details on the information string format refer to paragraph 3.11.1.

The reading sequence is conducted as follows:

1. The controller sets the ATN line true.
2. The Model 775 is addressed to talk.
3. The controller sets ATN false.
4. The instrument sends the information string over the bus one byte at a time.
5. The controller recognizes that the string is terminated.
6. The controller sets the ATN line true.
7. The UNT (untalk) command is placed on the bus by the controller.

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NOTE

Most controllers use the CR (Carriage Return) or LF (Line Feed) character to terminate their input sequences, but other techniques may be used as well to recognize the end of input sequence (e.g. EOI line is low on the bus during the transfer of the last byte).

Programming Example—The command sent by HP-85 to request the data string from the Model 775 has the following format:

```
ENTER 723;A$
DISP A$
```

A$ in this case contains ASCII characters that form the data string.

Upon power-up, or after the instrument receives a DCL or SDC command, the Model 775 will respond to a request for a data string by sending the data string contained in the measuring buffer. This data string is sent only once for each measuring cycle. After this string has been sent, the next request for a data string will be delayed until completion of the next measurement cycle. The data format for the measuring string is described in Table 3-17.

To read other strings of information besides the measuring buffer, a data control device-dependent command has to be sent by the controller. This is covered in detail in the following paragraph.

3.11.1 Data Control Commands (B)

The data control commands allow access to information concerning the present operating conditions of the instrument. When the data control command is given, the Model 775 will transmit the associated data string instead of its normal data string the next time it is addressed to talk the Model 775 data control commands include:

B0=Normal data string (measuring buffer)
B1=Gate Time string
B2=Delay Time string
B3=Trigger Level A string
B4=Trigger Level B string

Table 3-17 shows the general data string format for each of five commands.

NOTES

1. Data strings have fixed length of 14 ASCII characters for the B0 command without the prefix and terminator. For all other data strings (B1, B2 B3 and B4), the length of the data string is five ASCII characters without the prefix and terminator. If the data string is sent with a prefix, four additional ASCII characters are included (refer to paragraph 3.11.4). If the data string is sent with one or two terminators, the length of the data string increases by one or two characters respectively. If the Model 775 was programmed to the S3 measuring rate (see paragraph 3.10.13), the B0 data string is no longer ASCII characters but 12 binary coded digits (BCD), incorporated into six bytes. See paragraph 3.11.5 for detailed information on using the dump mode (S3).
2. All data string information, besides the normal data string, will be sent only once each time the command is sent. Once the data string is read, the instrument will send its normal data string the next time it is addressed to talk.
3. To ensure that the correct data string is received, the data string should be read immediately after sending the command, to avoid having an incorrect data string transmitted.

Table 3-17. Data String Format

Command	Data String Format*	Description
B0	(prefix)+1.23456789E+0(CR LF)	Normal Data String**
B1	GATE+1E+0(CR LF) GATE=USER (CR LF)	Data String Format for Gate Time
B2	DLAY+1E+0(CR LF) DLAY=USER (CR LF)	Data String Format for Delay Time
B3	TRGA+0.00 (CR LF)	Data String Format for Trig Level A
B4	TRGB+0.00 (CR LF)	Data String Format for Trig Level B

*CR LF is normal terminator. The terminator may be changed (see paragraph 3.11.3). The prefixes are listed in Table 3-18.

**This format is valid for all measuring rates except for the S3 rate mode. S3 mode is covered in more detail in paragraph 3.11.5.

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Table 3-18. Prefixes

Data String	Prefixes	Description
B0	NFRA *	FREQ A measurements
	NFRB *	FREQ B measurements
	NPER *	PERIOD A measurements
	NAVG *	PERIOD AVERAGE A measurements
	NTAB *	TIME A → B measurements
	NPLS *	PULSE A measurements
	NFRC *	FREQ C measurements

*The prefix defines a normal or overflow reading as well as the measuring function. If a reading is overflow, N- prefix become O- and the number is set to: +9.99999999E+9.

Programming Example—Enter the following program into the HP-85:

PROGRAM	COMMENTS
`10 REMOTE 723`	Set up remote operation.
`20 OUTPUT 723; ''B1X''`	Program Model 775 to send the gate time data string.
`30 ENTER 723;A`	Enter reading into computer.
`40 DISP A$`	Display reading into computer.
`50 END`	Display on CRT

Press the HP-85 RUN key. The computer reads and displays the gate time string.

3.11.2 Status Word (U)

The status word commands allows access to information concerning present operating modes and the error history of the instrument. When the status word command is given, the Model 775 will transmit the appropriate status information instead of its normal data string the next time it is addressed to talk. The Model 775 status word commands include:

U0=Operating mode status word
U1=Error status word

Table 3-19 shows the general format for each of the status words.

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Table 3-19. Status Word Formats

Command	Status Word Format
U0	775 F AC AA AF AS BC BA BF BS I D P N K M * S Y TO (CR LF)
U1	775 IDDC IDDCO GATEERROR SELFTEST 0 0 0 0 0 (CR LF)

CR LF is normal terminator. The terminator may be changed (see paragraph 3.11.3).
*The U0 status word sends 2 bytes for the M status and 1 byte for all others.

NOTES

1. Status word information will be returned only once each time the command is sent. Once status is read, the instrument will send its normal data string the next time it is addressed to talk.
2. To ensure that the correct status is received, the status word should be read immediately after sending the command, to avoid having an incorrect status transmitted.
3. The status word should not be confused with the status byte. The status word contains a string of bytes pertaining to the various operating modes of the instrument. The status byte is a single byte that is read with the SPE, SPD command sequence and contains information on SRQ status.
4. The returned U1 value is 1 for an IDDC error, for an IDDCO error, for a GATE ERR that occurs after the U1 status word has been cleared the last time and if the self test failed.
5. U1 error status word is cleared by reading U1 status word. Reading this status word also clears the self test done and the error bits in the SRQ status byte (see paragraph 3.10.15).

Programming Example—Enter the following program into the HP-85:

PROGRAM	COMMENTS
`10 REMOTE 723`	Set up remote operation.
`20 OUTPUT 723; ''U1X''`	Program Model 775 to send the error status word.
`30 ENTER 723;A$`	Enter reading into computer.
`40 DISP A$`	Display on CRT.
`50 END`	

Press the HP-85 RUN key. The computer reads and displays the error status word.

3.11.3 Terminator (Y)

To allow for a wide variety of controllers to be used, the terminator can be changed by sending an appropriate command over the bus. The default value is the commonly used carriage return, line feed (CR LF) sequence (mode Y0). The terminator sequence will assume this default value upon power-up, or after receiving a DCL or SDC. The terminator for the Model 775 may be programmed by sending one of the following commands:

Y0=(CR LF)
Y1=(LF CR)
Y2=(CR)
Y3=(LF)
Y4=No terminator

NOTE

Most controllers use the CR or LF character to terminate their input sequence. Using the no terminator mode Y4 may cause the controller to hang up unless special programming is used.

Programming Example—The terminator can be eliminated by sending the following HP-85 statements:

```
REMOTE 23
OUTPUT 723;''Y4X''
```

When END LINE is pressed the second time, the terminator is suppressed; no terminator will be sent by the instrument when data is requested. The absence of the normal terminator may be verified by entering the following statement into the HP-85 keyboard:

```
ENTER 723;A$
```

At this point, the HP-85 ceases to operate because it is waiting for the standard CR LF terminator sequence to terminate the ENTER statement. The computer may be reset by holding down the SHIFT key and then pressing RESET

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on the keyboard. To return the instrument to normal terminator sequence, enter the following statement into HP-85:

```
OUTPUT 723;''Y0X''
```

3.11.4 Prefix (P)

The prefix on the data string may be suppressed using this command. When the prefix is suppressed the output data string is four bytes shorter. The P command is also used to replace leading space character (ASCII 20 HEX) in the data string with character 0 (ASCII 30 HEX). For some controllers an attempt to read a number, instead of a string, will result in a reading error because of its inability to read the spaces before the first significant digit. To eliminate this problem, the Model 775 should be programmed to send the data string with leading zeros. P command parameters incude:

P0=With prefix, without leading zero
P1=Without prefix, without leading zero
P2=With prefix, with leading zero
P3=Without prefix, with leading zero

Programming Example—Enter the following program into the HP-85:

PROGRAM	COMMENTS
`10 REMOTE 723`	Set up remote operation.
`20 OUTPUT 723; ''P3B0X''`	Program Model 775 to send the data string without prefix and with leading zeros.
`30 ENTER 723;A$`	Enter reading into computer.
`40 DISP A$`	Display on CRT.
`50 END`	

Press te HP-85 RUN key. The computer reads and displays the data string without prefix and with leading zeros.

NOTE

Note that in the previous programming example two device-dependent commands have been sent in the same command string.

3.11.5 Dump Mode (S3 Rate Mode)

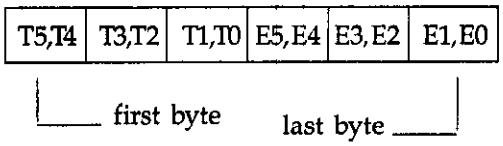
The S3 rate mode may be used when it is desired to output Model 775 readings to the bus at an extremely fast rate or to analyze raw measurement data. In this mode the processing and the display cycles are bypassed and a "busy" message is displayed on the front panel. Table 3-20 lists the dump mode specifications and considerations. When Model 775 is addressed to talk, the instrument sends a data string of 12 binary coded digits (BCD), in six bytes plus the terminator if the instrument is in the Y0, Y1, Y2 or Y3 terminator modes. The first six BCD digits are from the TIME register and the other six BCD digits are from the EVENT register.

Table 3-21 lists the formulas which are used to calculate the result for the different functions. Examples for some calculations are also given.

PROGRAM	COMMENTS
`1`	
`2`	Program to exercise binary dump of 775.
`10 D=723`	
`20 DIMG$[33],A$ [11],A(8)`	
`30 REMOTE D`	
`40 INPUT G$`	
`50 OUTPUT D;G$`	Configure 775 suggest "G.001S3X".
`55 P=SPOLL (D)`	
`56 DISP ''SPOLL='';P`	B0 is OFLO bit.
`60 ENTER D; A$`	
`61 FOR I=1 TO 6 @ A(I) =NUM (A$[I])@ NEXT I`	Binary equivalent of BCD string.
`64 I=1 @ GOSUB 200@ T=R`	Decimal time value.
`66 I=4 @ GOSUB 200@ E=R`	Decimal event count.
`68 F=10 v8*(E/T)`	
`70 DISP ''FREQ='';F`	
`71 DISP ''LSD OF RESOLUTION='';F/T`	
`75 DISP ''E/T ='';E;''/'';T`	
`80 GOTO 40`	
	Packed BCD to decimal.
`200 R=0`	
`202 FOR N=2 TO 0 STEP -1`	
`210 R=R+(A(I+N) MOD 16+A(I+N) DIV 16*10)*10 v(2* (2-N))`	
`225 NEXT N`	
`230 RETURN`	

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Table 3-20. Dump Mode Specifications

Device-depedent Command:	S3
Display During Dump:	bu,SY
Processing Time Between Measurements:	Less than 5.5msec (measurement processing and display are suppressed).
Data Transfer:	Controller speed dependent (2.75msec using PSI 80).
Minimum Readings/Sec:	40 (with a gate time of 9.99999msec).
Maximum Readings/Sec:	140 (with a gate time of 100μsec).
Operational Functions Disabled During Dump:	Normal display, external trigger.
Data Format:	BCD except terminator.
Output Format:	
Interpretation:	T5-T0=TIME REGISTER E5-E0=EVENT REGISTER
Gate Time Limits:	100μsec to 9msec with internal gate-time. 100μsec to 9.99999msec with external gate-time.
Overflow Indication:	999999 in either time or event registers. Overflow bit in the SPOLL byte is set, RQS in M1 mode.

Conditions that cause overflow:

1. Gate-time longer than 9.99999msec.
2. In FREQ A or B and PERIOD AVG when maximum frequency x gate time is greater than 999,999, but under no condition should gate time be longer than 9.99999msec.
3. In TIME INTERVAL A to B, PERIOD A and PULSE A + delay time longer than 9.99999msec.
4. In FREQ C when frequency/256 x gate time is greater than 999,999.

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Dump Output Mode Calculation Examples:

Frequency

Mode: F0G1E-3Y4S3X
Output:

08	98	52	00	00	05

Time Register: 089852
Event Register: 000005

$$\text{Frequency: } \frac{5 \times 10^8}{89852} = 5564.706407\text{Hz}$$

$$\text{*LSD: } \frac{5564.706407}{89852} = 0.061931914\text{Hz}$$

This is rounded to 0.1Hz.

Adjusted Frequency Reading: 5.5647E+3Hz.

Period

Mode: F2Y4S3X
Output:

73	22	78	00	00	00

Time Register: 732278
Event Register: 0

Period: 732278×10^{-8}

Adjusted Period Reading: 7.32278E−3sec.

Period Averaged

Mode: F3G1E−3Y4S3X

Output:

10	12	64	00	03	09

Time Register: 101264
Event Register: 000309

$$\text{Period Averaged: } \frac{101264 \times 10^{-8}}{309} = 327.7152104 \times 10^{-8}$$

$$\text{*LSD: } \frac{327.7152104 \times 10^{-8}}{101264} = 0.003236245 \times 10^{-8}$$

This is rounded to $.01 \times 10^{-8}$.

Adjusted Period Averaged Reading: 327.71E-6sec.

Frequency C

Mode: F6G9E-3Y4S3X
Output:

90	17	89	03	73	06

Time Register: 901789
Event Register: 037306

$$\text{Frequency: } \frac{256 \times 37306 \times 10^8}{901787} = 10.5904565 \times 10^8\text{Hz}$$

$$\text{*LSD: } \frac{10.5904565 \times 10^8}{901787} = 0.00001174 \times 10^8\text{Hz}$$

This is rounded to 0.00001×10^8Hz

Adjusted Frequency Reading = 1.059045E+9Hz

*LSD is the least significant usable digit.

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Table 3-21. Dump Output Mode Result Calculation

Function	TIME Register Content (T)	EVENT Register Content (E)	Result Calculation	LSD Calculation
F0, F1	Timebase Counts	Channel A,B Events Counts	$\frac{E \times 10^8(Hz)}{T}$	$\frac{F}{T}$
F3	Timebase Counts	Channel A Events Counts	$\frac{T \times 10^{-8}(sec)}{E}$	$\frac{Per\ Avg}{T}$
F2,F4,F5	Timebase Counts	0	$T \times 10^{-8}(sec)$	10nsec
F6	Timebase Counts	Channel C Events Counts	$\frac{256 \times E \times 10^8(Hz)}{T}$	$\frac{Fc}{T}$

3.12 FRONT PANEL ERROR MESSAGES

The process of programming the Model 775 involves the proper use of syntax. Syntax is defined as the orderly or systematic arrangement of programming commands or languages. The Model 775 must receive valid commands with proper syntax or it will:

1. Ignore the entire command string in which the invalid command appears.
2. Set appropriate bits in the status byte and error word.
3. Generate an SRQ if programmed to do so.
4. Display an appropriate front panel message.

Device-dependent commands are sent as a string of several ASCII characters. Some examples of valid command strings include:

F0X Single command string.
F0D2B2X Multiple command string.
B1 X Space is ignored.

Examples of invalid command strings are:

C0X Invalid command; C is not a command.
F8X Invlaid command option; 8 is not an option of the F command.

Figure 3-10 shows the front panel error messages employed by the Model 775. The messages in Figure 3-10(a) results from an Illegal Device-Dependent Command (IDDC), while the message in Figure 3-10 (b) results from an Illegal Device-Dependent Option (IIDCO).

3.12.1 IDDC Error

An IDDC error results when the Model 775 receives an invalid command such as C1X. This command is invalid because no such letters exists in the instruments programming language.

Programming Example—To demonstrate an IDDC error enter the following statements into the HP-85 keyboard:

```
REMOTE 723
OUTPUT 723;''C1X''
```

When END LINE is pressed the second time, the error message in Figure 3-10 (a) is displayed for about one second.

3.12.2 IDDCO Error

An IDDCO error occurs when the numeric parameter associated with a legal command letter is invalid. For example, the command D7X has an invalid option because the instrument has no display mode associated with that number.

Programming Example—To demonstrate an IDDCO error enter the following statements into the HP-85 keyboard;

```
REMOTE 723
OUTPUT 723;''D7X''
```

When END LINE is pressed the second time, the error message in Figure 3-10(b) is displayed for about one second.

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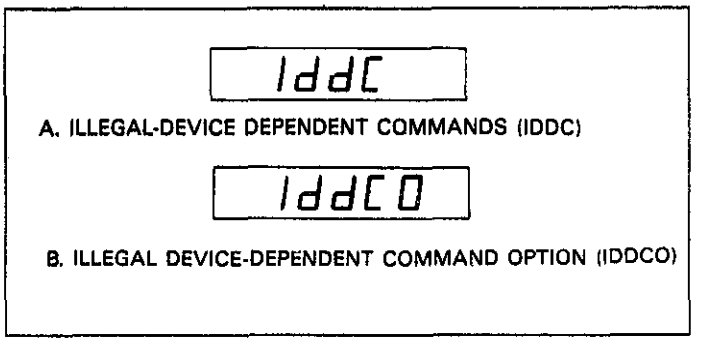


Figure 3-10. IEEE-488 Display Error Messages

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SECTION 4
PERFORMANCE VERIFICATION

4.1 INTRODUCTION

This section contains information necessary to verify that the Model 775 is performing within the specified accuracy. The Model 775 specifications may be found preceding Section 1 of this manual. Ideally, performance verification should be performed when the instrument is first received to ensure that no damage or change in calibration has occurred during shipment. The verification procedure may also be performed whenever instrument operation is suspect or following calibration. If performance on any of the functions is substandard, adjustments can be performed as described in Section 6.

NOTE

If the instrument does not meet specifications and it is still under warranty (less than 12 months since date of shipment), contact your Keithley representative or the factory to determine the action to be taken.

4.2 ENVIRONMENTAL CONDITIONS

All measurements should be made at an ambient temperature between 0 and 40°C with a relative humidity of less than 80%.

4.3 RECOMMENDED TEST EQUIPMENT

Recommended test equipment for the Model 775 performance verification is listed in Table 4-1. Different equipment may be used as long as the accuracy specifications are equal or exceed the specifications listed in Table 4-1.

4.4 INITIAL CONDITIONS

Before performing the verification procedures, make sure the Model 775 meets the following conditions:

1. If the instrument has been subject to temperatures below 0°C or above 50°C, allow sufficient time for the instrument to reach temperatures within the range. Generally, it takes one hour to stabilize an instrument that is 10°C (18°F) outside of this range.
2. Turn on the power to the Model 775 and allow it to warm-up for at least two hours before beginning the verification procedure.

4.5 VERIFICATION PROCEDURES

The following paragraphs give the basic verification procedure for the following functions: Channels A, B and C input sensitivity, Period A, Period Averaged A, Pulse A, Time Interval A→B, Delay, Ext. Gate/Delay, and Ext. Arming.

Table 4-1. Recommended Test Equipment For Performance Verification

Instrument	Recommended Model	Specifications
Oscilloscope	Tektronics 465	100MHz bandwidth
Multimeter	Keithley 175	0.1% basic DC accuracy
Synthesized Signal Generator	Marconi 2019	1040MHz, 10^{-7} 0-50°C
Function Generator	HP-3312A	13MHz pulse, sine, triangle, triggered
10MHz Standard	Oscilloquartz 2200	10^{-10}/day, 5×10^{-10} 0-50°C

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NOTE

Channel C input sensitivity verification procedure requires that the Model 7751 option be installed. TCXO accuracy verification requires that Model 7752 option be installed.

4.5.1 Channels A, B and C Input Sensitivity

The input sensitivity verification procedure is done by applying an accurate sine signal to the channels A, B and C input terminals and then checking to see if the displayed value is stable within the required range.

NOTE

Unless otherwise specified the initial set up of the Model 775 throughout the verification procedure should be the default position upon power-up. Should this set up change during one of the following verification procedures, it is imperative that the default condition is restored before the next procedure is started.

The output of the synthesized signal generator should always be terminated, at the input terminals of the Model 775, with 50Ω feedthrough terminator.

1. Set the synthesized signal generator to 10MHz and an amplitude of 25mV RMS. Apply this signal to the channel A input terminal.
2. Observe that the reading on the display is stable within the limits of 10.0000000E+6Hz ±500 counts.
3. Change the signal generator settings to 100MHz and an amplitude to 50mV RMS.
4. Observe that the reading on the display is stable within the limits of 100.000000E+6Hz ±500 counts.
5. Change Model 775 setting to frequency B and repeat steps 1 through 4 while applying the signal to the channel B input terminal.
6. Change the Model 775 setting to frequency C.
7. Set the signal generator to 100MHz and an amplitude of 25mV RMS, remove the 50Ω feedthrough terminator and apply this signal to the channel C input terminal.
8. Observe that the reading on the display is stable within the limits of 100.000000E6Hz ±500 counts.
9. Change the signal generator setting to 1040MHz.
10. Observe that the reading on the display is stable within the range of 1.04000000E+9Hz ±500 counts.

4.5.2 Period Measurement Accuracy Check

The period measurement verification procedure is done by applying an accurate sine signal to the channel A input terminal and then checking to see if the displayed value is within the required range.

1. Set the synthesized signal generator to 1MHz and an amplitude of 100mV RMS. Apply this signal to the channel A input terminal.
2. Change the Model 775 setting to PERIOD A.
3. Observe that the reading on the display is stable within the limits of 1.00E-6 second ±1 count.
4. Change signal generator setting to 100MHz.
5. Observe that the reading on the display is stable within the limits of 0.01E-6 second ±1 count.

4.5.3 Period Averaged Measurement Accuracy Check

The period averaged measurement verification procedure is done by applying an accurate sine signal to the channel A input terminal and then checking to see if the displayed value is within the required range.

1. Set the synthesized signal generator to 1MHz and an amplitude of 100mV RMS. Apply this signal to the channel A input terminal.
2. Change the Model 775 setting to PERIOD A.
3. Observe that the reading on the display is stable within the limits of 1.00000000E-6 second ±500 counts.
4. Change signal generator setting to 100MHz.
5. Observe that the reading on the display is stable within the limits of 10.0000000E-9 second ±500 counts.

4.5.4 Time Interval A→B Measurement Operation Check

The time interval A→B measurement verification procedure is done by applying a square wave signal to the channels A and B input terminals simultaneously, and then checking to see if the displayed value is within the required range.

1. Set the function generator to 500kHz square wave and an amplitude of 1V RMS. Apply this signal through a "T" BNC adapter to the channels A and B input terminals.

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2. Change the Model 775 setting to TIME A→B, and SLOPE B setting to negative slope.
3. Observe that the reading on the display is approximately 1.00E-6 second.
4. Change the Model 775 setting to positive SLOPE B and negative SLOPE A.
5. Observe that the reading on the display is approximately 1.00E-6 second.

4.5.5 Pulse A Measurement Operation Check

The pulse A measurement verification procedure is done by applying a square wave signal to the channel A input terminal and then checking to see if the displayed value is within the required range.

1. Set the function generator to 500kHz square wave and an amplitude of 1V RMS. Apply this signal to the channel A input terminal.
2. Change the Model 775 setting to PLS A.
3. Observe that the reading on the display is approximately 1.00E-6 second.

4.5.6 Delay Operation Check

The delay function verification procedure is done by applying a square wave signal, to the channels A and B input terminals simultaneously, and then checking to see of the displayed values, with and without the delay, are within the required range.

1. Set the function generator to 1Hz square wave and an amplitude of 1V RMS. Apply this signal through a "T" BNC adapter to the channels A and B input terminals.
2. Change the Model 775 setting to TIME A→B, and SLOPE B setting to negative slope.
3. Observe that the reading on the display is approximately 500E-3 second.
4. Change the Model 775 MODE setting to DELAY.
5. Observe that the reading on the display is approximately 1.5 second.

4.5.7 External Gate Operation Check

The external gate operation verification is done by applying a gating signal through the rear panel input terminal and then checking to see if the reading on the display is within the required range.

1. Set the synthesized signal generator to 10MHz and an amplitude of 50mV RMS. Apply this signal to the channel A input terminal.
2. Change the Model 775 setting to frequency A and user gate mode.
3. Change function generator setting to .5Hz square wave.
4. Apply this SYNC output (TTL) to the rear panel EXT ARMING & GATE/DELAY input terminal.
5. Observe that the Model 775 displays 10MHz with a resolution of nine digits.
6. Change the function generator setting to 1kHz.
7. Observe that the Model 775 displays 10MHz with a resolution of five digits.
8. Change the function generator frequency setting throughout the range of .5Hz to 10kHz and observe that the displayed resolution on the Model 775 increases when frequency setting on the function generator decreases and vice-versa.

4.5.8 Arming Operation Check

The arming operation verification is done by applying a signal to the channel A input terminal when the Model 775 is in the hold mode; then applying an arming signal to the rear panel EXT ARMING & GATE/DELAY input terminal or depressing the RESET button to activate one measuring cycle.

1. Set the synthesized signal generator to 10MHz and an amplitude of 50mV RMS. Apply this signal to the channel A input terminal.
2. Change the Model 775 setting to the frequency A hold mode. Note that the GATE LED does not flash, indicating that the Model 775 is in hold mode but has not received an arming signal yet.
3. Change the function generator setting to 1kHz square wave and manual trigger, and apply the SYNC output (TTL) to the rear panel EXT ARMING & GATE/DELAY terminal.
4. Depress the MAN button on the function generator and observe that the GATE light flashed once and the Model 775 displays 10.0000000E+6Hz ±500 counts.
5. Remove the cable from the rear panel EXT ARMING & GATE/DELAY terminal leaving the above set-up as is.
6. Press once the front panel RESET button and observe that the display reading is cleared (0), the GATE indicator illuminates for about one second and then the following reading is displayed: 10.0000000E+6Hz ±500 counts.

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4.5.9 Model 7752 TCXO Accuracy Check

Model 7752 performance verification is done by using the same procedures as described above. The difference is in the resulted display, where instrument equipped with the Model 7752 option should display a reading with a tighter tolerance. Therefore, instruments which are equipped with the Model 7752 option where specified tolerance in the above checks is 500 counts, tolerance should change to 100 counts.

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SECTION 5
THEORY OF OPERATION

5.1 INTRODUCTION

This section contains an overall functional description of the Model 775 as well as detailed circuit analysis of the various sections of the instrument. Information pertaining to the standard IEEE interface and the Models 7751 Channel C and 7752 TCXO options are also included.

Information is arranged to provide a description of individual functional circuit blocks. As an aid to understanding, the descriptions are keyed to accompanying block diagrams and simplified schematics. Detailed schematics and componet layout drawings are located at the end of this instruction manual.

5.2 OVERALL FUNCTIONAL DESCRIPTION

The Model 775 is a nine digit counter with six standard measurement functions as well as one optional measurement function. Model 775 utilizes a modern reciprocal measurement technique hence increasing resolution in low frequency measurements; as compared to other counters which utilize the more conventional fixed gate technique. As an example, a conventional counter measuring 1kHz with a gate time of one second will display a resolution of 1Hz; where as the Model 775 with the same gate time, will always display a minimum of eight digits of resolution.

A simplified block diagram of the Model 775 is shown in Figure 5-1. The heart of the Model 775 is the two counting registers: one totalizing the number of input events - the EVENT COUNTER; and one, at the same time, totalizing the number of pulses from the reference oscillator - the TIME COUNTER. The internal microcontroller then computes the result to be displayed, using the following formula:

$$F = \frac{\text{EVENT COUNTER}}{\text{TIME COUNTER} \times T}$$

where: T=the period of the reference oscillator.

The input signal is applied through the input amplifiers to switching circuits which in turn routes the signals to the correct counting circuits. If the Model 7751 is installed, a signal from the channel C input terminal will pass through the channel C input amplifier to the internal selectors. The microcontroller, working under software control, then converts the signal into a form suitable for the display on the front panel or over the IEEE bus.

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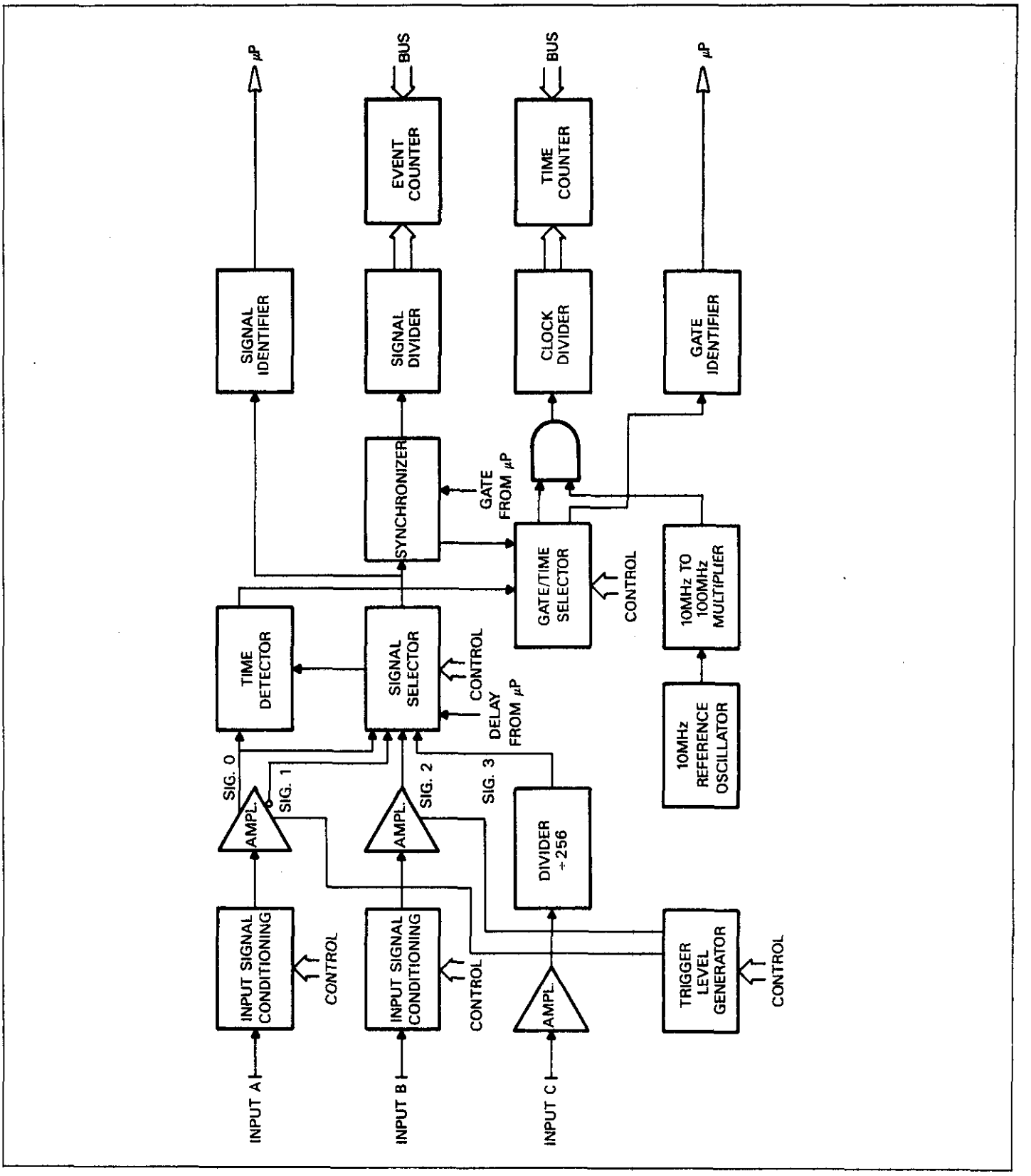


Figure 5-1. Model 775 Simplified Block Diagram

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5.3 ANALOG CIRCUITRY

The following paragraphs contain a description of the input circuits, measurement circuits, frequency multiplier and the power supply. These circuits may be found on schematic diagrams located at the end of this manual.

5.3.1 Input Circuits A and B

NOTE

Channels A and B are identical in terms of components and operation. Therefore, the following description, which reviews channel A circuits, applies to channel B as well. Note that letter designations for components in channel A are different for similar components in channel B.

The signal which is applied to the channel A input signal is preconditioned in front of the amplifier circuit by means of relays and electronic components as follows:

Coupling—Coupling is controlled by a relay K1 and capacitor C11. When the instrument is DC coupled, K1 contacts are closed. When the instrument is AC coupled, K1 contacts are open and C11 blocks the DC components of the input signal.

Attenuation—Attenuation is controlled by relay K2, resistor network R14 and R15 and capacitor network C12 and C13. When K2 is shorting between points 1 and 8 on the relay, there is no attenuation. When K2 is shorting between points 8 and 14 on the relay, attenuation is x10.

Filtering—The low-pass filter is controlled by relay K3. Contacts on K3 are normally closed thus, C15 is in parallel to R16. When the relay contact is open, the impedance of R16 shunted by the input capacitance of the impedance converter, act as a low-pass filter.

Input Protection—Front panel conditioning is capable of handling signals within the specified dynamic range of the Model 775. Protection of the input circuit from over-voltage signals (up to the specified limits) are accomplished by R17, CR2, 3 and CR21.

Amplifier—The amplifier consists of an impedance converter formed by Q20, an amplifier formed by Q21 and Q22 and U34a, and a Schmidt trigger which is formed by U34b and their associated components. The trigger level is controlled by Q22 via L15 and R33. The slope that the input signal triggers on is controlled by an exclusive OR circuit-U35.

5.3.2 Input Circuit C

The signal which is applied to the channel C input terminal is AC coupled through C1 and through the amplitude limiting network CR1 to CR6 and CR12 and CR13 to the input of the first stage amplifier. Further protection is achieved with a fuse F1. The amplifier consists of a two stage amplifier. Q1 and Q2 with their associated components form the first stage, while Q3 and Q4 and their associated components form the second stage. The output of the second stage amplifier (the collector of Q4) is AC coupled through C20 to a divide by 256-U1.

5.3.3 10MHz Standard Reference Oscillator

The reference oscillator includes a hibrid oscillator Y1, buffers U2a, b and d and a voltage regulator U1. C2 through C4 adjust the oscillator frequency to a known reference; C4 provides a coarse adjustment and C3 provides a fine adjustment. S1 selects the signal to be applied to the Model 775 internal circuitry either an internal reference or an external standard. CR1 and CR2 protect the external input against overloads.

5.3.4 10MHz TCXO Reference Oscillator (Option 7752)

The TCXO reference oscillator circuit consists of a hybrid oscillator Y1, buffers U2a, b and d and a voltage regulator U1 U2d is an output buffer which connects the internal 10MHz signal to a rear panel BNC terminal.

5.3.5 100MHz Multiplier

The 10MHz reference oscillator is multiplied internally to generate a stable 100MHz signal which is related both in phase and accuracy to the 10MHz reference oscillator. The 10MHz signal from the reference oscillator is coupled to the multiplier via C49. U50a converts the TTL signal coming from the oscillator to a sine wave which is then fed to Q37. Q37 amplifies the 10MHz signal and produces two 10MHz signals with a phase difference of 180°. CR16 and CR17 act as full wave rectifiers, thus creating a 20MHz signal. The 20MHz signal is fed via C58 to a tuned circuit where L4 and C62 are tuned for 20MHz. The x5 multiplier consists of U51a and U51b which are tuned by the tank circuits L5-C67 and L6-C70 to the fifth harmonic of the 20MHz signal.

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The 100MHz signal is finally coupled through C72 to the 100MHz buffer Q38 and its associated components.

5.3.6 Measurement Section

The measurement section is a block which controls various switching, routes the internal signals to the correct ports. It also controls the sequence of the gate and resets and synchronizes the time and the event counters for the microcontroller. Figures 5-2 to 5-7 show the routes for the input signal and the reference signal in every measurement function. The following is a brief explanation of the various segments in the measurement section.

Control—The control circuit consists of U26, U28 and U30. Information from the microcontroller is sent in a serial form to control the ICs which in turn convert the serial information to a parallel format. The parallel outputs of these ICs are being used to control the D to A converters and the signal routes as described previously.

Trigger Level—The trigger level circuit comprises U31, U32, U33, U27, U29 and their associated components. Binary data which is received from the control circuit is converted by U31 and U27 to a known DC voltage with U32 and U29 respectively. U33 is a +5V voltage reference with very good stability. R6 adjusts the full scale voltage of the D to A converters.

Signal Selector—The signal selector circuit comprises U37, U38a and U38b. One of Sig 0 through Sig 3 are selected to be transmitted to the time detect, signal identifier or the synchronizer.

Time Detect—The time detect circuit consists of a dual D flip-flop U39 and a gate U38d. U39a receives the start signal and U39b (clk in) receives a stop signal. Following a reset signal at the reset input of U39, U38d outputs a single negative going pulse with a duration which is equal to the time interval between the start and the stop signals, regardless if the start and the stop signals are repetitive.

Synchronizer—The synchronizer consists of a D flip-flop U40a and a gate U38c and their associated components. A gate signal is applied from the microcontroller to the D input of U40a and the measured signal is coupled to the CLK input on the same IC. After a reset cycle, and assuming that a signal is present at the appropriate input terminal, the output of U40a will generate a pulse with an approximate width of the original gate signal from the microcontroller, but with a new adjusted width which is equal to an integer number of periods of the signal being measured. This pulse will be used as the main gating signal throughout the instrument. Gates U42a, U42b and U42d control the routing of the synchronized gate and the time interval pulses to the main gate of the Model 775-U42c.

Main Gate—The main gate of the Model 775 consists on U42c. Signals from the synchronizer or the time detector are applied to one input of this gate and the 100MHz reference signal is applied to the second input resulting at the output of the gate a 100MHz burst of pulses.

Clock Divider—The burst of pulses with a frequency of 100MHz divided by two by U41b and applied to the ECL to the TTL converter which in turn outputs a TTL signal through U43a to the dividers chain.

Signal Divider—The signal coming from the synchronizer circuit is divided by two using a D flip-flop U40b and applied to the ECL to the TTL converter which in turn outputs a TTL signal through U49b to the divider chain.

Signal Identifier—The signal identifier comprises U41a, Q28 and Q29 and their associated components. A signal when present at the appropriate input terminal, is applied to the CLK input of U41a, converted to a TTL level signal with Q28 and Q29 and then fed to one of the microcontroller ports via U49a. This port will be used to flag the presence of a signal at the input terminals. This signal is also used as the arming signal of the counter.

Gate Identifier—The gate identifier informs the microcontroller of the state of the main gate. The gate identifier circuit also serves as a time stretcher of gate signals with very small periods. The gate identifier consists of U43b, Q33, C10 and is buffered by U43d and U43c.

Event Counter—The event counter counts the number of pulses or events which occur at the input terminal. The event counter comprises a high speed divider chain which is formed by the signal divider circuit in combination with U44 and U45 and a low speed counter U12.

Time Counter—The time counter counts the number of pulses from the reference oscillator. The time counter comprises a high speed divider chain which is formed by the clock divider circuit in combination with U46, U47a, U48 and a low speed counter U13.

5.3.7 Power Supply

For the following discussion, refer to the power supply schematic at the end of the manual. The power supply is made up of a line fuse, power on-off switch, line voltage selection switch, power transformer, two bridge rectifiers, two regulators and a 5V regulator which is formed by U54, Q40, Q41 and Q39 and their associated components.

Fuse F1 is the LINE FUSE which is accessible on the rear panel. S2 is the LINE VOLTAGE SELECT switch which is accessible on the rear panel to select 115V or 230V operation and S1 is the power on-off switch.

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CR18 is used as a full wave rectifier to provide a sufficient DC voltage for the +12V and -12V regulators U52 and U53 respectively.

U54 receives a reference voltage of 5V from the 12V supply. This reference is then buffered by U54 amplifier and applied through Q41 to the series regulator Q40. Q40 is mounted on the rear panel to absorb the heat generated by the power transistor. Q39 and R123 form a protection circuit against accidental shorts or overload.

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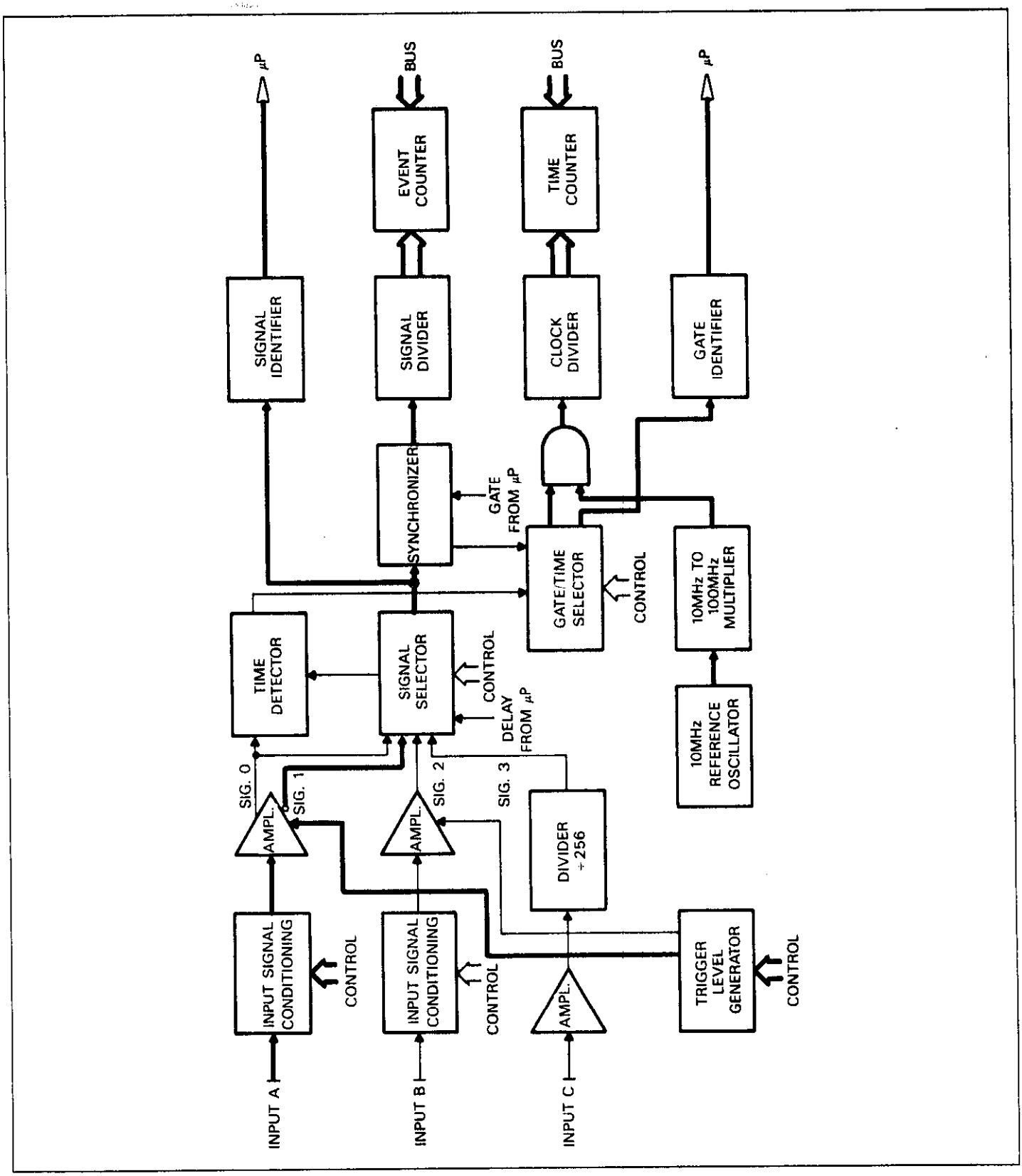


Figure 5-2. Frequency A Measurement Block Diagram

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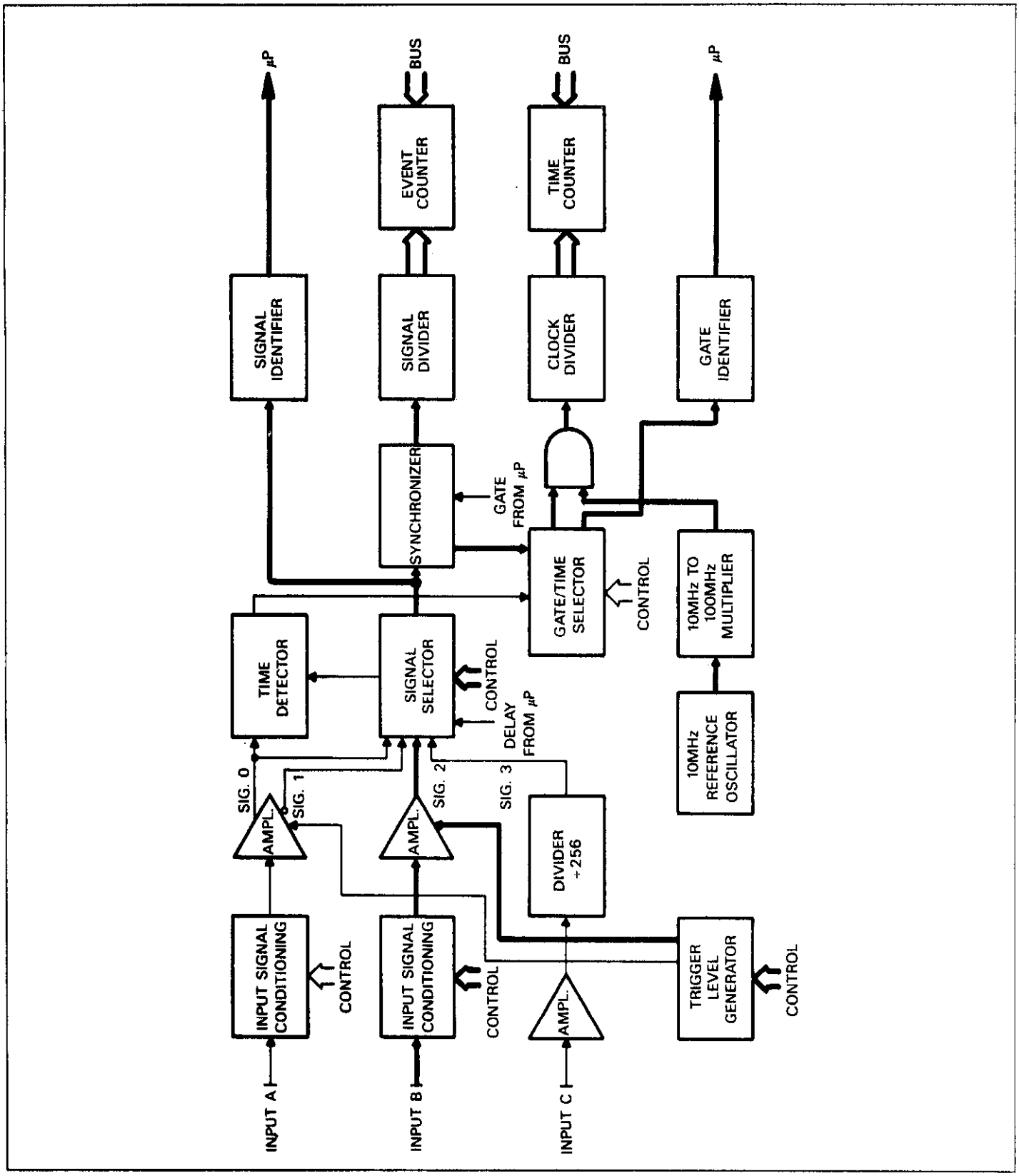


Figure 5-3. Frequency B Measurement Block Diagram

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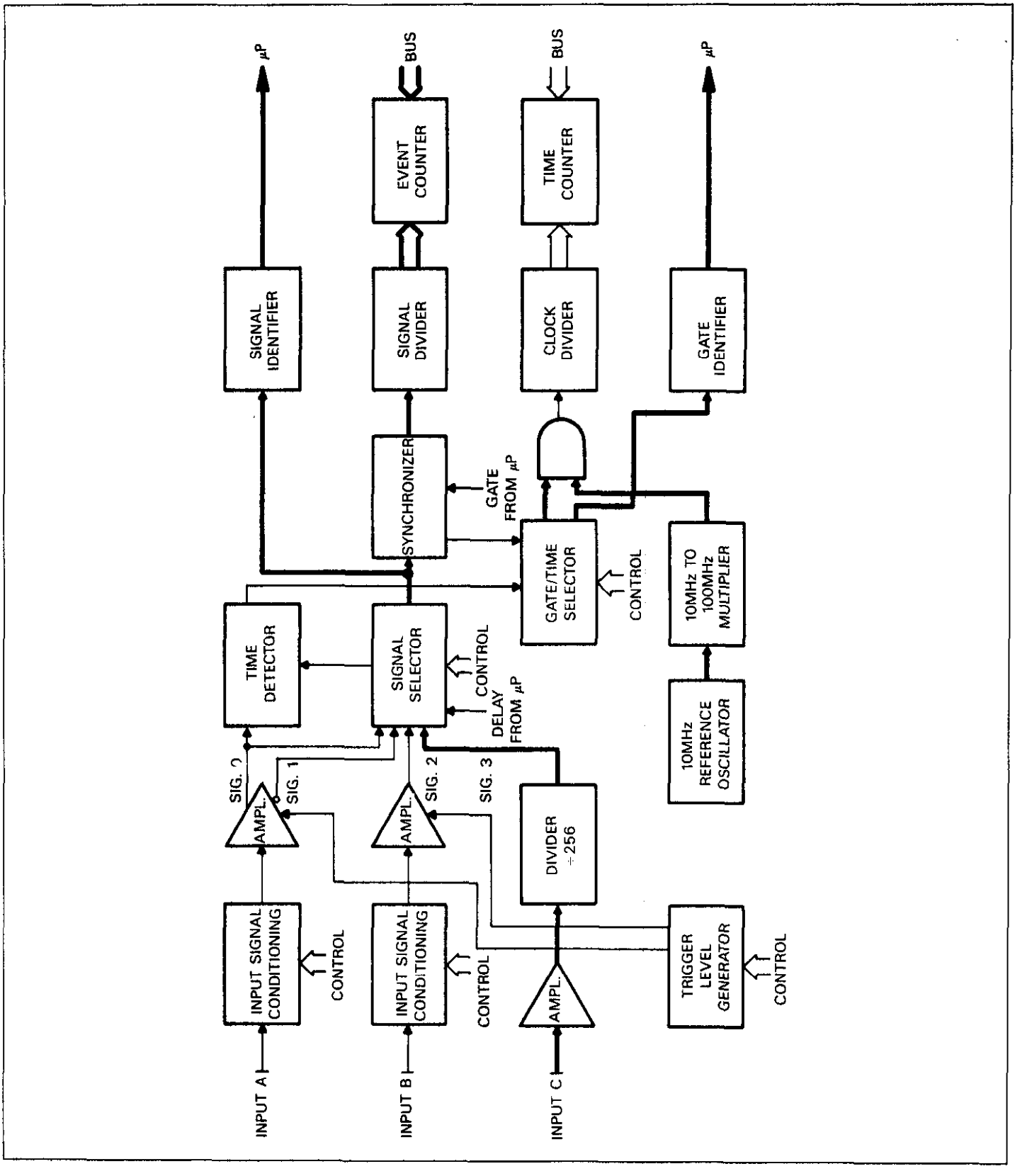


Figure 5-4. Frequency C Measurement Block Diagram

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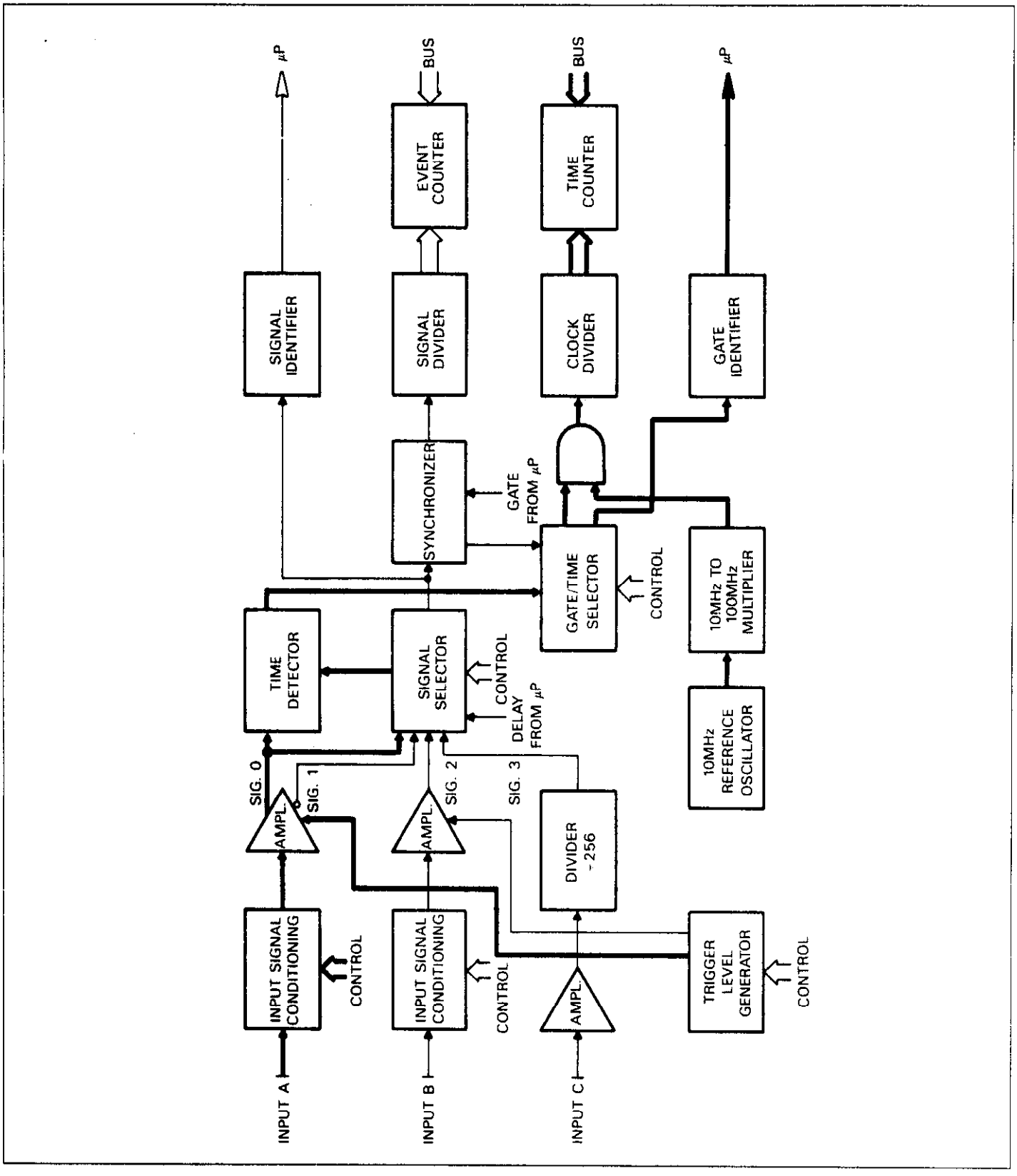


Figure 5-5. Period A Measurement Block Diagram

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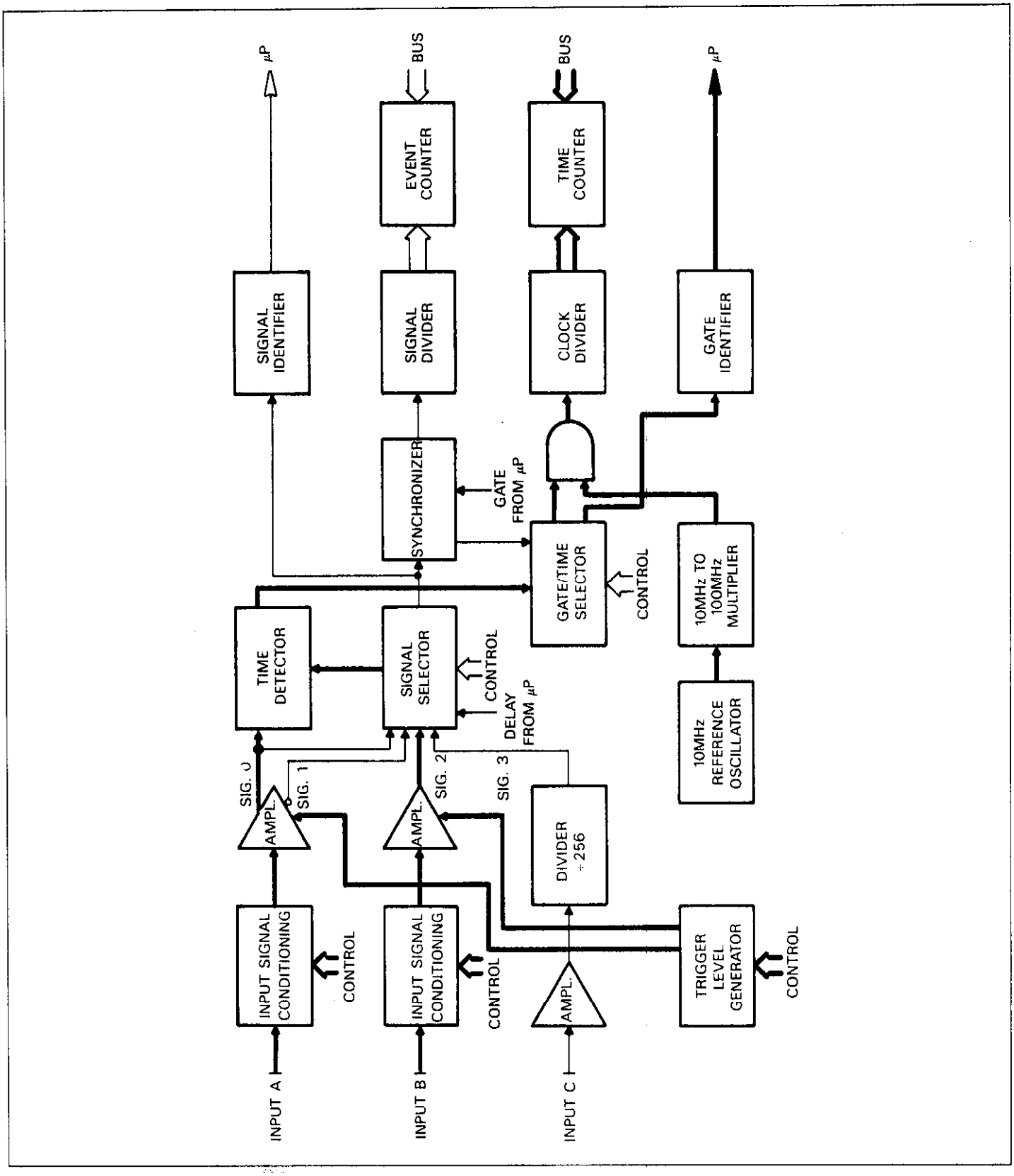


Figure 5-6. Time Interval A→B Measurement Block Diagram

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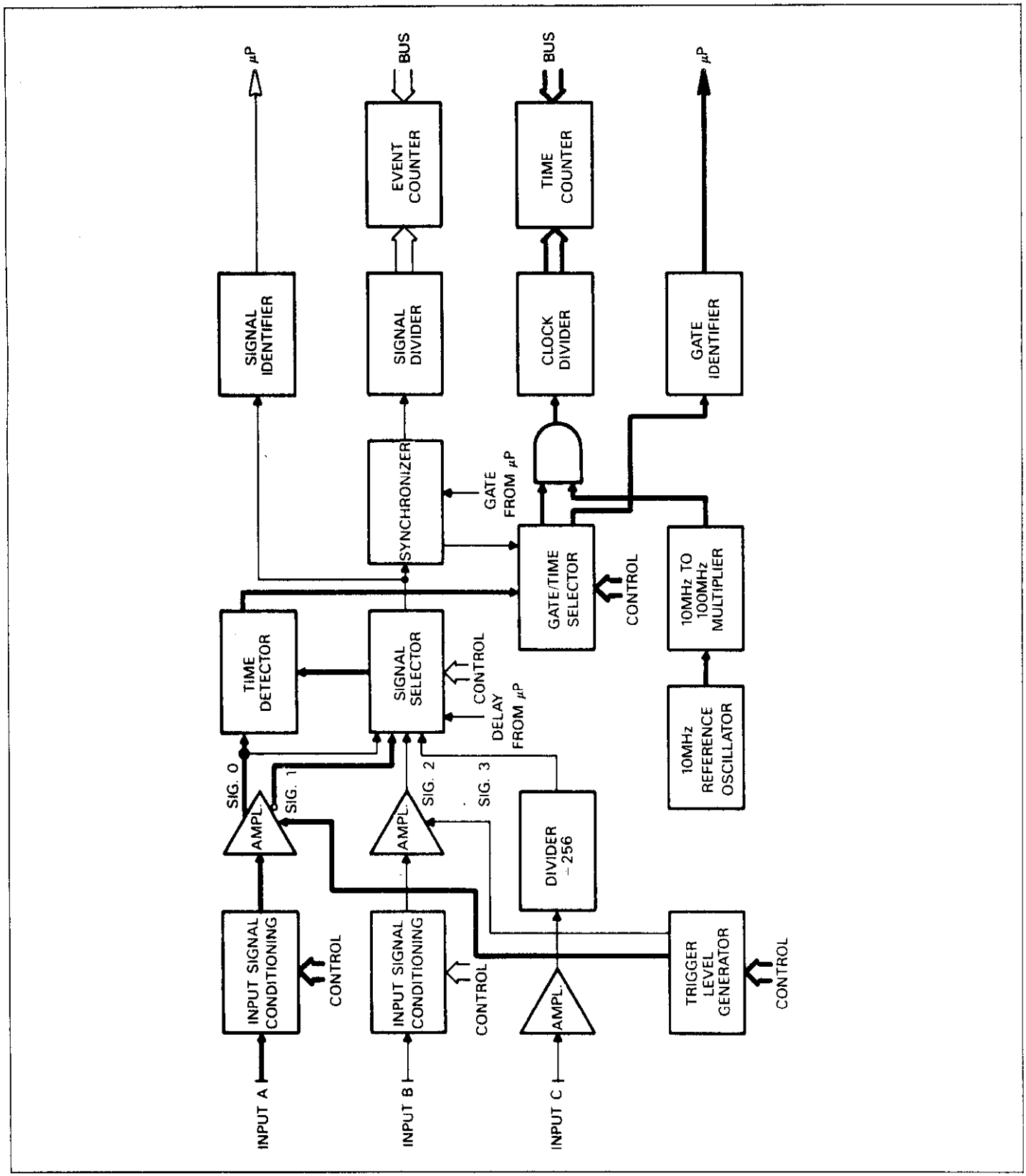


Figure 5-7. Pulse Width Measurement Block Diagram

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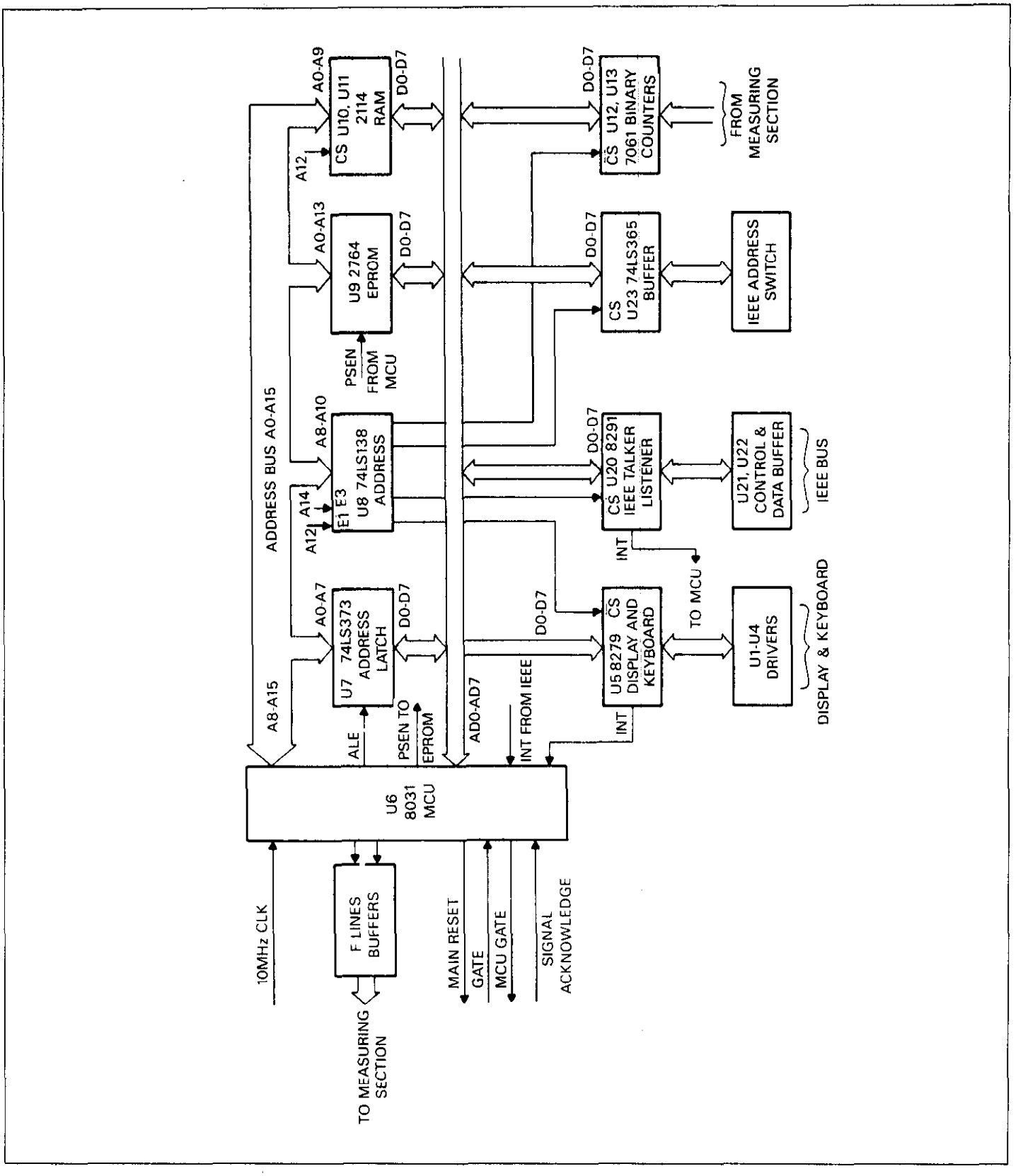


Figure 5-8. Microcomputer Block Diagram

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5.4 DIGITAL CIRCUITRY

Model 775 operation is supervised by the internal microcomputer. Through the MCU, the counter measurement process, the front panel switching, display, and IEEE operation are all performed under software control. This section briefly describes the operation of the various sections of the microcomputer and associated digital circuitry. A simplified block diagram is included for user reference; for more complete circuit details refer to the digital schematics at the end of this manual.

5.4.1 Microcomputer Block Diagram

A block diagram of the Model 775 microcomputer is shown in Figure 5-8. Circuit operation centers around the microcontroller unit (MCU), U6. The 8031 is an 8-bit microcontroller capable of directly addressing up to 64K bytes of program memory (ROM) and up to another 64K bytes of data memory (RAM). The microcontroller works with a 10MHz clock which is divided internally to provide bus operation of about 1MHz.

Software for the MCU is contained in an EPROM (Erasable Programmable Read-Only Memory). U9 is a 2764 EPROM containing 8K bytes of software. Temporary storage is provided by U10 and U11 RAMs which can store up to 1024 bytes of information.

Interfacing between the MCU and the IEEE bus is performed by the dedicated IEEE-488 bus interface IC, U20. This IC performs many bus functions automatically to minimize MCU overhead. Buffering between the 8291 IC and the IEEE bus lines is done with the bus drivers U21 and U22.

Interfacing between the MCU to the keyboard and the display is performed by the Keyboard/Display interface IC-U5.

5.4.2 Memory Mapping

The 8031 microcontroller is capable of directly addressing two banks of 64K (65,536) byte memory. One bank of memory is the program memory and the second memory bank is the data memory. The selection of the banks is done internally by the MCU. Although the MCU has this large addressing capability, only a portion of the possible memory space is actually needed.

The Model 775 uses a total of 8K of program memory stored in the 2764 EPROM U9, and a total of 1K of data memory is stored in U10 and U11. The 8031 MCU uses a memory-mapped I/O scheme, additional memory locations must be allocated for the various I/O functions. All the memory-mapped I/O functions are in the data memory space. Table 5-1 lists the memory locations for the various memory elements.

Because of a partial decoding scheme used in this instrument, for some memory elements, a larger memory slot is allocated than the actual memory needed.

5.4.3 Address Decoding

The MCU has a total of 16 address lines which are used to locate a specific memory slot. The LOW address line (A0 to A7) are multiplexed on the address/data bus, and the ALE (address latch enable) signal is used to separate the LOW address from the address/data bus which is done by U7 address latch. Since no memory or interface element can fully decode address locations, additional address decoding must be used.

U8 is 1-of-8 decoder. The decoder is enabled when address lines A14 is HIGH and A12 is LOW. Once the decoder is selected the decoding is done by addressing line A8, A9 and A10. When address line A12 is HIGH the RAMs are selected.

Table 5-1. Model 775 Memory Mapping

Selected Device	Allocated Memory	Actual Memory Location	Address Lines				
			A14	A12	A10	A9	A8
RAMs U10, U11)	$1000-$3FFF	$1000-$13FF	0	1	X	X	X
Display Interface (U5)	$4000-$40FF	$4000-$4001	1	0	0	0	0
IEEE (U20)	$4300-$4FFF	$4300-$4307	1	0	0	1	1
Address Switch (U23)	$4600-$46FF	$4600	1	0	1	1	0
Counters (U12, U13)	$4700-$47FF	$4700	1	0	1	1	1

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5.4.4 Keyboard/Display Interface

The Keyboard/Display Interface IC U5 is used to control the front panel display and to determine which one of the buttons was pushed.

5.4.5 IEEE Interface

The Model 775 has a built in IEEE-488 interface that allows the instrument to be controlled through the system controller. Commands may be given over the bus and data may be requested from the instrument as well.

The IEEE interface is made up of U20, a 8291 GPIA (General Purpose Interface Adapter), and U21 and U22, which are interface bus drivers. On the MCU side of the GPIA, data transmission is handled much like any other bus transaction. The MCU accesses the GPIA through the usual D0 through D7 data lines. Address decoding for the internal 16 registers (8 read and 8 write) is provided by the CS, WR, RD and A0, A1 A2 terminals.

The output of the 8291 IC is standard IEEE format; the eight data lines (DI01 through DI08) the three handshake lines (DAV, NDAC, NRFD), and the five management lines (ATN, REN, IFC, SRQ, EOI), are all active low with approximately zero volts representing a logic one. The two IEEE bus drivers, U21 and U22 are necessary to bring the drive capability of the interface up to the normal IEEE maximum 15 devices.

The GPIA simplifies MCU interfacing to the IEEE bus because many control sequences take place automatically. For example, when a write is done to the data output register, the handshake sequence is automatically performed at the proper time. Without the GPIA chip, complictaed MCU routines would be required to accomplish control sequence that are performed automatically.

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SECTION 6
MAINTENANCE

6.1 INTRODUCTION

This section contains informaton necessary to maintain, calibrate and troubleshoot the Model 775, Model 7751 Channel C option and Model 7752 TCXO option. Fuse replacement procedures, line voltage selection and Model 7751 and Model 7752 installation procedures are also included.

WARNING

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

6.2 LINE VOLTAGE SELECTION

The Model 775 may be operated from either 115V or 230V nominal 50-60Hz power sources. A special transformer may be installed for 100V and 200V ranges. The instrument was shipped from the factory set for the operating voltage marked on the rear panel immediately above the power line receptacle. To change the line votlage, proceed as follows:

WARNING

Disconnect the Model 775 from the power cord and all other sources before changing the line voltage setting.

1. Using a flat-blade screwdriver, place the line voltage selection switch in the desired position. The voltage selection switch is located above the power line receptacle.
2. Install a power line fuse consistent with the operating voltage (see paragraph 6.3 step 1).

CAUTION

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

3. Mark the selected voltage on the rear panel with a water soluable marking pen for future reference.

6.3 FUSE REPLACEMENT

The Model 775 has a line fuse to protect the instrument from excessive current. This fuse may be replaced by using the procedure described in the following:

WARNING

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

1. Place the end of a flat-blade screwdriver into the slot in the LINE FUSE holder on the rear panel. Push in and rotate the fuse carrier one quarter turn counterclockwise. Release pressure on the holder and its internal spring will push the fuse and the carrier out of the holder.
2. Remove the fuse and replace it with the proper type using Table 6-1 as a guide.

CAUTION

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

Table 6-1. Line Fuse Selection

Power Line Voltage	Fuse Type
90-125V	0.3A, 250V, 3AG
195-250V	0.15A, 250V, 3AG

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6.4 USING AN EXTERNAL TIMEBASE

The Model 775A may use an external 10MHz time base with the standard 5ppm time base of the 7752 TCXO time base. The following steps are required to use an external timebase.

1. Remove the top cover of the instrument as described in the disassembly instructions in paragraph 6.9
2. For the standard 5ppm time base locate switch S1 on the timebase board and slide it to the EXT position. See Figure 6-1A for the location of S1. The EXT position is with the switch towards the front of the Model 775.A
3. For the TCXO time base, locate switch S1 and slide it to the EXIT position. The EXT position is with the switch towards the top of the Model 775A.
4. Reinstall the top cover as described in paragraph 6.9.
5. Apply the TTL level (0 to +5V) 10MHz to the CLOCK IN/OUT BNC terminal on the rear panel. See Figure 2.2 for the location of this terminal.

CAUTION

Do not exceed the TTL voltage levels or damage to the Model 775 or the external source may occur. The EXT CLOCK input impedance of the Model 775 is nominally 200Ω, be sure to use the appropriate impedance matching devices to ensure that ringing and cable reflections are minimized. Severe ringing and waveform deformation may cause false or improper clock operation.

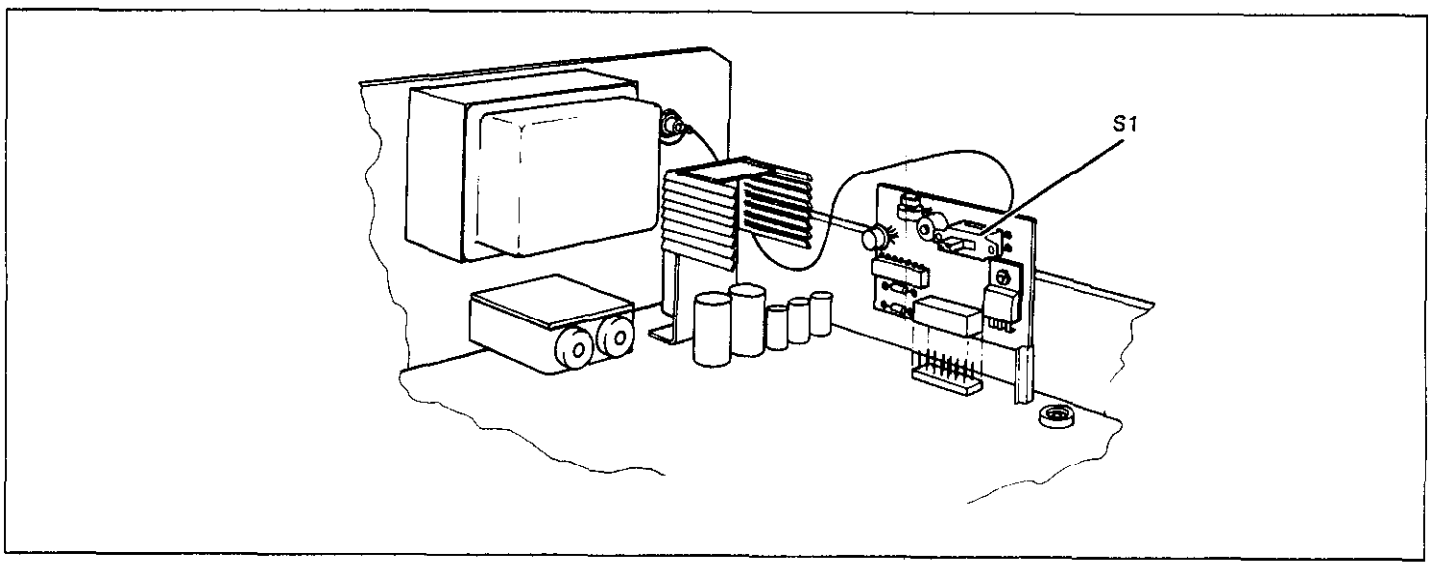


Figure 6-1A. Model 775A Standard 5 ppm Time Base

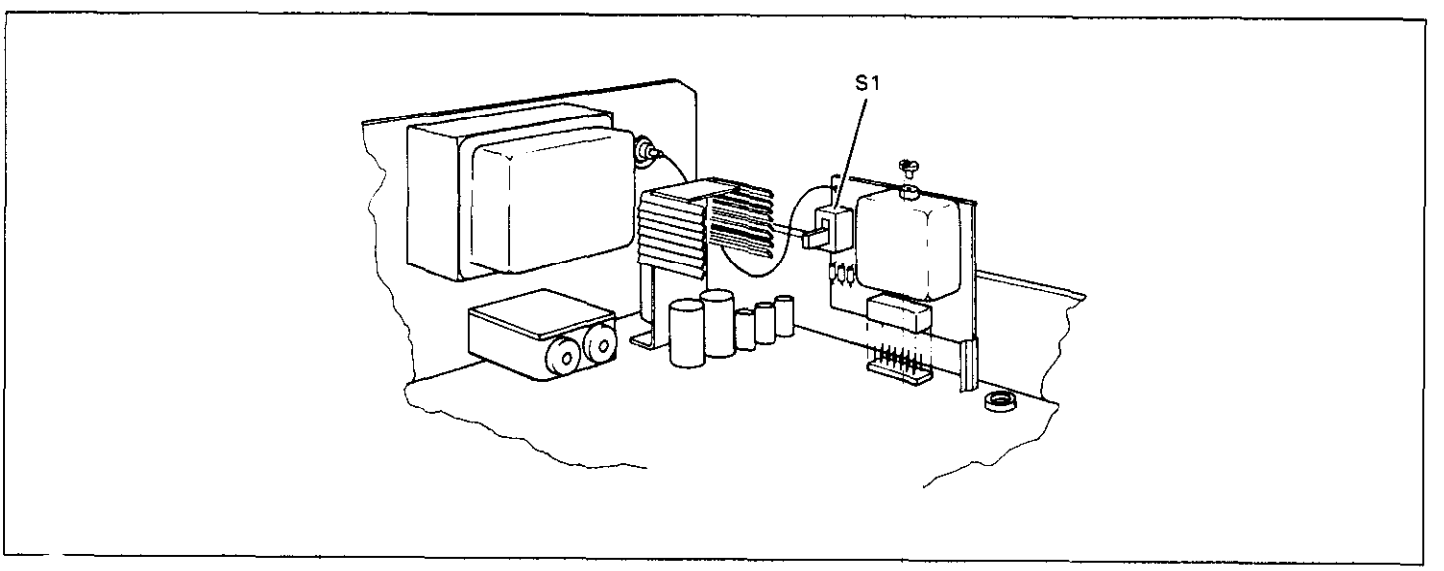


Figure 6-1B. Model 775A TCXO Time Base

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6.5 MODEL 7751 CHANNEL C OPTION INSTALLATION

The Model 7751 Channel C option expands the capability of the Model 775 by allowing it to measure frequencies up to 1.0GHz. If purchased with the Model 775, the Model 7751 will be factory installed; however, removal for service will require installation as follows:

1. Remove the top cover of the instrument as described in the disassembly instructions in paragraph 6.9.

WARNING
Disconnect the line cord and test leads from the instrument before removing the top cover.

2. Plug the Model 7751 into the comb type connector which is located in the front section of the instrument. The Model 7751 PC board should slide easily to its place between the two card guides.
3. Locate the shielded cable which is connected on one side to the channel C input terminal. The other side of this cable is soldered to one card guide to prevent this end from rattling inside the instrument and causing shorts. Unsolder the shielded cable from the guide and solder the prestripped cable as illustrated in Figure 6-2.
4. Solder both sides of the PC board to the card guides. This will secure the Model 7751 to its place and will prevent Model 7751 from loosening during transit.
5. Replace the top cover.
6. Turn on the power and wait until the power up procedure is complete. Then depress the FREQ C button and observe that the FREQ C light turns on. The instrument is now ready to take measurements of frequencies up to 1.0GHz.

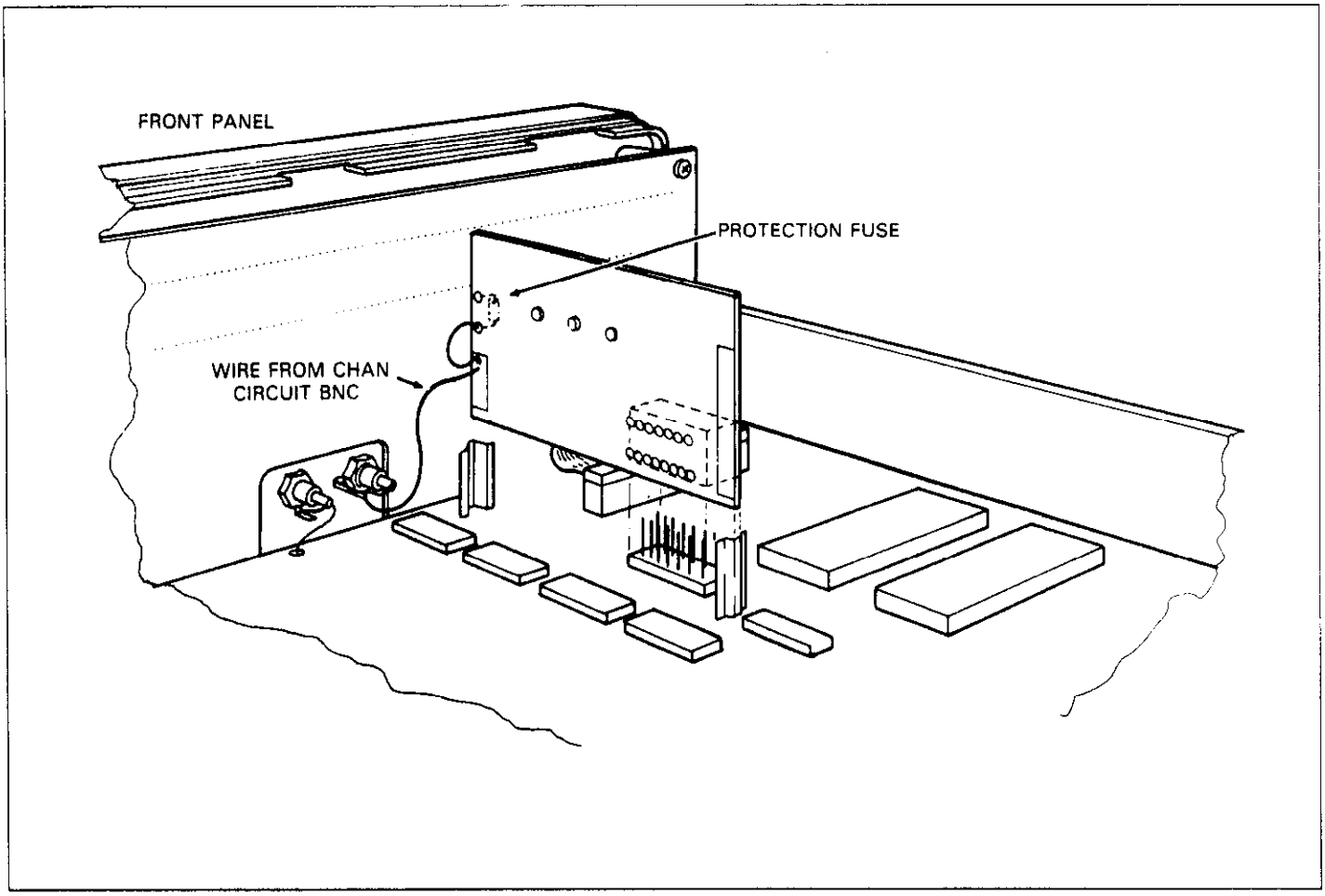


Figure 6-2. Model 7751 Installation

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6.6 MODEL 7752 TCXO OPTION INSTALLATION

The Model 7752 TCXO option increases the accuracy of the Model 775 by improving the accuracy and the stability of the reference oscillator. If purchased with the Model 775, the Model 7752 will be factory installed; however, removal for service will require installation as follows:

1. Remove the top cover of the instrument as described in the disassembly instructions in paragraph 6.9.

WARNING
Disconnect the line cord and test leads from the instrument before removing the top cover.

2. The standard oscillator circuit is built on a separate PC board and is located in the back of the Model 775 near the transformer. Locate the oscillator circuit and remove the solder joint that secures the board to the guide.
3. Remove the oscillator board by pulling the board up until it disconnects from the comb type connector.
4. Disconnect the shielded cable, coming from the oscillator board, from the rear panel BNC connector.
5. Slide the Model 7752 option along the card guide and push the card down until it locks into place as shown in Figure 6-3.

CAUTION
Make sure that Model 7752 is plugged correctly into to the main connector. No pin should be left free.

6. Solder the loose end of the shielded cable to the rear panel BNC terminal. The inner wire of the cable should be soldered to the center conductor on the BNC where as the shield part of the cable should be soldered to the shell of the same connector.
7. Solder the side of the PC board to the card guide. This will secure the Model 7752 to its place and will prevent the Model 7752 from loosening during transit.
8. Replace the top cover.
9. Mark the correct option installation on the rear panel with a water soluable marking pen for future reference.

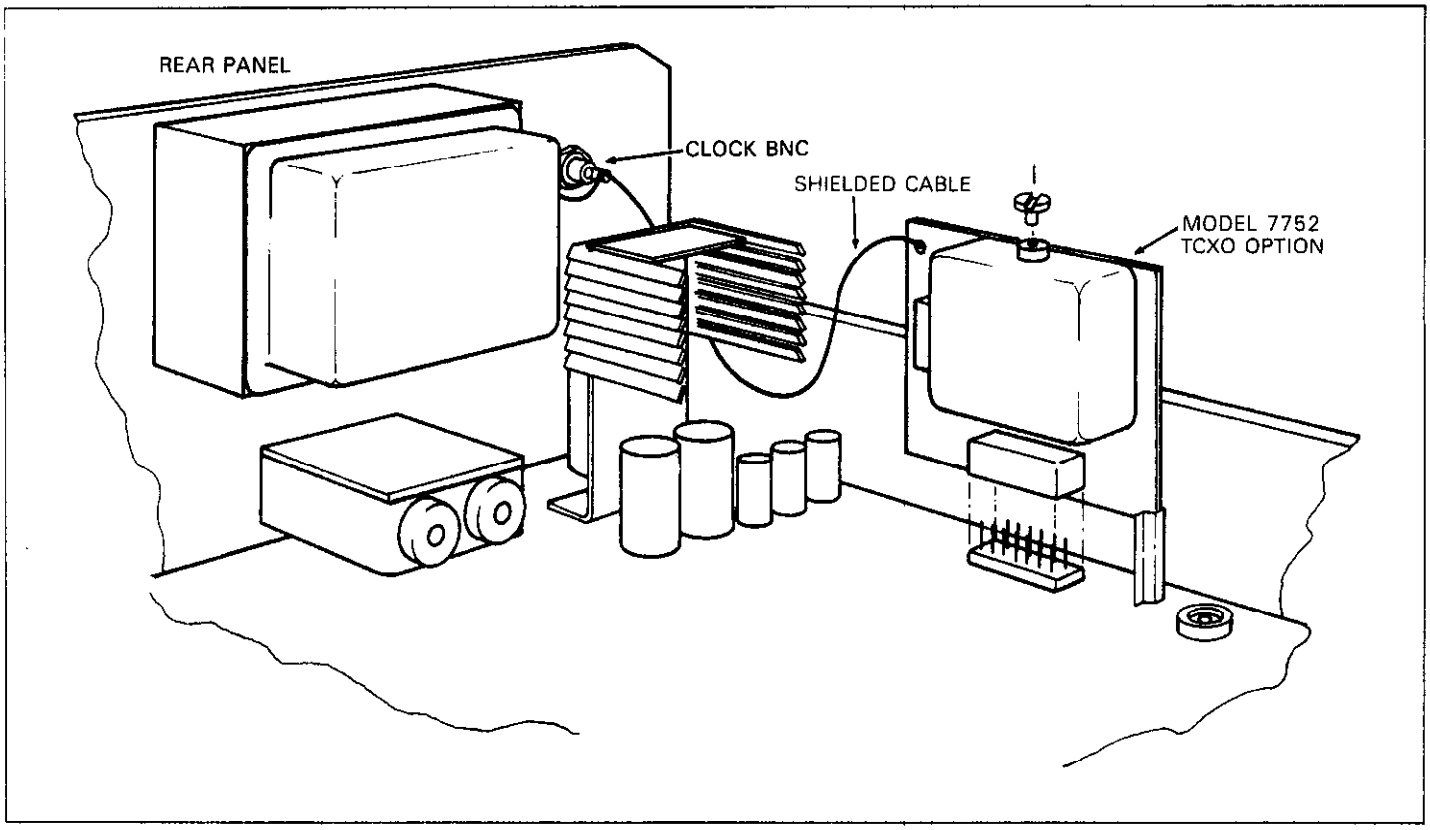


Figure 6-3. Model 7752 Installation

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6.7 CALIBRATION

6.7.1 Environmental Conditions

Adjustments should be performed under laboratory conditions having an ambient temperature of 24 ±2°C and a relative humidity of less than 70%. If the instrument has been subjected to conditions outside these ranges, allow at least one additional hour for the instrument to stabilize before beginning the adjustment procedure.

6.7.2 Warm-Up Period

Most equipment is subject to at least a small amount of drift when it is first turned on. To ensure long-term calibration accuracy, turn on the power to the Model 775 and allow it to warm-up for at least two hours before beginning the adjustment procedure.

6.7.3 Recommended Test Equipment

Recommended test equipment for calibration is listed in Table 6-2. Test instruments other than those listed may be used only if their specifications equal or exceed the required characteristics.

6.7.4 Calibration Procedure

All adjustments are performed with the POWER switch ON. The top cover should be removed to allow access to test points and adjustments. Between adjustments, always leave top cover on the unit to keep maintain temperature.

NOTE

In order to perform the following calibration procedures, the top shield must be removed to gain access to various components. To do so, remove the three screws that secure the shield to the board. Replace the shield after adjustments are complete.

WARNING

Take special care to prevent contact with live circuits or power line area which could cause electrical shock resulting in serious injury or death. Use an isolated tool when making adjustments. Use plastic or nylon screwdriver when adjusting the time base trimmer.

Refer to Figure 6-4 and the component layout in Section 7 when necessary for determining adjustment points. Follow the procedure in the sequence indicated since some of the adjustments are interrelated and dependent on the proceeding steps.

Verify that the Model 775 is functioning according to the performance checks. Make sure that all results are within or close to the range of the required specifications, otherwise refer to the troubleshooting information given at the end of this section.

Perform the following adjustment procedure. If an adjustment can not be made to obtain a specific reading, refer to the troubleshooting information at the end of this section.

NOTE

If not otherwise specified, perform all adjustments on the Model 775 in the power up default position.

Table 6-2. Recommended Test Equipment For Calibration

Instrument	Recommended Model	Specifications
Oscilloscope	Tektronics 465	100MHz bandwidth
Multimeter	Keithley 175	.1% basic DC accuracy
Function Generator	HP-3312A	13MHz pulse, sine, triangle, triggered
10MHz Standard	Oscilloquartz 2200	1×E-10/day, 5×E-10 0-50°C

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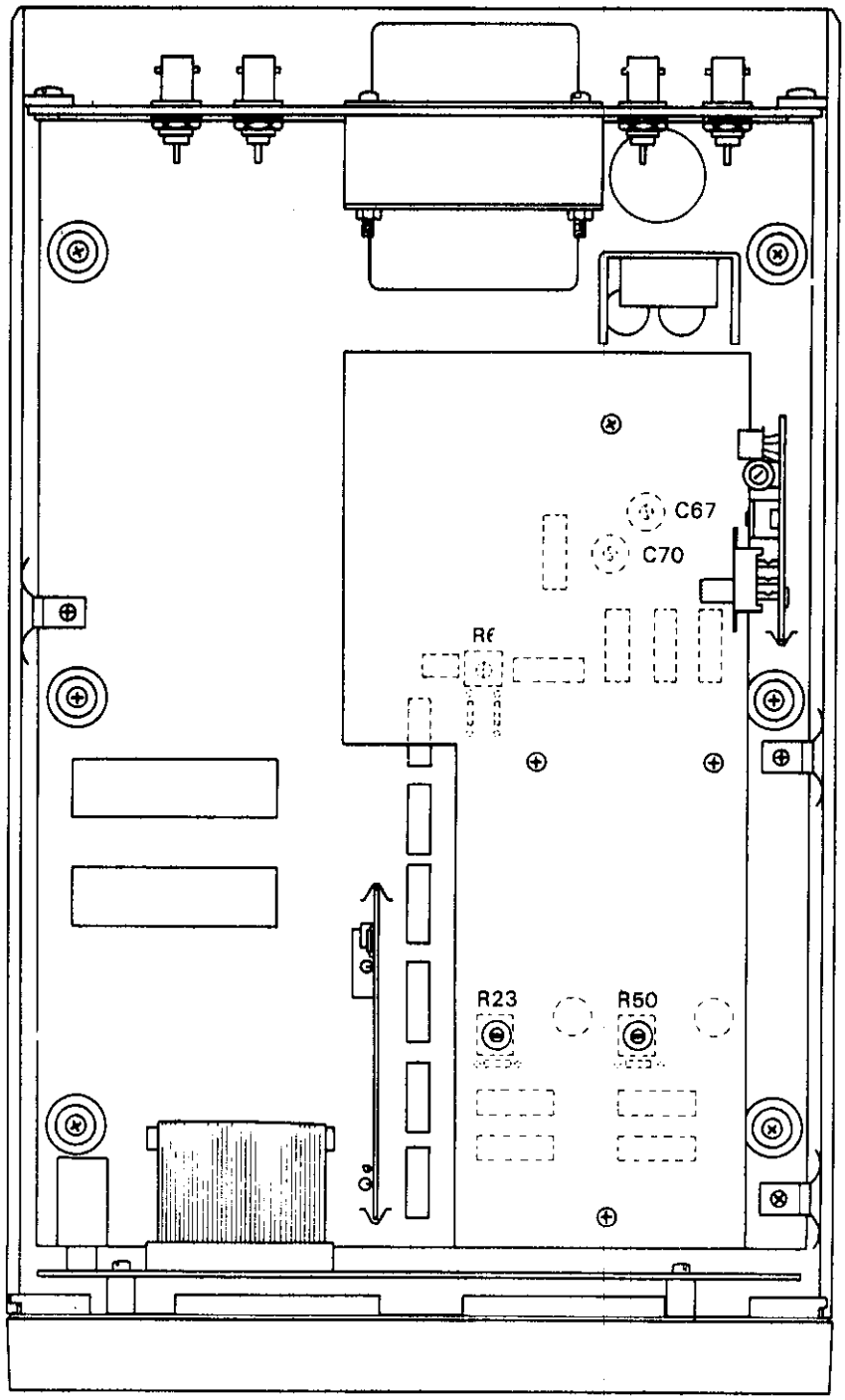


Figure 6-4. Model 775 Calibration Adjustments

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6.7.5 Multiplier Adjustment

1. Connect the probe to the collector of Q38. Use a short ground clip. Refer to Table 6-2 for recommended test equipment.
2. Set up the oscilloscope and adjust C67 and C70 to get a maximum amplitude of 100MHz sinusodial signal. Note that the signal may appear modulated and distorted. This has no effect on the normal operation of the Model 775. Alter adjustments between C67 and C70 until a peak to peak amplitude of about 1.5V is reached.

6.7.6 Trigger Level Adjustment

1. Set the multimeter to DC voltage measurement. Refer to Table 6-2 for recommended test equipment.
2. Connect the multimeter probes between pin 15 of U27 and case ground.
3. Adjust R6 to give a voltage reading of 2.55V ±10mV on the DMM.

6.7.7 Channels A and B Sensitivity Adjustment

1. Set the function generator to 1kHz sine wave and 40dB attenuation. Refer to Table 6-2 for recommended test equipment.
2. Set the multimeter to ACV and 200mV range.
3. Connect the function generator output to the DMM and adjust function generator amplitude control to give a reading of 15mV on the DMM.
4. Connect the function generator output to the channel A input terminal.
5. Connect the oscilloscope probe to pin 3 of U38.
6. Set up the oscilloscope and adjust R23 to display a rectangular waveform of 1kHz with a duty cycle of 50% ±10%.
7. Change the Model 775 setting to FREQ B.
8. Connect the function generator to the channel B input terminal.
9. Set up the oscilloscope and adjust R50 to display a rectangular waveform of 1kHz with a duty cycle of 50% ±10%.

6.7.8 Inputs A and B Attenuator Compensation

1. Set the function generator to give 10kHz rectangular waveform with an amplitude of 10V peak to peak. Refer to Table 6-2 for recommended test equipment.
2. Change the Model 775 setting to AC coupling and x10 attenuation on both channels A and B.
3. Connect the function generator output to channel A input terminal.
4. Connect the oscilloscope probe to the junction of R20 and R21.
5. Set up the oscilloscope and select C13 to give a rising edge with a minimum overshoot or undershoot. C13 should be in the range of 15pF to 20μF.
6. Change 775 setting to FREQ B and connect function generator to channel B input terminal.
7. Connect the oscilloscope to the junction of R47 and R48.
8. Set oscilloscope and select C33 to give a rising edge with a minimum overshoot and undershoot. C33 should be in the range of 15pF to 20pF.

6.7.9 Time Base Adjustment (Standard 5 PPM Time Base)

1. Allow the Model 775 to warm up for at least two hours with covers installed at an ambient temperature of 25°C ±2°C. Refer to Table 6-2 for recommended test equipment.
2. Connect 10MHz standard output to the channel A input terminal.
3. Set C3 to about mid range (5 turns trimmer capacitor).
4. Adjust C4 to give a reading of 10.0000000 ±200 counts on the display. If proper adjustment cannot be obtained, adjust C2 to bring C4 within range. (C2 should be in the range of 8pF to 12pF).
5. Adjust C3 to give a reading of 10.0000000 ±50 counts on the display.
6. Allow an additional warm-up time of approximately 30 minutes. Repeat step 5 if necessary.

6.7.10 Time Base Adjustment (Optional 1 PPM Time Base)

1. Allow the Model 775 to warm up at least two hours with covers installed at an ambient temperature of 25°C ±2°C. Refer to Table 6-2 for recommended test equipment.
2. Connect 10MHz standard output to the channel A input terminal.
3. Adjust the trimmer on top of the TCXO case using with a very narrow plastic screwdriver to give a reading of 10.0000000 ±10 counts on the display.
4. Allow an additional warm-up time of approximatly 30 minutes. Repeat step 3 if necessary.

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6.8 SPECIAL HANDLING OF STATIC SENSITIVE DEVICES

MOS devices are designed to operate at a very high impedance levels for low power consumption. As a result, any normal static charge that builds up on your person or clothing may be sufficient to destroy these devices if they are not handled properly. Table 6-3 lists the static sensitive devices in the Model 775. When handling these devices, use precautions which are described in the following table to avoid damaging them.

Table 6-3. Static Sensitive Device

Schematic Designation	Keithley Part Number
U6	K0500-2141
U9	LSI-52
U12	K0550-0010
U13	K0550-0010
U20	K0500-2130
U25	IC-251
U26	IC-251
U27	K0560-0070
U28	IC-2
U30	IC-251
U31	K0560-0070

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

6.9 DISASSEMBLY INSTRUCTIONS

If it is necessary to troubleshoot or replace a component, use the following disassembly procedure to remove the top cover and refer to Figure 6-5.

1. Remove the two screws that secure the top cover to the rear panel.
2. Grasp the top cover at the rear and carefully lift if off the instrument. When the tabs at the front of the cover clear the front panel, the cover may be pulled completely clear.
3. When replacing the top cover, reverse the above procedure; be sure to install the tabs at the front panel before completely installing the cover.

NOTE

The Model 775 covers are coated with shielding material to suppress RFI and EMI noises which are generated by the internal circuits. When replacing the top cover on the Model 775, make sure that the springs that are mounted on both sides of the rear panel make contact with the internal shield of the top cover. If the springs are loose or are not making contact, push the loose ends toward the outside.

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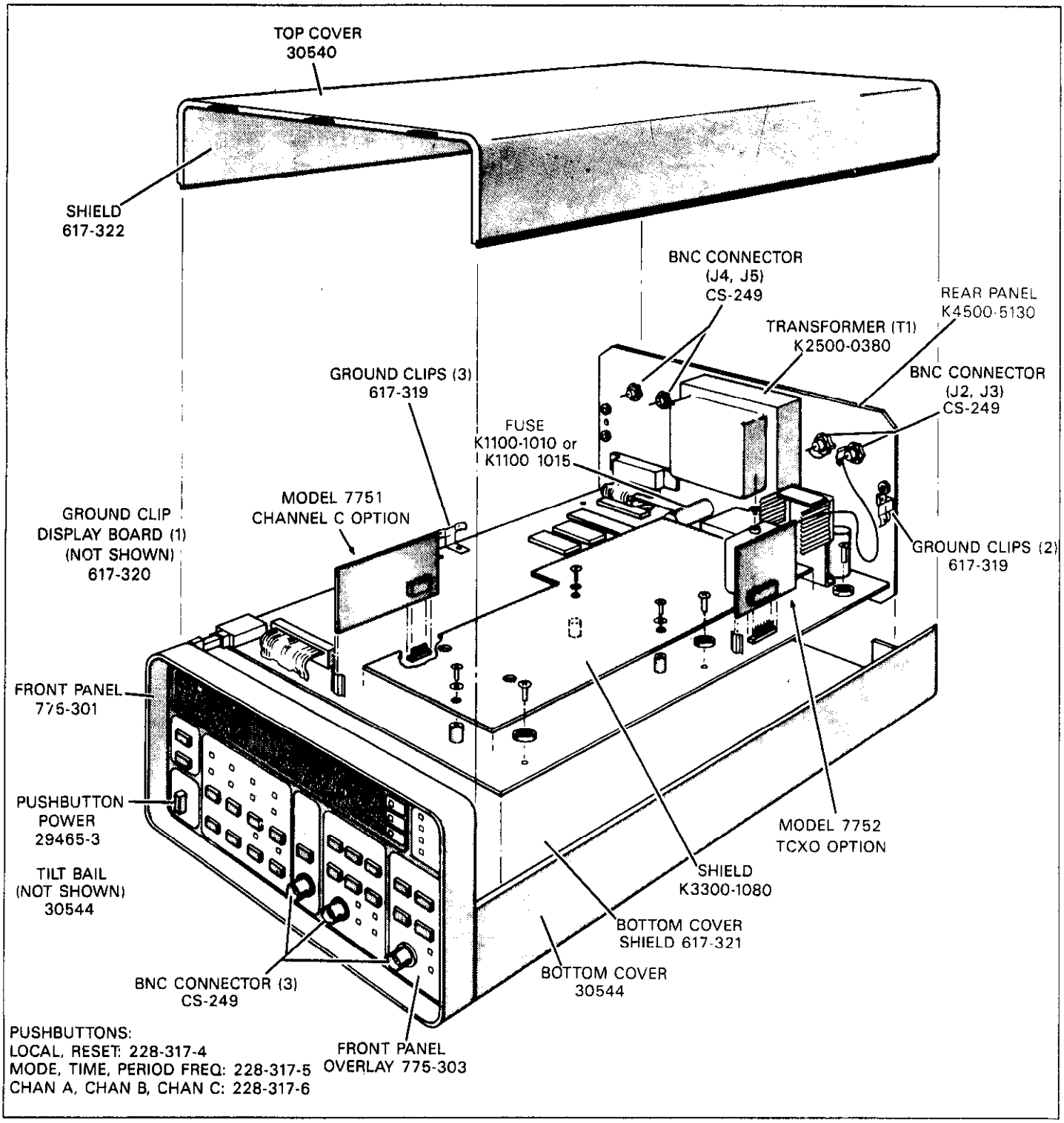


Figure 6-5. Model 775 Exploded View

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6.10 TROUBLESHOOTING

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

6.10.1 Recommended Test Equipment

The success or failure in troubleshooting a complex piece of equipment like the Model 775 depends not only on the skill of the technician, but also relies heavily on accurate, reliable test equipment. Table 6-2 lists the recommended test equipment for a complete troubleshooting and adjustment of the Model 775. However, it is also possible to troubleshoot the Model 775 with the minimum equipment which is listed in Table 6-4. Other equipment such as a logic analyser, an in-circuit emulator etc, could also be helpful in difficult situation.

6.10.2 Power-Up Self Diagnostics

An advanced feature of the Model 775 is its self diagnosing capabilities. Upon power-up the Model 775 performs a set of tests which is described in paragraph 2.4. If the Model 775 locks up due to ROM or RAM fail, there is little point in attempting to troubleshoot elsewhere until the microcontroller circuit is operating properly.

The power-up diagnostic test may be run either upon power-up or through the IEEE-488 interface bus. The procedure to run a self diagnostic program through the bus is described in detail in Section 3.

6.10.3 Power Supply Checks

It is highly recommended that the first step in troubleshooting the Model 775, as well as any similar equipment, would be to check the power supply. If the various supply voltages within the instrument are not within the required limits, troubleshooting the remaining circuits can be very difficult. Table 6-5 shows the various checks that can be made to the power supplies within the Model 775. In addition to the normal voltage checks, it is also a good idea to check the various supplies with an oscilloscope to make sure no noise or ringing is present.

In case of a "dead short" between one of the supplies to the common ground, it would be best to disconnect the entire supply section from the remaining circuitry and then identify if the problem is in the power supply or in the remaining circuitry. Model 775 is equipped with points which are located on the bottom side of the main PC board To access these points, remove the bottom cover and the solder from the quick-disconnect points.

Table 6-4. Recommended Minimum Test Equipment for Troubleshooting

Instrument	Recommended Model	Specifications
Oscilloscope	Tektronics 465	100MHz bandwidth
Multimeter	Keithley 175	.1% basic DC accuracy
Function Generator	HP-3312A	13MHz pulse, sine, triangle, triggered

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6.10.4 Reference Oscillator and Clock Checks

The most important section to be verified after the power supply checks, is the reference oscillator. The reference oscillator supplies different clock signals to the various sections of the Model 775. Without these clock signals, the microcomputer would not start to generate the control lines thus, making it impossible to troubleshoot the remaining circuitry.

Table 6-6 shows the various checks that can be made to verify the operation of the clocks and the reference oscillator.

6.10.5 Digital Circuitry and Display Checks

Problems with the digital and display circuitry could cause erratic operation or false readings on the display. Check the various components associated with the digital circuitry, including the IEEE-488 interface, using the information in Table 6-7.

6.10.6 Signal Conditioning and Input Circuit Checks

Problems in these circuits could generate false results on the Model 775. Tables 6-8 and 6-9 list checks to be made on the signal conditioning and the input circuits respectively.

6.10.7 Multiplier Circuit Checks

Problems with the multiplier circuit will definitely cause false results on the Model 775 or may cause no result at all. Problems in the multiplier circuit may be identified using Table 6-10.

6.10.8 Trigger Level Checks

The trigger level circuits control the threshold point where the input circuit triggers. The Model 775 may not trigger at all on a signal that appears to be within the specified limits. Problems in the trigger circuit may be located using the checks given in Table 6-11.

6.10.9 Measurement Section Checks

The measurement section circuitry is mainly used as a digital control to the analog signals within the Model 775. Due to high speed signals, it was necessary to implement ECL technology. It is recommended that the checks in Table 6-12, using an oscilloscope, be made with a special high frequency probe that has a very short grounding clip.

Table 6-5. Power Supply Checks

Step	Item/Component	Required Condition	Remarks
1	S2 Line Switch	Set to 115V or 230V	See paragraph 6.2.
2	F1 Line Fuse	Continuity	Remove fuse to check.
3	J1 Line Power	Plugged into live receptacle; power on.	
4	+12V Supply	+12V ±5%	+12V on U52 output
5	U52 Input	+15V minimum	Positive output of CR18
6	−12V Supply	−12V ±15%	−12V on U53 output
7	U53 Input	−15V minimum	Negative output of CR18
8	+5V Supply	+5V ±5%	Collector of Q40
9	Input to +5V Supply	+7V minimum	Positive output of CR19
10	Reference to +5V Supply	+5V ±5%	Input 3 to U54

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Table 6-6. Reference Oscillator and Clock Checks

Step	Item/Component	Required Condition	Test Point/Remarks
		Turn on power.	
1	10MHz Reference	0 to +4V 10MHz square	Pin 6 on U2d on standard oscillator board.
	Or		
2	10MHz Reference	0 to +4V 10MHz square wave	Pin 3 on U2a on TCXO oscillator board.
3	Multiplier Clock	−0.2V to +0.2V 10MHz square wave	Pin 2 on U50a. Signal may appear very noisy.
4	Microprocessor Clock	0 to +4V 10MHz square wave	Pin 19 on U6
5	Microprocessor Timer	0 to +4V 5kHz square wave	Pin 14 on U6
6	Keyboard and Display Control Clock	0 to +4V 1.25MHz square wave	Pin 3 on U5
7	IEEE Interface Clock	0 to +4V 5MHz square wave	Pin 3 on U20

Table 6-7. Digital Circuitry and Display Checks

Step	Item/Component	Required Condition	Test Point/Remarks
1		Turn on power.	Some tests here could fail due to digital problems.
2	Reset Input	Turn off instrument then back on.	Pin 9 on U6 stays low for about .1sec and then goes high.
3	ALE Line	0 to +4V 168nsec pulses	Pin 30 on U6
4	PSEN Line	0 to +4V 276nsec negative going pulses	Pin 29 on U6
5	RD WR Lines	0 to +4V 480nsec negative going pulses	Pins 16 and 17 on U6
6	Address/Data Bus	0 to +4V variable pulse train	Pins 21 thru 28 and Pins 32 thru 39 on U6
		Depress and hold the LEVEL ▲ button during the next two tests.	This will generate serial data on the RXD lines.
7	Serial Data In	0 to +4V variable pulse train	Pin 2 of U30 Pin 2 of U28 Pin 2 of U26 Pin 2 of U25
8	Serial to Parallel Converters Clocks	0 to +4V burst of pulse train	Pin 3 of U30 Pin 3 of U28 Pin 3 of U26 Pin 3 of U25
		Depress each one of the buttons, in turn, on the front panel throughout the next test.	This test will check all buttons on the front panel as well as the interrupt line.
9	Keyboard Interrupt Line	0 to +4V variable negative going pulse.	Pin 4 of U5
10	LEDs Sink Lines	0 to +4V variable pulses	Pins 10 to 16 on U2 and Collector of Q16

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Table 6-8. Signal Conditioning Checks

Step	Item/Component	Required Condition	Test Point/Remarks	
1		Turn on power.	The following tests are performed on U25	
	Input conditioning signals:		Channel A	Channel B
2	DC	TTL High Level	Pin 4	Pin 6
3	AC	TTL Low Level	Pin 4	Pin 6
4	x1	TTL Low Level	Pin 14	Pin 12
5	x10	TTL High Level	Pin 14	Pin 12
6	Filter On	TTL Low Level	Pin 13	Pin 5
7	Filter Off	TTL High Level	Pin 13	Pin 5
8	Negative Slope	TTL Low Level	Pin 11	Pin 7
9	Positive Slope	TTL High Level	Pin 11	Pin 7

Table 6-9. Input Circuit Checks

Step	Item/Component	Required Condition	Test Point/Remarks
1		Turn on power.	Apply 1MHz .1Vp-p sine to Channel A input BNC.
2	Channel A Front End	1MHz .1Vp-p sine	Base of Q21
3	Input Amplifier A Gain	+3.2 to +4.2V pulses with 50% duty cycle	Pin 3 of U34b
		Depress FREQ button FREQ B light should be on.	Apply 1MHz .1Vp-p sine to Channel B input BNC.
4	Channel B Front End	1MHz .1Vp-p sine	Base of Q25
5	Input Amplifier B Gain	+3.2 to +4.2V 1MHz pulses with 50% duty cycle	Pin 3 of U36

Table 6-10. Multiplier Circuit Checks

Step	Item/Component	Required Condition	Test Point/Remarks
1		Turn on power.	Signal may appear noisy in the following tests.
2	TTL to Sine Converter	10MHz sine wave 2V p-p	Pin 14 of U50a
3	x2 Multiplier	20MHz sine wave 1V p-p	Pin 8 of U50b
4	x5 Multiplier	100MHz sine wave 1V p-p	Collector of Q38

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Table 6-11. Trigger Level Circuit Checks

Step	Item/Component	Required Condition	Test Point/Remarks
1		Turn on power.	
2	D to A Reference	+2.55V ±20mV Change front panel trigger level setting for Channels A and B to +2.55V.	Pin 15 of U27 and Pin 15 of U31
3	Channel A Positive Trigger Level	+2.55V ±20mV	Pin 10 of U29b
4	Channel B Positive Trigger Level	+2.55V ±20mV Change front panel trigger level setting for Channels A and B to −2.55V.	Pin 12 of U32a
5	Channel A Negative Trigger Level	−2.55V ±20mV	Pin 10 of U29A
6	Channel B Negative Trigger Level	−2.55V ±20mV	Pin 12 of U32a

Table 6-12. Measuring Section Circuit Checks

Step	Function	Required Condition	Test Point/Remarks
1		Turn on power.	The next six tests would be performed on U28.
		Pin4 Pin5 Pin6 Pin7 Pin11 Pin12	
2	FREQ A	1 1 0 1 1 0	
3	FREQ B	1 0 1 1 1 0	
4	FREQ C	1 1 1 0 1 0	Possible with Model 7751.
5	PERIOD A	0 1 1 1 0 1	
6	PERIOD AVG A	1 1 0 1 1 0	
7	TIME A→B	1 0 1 1 0 1	
8	TIME PLS A	1 1 0 1 0 1 Change panel setting to FREQ A and 1sec gate time. Apply 1MHz 1V p-p sine to Channel A BNC.	
9	Signal Selector	+3.2V to +4.2V 1MHz pulse.	Pin 15 of U37d
10	Time Detect	Don't care.	Pin 9 of U38d
11	Synchronizer	+3.2V to +4.2V 1MHz burst. Width of burst is approx. 1sec.	Pin 14 of U38c
12	Signal Divider	TTL 500KHz burst. Width of burst about 1sec.	Pin 6 of U49b
13	Signal Identifier	TTL low level during measurement cycle, TTL high for about 1msec after each cycle.	Pin 3 of U49a
14	Gate Identifier	TTL low level when gate is open, TTL high for about 300msec after gate closure.	Pin 8 of U43c
15	Main Gate	+3.2V to +4.2V 100MHz burst. Width of burst is about 1sec.	Pin 14 of U42c
16	Clock Divider	TTL 50MHz burst. Width of burst approx 1sec.	Pin 3 of U43a

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SECTION 7
REPLACEABLE PARTS

7.1 INTRODUCTION

This section contains replacement parts information, component location drawings and schematic diagrams for the Model 775.

7.2 PARTS LIST

Parts for each board are listed alphanumerically in order of their circuit designations. When ordering a part, indicate the printed circuit board that the part is located on as well as the part number. Table 7-1 contains parts list information for the mother board. Table 7-2 contains a parts list for the display board. Table 7-3 contains a mechanical parts list for the Model 775.

7.3 ORDERING INFORMATION

To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory. See inside front cover for addresses. When ordering include the following information:

1. Instrument Model Number
2. Instrument Serial Number
3. Parts Description
4. Circuit Designation (if applicable)
5. Keithley Part Number

If an additional instruction manual is required, order the manual package (Keithley Part Number 775-901-00). The manual package contains an instruction manual and any applicable addenda.

7.4 FACTORY SERVICE

If the instrument is to be returned to the factory for service, please complete the service form which follows this section and return it with the instrument.

7.5 SCHEMATIC DIAGRAMS AND COMPONENT LOCATION DRAWINGS

Schematic diagrams and component location drawings follow the appropriate replaceable parts list for that particular board.

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Table 7-1. Mother Board, Parts List

Circuit Desig.	Description	Keithley Part Number
C1	Capacitor Ceramic, 0.1μ	C-237-0.1
C2	Capacitor Ceramic, 0.1μ	C-237-0.1
C3	Capacitor Tantalum, 3.3μ	K1540-0335
C4	Capacitor Ceramic, 0.1μ	C-237-0.1
C5	Capacitor Ceramic, 0.1μ	C-237-0.1
C6	Capacitor Ceramic, 0.1μ	C-237-0.1
C7	Capacitor Electrolytic, 100μ, 16V	K1532-0107
C8	Capacitor Ceramic, 0.1μ	C-237-0.1
C9	Capacitor Ceramic, 0.1μ	C-237-0.1
C10	Capacitor Ceramic, 0.1μ	C-237-0.1
C11	Capacitor Myler, 33n, 250V	K1521-0333
C12	Capacitor Ceramic, 3.3p	K1500-03R3
C13	Selected value 15p-18p Mica	
C14	Capacitor Ceramic, 0.1μ	C-237-0.1
C15	Capacitor Myler, 10n, 250V	K1521-0103
C16	Capacitor Ceramic, 33p	K1500-0330
C17	Capacitor Ceramic, 0.1μ	C-237-0.1
C18	Capacitor Ceramic, 0.1μ	C-237-0.1
C19	Capacitor Ceramic, 0.1μ	C-237-0.1
C20	Capacitor Ceramic, 33p	K1500-0330
C21	Capacitor Ceramic, 0.1μ	C-237-0.1
C22	Capacitor Ceramic, 0.1μ	C-237-0.1
C23	Capacitor Ceramic, 33p	K1500-0330
C24	Capacitor Ceramic, 0.1μ	C-237-0.1
C25	Capacitor Ceramic, 0.1μ	C-237-0.1
C26	Capacitor Ceramic, 0.1μ	C-237-0.1
C27	Capacitor Ceramic, 0.1μ	C-237-0.1
C28	Capacitor Ceramic, 0.1μ	C-237-0.1
C29	Capacitor Ceramic, 0.1μ	C-237-0.1
C30	Capacitor Ceramic, 0.1μ	C-237-0.1
C31	Capacitor, Myler, 33n, 250V	K1521-0330
C32	Capacitor Ceramic, 3.3p	K1500-03R3
C33	Selected value 15p-18p, Mica	
C34	Capacitor, Myler, 10n, 250V	K1521-0103
C35	Capacitor Ceramic, 33p	K1500-0330
C36	Capacitor Ceramic, 0.1μ	C-237-0.1
C37	Capacitor Ceramic, 0.1μ	C-237-0.1
C38	Capacitor Ceramic, 0.1μ	C-237-0.1
C39	Capacitor Ceramic, 33p	K1500-0330
C40	Capacitor Ceramic, 0.1μ	C-237-0.1
C41	Capacitor Ceramic, 0.1μ	C-237-0.1
C42	Capacitor Ceramic, 33p	K1500-0330
C43	Capacitor Ceramic, 0.1μ	C-237-0.1
C44	Capacitor Ceramic, 0.1μ	C-237-0.1
C45	Capacitor Ceramic, 0.1μ	C-237-0.1
C46	Capacitor Ceramic, 0.1μ	C-237-0.1
C47	Capacitor Ceramic, 0.1μ	C-237-0.1

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Table 7-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Keithley Part Number
C48	Capacitor Ceramic, 0.1μ	C-237-0.1
C49	Capacitor Ceramic, 0.1μ	C-237-0.1
C50	Capacitor Ceramic, 0.1μ	C-237-0.1
C51	Capacitor, Mica, 62p	K1510-0620
C52	Capacitor Ceramic, 0.1μ	C-237-0.1
C53	Capacitor Ceramic, 0.1μ	C-237-0.1
C54	Capacitor Ceramic, 0.1μ	C-237-0.1
C55	Capacitor Ceramic, 0.1μ	C-237-0.1
C56	Capacitor Ceramic, 0.1μ	C-237-0.1
C57	Capacitor Ceramic, 0.1μ	C-237-0.1
C58	Capacitor Ceramic, 0.1μ	C-237-0.1
C59	Capacitor Ceramic, 0.1μ	C-237-0.1
C60	Capacitor Ceramic, 0.1μ	C-237-0.1
C61	Capacitor Ceramic, 0.1μ	C-237-0.1
C62	Capacitor, Mica, 47p	K1510-0470
C63	Capacitor Ceramic, 0.1μ	C-237-0.1
C64	Capacitor Ceramic, 0.1μ	C-237-0.1
C65	Capacitor Ceramic, 0.1μ	C-237-0.1
C66	Capacitor Ceramic, 0.1μ	C-237-0.1
C67	Capacitor, Trim, 5-18p	K1550-0180
C68	Capacitor Ceramic, 0.1μ	C-237-0.1
C69	Capacitor Ceramic, 0.1μ	C-237-0.1
C70	Capacitor, Trim, 5-18p	K1550-0180
C71	Capacitor Ceramic, 0.1μ	C-237-0.1
C72	Capacitor Ceramic, 0.1μ	C-237-0.1
C73	Capacitor Ceramic, 0.1μ	C-237-0.1
C74	Capacitor Ceramic, 0.1μ	C-237-0.1
C75	Capacitor Ceramic, 0.1μ	C-237-0.1
C76	Capacitor Ceramic, 0.1μ	C-237-0.1
C77	Capacitor Ceramic, 0.1μ	C-237-0.1
C78	Capacitor, Electrolytic, 470μ, 25V	K1533-0477
C79	Capacitor, Electrolytic, 470μ, 25V	K1533-0477
C80	Capacitor, Electrolytic, 100μ, 25V	K1533-0107
C81	Capacitor, Electrolytic, 100μ, 25V	K1533-0107
C82	Capacitor, Electrolytic, 100μ, 16V	K1532-0107
C83	Capacitor, Electrolytic, 10,000μ, 16V	K1532-0109
C84	Capacitor, Electrolytic, 100μ, 16V	K1532-0107
C85	Capacitor Ceramic, 0.1μ	C-237-0.1
C86	Capacitor Ceramic, 0.1μ	C-237-0.1
C87	Capacitor Ceramic, 0.1μ	C-237-0.1
C88	Capacitor Ceramic, 0.1μ	C-237-0.1
C89	Capacitor, Mica, 100p	K1510-0101
C90	Capacitor Ceramic, 0.1μ	C-237-0.1
C91	Capacitor Ceramic, 0.1μ	C-237-0.1
C92	Capacitor Ceramic, 0.1μ	C-237-0.1
C93	Capacitor Ceramic, 0.1μ (mounted on rear panel)	C-237-0.1
C94	Capacitor Ceramic, 0.1μ (mounted on rear panel)	C-237-0.1

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Table 7-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Keithley Part Number
C97	Capacitor Ceramic, 0.1μ	C-237-0.1
C98	Capacitor Ceramic, 0.1μ	C-237-0.1
C99	Capacitor Ceramic, 0.1μ	C-237-0.1
C100	Capacitor Ceramic, 0.1μ	C-237-0.1
C101	Capacitor Ceramic, 0.1μ	C-237-0.1
CR1	1N751A	K0300-2001
CR2	PAD50	K0301-1000
CR3	1N750A	K0300-2080
CR4	1N4151	K0300-0046
CR5	BAR10	K0300-1020
CR6	BAR10	K0300-1020
CR7	PAD50	K0301-1000
CR8	1N750A	K0300-2080
CR9	BAR10	K0300-1020
CR10	BAR10	K0300-1020
CR11	1N4151	K0300-0040
CR12	1N4151	K0300-0040
CR13	1N4151	K0300-0040
CR14	1N4151	K0300-0040
CR15	1N4151	K0300-0040
CR16	BAR10	K0300-1020
CR17	BAR10	K0300-1020
CR18	W04	K0300-5010
CR19	KBL005	K0300-5020
CR20	1N4151	K0300-0040
CR21	PAD50	K0301-1000
CR22	PAD50	K0301-1000
J1	Connector 34 pin	CS-389-1
J3	Connector 14 pin	CS-389-5
J4	Connector 14 pin	CS-389-5
K1	RA3046 1051	K0900-0110
K2	RA3044 1051	K0900-0100
K3	RA3046 1051	K0900-0110
K4	RA3046 1051	K0900-0110
K5	RA3044 1051	K0900-0100
K6	RA3046 1051	K0900-0110
L1	Beed	K4200-0000
L2	Beed	K4200-0000
L3	3.3μH, 1537	K0600-0333
L4	1μH, 1537	K0600-0103
L5	0.15μH, 1537	K0600-0R15

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Table 7-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Keithley Part Number
L6	0.15μF, 1537	K0600-0R15
L7	Beed	K4200-0000
L8	Beed	K4200-0000
L9	Beed	K4200-0000
L10	Beed	K4200-0000
L11	Beed	K4200-0000
L12	Beed	K4200-0000
L13	Beed	K4200-0000
L14	Beed	K4200-0000
L15	330MH, 50MA, 1025-80	K0600-0331
L16	330MH, 50MA, 1025-80	K0600-0331
Q1	2N4403	K0400-0180
Q2	2N4403	K0400-0180
Q3	2N4403	K0400-0180
Q4	2N4403	K0400-0180
Q5	2N4403	K0400-0180
Q6	2N4403	K0400-0180
Q7	2N4403	K0400-0180
Q8	2N4403	K0400-0180
Q9	2N4403	K0400-0180
Q10	2N4403	K0400-0180
Q11	2N4403	K0400-0180
Q12	2N4403	K0400-0180
Q13	2N4403	K0400-0180
Q14	2N4403	K0400-0180
Q15	2N4403	K0400-0180
Q16	2N4401	K0400-0180
Q17	2N4124	K0400-0030
Q18	2N4124	K0400-0030
Q19	2N4124	K0400-0030
Q20	DN5566 2N5912 replaces DN5566 (cut off pin 4 on 2N5912)	K0400-4020
Q21	BFY 90	K0400-0070
Q22	BFY 90	K0400-0070
Q23	2N4124	K0400-0030
Q24	DN5566	K0400-4020
Q25	BFY 90	K0400-0070
Q26	BFY 90	K0400-0070
Q27	2N4124	K0400-0030
Q28	2N3906	TG-84
Q29	2N3906	TG-84
Q30		
Q31	PN3640	K0400-0010
Q32	PN3640	K0400-0010
Q33	PN3640	K0400-0010
Q34	PN3640	K0400-0010
Q35	PN3640	K0400-0010

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Table 7-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Keithley Part Number
Q36	PN3640	K0400-0010
Q37	PN3646	K0400-0020
Q38	BFY 90	K0400-0070
Q39	2N4126	K0400-0040
Q40	MJE 2955	K0400-4030
Q41	2N4124	K0400-0030
R1	Resistor, Composition, 3.3k, 5%, ¼W	R-76-3.3k
R2	Resistor, Composition, 220, 5%, ¼W	R-76-220
R3	Resistor, Composition, 3.3k, 5%, ¼W	R-76-3.3k
R5	Resistor, Composition, 100, 5%, ¼W	R-76-100
R6	Trim Pot 5k	RP-97-5k
R7	Resistor, MTF, 2.49k, 1%, ¼W	K0104-2491
R8	Resistor, MTF, 10.0k, 1%, ¼W	K0104-1002
R9	Resistor, MTF, 10.0k, 1%, ¼W	K0104-1002
R10	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R11	Resistor, MTF, 10.0k, 1%, ¼W	K0104-1002
R12	Resistor, MTF, 10.0k, 1%, ¼W	K0104-1002
R13	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R14	Resistor, MTF, 900.0k, 1%, ½W	K0101-9003A
R15	Resistor, MTF, 100.0k, 1%, ¼W	K0104-1003
R16	Resistor, Composition, 220k, 5%, ½W	K0101-0224
R17	Resistor, Composition, 12k, 5%, ¼W	R-76-12k
R18	Resistor, Composition, 10, 5%, ¼W	R-76-10
R19	Resistor, Composition, 33, 5%, ¼W	R-76-33
R20	Selected value, 100:150:200, 1%, ¼W	
R21	Resistor, Composition, 820, 5%, ¼W	R-76-820
R22	Selected value, 49.9:100:150, 1%, ¼W	
R23	Resistor, Trim, 100	RP-97-100
R24	Resistor, Composition, 22, 5%, ¼W	R-76-22
R25	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R26	Resistor, MTF, 49.9, 1%, ¼W	K0104-49R9
R27	Resistor, MTF, 49.9, 1%, ¼W	K0104-49R9
R28	Resistor, Composition, 13k, 5%, ¼W	R-76-13k
R29	Resistor, Composition, 10k, 5%, ¼W	R-76-10k
R30	Resistor, Composition, 330, 5%, ¼W	R-76-330
R31	Resistor, MTF, 178.0, 1%, ¼W	K0104-1780
R32	Resistor, MTF, 178.0, 1%, ¼W	K0104-1780
R33	Resistor, Composition, 100, 5%, ¼W	R-76-100
R34	Resistor, Composition, 510, 5%, ¼W	R-76-510
R35	Resistor, Composition, 510, 5%, ¼W	R-76-510
R36	Resistor, Composition, 82, 5%, ¼W	R-76-82
R37	Resistor, Composition, 390, 5%, ¼W	R-76-390
R38	Resistor, Composition, 510, 5%, ¼W	R-76-510
R39	Resistor, Composition, 510, 5%, ¼W	R-76-510
R40	Resistor, Composition, 510, 5%, ¼W	R-76-510

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Table 7-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Keithley Part Number
R41	Resistor, MTF, 900.0k, 1%, ½W	K0101-9003A
R42	Resistor, Composition, 100.0k, 1%, ¼W	K0104-1003
R43	Resistor, Composition, 220k, 5%, ½W	K0101-0224
R44	Resistor, Composition, 12k, 5%, ¼W	R-76-12k
R45	Resistor, Composition, 10, 5%, ¼W	R-76-10
R46	Resistor, Composition, 33, 5%, ¼W	R-76-33
R47	Selected value, 100:150:200, 1%, ¼W	
R48	Resistor, Composition, 820, 5%, ¼W	R-76-820
R49	Selected value, 49.9:100:150, 1%, ¼W	
R50	Trim Resistor, 100	RP-97-100
R51	Resistor, Composition, 22, 5%, ¼W	R-76-22
R52	Resistor, MTF, 178.0, 1%, ¼W	K0104-1780
R53	Resistor, MTF, 49.9, 1%, ¼W	K0104-49R9
R54	Resistor, MTF, 49.9, 1%, ¼W	K0104-49R9
R55	Resistor, Composition, 13k, 5%, ¼W	K0100-0133
R56	Resistor, Composition, 10k, 5%, ¼W	R-76-10k
R57	Resistor, Composition, 330, 5%, ¼W	R-76-330
R58	Resistor, MTF, 178.0, 1%, ¼W	K0104-1780
R59	Resistor, Composition, 100, 5%, ¼W	R-76-100
R60	Resistor, Composition, 510, 5%, ¼W	R-76-510
R61	Resistor, Composition, 510, 5%, ¼W	R-76-510
R62	Resistor, Composition, 390, 5%, ¼W	R-76-390
R63	Resistor, Composition, 82, 5%, ¼W	R-76-82
R64	Resistor, Composition, 510, 5%, ¼W	R-76-510
R65	Resistor, Composition, 510, 5%, ¼W	R-76-510
R66	Resistor, Composition, 510, 5%, ¼W	R-76-510
R67	Resistor, Composition, 510, 5%, ¼W	R-76-510
R68	Resistor, Composition, 100, 5%, ¼W	R-76-100
R69	Resistor, Composition, 330, 5%, ¼W	R-76-330
R70	Resistor, Composition, 510, 5%, ¼W	R-76-510
R71	Resistor, Composition, 510, 5%, ¼W	R-76-510
R72	Resistor, Composition, 510, 5%, ¼W	R-76-510
R73	Resistor, Composition, 510, 5%, ¼W	R-76-510
R74	Resistor, Composition, 510, 5%, ¼W	R-76-510
R75	Resistor, Composition, 510, 5%, ¼W	R-76-510
R76	Resistor, Composition, 510, 5%, ¼W	R-76-510
R77	Resistor, Composition, 510, 5%, ¼W	R-76-510
R78	Resistor, Composition, 68, 5%, ¼W	R-76-68
R79	Resistor, Composition, 220, 5%, ¼W	R-76-220
R80	Resistor, Composition, 510, 5%, ¼W	R-76-510
R81	Resistor, Composition, 510, 5%, ¼W	R-76-510
R82	Resistor, Composition, 510, 5%, ¼W	R-76-510
R83	Resistor, Composition, 33, 5%, ¼W	R-76-33
R84	Resistor, Composition, 47, 5%, ¼W	R-76-47
R85	Resistor, Composition, 220, 5%, ¼W	R-76-220
R86	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R87	Resistor, Composition, 510, 5%, ¼W	R-76-510

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Table 7-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Keithley Part Number
R88	Resistor, Composition, 33, 5%, ¼W	R-76-33
R89	Resistor, Composition, 330, 5%, ¼W	R-76-330
R90	Resistor, Composition, 750, 5%, ¼W	R-76-750
R91	Resistor, Composition, 560, 5%, ¼W	R-76-560
R92	Resistor, Composition, 510, 5%, ¼W	R-76-510
R93	Resistor, Composition, 47, 5%, ¼W	R-76-47
R94	Resistor, Composition, 220, 5%, ¼W	R-76-220
R95	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R96	Resistor, Composition, 510, 5%, ¼W	R-76-510
R97	Resistor, Composition, 150, 5%, ¼W	R-76-150
R98	Resistor, Composition, 150, 5%, ¼W	R-76-150
R99	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R100	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R101	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R102	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R103	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R104	Resistor, Composition, 22k, 5%, ¼W	R-76-22k
R105	Resistor, Composition, 22k, 5%, ¼W	R-76-22k
R106	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R107	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R108	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R109	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R110	Resistor, Composition, 510, 5%, ¼W	R-76-510
R111	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R112	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R113	Resistor, Composition, 6.8k, 5%, ¼W	R-76-6.8k
R114	Resistor, Composition, 6.8k, 5%, ¼W	R-76-6.8k
R115	Resistor, Composition, 6.8k, 5%, ¼W	R-76-6.8k
R116	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R117	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R118	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R119	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R120	Resistor, Composition, 100, 5%, ¼W	R-76-100
R121	Resistor, Composition, 750, 5%, ¼W	R-76-750
R122	Resistor, Composition, 100, 5%, ¼W	R-76-100
R123	Resistor, Composition, 0.27, 5%, 2W	K0103-0R27
R124	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R125	Resistor, Composition, 100, 5%, ¼W	R-76-100
R126	Resistor, Composition, 1k, 5%, ¼W	R-76-1k
R127	Resistor, MTF, 4.99k, 1%, ¼W	K0104-4991
R128	Resistor, MTF, 6.98k, 1%, ¼W	K0104-6981
R129	Resistor, Composition, 510, 5%, ¼W	R-76-510
R130	Resistor, Composition, 510, 5%, ¼W	R-76-510
R131	Resistor, Composition, 3.3k, 5%, ¼W	R-76-3.3k
R132	Resistor, Composition, 39, 5%, ¼W	R-76-39
R133	Resistor, Composition, 39, 5%, ¼W	R-76-39
R134	Resistor, Composition, 3.3k, 5%, ¼W	R-76-3.3k

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Table 7-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Keithley Part Number
R135	Resistor, Composition, 150, 5%, ¼W	R-76-150
R201	Resistor, Composition, 510, 5%, ¼W	R-76-510
R202	Resistor, Composition, 510, 5%, ¼W	R-76-510
RN1	MDP 1603 27	K0109-0270
RN2	MDP 1603 1k	K0109-0102
RN3	MDP 1603 1k	K0109-0102
RN4	MSP 08A01 103-G 10k	K0110-0103B
RN5	MSP 08A01 103-G 10k	K0110-0103B
RN6	MSP 08A01 103-G 10k	K0110-0103B
SP1	Beeper	K0900-0190
U1	74LS138	IC-182
U2	L204B	K0500-1160
U3	74LS138	IC-182
U4	74LS138	IC-182
U5	8279	K0500-2070
U6	8031	K0500-2141
U7	74LS373	IC-357
U8	74LS138	IC-182
U9	Eprom 2764 max 300ms	LSI-52
U10	RAM 2114	LSI-15
U11	RAM 2114	LSI-15
U12	7061	K0550-0010
U13	7061	K0550-0010
U14	74LS90	IC-377
U15	74LS390	IC-212
U16	74LS93	K0510-0240
U17	74LS00	IC-163
U18	74LS00	IC-163
U20	8291	K0500-2130
U21	75160A	IC-298
U22	75161A	IC-299
U23	74LS365	K0510-0355
U24	7406	IC-62
U25	4094B	IC-251
U26	4094B	IC-251
U27	AD7533	K0560-0070
U28	4094B	IC-2
U29	LM747EN	K0500-5610
U30	4094B	IC-251
U31	AD7533	K0560-0070
U32	LM747EN	K0500-5610
U33	Ref 02C	K0530-0010
U34	10216	K0500-4110
U35	10107	K0500-4095
U36	10216	K0500-4110

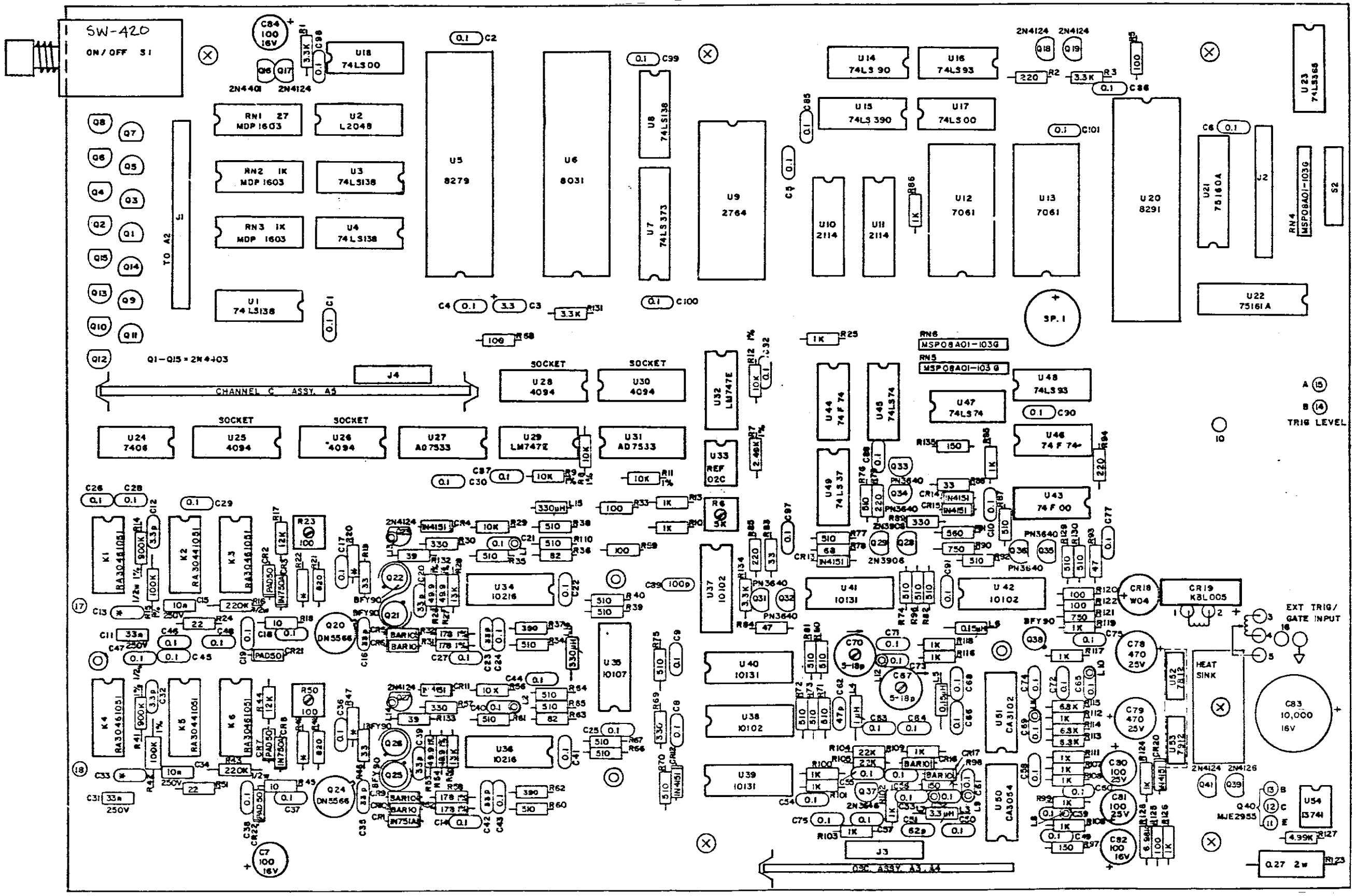
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Table 7-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Keithley Part Number
U37	10102	K0500-4090
U38	10102	K0500-4090
U39	10131	K0500-4120
U40	10131	K0500-4120
U41	10131	K0500-4120
U42	10102	K0500-4090
U43	74F00	K0500-1190
U44	74F74	K0500-1260
U45	74LS74	IC-144
U46	74F74	K0500-1260
U47	74LS74	IC-144
U48	74LS93	K0510-0240
U49	74LS37	K0510-0520
U50	CA3054	K0500-5760
U51	CA3102	K0500-5770
U52	7812	K0500-5220
U53	7912	K0500-5230
U54	13741	K0500-5600
U200	10102	K0500-4090

Item	Description	Qty	Part No.
1	Input circuit shield	1	K3300-1080
2	Ground clip	3	617-319
3	#4-40 × ¼ LG. Phil. Pan Hd. SEMS (ground clips & input circuit shield to mother board)	7	4-40×¼ PPHSEM
4	Heat sink	1	K3300-1070
5	#4-40 × ¼ LG. Phil. Pan Hd. SCR. (transistor to heat sink, heat sink to mother board)	3	4-40×¼ PPH
6	#4-40 Kepnut (heat sink to mother board)	1	4-40 KEPNUT
7	Card guide	3	K3000-9000
8	Connector Assy. (IEEE) (contains A and B)	1	K6200-0300
	A. connector and cable, 24 pin	1	K6200-0240
	B. IEEE connector (shielded)	1	K3000-4030
9	Pushbutton (power)	1	29465-3

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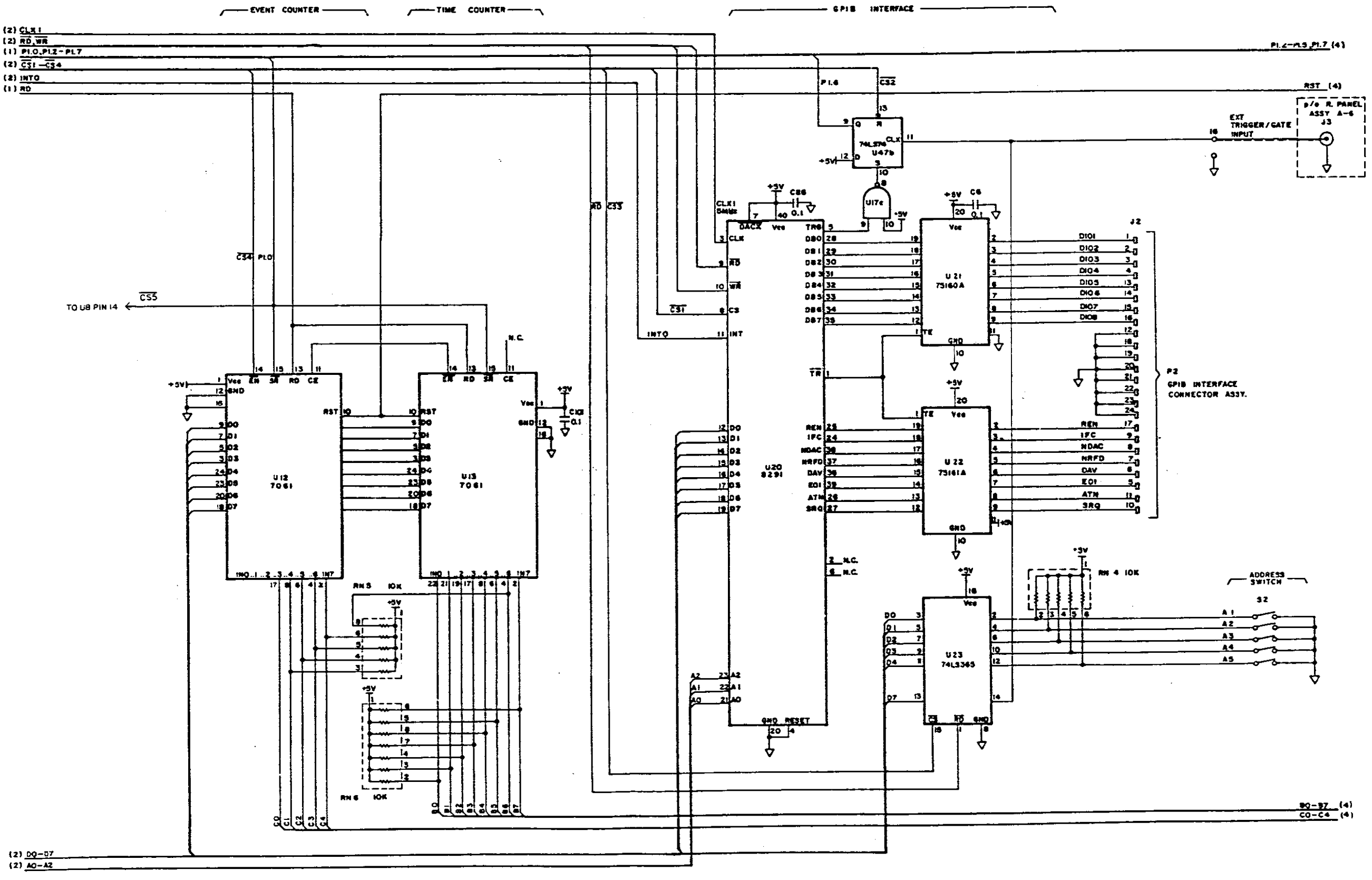


NOTES:

1. ALL CAP. VALUES ARE GIVEN IN μF UNLESS OTHERWISE NOTED.
2. ALL RES. VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED.
3. * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN.
4. Q21, Q22 AND Q25, Q26 ARE MATCHED PAIRS.

Figure 7-1. Mother Board, Component Location Drawing

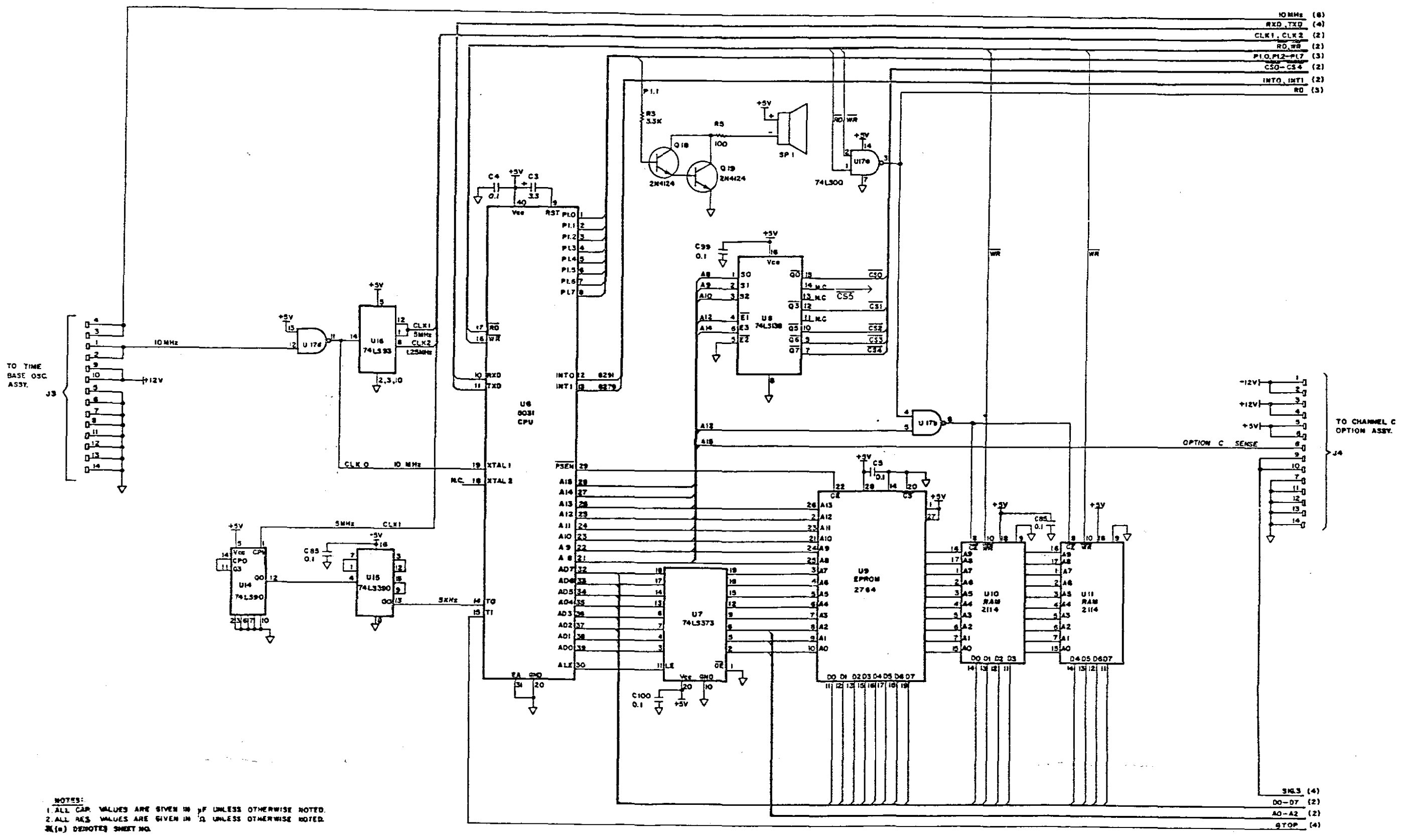
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2. ALL RES. VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED.
3. (a) DENOTES SHEET NO.

Figure 7-2. Mother Board (GPIB), Schematic Diagram (Sheet 1 of 6)

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2. ALL RES. VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED.
3. (n) DENOTES SHEET NO.

Figure 7-2. Mother Board (CPU), Schematic Diagram (Sheet 2 of 6)

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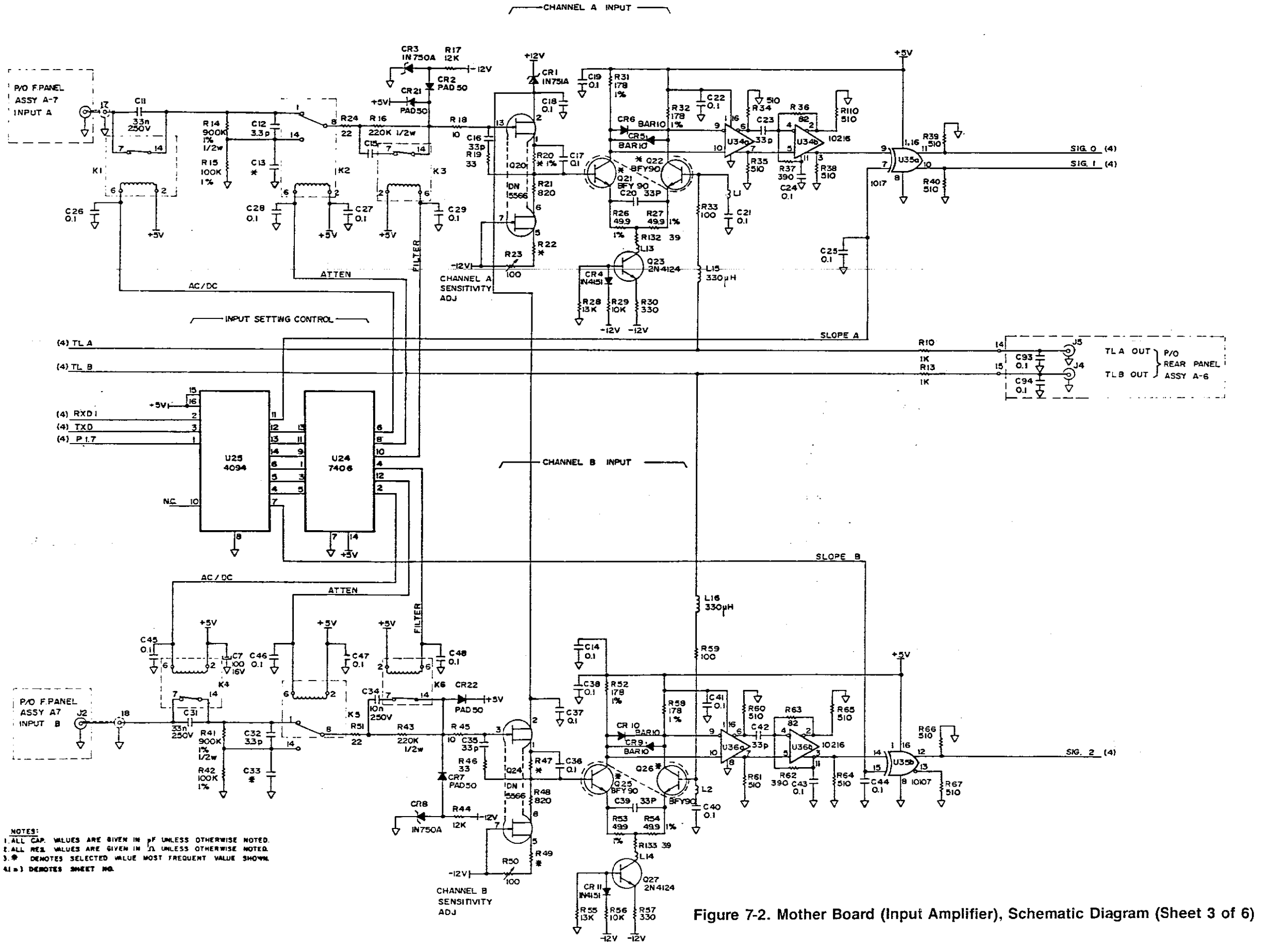
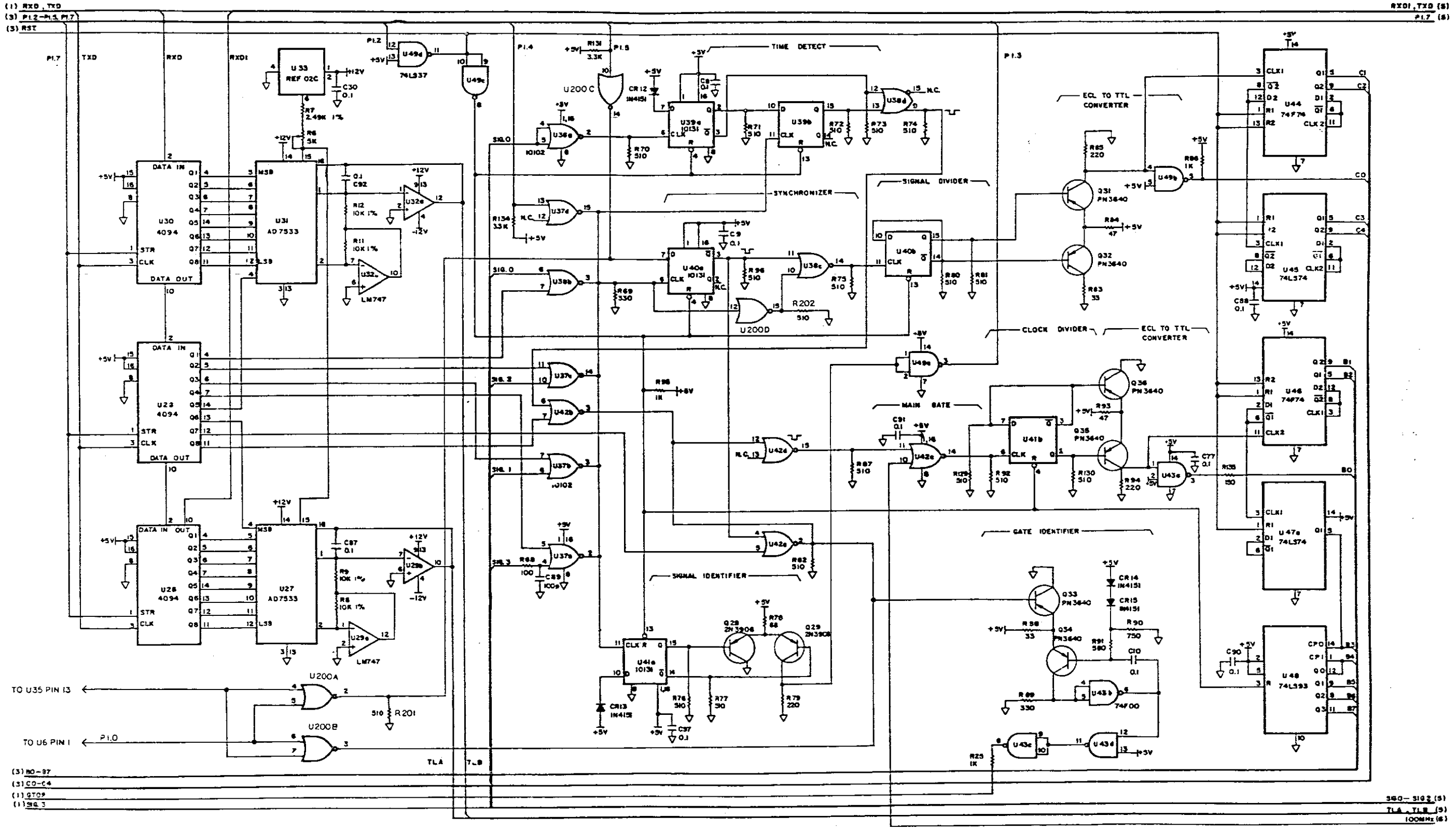


Figure 7-2. Mother Board (Input Amplifier), Schematic Diagram (Sheet 3 of 6)

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2. ALL RES. VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED
3. (n) DENOTES SHEET NO.

Figure 7-2. Mother Board (Measuring Section), Schematic Diagram (Sheet 4 of 6)

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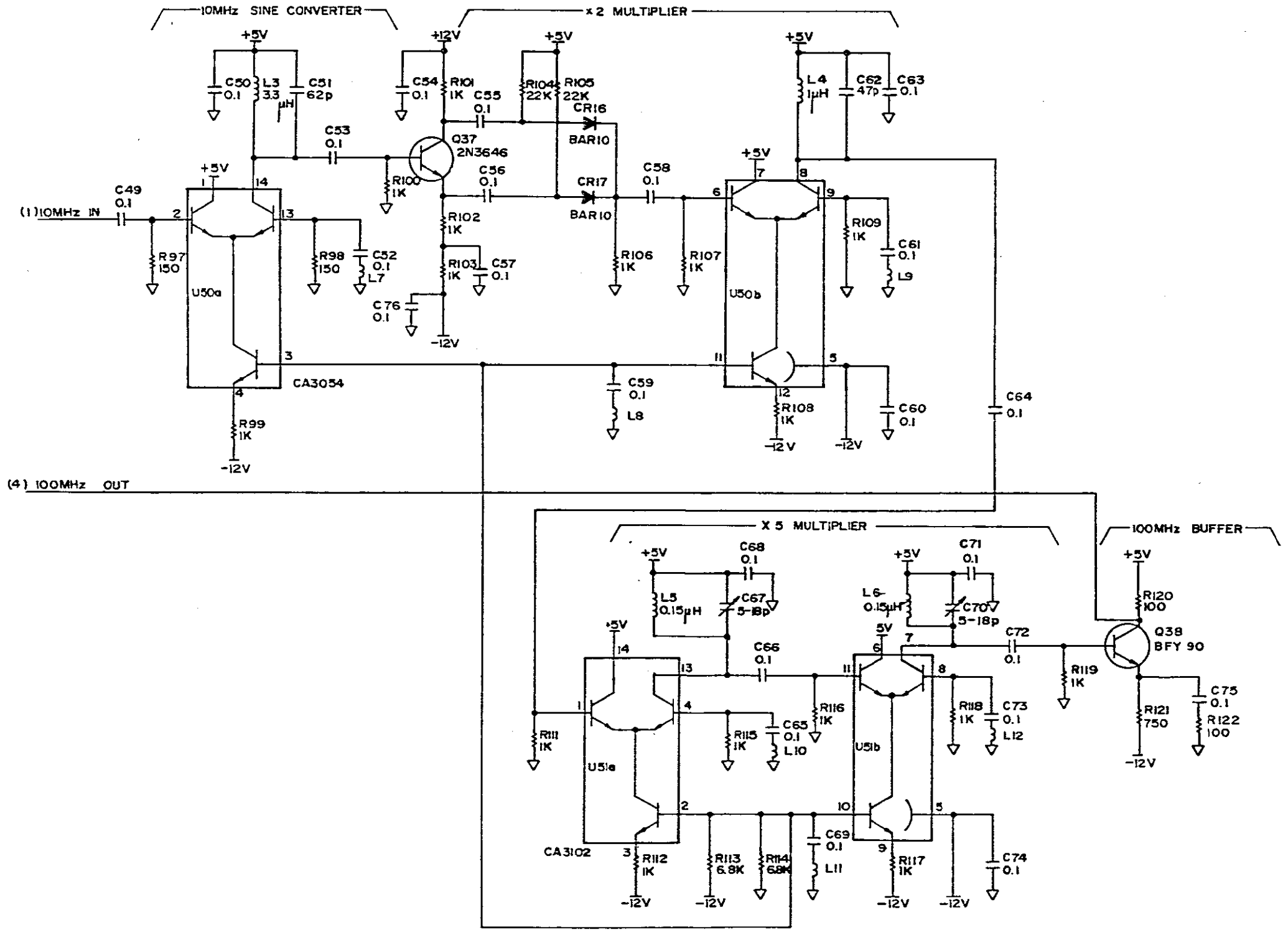
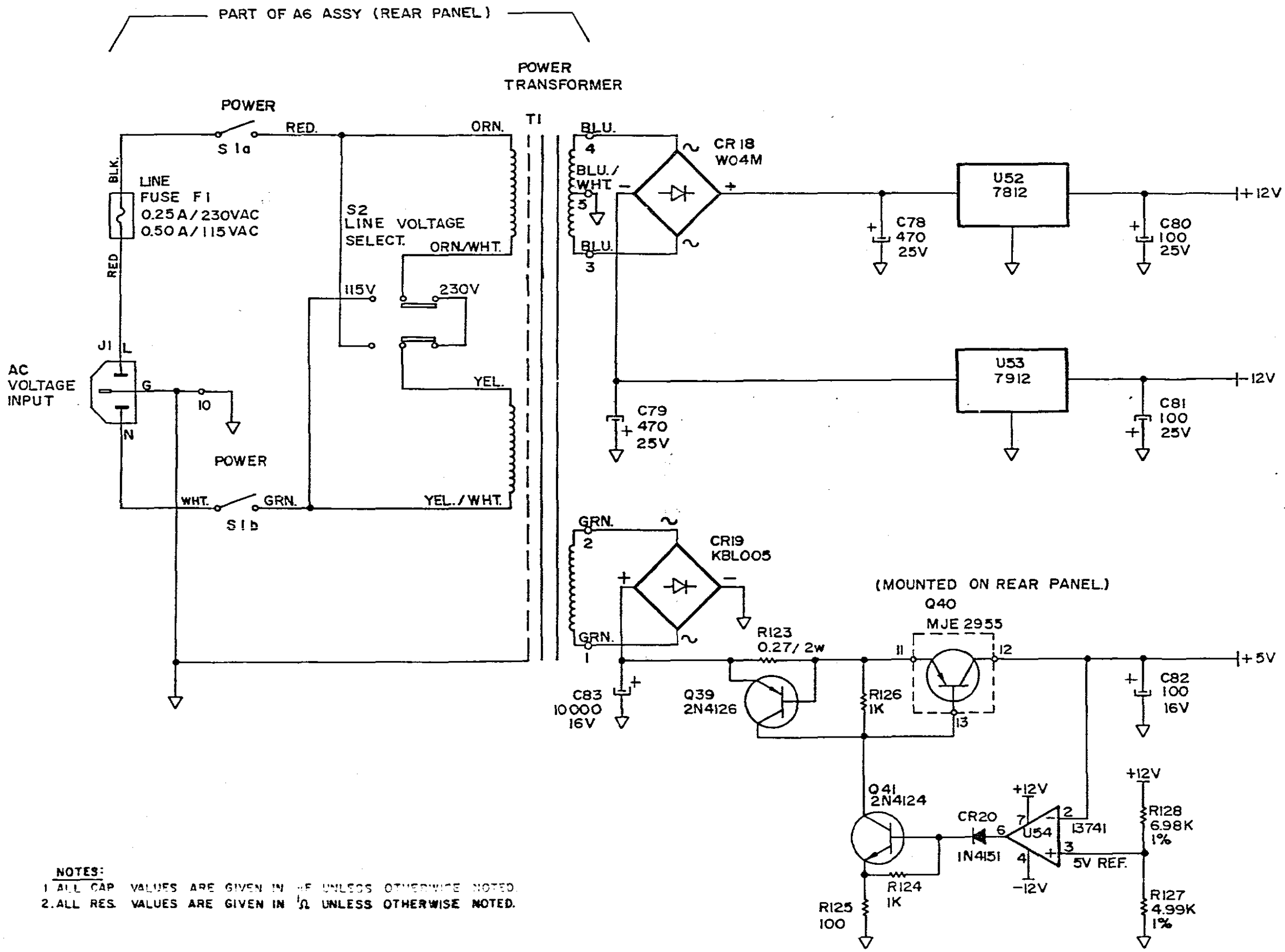


Figure 7-2. Mother Board (10MHz to 100MHz Multiplier), Schematic Diagram (Sheet 5 of 6)

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Figure 7-2. Mother Board (Power Supply), Schematic Diagram (Sheet 6 of 6)

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Table 7-2. Display Board, Parts List

Quantity	Description	Part Number
1	P.C. Board	K7100-1561
26	Red LED Mini	PL-71
10	LED	K1200-1080
1	LED ±1	K1200-1090
23	Switch Key (Keithley)	SW-435
23	Spacer, LED (PL-71)	MK-22-3
1	Ground Clip	617-320
1	#4-40 × ¼ LG. Phil. Pan Hd. SCR. (ground clip to display board)	4-40×¼ PPH
1	4 split ring lockwasher (ground clip to display board)	4 SPLTRGLKWA

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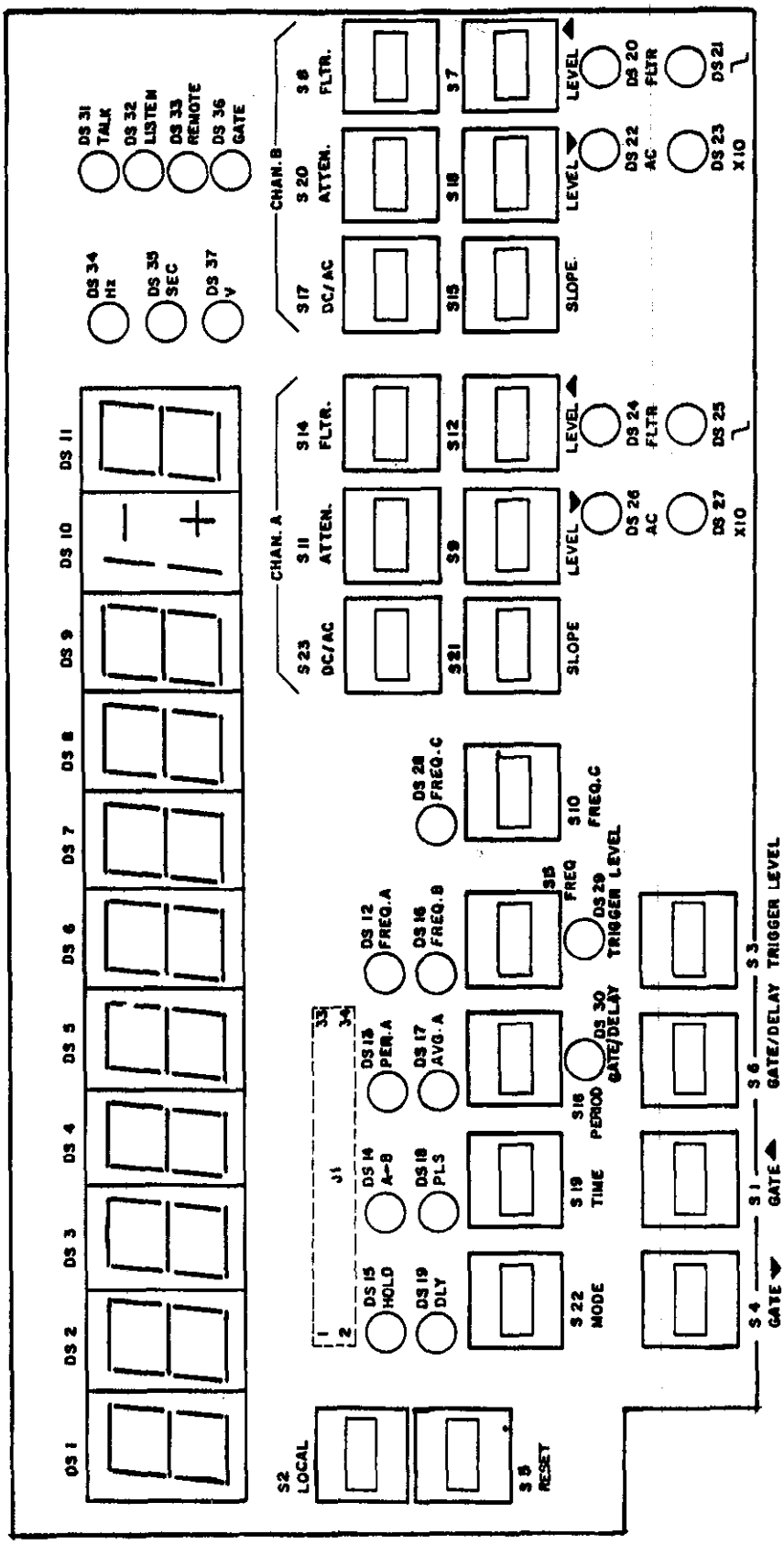


Figure 7-3. Display Keyboard and Control, Component Location Drawing

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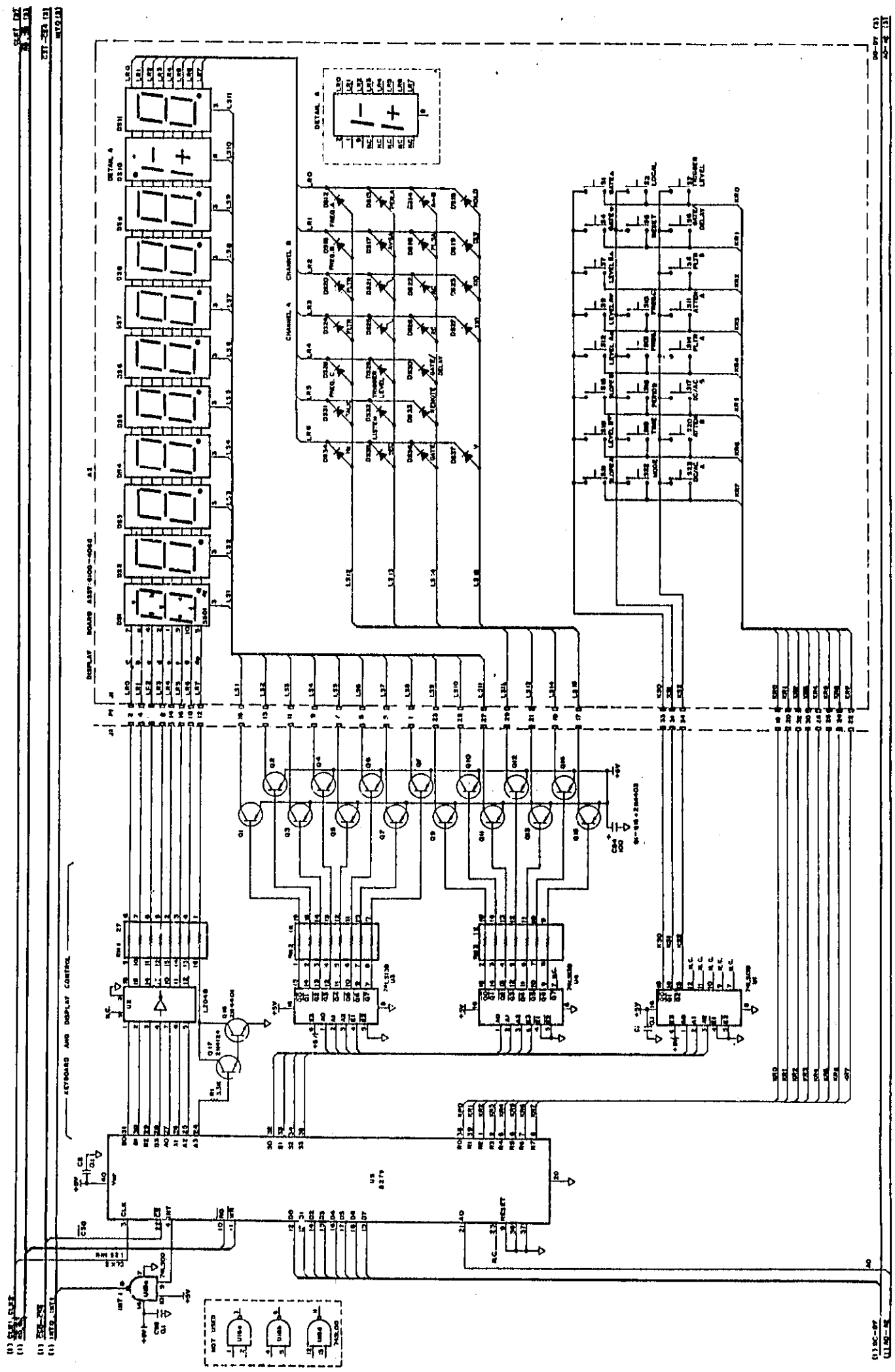


Figure 7-4. Display Keyboard and Control, Schematic Diagram

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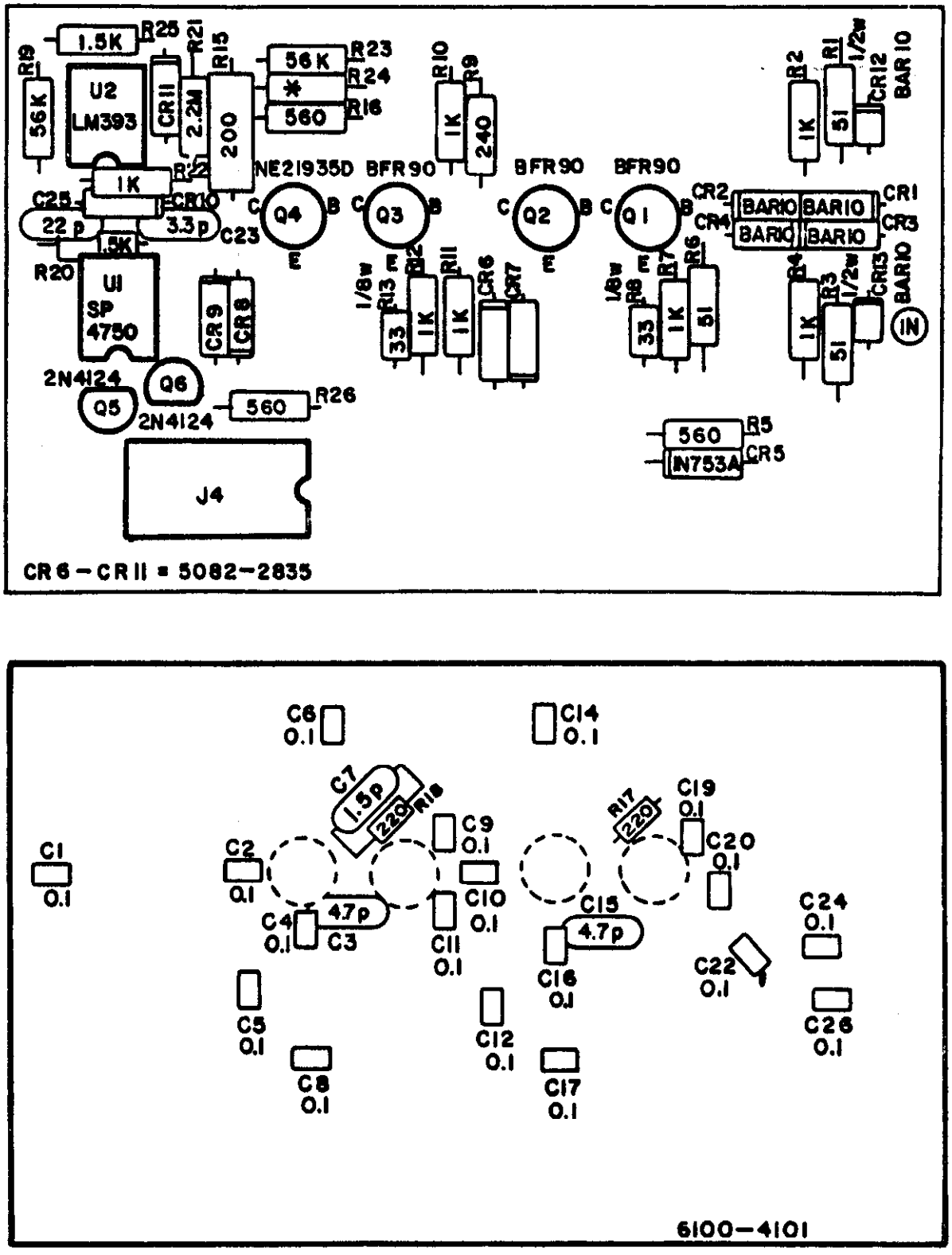


Figure 7-5. Model 7751, Component Location Drawing

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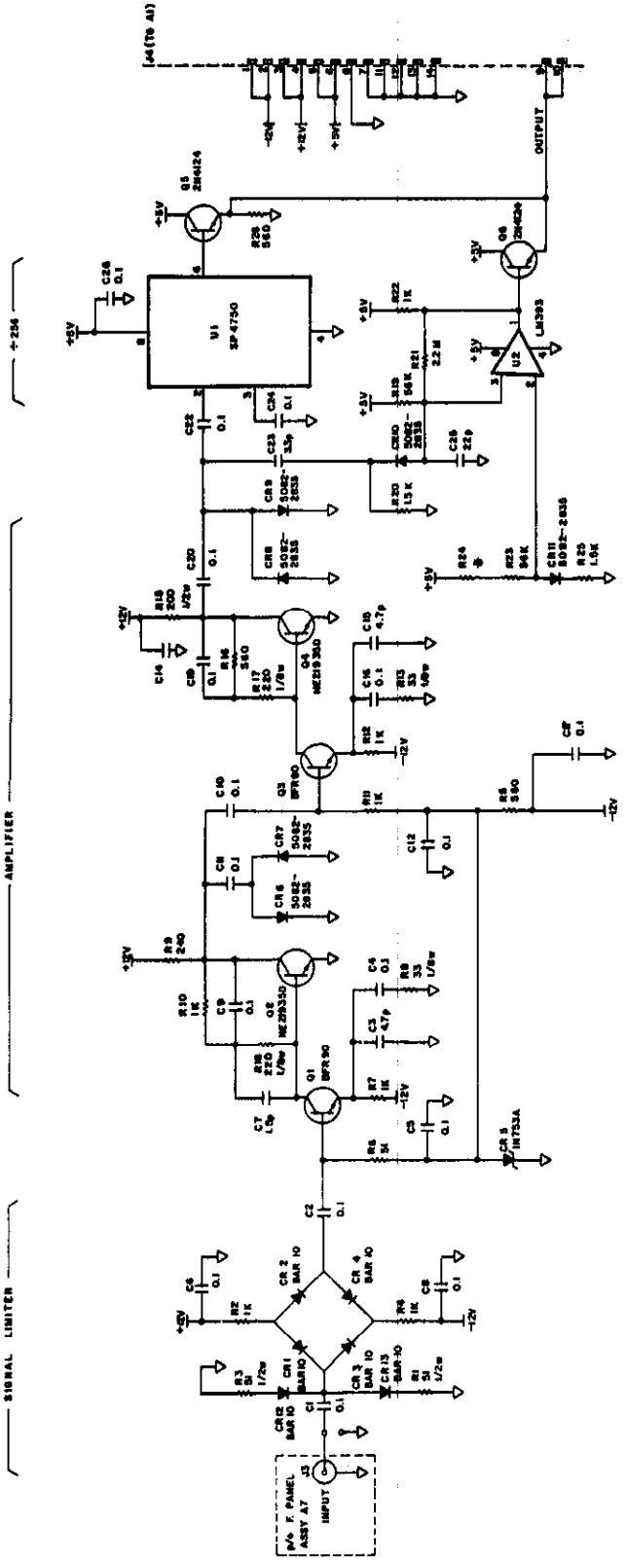


Figure 7-6. Model 7751, Schematic Diagram

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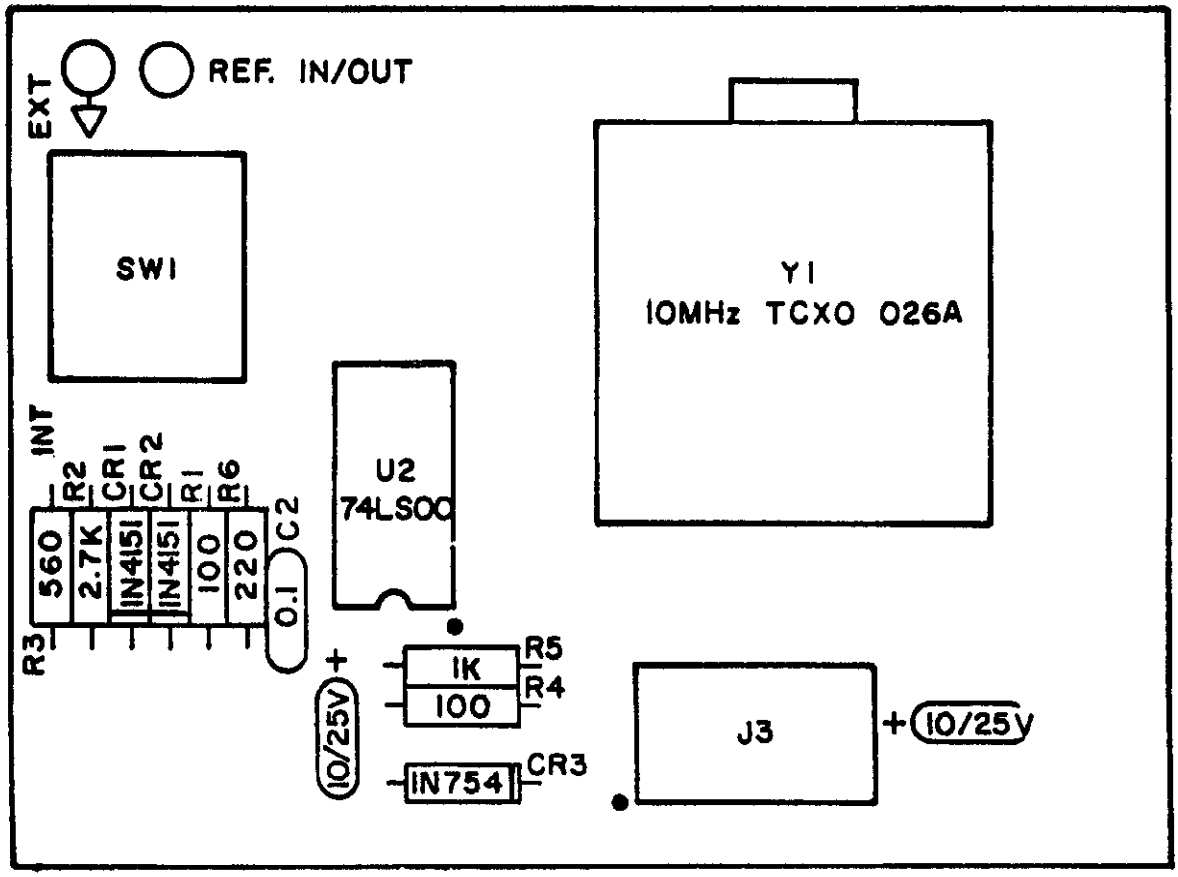


Figure 7-7. Model 7752, Component Location Drawing

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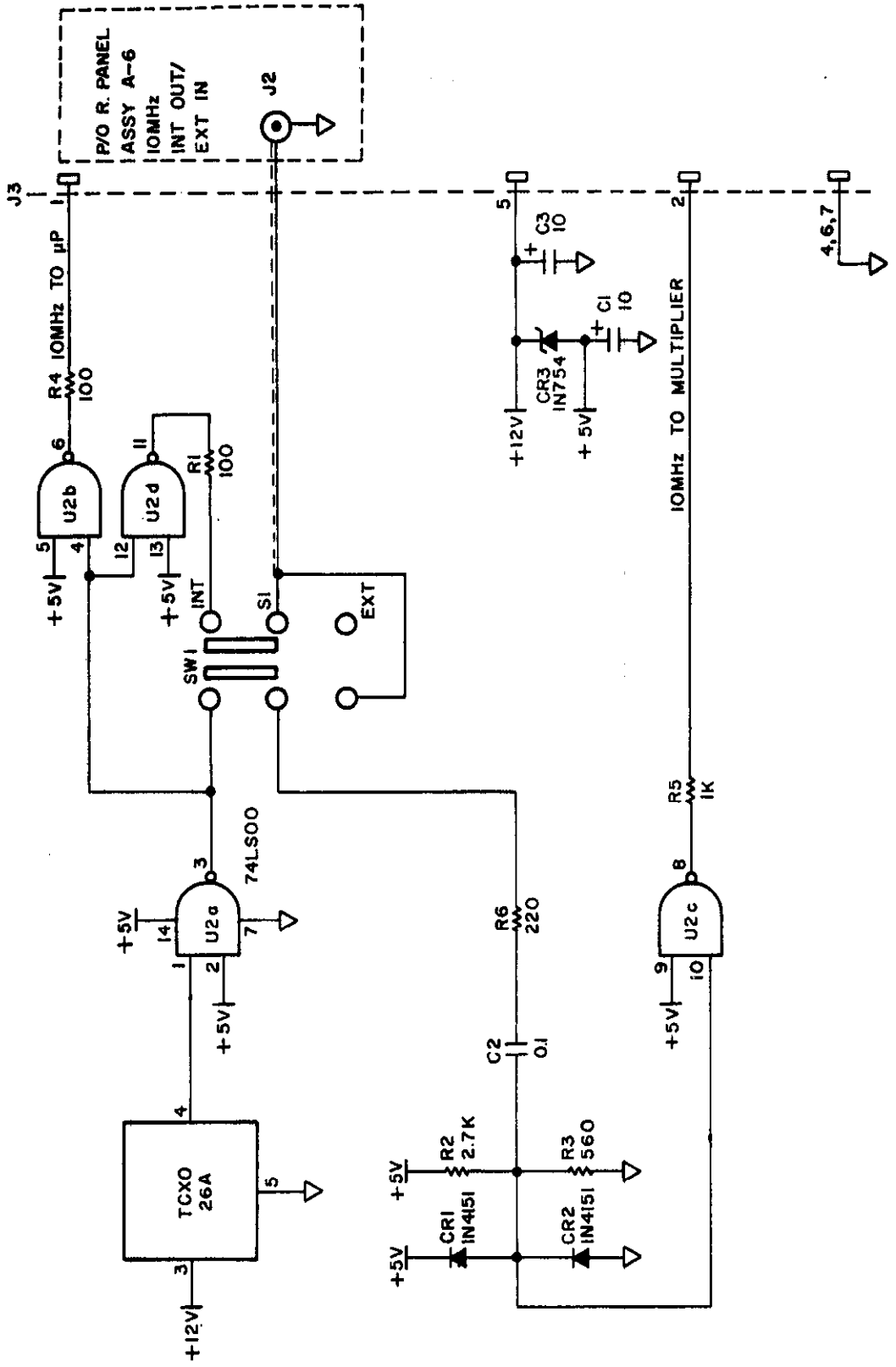


Figure 7-8. Model 7752, Schematic Diagram

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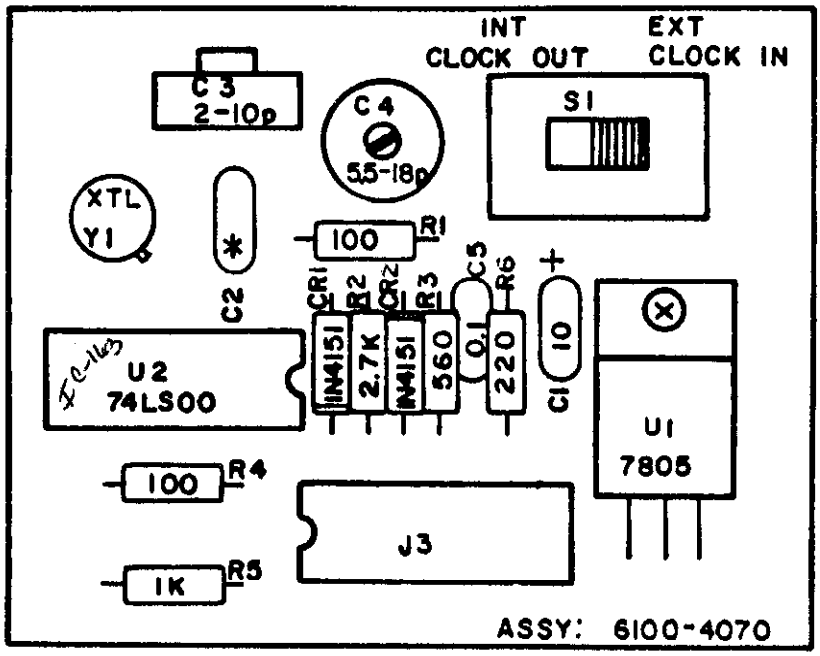


Figure 7-9. 5ppm Oscillator, Component Location Drawing

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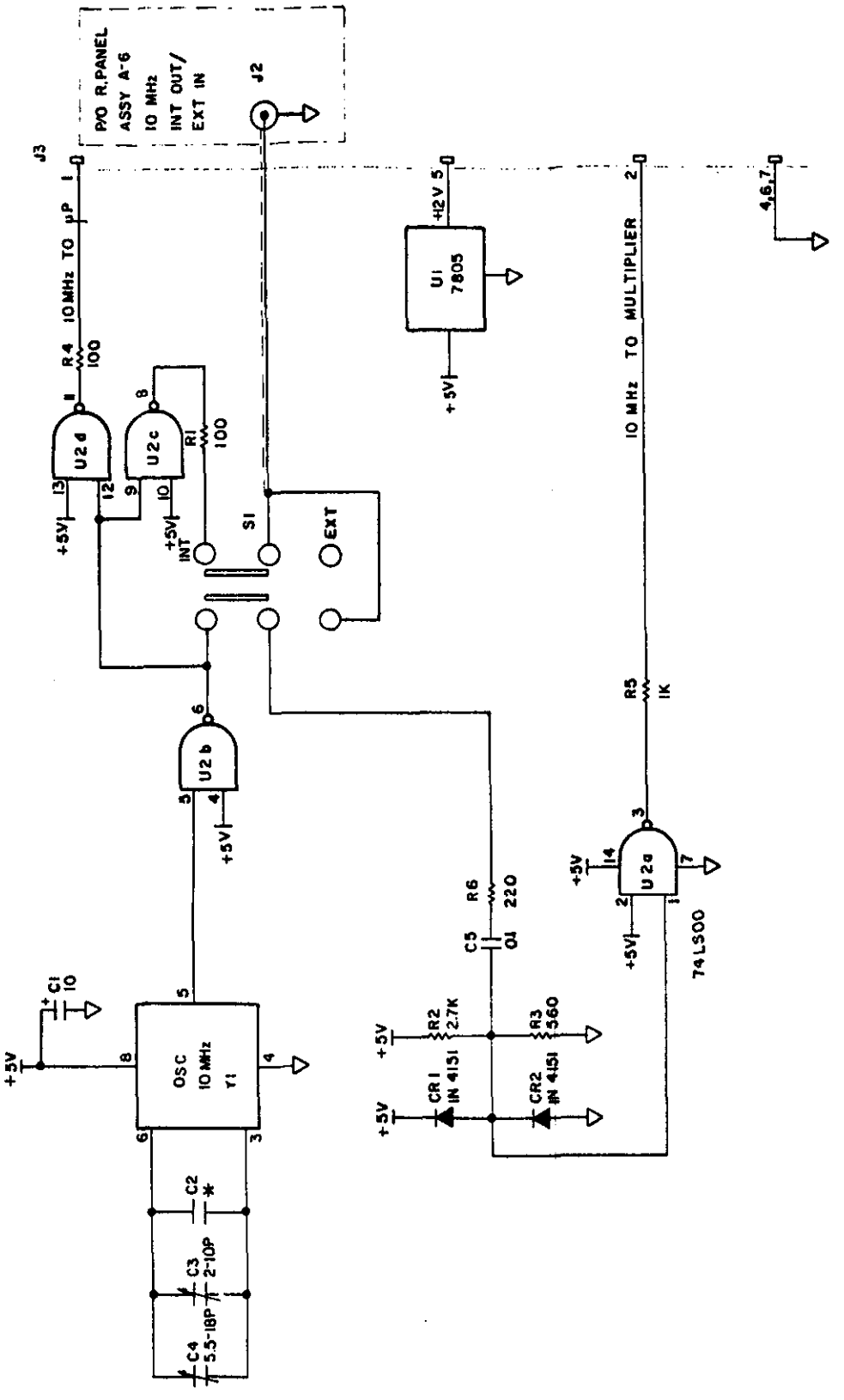


Figure 7-10. 5ppm Oscillator, Schematic Diagram

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Table 7-3. Model 775 Mechanical Parts List

Item	Description	Qty	Part No.
	FRONT PANEL		
1	Front panel assembly (contains A thru C)	1	—
	A. Front panel	1	775-301
	B. Window, display (red)	1	775-304
	C. Shield, front panel	1	K4900-0040
2	Pushbutton, (Local, Reset)	2	228-317-4
3	Pushbutton, (Mode, Time, Period, Freq)	8	228-317-5
4	Pushbutton, (Chan A, Chan B, Chan C)	13	228-317-6
5	Front panel overlay	1	775-303
6	BNC	3	CS-249
7	#4-40 × ¼ LG. Phil. Pan Hd. Scr. (display board to front panel)	2	4-40×¼ PPH
8	#4 Split Ring Lockwasher (display board to front panel)	2	4 SPLTRGLKWA
9	#6-32×$^{5}/_{16}$ Phil. Pan Hd. Sems (front panel to bottom cover)	2	6-32×$^{5}/_{16}$ PPHSEM
10	Lug, solder	3	LU-100
	BOTTOM COVER		
1	Bottom cover assembly (contains A thru F)	1	—
	A. Bottom cover	1	~~30544~~ 30541
	B. Shield, bottom cover	1	617-321
	C. Tilt bail	1	30544
	D. Insert, tilt bail	1	30587
	E. Drive pin (tilt bale to bottom cover)	1	FA-143-1
	F. Foot	4	FE-14
2	Isolating collar	6	30545
3	#6-32×$^{3}/_{8}$ LG. Phil. Pan Hd. Scr (collar to bottom cover)	6	6-32×$^{3}/_{8}$ PPH
	TOP COVER		
1	Top cove assembly (contains A and B)	1	—
	A. Top cover	1	30540
	B. Shield, top cover	1	617-322
	REAR PANEL		
1	Rear panel assembly (contains A thru T)	1	—
	A. Rear panel	1	K4500-5130
	B. #8-32×¼ LG. Phil. Pan Hd. Scr (rear panel to top and bottom cover)	4	8-32×¼ PPH
	C. Transformer (T1)	1	K2500-0380
	D. Transformer Cover (inside)	1	K5000-0060
	E. Transformer Cover (outside)	1	K5000-0010
	F. #6-32×1½ LG. Slotted Filister Hd. Scr. (transformer and covers to rear panel)	4	6-32×1½ PHFILH
	G. #6-32 Nut (transformer and covers to rear panel)	4	6-32 NUT
	H. #6-32 split ring lockwasher (transformer and covers to rear panel)	4	6-32 SPLTRGLKWA
	J. Rubber grommet (to bottom of inside transformer cover)	2	K3900-1000
	K. BNC (J3, J4, J5, J6)	4	CS-249

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Table 7-3. Model 775 Mechanical Parts List (Cont.)

Item	Description	Qty	Part No.
	L. LUG (BNC)	4	LU-100
	M. Line filter (J1)	1	LF-2
	N. Line selector (voltage)	1	K2000-1020
	O. #4-40×½ LG. Phil. Pan Hd. Scr. (line filter and line selector to rear panel)	4	4-40×½ PPH
	P. #4-40 KEPNUT (line filter and line selector to rear panel)	4	4-40 KEPNUT
	Q. Fuse carrier, body	1	FH-24
	R. Fuse carrier	1	FH-26
	S. Ground clip	2	617-319
	T. #6-32 KEPNUT (ground clips and YE/GRN ground wire to rear panel)	3	6-32 KEPNUT
2	Hardware kit (IEEE connector to rear panel)	1	CS-378
3	Fuse (0.3A/115V or 0.15A/230V)	1	K1100-1010 or K1100-1015
4	#4-40×¼ LG. Rear Pan. Hd. Scr (MJE-2955T, transistor to rear panel)	1	4-40×¼ PPH
5	#4-40 NUT (MJE-2955T, transistor to rear panel)	1	4-40 NUT
	MISCELLANEOUS		
1	Line cord	1	CO-7

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APPENDIX A

IBM PC or XT (Keithley Model 8573 Interface)

The following program sends a command string to the Model 775 from an IBM PC or XT computer and displays the instrument reading string on the CRT. The computer must be equipped with the Keithley Model 8573 IEEE-488 Interface and the DOS 2.00 operating system. Model 8573 software must be installed and configured as described below.

DIRECTIONS

1. Set switches on the Model 775 to addressable mode, primary address 23.
2. With the power off, connect the Model 775 to the IEEE-488 interface installed in the IBM computer.
3. Type in BASICA on the computer keyboard to get into the IBM interpretive BASIC language.
4. Place the interface software disc in the default drive, type LOAD"DECL", and press the return key.
5. Add the lines below to lines 1-6 which are now in memory. Modify the address in lines 1 and 2, as described in the Model 8573 Instruction Manual.
6. Run the program and type in the desired command string.
7. The instrument reading string will then appear on the display.
8. To exit the program, type in EXIT at the command prompt and press the return key.

PROGRAM	COMMENTS
10 CLS	
20 NA$="GPIBO":CALL IBFIND(NA$,BRD0%)	Look up the controller configuration.
30 NA$="DEV15":CALL IBFIND(NA$,M775%)	Look up the device configuration.
40 V%=23:CALL IBPAD(M775%,V%)	Set 775 primary address to 23.
50 V%=1:CALL IBSRE(BRD0%,V%)	Set remote enable true.
60 INPUT"COMMAND":CMD$	Prompt for command string.
70 IF CMD$="EXIT" THEN 150	See if program is to be halted.
80 IF CMD$=" " THEN 60	If null command string go back and get another.
90 CALL IBWRT(M775%,CMD$)	Address 775 to listen and send command string.
100 RD$=SPACE$(25)	Assign reading input buffer.
110 CALL IBRD(M775%,RD$)	Address 775 to talk and input reading string.
120 RD$=LEFT$(RD$,IBCNT%)	Trim string to proper size.
130 PRINT RD$	Display the reading on the CRT.
140 GOTO 60	Repeat.
150 V%=0:CALL IBONL(BRD0%,V%)	Close the controller file.
160 CALL IBONL(M775%,V%)	Close the device file.
170 END	

NOTE: If the Model 775 does not have an input signal (i.e. the gate is not running), no valid reading is available to send over the bus. In this case, the IBRD statement, in line 110, will time out after approximately 10 seconds.

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SERVICE FORM

Model No. _____ **Serial No.** _____ **P.O. No.** _____ **Date** _____

Name _____ **Phone** _____

Company _____

Address _____

City _____ **State** _____ **Zip** _____

List all control settings and describe problem. _____

_____

_____

_____ (Attach additional sheets as necessary.)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.) _____

What power line voltage is used? _____ Variation? _____

Frequency? _____ Ambient Temperature? _____ °F.

Variation? _____ °F. Rel. Humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe below.)

_____

_____

*Be sure to include your name and phone number on this service form.

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