User Manual

6020

225 MHz Programmable Counter / Timer

Serial Prefix: 64

Tabor Electronics Ltd.

9 Hatasia Street, Tel Hanan, Israel 20302

TEL: (972) 4 821 3393, FAX: (972) 4 821 3388

[www.taborelec.com]

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Warranty

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

REPAIR AND CALIBRATION

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

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

Tabor Electronics Ltd.

REPAIR AND CALIBRATION REQUEST FORM

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

Model________________Serial No.__________________Date_________________

Company Name________________________Purchase Order #_________________

Billing Address____

City

____

State/Province Zip/Postal Code Country

Shipping Address____

City

____

State/Province Zip/Postal Code Country

Technical Contact_________________Phone Number (   )______________________

Purchasing Contact _________________Phone Number (   )______________________

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

____

____

____

____

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

____

____

____

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

____

____

____

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

Call before shipping
Note: We do not accept "collect" shipments.

Ship instruments to nearest support office listed on back.

Safety Precautions

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

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

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

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

Declaration of Conformity

We:

Tabor Electronics, Ltd.

P.O. Box 404

Tel Hanan, Israel 20302

declare, that the Arbitrary Waveform/Function Generator

Model 6010 and model 6020

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

Safety:

EN 61010-1

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

EMC:

EN 50081-1 Emissions:

EN 55022 - Radiated, Class B

EN 55022 - Conducted, Class B

EN 50082-1 Immunity:

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SECTION 1

GENERAL INFORMATION

1-1. INTRODUCTION

This manual provides operating and maintenance information for the Model 6020 Programmable Counter/Timer. Section 1 is a general description of the instrument. Section 2 and 3 obtain installation and operating instructions. IEEE programming is explained in Section 4. Maintenance and performance checks are provided in Section 5. The theory of operation is described in Section 6. Section 7 outlines calibration and troubleshooting procedure. Section 8 contains tables of replaceable parts. Section 9 contains schematic and component location diagrams.

Model 6020 is a nine digit microprocessor based fully programmable three channels Universal Counter Timer. The instrument measures with a very high resolution and precision the following parameters: Frequency A, Frequency B, Frequency C, Period A, Pulse-width, Time interval A to B, Total count, Ratio A/B, θ A to B and Amplitude peaks. For improved resolution in time measurement, an averaging function is available - resolving intervals of Pico seconds. To simplify various repetitive tests, any of 10 pre-programmed complete set-up states, stored in a non-volatile memory, can be recalled by a simple key stroke, insuring exact duplication of previous set-ups no matter how complex.

Model 6020 utilizes a combination of two measurement techniques in order to always achieve maximum resolution of up to nine digits from as low as 0.1 Hz to more than 225 MHz. The reciprocal technique is being used in low frequency measurement up to exactly 10MHz where the measurement technique is changed to conventional measurement technique. Model 6020 measures frequency of the input signal with a minimum resolution of seven digits in one second of gate time. Option 1 adds a x10 multiplier to the internal time-base which increases the minimum number of digits that are displayed in one second to eight. Option 1 also adds a temperature controlled oscillator for improved reading stability and accuracy.

In the Model 6020 the traditionally featured decade steps of gate times is replaced by a more flexible variable gate time. This allows a choice of 50 internally pre-selected gate intervals or any external gate interval which is applied to a rear panel BNC connector. Internal gate ranges from 100 μS to 10 S. External gate expands this range to 1000 S. Trigger level may be selected manually or left to be automatically adjusted by the instrument to the optimum level, thus eliminating false triggering on unknown signals.

NOTE

> This manual provIdes a complete description of all features of the 6020 Series. Therefore, several of the features which are described in the following paragraphs may not be installed in your instrument.

1-2. INSTRUMENT AND MANUAL IDENTIFICATION

These Tabor instruments are identified by a serial number which is located on the rear panel. The two most significant digits identify instrument modification. If this prefix differs from that listed on the title page of this manual, there are differences between this manual and your instrument. Technical corrections to this manual (if any) are listed in the back of this manual on an enclosed MANUAL CHANGES sheet.

1-3. OPTIONS

There are several options available with Model 6020:

Option 1 - TCXO and clock multiplier
Option 2 - 1.3 GHz Channel C input
Option 3 - Analog output

Options are field installable or may be ordered with new instruments from the factory. There are no software modifications necessary when installing the options. The instrument will automatically sense the presence of the new option and will then allow access to the parameters which are associated with the newly installed option.

1-4. SPECIFICATIONS

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

NOTE

> All specifications in the following table apply after a warm-up period of 1 hour and at ambient temperature of 0 to 40°C.

1-5. ACCESSORIES SUPPLIED

The 6020 Counter/Timer is supplied with ac mains power cable and an instruction manual.

Table 1-1. Model 6020 Specifications

INPUT CHARACTERISTICS
(Channel A and B)

RANGE		
DC coupled		: 0 to 225 MHz
AC coupled	1 MΩ	: 30 Hz to 225 MHz
	50 Ω	: 1 MHz to 225MHz
SENSITIVITY (X1)		
35 mV rms sine wave		: 0 to 100 MHz
50 mV rms sine wave		: 100 MHz to 225 MHz
100 mV p-p		: 5 nS min pulse width
SIGNAL OPERATING RANGE		
(X1)		: -5.00 V DC to +5.00 V DC
(X10)		: -50.0 V DC to +50.0 V DC
DYNAMIC RANGE (x1)		
100 mV - 5 Vp-p		: 0 to 100 MHz
150 mV - 2.5 Vp-p		: 100 MHz to 225 MHz
COUPLING		: AC or DC, switchable
IMPEDANCE		: 1 MΩ or 50 Ω nominal shunted by less than 45 pF, switchable
SLOPE		: Independent selection of + or - slope, switchable
LOW PASS FILTER		: -3db nominal at 100 KHz, switchable
DAMAGE LEVEL (AC or DC)		
50 Ω		: 5 V rms
1 MΩ (X1)		: DC to 2 kHz - 200 V (DC + peak AC) 2 KHz to 100 KHz - 4 x 10E5 V rms Hz/Freq. Above 100 KHz - 5 V rms
1 MΩ (X10)		: DC to 20 kHz - 200 V (DC + peak AC) 20 kHz to 100 KHz - 4x10E6 V rms Hz/Freq. Above 100KHz - 50 V rms
MANUAL ATTENUATOR		: X1 or X10 nominal, switchable

AUTO TRIGGER LEVEL CHARACTERISTICS (Channel A and B)

TRIGGER LEVEL RANGE		
(automatic mode)		: -50.0 VDC to +50.0 VDC
FREQUENCY RANGE		
DC coupled		: 100 Hz to 150 MHz (typically 225 MHz)
AC coupled	@ 1 MΩ	: 100 Hz to 150 MHz (typically 225 MHz)
	@ 50 Ω	: 1 MHz to 150 MHz (typically 225 MHz)

NOTES:

1. Auto trigger is disabled in the following functions: Totalize B and Frequency C.
2. Auto trigger function requires that a repetitive signal be present at the input connector.

Table 1-1. Model 6020 Specifications (continued)

AUTO ATTENUATION

Mode	: Automatically enabled with the Auto Trigger.
x10 attenuator	: Automatically enabled when either peak is greater than ± 5.1 V or when the difference between maximum and minimum peaks exceeds 5.1 V.
Minimum amplitude	: 100 mV rms sine wave, 280 mV p-p

MANUAL TRIGGER LEVEL CHARACTERISTICS (Channel A and B)

RANGE	
(X1)	: -5.00 VDC to +5.00 VDC
(X10)	: -50.0 VDC to +50.0 VDC
PRESET	
(X1)	: 0.00 VDC
(X10)	: 00.0 VDC
RESOLUTION	
(X1)	: 10 mV
(X10)	: 100 mV

SETTING ACCURACY

(X1)	: ±(35 mV + 3% of the reading)
(X10)	: ±(350 mV + 3% of the reading)

FREQUENCY A, B

Mode	: Reciprocal below 10 MHz and when EXT GATE mode or HOLD mode are selected. Conventional above 10MHz. Mode of operation is automatically selected by the instrument. (10 MHz above changes to 100 MHz with opt 1)

RECIPROCAL FREQUENCY MEASUREMENT CHARACTERISTICS

Range	: 0.1 Hz to 125 MHz (see mode above).
LSD(1) Displayed	: $\frac{4 \times 100 \text{ nS} \times \text{frequency}}{\text{gate time.}}$
	e.g min 7 digits in one second of gate time
with option 1 installed	: $\frac{4 \times 10 \text{ nS} \times \text{frequency}}{\text{gate time.}}$
	e.g min 8 digits in one second of gate time
Resolution	: ± LSD ± $\frac{\pm(1.4 \times \text{Trig error(2)} + 2 \text{ nS}) \times \text{Freq}}{\text{gate time}}$
Accuracy	: ±resolution ±Time Base Error(3) x Freq

Table 1-1. Model 6020 Specifications (continued)

CONVENTIONAL FREQUENCY MEASUREMENT CHARACTERISTICS

Range	: 10 MHz to 225 MHz.
with option 1 installed	: 100 MHz to 225 MHz.
LSD(1) Displayed	: 4 gate time
Resolution	: ± 1 LSD
Accuracy	: ± 1 LSD ± Time Base error(3) x Freq

FREQUENCY C (available with option 2 only)

Mode	: Reciprocal mode only
Range	: 50 MHz to 1300 MHz
LSD(1) Displayed	: Same as for Frequency A and B
Resolution	: Same as for Frequency A and B
Accuracy	: Same as for Frequency A and B

PERIOD A, PULSE A, TIME INTERVAL A to B

Range	: 100 nS to 10E5 S
with option 1 installed	: 10 nS to 10E4 S
LSD(1) Displayed	: 100 nS for time less than 100 S 5 E-9 x time for time more than 100 S
with option 1 installed	: 10 nS for time less than 10 S 5 E-9 x time for time more than 10 S
Resolution	: ± 1 LSD ñ start trig error(2) ± ± stop trig error(2)
Accuracy	: ± resolution ± (Time Base error(3) x Time) ± Trig level timing error(4) ± 2 nS

PERIOD A - AVERAGED (*)

Range	: 8 nSec to 10 Sec
LSD(1) Displayed	: 4 x 100 nS x Period gate time
e.g	min 7 digits in 1 second of gate time.
with option 1 installed	: 4 x 10 nS x Period gate time
e.g	min 8 digits in 1 second of gate time
Resolution	: ñ LSD ñ(1.4 x Trig error(2)+ 2 nS) x Per gate time
Accuracy	: ± resolution ± Time Base error(3) x Period
Number of Periods Averaged	: N = gate time Period

Table 1-1. Model 6020 Specifications (continued)

PULSE A, TIME INTERVAL A to B - AVERAGED (*)

Range	
Pulse A	: 5 nS to 10 S
T.I A to B	: 0 nS to 10 S. A and B signals must have the same repetition rate.
LSD(1) Displayed	: $\frac{5 \times 100\ nS}{\sqrt{N}}$
with option 1 installed	: $\frac{5 \times 10\ nS}{\sqrt{N}}$
Resolution	: ± 1 LSD
Accuracy	: $\pm$ resolution $\pm \frac{\text{Trig error(2)}}{\sqrt{N}} \pm$ ± Time Base error(3) x Time ± 2 nS
Dead Time Stop to Start	: 20 nS minimum
Number of Samples Averaged	: N = gate time x Frequency A

PHASE A to B - AVERAGED (*)

Range	: 0 to 360° x (1 - 20 nS x Freq A). example: 0 to 359.99° at 1 KHz 0 to 180.0° at 25 MHz
Frequency Range	: 0.1 Hz to 25 MHz. A and B signals must have the same frequency.
LSD(1) Displayed	: $\frac{2.5 \times 100\ nS \times 360ø \times (1 + \sqrt{N})}{\text{gate time}}$ or 0.01°, whichever is greater
with option 1 installed	: $\frac{2.5 \times 10\ nS \times 360° \times (1 + \sqrt{N})}{\text{gate time}}$ or 0.01°, whichever is greater
Resolution	: ± 1 LSD.
Accuracy	: ± resolution ± 2 nS x Freq A x 360° $\frac{\pm \text{Trigger error(2)} \times \text{Freq A} \times 360°}{\sqrt{N}}$
Number of Cycles Averaged	: N = gate time x Frequency A
Minimum Amplitude	: 100 mV rms sine wave

(*) In Averaged measurements, no phase relation is allowed between the external source to the instrument's Time Base.

TOTALIZE B

Gate Modes (*)	
Infinite	: Totalizing on B indefinitely
Totalize by A	: Totalizing on B during pulse duration on A
Totalize by AA	: Totalizing on B between a pair of two consecutive transitions of the same direction on A

Range	: 0 to 10E16 - 1
Frequency range	: 0 to 100 MHz

Table 1-1. Model 6020 Specifications (continued)

Dead Time Stop to Start(7)		: 20 nS minimum between stop transition to the next start transition
LSD displayed		: 1 count of channel B input signal
Resolution		: 1 LSD
Accuracy		
	Infinite	: Absolute
	Totalize by A	: $\pm \frac{\text{pulse rep rate B x Trig(2) error A}}{\text{total counts B}}$
	Totalize by AA	: Same as for Totalize by A

(*) Direction of the gating transition is front panel selectable.

RATIO A/B

Frequency Range		
	A	: 0.1 Hz to 225 MHz
	B	: 0.1 Hz to 125 MHz
LSD(1) displayed		: $\frac{\text{4 x Ratio}}{\text{Freq A x gate time}}$
Resolution		: $\pm$ LSD $\pm \frac{\text{Trig error B(2) x Ratio}}{\text{gate time}}$
Accuracy		: Same as resolution

V PEAK A

Function		: Maximum and minimum peaks of Channel A input signal are simultaneously displayed, each with 3 digits. Decimal points and polarity are automatically displayed.
Frequency range		
	@ Fast rate	: 100 Hz to 10 MHz
	@ Slow rate	: 40 Hz to 10 MHz
Dynamic range		: 280 mV p-p to 51 V p-p
Resolution	x1	: 10 mV
	x10	: 100 mV. Attenuator is automatically activated if either the positive or the negative peaks of the input signal exceeds ±5.1V or when the peak to peak voltage exceeds 5.1V.
Accuracy		: ±resolution ±0.1(Vpos pk - Vneg pk) ± ±35mV

DELAY

Function	: Active only with Time Measurements First input transition opens the gate. Delay inhibits the consequent transitions.

Table 1-1. Model 6020 Specifications (continued)

Modes	: Internal through front panel programming or externally applied through rear panel BNC.
Internal range	: 100 μS to 10 S
Preset position	: 1 S
External range	: 100 μS to 10E5 S
with option 1 installed	: 100 μS to 10E4 S

GATE TIME

Modes	: Internal through front panel programming or externally applied through rear panel BNC.
Internal range	: 100 μS to 10 S or one period of the input.
External range	: 100 μs to 1000 S. Ext gate not available with Time measurements, Totalize and θ A to B
Preset position	: 1 S
External gate delay(6)	: < 10 μS

EXTERNAL ARMING (TRIGGER)

Function	: Arms the instrument when set to HOLD mode.
Trigger Delay(5)	: < 50 μS
Minimum Pulse width	: 10 μS

EXTERNAL INPUT - GATE, DELAY, ARMING

Input	: TTL levels, via rear panel BNC
Input Impedance	: 1 KΩ nominal
Logic	: Positive true

TIME BASE

Frequency	: 10 MHz
Aging Rate	: <5 X 10E -7 / month
Stability	: <5 X 10E -6, 0 to 50 °C
Line Voltage	: 1 X 10E -7 for 10% change (short term)
Clock IN/OUT	: Selected with an internal switch
External Time Base Input	: Rear Panel BNC accepts 10 MHz TTL
Time Base Out	: 10 MHz approx 2 V from a 51 Ω source

GPIB INTERFACE

Programmable Controls	: All front panel controls except POWER switch.
Multiline Commands	: DCL, LLO, SDC, GET, GTL, UNT, UNL, SPE, SPD
Uniline Commands	: IFC, REN, EOI, SRQ, ATN

Table 1-1. Model 6020 Specifications (continued)

Interface Functions	: SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1
Data Output Format Reading	: With prefix 18 ASCII characters plus terminator. Without prefix - 14 ASCII characters plus terminator
Gate/Delay time and trigger level	: With prefix - 9 ASCII characters plus terminate or. Without prefix - 5 ASCII characters plus terminator
Address selection	: By front panel controls. Address is stored in a non-volatile memory.

GENERAL

Display Rate	: Normal- Approx four measurements per S. Hold - Single shot measurement, one measurement taken with each press of RESET button. Fast - Approximately 27 measurements per S.
Arming	: Each channel is armed by it's own signal
Reset	: Clears front panel display and begins a new measurement cycle.
Trigger Level Outputs	: DC Outputs via rear panel terminals, not adjusted for attenuators.
Accuracy	: DC (X1) ñ50 mV ñ 5% of trigger level reading.
Output impedance	: 1 KΩ 1%
Display	: 9 digits seven segments LED 0.56" high. 2 digits for engineering notations. Operator may select through front panel programming the number of digits to be displayed. Selection may range from 9 to 3 most significant digits.
Decimal Point	: Automatically selected.
Gate	: LED indicator lights when gate is open.
Set-ups	: Ten measurement set-ups, including trigger levels, gate/delay time, input conditioning and measurement rate may be stored in memory and subsequently recalled. When AC mains power is removed, a non-volatile memory will preserve the stored set-ups for a typical period of 5 years.
Operating Temperature	: 0 to 40 °C ambient, 0 to 80% relative humidity
Storage temperature	: -25 to 65 °C
Power Requirements	: 115/230V rms ±10% (rear panel switch select) 48-63 Hz, 40 W max

Table 1-1. Model 6020 Specifications (continued)

Warm-up	: 1 hour to rated accuracy and stability
Dimensions	: 87 x 210 x 390 (H x W x D)
Weight	: approx 4 kg
Accessories Furnished	: Power Cord, Operating Manual

OPTIONS

OPTION 1 - TCXO + x10 clock multiplier

Frequency	: 10 MHz
Aging Rate	: <1 X 10E -7 / month
Stability	: <1 X 10E -6, 0 to 40 °C
Line Voltage	: 1 X 10E -7 for 10% change (short term)
Clock IN/OUT	: Selected with an internal switch
External Time Base Input	: Rear Panel BNC accepts 1, 5 or 10 MHz TTL. Selected via an internal switch.

Time Base Out : 10 MHz approx 2 V from a 51 Ω source

OPTION 2 - FREQ C TO 1.3 GHz

Range	: 50 MHz to 1.3 GHz
Sensitivity	: 25 mV rms to 1.0 GHz; 50 mV rms to 1.3 GHz
Input Impedance	: 50 Ω nominal
Dynamic Range	: 25 mV to 1 V rms up to 1.0 GHz; 50 mV to 1 V rms up to 1.3 GHz
Coupling	: AC
Damage Level	: DC to 100 KHz - 15 V (DC + peak AC) 100 KHz to 1.3 GHz - 5 V rms

OPTION 3 - ANALOG OUTPUT

Function	: Digital to analog converter, provides a high resolution analog output of any three conse-cutive digits.
Decade conversion	: Any 3 consecutive digits can be selected via front panel programming.
Normal mode	: Output is directly proportional to display reading. 000 produces 0.00 Vdc. 999 produces 9.99 Vdc.
Offset Mode	: Front panel programmed. Adds an offset to obtain analog recorder scale offset.
Offset range	: 0 to 9.00 Vdc in 1 V increments.
Output	: Through rear panel BNC connector
Full scale deflection	: 9.99 Vdc
Accuracy	: ± 2 mV
Output impedance	: 1 KΩ 1%
Nonlinearity	: ± 2mV
Settling time	: <1 mS after end of measurement.

Table 1-1. Model 6020 Specifications (continued)

DEFINITION OF TERMS

(1) LSD: Unit value of least significant digit. Calculation should be rounded as follows 1 to <5 Hz becomes 1 Hz, 5 nS to <10 nS becomes 10 nS etc.

(2) Trigger Error:

$$\frac{(ei2 + en2)}{\text{Input slew rate at trigger point}} \text{ seconds rms}$$

Where: ei is the rms noise voltage of the counter's input channel (250 μV typ.)
en is the rms noise of the input signal for 225 MHz bandwidth.

(3) Time base error: Maximum fractional frequency change in time base frequency due to all errors: e.g aging, temperature, line voltage etc.

(4) Trigger Level Timing Error (x1):

$$\frac{18\text{ mV}}{\text{Input slew rate at start trigger point}} - \frac{18\text{ mV}}{\text{Input slew rate at stop trigger point}}$$

(5) External arming (trigger) delay: Delay from the positive going slope of the arming signal to the internal gate open signal.

(6) External gate delay: Delay from the positive going slope of the gating signal to the internal gate open signal.

(7) Dead Time: Minimum time between measurement which the counter is busy in performing the measurement. The counter will not at this time respond to any input transition.

SECTION 2

INSTALLATION

2-1. INTRODUCTION

This section contains information and instructions necessary for the installation and shipping of the Model 6020 Counter/timer. Details are provided for initial inspection, power connection, grounding safety requirements, installation information, and repacking instructions for storage or shipment.

2-2. UNPACKING AND INITIAL INSPECTION

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

2-3. PERFORMANCE CHECKS

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

CAUTION

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

2-4. POWER REQUIREMENTS

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

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

CAUTION

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

The instrument should be operated from a power source with its neutral at or near ground (earth potential). The instrument is not intended for operation from two phases of a multiphase ac system or across the legs of a single-phase, three-wire ac power system. Crest factor (ratio of peak voltage to rms) should be typically within the range of 1.3 to 1.6 at 10% of the nominal rms mains voltage.

2-5. GROUNDING REQUIREMENTS

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

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

CAUTION

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

2-6. INSTALLATION AND MOUNTING

The instrument is fully solid state and dissipates only a small amount of power. No special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 50 °C, when the relative humidity exceeds 80% or condensation appears anywhere on the instrument. Avoid operating the instrument close to strong magnetic fields which may be found near high power equipment such as motors, pumps, solenoids, or high power cables. Use care when rack mounting to locate the instrument away from sources of excessive heat or magnetic fields. Always leave 4 cm (1.5zinches) of ventilation space on all sides of the instrument.

2-7. BENCH MOUNTING

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

2-8. RACK MOUNTING

The instrument may be rack mounted in a standard 19 inch EIA rack. The instrument may be rack mounted in Rack Mount Kit option 6020-rack.

2-9. PORTABLE USE

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

2-10. SHORT TERM STORAGE

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

2-11. LONG TERM STORAGE OR REPACKAGING FOR SHIPMENT

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

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

1. If the original wrappings, packing material, and container have been saved, repack the instrument and accessories originally shipped to you. If the original container is not available, one may be purchased through the Tabor Service Department at the factory.

2. Be sure the carton is well sealed with strong tape or metal straps.

3. Mark the carton with the model number and serial number with indelible marking. If it is to be shipped, show sending address and return address on two sides of the box; cover all previous shipping labels.

If the original container is not available, proceed as follows:

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

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

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

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

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

6. Place bagged instrument and accessories into a 250 mm (10 inch) x 360 mm (14 inch) x 508 mm (20 inch) fiber board box (per PPP-B-636 type CF, class WR, variety SW, grade V3C). Fill additional spaces with rubberized hair or cellular plastic cushioning material. Close box in accordance with container specifications. Seal with sturdy water resistant tape or metal straps.

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

NOTE

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

2-12. SAFETY

Be fully acquainted and knowledgeable with all aspects of this instruction manual before using the instrument to assure operator safety and protection against personnel shock hazard.

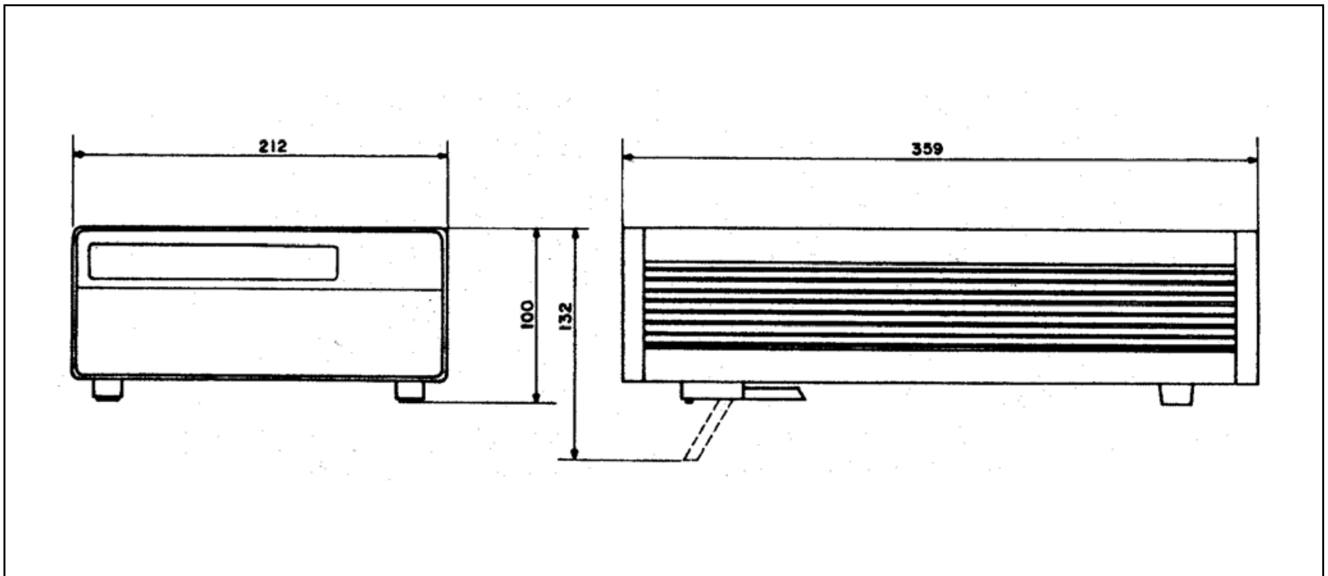


Figure 2-1. Model 6020 outline dimensions.

SECTION 3

BASIC COUNTER/TIMER OPERATION

3-1. INTRODUCTION

Model 6020 operation is divided into two general categories: basic bench operation, and IEEE-488 operation. Basic bench operation, which is covered in this section, consists of using the Model 6020 to perform basic frequency and time measurements. IEEE programming can also be used to greatly enhance the capability of the instrument in applications such as automatic test equipment. These aspects are covered in details in Sections 3 and 4.

3-2. FRONT PANEL FAMILIARIZATION

The front panel layout of the Model 6020 is shown in Figure 3-1. The front panel is generally divided into three sections: controls, connectors, display and indicators. The following paragraphs describe the purpose of each of these items in details.

3-2-1. CONTROLS

All the front panel controls except POWER are momentary contact switches. Many controls include an enunciator light to indicate the selected mode. Controls which do not have an enunciator light, when pressed, will cause an immediate reaction on the display. The controls are divided into functional groups for easier operation. Front panel controls may be divided into functional groups: power, mode, functions, display modifiers and input setting.

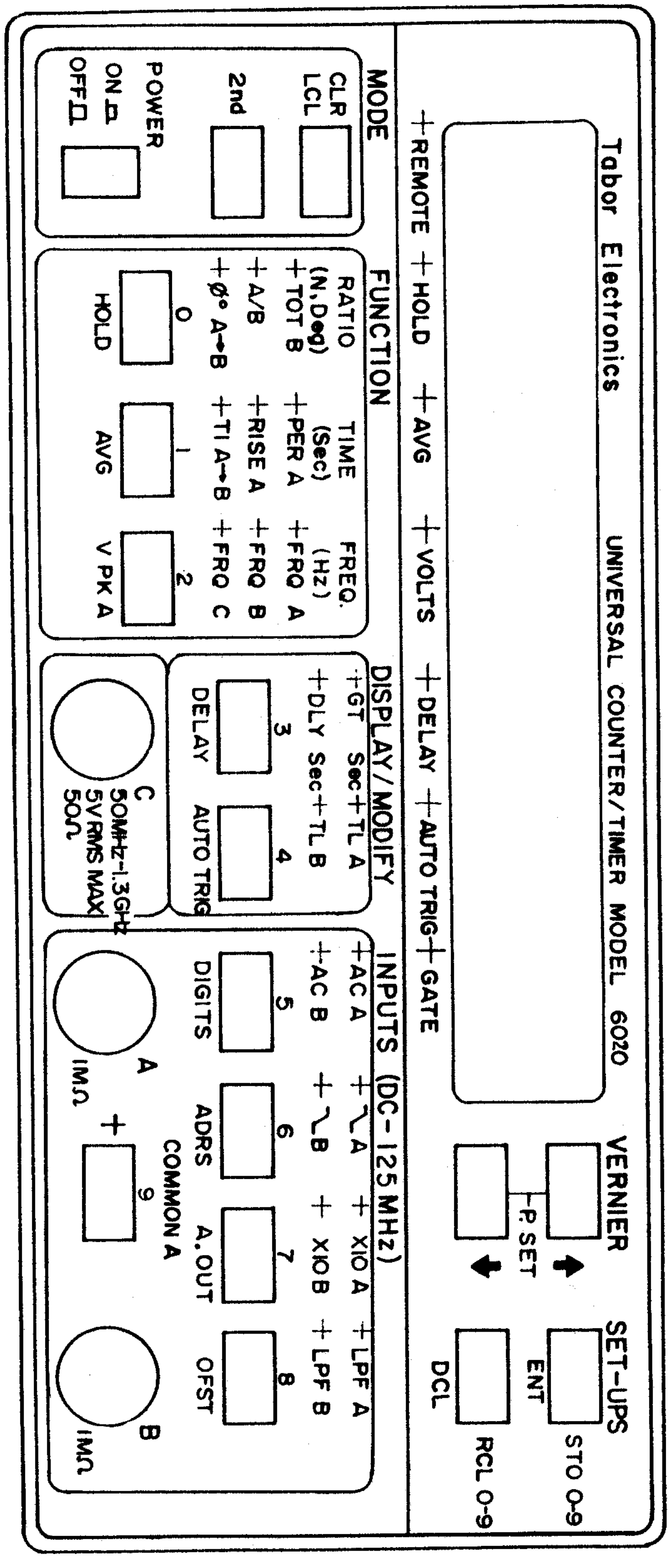
1. POWER - The POWER switch controls the AC power to the instrument. Pressing and releasing the switch once turns the power on. Pressing and releasing the switch a second time turns the power off.
2. MODE - There are two push-buttons in the MODE section: clear/local and 2nd. The 2nd push-button is used to select secondary functions. All functions which are marked on the panel with yellow are associated to the 2nd function. Pressing the 2nd push-button will cause the instrument to display the following reading:

2nd ?

The reading is blinking indicating that the counter is ready for a consequent press of another push-button which has a second function. Pressing the 2nd push-button again will restore normal operation. The clear/local push-button when pressed, and the instrument was in remote operation (but not in remote lockout condition LLO), restores local operation. When the instrument is in local operation, pressing this push-button clears the display and arms the counter for the next measurement cycle.

3. FUNCTION - The three FUNCTION push-buttons control the type of measurement. Each push-button is used to select one of three functions.

Figure 3-1. Front Panel Controls, Indicators and Connectors



FREQ. - The FREQ push-button places the instrument in one of three frequency measurement functions: Frequency A, Frequency B or Frequency C. Consecutive pressing of the FREQ push-button will toggle between frequency A, Frequency B and Frequency C functions.
TIME - The TIME push-button sets the Model 6020 up to measure one of three time measurement functions: Period A, Pulse A or Time Interval A to B. Consecutive pressing of the TIME push-button will toggle between these three functions.
RATIO - The RATIO push-button places the instrument in one of three ratio measurement functions: Totalize B (infinite, by A or by AA), A/B or θ A to B. Consecutive pressing of the FREQ push-button will toggle between Totalize B, A/B and θ A to B functions.

4. DISPLAY/MODIFY - The two DISPLAY/MODIFY push-buttons modify the display from normal frequency, time or ratio reading to another reading such as trigger level, gate time, totalize mode, V peak mode or delay time.

5. INPUTS - There are 5 push-buttons at the INPUTS section which control the signal conditioning for Channels A and B. Push-buttons control attenuation, coupling, slope, input impedance and low pass filter to suppress high frequency noise.

6. VERNIER - The two push-buttons in the VERNIER section are used as a digital potentiometer. The VERNIER operates in conjunction with the following functions: Trigger level, Gate time, Delay time, Digits, Address, Totalize mode, Vpeak mode, Analog out, and Offset. The two push-button also set these parameters to a pre-set position.

7. SET-UPS - There are two push-buttons in the SET-UPS section. One is use to store a complete front panel set-up. The other button is used to recall a stored set-up.

3-2-2 CONNECTORS

The connectors are used to connect the Model 6020 to the signal to be measured.

1. CHANNEL A - The CHANNEL A connector is used when making measurement which are related to channel A.

2. CHANNEL B - The CHANNEL B connector is used when making measurements which are related to channel B.

3. CHANNEL C - The CHANNEL C terminal is used for high frequency measurements, up to 1.3 GHz with a 50 ohm input impedance. Although this terminal is always installed, the internal circuitry to operate this function is optional and may not be installed in this model.

3-2-3. DISPLAY AND INDICATORS

1. DISPLAY - The function of the display is to show the result of the processed measurement. The display consists of a 9 digit mantissa and a single digit exponent. The exponent uses a leading minus to

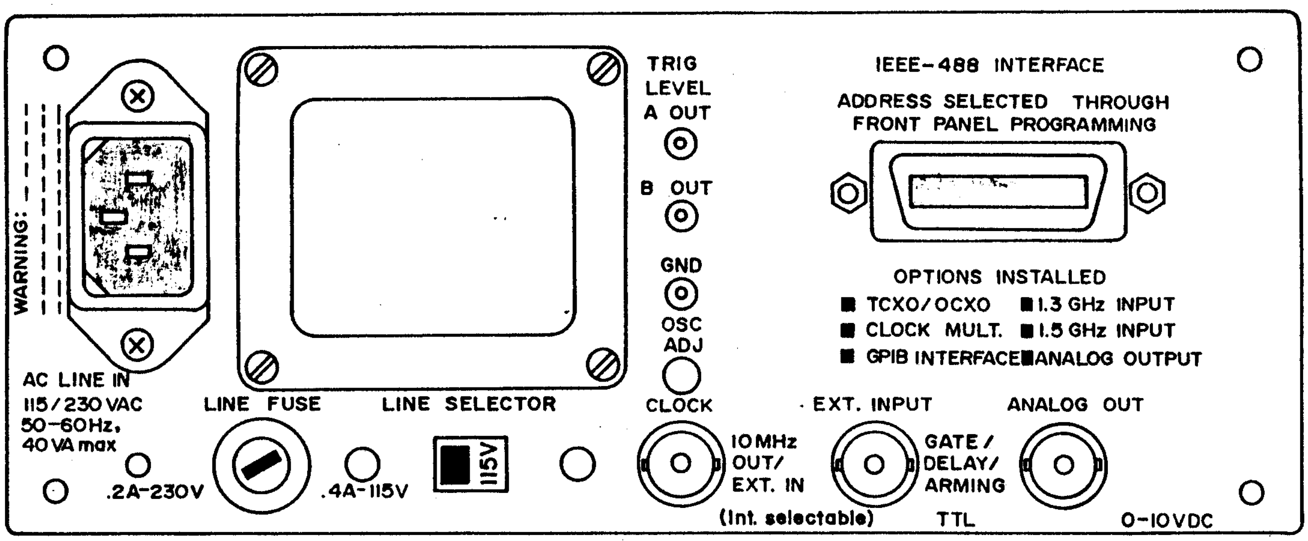
indicate negative values. The sign on the exponent changes to + for zero or positive values. The display is also used to indicate information other than the measurement such as the gate time or the trigger level.

2. INDICATORS - There are 30 indicators located on the front panel. The indicators are used to point at a selected function or signal to the user that the instrument is set to a special function like auto trigger or remote operation.

3-3 REAR PANEL FAMILIARIZATION

Figure 3-2 shows the rear panel layout of the model 6020.

Figure 3-2. Rear Panel Connectors



3-3-1. CONNECTORS AND TERMINALS

1. 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.
2. LINE SWITCH - The LINE VOLTAGE SELECTOR switch selects one of the primary voltage which are marked on both sides of the switch.
3. LINE FUSE - The line fuse provides protection for the AC power line input. For information on replacing this fuse, refer to Section 5.
4. IEEE-488 CONNECTOR - This connector is used to connect the instrument to the IEEE-488 bus.
5. TRIGGER LEVEL OUTPUTS - These three terminals are used for monitoring, by an external DMM or oscilloscope, the DC voltage coming from channels A and B trigger level circuits.
6. CLOCK - 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 reference. The function of this input/output is marked above the connector.
7. EXT. ARMING/GATE/DELAY - 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 then the internal times are required or to take one reading with model 6020 in synchronization with other equipment.
8. ANALOG OUTPUT - A BNC connector which output a voltage which is equivalent to the display readout. This voltage may then be connected to a chart recorder etc.

3-4. POWER-UP PROCEDURE

The basic procedure of powering up the Model 6020 is described below.

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

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.

****
** WARNING **
****

> The instrument is equipped with a 3-wire power cord designed to be used with grounded outlets. When the proper connections are made, the instrument chassis is connected to the power line ground. Failure to use a properly grounded outlet may result in personal shock hazard.

2. Turn on the power by pressing and releasing the POWER switch on the front panel.
3. The instrument will then begin operation by performing a display and indicator test which takes approximately 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.

4. To verify that all display segments are operating, compare the instrument's display with the above during the test.
5. Following the display test, the instrument proceeds by displaying the options installed. When no option is installed, the instrument will display the following message:

6020

If option 1 (TCXO and time base multiplier) is installed, the instrument will display the following message:

6020-1

If option 2 (1.3 GHz input) is installed, the instrument will display the following message:

6020-2

If option 3 (analog output) is installed, the instrument will display the following message:

6020-3

If more than 1 option is installed, the instrument will add on the right the number of the installed option. For example, if options 1 and 3 are installed, the instrument will display the following message:

6020-1.3

6. Once the model number and the installed options are displayed, the instrument will perform ROM and RAM tests. If all these tests are passed, the display will show the software revision level for about 1 second similar to the example below:

SoFt 1.1

7. Following the software revision level, the instrument will display the previously selected IEEE primary address which is set through front panel programming and stored in the non-volatile memory. For example, with the rear panel switch set to address 25, the display will show:

IE Adr 25

8. Following these display messages, the instrument will go into the normal operating mode and begin displaying readings. The instrument will be set to the previously programmed front panel set-up.

3-5. SOFTWARE RESET

One, who is not yet fully familiar with the front panel operation of the Model 6020, may find himself locked in a "dead-end" situation where nothing operates the way it should. The fastest way to restore the counter to a known condition is by resetting the instrument's software. This can be done by pressing the 2nd push-button and then pressing the DCL push-button (second function to the RCL push-button). The instrument will be then be set to it's factory selected default. Table 3-1 summarizes these defaults.

Table 3-1. Default States After Software Reset

FUNCTION	DEFAULT STATE
Function	Frequency A
Display/Modify	Normal reading
Gate / Delay Time	1 Sec
Trigger Levels A and B	0.00 V
Coupling	DC
Slope	Positive going
Attenuators	Off
Filters	Off
Impedance	1 MΩ
Averaging	Off
Auto Trigger	Off
Delay	Off
Sampling Rate	Normal - 3 reading per second
V Peak A Measuring Rate	Fast
Totalize mode	Infinite
Displayed digits	9
Analog output	3 LSD
Analog output offset	0.00 V
IEEE Status	Local

NOTE

Software reset has no effect on any of the front panel set-ups which were previously stored in the memory locations 0 through 9. The software reset also has no effect on the programmed GPIB address.

3-6. DISPLAY MESSAGES

The Model 6020 has several display messages associated with basic front panel operation. The instrument has also a few front panel indications that an operating error associated with front panel programming was detected. These messages are discussed in the following. Note that the instrument has a number of additional display messages associated with IEEE-488 programming.

3-6-1. NO BATTERY ERROR MESSAGE

The non-volatile memory stores complete 10 front panel set-ups. The same non-volatile memory, in case of power failure or upon regular power-up procedure, is responsible for reconstructing the last front panel set-up. The non-volatile memory is backed-up by a built-in battery which should last approximately 3 years. Losing the back-up power will cause a loss of the preselected set-ups. When back-up power is lost the instrument will display the following message:

no bAtt.

This message will be displayed for about 2 seconds in conjunction with the alarm signal, indicating that the back-up power test on the non-volatile memory has failed and that the previously elected set-ups are lost.

3-6-2. IEEE-488 ERROR MESSAGES

The counter incorporates a number of display messages which are associated with errors through the GPIB interface programming. These messages are discussed in detail in Section 4 of this manual. However, there is one message which should be explained at this point because it may interfere with front panel operation. A remote enable or a device dependent command sent to the counter through the bus will turn on the REMOTE light and enable remote operation. In this case, all front panel push-buttons except LCL are disabled. An attempt to press one of these push-buttons will cause the following message to be displayed:

PrESS LcL

This message indicates that the instrument will ignore any front panel programming sequence unless the LCL push-button is pressed and the REMOTE light turns off.

3-6-3. ERROR INDICATION

There are several error indications that are caused by either an incorrect front panel programming or insufficient input level conditioning which is otherwise required by the instrument for normal signal processing. These indications are either visible (blinking LED) or audible (beeper) and are described in the following.

1. AUDIBLE ALARM - The AUDIBLE ALARM will sound when attempting an incorrect sequence of front panel programming. This could occur under the following conditions:

1. Any two front panel push-buttons are pressed simultaneously except the two VERNIER push-buttons.
2. The instrument is in FREQ or RATIO or TIME AVG function and the operator attempts to turn the delay on.
3. The instrument is in FREQ or RATIO function and the operator attempts to turn the AVG function on.
4. Option 3 (analog output) is not installed and the operator attempts to access parameters which are associated with the analog output function.
5. The instrument is in remote condition (REOMTE LED on) and any

front panel push-button except LCL is pressed.

6. The VERNIER push-buttons were pressed and the instrument was not in DISPLAY/MODIFY mode of operation.
7. The instrument was in DISPLAY/MODIFY mode of operation and the VERNIER UP or DOWN push-buttons were pressed continuously until a parameter limit was reached. Parameter limits are summarized in Table 3-2.

Table 3-2. Front Panel Programming Limits

FRONT PANEL NOMENCLATURE	PARAMETER	LOW LIMIT	HIGH LIMIT
TL A	Trigger Level A	- 5.00	+ 5.00
TL B	Trigger Level B	- 5.00	+ 5.00
GT	Gate Time	100 μS	USER GATE
DLY	Delay Time	100 μS	USER DELAY
DIGITS	No of displayed digits	3	9
ADRS	GPIB address	0	30
A.OUT	Analog Out resolution	LSD	MSD
OFST	Analog Out Offset	100	900

2. GATE ERROR - The gate error is indicated on the front panel by the GATE LED. This error will occur when the counter is in FREQ or TIME AVG function and when the signal was removed from the input connector in the middle of the measurement process or when a radiated random noise was sensed by the input circuitry. The GATE LED will then blink once but no result will be registered on the display.

3. GATE TIME ERROR - The gate time error is indicated on the front panel by the GT LED. The gate time error will occur in FREQ or TIME AVG functions when the period of the input signal is larger than the period of the gate time. The gate error will also occur in θ A to B function when the gate time is not sufficient to permit the minimum resolution of 1ø. When one of the conditions above occurs, the gate time LED (GT) will blink for a couple of times and then resume a search routine. This sequence will repeat itself until a proper signal is found or until the gate time was readjusted to satisfy the required conditions.

4. TRIGGER LEVEL ERROR - The trigger level error will occur when the instrument is set to AUTO TRIG or V PEAK A modes and the input signal is either absent or below the specified auto trigger limits. The trigger level LED (either TL A or TL B) will then blink, for a couple of times, and then resume a search routine. This sequence will repeat itself until a signal has been found or until the auto trigger mode was turned off.

3-7. CONTROL SELECTION

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

3-8. SELECTING A FUNCTION

The Model 6020 must be set up for the proper measuring function with one of the three Function push-buttons. There are 16 different available functions in the FUNCTION block summarized in the following. To simplify the operating instruction for these functions, the functions are divided in the following table into three operational groups.

FUNCTIONS SUMMARY

1. FREQUENCY A	10. PERIOD AVG A	13. TOTALIZE B BY A
2. FREQUENCY B	11. PULSE AVG A	14. TOTALIZE B BY AA
3. FREQUENCY C	12. TIME INTERVAL AVG A TO B	15. V PEAK A FAST
4. PERIOD A		16. V PEAK A SLOW
5. PULSE A		
6. TIME INTERVAL A TO B		
7. TOTALIZE B (infinitely)		
8. RATIO A/B		
9. PHASE A TO B		

The letter after the function indicates the input connector where this measurement may be performed. For example, FREQUENCY C can only be measured if the signal is applied to Channel C input connector or V PEAK A can only be measured at the Channel A input connector. Some functions require that both Channel A and B be connected for a success-sful measurement - functions like Time Interval A to B or Totalize B by A.

Selecting a function from the first group is described in the following:

1. First bring the Model 6020 to a known state as described in paragraph 3-5. This is done by pressing first the 2nd push-button and then pressing the DCL push-button. The instrument will then default to a factory pre-selected state and the light next FRQ A will illuminate; indicating that Frequency A function is now selected.
2. To select Frequency B press the FREQ push-button once. The light next to FRQ B illuminates; indicating that Frequency B is now selected.
3. To select Frequency C press the FREQ push-button again. The light next to FRQ C illuminates; indicating that Frequency C is now selected. Note that this procedure assumes that option 2 (1.3 GHz Channel C is installed)
4. To select Period A press the TIME push-button once. The light next to PER A illuminates; indicating that Period A is now selected.
5. To select Pulse A press the TIME push-button again. The light next to PLS A illuminates; indicating that Period A is now selected.
6. To select Time Interval A to B press the TIME push-button again. The light next to TI A to B illuminates; indicating that Time Interval A to B is now selected.
7. To select Totalize B press the RATIO push-button once. The light next to TOT B illuminates; indicating that Totalize B is now selected.
8. To select Ratio A/B press the RATIO push-button again. The

light next to A/B illuminates; indicating that Ratio A/B is now selected.

9. To select θ A to B press the RATIO push-button again. The light next to θ A to B illuminates; indicating that θ A to B is now selected.

Selecting a function from the second group is described in the following:

10. To select Period Averaged A press the TIME push-button until the light next to PER A illuminates. Press the 2nd push-button and then press the AVG. push-button (second function to the TIME button). Observe that the AVG light illuminates; indicating that the Period Averaged A function is now selected.

11. To select Pulse Averaged A press the TIME push-button until the light next to PLS A illuminates. Press the 2nd push-button and then press the AVG. push-button (second function to the TIME button). Observe that the AVG light illuminates; indicating that the Pulse Averaged A function is now selected.

12. To select Time Interval Averaged A to B press the TIME push-button until the light next to TI A to B illuminates. Press the 2nd push-button and then press the AVG. push-button (second function to the TIME button). Observe that the AVG light illuminates; indicating that the Time Interval Averaged A to B function is now selected.

NOTE

> The averaging function, once it is selected, will automatically turn on whenever a TIME measuring function is selected. For example, Selecting PER A averaged turns the AVG light on . Changing the selected function to FRQ A will turn the AVG light off. Re-selecting one of the TIME functions will automatically turn the AVG light on.

Selecting a function from the third group requires additional operations and is described in the following:

13. To select Totalize B by A function press the RATIO push-button until the light next to TOT B illuminates. The counter is now set to totalize indefinitely. To select the Totalize B by A function press the GT push-button in the DISPLAY/MODIFY group and observe that the reading on the display is as follows:

tot InF

This reading indicates that the instrument is set to Totalize infinitely. Now press the VERNIER push-button once and observe that the display reading is changed to the following:

tot bY A

This reading indicates that the instrument is now set to Totalize at B with A serving as the gating signal. Press the GT push-button

again. The instrument is now ready to perform the required function.
14. To select Totalize B by AA function repeat the procedure as described above. Pressing the VERNIER UP push-button will change the display reading as follows:

tot bY AA

This reading indicates that the instrument is now set to Totalize at A with a pair of transitions at A, having the same direction, serving as the gating signal. Press the GT push-button again. The instrument is now ready to perform the required function.
15. The V Peak A function has two measurement rates: Fast - for frequencies above 100 Hz and Slow - for the range of 40 Hz to 10MHz. Note that the instrument, after DCL defaults to Fast rate. Selecting the measurement rate is described later in this manual.

3-9. SELECTING GATE AND DELAY TIME

The Model 6020 may be operated in the preset gate time or delay time of one second or one of 50 increments which are factory selected. When selecting the gate time, the instrument will move up or down one gate time each time the UP or DOWN push-button is pressed. The present gate time may be noted on the display by pressing the GT / DLY push-button.

The gate times may only be selected in conjunction with frequency, time averaged, ratio A/B and í A to B measurements.

The gate time may be selected as follows:

1. Select a frequency measurement function.
2. Press the GT / DLY push-button. The GT light will turn on and the instrument will display the following message:

1

This reading indicates the selected gate time in seconds.

3. To change the gate time press the VERNIER UP or DOWN push-buttons. Pressing the UP push-button will increase the gate time. Conversely, pressing the DOWN push-button will decrease the gate time. Holding in the Up or Down push-buttons for more than 1 second, causes the instrument to increment or decrement continuously.
4. Pressing the UP push-button when the instrument was at a gate time of 10 seconds will force the instrument into a USER GATE mode. This mode requires an external gating signal. Operating the counter with an external gate is explained later in this section.
5. Pressing the UP and DOWN simultaneously will change the gate time to a preset value of 1 Sec.
6. To resume normal display operation, press the GT /DLY push-button. The GT light will turn off and the instrument will be ready to perform measurements with the newly selected gate time. Table 3-1 lists the GATE/DELAY Times which are available.

Table 3-3. GATE/DELAY DETERMINATION

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

NOTE

To prevent operator error, there is an internal audible alarm that sounds whenever a limit is reached. (e.g low limit of 100 µSec).

The delay time may only be selected in conjunction with non averaged time measurement.

To select the delay time proceed as follows:

1. Select a non-averaging time measurement function.
2. Press the GT / DLY push-button. The DLY light will turn on and the instrument will display the following message:

1

This reading indicates the selected delay time in seconds.

3. To change the delay time press the VERNIER UP or DOWN push-buttons. Pressing the UP push-button will increase the delay time. Conversely, pressing the DOWN push-button will decrease the delay time. Holding in the Up or Down push-buttons for more than 1 second, causes the instrument to increment or decrement continuously.
4. Pressing the UP push-button when the instrument was at a delay time of 10 seconds will force the instrument into a USER DELAY mode. This mode requires an external delay signal. Operating the counter with an external delay is explained later in this section.
5. Pressing the UP and DOWN simultaneously will change the delay time to a preset value of 1 Sec.
6. To resume normal display operation, press the GT /DLY push-button. The DLY light will turn off and the instrument will be ready to perform measurements with the newly selected delay time. Table 3-1 lists the GATE/DELAY Times which are available.

3-10. SETTING TRIGGER LEVELS

There are two trigger level push-buttons associated with each Channel A (TL A) and Channel B (TL B). The VERNIER push-buttons, when operated in conjunction with TL A or TL B, 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. Access to TL A is possible only in conjunction with functions that relate to Channel A. Selecting a function which relates to Channel B will enable an access to TL B.

1. Using the procedure which is described above, set the instrument to Frequency A function. If other front panel lights illuminate, reset the counter using the software reset procedure which is described in paragraph 3-5.
2. Press the TL A push-button. The TL A and VOLTS indicators will turn on and the display will read as follows:

0.00

This reading indicates the selected trigger level in units of volts.

3. To set a positive trigger level press the VERNIER UP push-button. Holding in the UP or DOWN push-buttons for more than 1 second, will cause the instrument to increment or decrement continuously. To set a negative trigger level press the VERNIER DOWN push-button until the desired level has been reached.

NOTE

Pressing the VERNIER UP or DOWN push-buttons, when the limits of + 5.00 or - 5.00 respectively have been reached, will sound an audible alarm.

4. Simultaneously press the two VERNIER push-buttons and note that the display reading resets to 0.
5. Press the TL A push-button. The indicator light will turn off and the instrument will return to the previous measurement state.
6. To set the trigger level for both Channels A and B, select a function which involves both inputs (e.g ratio A/B, θ A to B, time interval A to B or totalize B by A). Pressing the TL push-button once will turn the TL A light on; indicating that the instrument displays the trigger level for Channel A. A second consecutive press will turn the TL B light on; indicating that the instrument displays the trigger level for Channel B. A third push will turn TL B light off. The instrument will then resume normal operation.

3-11. SETTING INPUT CONDITION CONTROLS

A proper set-up of the input controls will ensure proper operation of the instrument. There are five push-buttons which control the input. These push-buttons are common to both Channels A and B.

Changing one of the input setting controls is simply a matter of pressing the required push-button. There are 5 lights for each input channel which are associated with each of the five controls.

To set input condition controls for Channel A proceed as follows:

1. Set the instrument to operate at one of the following functions: FRQ A, PER A, PLS A or V Peak A.
2. To select the required coupling mode press the AC push-button. Coupling is DC when light is off. When the light is on the coupling to the instrument is AC.
3. To change the slope that the instrument will trigger on, press the SLOPE push-button. If the light is off the counter will trigger on the positive edge of the input signal. If the light is on the counter will trigger on the negative going edge.
4. When the signal exceeds the specified dynamic range of the input, attenuation is required. To attenuate the signal press the x10 push-button. The input signal will be attenuated by a factor of 10 when light is on. When light is off, the input signal will not be attenuated.
5. 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 low pass filter press LPF push-button. Filter is on when light is on. The filter is not activated when the light is off.
6. In high frequency - fast rise time measurements where the signal is sensitive to standing wave reflections, the use of 50 Ω termination is recommended. To change the input impedance from 1 MΩ to 50 Ω press the 50 Ω push-button. Termination is 50 Ω when the light is on. If the light is off the input impedance is 1 MΩ.

To set input condition controls for Channel B proceed as follows:

1. Set the instrument to operate in one of the following functions: FRQ B or TOT B.
2. use the same procedure as described above for Channel A.

To set input condition controls for both Channels A and B proceed as follows:

1. Set the instrument to operate in one of the following functions: Time Interval A to B, Ratio A/B, í A to B, TOT B by A or TOT B by AA.
2. To select the AC coupling mode for Channel A, press the AC push-button once. The AC A light will illuminate; indicating that Channel A is now ac coupled. Pressing the AC push-button again will turn the AC A light off but AC B light turns on; indicating that Channel A is dc coupled and Channel B is ac coupled. Pressing the button once more, turns both AC A and AC B light on; indicating that both channels are now ac coupled. Pressing the same push-button again will turn both light off. This now indicates that both channels are set to dc coupling mode.
3. use the same procedure to set the slopes, attenuation, impedance and filtering.

3-12. SELECTING THE NUMBER OF DISPLAYED DIGITS

A major advantage of Model 6020 is the capability to display a fixed number of digits regardless of the frequency of the signal. For example, with a one S gate time, the Model 6020 is capable of displaying a minimum of 8 digits. This however, may turn 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 6020 is designed in such a way that it truncates the unstable least significant digits, while still preserving the full performance of the Model 6020. To select the number of displayed digits proceed as follows:

1. Press the 2nd push-button. The instrument will prompt the following message:

2nd ?

2. Press the DIGITS push-button (second function to AC A). The instrument will now display the following:

x diGit

Where x is the selected number of digits and could range from 3 to 9 digits.

3. Use the VERNIER UP to increase the number of the displayed digits. Conversely, pressing the VERNIER DOWN decreases this number.
4. Pressing the VERNIER UP and DOWN simultaneously, presets x to 9.
5. To return to normal operation of the Model 6020 simply press and release the ENT push-button (second function to STO). The instrument will than display the processed measurement with the programmed 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 9 digits:

1.23456789

Display reading with selected 5 digits:

1.2345

NOTE

Under certain circumstances, it is possible that the Model 6020 will display less than nine digits. This may occur when the selected gate time is very small. In that 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, Model 6020 will again limit the number of displayed digits to the selected value.

3-13 SELECTING MEASUREMENT RATE

There are three measurement rates which are available on the Model 6020. Only two measurement rates are accessible through the front panel: Normal rate of about 3 readings per second and single cycle (hold). The third measurement rate is accessible only via the rear panel IEEE-488 bus and will be discussed in further details in Section 4. Refer to the front panel HOLD indicator: The HOLD light determines the rate of measurement. When the indicator is off, the instrument is in normal measurement rate.

To select the measurement rate proceed as follows:

1. Press the 2nd push-button and then press the HOLD push-button (second function to RATIO). The HOLD light will turn on; indicating that the instrument is now armed for a single-shot measurement cycle. Arming is explained in the following.
2. To return to normal measurement rate, press the 2nd push-button and then the HOLD push-button. The HOLD light will turn off; indicating that the instrument is now set to accept and process readings at a normal rate.

NOTE

> The measurement rate is gate time dependent. The Model 6020 can process 3 readings in one second when the gate time is set to below 100 mS.

3-14 ARMING

Arming allows a measurement to be triggered by and external arming signal or by the input signal. The Model 6020 may be armed to take readings in four ways:

1. Continuously armed by the input signal in the normal mode.
2. With the front panel CLR push-button when the instrument is in HOLD mode.
3. Through an arming pulse applied to the rear panel EXT. INPUT connector when the instrument is in the HOLD mode.
4. With commands given over the IEEE-488 bus as described in Section 4. This section covers front panel and external arming in detail.

3-14-1 Continuous Arming With the Input Signal

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. There is no special procedure to set the Model 6020 up for continuous arming. The continuous arming mode is especially useful in analyzing the content of a burst.

3-14-2 Front Panel Arming.

Front panel arming is done with the CLR push-button. To use front panel arming perform the following steps:

1. Enter the hold mode using the procedure described in paragraph 3-13. The HOLD light will turn on and the gate light will cease flashing; indicating that the instrument is in one-shot arming mode. The display will zero and no reading is processed until an arming stimulus is applied.
2. To trigger a single reading, press and release the CLR push-button. The instrument will be ready to take and process the next reading.
3. To arm the instrument for a new measurement, press the CLR push-button. The display will zero and a new measurement will be processed.
4. To remove the instrument from the one-shot arming mode, turn the hold function off by pressing in sequence 2nd and HOLD push-buttons.

3-14-3 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. INPUT connector. The input arming pulse must conform to TTL levels. To use external arming, proceed as follows:

1. Place the instrument in the hold mode using the procedure described in paragraph 3-13. Note that the GATE light will cease flashing; indicating that the instrument is in one-shot arming 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. INPUT connector. The first positive going transition at the EXT INPUT connector will arm the Model 6020 for taking and processing 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. The Model 6020 will ignore any transitions at this input when the gate is open.
3. To remove the instrument from the one-shot arming mode, turn the hold function off using the procedure described above.

3-15. USING AUTO TRIGGER LEVEL

The auto trigger function is useful when measuring repetitive signals having an unknown dc component. The auto trigger is capable of finding the peaks of the signal and then setting the trigger level exactly at their center. In addition, The auto trigger automatically sets the correct attenuation to adjust the input signal to the operating dynamic range. The auto trigger mode will not operate on totalize B and frequency C functions.

trigger level function works in conjunction with Channels A and B.

To set the Model 6020 to operate in auto trigger mode proceed as follow:

1. Press the 2nd push-button and then press the AUTO TRIG push-button. The AUTO TRIG light will illuminate; indicating that the auto trigger function is selected. When the indicator is off, the instrument is in normal manual trigger level mode.
2. Apply the signal to be measured to the appropriate input connector. After a short search sequence, the gate will open and the measurement will be processed.
3. TL A or TL B will blink if an error was detected. Refer to paragraph 3-6-3 for a additional error indications information.
4. To return the Model 6020 to normal trigger level mode, press the 2nd push-button and then press the AUTO TRIG button.

3-16. USING V PEAK A

Using the V PEAK function turns the Model 6020 into a versatile RF peak voltage meter where both low and high peaks are detected, processed and displayed. This is especially useful in analyzing the amplitude of the signal and the magnitude of the dc component. Their are two available measurement rates for the V Peak function: Fast for normal measurements above 100 Hz and slow rate for measurements of signals below 100 Hz. To select the V Peak function proceed as follows:

1. Press the 2nd push-button and then the V PK A push-button (second function to FREQ push-button). Observe that the VOLTS light illuminates. This indicates that the instrument is now set to V Peak A measurements. The normal display reading will transform into a two section display like the following:

0.00 0.00

The three digits on the left indicate the low peak. The right three digits indicate the high peak. Negative values have a leading minus sign where positive values have no sign. The minus sign and the decimal points are automatically set by the instrument.

2. To select the measurement rate press the GT push-button in the DISPLAY/MODIFY group and observe that the reading on the display is as follows:

FASt

This reading indicates that the instrument is set to the fast measuring rate. Now press the VERNIER UP push-button once and observe that the display reading is changed to the following:

SLO

This reading indicates that the instrument is set to V Peak A with a slow measuring rate. Press the GT push-button again. The instrument is now ready to perform the required function.

3. Press the GT push-button to return the counter to normal V Peak display.
4. Press one of the FUNCTION push-buttons to select another function. The display will return to normal display reading and the

VOLTS light will turn off.

3-17. USING USER GATE

The user gate is useful when a gate time other than the predetermined gate times listed in Table 3-3 is required. The limits which must be observed are the minimum limit of 100 µS and the maximum limit of 1000 S. The user gate function is accessible in FRQ A, B and C, A/B, PER AVG, PLS AVG and TI AVG A to B operating modes. To operate the instrument in the user gate mode proceed as follows:

1. Set the instrument to PRQ A. Press the GT push-button and observe that the GT light turns on and the instrument displays the gate time.
2. Press and hold the VERNIER UP push-button and observe that the display increments. After the 10 Sec gate time the instrument will enter the user gate mode and the instrument will display the following readout:

USEr GAtE

Pressing the UP push-button after the user gate is displayed will sound an audible alarm.
3. Press the GT push-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 INPUT connector. The high level duration of the TTL pulse determines the length of the gate time.
5. To exit the user gate function press the VERNIER DOWN push-button. Pressing both the UP and DOWN push-buttons will preset the gate time to 1 S.

3-18. USING DELAY

The Model 6020 has a delay function which disables the closure of the opened gate for the predetermined periods listed in Table 3-3. 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. The delay function is accessible in PER A, PLS A, and Time Interval A to B. The delay time may be selected as follows:

1. Set the instrument to PER A. Press the DLY push-button in the DISPLAY/MODIFY group and observe that the DLY light turns on and the instrument displays the delay time.
2. To change the delay time, press the VERNIER UP or DOWN push-buttons. When one of the UP or DOWN push-buttons are pressed for more than one second, the instrument will increment or decrement continuously.

3. Pressing the VERNIER UP and DOWN simultaneously will change the delay time to a preset value of 1 S.
4. To resume normal display, press the DLY push-button. The DLY light will turn off. When enabled, the instrument will perform measurements with the newly selected delay time. Table 3-3 lists the delay times which are available as preselected values.
5. To enable the delay mode, press the 2nd push-button and then the DELAY push-button (second function to GT/DLY push-button). Observe that the DELAY light illuminates. This indicates that the instrument is now set to operate in the delay mode. A selection of any other function, when DELAY light is on, will automatically turn off the delay light. Conversely, returning to one of these functions will again enable the delay mode.
6. To return to normal operation press 2nd push-button and then the GT/DLY push-button. The DELAY light will turn off; indicating that the instrument is no longer in delay mode.

NOTE

> To prevent operator's error, there is an internal audible alarm that beeps whenever a limit is reached. (e.g 100 μS low limit). Refer to Table 3-3.

3-19. USING USER DELAY

The user delay is useful when a delay time other than the predetermined delay times which are listed in Table 2-1 is required. The limits which must be observed are the minimum limit of 100 æS and the maximum limit of 10,000Sec. The user delay function is accessible in PER A, PLS A, and Time Interval A to B operating modes. To operate the instrument in the user delay mode proceed as follows:

1. Set the instrument to PER A. Press the DLY push-button and observe that the DLY light turns on and the instrument displays the delay time.
2. Press and hold the VERNIER UP push-button and observe that the display increments. After the 10 S delay time the instrument will enter the user gate mode and the instrument will display the following readout:

USEr dLAY

Pressing the UP push-button after the user gate is displayed will sound an audible alarm.

3. To resume normal display, press the DLY push-button. The DLY light will turn off. When enabled, the instrument will perform measurements with the user delay time.
4. To enable the user delay mode, press the 2nd push-button and then the DELAY push-button (second function to GT/DLY push-button). Observe that the DELAY light illuminates. This indicates that the instrument is now set to operate in the user delay mode. A selection of any other function, when DELAY light is on, will automatically turn off the delay light. Conversely, returning to one of these functions will again enable the user delay mode.

5. Apply a TTL high pulse to the rear panel EXT INPUT connector. Delay would then be enabled as long as this input is kept at 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 TTL low level.

3-20. USING FRONT PANEL SET-UPS

Setting up all parameters in a versatile instrument such as the Model 6020 takes some time. The set-up time is longer when more than one set-up is required. The Model 6200 incorporates a battery backed-up non-volatile memory that preserves stored information indefinitely. It is possible to store complete front panel set-ups in 10 different memory locations which are built into the instrument especially for this purpose.

3-20-1. STORE SET-UPS

First modify the front panel parameters as necessary to perform your tasks. When all parameters are set and checked, proceed to store this set-up as follows:

1. Depress the STO pushbutton and observe that the display is modified to indicate the following:

StorE ? (? appears flashing)

This reading indicates that the instrument is ready to receive one the memory location where front panel set-up is to be stored. Set-ups may be stored in locations 0 to 9. Depressing STO again cancels this function and the instrument resumes normal operation.

2. Select one memory location from 0 to 9 and depress the button which is marked with the selected number. The instrument will display the following for one second:

StorE D (Where D is the selected memory location)

This display indicates that the function generator acknowledges the entered memory location. The instrument will then resume normal operation.

3-20-2. RECALL SET-UPS

Turning AC Mains power off will not affect the stored data in the RAM which preserves the front panel set-up previously recorded by the user. To recall a front panel set-up proceed as follows:

1. Depress the RCL pushbutton and observe that the display is modified to indicate the following:

rEcALL ? (? appears flashing)

This reading indicates that the instrument is ready to recall the

memory location where front panel set-up was stored. Depressing the RCL button cancels this function and the instrument resumes normal operation.
2. Select one memory location from 0 to 9 so as to recall the desired set-up, and depress the button which is marked with the selected number. The instrument will display the following for one second:

rEcALL D (Where D is the selected memory location)

The instrument will then recall the parameters that were previously stored in the selected memory location and will update front panel indicators with the recalled parameters.

3-21. ANALOG OUTPUT

The analog output option provides an high accuracy source to drive a chart recorder. This option is especially useful in measuring and recording long term stability of oscillators, V to F convertors temperature drifts, etc. Front panel programming allows a selection of any three adjacent digits which would then be monitored by the instrument and supplied to the analog output as a dc voltage. Full scale output is +9.99 V. A 000 display reading is equivalent to 0.00 V at the output connector where a reading of 999 is equivalent to 9.99 V.

3-21-1. SETTING THE ANALOG OUTPUT RESOLUTION

First set up the instrument to the required function, gate time and input conditioning as described in paragraph 3-7. Make sure that the required resolution is displayed. As an example, let us assume that the display reading is as follows:

1.23<u>456</u>789 E+3

Let us also assume that we want to monitor the 3rd, 4th and 5th digits from the right, as underlined above. To program the Model 6020 to convert just these three digits to an equivalent dc voltage proceed

as follows:

1. Press the 2nd push-button and then the A.OUT push-button (second function to SLOPE). The display reading will change to display a group of three bars as follows:

_ _ _ _ _ _ 789 E+3

The least significant digits 6,7 and 8 are shown as whole digits These digits will be converted for the analog output. All other digits are replaced by vertical bars.
2. Press the VERNIER UP or DOWN push-buttons to move the digits from left to right and vise versa until the display indicates the following:

_ _ _ 456_ _ _ E+3

3. Press the ENT push-button to program the instrument for the selected resolution.
4. Connect a cable, from the rear panel analog output connector, to the chart recorder. The analog output will be updated about 100 mS following a completion of a measurement cycle. Output will then follow the readings on the display.

3-21-2. SETTING THE ANALOG OUTPUT OFFSET

Front panel programming allows to offset the analog output voltage so that the needle on the chart recorder would rest anywhere between the bottom to the top of the scale. To set the analog output offset proceed as follows:

1. Press 2nd push-button and then press OFST push-button (second function to LF). The VOLTS indicator will turn on and the display reading will be as follows:

xxx (xxx could range from 100 to 900)

This reading indicates the offset voltage that would be applied to the analog output reading. 100 indicates 1 V, 900 indicates 9 V.
2. Press the VERNIER UP or DOWN push-buttons to change the offset reading.
3. Press both VERNIER UP and DOWN push-buttons to reset the offset reading to 0 V.
4. Press the ENT push-button (second function to STO) to program the instrument to the new offset value. The counter will then return to normal display reading.

3-22. USING THE EXTERNAL REFERENCE

The Model 6020 provides, as standard, two accuracy grades for the internal time base: stabilized clock and an optional temperature compensated crystal oscillator (TCXO). The best accuracy, over the specified temperature operating range, that may be achieved with the TCXO is 1 PPM - accuracy which will satisfy most of the requirements. With special applications, where such an inaccuracy may be a limiting factor, an external reference may provide a better solution. An EXT REF connector is provided on the rear panel however, before applying the reference signal, it is first necessary to open the top cover and change a switch setting. The procedure of changing this switch is given in Section 5 of this manual.

3-23.CHANGING THE GPIB ADDRESS

GPIB address is modified using front panel programming. The non-volatile memory stores the GPIB address and conventional address switches are not provided. Detailed instructions to change the GPIB address are given in Section 4.

SECTION 4

IEEE-488 OPERATION

4-1. INTRODUCTION

The IEEE-488 bus is an instrumentation data bus with standards adopted by the IEEE (Institute of Electrical and Electronic Engineerings) in 1975 and given the IEEE-488 designation. The most recent revision of bus standards was made in 1978; hence the complete descryption for current bus standards is the IEEE-488-1978 designation. The Model 6020 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 4-2 through 4-5.

2. Information necessary to connect the Model 6020 to the bus and to change the bus address is contained in paragraphs 4-6 and 4-7.

3. Programming of the instrument with general bus command is covered in paragraph 4-8.

4. Device-dependent command programming is described in detail in paragraph 4-9. 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 4-11-1 and 4-11-2.

4-2. BUS DESCRIPTION

The IEEE-488 bus was designed as a parallel data transfer medium to optimize data transfer without using as excessive number of bus lines. In keeping with this goal, the bus has only eight data lines which 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 remote controlled operation is shown in Figure 4-1. The typical system will have one controller and one or more instruments to which commands are given and from which data is received. There are three categories that describe device operation. These include: controller; talker; listener.

The controller controls other devices on the bus. A talker sends data, while a listener receives data. an instrument, 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). Any number of talkers or listeners may be present up to the hardware constraints of the bus. The bus is limited to 15 devices, but this number may be reduced if higher than normal data transfer rates are required or if long interconnect 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 much like an individual is trying to select a single conversation out of a large crowd.

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 may be initiated. 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 is then be used to channel the information to the desired location.

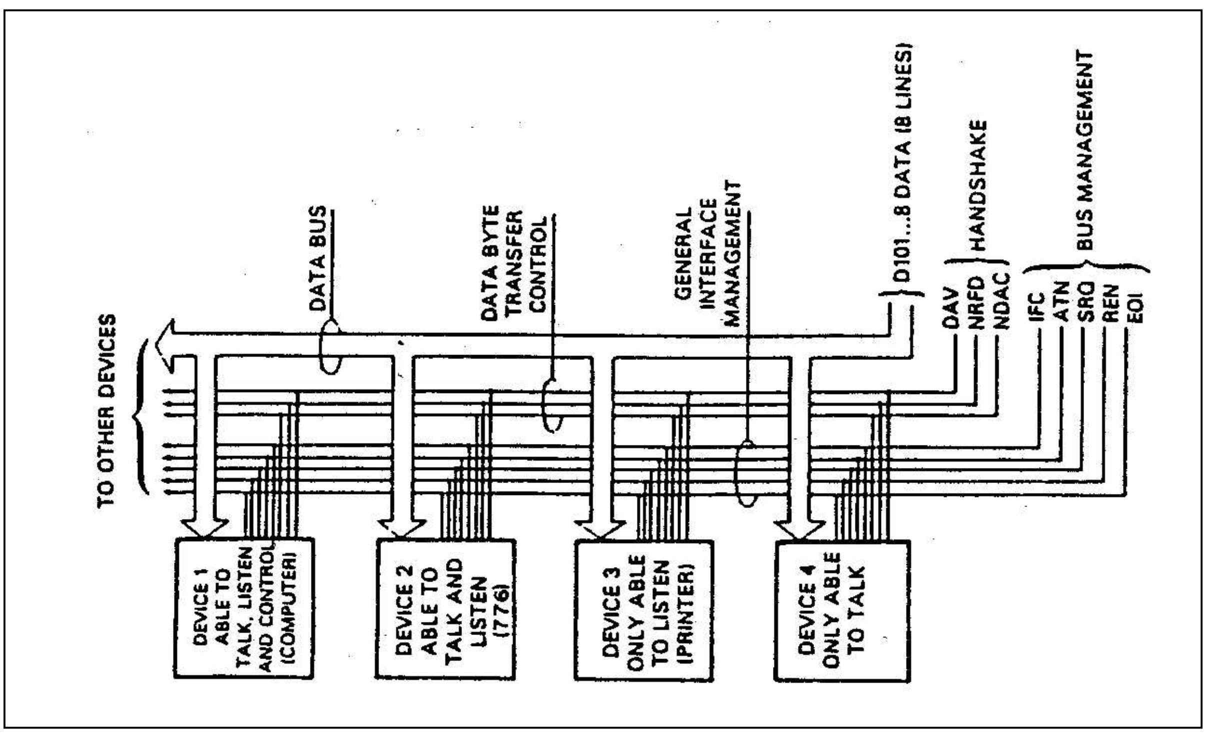


Figure 4-1. IEEE Bus Configuration

4-3. 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 assure 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 4-1.

4-3-1. BUS MANAGEMENT LINES

The bus management group is made up of five signal lines that provide orderly transfer of data. These lines are used to send the uniline commands described in paragraph 4-8-1.

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 4-8-2.
2. IFC (Interface Clear) - Setting the IFC line true (low) causes the bus to go to a known state.
3. REN (Remote Enable) - Setting the REM line low sends the REM command. This sets up instruments on the bus for remote operation.
4. EOI (End Or Identify) - The EOI line is used to send the EOI command that usually terminates a multi-byte transfer sequence.
5. SRQ (Service Request) - the SRQ line is set low by a device when it requires service from the controller.

4-3-2. Handshake Lines

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

1. DAV (Data Valid) - The source controls the state of the DAV line.
2. NRFD (Not Ready For Data) - the acceptor controls the state of the NRFD line.
3. NDAC (Not Data Accepted) - the acceptor also controls the NDAC line.

The complete handshake sequence for one data byte is shown in Figure 4-2. 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 controller, NRFD and NDAC must remain stable for at least 100ns 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.

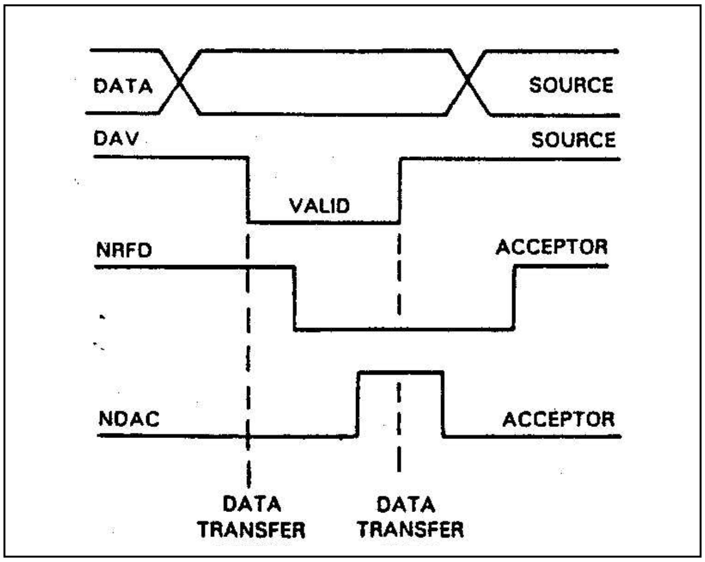


Figure 4-2. IEEE Handshake Sequence

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 command. The state of the ATN line determines whether the data bus contains data or commands.

4-3-3. 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 DI01 through DI08 instead of the more common D0 through D7 binary terminology. The data lines are bi-directional and, as with the remaining bus signal lines, low is true.

4-4. 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 4-1 lists the codes for the Model 6020. The numeric value following each one or two letter code define Model 6020 capability as follows:

SH (Source Handshake Function) - The ability for the Model 6020 to initiate the transfer of message/data on the data bus provided by the SH function.

AH (Acceptor Handshake Function) - The ability for the Model 6020 to guarantee proper reception of message/data on the data bus provided by the AH function.

T (Talker Function) - The ability of the Model 6020 to send device-dependent data over the bus (to another device) is provided by the T function. Model 6020 talker capabilities exist only after the instrument has been addressed to talk.

L (Listen Function) - The ability of the Model 6020 to receive device-dependent data over the bus (from anther device) is provided by the L function. Listener function capability of the Model 6020 exist only after it has been addressed to listen.

RS (Service Request Function) - The ability of the Model 6020 to request service from the controller is provided by the RS function.

RL (Remote-Local Function) - The ability of the Model 6020 to be placed in remote or local modes is provided by the RL function.

PP (parallel Poll Function) - The ability of the Model 6020 to respond to a parallel poll request from the controller is provided by the PP function.

DC (Device Clear Function) - The ability for the Model 6020 to be cleared (initialized) is provided by the DC function.

DT (Device Trigger Function) - The ability of the Model 6020 to have its output triggered is provided by the DT function.

C (controller Function) - The Model 6020 does not have a controller function.

TE (Extended Talker Capabilities) - The Model 6020 does not have extended talker capabilities.

LE (Extended Listener Function) - The Model 6020 does not have extended listener function.

Table 4-1. Model 6020 Interface Function Codes

CODE	INTERFACE FUNCTION
SH1	Source Handshake Function
AH1	Acceptor Handshake Capabilities
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
PP2	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

4-5. 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.

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 instrument. 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.

4-6. HARDWARE CONSIDERATIONS

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

4-6-1. Typical Controlled Systems

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

The simplest possible controlled system comprises a controller and one Model 6020. The controller is used to send commands to the instrument, which sends data back to the controller.

The system becomes more complex when 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 may then be used to store data.

4-6-2. Connections

The instrument is connected to the bus through an IEEE-488 connector. This connector is designed to be stacked to allow a number of parallel connections on one instrument.

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 to the connectors.

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.

Custom cables may be constructed using the information in Table 4-2. Table 4-2 also lists the contact assignments for the various bus lines. Contacts 18 through 24 are return lines for the indicated signal lines, and the cable shield is connected to contact 12. Each ground line is connected to digital common in the Model 6020.

****
** CAUTION **
****

> The voltage between IEEE common and ground must not exceed 0V or damage may result to your instrument.

Table 4-2. IEEE Contact Designations

Contact Number	IEEE-488 Designation	Type
1	DIO1	Data
2	DIO2	Data
3	DIO3	Data
4	DIO4	Data
5	EOI	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	Management
18	Gnd	Ground
19	Gnd	Ground
20	Gnd	Ground
21	Gnd	Ground
22	Gnd	Ground
23	Gnd	Ground
24	Gnd LOGIC	Ground

4-7. CHANGING GPIB ADDRESS

The primary address of your instrument may be programmed to any value between 0 and 30 as long as the selected address is different from other devices addresses in the system. This may be accomplished using a front panel programming sequence. Note that the primary address of the instrument must agree with the address specified in the controller's program.

NOTE

The programmed primary address is briefly displayed during the power-up cycle of the Model 6020. It is stored in the non-volatile memory of the instrument and is retained even when power is turned off.

To check the present address, or to enter a new one, proceed as follows:

1. Press the 2nd push-button once then press the ADR push-button (second function to SLOPE). The display will be modified to display the following:

IE Adr x — Where x may be any number from 0 to 30.

2. Press the VERNIER UP or DOWN push-buttons the select a new GPIB primary address.
3. To store the newly selected primary address depress ENT (second function to STO). The instrument will then resume normal operation.

4-8. BUS COMMANDS

While the hardware aspect of the bus is essential, the interface would be essentially worthless without appropriate commands to control the 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 categories:

1. Uniline commands: Sent by setting the associated bus line low.

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

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

Table 4-3. IEEE-488 Bus Command Summary

COMMAND TYPE	COMMAND	STATE OF ATN LINE*	COMMENTS
Uniline	REN	X	Set up for remote operation
	EOI	X	Sent by setting EOI low
	IFC	X	Clears Interface
	ATN	Low	Defines data bus contents
	SRQ	X	Controlled by external device
Multiline			
Universal	LLO	Low	Locks out front panel controls
	DCL	Low	Returns device to default conditions
	SPE	Low	Enable serial polling
	SPD	Low	Disables serial polling
Addressed	SDC	Low	Returns unit to default condition
	GTL	Low	Returns to local control
	GET	Low	Triggers device for reading
Unaddress	UNL	Low	Removes all listeners from bus
	UNT	Low	Removes all talkers from bus
Device-dependent**		High	Programs Model 6020 for various

* X = Don't Care, ** See paragraph 4-9 for complete description

4-8-1 Uniline Commands

Uniline commands are sent by setting the associated bus line to 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 description of each command.

REN (Remote Enable) - The remote enable command is sent to the Model 6020 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 6020 will indicate that it is in the remote mode by illuminating its front panel REM indicator.

To place the Model 6020 in the remote mode, the controller must perform the following steps:

1. Set the REN line true.
2. Address the Model 6020 to listen.

NOTE

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

EOI (End Or Identify) - The EOI command is used 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 the Model 6020 to a known state. Table 4-4 summarizes the instrument's state after IFC or DCL. 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 4-8-2, must be used to determine which has requested service.

4-8-2. Universal multiline 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 set low:

LLO (Local Lockout) - The LLO command is sent by the controller to remove the Model 6020 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 6020, the controller must perform the following steps:

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

DCL (Device Clear) - The DCL command may be used to clear the Model 6020, 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 6020 receives a DCL command, it will return to the default conditions listed in Table 4-4.

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

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

SPE (Serial Poll Enable) - The serial polling sequence is used to obtain the Model 6020 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 6020. For more information on status byte format, refer to paragraph 4-9-20. 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 6020 is addressed to talk.
4. The controller sets ATN false.
5. The Model 6020 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 trough 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.

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

Table 4-4. Default Conditions. (Status After SDC or DCL)

MODE	VALUE	STATUS
Function	F0	Frequency 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.
Impedance	AI0	1 MΩ 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.
Impedance	BI0	1 MΩ on channel B.
Auto Trigger	L0	Manual trigger disabled.
Delay	I0	Delay disabled.
V Peak Rate	V0	Fast measurement rate.
Totalize Mode	M0	Totalize infinitely.
Displayed Digits	N9	Set maximum displayed digits to 9.
Offset	O0	Set analog output offset to 0 V.
Resolution	P0	Set analog output resolution to LSD.
Rate	S1	Normal 3 readings per second.
SRQ mask	Q0	SRQ disabled.
Terminator	Z0	CR LF with EOI.
Display mode	D0	Display the measurement.
Data format	X0	prefix on, no leading zeros.
Trigger level	AL0	0 V on channel A.
Trigger level	BL0	0 V on channel B.
Gate time	G1	1 second gate time.
Delay time	W1	1 second delay time.

4-8-3. Addressed Commands

Addressed commands are multiline commands that must be proceeded 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. This command is useful for clearing only a selected instrument instead of all devices simultaneously. The Model 6020 will return to the default conditions listed in Table 4-4 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 6020 to listen.
3. Place the SDC command on the data bus.

GTL (Go To Local) - The GTL command is used to remove the instrument from the remote mode of operation. Also, front panel control operation will usually be restored if the LLO command was previously sent. To send the GTL command, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 6020 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 6020 in the local lockout state again.

GET (Group Execute Trigger) - The GET command is used to trigger or arm devices to perform a specific measurement that depends on device configuration. Although GET is considered to be an addressed command, many devices respond to GET without being addressed. Using the GET command is only one of several methods that can be used to initiate a measurement cycle. More detailed information on triggering can be found in Section 3 of this manual.

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

1. Set ATN true.
2. Address the Model 6020 to listen.
3. Place the GET command on the data bus.

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

4-8-4. Unaddress Command

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

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

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

4-8-5. 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 6020 to place the instrument in the FREQ A mode. The IEEE-488 bus treats device-dependent commands as data in that ATN is high (false) when the commands are transmitted.

4-9. DEVICE-DEPENDENT COMMAND PROGRAMMING

IEEE-488 device-dependent commands are sent to the Model 6020 to control various operating conditions such as display modify, operating mode, output and parameter insertion. Each command is made up of an ASCII alpha character followed by one or more numbers designating specific parameters. For example the output waveform is programmed by sending an ASCII "U" followed by a number representing the output. 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 6020 will ignore all non-printable ASCII characters (00 HEX through 20 HEX) except the "CR" (carriage return). A command string is terminated by an ASCII "CR" (carriage return) character (0D HEX) which tells the instrument to execute the command string. recognized as end of command string.

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

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

These programming aspects are covered in the following.

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.

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

1. Set ATN true.
2. Address the Model 6020 to listen.
3. Set ATN false.
4. Send the command string over the data bus one byte at a time.

NOTE

> REN must be true when attempting to program the Model 6020.

Commands that effect the Model 6020 are listed in Table 4-5.

Table 4-5. Device-Dependent Command Summary

Mode	Command	Description
Function	F0	Frequency on Channel A
	F1	Frequency on Channel B
	F2	Frequency on Channel C
	F3	Period on Channel A
	F4	Pulse on Channel A
	F5	Time interval from A to B
	F6	Totalize on B
	F7	Ratio A/B
	F8	θ A to B
	F9	V peak A
	F10	Period average on Channel A
	F11	Pulse average on Channel A
	F12	Time interval from A to B averaged
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
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
Impedance	AI0	1 MΩ impedance on Channel A
	AI1	50 Ω impedance on Channel A
	BI0	1 MΩ impedance on Channel B
	BI1	50 Ω impedance 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

Table 4-5. Device-Dependent Command Summary (continued)

Auto level	L0	Auto trigger level disabled
	L1	Auto trigger level enabled (mode overrides manual mode)
Gate Time	Gn	Set the Gate time in sec n = dE<sign>d d = digit
	GU	Set gate time to user gate
Delay Time	Wn	Set the Delay time in sec n = dE<sign>d d = digit
	WU	Set delay time to user delay
Delay	I0	Delay disabled
	I1	Delay enabled
Vpk measurement rate	V0	Fast rate
	V1	Slow rate
Totalize modes	M0	Totalize infinitely on B
	M1	Totalize on B by A
	M2	Totalize on B by AA
Displayed Digits	Nn	Set the maximum of the displayed digits (n=3 to 9)
ANALOG OUTPUT		
Offset	On	Set the analog output offset n = 0 to 10. (0 correspo-nds to 0Vdc offset. 5 centers niddle)
Resolution	Pn	Set the selected resolution for the analog output n = 0 to 6 (0 will output the three least significant digits. 6 will output the three most significant digits)
Set-ups		
Store	STn	Store front panel set-up in n memory location
Recall	REn	Recall front panel set-up from n memory location
Trigger	T	One-shot in S0 mode
Rate	S0	One-shot on T or GET
	S1	Normal. 3 readings per sec
	S2	Fast. 25 readings per sec
SRQ Mask	Q0	SRQ disabled
	Q1	SRQ on ready
	Q2	SRQ on reading done
	Q4	SRQ on error

Table 4-5. Device-Dependent Command Summary (continued)

Terminator	Z0	CR LF	with EOI
	Z1	CR LF	without EOI
	Z2	LF CR	with EOI
	Z3	LF CR	without EOI
	Z4	CR	with EOI
	Z5	CR	without EOI
	Z6	LF	with EOI
	Z7	LF	without EOI
	Z8	No Terminator	with EOI
	Z9	No Terminator	without EOI
Display Mode	D0	Display the Measurement	
	D1	Display the Gate Time	
	D2	Display the Delay Time	
	D3	Display the Trigger Level A	
	D4	Display the Trigger Level B	
	D5	Display the number of digits (Nn)	
	D6	Display Analog Output resolution	
	D7	Display Analog Output offset	
Prefix	X0	Reading with prefix, without leading zero	
	X1	Reading without prefix, without leading zero	
	X2	Reading with prefix, with leading zero	
	X3	Reading without prefix, with leading zero	
Read-back	R0	Send measuring data string	
	R1	Send Gate Time data string	
	R2	Send Delay Time data string	
	R3	Send Trigger Level A data string	
	R4	Send Trigger Level B data string	
	R5	Send Input conditioning status	
	R6	Send Operating Mode Status	
	R7	Send Error Status	

4-9-1. Function (F)

The function command select the type of measurement made by the Model 6020. The 10 parameters associated with the function command set the instrument to measure one of these functions. The function may be programmed by sending one of the following commands:

1. F0 = FRQ A
2. F1 = FRQ B
3. F2 = FRQ C
4. F3 = PER A
5. F4 = PLS A
6. F5 = TI A->B
7. F6 = TOT B
8. F7 = RATIO A/B
9. F8 = θ A->B

10. F9 = V peak A
11. F10 = PER AVG A
12. F11 = PLS AVG A
13. F12 = TI A->B AVG

4-9-2. 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 6020. The coupling may be programmed by sending one of the following commands:

1. AC0 = DC coupling channel A.
2. AC1 = AC coupling channel A.
3. BC0 = DC coupling channel B.
4. BC1 = AC coupling channel B.

4-9-3. Channels A, B Attenuator (AA, BA)

The attenuator command gives the user control over the input attenuator mode of the channel A and B inputs for the Model 6020. The attenuator may be programmed by sending one of the following commands:

1. AA0 = x1 attenuator channel A.
2. AA1 = x10 attenuator channel A.
3. BA0 = x1 attenuator channel B.
4. BA1 = x10 attenuator channel B.

4-9-4. Channels A, B Filter (AF, BF)

The filter command gives the user control over the input filter of the channel A and B inputs for the Model 6020. The filter may be programmed by sending one of the following commands:

1. AF0 = filter on channel A.
2. AF1 = filter off channel A.
3. BF0 = filter on channel B.
4. BF1 = filter off channel B.

4-9-5. Channels A, B Slope (AS, BS)

The slope selection command gives the user control over the input slope mode of the channel A and B inputs for the Model 6020. The slope may be programmed by sending one of the following commands:

1. AS0 = Positive slope channel A.
2. AS1 = Negative slope channel A.
3. BS0 = Positive slope channel B.
4. BS1 = Negative slope channel B.

4-9-6. Channels A, B Impedance (AI, BI)

The impedance selection command gives the user control over the input impedance mode of the channel A and B inputs for the Model 6020. The impedance may be programmed by sending one of the following commands:

1. AI0 = 1 MΩ impedance channel A.
2. AI1 = 50 Ω impedance channel A.
3. BI0 = 1 MΩ impedance channel B.
4. BI1 = 50 Ω impedance channel B.

4-9-7. 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 6020. The trigger level may be programmed by sending one of the following commands:

1. ALn = Trigger level channel A.
2. BLn = Trigger level channel B.

n is the trigger level in volts in engineering format. e.g. (<sign>D.DD<sign>D). The sign and the exponent are optional. The trigger level may range from -5.00 to +5.00 V in 10 mV steps or from -50.0 to +50.0 V in 100 mV steps. Selecting a trigger level in the range of ±5.00 V will automatically set up the x1 attenuator. Selecting a trigger level in the range of ±50.0 V will change the attenuator setting to x10 attenuator mode.

After DCL or SDC, the instrument will be in AL0 and BL0 (trigger levels set at 0.00 V)

4-9-8. Channels A, B Auto trigger level (L)

The auto trigger level command gives the user control over the auto trigger level mode for channels A and B. The auto trigger level mode may be programmed by sending one of the following commands:

1. L0 = Auto trigger level disabled.
2. L1 = Auto trigger level enabled.

4-9-9. Gate Time (G, GU)

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 formats:

1. Gn = Internal gate time
2. GU = External user gate time

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 3-3.

The gate time may also be programmed to the external user gate time by sending the GU command over the bus.

After DCL or SDC, the instrument will restart with a gate time of one second (G1)

4-9-10. Delay Time (W, WU)

The delay time command controls the amount of delay in closing the gate after the gate was open. The delay time may be programmed by sending a command using the following formats:

1. Wn = Internal delay time.
2. WU = External user delay time.

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

The delay time may also be programmed to the external user delay time by sending the GU command over the bus.

After DCL or SDC, the instrument will restart with a delay time of one second (W1)

4-9-11. V Peak Measurement Rate (V)

The v peak measurement rate command controls the rate of which the instrument will perform the v peak measurements at the input connector of the Model 6020. The fast rate is normally used where the frequency to be measured is above 100 Hz. The slow rate is used when performing measurements below 100 Hz. The v peak measurement rate may be programmed by sending a command using the following formats:

1. V0 = Fast measurement rate.
2. V1 = Slow measurement rate.

4-9-12. Totalize Modes (M)

There are three totalize modes available with the Model 6020: Totalize infinitely, totalize by A and totalize by AA. The totalize mode command gives the user control over the selection of one of these totalize modes. The totalize mode may be programmed by sending a command using the following format:

1. M0 = Totalize infinitely on B.
2. M1 = Totalize on B by A.
3. M2 = Totalize on B by AA.

4-9-13. Displayed Digits (N)

The displayed digits function sets the maximum number of digits that the Model 6020 will display. To program the number of digits send the following command:

Nn

Where n may have any value from 3 to 9. Upon DCL or SDC, the instrument will be set to N9.

4-9-14. Analog Output Resolution (P)

The analog output resolution selection command gives the user control over the resolution range of the analog output string. To program the analog output resolution send the following command:

- P0 = 3 least significant digits.
- Pn = any three adjacent digits, n indicates the location of the right most digit.
- P6 = 3 most significant digits.

n may range from 0 to 6. Upon DCL or SDC, the instrument will be set to P0.

4-9-15. Analog Output Offset (O)

The analog output offset command gives the user control over the offset which will be applied to the output readout at the analog output rear panel connector. To program the analog output offset send the following command:

On

Where n may range from 0 to 9V. Upon DCL or SDC, the instrument will be set to OV.

4-9-16. Set-ups (ST, RE)

The setups commands select the memory location where the actual set-up is to be stored (ST) or from where recalled (RE). To store or recall a set-up use one of the following commands:

STn
REn

Where n may range from 0 to 9. n is the memory address the set-up is to be stored or from where the set-up is to be recalled. DCL or SDC has no effect on the stored set-ups.

4-9-17. Triggering (T)

The "T" and GET commands are used to trigger the Model 6020 over the IEEE bus. Triggering arms a measurement cycle. In the continuous mode, the Model 6020 is always armed. In the hold mode (S0), a separate trigger stimulus is required to arm each measurement cycle. To arm the Model 6020 for a new measurement cycle use the following commands:

1. T = addressable trigger.
2. GET = group execute trigger.

4-9-18. Rate (S)

The rate command gives the user control over the measurement rate of the Model 6020. To change the measurement rate use the following commands:

1. S0 = Hold, One shot on T or GET or external arming input.
2. S1 = Normal, Approximately 3 reading per second.
3. S2 = Fast, Approximately 25 reading per second. This rate can not be selected through front panel programming.

4-9-19. Display Modes (D)

The display command controls what the Model 6020 places on the display. The eight parameters associated with the display command set the instrument to display the measurement, gate time, delay time, trigger level A, trigger level B, number of selected digits, analog output resolution and analog output offset. The display may be programmed using the following commands:

1. D0 = Display the normal measurement.
2. D1 = Display the gate time.
3. D2 = Display the delay time.
4. D3 = Display the A trigger level.
5. D4 = Display the B trigger level.
6. D5 = Display the number of digits.
7. D6 = Display the analog output resolution.
8. D7 = Display the analog output offset.

4-9-20. SRQ Mode (Q) and Serial Poll Status Byte Format

The SRQ command controls which of a number of conditions within the Model 6020 will cause the instrument to request service from the controller with the SRQ line command. Once the SRQ is generated, the Model 6020 status byte can be checked, via serial polling, to determine if it was the Model 6020 that requested service. Other bits in the status byte could also be set depending on certain data or error conditions. The Model 6020 can be programmed to generate SRQ under one of the following conditions.

1. If the Model 6020 is ready to receive device-dependent commands.
2. If a reading has been completed.
3. If an error condition has occurred.

<u>SRQ Mask</u>: In order to facilitate SRQ programming, the Model 6020 uses an internal mask to generate the SRQ. When a particular mask bit is set, the Model 6020 will send a SRQ when those conditions occur. Bits within the mask can be controlled by sending the ASCII letter "Q" followed by a decimal number to set the appropriate bits. Table 4-6 lists the commands to set the various mask bits, while Table 4-7 lists all legal SRQ Mask commands.

Table 4-6. SRQ Mask Commands

Command	Sets Bit Number	Condition to Generate SRQ
Q1	B0 (LSB)	Ready
Q2	B1	Reading done
Q4	B2	Error

Table 4-7. SRQ Mask Legal Commands

Bit Number	B3	B2	B0 (LSB)
Command	Error	Reading Done	Ready
Q0	NO	NO	NO
Q1	NO	NO	YES
Q2	NO	YES	NO
Q3	NO	YES	YES
Q4	YES	NO	NO
Q5	YES	NO	YES
Q6	YES	YES	NO
Q7	YES	YES	YES

NOTE

There are 8 legal SRQ mask commands that are possible with the Model 6020. Table 4-7 lists all combinations. e.g selecting Q6, Model 6020 will request service when one of reading done or error occurs.

Status Byte Format: The status byte contains information relating to data and error conditions within the instrument. Table 4-4 lists the meaning of the various bits. The status byte is obtained by using the SPE,SPD polling sequence.

Table 4-8. Status Byte Interpretation

Bit Number	B7	B6	B5	B4	B3	B2	B1	B0 (LSB)
Interpretation	0	rqs	0	0	0	Error	Reading Done	Ready

The various bits in the status byte are described below:

1. Ready: Set after power-up. This bit is cleared when the Model 6020 receives a command and set again when the instrument have completed to decode the command (Model 6020 is ready for the next command string).

2. Reading done: Set after completion of a measurement cycle. The reading done bit is cleared after Model 6020 was addressed to talk in R0 mode.

3. Error: Set if an illegal command has been received or one of gate error, gate time error or trigger level error has occurred in the last measurement cycle. This bit is cleared by reading the error status string (R7).

4. Rqs: Model 6020 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 6020 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 6020 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 the instrument is ready for the next string, the following command would be sent: Q5. All possible mask combinations are listed in Table 4-7.
3. If the instrument is programmed to generate an SRQ when 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 (R0).

4-10. READING FROM MODEL 6020

The Reading sequence is used to obtain from Model 6020, various information strings such as measurement, gate time, delay time or trigger level. Each information string is made up of ASCII alpha and alphanumeric characters. For more details on the information strings format refer to paragraph 4-10-1.

The reading sequence is conducted as follows:

1. The controller sets the ATN line true.
2. The Model 6020 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.

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(for example the EOI line is low on the bus during the transfer of the last byte).

4-10-1 Data Control commands (R)

The Data Control commands allows access to information concerning present operating conditions of the instrument. When the data control command is given, the Model 6020 will transmit the associated data string instead of its normal data string. The next time it is addressed to talk the Model 6020 will transmit its normal measurement data string (R0).

The Model 6020 Data Control commands include:

R0 = Send normal measuring data string
R1 = Send Gate Time data status string
R2 = Send Delay Time data status string
R3 = Send Trigger Level A data status string
R4 = Send Trigger Level B data status string
R5 = Send Input conditioning status string
R6 = Send Operating Mode Status string
R7 = Send Error Status string

Table 4-9 shows the general data string format for each of the seven commands (decimal point floats).

Table 4-10 shows the interpretation for the input conditioning status, operating mode status and error status strings (R5, R6 and R7)

NOTES

1. Data strings have fixed length of 14 ASCII characters for the R0, R5 and R6 commands without the prefix and terminator. For all other data strings (R1 through R4 and R7), the length of the data string is 5 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 4-2-3). If the data string is sent with one or two terminators, the length of the data string increases by one or two characters respectively.

2. All normal measurement data string information (R0), besides the status strings (R1 through R7), will be sent only once each time a measurement has been successfully completed. This may halt the controller for the duration of the gate or delay time. It is therefore recommended that the status byte will be continuously monitored and normal reading taken only after the READING DONE bit is set true.

3. All status string information, besides the normal data strings, 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 (R0) the next time it is addressed to talk.

Table 4-9. Data String Formats

Command	Data String Format	Description
R0	<FRQA>+1.23456789E+0(TERM)	for FRQ A measurements
	<FRQB>+1.23456789E+0(TERM)	for FRQ B measurements
	<FRQC>+1.23456789E+0(TERM)	for FRQ C measurements
	<PERS>+1.23456789E+0(TERM)	for PER A measurements
	<PLSS>+1.23456789E+0(TERM)	for PLS A measurements
	<TABS>+1.23456789E+0(TERM)	for T.I A->B measurements
	<TOTB>+1.23456789E+0(TERM)	for TOT B measurements
	<APRB>+1.23456789E+0(TERM)	for RATIO A/B measurements
	<PHAS>+1.23456789E+0(TERM)	for θ A->B measurements
	<VPKA>-0.00 -0.00 (TERM)	for V PeaK A measurements
	<PERV>+1.23456789E+0(TERM)	for PER AVG A measurements
	<PLSV>+1.23456789E+0(TERM)	for PLS AVG measurements
	<TABV>+1.23456789E+0(TERM)	for T.I A->B AVG measurements
R1	<GATE>+1E+0(TERM)	for Gate Time
R2	<DLAY>+1E+0(TERM)	for Delay Time
R3	<TRGA>+0.00(TERM)	for Trig Level A
R4	<TRGB>+0.00(TERM)	for Trig Level B
R5	<STAT>00000000000000(TERM)	Input conditioning status
R6	<6020>00000900100000(TERM)	Machine status
R7	<EROR>00000(TERM)	Error status

CR LF is normal terminator. The terminator may be changed (see paragraph 4-10-2). The prefixes are listed in Table 4-9.

Table 4-10. Status Word Interpretation

Command	Status Word Format
R5	<STAT> F AC AA AF AS AI BC BA BF BS BI L I (term)
After SDC	<STAT> 00 0 0 0 0 0 0 0 0 0 0 0 0 (CR LF)
R6	<6020> OPT1 OPT2 OPT3 V M N O P S Q Z D X 0 (term)
After SDC	<6020> n n n 0 0 9 0 0 1 0 0 0 0 0 (CR LF)
R7	<EROR> ILI ILP GATEERR TLERR 0 (CR LF)
After SDC	<EROR> 0 0 0 0 0 (RC LF)

NOTES

1. The Error Status string will be returned only once each time the command is sent. Once status is read, the instrument will send its normal string the next time the instrument is addressed to talk and reading done bit is set true.

2. To ensure that the correct status is received, the status string should be read immediately after sending the command, to avoid having an incorrect status transmitted.

3. The status string should not be confused with the status byte. The status string 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 RSQ status.

4. The error status string is cleared by reading R7. Reading this status also clears the reading done and the error bits in the status byte.

4-10-2. Terminator (Z)

To allow 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 Z0). The terminator sequence will assume this default value after receiving a DCL or SDC.

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 6020 will normally send EOI during the last byte of its data string or status word. The terminator and the EOI response from the Model 6020 may be sent with one of the following commands:

```
 1. Z0 = CR,LF          with    EOI
 2. Z1 = CR,LF          without EOI
 3. Z2 = LF,CR          with    EOI
 4. Z3 = LF,CR          without EOI
 5. Z4 = CR             with    EOI
 6. Z5 = CR             without EOI
 7. Z6 = LF             with    EOI
 8. Z7 = LF             without EOI
 9. Z8 = No terminator  with    EOI
10. Z9 = No terminator  without EOI
```

NOTES

1. Most controllers use the CR or LF character to terminate their input sequence. Using the NO TERMINATOR mode (Z8 or Z9) may cause the controller to hang up unless special programming is used.

2. Some controllers may require that EOI be present at the end of transmitting.

4-10-3. Prefix (X)

The prefix from the data string may be suppressed using this command. When the prefix is suppressed the output data string is four byte shorter. The X 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 a reading error because of its inability to read spaces before the first significant digit. To eliminate this problem the Model 6020 should be programmed to send the data string with leading zeros. X command parameters include:

```
X0 = Send data string with    prefix, without leading zero
X1 = Send data string without prefix, without leading zero
X2 = Send data string with    prefix, with    leading zero
X3 = Send data string without prefix, with    leading zero
```

4-11. FRONT PANEL ERROR MESSAGES

The process of programming the Model 6020 involves the proper use of syntax. Syntax is defined as the orderly or systematic arrangement of programming commands or languages. The Model 6020 must receive valid commands with proper syntax or it will:

1. Ignore the entire commands 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.

4-11-1. ILL INS (Illegal Instruction) Error

An ILL INS error results when the Model 6020 receives an invalid command such as A0. This command is invalid because no such letter exist in the instruments programming language.

4-11-2. ILL PAR (Illegal Parameter) Error

An ILL PAR error occurs when the numeric parameter associated with a legal command letter is invalid. For example, the command D10 has an invalid option because the Model 6020 has no display mode associated with that number.

SECTION 5

MAINTENANCE AND PERFORMANCE TESTS

5-1. INTRODUCTION

This section provides maintenance, service information, and performance tests for the Model 6020, the TCXO and clock multiplier (option 1), the 1.3GHz input channel (option 2) and the analog output option (option 3). Fuse replacement procedure, line voltage selection and options installation procedure are also included.

****
** WARNING **
****

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

5-2. LINE VOLTAGE SELECTION

The Model 6020 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 an operating voltage of 230V. To change the line voltage, proceed as follows:

****
** WARNING **
****

Disconnect the Model 6020 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 voltages are marked on the selection switch.

2. Install a power line fuse consistent with the operating voltage. See paragraph 5-3.

CAUTION

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

5-3. FUSE REPLACEMENT

The Model 6020 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 the 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 5-1 as a guide.

CAUTION

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

Table 5-1. Line Fuse Selection

Power Line Voltage	Fuse Type
90 -125V	0.2A, 250V, 5x20 mm Slow Blow
195-250V	0.4A, 250V, 5x20 mm Slow Blow

5-4. TCXO/CLOCK MULTIPIER OPTION FIELD INSTALLTION (option 1)

The TCXO/Clock Multiplier option enhances the accuracy, stability and the displayed resolution of the Model 6020. Accuracy is improved to 1PPM. Resolution is increased to a minimum of 8 digits in one second of gate time. The phase lock circuit on the multiplier board also permits a connection of three different reference frequencies to the CLOCK IN BNC connector; 1 MHz, 5 MHz and 10 MHz. Selecting the required reference frequency is described in the following.

If purchased with the Model 6020, the option will be factory installed; however the instrument may be easily upgraded in the field by installing the option as described in the following. Software modification is not required. The Model 6020 will automatically sense the presence of the installed option and will adjust the software routines accordingly.

5-4-1. Option 1 Installation Procedure

1. Remove the top and bottom covers of the instrument as described in the disassembly instructions in paragraph 5-8.

****
** WARNING **
****

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

2. Remove U58, shorting link LK1a/LK1b and the shielded wire which is connected to the rear panel CLOCK IN/OUT BNC connector.
3. Assemble and solder J4 and the card guide on the main board as shown in Figure 5-1.
4. Slide the option board along the card guide and push the card down until it locks into place

CAUTION

Make sure that the option is plugged correctly to the main connector that is, when the option board is secured into place, no pin on the main board should by left free.

4. Solder the loose end of the shielded wire to the rear panel CLOCK IN/OUT BNC connector. Solder the inner wire to the center and the outside shield to the ground lug.
5. Bolt the spacer to the side extrusion. Insert a 6-32 screw through the supporting spacer to secure the board to its place and to prevent the option from loosening during transit.
6. LK1a/LK1b is used for selecting between internal and external references. Proper positioning of LK1a/LK1b is described in Figure 5-2. Note that the rear panel BNC connector is used as an output when the internal reference is selected. When LK1a/LK1b was set to accept an external reference, the same rear panel connector is used as an input for the reference frequency.
7. External reference frequency may be selected from one of three standard frequencies: 1 MHz, 5 MHz or 10 MHz. Option 1 has to be set to accept one of these frequencies. The required frequency may be selected by changing the position of LK2. Refer to Figure 5-2 for correct placement of LK2.
8. Replace the bottom and top covers.
9. Turn on the power and observe the power up procedure. If no other option is installed the instrument will display the following:

6020-1

This reading indicates that the instrument accepted the installed option.

Applying a wrong reference frequency to the rear panel connector and trying to measure frequency will cause the Model 6020 to display the following message:

no rEF

This reading indicates that the instrument can not lock to the external reference frequency. When such a reading occur, check the position of LK2 as described in the above.

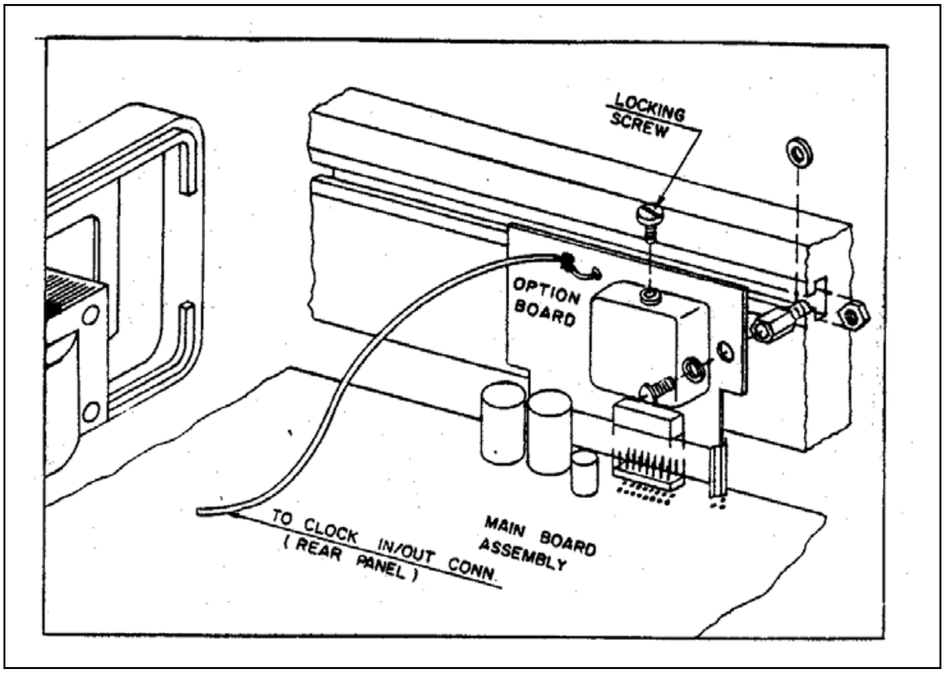


Figure 5-1. TCXO/Clock Multiplier Option Field Installation.

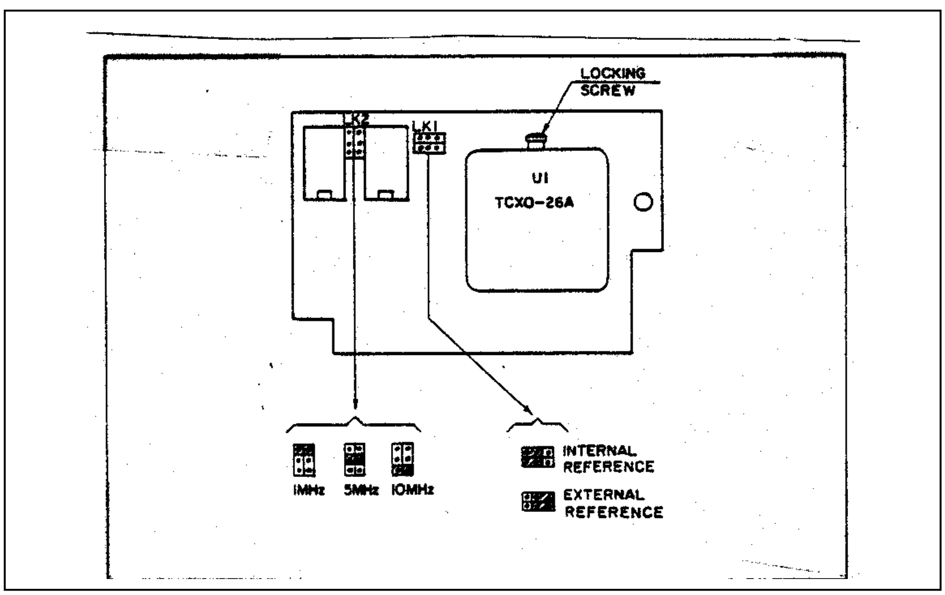


Figure 5-2. Reference Frequency and INT/EXT Clock Selection.

5-5. 1.3 GHz INPUT OPTION FIELD INSTALLATION (option 2)

The 1.3 GHz input option expands the capability of the Model 6020 by allowing it to measure frequencies up to 1.3 GHz (Typically 1.5 GHz). If purchased with the Model 6020, the option will be factory installed; however the instrument may be easily upgraded in the field by installing the option as described in the following procedure.

5-5-1. Option 2 Installation Procedure

1. Remove the top cover of the instrument as described in the disassembly instructions in paragraph 5-8.

****
** WARNING **
****

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

2. Assemble and solder J3 on the main board as shown in Figure 5-2.
3. Bolt the spacers to the side extrusion. Insert a 6-32 screw through the option board to the supporting spacer to secure the board to its place. Use lock-washers to prevent the option from loosening during transit.
4. Plug the loose end of the flat cable to J3 and press the connector to secure it to its place. Make sure that the cable is positioned properly, that pin 1 is connected to pin 1 on the main board and that no pin on the main board is left free.
5. Solder the loose end of the shielded wire to the front panel Channel C BNC connector. Solder the inner wire to the center and the outside shield to the ground lug.

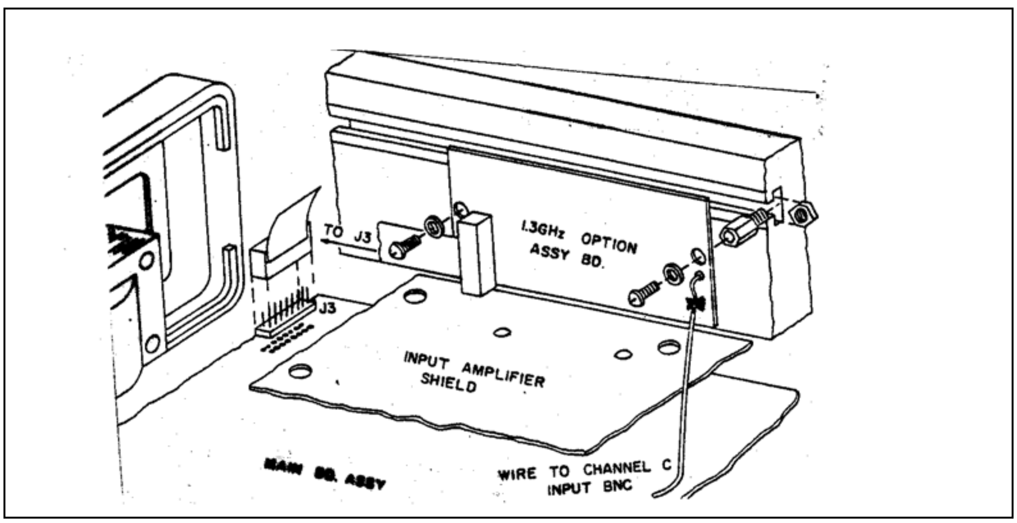


Figure 5-3. 1.3 GHz Input Option Installation

6. Replace the bottom and top covers.
7. Turn on the power and observe the power up procedure. If no other option is installed the instrument will display the following:

6020-2

This reading indicates that the instrument accepted the installed option and is now ready to take measurements of frequencies up to 1.3 GHz.

5-6. ANALOG OUTPUT OPTION (option 3)

The analog output option expands the capability of the Model 6020 by providing, through a rear panel BNC connector, a high accuracy dc voltage. This dc voltage is directly proportional to any three - selectable adjacent digits. This voltage may be later used to drive a chart recorder or XY plotter. If purchased with the Model 6020, the option will be factory installed. Option 3 can not be installed in the field; however the instrument may be sent to the factory for an upgrade. Consult your nearest service center when such an upgrade is required.

To check if option 3 is installed in your Model 6020, turn the power on and observe the power-up procedure. If no other option is installed the instrument will display the following:

6020-3

This reading indicates that option 3 is installed. For other indications during power-up sequence refer to section 3 paragraph 3-4.

5-7. SELECTING AN EXTERNAL REFERENCE

Model 6020 offers two options for the internal time base clock; a standard 5PPM oscillator and an optional 1PPM TCXO (option 1). These options are enough to satisfy most accuracy requirements; however, in applications where such an inaccuracy is a limiting factor, external standard may be applied to the counter. The basic accuracy of the Model 6020 is then converted to the accuracy of the applied frequency source.

Model 6020 features a rear panel input/output BNC connector designated as CLOCK 10 MHz OUT / EXT IN. This connector serves two functions; when an internal clock is selected, a 10 MHz signal from the internal time base circuit is available at this output. While using the instrument with an external reference, a signal is applied to the same connector .

Model 6020 is supplied with the instrument set to operate with the internal time base and with a 10 MHz signal available at the rear panel CLOCK output. Information of modifying the instrument to accept an external reference signal when option 1 is installed is given in paragraph 5-4-1. with standard time base clock proceed to modify the instrument as follows:

1. Remove the top cover of the instrument as described in the disassembly instructions in paragraph 5-8.

****
** WARNING **
****

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

2. Refer to Figure 5-4 and locate LK1 at the rear of the instrument near the power transformer.
3. The position of the two shorting links determines if the instrument is set to operate with an internal or external clocks. Position the shorting links as required.

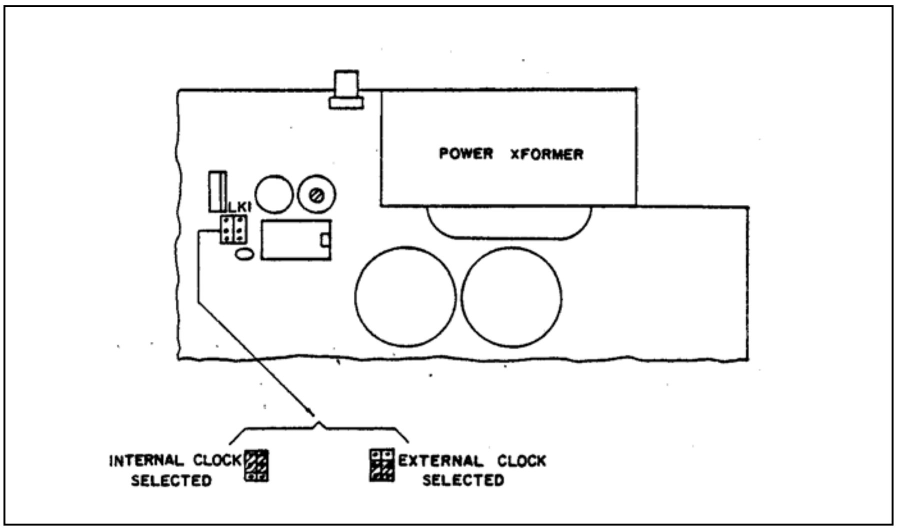


Figure 5-4. External/Internal time base clock selection

5-8. DIASSEMBLY INSTRUCTIONS

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

1. Remove the four screws that secure each of the top and the bottom covers.

2. Grasp the top cover at the side and carefully lift it off the instrument. Similarly remove the bottom cover.

3. When replacing the covers, reverse the above procedure.

5-9. SPECIAL HANDLING OF STATIC SENSITIVE DEVICES

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

1. The MOS ICs should be transported and handled only in 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 devices only by the body; do not touch the pins.
4. Any printed circuit board into which the device is to be inserted must also be grounded to the bench or table.
5. Use only anti-static type solder sucker.
6. Use only grounded soldering irons.
7. Once the device is installed on the PC board, the device is normally adequately protected, and normal handling resume.

5-10. CLEANING

Model 6020 should be cleaned as often as operating condition require. Thoroughly clean the inside and the outside of the instrument. Remove dust from inaccessible areas with low pressure compressed air or vacuum cleaner. Use alcohol applied with a cleaning brush to remove accumulation of dirt or grease from connector contacts and component terminals.

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

5-11. REPAIR AND REPLACEMENT

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

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

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

5-12. PERFORMANCE CHECKS

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

a. As part of incoming inspection of instrument specifications;
b. As part of troubleshooting procedure;
c. After any repair or adjustment, before returning instrument to regular service.

5-12-1. Environmental Conditions

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

stabilize before beginning the adjustment procedure.

5-12-2. Warm-Up Period

Most equipment is subject to at least a small amount of drift when it is first turned on. To ensure accuracy, turn on the power to the Model 6020 and allow it to warm-up for at least 30 minutes before beginning the performance tests procedure.

5-12-3. Recommended Test Equipment

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

Table 5-2. Required Test Equipment.

Instrument	Recommended Model	Minimum Specifications	Use *
DMM	Tabor 4121	.1V- 100VDC 0.05%, Ω	P,A,T
Pulse Generator	Tabor 8201	0.5 Sec - 20 nSec	P
Signal Generator	HP 8660A/C	1 MHz-1300MHz	P,A
DCV Calibrator	Fluke	1V - 100V 0.01%	A
Oscilloscope	Tektronics 465	100 MHz bandwidth	T
10 MHz Standard	Oscillatec	10 MHz ±10-12	P,A

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

5-13. PERFORMANCE CHECKS PROCEDURE

5-13-1. CHANNELS A AND B SENSITIVITY CHECK

Equipment: Synthesized signal generator

Procedure:

1. Connect the test equipment as described in Figure 5-5.

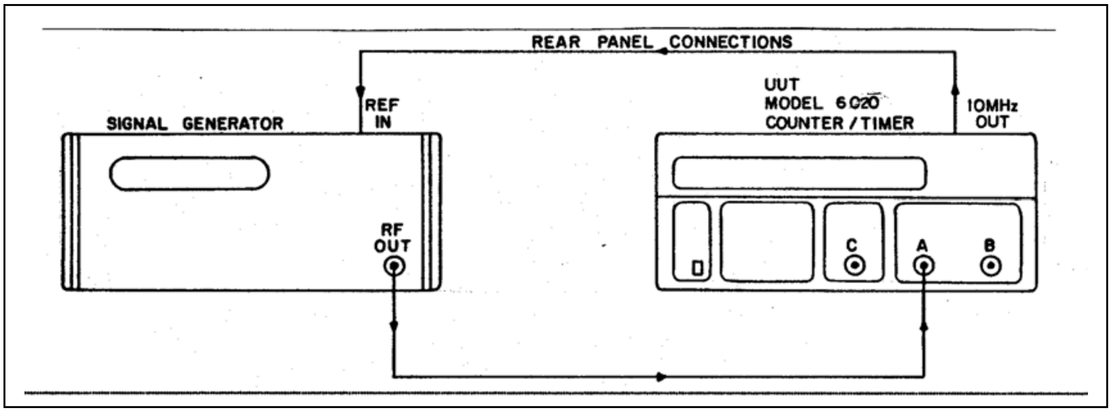


Figure 5-5. Channels A and B Sensitivity Test Set-up.

2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL] and then [50Ω].

3. Set Synthesizer frequency and amplitude as given in the following table and verify a stable counter readings as follows:

SYNTHESIZER FREQUENCY	SIGNAL LEVEL (rms)	REQUIRED COUNTER READING	ALLOWED ERROR
1 MHz	25 mV	1.0000000 E+6(*)	±2 Hz
80 MHz	25 mV	80.00000 E+6(*)	±2 LSD
100 MHz	25 mV	100.000000 E+6	±2 Hz
150 MHz	50 mV	150.000000 E+6	±2 Hz
225 MHz	50 mV	225.000000 E+6	±2 Hz

* Add one more 0 when option 1 is installed.

4. Change synthesizer frequency setting to 10 MHz and signal level setting to 25 mV rms.
5. Press [LPF] push-button and observe that the counter does not process any more readings.
6. Again press [LPF] and then [x10] push-button and observe that the Model 6020 still does not process readings.
7. Change synthesizer amplitude level setting to 250 mV rms.
8. Verify that counter reading is 10 MHz ± 2 Hz.
9. Modify the connections in Figure 5-5 above so that the synthesizer will now be connected to Channel B. Select [FREQ B]
10. Repeat the procedure above to verify Channel B sensitivity.

5-13-2. CHANNEL C SENSITIVITY CHECK

Equipment: Synthesized signal generator

Procedure:

1. Connect the test equipment as described in Figure 5-6.

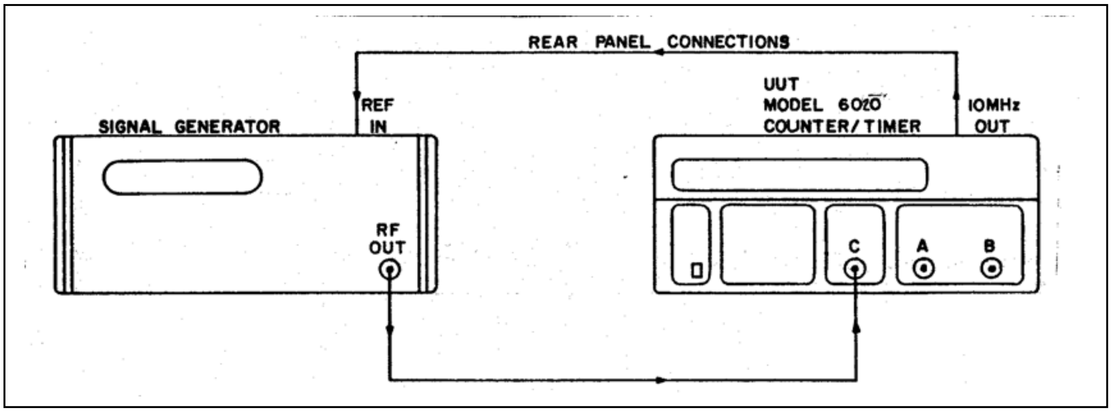


Figure 5-6. Channel C Sensitivity Test Set-up.

2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL] and then [FREQ C].

3. Set Synthesizer frequency and amplitude as given in the following table and verify a stable counter readings as follows:

SYNTHESIZER FREQUENCY	SIGNAL LEVEL (rms)	REQUIRED COUNTER READING (*)	ALLOWED ERROR
100 MHz	25 mV	100.0000 E+6	± LSD
500 MHz	25 mV	500.0000 E+6	± LSD
1000 MHz	25 mV	1.0000000 E+9	± LSD
1300 MHz	50 mV	1.300000 E+9	± LSD

* Add one more 0 when option 1 is installed.

5-13-3. PERIOD A, PERIOD A AVERAGED OPERATION CHECK

Equipment: Synthesized signal generator

Procedure:

1. Connect the test equipment as described in Figure 5-7.

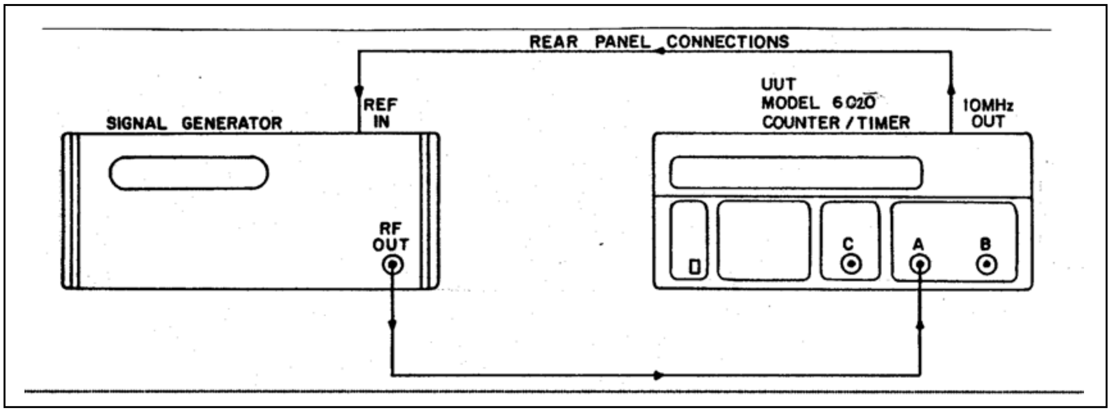


Figure 5-7. Period A and Period A Averaged Test Set-up.

2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [PER A] and then [50Ω].
3. Set Synthesizer frequency to 1 MHz and amplitude level to 50 mV rms.
4. Verify a stable counter readings as follows:

1.0 E-6 ±1 LSD or
1.00 E-6 ±1 LSD when option 1 is installed

5. Press [2nd] and then [AVG] push-buttons.
6. Set Synthesizer frequency to 125 MHz and amplitude level to 50 mV rms.
7. Verify a stable counter readings as follows:

8.000000 E-9 ± LSD or
8.0000000 E-9 ±1 LSD when option 1 is installed

5-13-4. RATIO A/B OPERATION CHECK

Equipment: Synthesized signal generator

Procedure:

1. Connect the test equipment as described in Figure 5-8.
2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [A/B], [AC B] and then [50Ω A&B].
3. Set Synthesizer frequency to 225 MHz and amplitude level to 50 mV rms.

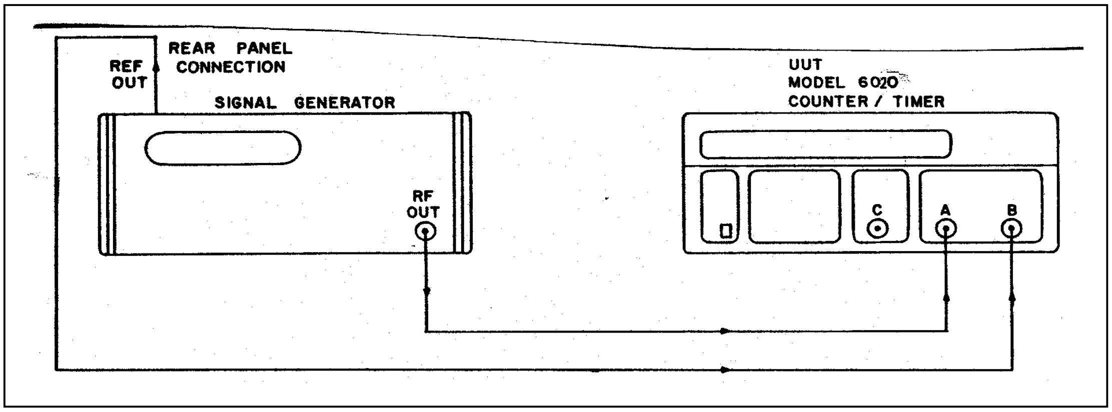


Figure 5-8. Ratio A/B Test Set-up.

4. Verify a stable counter readings as follows:

22.5000000 ±1 LSD

5-13-5. PULSE A, T.I A to B, PULSE A AVG and T.I. AVG OPERATION CHECK

Equipment: Pulse generator

Procedure:

1. Connect the test equipment as described in Figure 5-9. It is essential that both cables to channels A and B are exactly equal in length.

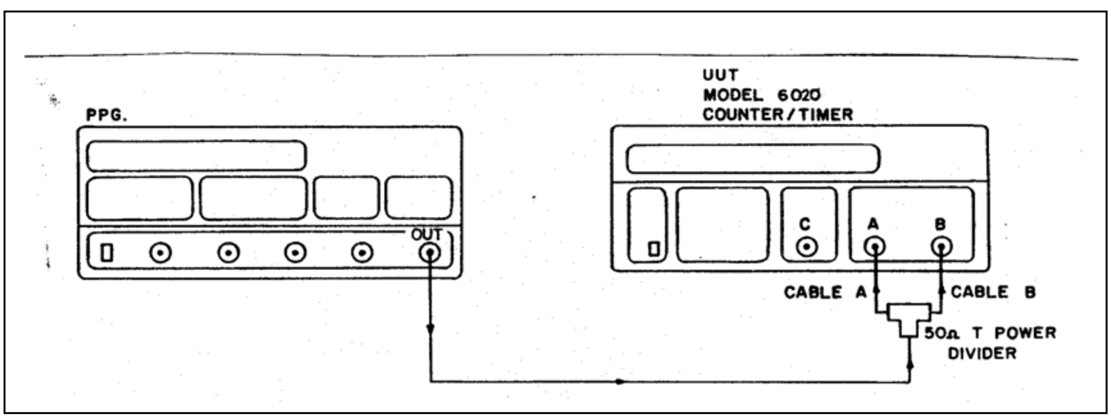


Figure 5-9. Pulse A, T.I A to B and Averaged Test Set-up.

2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [PLS A] and then [50Ω A&B].

3. Set Pulse generator parameters as follows:

Output Waveform - Pulse
Pulse Period - 8 μSec
Pulse Width - 2 μSec
Pulse Amplitude - 5 Vp-p
Pulse DC Offset - 0 V

4. Verify a stable counter readings as follows:

2.0 E-6 ±2 LSD or
2.00 E-6 ±11 LSD when option 1 is installed

5. Press [2nd] and then [AVG] to select PULSE A AVG.
6. Verify a stable counter readings as follows:

2.000 E-6 ±0.110 or
2.0000 E-6 ±0.1100 when option 1 is installed

7. Press [2nd] and then [AVG] to delete AVG function.
8. Select [T.I A to B] and [A] functions by pressing the appropriate push-buttons.
9. Verify a stable counter readings as follows:

6.0 E-6 ±2 LSD or
6.00 E-6 ±20 LSD when option 1 is installed

10. Select negative slope for Channel B.
11. Verify a stable counter readings as follows:

2.0 E-6 ±2 LSD or
2.00 E-6 ±11 LSD when option 1 is installed

12. Press [2nd] and then [AVG] to select T.I. A to B AVG.
13. Verify a stable counter readings as follows:

2.000 E-6 ±0.110 or
2.0000 E-6 ±0.1100 when option 1 is installed

5-13-6. PHASE A to B OPERATION CHECK

Equipment: Pulse generator

Procedure:

1. Connect the test equipment as described in Figure 5-10. It is essential that both cables to channels A and B are exactly equal in length.
2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [θ A-B], [A] and then [50Ω A&B].

3. Set Pulse generator parameters as follows:

Output Waveform	-	Square wave
Frequency	-	15 KHz
Amplitude	-	5 Vp-p
Offset	-	0 V
Symmetry	-	50%

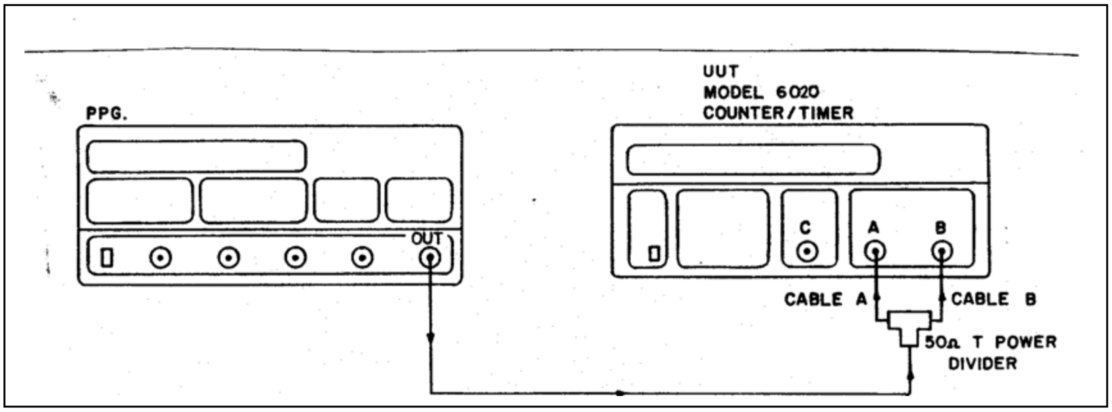


Figure 5-10. Phase A to B Test Set-up.

4. Verify a stable counter readings as follows:

180.00 ±2.00

5-13-7. TOTALIZE B OPERATION CHECK

Equipment: Pulse generator

Procedure:

1. Connect the test equipment as described in Figure 5-11.

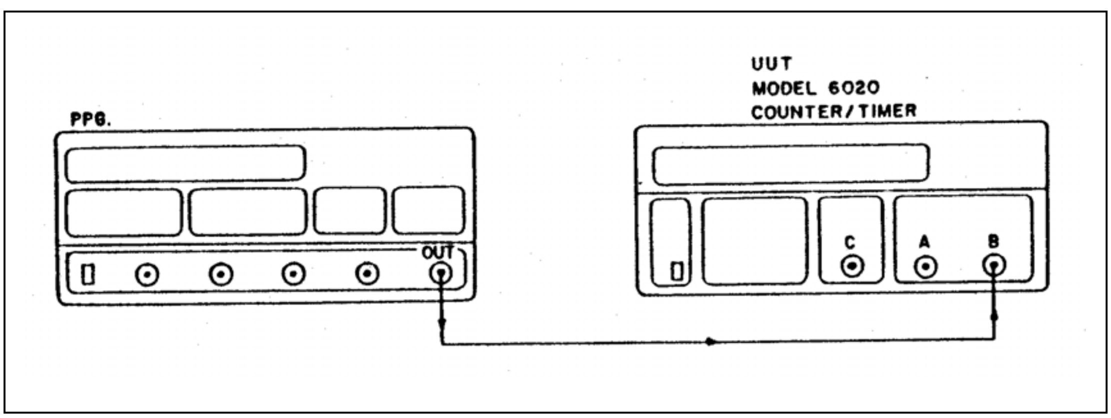


Figure 5-11. Totalize B Test Set-up.

2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [TOT B], [50Ω] and then [CLR].

3. Set Pulse generator parameters as follows:

Output Waveform	- Square wave		
Trigger Mode	- Burst	Trigger Source	- EXT.
Frequency	- 10 MHz	Trigger Slope	- Positive
Amplitude	- 5 Vp-p	Burst	- 349525

4. Press the pulse generator MANUAL trigger push-button. Verify a counter readings as follows:

349525

5. Again press the pulse generator MANUAL trigger push-button. Verify a counter readings as follows:

699050

5-13-8. AUTO TRIGGER LEVEL A and B OPERATION CHECK

Equipment: Pulse generator

Procedure:

1. Connect the test equipment as described in Figure 5-12.

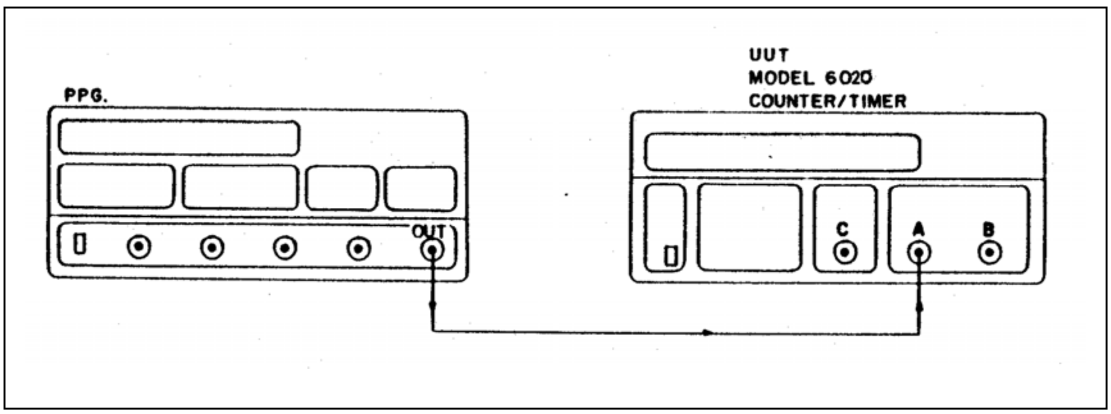


Figure 5-12. Auto Trigger A and B Test Set-up.

2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [50Ω A], [2nd], [AUTO TRIG] and then [TL A].
3. Set Pulse generator parameters as follows:

Output Waveform	- Square wave
Frequency	- 50 KHz
Amplitude	- 1.6 Vp-p
Offset	- 3.8 V
Symmetry	- 50%

4. Verify that trigger level A reading is as follows:

3.80 V ±0.20 V

5. Modify the connections in Figure 5-12 above so that the pulse generator will now be connected to Channel B.
6. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [FREQ B], [50Ω B], [2nd], [AUTO TRIG] and then [TL B].
7. Repeat the procedure above to verify Channel B auto trigger level operation.

5-13-9. DELAY OPERATION CHECK

Equipment: Pulse generator

Procedure:

1. Connect the test equipment as described in Figure 5-13.

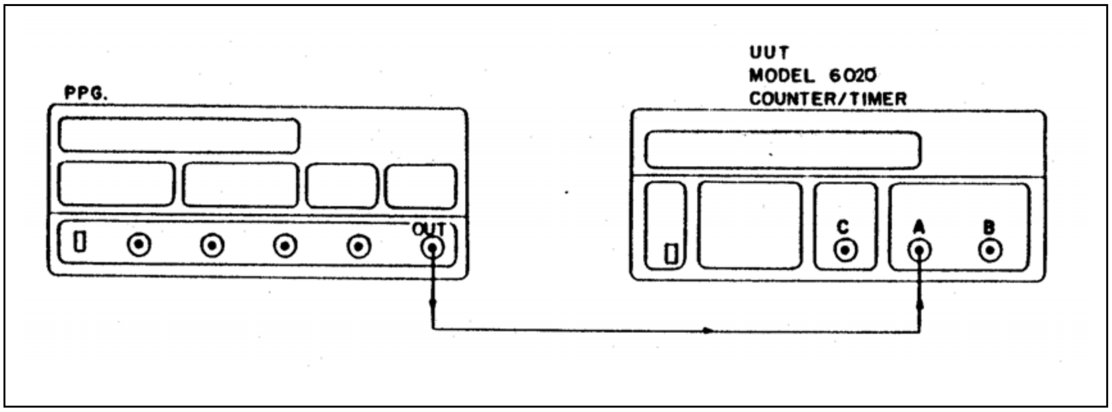


Figure 5-13. Delay Test Set-up.

2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [PER A], [50Ω], [2nd] and then [DELAY].
3. Set Pulse generator parameters as follows:

Output Waveform	- Square wave
Frequency	- 20 MHz
Amplitude	- 5 Vp-p
Offset	- 0 V
Symmetry	- 50%

4. Verify a stable counter reading as follows:

1 Sec ±5 mSec

5-13-10. USER GATE OPERATION CHECK

Equipment: Pulse generator

Procedure:

1. Connect the test equipment as described in Figure 5-14.

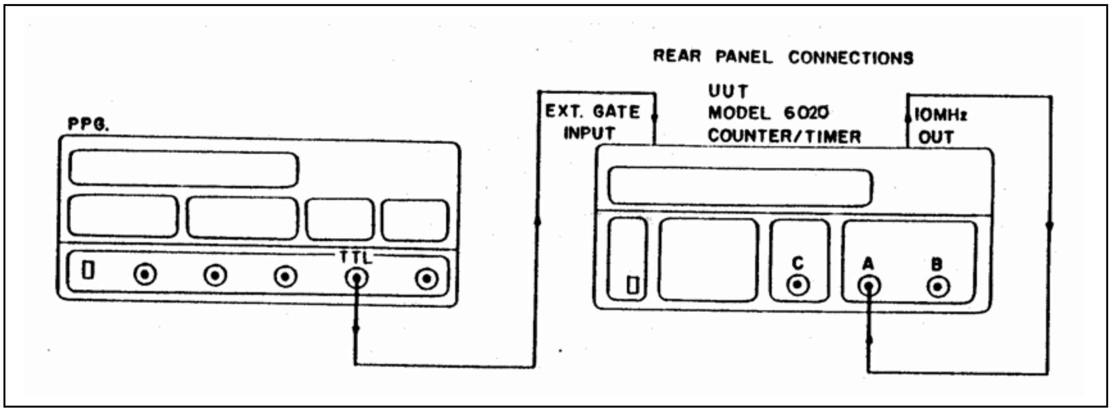


Figure 5-14. User Gate Test Set-up.

2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [50Ω] and then [AC A].
3. Select the USER GATE function on the counter. (Refer to section 3 paragraph 3-17).
4. Set Pulse generator frequency to 5MHz.
5. Verify a stable counter reading as follows:

    10.00000 E+6 ±1 LSD or
    10.000000 E+6 ±1 LSD when option 1 is installed

5-13-11. ANALOG OUTPUT OPERATION CHECK

Equipment: DMM

Procedure:

1. Connect the test equipment as described in Figure 5-15.
2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [50Ω], [AC A], [2nd] and then [A OUT].
3. Use the VERNIER UP bush-button to select the following reading on the display: (Refer to section 3 paragraph 3-21).

    _10.0_ _ _ _ _ or
    10.0_ _ _ _ _ _ with option 1 installed

4. Press [2nd] and then [OFST] push-buttons.

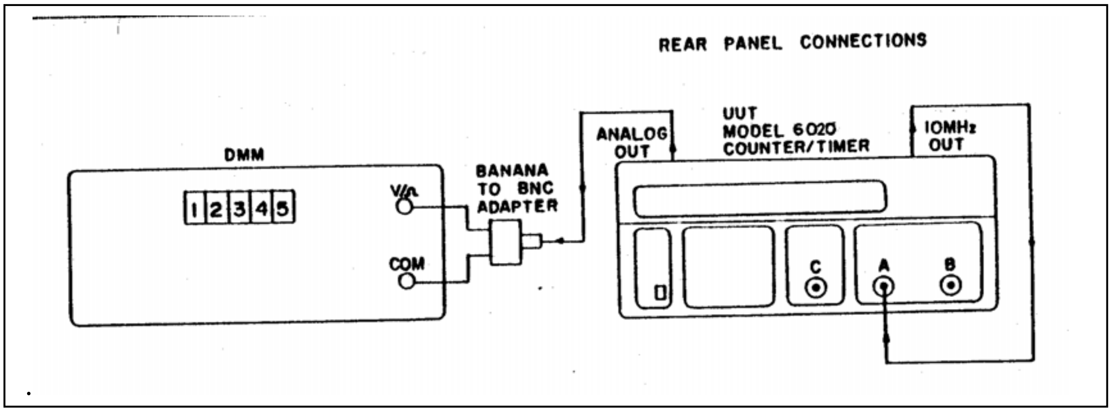


Figure 5-15. Analog Output Test Set-up.

5. Use the VERNIER UP bush-button to modify the offset to 800. (Refer to section 3 paragraph 3-21).
6. Verify a DMM reading as follows:

9.000 V ±0.005 V

5-13-12. TIME BASE ACCURACY CHECK

Equipment: 10 MHz standard

Procedure:

1. Connect the test equipment as described in Figure 5-16.

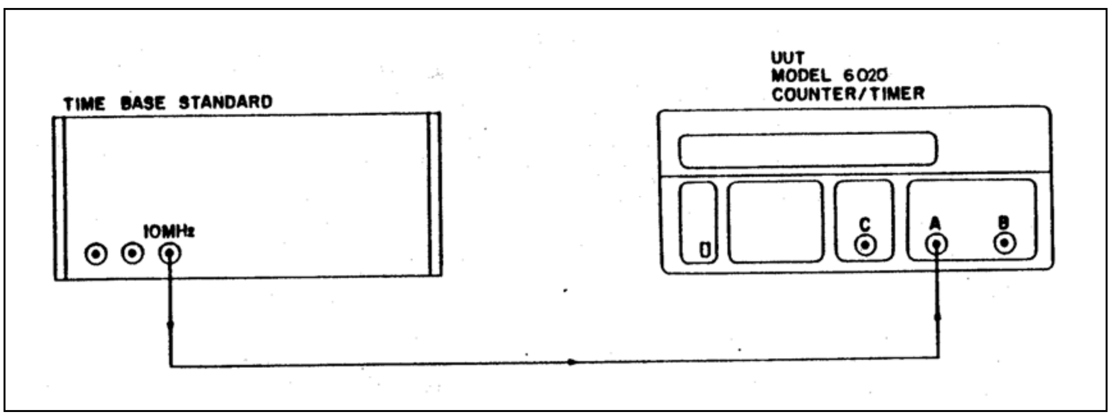


Figure 5-16. Time Base Accuracy Test Set-up.

2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [50Ω], [2nd] and then [AUTO TRIG].
3. Verify a stable counter reading as follows:

10.000000 E+6 ± 50 LSD or
10.0000000 E+6 ± 100 LSD with option 1 installed

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SECTION 6

THEORY OF OPERATION

6-1. INTRODUCTION

This section contains an overall functional description of the Model 6020 as well as detailed circuit analysis of the various sections of the instrument. Information pertaining to the standard IEEE interface and the various 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 component layout drawings are located at the end of this instruction manual.

6-2. OVERALL FUNCTIONAL DESCRIPTION

The Model 6020 is a 9 digit counter with 15 different measurement functions as standard and 1 additional measurement function as an option. The counter utilizes a modern technique which combines both reciprocal and conventional measurement techniques hence, increasing resolution in low frequency measurements as well as high frequency measurements; as compared to other available counters which utilize the more conventional-fixed-gate-time technique. As an example, a conventional counter measuring 1 KHz with a gate time of 1 second will display a resolution of 1 Hz where Model 6020 with the same gate time will always display a minimum of seven digits of resolution (eight digits with option 1).

The heart of the instrument comprises two counting registers; N1 and N2, two synchronizers, selectors and gates. Figures 5-1 and 5-2 demonstrate the inter-connection of these four elements. The Model 6020, while performing frequency measurements, will automatically determine which one of these configurations are to be used. The criteria for this decision is built into the software. However, under certain conditions the counter can only operate using the reciprocal technique (e.g. Frequency C and single shot frequency measurements).

During frequency measurement, using the reciprocal measurement technique (Figure 5-1). Selector 1 routes the input signal (F) to clock 1 (CLK 1). Selector 2 routes the reference clock signal to clock 2 (CLK 2). The gate time (GT) is generated by the CPU and is synchronized to the unknown input signal (CLK 1) in such a way that the synchronized gate time 1 (SGT 1) now has a period with an exact integer multiple of pulses from the unknown input signal. Counter N1 then totalizes the number of input pulses during the SGT 1.

Synchronizer #2 generates the synchronized gate time 2 (SGT 2) from SGT 1. SGT 2 now has a period with an exact integer multiple of pulses from the reference clock signal. Counter N2 totalizes the number of reference clock pulses (CLK 2). The CPU then computes the result to be displayed, using the following formula:

$$F = \frac{N1}{N2 \times T}$$

where; T = the period of the reference clock

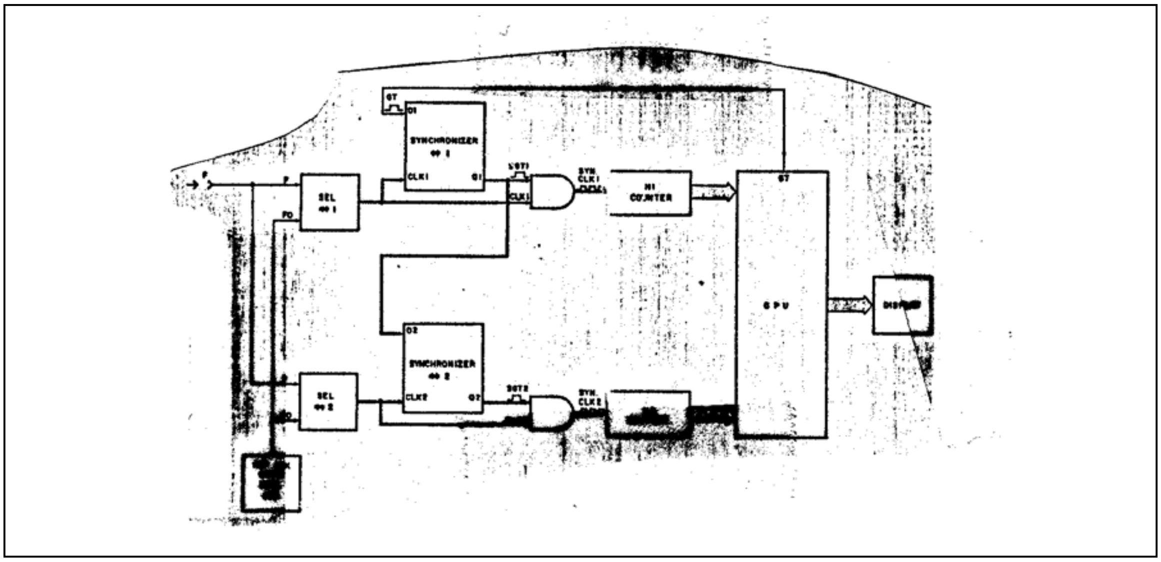

Figure 6-1. Reciprocal Frequency Measurement.

While performing frequency measurements above 10 MHz (100MHz with option 1), the inter-connection configuration is automatically changed to the conventional mode of operation, as shown in Figure 5-2.

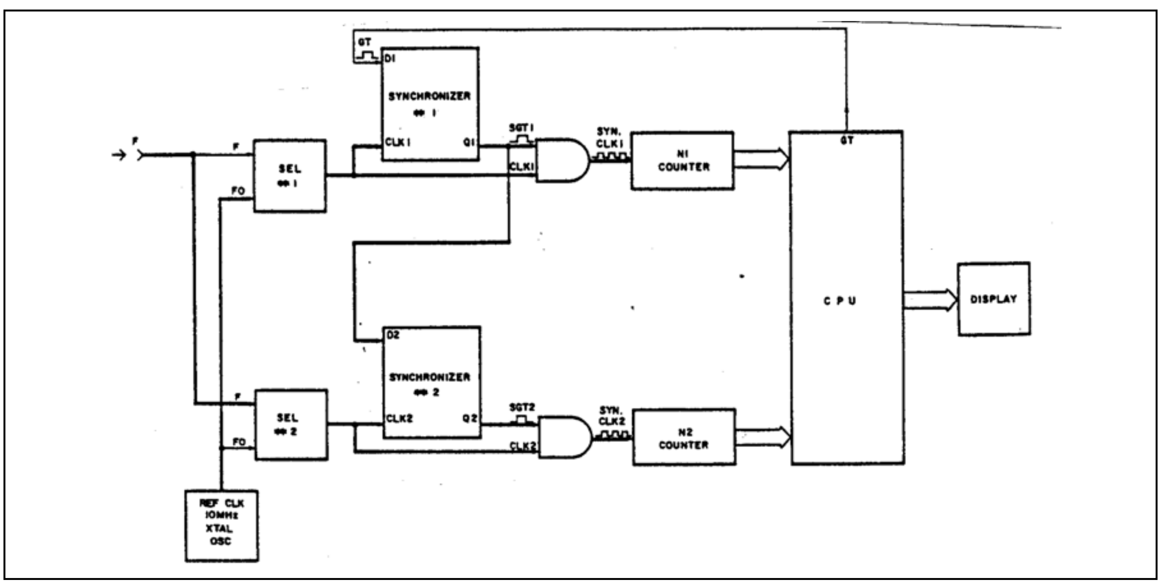

Figure 6-2. Conventional Frequency Measurement.

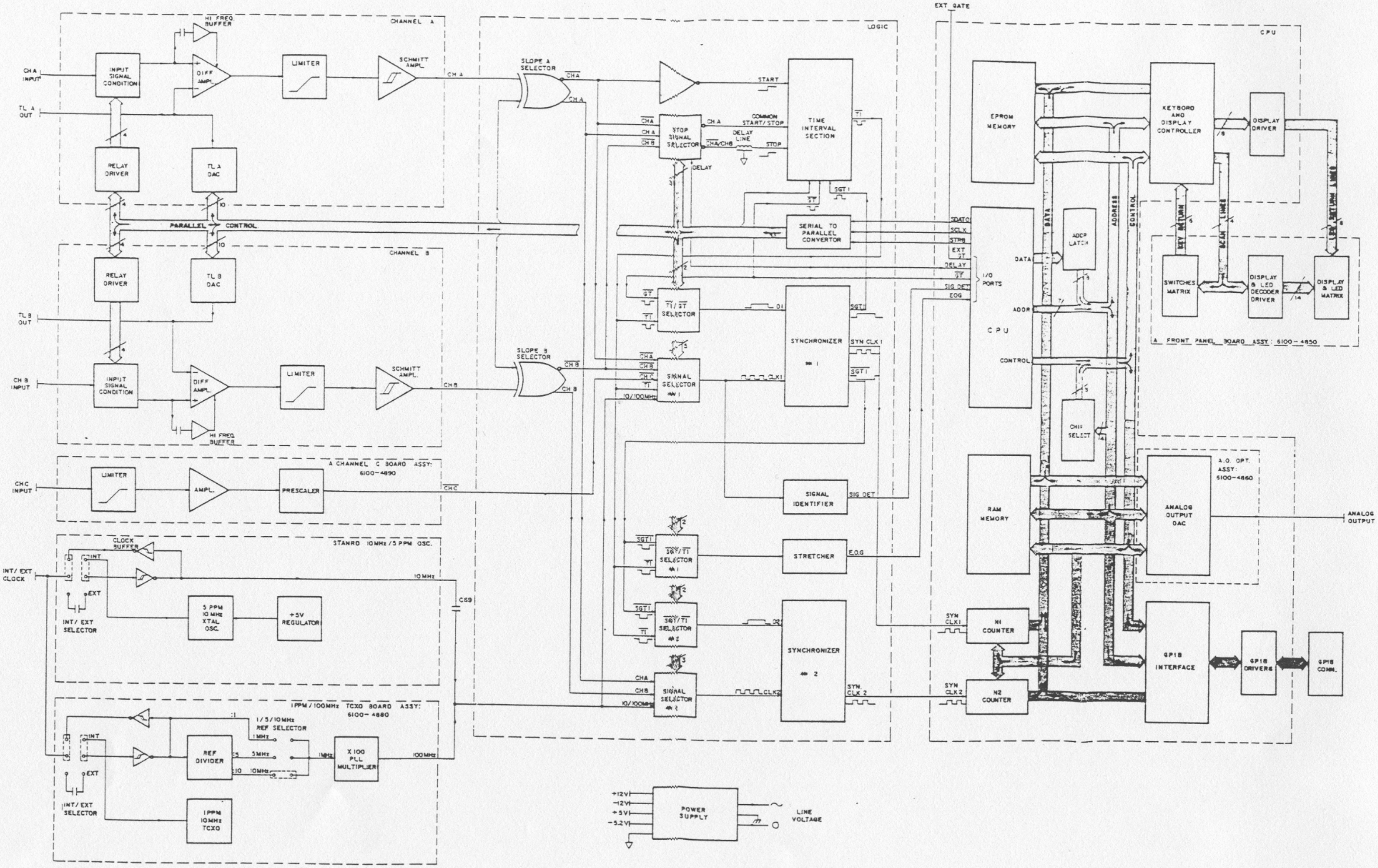

Figure 6-3. Model 6020 - General Block Diagram

In this case, selector 2 routes the input signal (F) to clock 2 (CLK 2). Selector 1 routes the reference clock signal to clock 1 (CLK 1). The gate time (GT) which is generated by the CPU is synchronized to clock 1 (CLK 1) in such a way that the synchronized gate time #1 (SGT 1) now has a period with an exact integer multiple of the reference clock pulses. Counter N1 then totalizes the number of the reference clock pulses during SGT 1. Synchronizer #2 generates the synchronized gate time 2 (SGT 2) from SGT 1. SGT 2 now has a period with an exact integer multiple of pulses from the input signal (F). Counter N2 totalizes the number of input signal pulses (CLK 2). The CPU then computes the result to be displayed, using the following formula:

$$F = \frac{N2}{N1 \times T}$$

where; T = the period of the reference clock (CLK)

A simplified block diagram of the complete Model 6020 is given in Figure 5-3. The input signal is applied through the input amplifiers to switching circuits which in turn routes the signals to the correct counting circuits. If channel C is installed, a signal from the Channel C input terminal will pass through the channel C input amplifier to the internal selectors. The CPU, working under software control, then converts the signals into a form suitable for displaying on the front panel or for the IEEE bus.

6-3. ANALOG CIRCUITRY

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

6-3-1. Input Circuits A and B

NOTE

> Channels A and B are identical in terms of components and operation. Therefore, the following description, which reviews only 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 terminal 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 C1. When instrument is DC coupled, K1 contacts are closed. When instrument is AC coupled, K1 contacts are open and C1 blocks the DC components of the input signal.

Attenuation: Attenuation is controlled by relay K3, resistor network R3 and R39 and capacitor network C3 and C6. When K2 shorts between contacts 1 and 7, R3 and C6 are shorted and there is no attenuation. Actuating K2 shorts between contacts 7 and 14 thereby introduces a x10 voltage attenuation.
Filtering: The low pass filter is controlled by relay K4. Contacts on K3 are normally closed; shorting R6. When the relay contact open, the impedance of R16 and the capacitance of Q2 act as a low pass filter.
Termination: Termination is controlled by relay K2. Relay is normally open leaving a 1 MΩ impedance (R4+R5) in front of the input amplifier. When the relay contacts are closed, the input impedance is shunted by R1 and R2 (50Ω)
Input Protection: Front panel input conditioning are capable of handling signals within the specified dynamic range of the Model 6020. Protection of the input circuit from over-voltage signals (up to the specified limits) are done by R4, clipping diodes within U10, C8, R7, CR 2 and Q2.
Amplifier: The amplifier comprises a band split/differential amplifier. This section consists of a high frequency amplifier - Q2 and low frequency differential amplifier - U10 and Q5. The two bands are summed at the junction of R12 and R10 and then buffered by Q3. The diode network - CR5 to CR8 limit the amplitude of the signal which is then applied to the comparator U12a. U12a operates as a Schmidt trigger amplifier which translates, for the preceding stages, the various input waveforms to the appropriate ECL logic levels.
Trigger Level Control: The trigger level control circuit generates a DC voltage which is directly proportional to the required input threshold point. This voltage is then applied through R22 to the negative input of the differential amplifier which was previously discussed. U7 and U6 are a serial to parallel converters which control the D to A converter - U8, U9a U9b and their associated components. The output of U9b generates a dc voltage in the range of -5 V to +5 V. This voltage is then applied, in parallel, to the rear panel TRIGGER LEVEL A and through the voltage divider R21 and R35 to the negative input of the differential amplifier.

6-3-2. 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 CR4, CR12 and CR13 to the input of the first stage amplifier. The amplifier consists on a two stage amplifiers. 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. The output is also coupled through C23 to a peak level detector CR10 and C25, comparator U2 and its associated components. When the amplitude level at the input of U1 is insufficient to successfully operate it, the emitter of Q6 is forced to ECL high level thus eliminating false oscillation of U1 to be sensed by the following stage.

6-3-3. 10MHz Standard Reference Oscillator

The reference oscillator circuit comprises an hybrid oscillator U57, buffers U56 and voltage regulator U55. C124, C125 and C126 adjust the oscillator frequency to a known reference. C124 is a coarse adjust and C126 is a fine adjustment. LK1a/b is used for selecting between an internal reference which is generated by U57 and external reference frequency which may be applied to a rear panel BNC connector. CR35, CR36, C120 and R192 protects the rear panel input against accidental overloads. U56d is configured as a Schmidt trigger circuit which converts the external amplitude level to TTL level.

6-3-4. 10 MHz TCXO Reference Oscillator and x10 Multiplier (Option 1)

Option 1 board performs two tasks; a) Improving the temperature stability of the internal reference to 1PPM and b) multiplying the reference frequency, either internal or external, to 100 MHz.

The TCXO reference oscillator circuit comprises U1, U2 and input protection circuit CR1, CR2, C2 and R1. U2b buffers the TCXO output. U2c buffers the 10 MHz to the rear panel BNC connector. LK1a/b is used for selecting between an internal reference which is generated by U1 and external reference frequency which may be applied to the rear panel BNC connector. CR1, CR2, C2 and R1 protects the rear panel input against accidental overloads. U2d is configured as a Schmidt trigger circuit which converts the external amplitude level to TTL level.

The reference frequency is divided by U3 to 1MHz and then is phase locked and internally multiplied to generate a stable 100MHz. The 100 MHz signal is related both in phase and accuracy to the reference oscillator.

The 1MHz signal from the selected reference is applied to the phase detector - U5. U5 compares the phase from U4 to the phase of the reference signal. U4 divides the VCO frequency, coming from U7, by 100 to generate the feedback signal to the phase comparator. U6 operates as a low pass filter to smooth the correction pulses from the output of U5. The dc level at the output of U6, controls through CR3 the oscillation frequency of U7. Q1 buffers the 100 MHz signal for the next stage. U2a senses the presence of the reference signal and blocks the 100 MHz signal to the next stage when the external signal is outside of the locking range of the phase lock circuit.

6-3-5. Measurement Logic Section

The measurement logic 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 main registers N1 and N2 for the CPU. Figures 5-4 to 5-9 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 logic section

Control: The control circuit consists of U15, U14 and U13. Information from the CPU is sent in a serial form to the control ics which in term convert the serial information to a parallel format. The parallel outputs of these ICs are being used to control the signal selectors, and the signal routing to the various sections within the measuring logic section. Q11 through Q13 convert the TTL logic levels from the CPU to an appropriate voltage levels for U15 (0 V to -5.2 V).

Signal Selector: The signal selector circuit comprises U19, U20, U21, U25, and U26. The function of the signal selector is to route one of Channel A input, Channel B input, Channel C input or the reference clock to the appropriate processing sections.

Time Interval Section: The time interval section circuit consists of a dual D flip-plop U17a/b and gates U18a,b and c and U19b. U17a receives the start signal and U17b receives a stop signal. Following a reset signal at the reset input of U17a/b, U18c simultaneously produces a single positive pulse (TI) and its complement 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. While performing time averaged measurements, these pulses will repeat as long as the gate stays open.

Synchronizer #1: The synchronizer #1 consists of a D flip flop U22b and a gate U26b/d and their associated components. During reciprocal frequency measurement, a gate signal is applied from the CPU to the D input of U22d 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 U22b will generate a pulse with an approximate width of the original gate signal from the CPU, 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 synchronized #1 (SGT 1) gating signal throughout the instrument. In conventional frequency measurements, in the above description, the gate time is synchronized to the reference clock. SGT 1 opens the gate U26d for the appropriate signal to be later divided and counted by N1 dividing chain.

Synchronizer #2: The synchronizer #2 consists of a D flip flop U29b, gate U28d and their associated components. During reciprocal frequency measurement, SGT 1 signal is applied to the D input of U29b. at the same time, the reference clock is applied to the CLK input on the same IC. the output of U29b will generate a pulse SGT 2 with an approximate width of SGT 1, but with a new adjusted width which is equal to an integer number of periods of the reference clock. In conventional frequency measurements, in the above description, the gate time is synchronized to the input signal. SGT 2 opens the gate U28d for the appropriate signal to be later divided and counted by N2 dividing chain.

Signal Identifier: The signal identifier comprises U22a and U31a and their associated components. A signal when present at the appropriate input terminal, is applied to the CLK input of U22a, converted to a TTL level signal with U31a and then fed to a CPU port 1.1. This port is later on being used to flag the presence of a signal at the input terminals. This signal is also used as the arming signal of the counter.

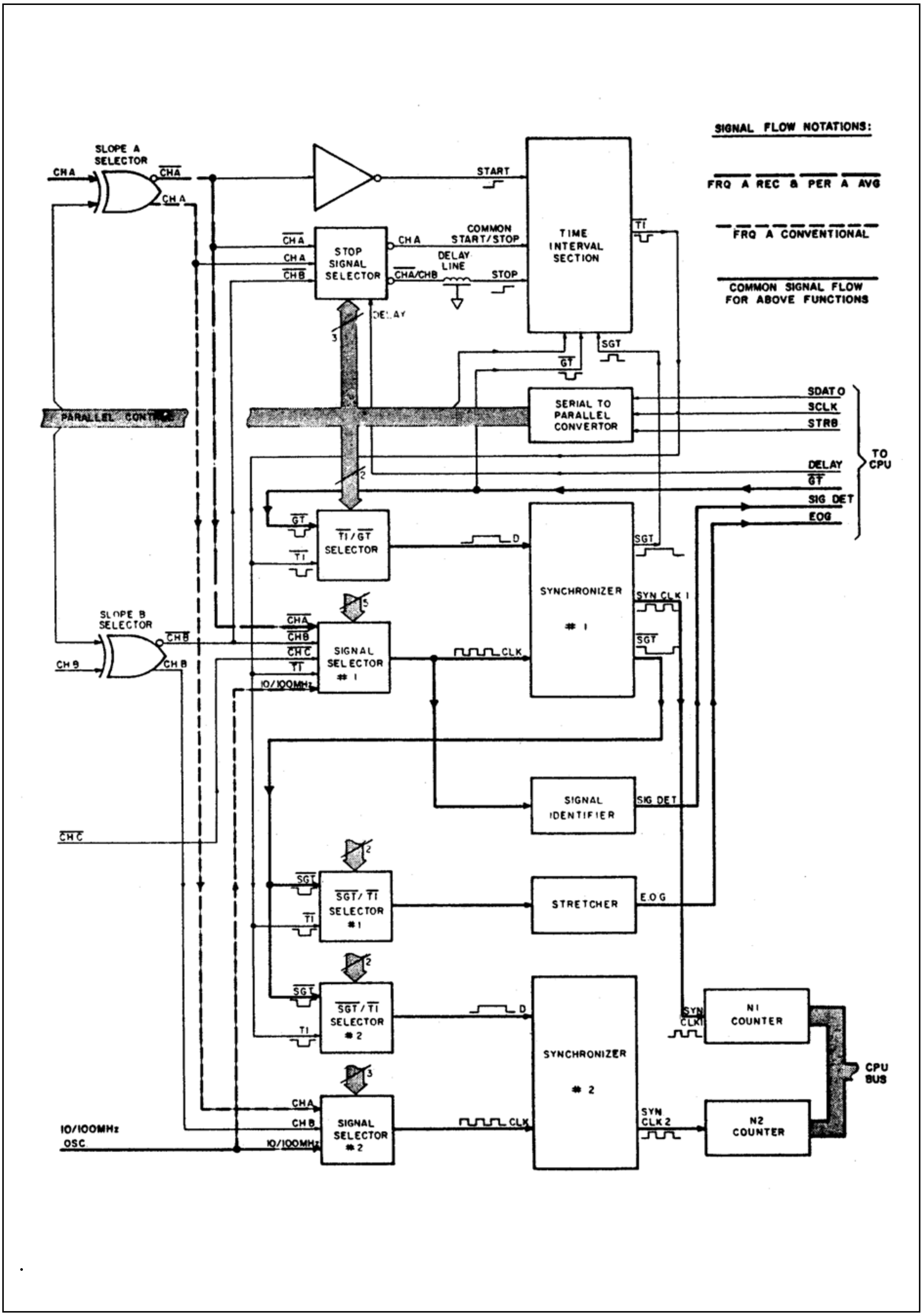

Figure 6-4. FREQ A Reciprocal/PER A Averaged and FREQ A Conventional Signal Flow Diagram.

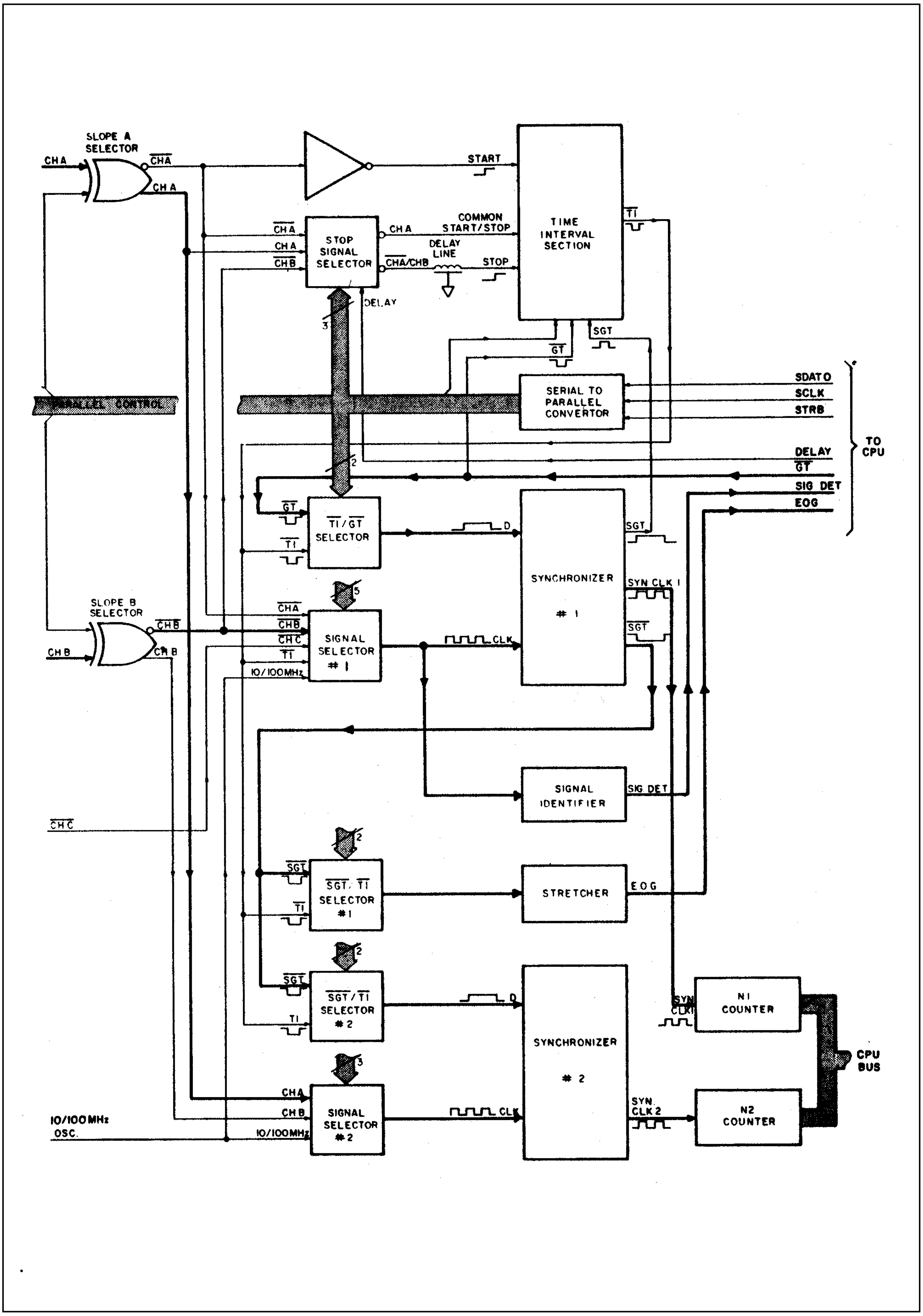

Figure 6-5. Frequency Ratio A/B Signal Flow Diagram.

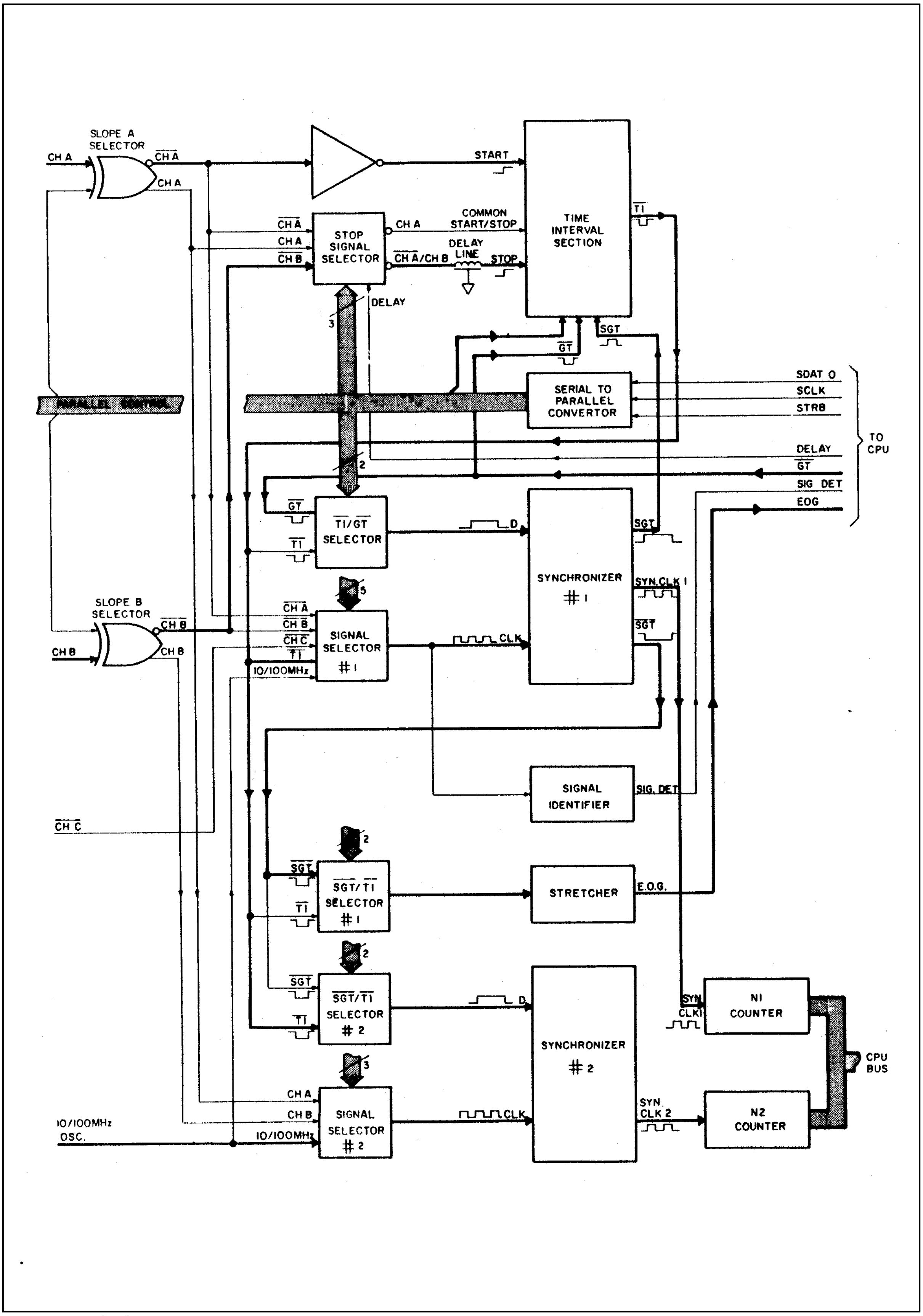

Figure 6-6. PER A and T.I A to B Signal Flow Diagram.

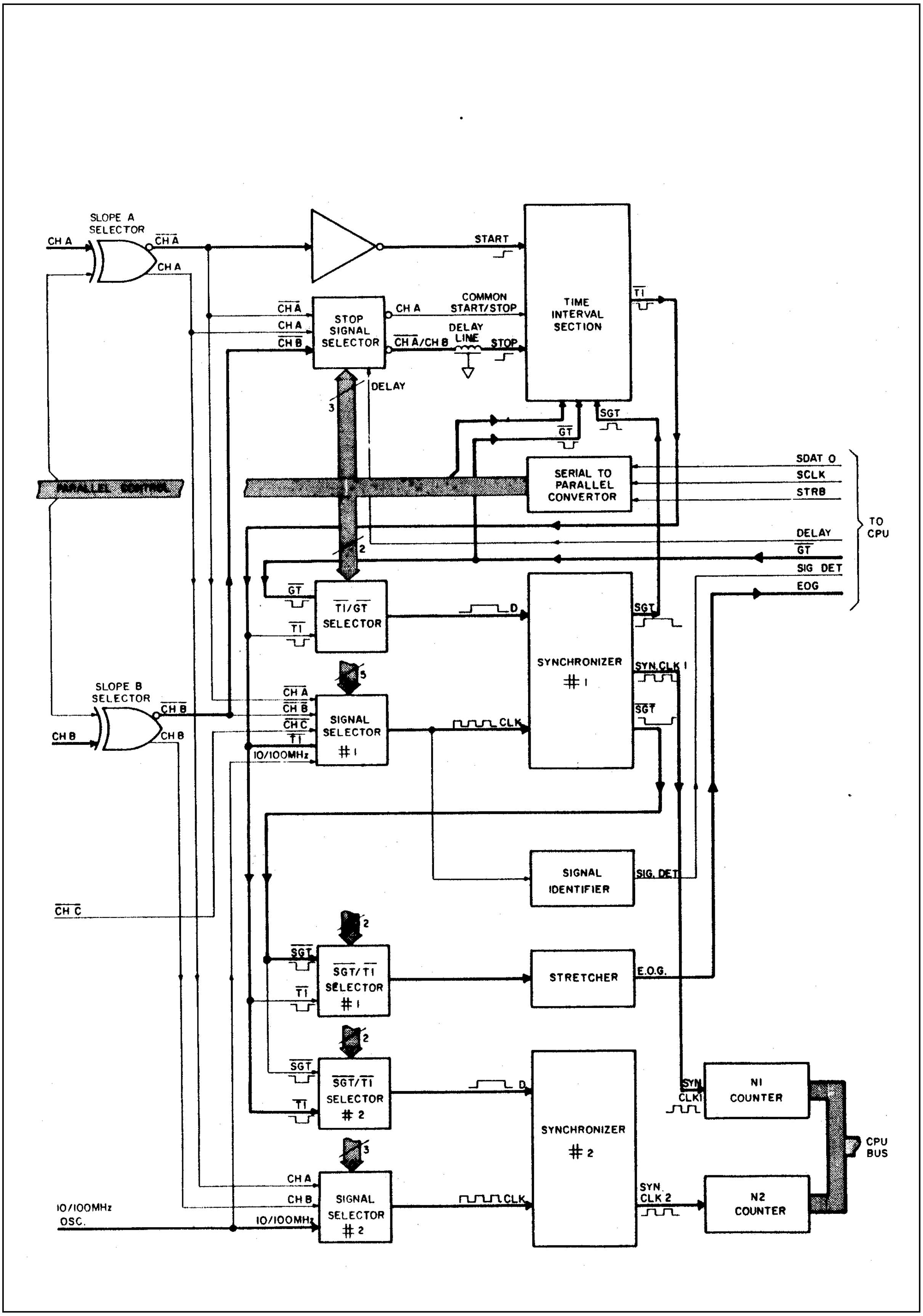

Figure 6-7. Pulse A Averaged and T.I A to B Averaged Signal Flow Diagram.

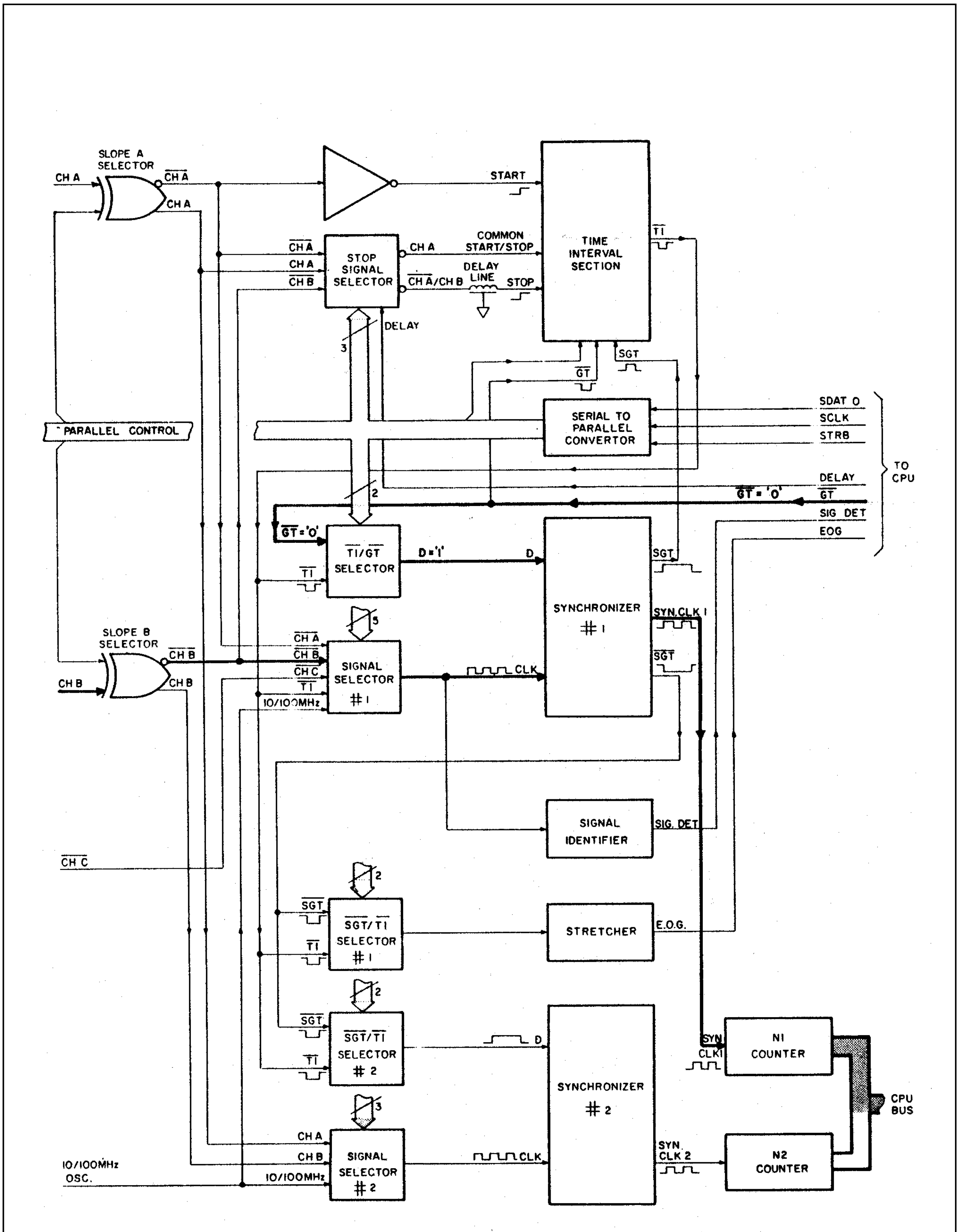

Figure 6-8. Totalize B Infinite Signal Flow Diagram.

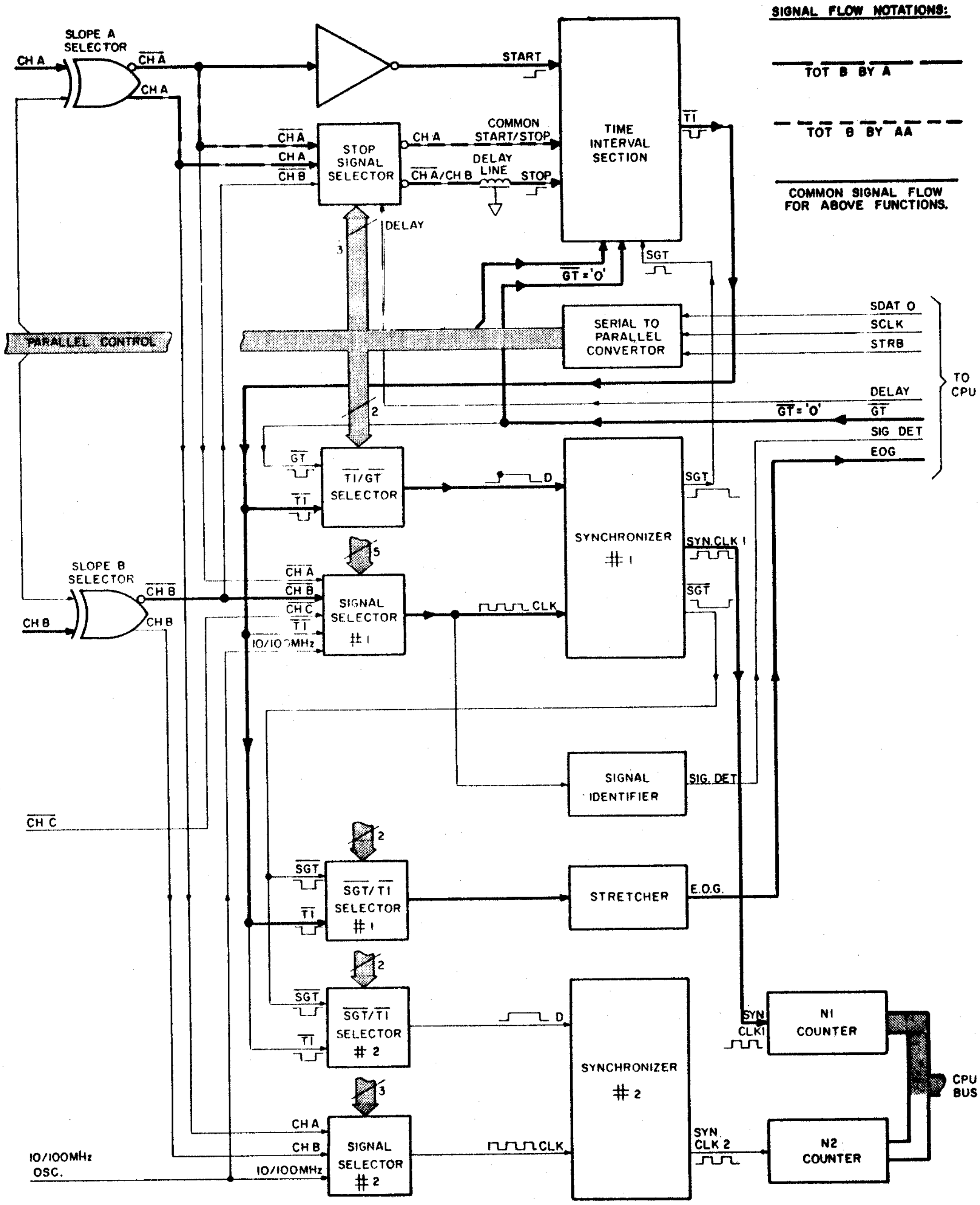

Figure 6-9. Totalize B By A and Totalize B By AA Signal Flow Diagram.

Gate Identifier: The gate identifier informs the CPU on the state of the synchronized gate time #1. The gate identifier circuit also serves as a time stretcher of gate signals with very small periods. The gate identifier consists of U26a, U26c, U31d, R158 and C86.
N1 Counter Chain: The N1 counter chain comprises U30b, U31c, U27a, U23a, U46a and U44 and their associated components. U30b, U27a, U23a and U46a are configured as 7 bit binary up counter with its output connected to U44. U44 is a 32 bit counter with its outputs connected to the data bus. U31c converts the ECL logic level from U30b to TTL.
N2 Counter Chain: The N2 counter chain comprises U29a, Q15, U30a, U31b, U27b, U23b, U46b and U45 and their associated components. U29a, U30a, U27b,U23b and U46b are configured as 8 bit binary up counter with its output connected to U45. U45 is a 32 bit counter with its outputs connected to the data bus. Q15 and U31b convert the ECL logic level from U29a and U30a respectively to TTL.

6-3-6. Analog Output Option

The analog output option converts digital information, which is received from the CPU on the data bus, to an analog dc voltage. The dc voltage may range from 0 V to +9.99 V. The analog output section comprises a D/A converter U59, chip select gates U58a/d and their associated components. U59 receives parallel data from the CPU and converts this data to dc levels. LK3 has to be shorted so that the CPU will sense that this option is installed. With LK3 removed, the CPU will simply ignore front panel programming which is associated with this option. The dc voltage from the D/A converter is then routed to the rear panel BNC connector designated as ANALOG OUTPUT.

6-3-7. Power Supply

For the following discussions, 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 monolithic regulators and two discrete regulators which is formed by U52, Q30, Q31, Q32, 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.

CR25 is used as a full-wave rectifier to provide a sufficient DC voltage for the +12 V and -12 V regulators U50 and U51 respectively.

U52b receives a reference voltage of +5 V from the +12V supply. This reference is then compared to the regulated +5 V. U52b then controls through Q30 the current through the series pass transistor - Q31.
The +5 V supply then acts as the reference for the -5.2 V regulated supply. The operation of U52a is similar to the operation of U52b except, U52a operates as an inverting amplifier. CR 29 and CR30 protect the +5 V and the -5.2 V respectively against accidental over-voltage.

6-4. DIGITAL CIRCUITRY

Model 6020 operation is supervised by the internal CPU. Through the CPU, 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 CPU and associated digital circuitry. A simplified block diagram is included for user reference; for more complete circuit details refer to digital schematics at the end of this manual.

6-4-1. CPU Block Diagram

A block diagram of the Model 6020 CPU is shown in Figure 5-3. Circuit operation centers around the CPU unit, U39. The 8031 is an 8-bit CPU capable of directly addressing up to 64K bytes of program memory (ROM) and up to another 64K bytes of data memory (RAM). The CPU works with a 10 MHz clock which is divided internally to provide a bus operation of about 1MHz.

Software for the CPU is contained in an EPROM (Erasable Programmable Read-Only Memory). U42 is a 27128 EPROM containing 16K bytes of software. Temporary storage is provided by U43, RAM's (Random Access Memory) which can store up to 2048 bytes of information.

Interfacing between the CPU and the IEEE bus is performed by dedicated IEEE-488 bus interface IC, U36. This IC performs many bus functions automatically to minimize CPU overhead. Buffering between the 8291 IC and the IEEE bus lines is done with bus drivers U21 and U22.

Interfacing between the CPU to the keyboard and the display is performed by the Keyboard/Display interface IC - U36.

6-4-2 Memory Mapping

The 8031 CPU is capable of directly addressing two banks of 64k (65,536) bytes 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 CPU. Although the CPU has this large addressing capability, only a portion of the possible memory space is actually needed.

The Model 6020 uses a total of 16K of program memory stored in the 27128 EPROM U43, and a total of 1K of data memory is stored in U10 and. The 8031 CPU uses a memory-mapped I/O scheme, additional memory location must be allocated for the various I/O function. 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.

6-4-3. Address Decoding

The CPU 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 witch is done by U40 address latch. Since no memory or interface element can fully decode address locations, additional address decoding must be used.

U38 is 1-of-8 decoder. The decoder is enabled when address lines A15 is HIGH. Once the decoder is selected the decoding is done by addressing lines A11, A12 and A13.

Table 6-1. Model 6020 Memory Mapping

Selected Device/Operation	Allocated Memory	Actual Memory Location	Address Lines A15 A13 A12 A11
Strobes for shift registers	8000H - 87FFH	8000H	1 0 0 0
Digital to analog converters	8800H - 8FFFH	880EH, 880DH 8803H	1 0 0 1
GPIB interface	9000H - 97FFH	9000H - 9007H	1 0 1 0
RAM	9800H - 9FFFH	9800H - 9BFFH	1 0 1 1
Hardware reset	A000H - A7FFH	A000H	1 1 0 0
N1 & N2 counters	A800H - AFFFH	A800H	1 1 0 1
Key board and display controller	B000H - B7FFH	B000H, B001H	1 1 1 0
Scan reset for counters N1 & N2	B800H - BFFFH	B800H	1 1 1 1

6-4-4. Keyboard/Display Interface

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

6-4-5. IEEE Interface

The Model 6020 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 U47, a 8291 GPIA (General Purpose Interface Adapter), and U48 and U49, which are interface bus drivers. On the CPU side of the GPIA, data transmission is handled much like any other bus transaction. The CPU accesses the GPIA through the usual D0 through D7 data lines. Address decoding for the internal 14 registers (7 read and 7 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 (DIO1 through DIO8) 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, U48 and U49 are necessary to bring the drive capability of the interface up to the normal IEEE maximum 15 devices.

The GPIA simplifies CPU 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, complicated CPU routines would be required to accomplish control sequence that are performed automatically.

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SECTION 7

ADJUSTMENTS AND TROUBLESHOOTING

7-1. INTRODUCTION

This section contains information necessary to adjust and troubleshoot the Model 6020, the TCXO and time base multiplier (option 1), the 1.3 GHz channel C input (option 2) and, the analog output (option 3).

WARNING

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

7-2. ADJUSTMENTS

7-2-1. Environmental Conditions

Adjustments should be performed under laboratory conditions having an ambient temperature of 25 ±5 °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.

7-2-2. Warm-Up Period

Most equipment is subject to at least a small amount of drift when it is first turned on. To ensure long-term calibration accuracy, turn on the power to the Model 6020 and allow it to warm-up for at least 30 minutes before beginning the adjustment procedure.

7-2-3. Recommended Test Equipment

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

7-2-4. Adjustment Procedures

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

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 screw-driver when adjusting the time base trimmer as other material will cause confusion in this adjustment.

Refer to Figure 7-1, throughout the following adjustment procedures, for determining adjustment points. Follow the procedure in the sequence indicated because some of the adjustments are interrelated and dependent on the proceeding steps.

Verify that Model 6020 is functioning according to the performance checks. Make sure that all results are within, or close to, the range of the required specifications, otherwise refer to the troubleshooting procedures given later in this section.

Center all trimmers and if necessary, remove selected components and clear the holes to allow a selection of new components.

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

7-3. ADJUSTMENT PROCEDURE

7-3-1. POWER SUPPLY ADJUSTMENT

Equipment: DMM

Procedure:

1. Set DMM to DCV measurements. Connect the DMM between ground and the +5 V test point.
2. Adjust R190 for a DMM reading of +5.000 V ±10 mV dc.

7-3-2. TRIGGER LEVEL A ADJUSTMENT

Equipment: DMM, dc voltage calibrator

Procedure:

1. Set DMM to DCV measurements.
2. Set [TL A] to 0.00 V.
3. Measure and record the voltage at U12 pin 8. Record this voltage with a resolution of ±0.001 V.
4. Set [TL A] to 5.00 V.
5. Set dc calibrator output setting to +5.000 V.
6. Using a banana to BNC adapter, connect the calibrator output to the Channel A input connector.
7. Re-connect the DMM probes to U12 pin 8 and adjust R80 to obtain the same voltage level as recorded in step 3.

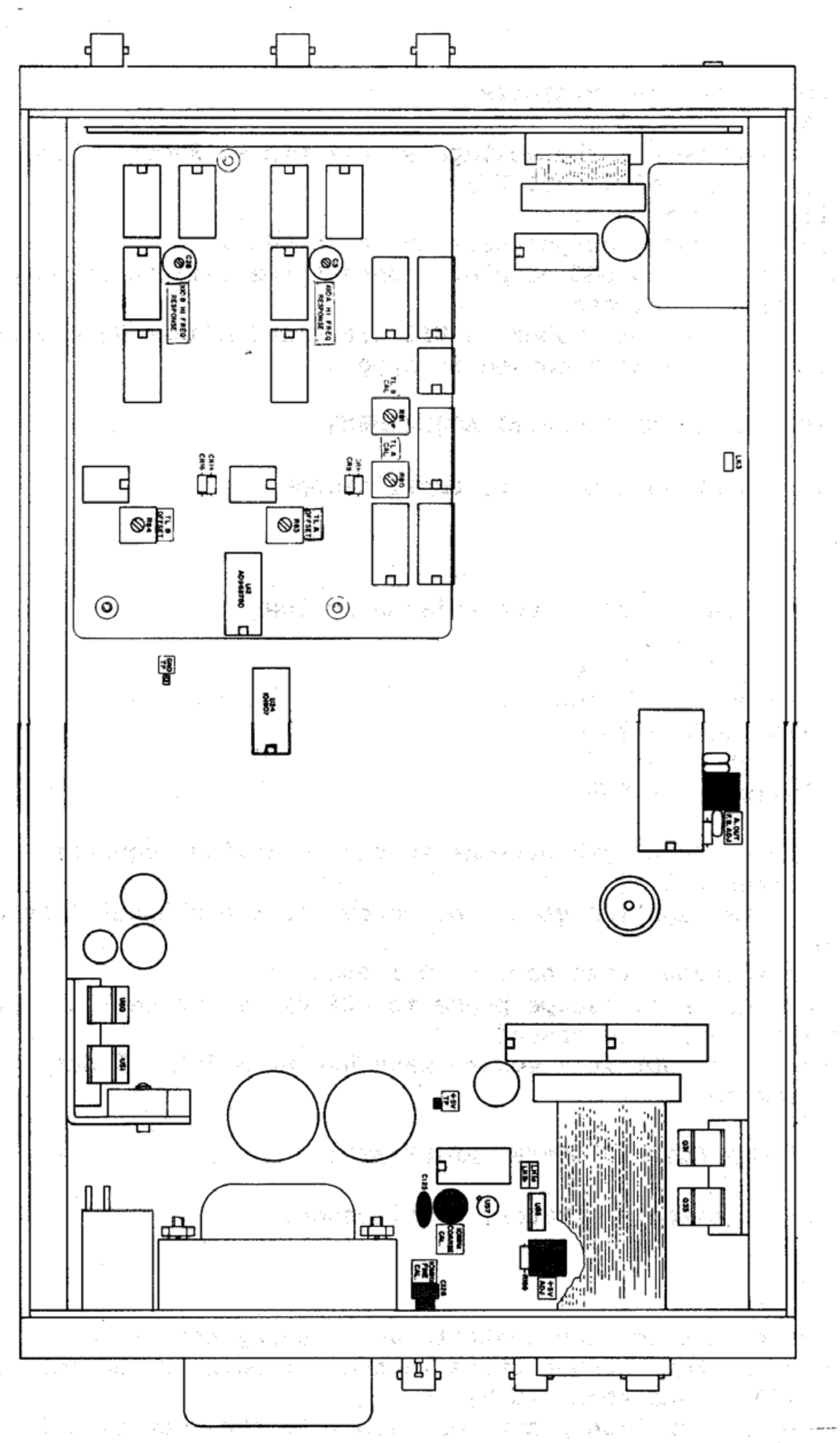

Figure 7-1. Model 6020 Adjustment Points Location.

7-3-3. TRIGGER LEVEL B ADJUSTMENT

Equipment: DMM, dc voltage calibrator

Procedure:

1. Set DMM to DCV measurements.
2. Set [TL B] to 0.00 V.
3. Measure and record the voltage at U12 pin 9. Record this voltage with a resolution of ±0.001 V.
4. Set [TL B] to 5.00 V.
5. Set dc calibrator output setting to +5.000 V.
6. Using a banana to BNC adapter, connect the calibrator output to the Channel B input connector.
7. Re-connect the DMM probes to U12 pin 9 and adjust R81 to obtain the same voltage level as recorded in step 3.

7-3-4. TRIGGER LEVEL A OFFSET ADJUSTMENT

Equipment: Function generator, oscilloscope

Procedure:

1. Set function generator controls as follows:

    Waveform - Sine
    Frequency - 1 KHz
    Amplitude - 25 mVp-p
    Offset - 0 V
    Symmetry - 50%

2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL] and then [AC A].
3. Connect the function generator output to the Channel A input connector.
4. Set oscilloscope time base to 0.1 mSec/div.
5. Connect the oscilloscope probe to U24 pin 9. Connect the ground lead from the probe to ground.
6. Adjust R83 to obtain a square wave having a 50% ñ1% duty cycle on the oscilloscope.

7-3-5. TRIGGER LEVEL B OFFSET ADJUSTMENT

Equipment: Function generator, oscilloscope

Procedure:

1. Set function generator controls as in paragraph 7-3-4.
2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [FREQ B] and then [AC B].
3. connect the function generator output to the Channel B input connector.
4. Set oscilloscope time base to 0.1 mSec/div.
5. Connect the oscilloscope probe to U24 pin 14. Connect the ground

lead from the probe to ground.
6. Adjust R84 to obtain a square wave having a 50% ±1% duty cycle on the oscilloscope.

7-3-6. INPUT A x10 HIGH FREQUENCY ADJUSTMENT

Equipment: Function generator, oscilloscope

Procedure:
1. Set function generator controls as follows:

Waveform - Square wave
Frequency - 10 KHz
Amplitude - 5 Vp-p
Offset - 0 V
Symmetry - 50%

2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [50Ω A] and then [x10 A].
3. connect the function generator output to the Channel A input connector.
4. Connect the oscilloscope probe to the cathode of CR6. Connect the ground lead from the probe to ground.
5. Set oscilloscope and adjust C3 to obtain the best square wave response having minimum overshoot and undershoot.

7-3-7. INPUT B x10 HIGH FREQUENCY ADJUSTMENT

Equipment: Function generator, oscilloscope

Procedure:

1. Set function generator controls as in paragraph 7-3-5.
2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [FREQ B], [50Ω B] and then [x10 B].
3. Connect the function generator output to the Channel B input connector.
4. Connect the oscilloscope probe to the cathode of CR14. Connect the ground lead from the probe to ground.
5. Set oscilloscope and adjust C28 to obtain the best square wave response having minimum overshoot and undershoot.

7-3-8. STANDARD - 5PPM TIME BASE ADJUSTMENT

Equipment: 10 MHz Standard

Procedure:

1. The following adjustment must be performed in a stable temperature environment of 25°C ±2°C. Remove the top cover and set C126 to about mid-range. Replace the top cover. Power-up Model 6020 and allow it to operate, for at least « an hour, with its covers closed.
2. Press Model 6020 push-buttons in the following sequence: [2nd],

[DCL] and then [50Ω B].
3. Connect the 10 MHz standard to the Model 6020 Channel A.
4. Remove the top cover and adjust C124 to give a reading of:

10.000000 E+6 ± LSD

If range can not be reached, select C125 (in the range of 8 - 10pF) to bring C124 within range.
5. Replace the top cover and allow the Model 6020 to operate with the covers on for an additional period of 15 minutes.
6. Using a plastic material screwdriver, adjust C126 from the rear panel to give a display reading of:

10.000000 E+6 ±2LSD.

If range can not be reached, repeat steps 4 through 6.

7-3-9. TCXO TIME BASE ADJUSTMENT (option 1)

Equipment: 10 MHz Standard

Procedure:

1. The following adjustment must be performed in a stable temperature environment of 25°C ñ2°C. Remove the top cover, refer to Figure 5-1 and remove the adjustment plug at the top of the oscillator bulk. Replace the top cover. Power-up Model 6020 and allow it to operate, for at least « an hour, with its covers closed.
2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL] and then [50Ω A].
3. Connect the 10 MHz standard to the Model 6020 Channel A.
4. Remove the top cover and using a plastic-tip screwdriver, adjust the trimming capacitor on top of the TCXO to give a reading of:

10.0000000 E+6 ±10 LSD

5. Replace the adjustment plug and the top cover and allow the Model 6020 to operate with the covers on for an additional period of 15 minutes.
6. Check if frequency is still in the range as in step 4. If reading shifted, repeat steps 4 through 6.

7-3-10. ANALOG OUTPUT ADJUSTMENT (option 3)

Equipment: DMM

Procedure:

1. Using a BNC cable, connect the 10 MHz reference signal from the rear panel to Channel A input connector.
2. Press Model 6020 push-buttons in the following sequence: [2nd], [DCL], [50Ω], [AC A], [2nd] and then [A OUT].
3. Use the VERNIER UP bush-button to select the following reading on the display: (Refer to section 3 paragraph 3-21).

_10.0_ _ _ _ _ or
10.0_ _ _ _ _ _ with option 1 installed

4. Press [2nd] and then [OFST] push-buttons.
5. Use the VERNIER UP bush-button to modify the offset to 800. (Refer to section 3 paragraph 3-21).
6. Set the DMM to DCV measurements. Connect the DMM probes through a banana to BNC adapter to the rear panel ANALOG OUTPUT BNC connector.
7. Adjust R168 for a DMM reading as follows:

9.000 V ±0.001 V

7-4. 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.

7-4-1. Recommended Test Equipment

The success or failure in troubleshooting a complex piece of equipment like the Model 6020 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 6020. However, it is also possible to troubleshoot Model 6020 with the minimum equipment which is listed in Table 7-1. Other equipment such as logic analyzer, and in-circuit emulator etc, could also be helpful in difficult situation.

7-4-2. Power-Up Self Diagnostics

An advanced feature of the Model 6020 is its self diagnosing capabilities. Upon power-up the Model 6020 performs a set of tests which is described in paragraph 3-4. If the Model 6020 locks up due to ROM or RAM fail, there is a little point in attempting to troubleshoot elsewhere unless the micro controller circuit is operating properly.

Table 7-1. Recommended minimum Test Equipment For Troubleshooting

Instrument	Recommended Model	Specifications
DMM	Tabor 4121	.005% basic dc accuracy
Pulse Generator	Tabor 8201	0.5 Sec - 20 nSec
Signal Generator	HP 8660A/C	1 MHz-1300MHz
Oscilloscope	Tektronics 465	100 MHz bandwidth

7-5. TROUBLESHOOTING PROCEDURE

7-5-1. Power Supply Checks

It is highly suggested that the first step in troubleshooting the Model 6020, 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 7-2 shows several checks that can be made to the power supplies within the Model 6020. 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 of the circuitry and then determine whether the problem is in the power supply or in the remaining circuits. Model 6020 is equipped with such quick-disconnect points, which are located on the bottom side of the main PC board. To access these points, it is necessary to remove the bottom cover and then to remove the solder from these points.

While troubleshooting the power supply section, bear in mind that the +12 V supply also provides the reference voltage to the +5V. Therefore, it would be impossible to troubleshoot the +5 V supply if the +12 V supply is defective. Similarly, the +5 V supply is used as a reference voltage to the -5.2 V supply.

Table 7-2. Power Supply Checks

Step	Item/Component	Required Condition	Remarks
1	S2 Line Switch	Set to 115V or 230V	See paragraph 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%	
5	U50 Input	+15V minimum	Positive output of CR25
6	-12V Supply	-12V ±5%	
7	U51 Input	-15V minimum	Negative output of CR25
8	+5V Supply	+5V ±2%	Cathode of CR29
9	Input to +5V Supply	Approx. +7V	Positive output of CR28
10	Reference to +5V Supply	+5V ±5%	U52b pin 5
11	-5.2V Supply	-5.2V ±2%	Anode of CR30
12	Input to -5.2V Supply	Approx. -7V	Negative output of CR28
13	+5V Supply to osc	+5V ±5%	U57 pin 8
14	Input to +5V U55	+12V	U55 input/+12V supply

7-5-2. Digital Circuitry and Display Checks

The most important section, to be verified after the power supply checks, is the digital section with its various clocks. Problems with the digital circuitry could cause erratic operation or false display readings. Problems in the clock generator for the CPU and the digital circuit may cause a complete malfunction of the entire section. The CPU would not even start to generate the control lines which makes it impossible to troubleshoot the remaining of the circuitry. Check the various components, associated with the digital circuitry, clocks and the IEEE-488 interface, using the information in Table 7-3.

7-5-3. Standard 5PPM Reference Oscillator Checks

The reference oscillator supplies a precise signal to the measurement logic section of the Model 6020. Without this clock the instrument will operate erratically. Verify that a 10 MHz TTL level signal is present at U57 pin 5, U56 pin 6, 3 and 8 and at the CLOCK output rear panel connector. Check LK1a/b position.

7-5-4. TCXO Reference and x10 Multiplier Checks.

When option 1 is installed, the reference TCXO replaces the standard reference oscillator. The TCXO supplies a precise signal to the measurement logic section of the Model 6020. Without this clock the instrument will operate erratically. The multiplier circuit generates 100MHz from the 10 MHz reference signal. Problems with the TCXO and the multiplier circuit will definitely cause false results on the Model 6020 or may cause no result at all. Problems in the multiplier circuit may be identified using Table 7-4.

7-5-5. Trigger Level Checks

The trigger level circuits control the threshold point where the input circuit triggers. The Model 6020 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 7-5.

7-5-6. Signal Conditioning And Input Circuits Checks

Problems in these circuits could generate false results on the Model 6020. Tables 7-6 and Table 7-7 list the checks to be made on the signal conditioning and the input circuits respectively.

7-5-7. Measurement Logic Section Checks

The measurement logic section circuitry in mainly used as a digital control to the analog signals within the Model 6020. The function control circuit checks is given in Table 7-8. Table 7-9 describes the remaining of the measurement logic circuit. Due to high speed signals, it was necessary to implement ECL technology. It is recommended that checks that are performed in Table 7-9, using an oscilloscope, be made with a special high frequency probe that has a very short grounding clip.

Table 7-3. Digital Circuitry and Display Checks

	Component	Required Condition	Remarks
1		Turn on power	Some tests here could fail due to digital problems
2	Microprocessor Clock	0 to +4V 10 MHz square wave	Pin 18 on U39
3	Microprocessor Timer	0 to +4V 4.88 KHz square wave	Pin 14 on U39
4	KeyBoard/Display Control Clock	0 to +4V 1.25 MHz square wave	Pin 3 on U36
5	IEEE Interface Clock	0 to +4V 5 MHz square wave	Pin 3 on U47
6	Beeper clock	0 to +4V 1.5 KHz square wave	pin 1 on U41
7	Reset Input	Turn off instrument then back on	Pin 9 on U39 stays low for about .1Sec and then goes high
8	ALE Line	0 to +4V 160nSec pulses	Pin 30 on U39
9	PSEN Line	0 to +4V 265nSec negative going pulses	Pin 29 on U39
10	RD WR Lines	0 to +4V 500nSec negative going pulses	Pins 16 and 17 on U39
11	Address/Data Bus	0 to +4V variable pulse train	Pins 21 thru 28 and Pins 32 thru 39 on U39 Pins 3 thru 10 on U42
		Depress and hold the UP Level A during the next two tests	This will generate serial data on the RXD lines
12	TTL Serial Data Input	0 to +5V variable pulse train	Pin 2 of U1 Pin 2 of U3 Pin 2 of U6 Pin 2 of U7
13	ECL Serial Data Input	-5.2 to 0V variable pulse train	Pin 2 of U15 Pin 2 of U14 Pin 2 of U13
14	TTL Serial to Parallel converters clocks	0 to +5V bursts of pulse train	Pin 4 of U37 Pin 3 of U1 Pin 3 of U3 Pin 3 of U6 Pin 3 of U7
15	ECL Serial to Parallel converters clocks	-5.2 to 0V bursts of pulse train	Pin 3 of U15 Pin 3 of U14 Pin 3 of U13
16	TTL Serial to Parallel converters strobes	0 to +5V bursts of pulse train	Pin 15 of U37 Pin 1 of U1 Pin 1 of U3 Pin 1 of U6 Pin 1 of U7
17	ECL Serial to Parallel converters strobes	-5.2 to 0V bursts of pulse train	Pin 1 of U15 Pin 1 of U14 Pin 1 of U13

Table 7-3. Digital Circuitry and Display Checks (continued)

	Component	Required Condition	Remarks
		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
18	Keyboard Interrupt Line	0 to +4V variable negative going pulse	Pin 4 of U36
19	LEDs Sink Lines	0 to +4V variable pulses	Pins 10 to 16 on U35 and Collector of Q20

Table 7-4. TCXO and x10 Multiplier Circuit Checks

	Component	Required Condition	Remarks
1		Turn on power	
2	TCXO 10 MHz	0 to +4V pulses	U1 pin 1, U2 pin 6,11,8
3	Phase Detector Signal Input	0 to +5V 1 MHz pulse	U5 pin 14
4	Phase Detector Compare Input	0 to +4V 1 MHz pulse	U5 pin 3
5	L.P Filter Out	-3.5V ±0.5V dc	U6 pin 6
			Perform the following check with a 1:10 probe
6	VCO out	100 MHz pulses 1Vp-p around -1.3V	Q2 collector

Table 7-5. Trigger Level Circuit Checks

	Component	Required Condition	Remarks
1		Turn on power	
2	D to A Reference	+6.2V +/- 300mV	Pin 15 of U4 and Pin 15 of U8
		Change front panel trigger level setting for Channels A and B to +0.00V	
3	Channel A zero Trigger Level	+0.00V +/- 35mV	Pin 7 of U9b
4	Channel B zero Trigger Level	+0.00V +/- 35mV	Pin 7 of U5b

Table 7-5. Trigger Level Circuit Checks (continued)

	Component	Required Condition	Remarks
		Change front panel trigger level setting for Channels A and B to +5.00V	
5	Channel A Positive Trigger Level	+5.00V +/- 100mV	Pin 7 of U9b
6	Channel B Positive Trigger Level	+5.00V +/- 100mV	Pin 7 of U5b

Table 7-6. Signal Conditioning Checks

	Component	Required Condition	Remarks	
1		Turn power on	The following tests are performed on U2	
	Input conditioning signals:		Channel A	Channel B
2	DC	+5 V dc	Pin 14	Pin 11
3	AC	+0.5 V dc	Pin 14	Pin 11
4	Filter On	+0.5 V dc	Pin 15	Pin 13
5	Filter off	+5 V dc	Pin 15	Pin 13
6	50 Ω	+0.5 V dc	Pin 12	Pin 10
7	1 MΩ	+5 V dc	Pin 12	Pin 10
8	Negative Slope	+0 V dc	U13 Pin 11	U13 Pin 14
7	Positive Slope	-5.2 V dc	U13 Pin 11	U13 Pin 14
9	x1	+5 V dc	K3 Pin 6	K7 Pin 6
10	x10	+0.5 V dc	K3 Pin 6	K7 Pin 6

Table 7-7. Input Circuits Checks

	Component	Required Condition	Remarks
1		Turn on power Press [2nd], [DCL]	Apply 1MHz .2Vp-p sine to Channel A input BNC
2	Channel A Input Amplifier	1MHz .150Vp-p sine	CR6 Cathode
3	Schmidt Trigger A Operation	-1.7V to -0.8V 1MHz square wave	Pin 1 on U12a
		Select FREQ B function	Apply 1MHz .2Vp-p sine to Channel B input BNC
4	Channel B Input Amplifier	1MHz .150Vp-p sine	CR14 Cathode
5	Schmidt Trigger B Operation	-1.7V to -0.8V 1MHz square wave	Pin 16 on U12b

Table 7-8. Function Control Circuit Checks

FUNCTION \ CONTROL (1) LINE		U19 PIN12	U26 PIN5	U26 PIN11	U18, U19 PIN9	U25 PIN5	U25 PIN12	U25 PIN6	U25 PIN11	U21 PIN10	U21 PIN12	U21 PIN5	U21 PIN7	U20 PIN7	U28 PIN5	U28 PIN7	U28 PIN10	U20 PIN12	U20 PIN10
FREQ A	(2) REC	0	0	1	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1
	CONV	0	0	1	1	1	0	1	0	1	1	1	1	1	0	1	1	1	1
FREQ B	(2) REC	0	0	1	1	1	0	1	1	1	1	1	0	1	1	1	0	1	1
	CONV	0	0	1	1	1	0	1	0	1	1	1	1	1	1	0	1	1	1
FREQ C	REC	0	0	1	1	1	0	1	1	0	1	1	1	1	1	1	0	1	1
V PEAK	A	Ø	Ø	1	1	1	Ø	Ø	1	1	1	1	1	1	1	1	Ø	1	1
PER A	SINGLE	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	0	0	1
	AVG	0	0	1	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1
PLS A	SINGLE	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	0	1	0
	AVG	0	0	1	0	0	1	1	1	1	0	1	1	1	1	1	0	1	0
TI A→B	SINGLE	1	1	0	1	0	1	1	1	1	1	1	1	0	1	1	0	1	1
	AVG	0	0	1	0	0	1	1	1	1	0	1	1	0	1	1	0	1	1
TOT B	INF	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
	BY A	1	1	0	0	1	1	1	1	1	1	0	0	1	1	1	1	1	0
	BY A→A	1	1	0	0	1	1	1	1	1	1	0	0	1	1	1	1	0	1
FA/FB		0	0	1	1	1	0	1	1	1	1	1	0	1	0	1	1	1	1
ØA→B°	(3) F_A REC	0	0	1	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1
	$TI_{A \to B}$	0	0	1	0	0	1	1	1	1	0	1	1	0	1	1	0	1	1

NOTES: (1) 0 DENOTES −5.2V , 1 DENOTES 0V, Ø DENOTS DONT CARE.

(2) FOR FREQ A AND B MEASUREMENTS THE LOGIC LEVELS OF THE CONTROL LINES CHANGE BETWEEN REC AND CONV DURING MEASUREMENT CYCLE AUTOMATICALY.

(3) FOR ØA→B° THE FIRST MEASUREMENT IS F_A REC AND THE SECOND MEASUREMENT IS $TI_{A \to B}$

Table 7-9. Measurement Logic Section Circuits Checks

	Component	Required Condition	Remarks
1		Turn on power	
		Press [2nd], [DCL]. Apply 1MHz 1V p-p sine to Channel A input BNC.	
9	Signal Selector #1	-1.7V to -0.7V 1MHz square wave	Pin 3 of U25
10	Synchronized Clock #1	-1.7V to -0.7V 1MHz bursts. Duration of burst is approx 1Sec	Pin 15 of U26
		The following are variable TTL level signals with about 1 Sec burst duration - square waves.	
		Square wave period	
11	N1 Divider Chain	2µS	U31 Pin 12
		4µS	U27 Pin 5
		8µS	U23 Pin 5
		16µS	U46 Pin 11
		32µS	U46 Pin 10
		64µS	U46 Pin 9
		128µS	U46 Pin 8
12	Signal Identifier	TTL low level during measurement cycle.	U31 Pin 4
13	Gate Identifier	TTL low level when gate is open.	U31 Pin 13
			For the following check use a 1:10 probe
14	Synchronized Clock #2	-1.7 to -0.7V 10MHz bursts. Duration of burst is approx 1Sec. (Burst may be 100MHz with option 1 installed)	Pin 15 of U28
		The following are variable signals with about 1 Sec burst duration - square waves.	
		Square wave period: W/O opt. 1 / With opt. 1	
15	N2 Divider Chain	ECL 0.2æS / ECL 20nS	U29 Pin 2
		TTL 0.4æS / TTL 40nS	U31 Pin 5
		TTL 0.8æS / TTL 80nS	U27 Pin 9
		TTL 1.6æS / TTL 160nS	U23 Pin 9
		TTL 3.2æS / TTL 320nS	U46 Pin 3
		TTL 6.4æS / TTL 640nS	U46 Pin 4
		TTL 12.8æS / TTL 1.28æS	U46 Pin 5
		TTL 25.6æS / TTL 2.56æS	U46 Pin 6

Table 7-9. Measurement Logic Section Circuits Checks (continued)

Component	Required Condition	Remarks
	Change panel setting to PER A. Apply 1 KHz 1V p-p square wave to Channel A input BNC.	
16 Start/Stop Signal	-1.7V to -0.7V 1 KHz square wave	U17 Pin 9
17 Time Interval	-1.7V to -0.7V 1 mSec negative going pulse for each cycle	U18 Pin 15
18 Gate Identifier	TTL low level for 1mSec, TTL high for about 300mSec after gate closure	U31 Pin 13

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SECTION 8

PARTS LIST

8.1 GENERAL

This section contains information for ordering replacement parts. the replacement parts are available from the vendors listed or from Tabor Electronics. Mechanical parts are shown separately on Figure 8-1.

8.2 ORDERING INFORMATION

When ordering replacement parts, always include the following information:

a) Instrument Model number.
b) Instrument Serial number.
c) Tabor part number.
d) Part description.
e) Circuit designation (where applicable).

8.3 MAINTENANCE KIT

A maintenance Kit is available. This Kit contains a complement of spare parts which will maintain up to ten Model 6010 Function Generators. A list of the Kit parts is available upon request.

Tabor will do its best to improve the instrument and make changes in style of components and replacement parts. Replacement parts may differ in appearance from those found in your instrument but are always equal or superior in performance.

8.4 PARTS DESCRIPTION

In the following Parts List Tables, unless otherwise noted, resistors power rating is 1/4W, resistance is given in ohms, and capacitance is given in µF.

Some parts in the following parts lists are marked with an asterisk (*). These parts belong to the standard time base circuit. These parts will not be assembled when option 1 (TCXO) is installed.

Matched or selected components may only be bought from the factory. Selection guides for such components are not given anywhere in this manual.

Table 8-1. Model 6020 PARTS LIST - MAIN BOARD ASSEMBLY

DWG REF	PART NUMBER	DESCRIPTION
U1	0540-01100	8 BIT SHIFT REGISTER CD 4094B
U2	0500-11600	BUFFER 9668 (L204)
U3	0540-01100	8 BIT SHIFT REGISTER CD 4094B
U4	0560-00700	D-A 10 BIT CONVERTOR AD7533JN
U5	0500-56500	DUAL OP AMP LM1458N
U6	0540-01100	8 BIT SHIFT REGISTER CD 4094B
U7	0540-01100	8 BIT SHIFT REGISTER CD 4094B
U8	0560-00700	D-A 10 BIT CONVERTOR AD7533JN
U9	0500-56500	DUAL OP AMP LM1458N
U10	0500-53400	SUPER GAIN OP AMP LM308A
U11	0500-53400	SUPER GAIN OP AMP LM308A
U12	0500-60500	AD 9687 BD
U13	0540-01100	8 BIT SHIFT REGISTER CD 4094B
U14	0540-01100	8 BIT SHIFT REGISTER CD 4094B
U15	0540-01100	8 BIT SHIFT REGISTER CD 4094B
U16	0540-00630	HEX INVERTER CD 4049B
U17	0500-45300	ECL FLIP-FLOP MC 10H131 P
U18	0500-40910	ECL OR/NOR GATE MC10105P
U19	0500-40910	ECL OR/NOR GATE MC10105P
U20	0500-40900	ECL NOR 10102
U21	0500-40900	ECL NOR 10102
U22	0500-45300	ECL FLIP-FLOP MC 10H131 P
U23	0500-12600	D-FLIP-FLOP 74F74
U24	0500-40950	ECL XOR/XNOR MC 10107P
U25	0500-40900	ECL NOR 10102
U26	0500-40900	ECL NOR 10102
U27	0500-12600	D-FLIP-FLOP 74F74
U28	0500-40900	ECL NOR 10102
U29	0500-41200	ECL FLIP-FLOP MC10131P
U30	0500-41200	ECL FLIP-FLOP MC10131P
U31	0500-40920	ECL TO TTL TRANSLATOR MC10125P
U35	0500-11600	BUFFER 9668 (L204)
U36	0500-20700	KEYBOARD/DISPLAY CONTROL P8279
U37	0540-00630	HEX INVERTER CD4049B
U38	0510-02700	LOW POWER SCHOTTKY 74LS138
U39	0500-21410	SINGLE CHIP CPU P8031
U40	0510-03650	LOW POWER SCHOTTKY 74LS373
U41	0520-07000	H-CMOS-DIVIDER SN74HC4040
U42	0500-21230	EPROM 27128
U43	0500-11160	MK48ZO2B-20 MOSTEK RAM
U44	0550-00100	32BIT BINARY COUNTER LS7061
U45	0550-00100	32BIT BINARY COUNTER LS7061
U46	0510-03930	LOW POWER SCHOTTKY 74LS393N
U47	0500-21300	G.P.I.B P8291A
U48	0500-21510	BUFFER FOR G.P.IB DS 75160 N
U49	0500-21520	BUFFER FOR G.P.IB DS 75161 N
U50	0500-52200	VOLTAGE REGULATOR MC7812CP
U51	0500-52300	VOLTAGE REGULATOR MC7912CP
U52	0500-56500	DUAL OP AMP LM1458N

Table 8-1. Model 6020 PARTS LIST - MAIN BOARD ASSEMBLY (continued)

DWG REF	PART NUMBER	DESCRIPTION
U55	0500-52000	(*) VOLTAGE REGULATOR MC7805CP
U56	0500-12650	(*) FAST SCHOTTKY 74LS132
U57	0800-50000	(*) OSCILLATOR 10MHz 5PPM TAD
K1	0900-01100	RELAY DUAL INLINE 1A 5V-6007
K2	0900-01000	RELAY DUAL INLINE 1C HE721C05-10
K3	0900-01000	RELAY DUAL INLINE 1C HE721C05-10
K4	0900-01100	RELAY DUAL INLINE 1A 5V-6007
K5	0900-01100	RELAY DUAL INLINE 1A 5V-6007
K6	0900-01000	RELAY DUAL INLINE 1C HE721C05-10
K7	0900-01000	RELAY DUAL INLINE 1C HE721C05-10
K8	0900-01100	RELAY DUAL INLINE 1A 5V-6007
Q1	0400-00300	TSTR NPN 2N4124
Q2	0400-40700	TSTR JFET 2N4416A (SELECTED)
Q3	0400-00700	TSTR NPN 2N5179
Q4	0400-00700	TSTR NPN 2N5179
Q5	0400-00700	TSTR NPN 2N5179
Q6	0400-00300	TSTR NPN 2N4124
Q7	0400-40700	TSTR 2N4416A (SELECTED)
Q8	0400-00700	TSTR NPN 2N5179
Q9	0400-00700	TSTR NPN 2N5179
Q10	0400-00700	TSTR NPN 2N5179
Q11	0400-00400	TSTR PNP 2N4126
Q12	0400-00400	TSTR PNP 2N4126
Q13	0400-00400	TSTR PNP 2N4126
Q14	0400-00300	TSTR NPN 2N4124
Q15	0400-00300	TSTR NPN 2N4124
Q20	0400-01810	TSTR 2N4401
Q21	0400-00300	TSTR NPN 2N4124
Q23	0400-00300	TSTR NPN 2N4124
Q24	0400-00300	TSTR NPN 2N4124
Q30	0400-40100	TSTR 2N2219A
Q31	0400-40300	TSTR MJE 2955A
Q32	0400-01500	TSTR PNP 2N2905A
Q33	0400-40400	TSTR MJE 3055
C1	1521-04730	CAP POL.047UF 20% 250V MKT1818
C2	1500-01040	CAP CER .1 UF-20%+80% 50V
C3	1550-01800	CAP VAR 5-18PF DV11PS18A
C5	1500-01040	CAP CER .1 UF-20%+80% 50V
C6	1510-03R00	CAP MICA 3 PF 10% 500V
C7	1500-01040	CAP CER .1 UF-20%+80% 50V
C8	1510-06200	CAP MICA 62PF 10% 500V
C9	1500-01040	CAP CER .1 UF-20%+80% 50V
C10	1500-01040	CAP CER .1 UF-20%+80% 50V
C11	1500-01040	CAP CER .1 UF-20%+80% 50V
C14	1500-01030	CAP CER 10 NF 20% 50V

Table 8-1. Model 6020 PARTS LIST - MAIN BOARD ASSEMBLY (continued)

DWG REF	PART NUMBER	DESCRIPTION
C15	1500-01040	CAP CER .1 UF-20%+80% 50V
C16	1510-06200	CAP MICA 62PF 10% 500V
C17	1500-01040	CAP CER .1 UF-20%+80% 50V
C18	1500-01010	CAP CER 100 PF 20% 50V
C20	1500-01040	CAP CER .1 UF-20%+80% 50V
C21	1500-01040	CAP CER .1 UF-20%+80% 50V
C22	1500-01030	CAP CER 10 NF 20% 50V
C23	1540-01060	CAP TANT 10 UF 25V
C24	1500-01040	CAP CER .1 UF-20%+80% 50V
C25	1500-01010	CAP CER 100 PF 20% 50V
C26	1521-04730	CAP POL.047UF 20% 250V MKT1818
C27	1500-01040	CAP CER .1 UF-20%+80% 50V
C28	1550-01800	CAP VAR 5-18PF DV11PS18A
C30	1500-01040	CAP CER .1 UF-20%+80% 50V
C31	1510-03R00	CAP MICA 3 PF 10% 500V
C32	1500-01040	CAP CER .1 UF-20%+80% 50V
C33	1510-06200	CAP MICA 62PF 10% 500V
C34	1500-01040	CAP CER .1 UF-20%+80% 50V
C35	1500-01040	CAP CER .1 UF-20%+80% 50V
C36	1500-01040	CAP CER .1 UF-20%+80% 50V
C39	1500-01030	CAP CER 10 NF 20% 50V
C40	1500-01040	CAP CER .1 UF-20%+80% 50V
C41	1510-06200	CAP MICA 62PF 10% 500V
C42	1500-01040	CAP CER .1 UF-20%+80% 50V
C43	1500-01010	CAP CER 100 PF 20% 50V
C45	1500-01040	CAP CER .1 UF-20%+80% 50V
C46	1500-01040	CAP CER .1 UF-20%+80% 50V
C47	1540-01060	CAP TANT 10 UF 25V
C48	1500-01030	CAP CER 10 NF 20% 50V
C49	1500-01040	CAP CER .1 UF-20%+80% 50V
C50	1500-01010	CAP CER 100 PF 20% 50V
C51	1500-01040	CAP CER .1 UF-20%+80% 50V
C52	1500-01040	CAP CER .1 UF-20%+80% 50V
C53	1500-01040	CAP CER .1 UF-20%+80% 50V
C54	1500-01040	CAP CER .1 UF-20%+80% 50V
C55	1500-01040	CAP CER .1 UF-20%+80% 50V
C56	1540-01060	CAP TANT 10 UF 25V
C57	1540-01060	CAP TANT 10 UF 25V
C58	1500-01040	CAP CER .1 UF-20%+80% 50V
C59	1540-01060	CAP TANT 10 UF 25V
C60	1540-01060	CAP TANT 10 UF 25V
C65	1500-01040	CAP CER .1 UF-20%+80% 50V
C66	1500-01040	CAP CER .1 UF-20%+80% 50V
C67	1500-01040	CAP CER .1 UF-20%+80% 50V
C68	1500-01040	CAP CER .1 UF-20%+80% 50V
C69	1500-01040	(*) CAP CER .1 UF-20%+80% 50V
C70	1500-01040	CAP CER .1 UF-20%+80% 50V

Table 8-1. Model 6020 PARTS LIST - MAIN BOARD ASSEMBLY (continued)

DWG REF	PART NUMBER	DESCRIPTION
C71	1500-04R70	CAP CER 4.7 PF 20% 50V
C72	1500-01010	CAP CER 100 PF 20% 50V
C73	1500-01040	CAP CER .1 UF-20%+80% 50V
C74	1500-01040	CAP CER .1 UF-20%+80% 50V
C75	1500-01040	CAP CER .1 UF-20%+80% 50V
C76	1500-01040	CAP CER .1 UF-20%+80% 50V
C77	1500-01040	CAP CER .1 UF-20%+80% 50V
C78	1500-01040	CAP CER .1 UF-20%+80% 50V
C79	1500-01040	CAP CER .1 UF-20%+80% 50V
C80	1500-01040	CAP CER .1 UF-20%+80% 50V
C81	1500-01040	CAP CER .1 UF-20%+80% 50V
C82	1500-01040	CAP CER .1 UF-20%+80% 50V
C83	1500-01040	CAP CER .1 UF-20%+80% 50V
C84	1500-01040	CAP CER .1 UF-20%+80% 50V
C85	1500-01040	CAP CER .1 UF-20%+80% 50V
C86	1500-01030	CAP CER 10 NF 20% 50V
C87	1532-01070	CAP ELEC 100UF 16V
C89	1533-01080	CAP ELECTR 1000 MF/25V
C90	1500-01040	CAP CER .1 UF-20%+80% 50V
C91	1500-01040	CAP CER .1 UF-20%+80% 50V
C92	1540-03350	CAP TANT 3.3UF/25V
C93	1500-01040	CAP CER .1 UF-20%+80% 50V
C94	1500-01040	CAP CER .1 UF-20%+80% 50V
C95	1500-01040	CAP CER .1 UF-20%+80% 50V
C96	1500-01040	CAP CER .1 UF-20%+80% 50V
C97	1500-01040	CAP CER .1 UF-20%+80% 50V
C98	1500-01040	CAP CER .1 UF-20%+80% 50V
C99	1500-01040	CAP CER .1 UF-20%+80% 50V
C100	1500-01040	CAP CER .1 UF-20%+80% 50V
C101	1500-01040	CAP CER .1 UF-20%+80% 50V
C102	1500-01040	CAP CER .1 UF-20%+80% 50V
C105	1533-01080	CAP ELECTR 1000 MF/25V
C106	1533-01080	CAP ELECTR 1000 MF/25V
C107	1533-01070	CAP ELECTR 100UF/25V
C108	1533-01070	CAP ELECTR 100UF/25V
C109	1532-01090	CAP ELEC 10.000UF 16V
C110	1532-01090	CAP ELEC 10.000UF 16V
C111	1532-04770	CAP ELECTR 470 MF/16V
C112	1500-01040	CAP CER .1 UF-20%+80% 50V
C113	1500-02210	CAP CER 220 PF 20% 50V
C114	1500-02210	CAP CER 220 PF 20% 50V
C116	1532-04770	CAP ELECTR 470 MF/16V
C120	1500-01030	(*) CAP CER 10 NF 20% 50V
C121	1540-01060	(*) CAP TANT 10 UF 25V
C122	1540-01060	(*) CAP TANT 10 UF 25V
C123	1500-01040	(*) CAP CER .1 UF-20%+80% 50V
C124	1550-01800	(*) CAP VAR 5-18PF DV11PS18A
C126	1550-01000	(*) CAP VAR 2-10PF JACKS 5750
C127	1500-01040	CAP CER .1 UF-20%+80% 50V
C128	1500-01040	CAP CER .1 UF-20%+80% 50V

Table 8-1. Model 6020 PARTS LIST - MAIN BOARD ASSEMBLY (continued)

DWG REF	PART NUMBER	DESCRIPTION
R3	0104-9003A	RES MF 900K 1% 1/2W
R4	0104-9003A	RES MF 900K 1% 1/2W
R5	0104-10030	RES MF 100K 1% 1/4W
R6	0100-01540	RES COMP 150K 5% 1/4W
R7	0100-03300	RES COMP 33 5% 1/4W
R8	0100-01510	RES COMP 150 5% 1/4W
R9	0100-01060	RES COMP 10M 5% 1/4W
R10	0100-04710	RES COMP 470 5% 1/4W
R11	0100-01030	RES COMP 10K 5% 1/4W
R12	0100-03300	RES COMP 33 5% 1/4W
R13	0100-03910	RES COMP 390 5% 1/4W
R14	0100-01510	RES COMP 150 5% 1/4W
R15	0100-07520	RES COMP 7.5K 5% 1/4W
R16	0100-01520	RES COMP 1.5K 5% 1/4W
R17	0104-66530	RES MF 665K 1% 1/4W
R18	0100-01810	RES COMP 180 5% 1/4W
R19	0100-02720	RES COMP 2.7K 5% 1/4W
R20	0100-03920	RES COMP 3.9K 5% 1/4W
R21	0104-86610	RES MF 8.66K 1% 1/4W
R22	0104-10030	RES MF 100K 1% 1/4W
R23	0104-28010	RES MF 2.8K 1% 1/4W
R24	0104-28010	RES MF 2.8K 1% 1/4W
R25	0104-10000	RES MF 100 1% 1/4W
R26	0105-10020	RES MF 10K .1% 1/4W
R27	0104-15020	RES MF 15K 1% 1/4W
R28	0104-10010	RES MF 1K 1% 1/4W
R29	0105-20020	RES MF 20K .1% 1/4W
R30	0104-10010	RES MF 1K 1% 1/4W
R33	0104-4R020	RES MF 4.02 1% 1/4W
R34	0104-30100	RES MF 301 1% 1/4W
R35	0104-11310	RES MF 1.13K 1% 1/4W
R36	0100-02210	RES COMP 220 5% 1/4W
R37	0100-03310	RES COMP 330 5% 1/4W
R38	0100-02220	RES COMP 2.2K 5% 1/4W
R39	0104-11030	RES MTF 110K 1/4W 1%
R42	0104-9003A	RES MF 900K 1% 1/2W
R43	0104-9003A	RES MF 900K 1% 1/2W
R44	0104-10030	RES MF 100K 1% 1/4W
R45	0100-01540	RES COMP 150K 5% 1/4W
R46	0100-03300	RES COMP 33 5% 1/4W
R47	0100-01510	RES COMP 150 5% 1/4W
R48	0100-01060	RES COMP 10M 5% 1/4W
R49	0100-04710	RES COMP 470 5% 1/4W
R50	0100-01030	RES COMP 10K 5% 1/4W
R51	0100-03300	RES COMP 33 5% 1/4W

Table 8-1. Model 6020 PARTS LIST - MAIN BOARD ASSEMBLY (continued)

DWG REF	PART NUMBER	DESCRIPTION
R52	0100-03910	RES COMP 390 5% 1/4W
R53	0100-01510	RES COMP 150 5% 1/4W
R54	0100-07520	RES COMP 7.5K 5% 1/4W
R55	0100-01520	RES COMP 1.5K 5% 1/4W
R56	0104-66530	RES MF 665K 1% 1/4W
R57	0100-01810	RES COMP 180 5% 1/4W
R58	0100-02720	RES COMP 2.7K 5% 1/4W
R59	0100-03920	RES COMP 3.9K 5% 1/4W
R60	0104-86610	RES MF 8.66K 1% 1/4W
R61	0104-10030	RES MF 100K 1% 1/4W
R62	0104-28010	RES MF 2.8K 1% 1/4W
R63	0104-28010	RES MF 2.8K 1% 1/4W
R64	0104-10000	RES MF 100 1% 1/4W
R65	0105-10020	RES MF 10K .1% 1/4W
R66	0104-15020	RES MF 15K 1% 1/4W
R67	0105-20020	RES MF 20K .1% 1/4W
R68	0104-10010	RES MF 1K 1% 1/4W
R69	0104-10010	RES MF 1K 1% 1/4W
R72	0104-4R020	RES MF 4.02 1% 1/4W
R73	0104-30100	RES MF 301 1% 1/4W
R74	0104-11310	RES MF 1.13K 1% 1/4W
R75	0100-02210	RES COMP 220 5% 1/4W
R76	0100-03310	RES COMP 330 5% 1/4W
R77	0100-02220	RES COMP 2.2K 5% 1/4W
R78	0104-11030	RES MTF 110K 1/4W 1%
R79	0100-06210	RES 620 1/4W 5%
R80	0203-02020	RES VAR 2K 3386F-1-502
R81	0203-02020	RES VAR 2K 3386F-1-502
R83	0203-02020	RES VAR 2K 3386F-1-20
R84	0203-02020	RES VAR 2K 3386F-1
R90	0100-05110	RES COMP 510 5% 1/4W
R91	0100-01020	RES COMP 1K 5% 1/4W
R92	0100-05110	RES COMP 510 5% 1/4W
R93	0100-05110	RES COMP 510 5% 1/4W
R94	0100-02410	RES COMP 240 5% 1/4W
R95	0100-05110	RES COMP 510 5% 1/4W
R96	0100-03310	RES COMP 330 5% 1/4W
R97	0100-02720	RES COMP 2.7K 5% 1/4W
R98	0100-02220	RES COMP 2.2K 5% 1/4W
R99	0100-03310	RES COMP 330 5% 1/4W
R100	0100-05110	RES COMP 510 5% 1/4W
R101	0100-05110	RES COMP 510 5% 1/4W
R102	0100-03310	RES COMP 330 5% 1/4W
R103	0104-24910	RES MF 2.49K 1% 1/4W
R104	0104-75100	RES MF 750 1% 1/4W
R105	0100-05110	RES COMP 510 5% 1/4W
R106	0100-08210	(*) RES COMP 820 5% 1/4W
R107	0100-01020	RES COMP 1K 5% 1/4W
R108	0100-05110	RES COMP 510 5% 1/4W

Table 8-1. Model 6020 PARTS LIST - MAIN BOARD ASSEMBLY (continued)

DWG REF	PART NUMBER	DESCRIPTION
R109	0100-05110	RES COMP 510 5% 1/4W
R110	0100-05110	RES COMP 510 5% 1/4W
R111	0100-03310	RES COMP 330 5% 1/4W
R112	0100-02410	RES COMP 240 5% 1/4W
R113	0100-01010	RES COMP 100 5% 1/4W
R114	0100-05110	RES COMP 510 5% 1/4W
R115	0100-03310	RES COMP 330 5% 1/4W
R116	0100-07520	RES COMP 7.5K 5% 1/4W
R117	0100-05110	RES COMP 510 5% 1/4W
R118	0100-07520	RES COMP 7.5K 5% 1/4W
R119	0100-05110	RES COMP 510 5% 1/4W
R120	0100-01020	RES COMP 1K 5% 1/4W
R121	0100-02720	RES COMP 2.7K 5% 1/4W
R122	0100-05110	RES COMP 510 5% 1/4W
R123	0100-02220	RES COMP 2.2K 5% 1/4W
R124	0100-05110	RES COMP 510 5% 1/4W
R125	0100-05110	RES COMP 510 5% 1/4W
R126	0100-05110	RES COMP 510 5% 1/4W
R127	0100-05110	RES COMP 510 5% 1/4W
R128	0100-05110	RES COMP 510 5% 1/4W
R129	0100-05110	RES COMP 510 5% 1/4W
R130	0100-05110	RES COMP 510 5% 1/4W
R131	0100-05110	RES COMP 510 5% 1/4W
R132	0100-05110	RES COMP 510 5% 1/4W
R133	0100-05110	RES COMP 510 5% 1/4W
R134	0100-05110	RES COMP 510 5% 1/4W
R135	0100-05110	RES COMP 510 5% 1/4W
R136	0100-05110	RES COMP 510 5% 1/4W
R137	0100-01030	RES COMP 10K 5% 1/4W
R138	0100-01020	RES COMP 1K 5% 1/4W
R139	0100-02720	RES COMP 2.7K 5% 1/4W
R140	0100-08210	RES COMP 820 5% 1/4W
R141	0100-08210	RES COMP 820 5% 1/4W
R142	0100-01030	RES COMP 10K 5% 1/4W
R143	0100-01510	RES COMP 150 5% 1/4W
R144	0100-08210	RES COMP 820 5% 1/4W
R145	0100-02020	RES COMP 2K 5% 1/4W
R146	0100-03310	RES COMP 330 5% 1/4W
R147	0100-01030	RES COMP 10K 5% 1/4W
R148	0100-01030	RES COMP 10K 5% 1/4W
R149	0100-01030	RES COMP 10K 5% 1/4W
R150	0100-05110	RES COMP 510 5% 1/4W
R151	0100-01020	RES COMP 1K 5% 1/4W
R152	0100-01030	RES COMP 10K 5% 1/4W
R153	0100-01030	RES COMP 10K 5% 1/4W
R154	0100-01020	RES COMP 1K 5% 1/4W
R155	0100-01020	RES COMP 1K 5% 1/4W
R156	0100-01030	RES COMP 10K 5% 1/4W
R157	0100-01020	RES COMP 1K 5% 1/4W

Table 8-1. Model 6020 PARTS LIST - MAIN BOARD ASSEMBLY (continued)

DWG REF	PART NUMBER	DESCRIPTION
R158	0100-03310	RES COMP 330 5% 1/4W
R159	0100-01020	RES COMP 1K 5% 1/4W
R160	0100-03310	RES COMP 330 5% 1/4W
R166	0100-03320	RES COMP 3.3K 5% 1/4W
R167	0100-01030	RES COMP 10K 5% 1/4W
R172	0100-01010	RES COMP 100 5% 1/4W
R173	0100-01520	RES COMP 1.5K 5% 1/4W
R174	0100-01030	RES COMP 10K 5% 1/4W
R180	0100-01020	RES COMP 1K 5% 1/4W
R181	0100-01210	RES COMP 120 5% 1/4W
R182	0100-04720	RES COMP 4.7K 5% 1/4W
R183	0104-57610	RES MF 5.76K 1% 1/4W
R184	0100-01020	RES COMP 1K 5% 1/4W
R185	0100-01210	RES COMP 120 5% 1/4W
R186	0100-01020	RES COMP 1K 5% 1/4W
R187	0104-66510	RES MF 6.65K 1% 1/4W
R188	0104-60410	RES MF 6.04K 1% 1/4W
R189	0104-10020	RES MF 10K 1% 1/4W
R190	0203-01020	RES VAR 1K 3386F-1-102
R191	0100-02210	RES COMP 220 5% 1/4W
R192	0100-05100	(*) RES COMP 51 5% 1/4W
R193	0100-01820	(*) RES COMP 1.8K 5% 1/4W
R194	0100-05610	(*) RES COMP 560 5% 1/4W
R195	0100-01020	RES COMP 1K 5% 1/4W
R196	0100-01020	RES COMP 1K 5% 1/4W
CR1	0300-00400	DIODE SI 1N4151
CR2	0301-10000	DIODE PIC AMP PAD 50
CR3	0300-20400	DIODE ZENER 1N758A 10 V
CR4	0300-20010	DIODE ZENER 1N751A 5.1 V
CR5	0300-10300	DIODE HP2835- MATCHED WITH CR6
CR6	0300-10300	DIODE HP2835- MATCHED WITH CR5
CR7	0300-10300	DIODE HP2835- MATCHED WITH CR8
CR8	0300-10300	DIODE HP2835- MATCHED WITH CR7
CR9	0300-00400	DIODE SI 1N4151
CR10	0301-10000	DIODE PIC AMP PAD 50
CR11	0300-20400	DIODE ZENER 1N758A 10 V
CR12	0300-20010	DIODE ZENER 1N751A 5.1 V
CR13	0300-10300	DIODE HP2835- MATCHED WITH CR14
CR14	0300-10300	DIODE HP2835- MATCHED WITH CR13
CR15	0300-10300	DIODE HP2835- MATCHED WITH CR16
CR16	0300-10300	DIODE HP2835- MATCHED WITH CR15
CR17	0300-21100	DIODE REF 1N825A
CR23	0300-00400	DIODE SI 1N4151
CR25	0300-50100	DIODE BRIDGE WL005
CR26	0300-30000	DIODE RECT 1N4003
CR27	0300-30000	DIODE RECT 1N4003
CR28	0300-50200	DIODE BRIDGE KBL-005 5A GI
CR29	0300-90300	DIODE SA-5A

Table 8-1. Model 6020 PARTS LIST - MAIN BOARD ASSEMBLY (continued)

DWG REF	PART NUMBER	DESCRIPTION
CR30	0300-90300	DIODE SA-5A
CR31	0300-00400	DIODE SI 1N4151
CR32	0300-00400	DIODE SI 1N4151
CR35	0300-00400	(*) DIODE SI 1N4151
CR36	0300-00400	(*) DIODE SI 1N4151
DL1	0600-10000	DELAY LINE 7nSEC 0402-0007-93
RN1	0109-01500	RES NET MDP-16-03-150G 15/16
RN2	0111-0103B	RES NET 10K/10 MSP-10A-01-103G
SP1	0900-01900	BEEPER AT-02
Y1	0800-30000	CRYSTAL 10MHZ C.T.S
SW1	2000-10600	SW ON-OFF

Table 8-2. Model 6020 PARTS LIST - FRONT PANEL ASSEMBLY

DWG REF	PART NUMBER	DESCRIPTION
U1	0510-02700	LOW POWER SCHOTTKY 74LS138
U2	0510-02700	LOW POWER SCHOTTKY 74LS138
Q1	0400-01800	TSTR PNP 2N4403
Q2	0400-01800	TSTR PNP 2N4403
Q3	0400-01800	TSTR PNP 2N4403
Q4	0400-01800	TSTR PNP 2N4403
Q5	0400-01800	TSTR PNP 2N4403
Q6	0400-01800	TSTR PNP 2N4403
Q7	0400-01800	TSTR PNP 2N4403
Q8	0400-01800	TSTR PNP 2N4403
Q9	0400-01800	TSTR PNP 2N4403
Q10	0400-01800	TSTR PNP 2N4403
Q11	0400-01800	TSTR PNP 2N4403
Q12	0400-01800	TSTR PNP 2N4403
Q13	0400-01800	TSTR PNP 2N4403
Q14	0400-01800	TSTR PNP 2N4403
CR1	0300-00400	DIODE SI 1N4151
CR2	0300-00400	DIODE SI 1N4151
CR3	0300-00400	DIODE SI 1N4151
R1	0100-02210	RES COMP 220 5% 1/4W
R2	0100-02210	RES COMP 220 5% 1/4W
R3	0100-02210	RES COMP 220 5% 1/4W
R4	0100-02210	RES COMP 220 5% 1/4W
R5	0100-02210	RES COMP 220 5% 1/4W
R6	0100-02210	RES COMP 220 5% 1/4W
R7	0100-02210	RES COMP 220 5% 1/4W
R8	0100-02210	RES COMP 220 5% 1/4W
R9	0100-02210	RES COMP 220 5% 1/4W
R10	0100-02210	RES COMP 220 5% 1/4W
R11	0100-02210	RES COMP 220 5% 1/4W
R12	0100-02210	RES COMP 220 5% 1/4W
R13	0100-02210	RES COMP 220 5% 1/4W
R14	0100-02210	RES COMP 220 5% 1/4W

Table 8-2. Model 6020 PARTS LIST - FRONT PANEL ASSEMBLY (continued)

DWG REF	PART NUMBER	DESCRIPTION
DS1-9	1200-10800	7 SEGMENT DISPLAY HDSP 5501
DS10-DS11	1200-10200	LED HDSP 7501 7 SEG 6010
DS12-DS18	1000-00300	MINI 3MM LED RED 5082-4480
DS19-DS41	1000-00700	LED RED MV 57124-18 G.I
S1-16	2000-61600	SW UNIMEC FOR 8200
J1-3	3000-10000	CON BNC MALE UG-1094-U
J4	3000-40150	CON 20 PIN MALE FOR SOLDER
J5	3000-40160	CON 20 PIN FEMALE

Table 8-3. Model 6020 PARTS LIST - ANALOG OUTPUT ASSEMBLY

DWG REF	PART NUMBER	DESCRIPTION
U58	0510-00110	LOW POWER SCHOTTKY 74LS02
U59	0560-00900	AD667JN DIGITAL TO ANALOG CONV
R168	0203-01010	RES VAR 100 3386F-1-101
R169	0104-12100	RES MTF 121 1/4W 1%
R170	0104-10010	RES MF 1K 1% 1/4W
C88	1500-02200	CAP CER 22PF 20% 50V
C103	1540-01060	CAP TANT 10 UF 25V
C104	1540-01060	CAP TANT 10 UF 25V
C115	1500-01030	CAP CER 10 NF 20% 50V
L1	0600-01030	COIL 1µH
L2	0600-01030	COIL 1µH

Table 8-4. Model 6020 PARTS LIST - TCXO ASSEMBLY

DWG REF	PART NUMBER	DESCRIPTION
U1	0800-90000	TCXO 10MHz 1 PPM
U2	0500-12650	FAST SCHOTTKY 74F132
U3	0510-02300	LOW POWER SCHOTTKY 74LS90
U4	0500-64300	SP 8629
U5	0520-07100	74HCT4046 PLL
U6	0500-56700	SINGLE OP. AMP TL081CP
U7	0540-01500	ECL VCO MC 1648
CR1	0300-00400	DIODE SI 1N4151
CR2	0300-00400	DIODE SI 1N4151
CR3	0301-00100	DIODE VARICAP MV-104

Table 8-4. Model 6020 PARTS LIST - TCXO ASSEMBLY (continued)

DWG REF	PART NUMBER	DESCRIPTION
L1	0600-03310	COIL 330 UH 2500-04 DEL.
L2		COIL 5 TURN TABOR MADE
Q1	0400-00750	TSTR PNP 2N5771
Q2	0400-00700	TSTR NPN 2N5179
R1	0100-05100	RES COMP 51 5% 1/4W
R2	0100-05610	RES COMP 560 5% 1/4W
R3	0100-01820	RES COMP 1.8K 5% 1/4W
R4	0100-04720	RES COMP 4.7K 5% 1/4W
R5	0100-01020	RES COMP 1K 5% 1/4W
R6	0100-01510	RES COMP 150 5% 1/4W
R7	0100-03330	RES COMP 33K 5% 1/4W
R8	0100-02010	RES COMP 2K 5% 1/4W
R9	0100-01030	RES COMP 10K 5% 1/4W
R10	0104-10020	RES MF 10K 1% 1/4W
R11	0104-10020	RES MF 10K 1% 1/4W
R12	0100-02720	RES COMP 2.7K 5% 1/4W
R13	0100-01520	RES COMP 15K 5% 1/4W
R14	0100-01020	RES COMP 1K 5% 1/4W
R15	0100-01020	RES COMP 1K 5% 1/4W
R16	0100-01800	RES COMP 18 5% 1/4W
C1	1540-01060	CAP TANT 10 UF 25V
C2	1500-01030	CAP CER 10 NF-20%+80% 50V
C3	1500-01040	CAP CER .1 UF-20%+80% 50V
C4	1540-01060	CAP TANT 10 UF 25V
C5	1500-01040	CAP CER .1 UF-20%+80% 50V
C6	1500-01030	CAP CER 10 NF 20% 50V
C7	1500-01030	CAP CER 10 NF 20% 50V
C8		CAP MICA SELECTED
C9	1510-08200	CAP MICA 82PF 10% 500V
C10	1500-01040	CAP CER .1 UF-20%+80% 50V
C11	1500-01040	CAP CER .1 UF-20%+80% 50V
C12	1500-01030	CAP CER 10 NF 20% 50V
C13	1500-01040	CAP CER .1 UF-20%+80% 50V
C14	1500-01040	CAP CER .1 UF-20%+80% 50V
C15	1500-01040	CAP CER .1 UF-20%+80% 50V
C16	1500-01020	CAP CER 1 NF-20%+20% 50V
C17	1500-01040	CAP CER .1 UF-20%+80% 50V
C18	1500-01040	CAP CER .1 UF-20%+80% 50V
C19	1500-01040	CAP CER .1 UF-20%+80% 50V
C20	1500-01040	CAP CER .1 UF-20%+80% 50V
C21	1500-01040	CAP CER .1 UF-20%+80% 50V

Table 8-5. Model 6020 PARTS LIST - 1.3 GHz Input C.

DWG REF	PART NUMBER	DESCRIPTION
R1	0101-05100	RES COMP 51 5% 1/2W
R2	0100-01020	RES COMP 1K 5% 1/4W
R3	0101-05100	RES COMP 51 5% 1/2W
R4	0100-01020	RES COMP 1K 5% 1/4W
R5	0100-05610	RES COMP 560 5% 1/4W

Table 8-5. Model 6020 PARTS LIST - 1.3 GHz Input C. (continued)

DWG REF	PART NUMBER	DESCRIPTION
R6	0100-05100	RES COMP 51 5% 1/4W
R7	0100-01020	RES COMP 1K 5% 1/4W
R8	0102-03300	RES COMP 33 5% 1/8W BB3305
R9	0100-02410	RES COMP 240 5% 1/4W
R10	0100-01020	RES COMP 1K 5% 1/4W
R11	0100-01020	RES COMP 1K 5% 1/4W
R12	0100-01020	RES COMP 1K 5% 1/4W
R13	0102-03300	RES COMP 33 5% 1/8W BB3305
R14	0100-02220	RES COMP 2.2K 5% 1/4W
R15	0101-02010	RES COMP 200 5% 1/2W
R16	0100-05610	RES COMP 560 5% 1/4W
R17	0102-02210	RES COMP 220 5% 1/8W BB2215
R18	0102-02210	RES COMP 220 5% 1/8W BB2215
R19	0100-01540	RES COMP 150K 5% 1/4W
R20	0100-01020	RES COMP 1K 5% 1/4W
R21	0100-02250	RES COMP 2.2M 5% 1/4W
R22	0100-01020	RES COMP 1K 5% 1/4W
R23	0100-01540	RES COMP 150K 5% 1/4W
R24		RES COMP SELECTED VALUE
R25	0100-03320	RES COMP 3.3K 5% 1/4W
R26	0100-05110	RES COMP 510 5% 1/4W
C1	1560-01040	CAP CHIP .1 UF 50V
C2	1560-01040	CAP CHIP .1 UF 50V
C3		CAP CER SELECTED
C4	1560-01040	CAP CHIP .1 UF 50V
C5	1560-01040	CAP CHIP .1 UF 50V
C6	1560-01040	CAP CHIP .1 UF 50V
C7		CAP CER SELECTED
C8	1560-01040	CAP CHIP .1 UF 50V
C9	1560-01040	CAP CHIP .1 UF 50V
C10	1560-01040	CAP CHIP .1 UF 50V
C11	1560-01040	CAP CHIP .1 UF 50V
C12	1560-01040	CAP CHIP .1 UF 50V
C14	1560-01040	CAP CHIP .1 UF 50V
C15		CAP CER SELECTED
C16	1560-01040	CAP CHIP .1 UF 50V
C17	1560-01040	CAP CHIP .1 UF 50V
C19	1560-01040	CAP CHIP .1 UF 50V
C20	1560-01040	CAP CHIP .1 UF 50V
C22	1560-01040	CAP CHIP .1 UF 50V
C23	1500-03R30	CAP CER 3.3 PF 20% 50V
C24	1560-01040	CAP CHIP .1 UF 50V
C25	1500-02200	CAP CER 22 PF 20% 50V
C26	1560-01040	CAP CHIP .1 UF 50V

Table 8-5. Model 6020 PARTS LIST - 1.3 GHz Input C. (continued)

DWG REF	PART NUMBER	DESCRIPTION
Q1	0400-20100	TSTR BFR-90
Q2	0400-20300	TSTR NE21935A
Q3	0400-20100	TSTR BFR-90
Q4	0400-20300	TSTR NE21935A
Q5	0400-00300	TSTR NPN 2N4124
Q6	0400-00300	TSTR NPN 2N4124
U1	0500-64200	SP4750
U2	0500-53700	LM393N
CR1	0300-10300	DIODE HOT CARRIER 5082-2835
CR2	0300-10300	DIODE HOT CARRIER 5082-2835
CR3	0300-10300	DIODE HOT CARRIER 5082-2835
CR4	0300-10300	DIODE HOT CARRIER 5082-2835
CR5	0300-20200	DIODE ZENER 1N753A 6.2 V
CR6	0300-10300	DIODE HOT CARRIER 5082-2835
CR7	0300-10300	DIODE HOT CARRIER 5082-2835
CR8	0300-10300	DIODE HOT CARRIER 5082-2835
CR9	0300-10300	DIODE HOT CARRIER 5082-2835
CR10	0300-10300	DIODE HOT CARRIER 5082-2835
CR11	0300-10300	DIODE HOT CARRIER 5082-2835
CR12	0300-10200	DIODE HOT CARRIER 5082-2810
CR13	0300-10200	DIODE HOT CARRIER 5082-2810

SECTION 9

SCHEMATIC DIAGRAMS

DWG.	DESCRIPTION	PAGE
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9-3	Main Board - CPU Circuit	9-3
9-4	Main Board - Standard 5PPM Time Base Circuit	9-4
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9-10	Option 1 - Components Location Diagram	9-10
9-11	Option 2 - 1.3 GHz Input Amplifier Circuit	9-11
9-12	Option 2 - Components Location Diagrams	9-12

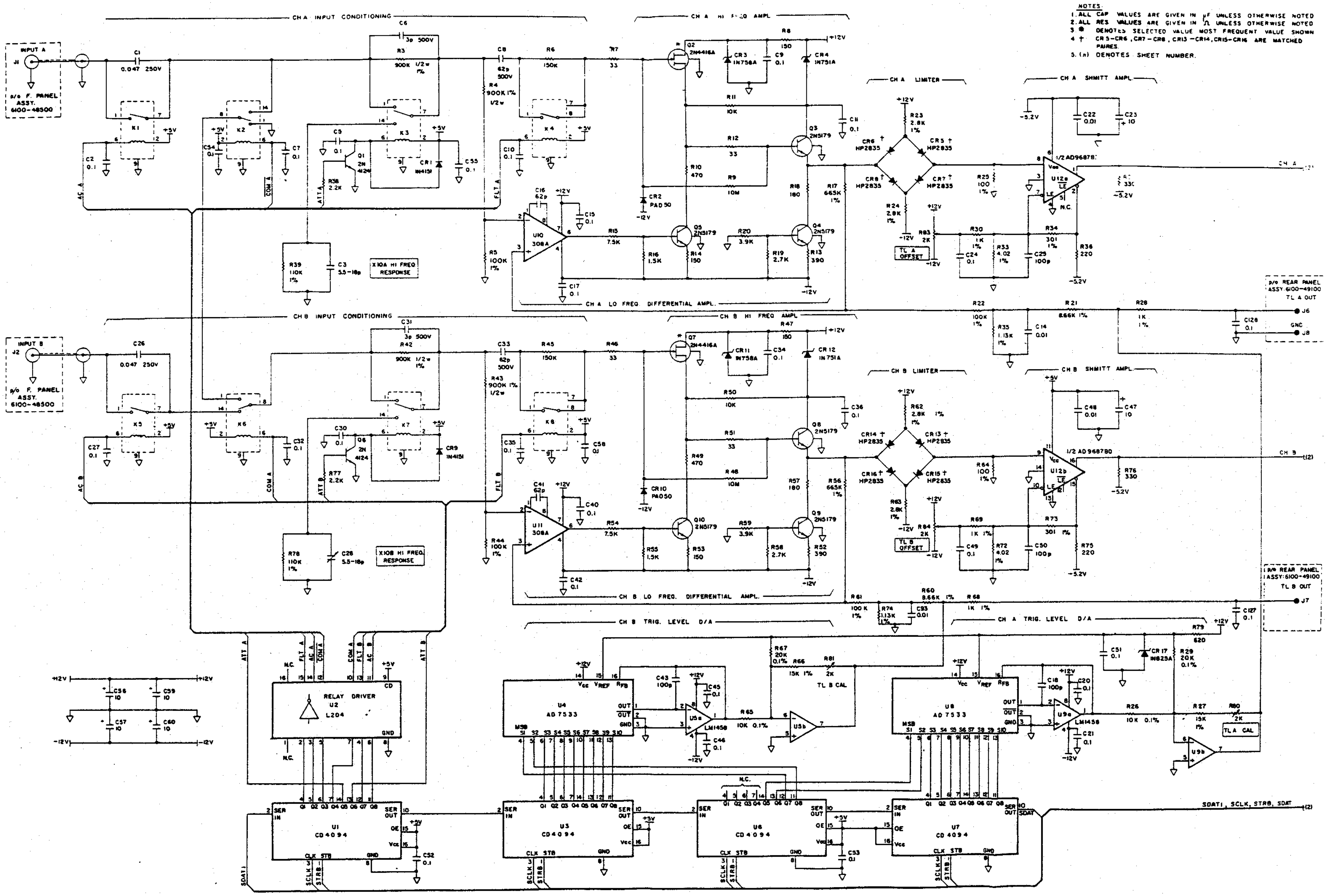


Figure 9-1. Main Board - Input Amplifiers and Trigger Level Control

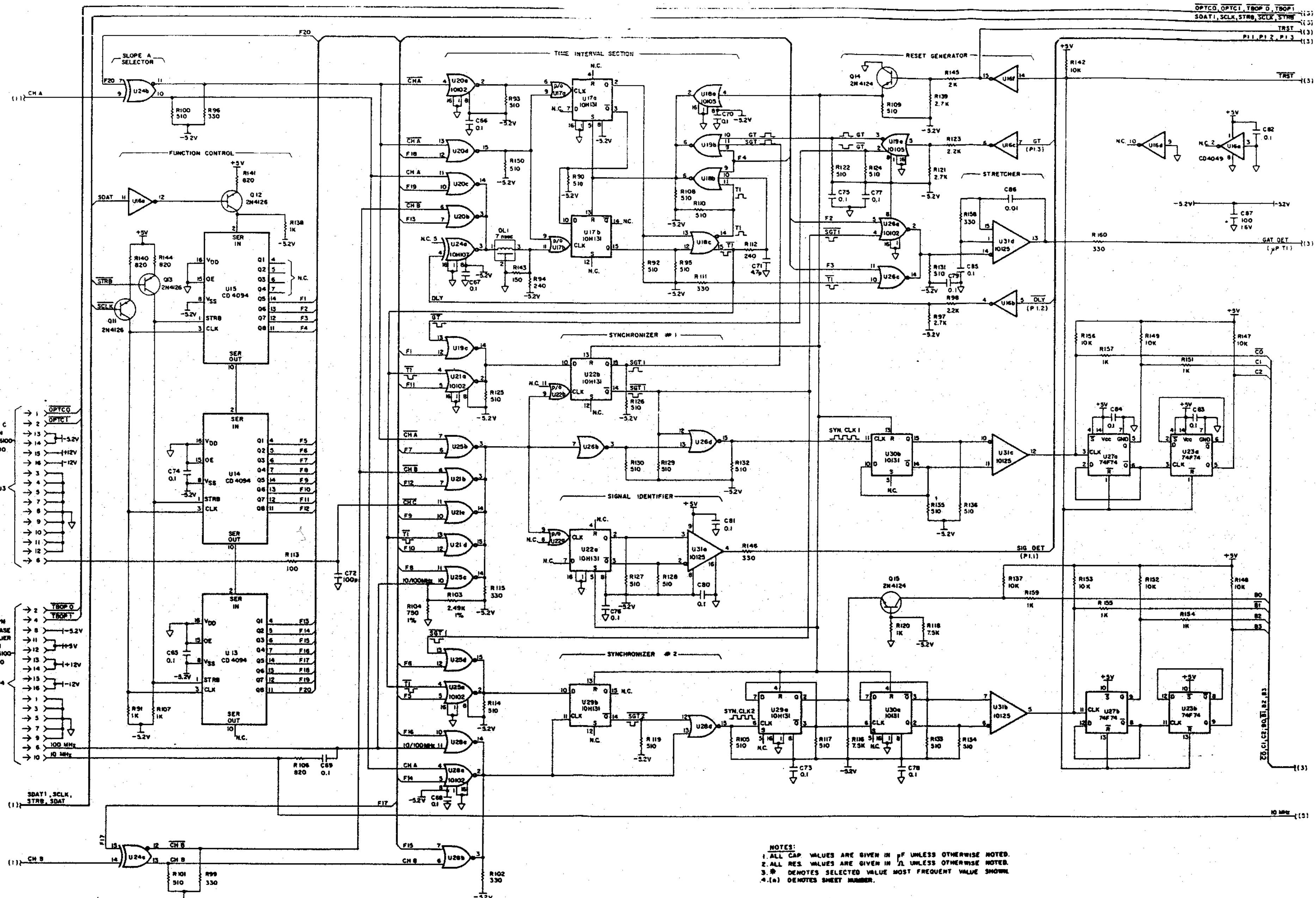
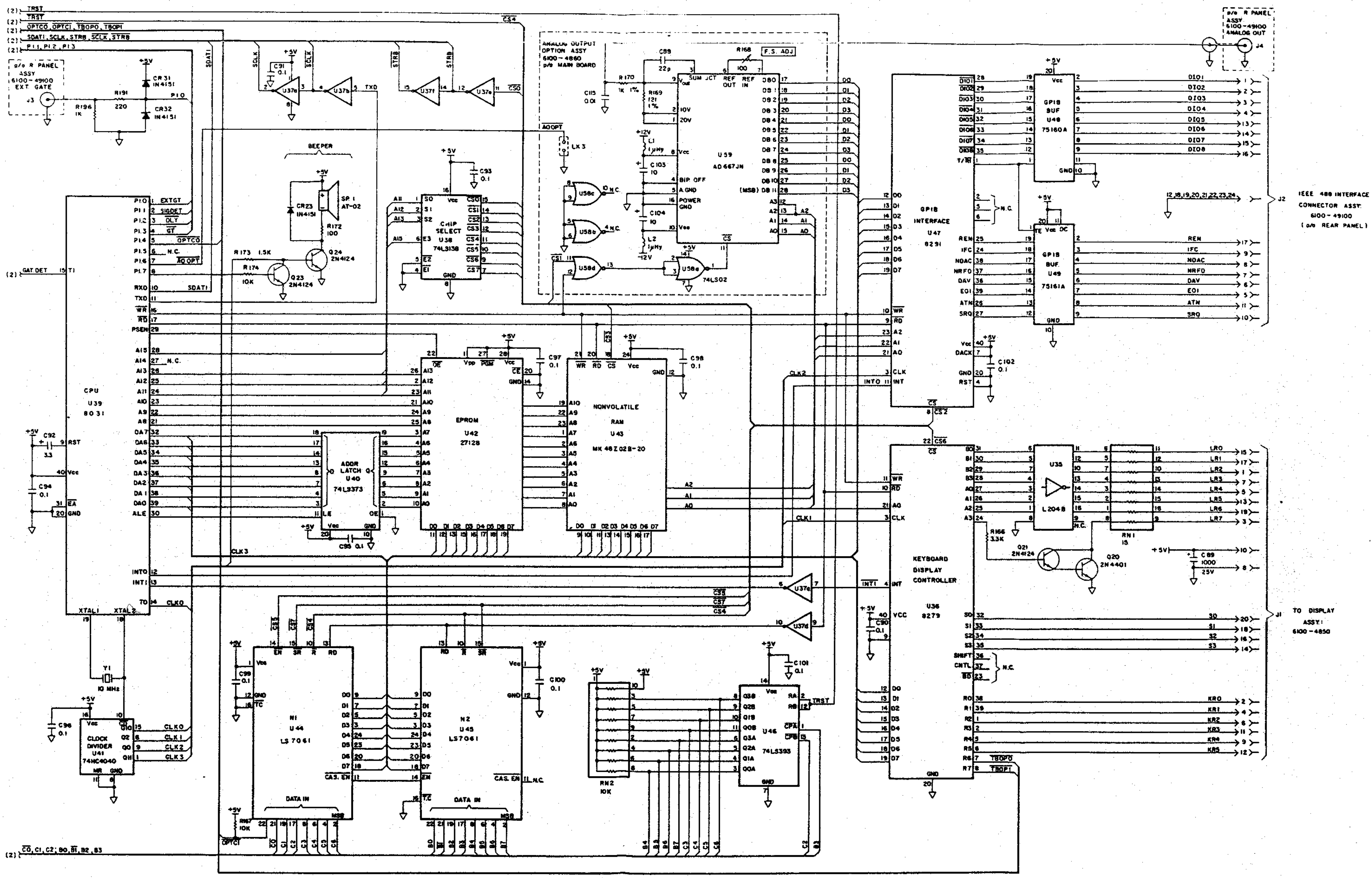


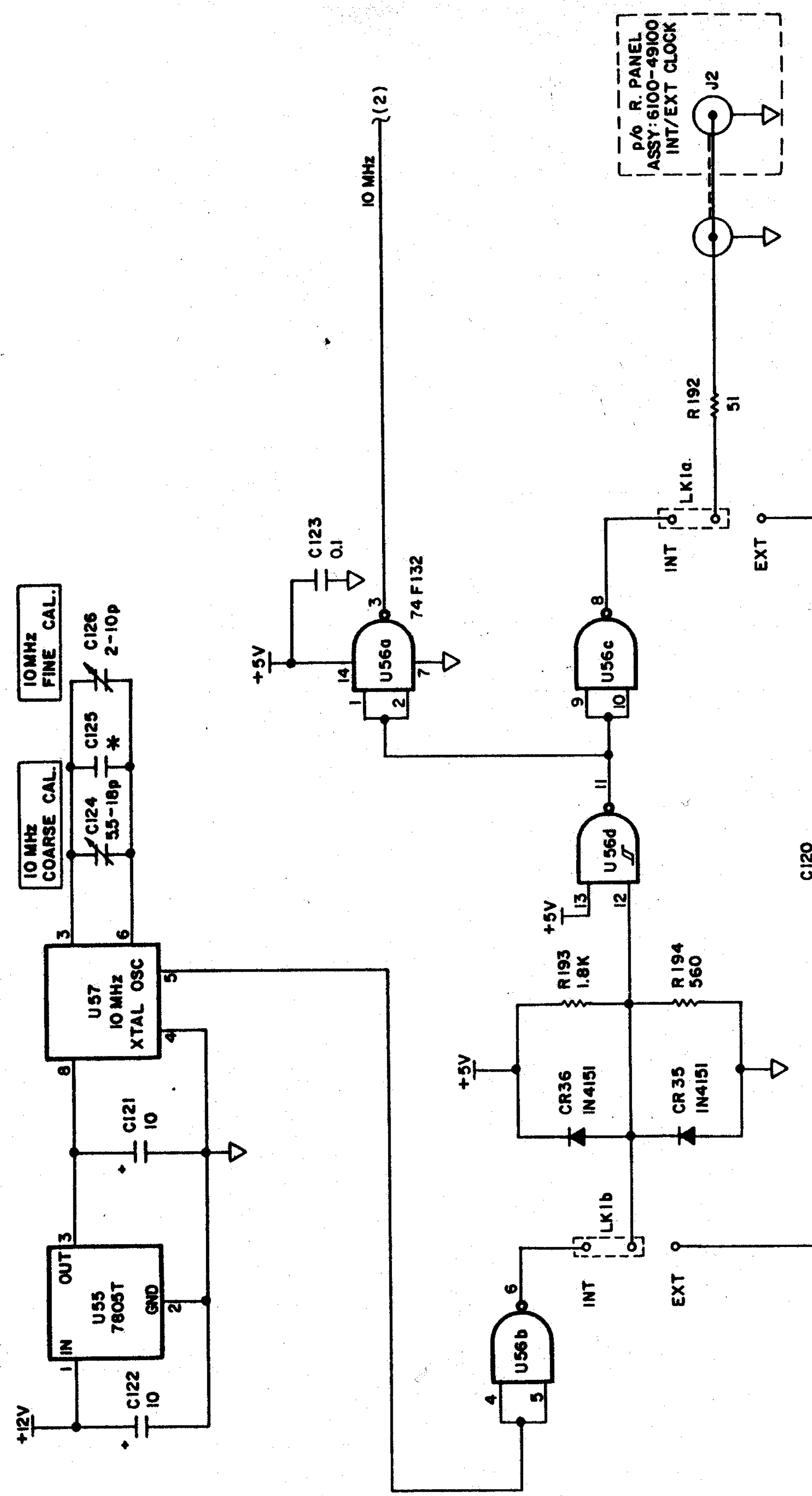
Figure 9-2. Main Board - Measurement Logic Circuit



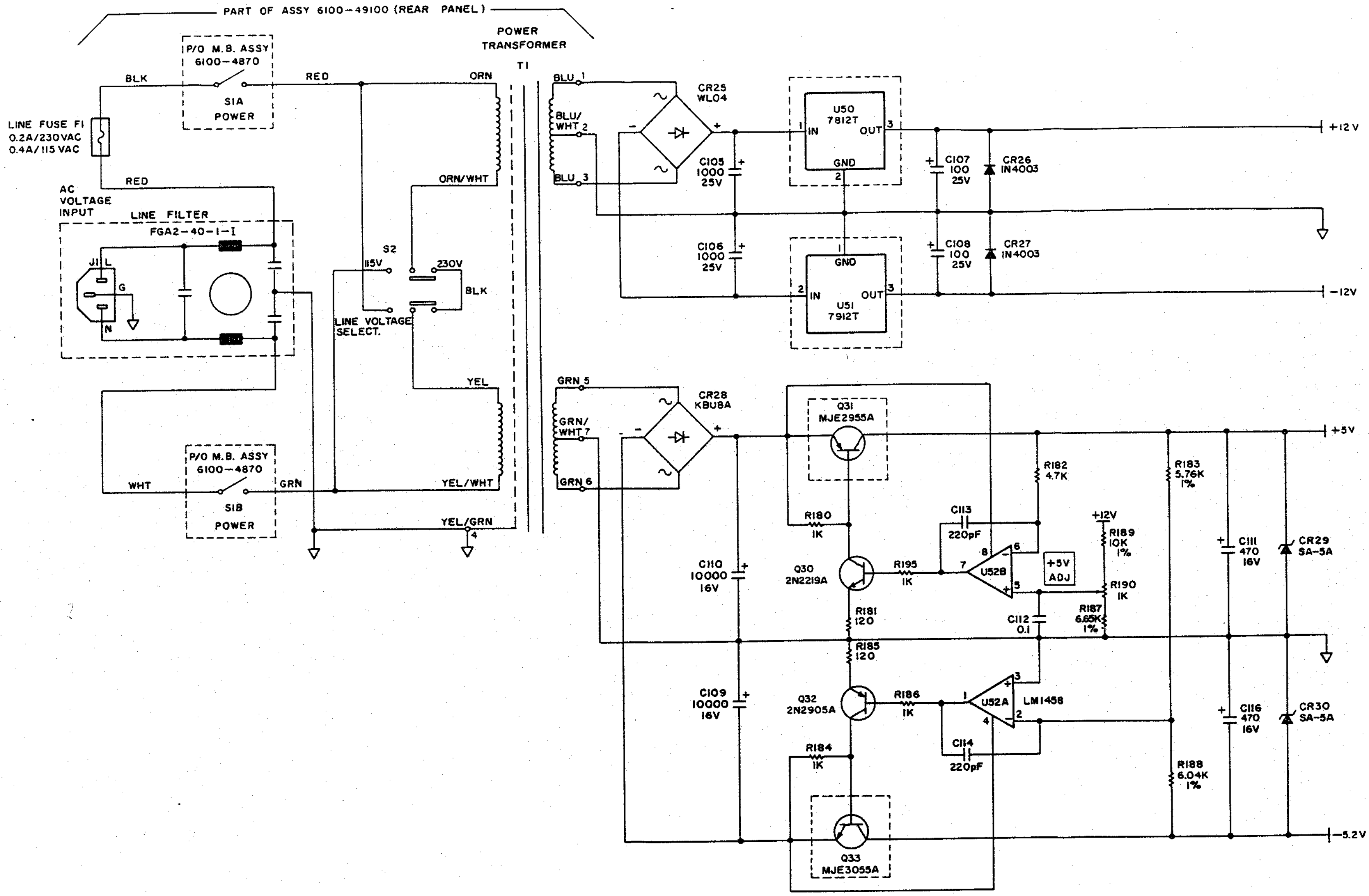
NOTES:

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. (n) DENOTES SHEET NUMBER.

Figure 9-3. Main Board - CPU Circuit



Page 9-4. Main Board - Standard 5PPM Time Base Circuit



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.

Figure 9-5. Main Board - Power Supply Circuit

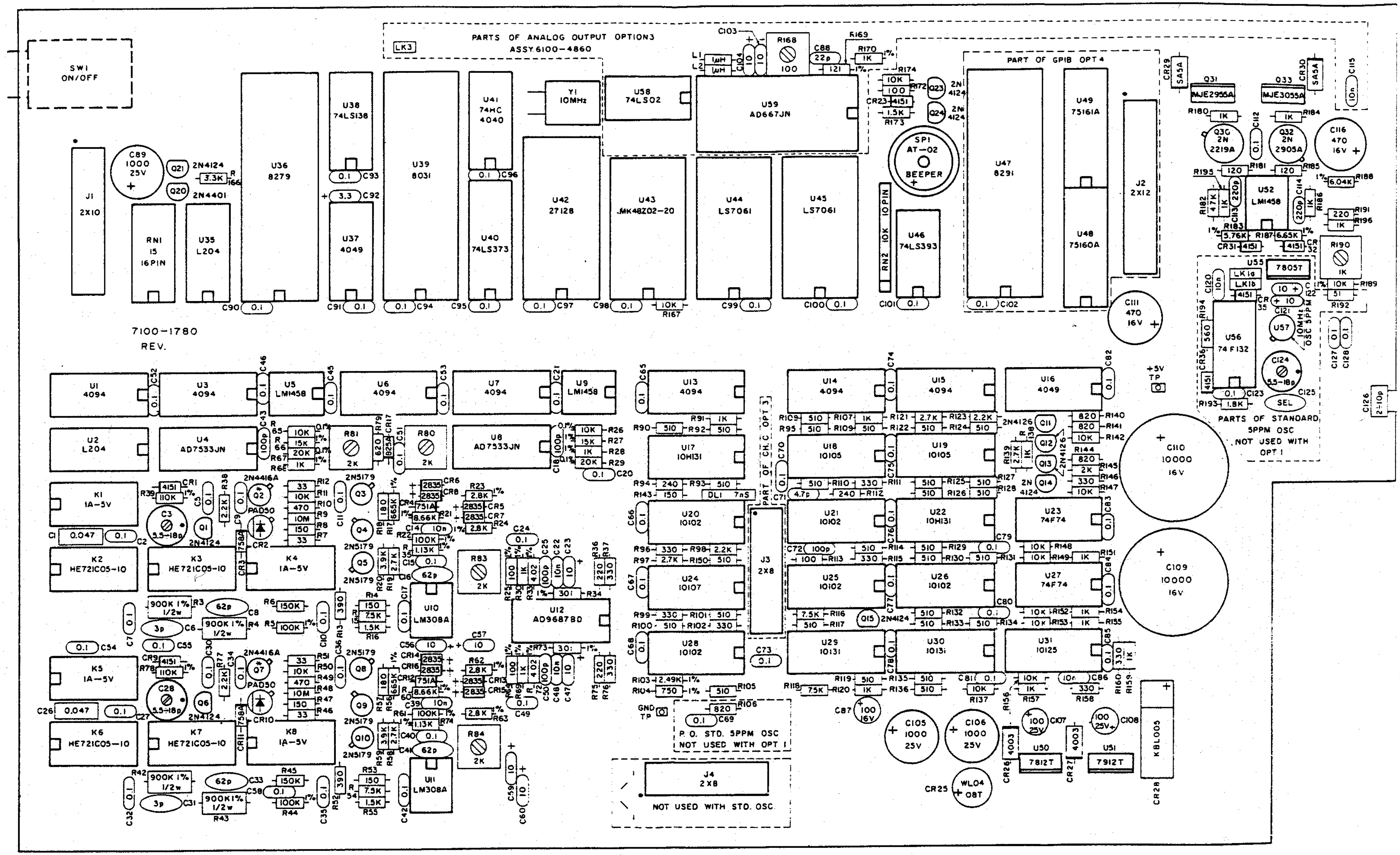


Figure 9-6. Main Board - Components Location Diagram

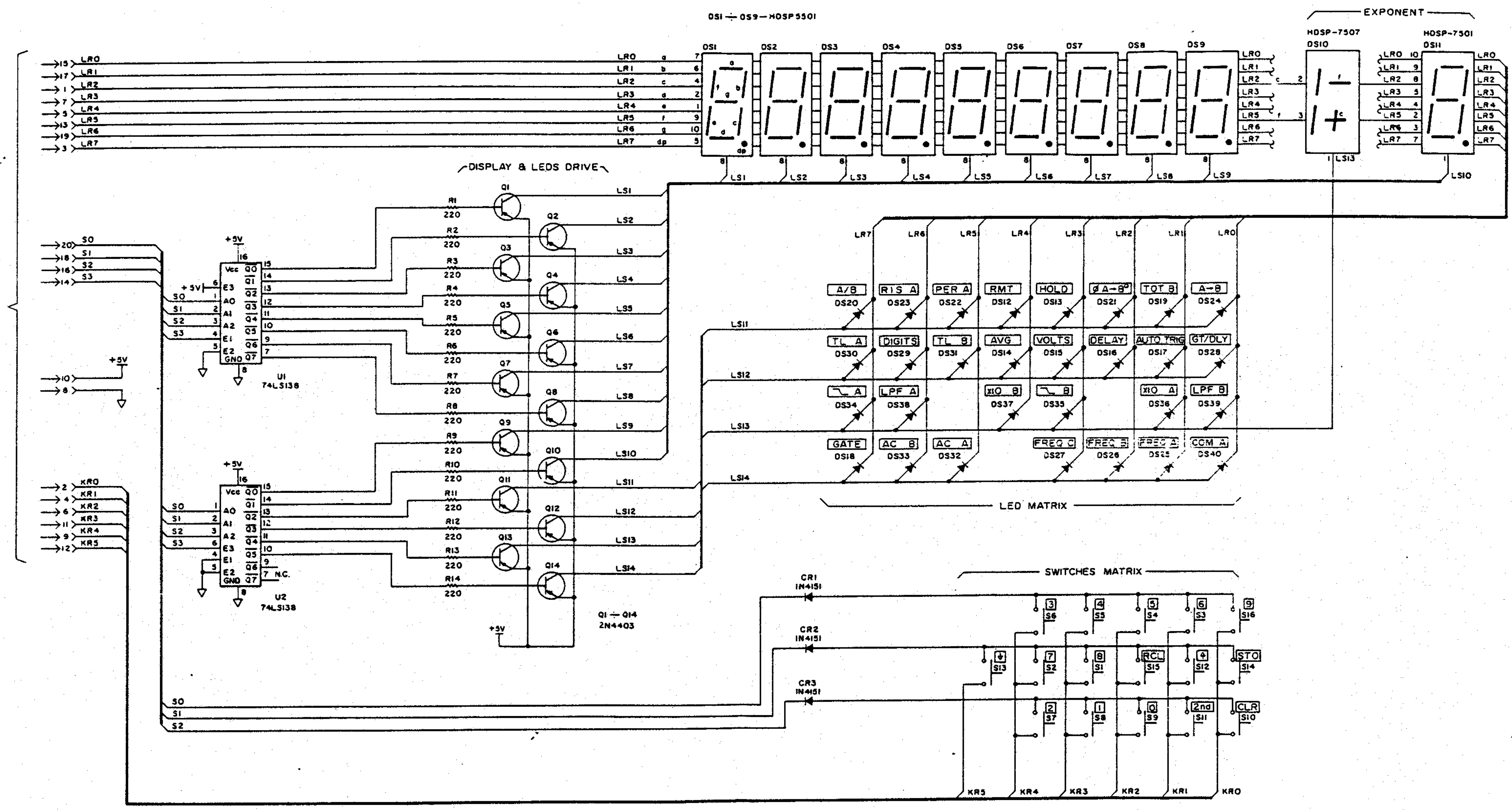
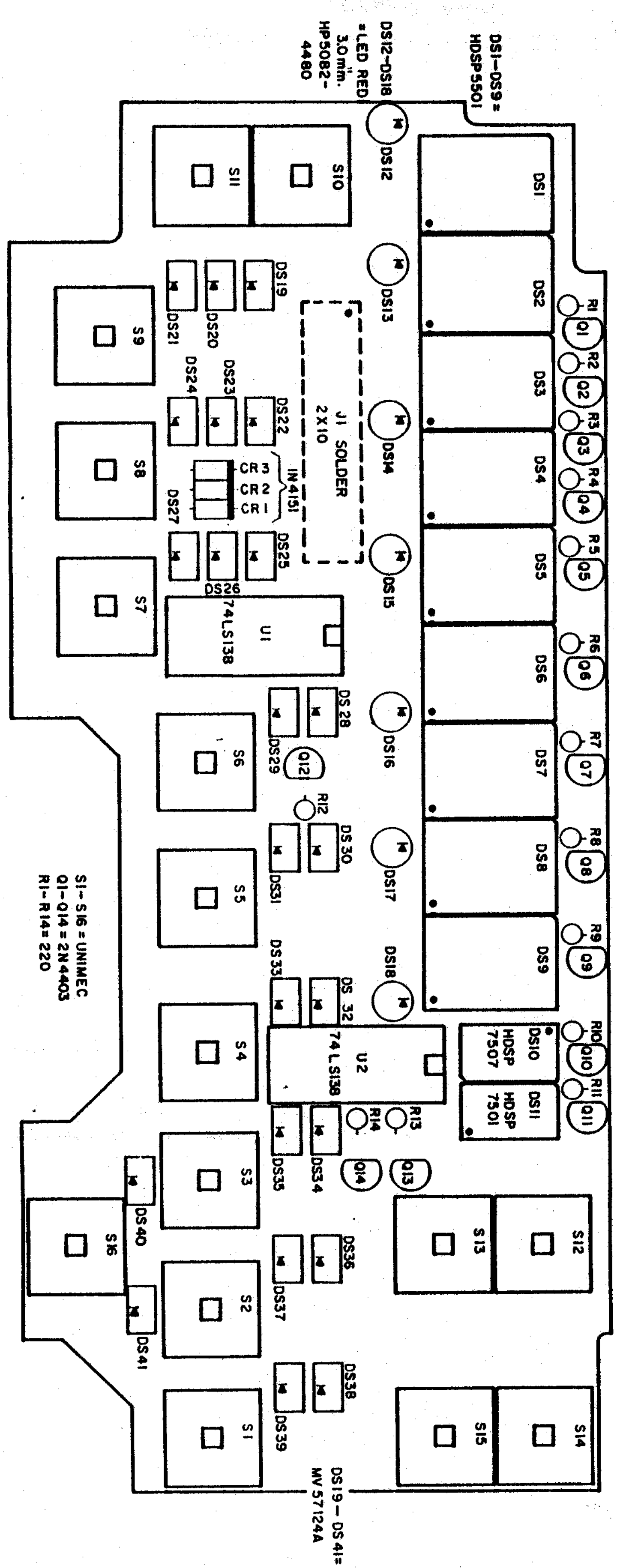
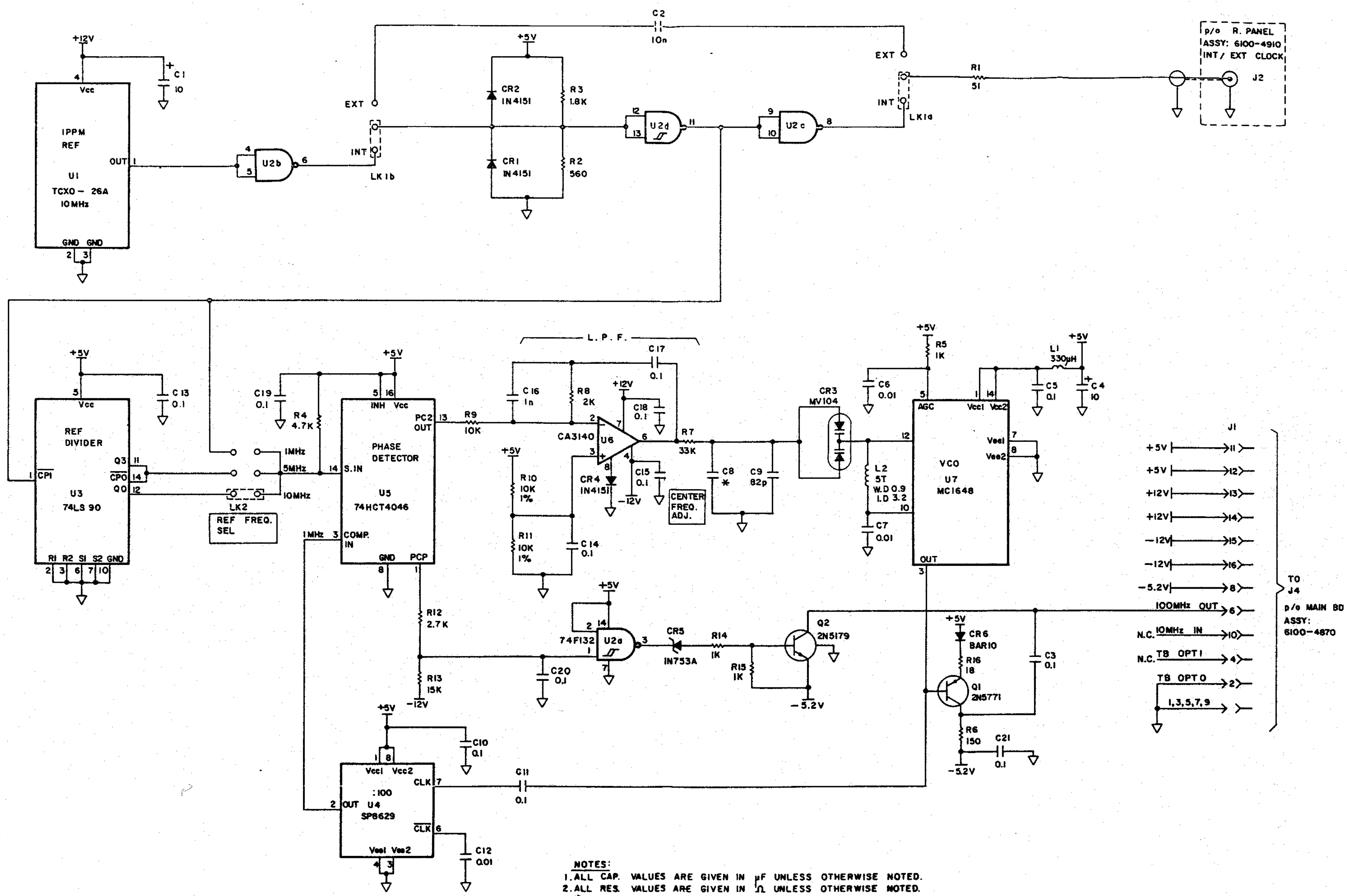


Figure 9-7. Front Panel - Keyboard and Display Circuit

* 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.

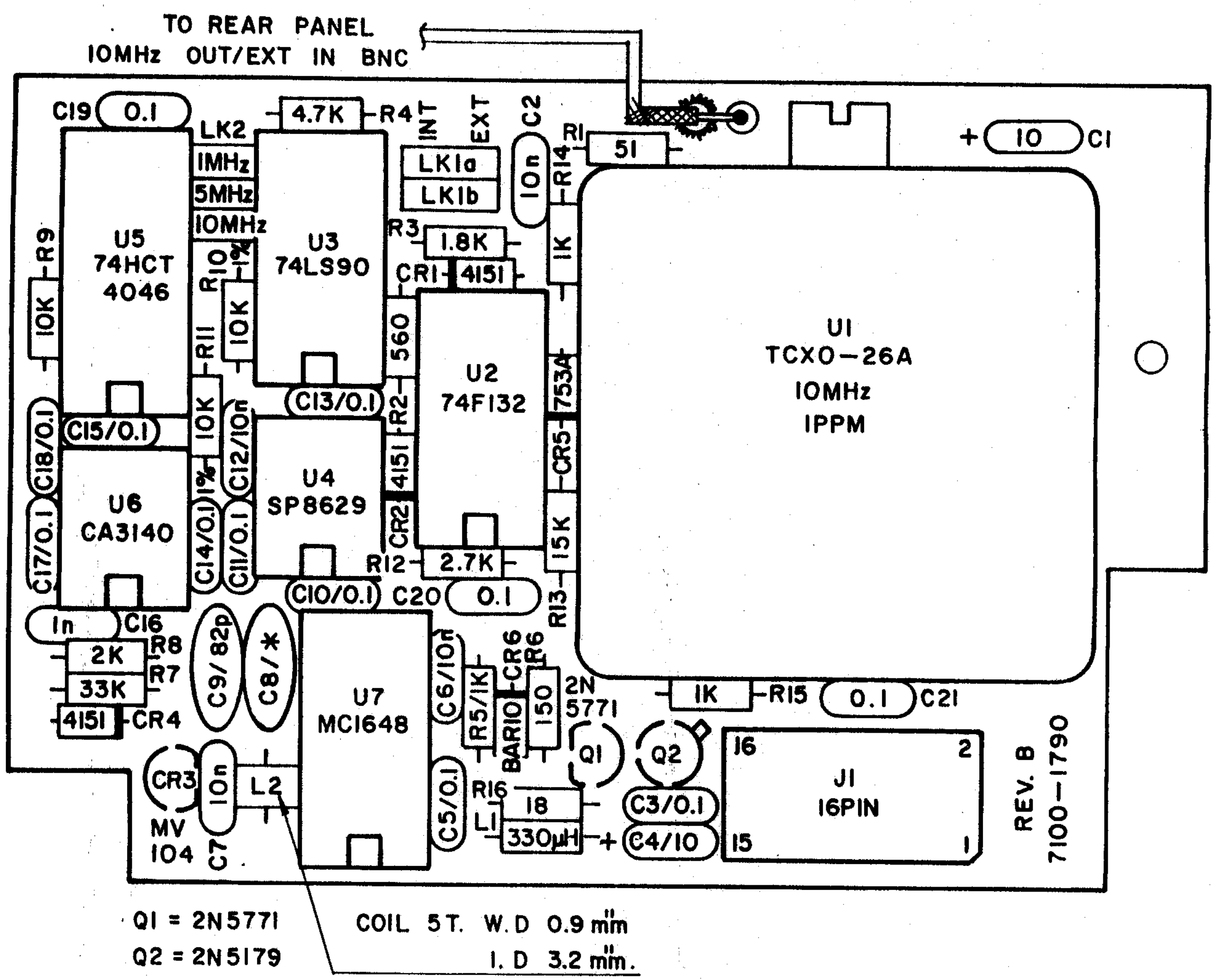


Page 9-8. Front Panel - Components Location Diagram

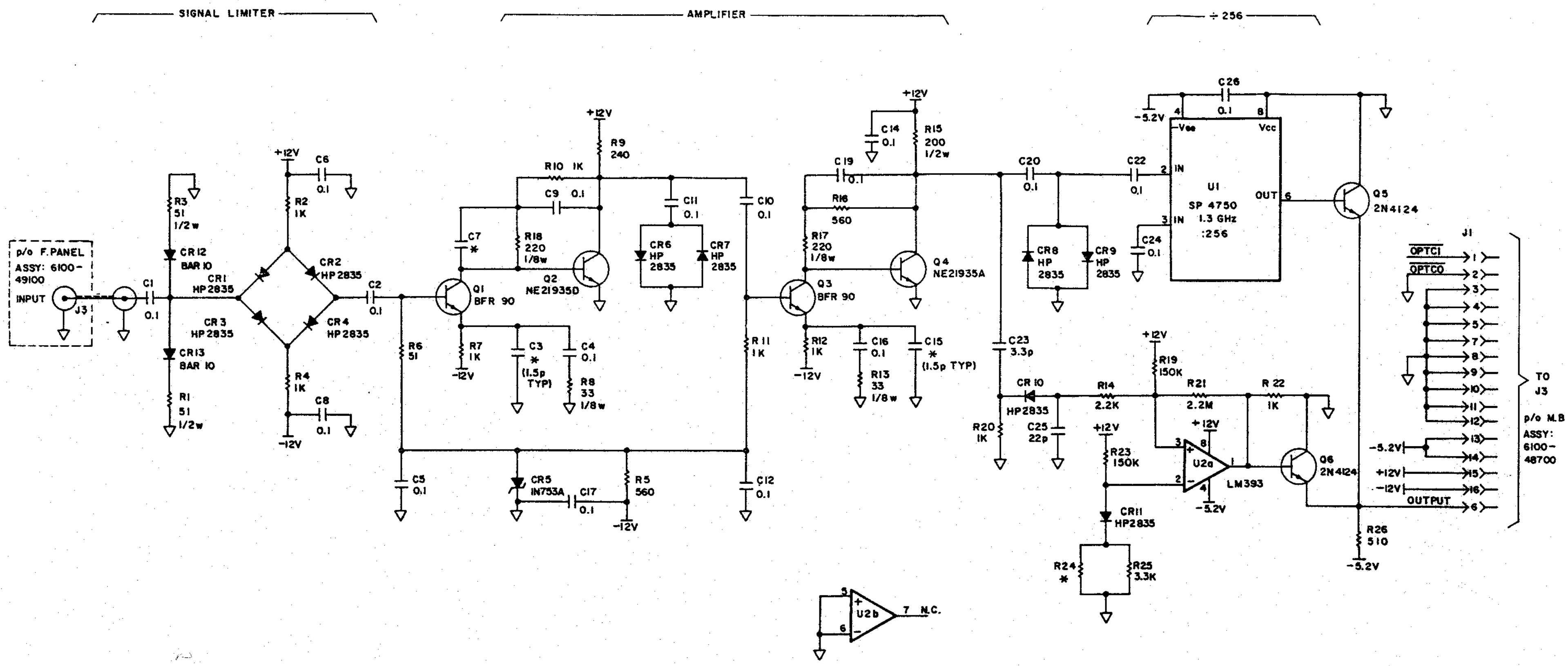


NOTES:
1. ALL CAP. VALUES ARE GIVEN IN µF UNLESS OTHERWISE NOTED.
2. ALL RES. VALUES ARE GIVEN IN Ω UNLESS OTHERWISE NOTED.
3. * DENOTES SELECTED VALUE MOST FREQUENT VALUE SHOWN.

Figure 9-9. Option 1 - TCXO and x10 Multiplier Circuit



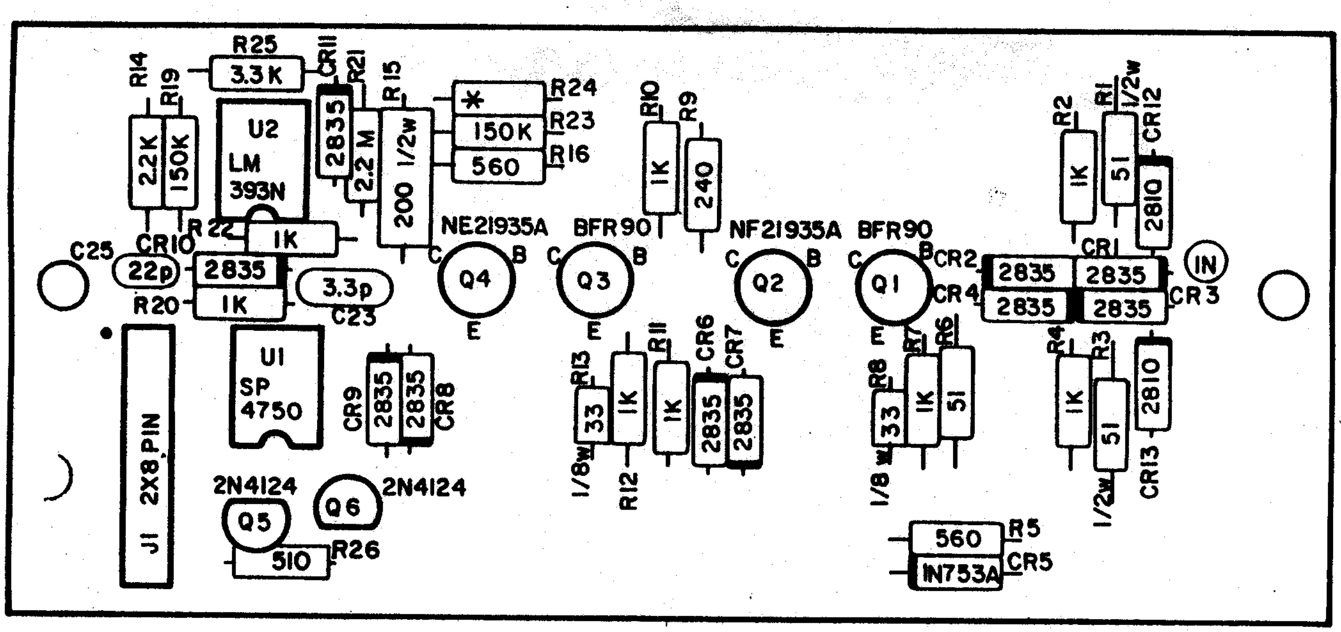
Page 9-10. Option 1 - Components Location Diagram



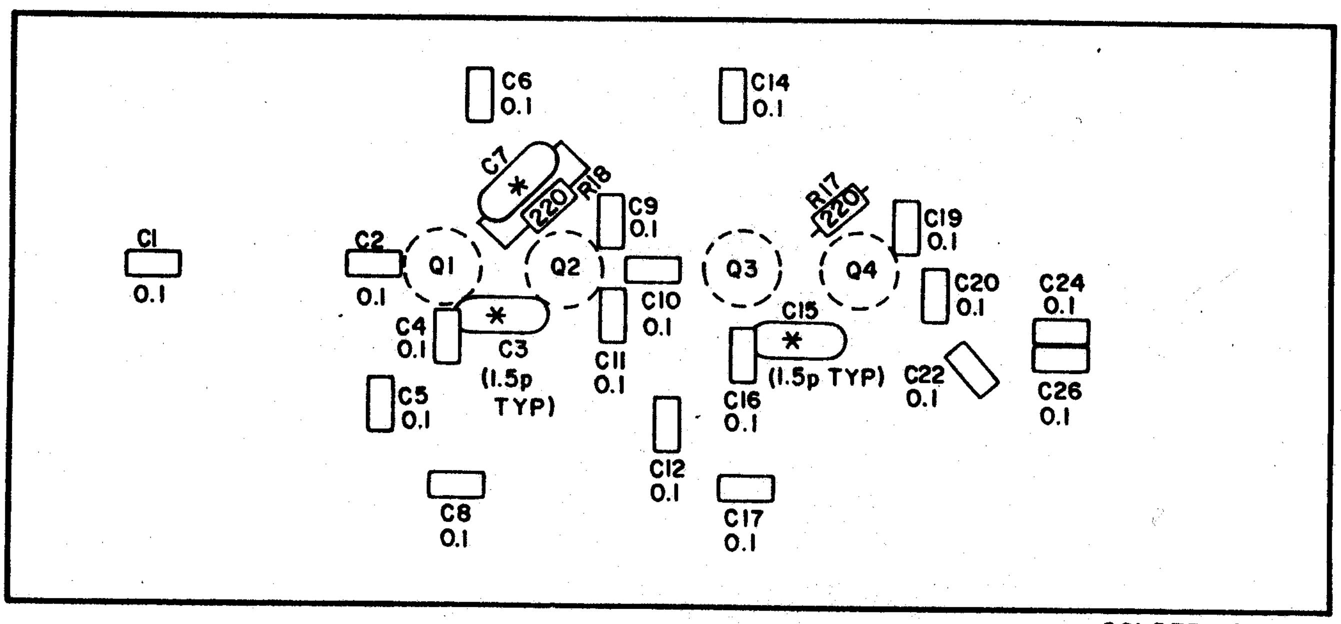
NOTES:

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. (n) DENOTES SHEET NUMBER.

Figure 9-11. Option 2 - 1.3 GHz Input Amplifier Circuit



COMPONENT SIDE



SOLDER SIDE

Page 9-12. Option 2 - Components Location Diagrams