

INSTRUCTION MANUAL



MODEL 1822

175 MHz UNIVERSAL COUNTER



TEST INSTRUMENT SAFETY

WARNING

Normal use of this instrument exposes you to a certain amount of danger from electrical shock because measurements must sometimes be taken in equipment that contains high voltage. An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Voltage as low as 35 volts dc or ac rms should be considered dangerous and hazardous since it can produce a lethal current under certain conditions. Higher voltage poses an even greater threat because it can more easily produce a lethal current. Your normal work habits should include all accepted practices that will prevent contact with exposed high voltage, and that will steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

1. Measurements should never be made at circuit points that exceed the maximum input voltages to the counter as listed in the "SPECIFICATIONS" section, or damage to the instrument may occur. Even when measurements are made at low voltage points, be careful to avoid touching any high voltage point. Remember that ac line voltage is usually present on some power input circuits such as on-off switch, fuses, power transformer, etc. any time the equipment is connected to an ac outlet, even if it is turned off.
2. If possible, familiarize yourself with the equipment being tested and the location of its high voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.
3. Use the time-proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contacting a nearby metal object that could provide a good ground return path.
4. Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment; make certain such surfaces are not damp or wet.
5. Connect the counter's ac power cord only to a 3-wire outlet to assure that the instrument's chassis, connectors, and probe ground lead are at earth ground.

(continued on inside back cover)

**Instruction Manual
for**



**Model 1822
175 MHz
Universal Counter**



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INTRODUCTION

The **B&K-Precision** Model 1822 Universal Counter is a high-quality, lightweight counter capable of frequency measurements from 5 Hz to 175 MHz. It features an eight-digit display which provides up to 0.1 Hz resolution at all frequencies below 10 MHz, and 1 Hz resolution at all frequencies to 175 MHz.

In addition to frequency measurements, the versatile Model 1822 also provides a number of other very useful operating modes.

In period mode, the unit measures the period (in microseconds or milliseconds) of one cycle, over the range of 5 Hz to 2 MHz. At low frequencies, much greater accuracy can be achieved by period measurement than by frequency measurement.

In frequency ratio mode, frequencies of two input signals are compared and their ratio displayed. This is useful in cases where a number of different signals are related to some reference, such as a clock signal in digital circuits.

In time interval mode, the counter measures the elapsed interval (in microseconds or milliseconds) from a selected edge of one input signal to a selected edge of another. Time interval mode is especially useful in duty cycle measurements, where both inputs are connected to the same signal and different edges are selected to display "on" or "off" time. Measurement of time interval between two "once-only" events is also possible.

Totalize mode permits counting of individual events. The counting process can be gated, either manually by a front panel switch, or by a gating signal applied to a rear panel jack, for more exact electronic control.

A self test mode is also provided which enables a quick check of several facets of instrument operation.

Each operating mode, and one of four decades of resolution are selected by front panel pushbutton switches. Easy-to-interpret readouts are provided by large bright digits, automatic decimal point placement, leading zero blanking, and LED display of proper measurement units. Overrange and GATE function (indication of a measurement in progress) are also shown on front panel indicators.

A number of signal conditioning controls are provided to prevent mis-counting due to input noise, etc. These include edge selectors and selectable X10 attenuators for both channels, and a 10 kHz low-pass filter and variable trigger threshold control for Channel A.

A front panel HOLD switch is provided which "freezes" the display at the present reading, as well as a RESET button which clears the counter display and initiates a new measurement when released.

The standard input impedance of one megohm in conjunction with a ten-to-one scope probe makes this instrument ideal for use in applications where source loading must be kept to a minimum.

The 10 MHz time base is generated by a crystal controlled oscillator for good stability with regard to temperature (± 10 ppm, 0°C to 50°C) and line voltage variation (± 1 ppm for 10% variation). Even better temperature stability (± 1 ppm, 0°C to 50°C) is available with an optional temperature-compensated crystal oscillator (TCXO), which may be installed by the user.

The exceptional accuracy, sensitivity, and versatility of this counter makes it an extremely valuable instrument to the scientist, engineer, experimenter, and communications technician. Its ruggedness and compactness make it practical for use by the hobbyist or field technician.

SPECIFICATIONS

FUNCTIONS

Frequency.	Time Interval.
Period.	Totalize.
Period Average.	Self Test.
Ratio.	

FEATURES

8 Digits.	Adjustable Trigger Level (Ch. A).
Metal Case.	Selectable Trigger Slope (Ch. A & Ch. B).
Dual Input.	
Low Pass Filter (Ch. A).	
2-Position Attenuator (Ch. A & Ch. B).	

FREQUENCY A

Range:	5 Hz to 175 MHz sine wave: 5 Hz - 10 MHz in kHz mode, 50 kHz - 175 MHz in MHz mode.
Resolution:	0.1 Hz to 1 kHz, in decade steps.
Accuracy:	± 1 count \pm time base error.
Display:	kHz or MHz with decimal point.

PERIOD A

Range:	0.5 μ s to 200,000 μ s.
Freq. Range:	5 Hz to 2 MHz sine wave.
Resolution:	100 ps to 100 ns in decade steps.
Accuracy:	± 1 count \pm time base error \pm trigger error ¹

¹NOTE: Trigger error is typically $\pm 0.3\%$ of reading divided by the number of cycles averaged, for input signals having better than 40 dB S/N ratio and greater than 100 mV amplitude.

PERIOD A (cont.)

Display: ms or μ s with decimal point.

Minimum Pulse Width: 250 ns.

Average: 1, 10, 100, or 1000 cycles averaged, depending on RESOLUTION setting.

RATIO A/B

Freq. Range A: 5 Hz to 10 MHz sine wave.

Freq. Range B: 5 Hz to 2 MHz sine wave.

Resolution: $\pm \frac{\text{Freq B}}{\text{Freq A} \times N}$ where N = 1, 10, 100, or 1000.

Accuracy: $\pm(\text{Freq B} + \text{Freq (A} \times \text{N)}) \pm \frac{(\text{Freq B} \times \text{Trigger Error}^1)}{N}$

Display: Numerical ratio with decimal point.

TIME INTERVAL A TO B

Range: 0.5 μ s to 200,000 μ s.

Freq. Range: 5 Hz to 2 MHz, sine wave.

Resolution: 100 ps to 100 ns in decade steps.

Accuracy: ± 1 count \pm time base error \pm trigger error¹ \pm N, where N = intervals averaged.

Minimum Pulse Interval (A to B): 250 ns.

Display: msec or μ sec with decimal point.

Average: 1, 10, 100, or 1000 intervals averaged.

Single Event Capability: Pressing RESET primes unit for measurement of "once-only" event.

TOTALIZE A

- Range:** 5 Hz to 10 MHz sine wave.
- Count Capability:** 0 to 99,999,999 before OVERflow.
- Control:** Manual reset and hold from the front panel. Normally enabled, except when signal at back panel START/STOP jack is low.

SELF TEST

- Display:** 10 MHz with user-selectable MHz, kHz.
- Gate Times:** 10 ms, 100 ms, 1 s, or 10 s accumulation times.
- Resolution:** 0.1 Hz to 100 Hz.

CHANNEL A INPUT CHARACTERISTICS

Bandwidth: 5 Hz to 175 MHz, ac coupled.

Sensitivity:

kHz FREQUENCY mode:	MHz FREQUENCY mode;
20 mV rms, 5 Hz to 5 MHz.	20 mV rms, 5 MHz to 125 MHz.
-----	40 mV rms, 125 MHz to 150 MHz.
-----	100 mV rms, 150 MHz to 175 MHz.

- Impedance:** 1 MΩ, < 40 pF.
- Attenuator:** X1, X10 switchable.
- Slope:** +, - switchable.
- Trigger Level:** Preset or variable.
- LP Filter:** 10 kHz, nominal -3 dB cutoff frequency.
- Maximum input:** 250 V rms.

CHANNEL B INPUT CHARACTERISTICS

- Bandwidth:** 5 Hz to 2 MHz, ac coupled.
- Sensitivity:** 30 mV rms.
- Impedance:** 1 MΩ, < 40 pF.
- Attenuator:** X1, X10 switchable.
- Slope:** +, - switchable.
- Maximum input:** 125 V rms.

TOTALIZE START/STOP INPUT

Logic Levels:	Standard TTL levels; low level inhibits totalizing, high level enables it.
Loading:	One standard TTL gate.

TIME BASE CHARACTERISTICS

Type:	Crystal controlled oscillator.
Frequency:	10 MHz.
Setability:	± 0.1 ppm (± 1 Hz).
Line Voltage Stability:	Less than ± 1 ppm with $\pm 10\%$ line voltage variation.
Temperature Stability:	Less than $\pm 0.001\%$ (± 10 ppm) from 0°C to 50°C ambient.
Maximum aging rate:	± 10 ppm/yr.
TCXO Option:	Temp. stability: less than $\pm 0.0001\%$ variation (± 1 ppm) from 0°C to 50°C ambient.

DISPLAY CHARACTERISTICS

Display:	Eight .43" seven-segment digits with kHz/ μ SEC, MHz/mSEC, GATE and OVERflow indicators.
OVERflow Indication:	LED indicator lights when count exceeds 99999999 during any selected gate time.
Display Update Time:	<ol style="list-style-type: none">1. kHz FREQUENCY and SELF TEST modes: user-selected gate time of .01, .1, 1, or 10 s plus fixed 200 ms interval.2. MHz FREQUENCY mode: user-selected gate time of .02, .2, 2, or 20 s plus fixed 400 ms interval.3. PERiod, RATIO, and Time Interval modes: user-selected cycles averaging of 1, 10, 100, or 1000 cycles plus fixed 200 ms interval.4. Continuous in TOTALize mode.

GENERAL CHARACTERISTICS

RESET:	Resets the counter and display to zero.
HOLD:	<p>Except in TOTALize mode, any measurement in progress is stopped, the counter is reset, and the last complete measurement is displayed. When HOLD is released, a new measurement begins.</p> <p>In the TOTALize mode, the counter is stopped but not reset, and the last count is displayed. When HOLD is released, the count continues from where the counter stopped.</p>
Power Requirements: (Universal)	100, 120, 220, 240 VAC (all $\pm 10\%$) set by internal PC jumpers; 50/60 Hz; 20 VA. Domestic units factory wired for 120 VAC.
Dimensions: (HWD)	9.5 x 24 x 32 cm (3.75 x 9.5 x 12.6").
Weight:	2.55 kg (5.6 lbs).

CONTROLS AND INDICATORS

Refer to Fig. 1.

1. **Display.** Eight-digit display used for all readings.
2. **GATE Indicator.** Lights whenever a measurement is being taken.
3. **kHz/ μ SEC Indicator.** In FREQUENCY mode, indicates that the frequency displayed is in kilohertz. In PERIOD or Time Interval mode, indicates that the period or time interval displayed is in microseconds. Not used in RATIO or TOTALize modes.
4. **MHz/mSEC Indicator.** In FREQUENCY mode, indicates that the frequency displayed is in megahertz. In PERIOD or Time Interval mode, indicates that the period or time interval displayed is in milliseconds. Not used in RATIO or TOTALize modes.

Items 5 through 9 apply to Channel A only.

5. **LPF (Low-Pass Filter) Switch.** With this switch pushed in, the Channel A input is routed through a low-pass filter with a -3 dB point of approximately 10 kHz. When it is released (out), the input is applied directly.
6. **-SL (Slope) Switch.** Selects positive-going or negative-going edge of Channel A signal for triggering. When pushed in, negative-going edge is selected; when released (out), positive-going edge is selected.
7. **X10 Attenuator Switch** When this switch is pushed in, the Channel A input is

attenuated 10:1 before application to the counter. With the switch released (out), the signal is applied unattenuated.

8. **TRIG LEVEL Control.** Adjusts trigger threshold level on the Channel A input signal. Pushing the knob in (PRESET-IN) sets this level at the mid-point of a symmetrical sine wave input. Pulling the knob out and rotating it varies the level from negative (-) to positive (+) around the midpoint.
9. **Channel A Input Jack.** Female BNC connector terminated in a 1 megohm input resistance, shunted by < 40 pF capacitance.

Items 10 through 12 apply to Channel B only.

10. **Channel B Input Jack.** Female BNC connector terminated in a 1 megohm input resistance, shunted by < 40 pF capacitance.
11. **X10 Attenuator Switch** When this switch is pushed in, the Channel B input is attenuated 10:1 before application to the counter. With the switch released (out), the signal is applied unattenuated.
12. **-SL (Slope) Switch.** Selects positive-going or negative-going edge of Channel B signal for triggering. When pushed in, negative-going edge is selected; when released (out), positive-going edge is selected.
13. **RESET Switch.** In all modes, pushing this momentary switch resets the counter to zero. When it is released, the measurement starts again.

CONTROLS AND INDICATORS

14. **HOLD Switch.** Functions as follows:

- a. All modes except TOTALize: Setting this switch to ON "freezes" the display at the existing reading and resets the counter. Releasing the switch starts a new measurement; the display is updated when this measurement is completed.
- b. TOTALize mode: Setting the switch to ON "freezes" the display at the existing reading and halts the totalizing process. When the switch is released, counting resumes, provided that the gating signal at the rear panel TOTALIZE START/ STOP jack (26) is high (or jack is open).

15. **k/ μ -M/m Switch.** When pushed in, this switch selects megahertz display for frequency readings, or millisecond display for period and time interval readings. When released (out), it selects kilohertz or microsecond display. Not used in RATIO and TOTALIZE modes.

16. **RESOLUTION Chart.** Used to determine degree of display resolution in PERiod μ SEC and both FREQUENCY modes. Use top row in FREQUENCY kHz mode, center in FREQUENCY MHz mode, and bottom in PERIOD μ SEC mode. Refer to operating instructions to determine resolution in other modes.

17. **RESOLUTION Switches.** These switches select the degree of display resolution in all modes except TOTALize. In PERiod μ SEC and both FREQUENCY modes, use them in conjunction with the RESOLUTION chart (16). In other modes, refer to the operating instructions to determine the resolution.

Set of four interlocking pushbutton switches. Pressing any button releases the previous selection.

Items 18 - 23 select the desired operating mode. Set of six interlocking pushbuttons; pressing any button releases the previous selection.

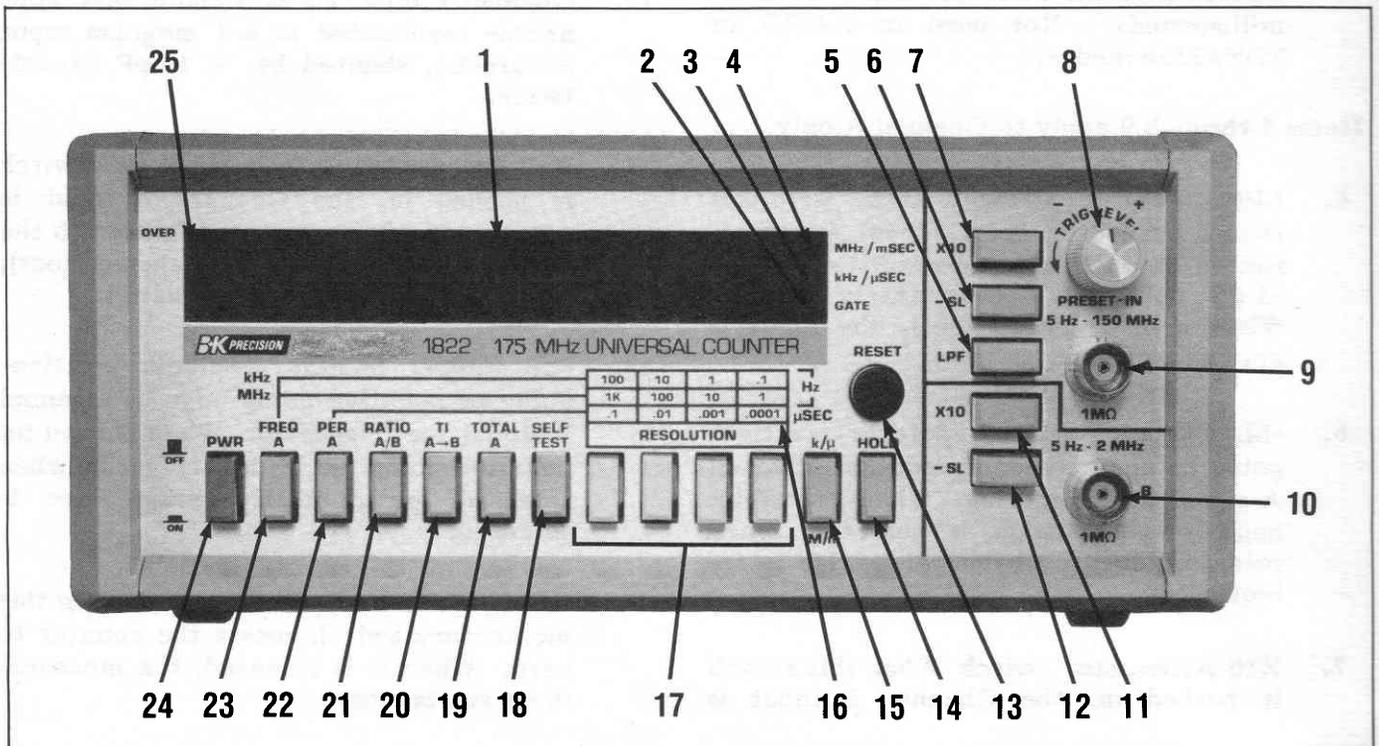


Fig. 1. Controls and indicators.

18. **SELF TEST Switch.** When this switch is pushed in, the unit displays the frequency of the internal time base, providing a general check of performance.
19. **TOTALize A Switch.** When this switch is engaged, the unit counts cycles of the Channel A input and continuously displays that count. Totalization can be controlled by a gate signal at the rear panel TOTALIZE START/STOP jack (26).
20. **TI (Time Interval) A → B Switch.** When this switch is pushed in, the unit measures the time interval from an edge of the Channel A signal to an edge of the Channel B signal. Positive-going or negative-going edge of each signal is selected by the -SL switches (6, 12). Display is in μ s or ms, as selected by the k/ μ -M/m switch (15), and as indicated by the kHz/ μ SEC or MHz/mSEC indicators (3, 4). Resolution is selected by the RESOLUTION switches (17).
21. **RATIO A/B Switch.** When this switch is pushed in, the unit measures the ratio of the Channel A frequency to the Channel B frequency. Resolution is selected by the RESOLUTION switches (17).
22. **PERiod A Switch.** When this switch is pushed in, the unit displays the period of one cycle of the Channel A signal. Readings are in μ s or ms as selected by the k/ μ -M/m switch (15), and as indicated by the kHz/ μ SEC or MHz/mSEC indicators (3, 4). Resolution is selected by the RESOLUTION switches.
23. **FREQuency A Switch.** This switch selects frequency counter mode, for signal at Channel A input. Readings are in kHz or MHz as selected by the k/ μ -M/m switch (15), and as indicated by the kHz/ μ SEC or MHz/mSEC indicators (3, 4). Resolution is selected by the RESOLUTION switches (17).
- Note: Guaranteed frequency measurement ranges are as follows:
- kHz mode: 5 Hz to 10 MHz (above 10 MHz, display may show zero with no OVERflow indication); sine wave sensitivity: 20 mV rms, 5 Hz to 5 MHz.
- MHz mode: 50 kHz to 175 MHz; sine wave sensitivity: 20 mV rms, 5 MHz to 125 MHz, 40 mV rms, 125 MHz to 150 MHz, 100 mV rms, 150 MHz to 175 MHz.
- Because of these limits, try both ranges for an unknown circuit point unless you are reasonably sure of its frequency.
24. **PWR Switch.** Turns the unit ON and OFF.
25. **OVERflow Indicator.** Lights whenever the range of the display is exceeded. One or more most significant digits are not displayed.
26. **TOTALIZE START/STOP Input Jack.** (Not shown; located on rear panel.) Input jack used to control the totalization function, if desired. Unit stops totalizing whenever the signal applied at this jack goes to a TTL low level (or is connected to chassis ground).

OPERATING INSTRUCTIONS

SAFETY PRECAUTIONS

Use only a polarized 3-wire ac outlet. This assures that the chassis and ground points of the counter are connected to a good earth ground, and reduces danger from electrical shock.

Some operating conditions may pose an electrical shock hazard. These conditions are identified, and corresponding precautions listed, in the "TEST INSTRUMENT SAFETY" recommendations which are found starting on the inside front cover of this manual. Know and observe these precautions.

CAUTION

Before connecting unit to ac power, check carton labels to be certain that the unit is wired correctly for your particular line voltage. Line voltage conversion is covered in the "MAINTENANCE AND CALIBRATION" section of this manual.

PRELIMINARY

Numbers in parentheses refer to items in "CONTROLS AND INDICATORS" section and Fig. 1.

1. Connect the unit to ac power.
2. Set the PWR switch (24) to ON (pushed in). If no other front panel buttons have been engaged, the display is blank except for the lit kHz/ μ SEC indicator (3).

CAUTION

1. Application of input voltages higher than the limits listed in the

"SPECIFICATIONS" section may damage the counter. Before applying any signal to the inputs, make certain that it does not exceed these specified maximums.

2. Engaging the X10 switches (7, 11) does NOT alter these upper limits.

3. Counter ground points are connected directly to earth ground. Always connect counter ground only to ground points in the circuit under test.

FREQUENCY MEASUREMENTS

Basic Procedure

1. Apply the signal to be measured to the Channel A input jack (9).
2. Engage the FREQUENCY A switch (23).
3. Select measurement units with the k/ μ M/m switch (15): in for megahertz, out for kilohertz. The kHz/ μ SEC or MHz/mSEC indicator (3, 4) lights accordingly.

Note: Guaranteed frequency measurement ranges are as follows:

kHz mode: 5 Hz to 10 MHz (above 10 MHz, display may show zero with no OVERflow indication); sine wave sensitivity: 20 mV rms, 5 Hz to 5 MHz.

MHz mode: 50 kHz to 175 MHz; sine wave sensitivity: 20 mV rms, 5 MHz to 125 MHz, 40 mV rms, 125 MHz to 150 MHz, 100 mV rms, 150 MHz to 175 MHz.

Because of these limits, try both ranges for an unknown circuit point unless you are reasonably sure of its frequency.

4. Select the degree of resolution desired, using the RESOLUTION switches (17) and RESOLUTION chart (16). Use the top row of the chart for kHz mode, and the center row for MHz mode.
5. Frequency is given by the display (1). The GATE indicator (2) lights while each measurement is in progress, and the display is updated at the end of each measurement interval.

Note: some measurement delay and display instability may be encountered; see "Display Interpretation".
6. The OVERflow indicator (25) lights whenever the range of the display is exceeded.
7. Engaging the HOLD switch (14) "freezes" the display at the existing reading. When HOLD is released, a new measurement begins (GATE indicator lights), but the display continues to hold the old reading until the new measurement is completed.
8. Pushing the RESET switch (13) resets the display to zero. When RESET is released, a new measurement begins (GATE indicator lights), but the display remains at zero until the new measurement is complete.

Input Controls

The following controls can be used as required to condition the input, to prevent mis-counting from input noise or ringing.

1. **Input Filter.** Engaging the LPF (Low Pass Filter) switch (5) routes the Channel A input through a low-pass filter (-3 dB frequency of approximately 10 kHz) before application to the counter. This helps eliminate counting errors in low frequency measurements by reducing effects of high-frequency noise.
2. **Input Attenuator.** Engaging the Channel A X10 switch (7) attenuates the Channel A signal approximately 10:1 before application to the counter. This

helps prevent mis-counting caused by noisy or improperly terminated high-amplitude signals.

3. **Slope Selection.** The Channel A -SL (Slope) switch (6) selects positive or negative edge of the Channel A signal for triggering. Pushing the switch in triggers the unit on the negative-going edge; leaving it out causes triggering on the positive-going edge.

Note: the Channel A -SL switch is bypassed whenever FREQUENCY MHz mode is selected. Unit then counts on negative slope.

4. **Trigger Level Adjustment.** Channel A trigger threshold can be varied by the TRIG LEVEL control (8) as follows:
 - a. Pushing the control in (PRESET-IN) fixes the trigger level at roughly the average value of the Channel A input signal.
 - b. Pulling the control out and rotating it varies the threshold level from negative (-) to positive (+) around the PRESET-IN level.

The TRIG LEVEL control is discussed in more detail in the "General Considerations".

PERIOD MEASUREMENTS

In PERiod mode, the unit displays the period, or time required for one cycle of the input signal to occur. The actual measurement is made by averaging over 1, 10, 100, or 1000 cycles.

Basic Procedure

1. Apply the signal to be measured to the Channel A input jack (9).
2. Engage the PERiod A switch (22).
3. Select measurement units with the k/ μ -M/m switch (15): in for milliseconds, out for microseconds. The kHz/ μ SEC or MHz/mSEC indicator (3, 4) lights accordingly.

4. Select the degree of resolution desired, using the RESOLUTION switches (17) and RESOLUTION chart (16). In μ SEC mode, use the bottom line of the chart; in mSEC mode, multiply the bottom values by .001 for resolution in milliseconds.

(The RESOLUTION switches determine how many cycles are averaged in the measurement: 1, 10, 100, or 1000.)

Note: The .1/1/.0001 RESOLUTION switch is not used in mSEC mode (k/ μ -M/m switch pushed in). Engaging this switch causes a display of all "eights" and decimal points to appear.

5. Period is given by the display (1). The GATE indicator (2) lights while each measurement is in progress, and the display is updated at the end of each measurement interval. (At higher frequencies, the GATE indicator may flash too quickly to be seen.)

Note: some measurement delay and display instability may be encountered; see "Display Interpretation".

6. The OVERflow indicator (25) lights whenever the range of the display is exceeded.
7. Engaging the HOLD switch (14) "freezes" the display at the existing reading. When HOLD is released, a new measurement begins (GATE indicator lights), but the display continues to hold the old reading until the new measurement is completed.
8. Pushing the RESET switch (13) resets the display to zero. When RESET is released, a new measurement begins (GATE indicator lights), but the display remains at zero until the new measurement is complete.
9. The Channel A input controls (filter, attenuator, trigger slope and level) may be used to condition the input, to prevent mis-counting from input noise or ringing. See "Frequency Measurements - Input Controls".

FREQUENCY RATIO MEASUREMENTS

In this mode of operation, the counter displays the ratio of the frequency applied to Channel A to the frequency applied to Channel B. The Channel A frequency should preferably be equal to or greater than that of Channel B, and both frequencies must be within the limits given in the "SPECIFICATIONS" section.

Frequency ratio is determined by counting the number of Channel A cycles occurring during a specified number of Channel B cycles (1, 10, 100, or 1000) and applying the result, with a proper decimal point, to the display.

Basic Procedure

1. Connect the signals to be measured to the Channel A and Channel B input jacks (9, 10).

Note: both channels may be connected to the same signal for a ratio of 1.

2. Engage the RATIO A/B switch (21).
3. Both the kHz/ μ SEC and MHz/mSEC indicators (3, 4) are off because the reading displayed is a ratio.
4. Select the resolution desired using the RESOLUTION switches (17). Four decades of resolution are available, from no decimal places (in 100/1K/.1 position) to 3 decimal places (in .1/1/.0001 position).

(The RESOLUTION switches determine over how many cycles of Channel B the measurement is taken: 1, 10, 100, or 100.)

Note: The k/ μ -M/m switch (15) is ignored in RATIO mode.

5. Frequency ratio is given by the display (1). The GATE indicator (2) lights while each measurement is in progress, and the display is updated at the end of each measurement interval. (At higher Channel B frequencies, the GATE indicator may flash too quickly to be seen.)

Note: some measurement delay and display instability may be encountered; see "Display Interpretation".

6. The OVERflow indicator (25) lights whenever the range of the display is exceeded.
7. Engaging the HOLD switch (14) "freezes" the display at the existing reading. When HOLD is released, a new measurement begins (GATE indicator lights), but the display continues to hold the old reading until the new measurement is completed.
8. Pushing the RESET switch (13) resets the display to zero. When RESET is released, a new measurement begins (GATE indicator lights), but the display remains at zero until the new measurement is complete.
9. The Channel A input controls (filter, attenuator, trigger slope and level) may be used to condition the inputs, to prevent mis-counting from input noise or ringing. See "Frequency Measurements - Input Controls". Channel B input controls are also provided (attenuator, 11, and trigger slope selector, 12), and operate identically to their Channel A counterparts.

TIME INTERVAL MEASUREMENTS

In Time Interval mode, the unit measures the elapsed time from a selected edge of the Channel A waveform to a selected edge of the Channel B waveform.

For a stable reading, the two input signals should be related to each other such that this time interval remains reasonably constant from one measurement to the next. For example, two digital waveforms derived from the same clock would be suitable; two arbitrary frequencies from separate function generators would not.

Both inputs may be connected to the same signal for duty cycle measurements; this is discussed in the "General Considerations".

Basic Procedure

1. Connect the signals to be measured to the Channel A and Channel B input jacks (9, 10).
2. Engage the TI A → B switch (20). The switch label serves as a reminder that the measurement starts at the Channel A edge and stops at the Channel B edge.
3. Select desired edge of each waveform using the Channel A and Channel B -SL switches (6, 12). Push switch in for negative-going edge, leave out for positive-going edge.

Note: When measuring time interval between similar edges on the same waveform (e.g. positive edge to next positive edge), it is advisable to use PERiod rather than Time Interval mode. See "General Considerations".

4. Set the Channel A TRIG LEVEL control (8) to PRESET-IN (pushed in). This ensures that both Channel A and Channel B are triggering at the same level (approximately the average) on their respective waveforms.
5. Select measurement units with the k/μM/m switch (15): in for milliseconds, out for microseconds. The kHz/μSEC or MHz/mSEC indicator (3, 4) lights accordingly.
6. Select the degree of resolution desired, using the RESOLUTION switches (17) and RESOLUTION chart (16).

Note: Selecting a finer Time Interval resolution results in more periods being averaged (1, 10, 100, 1000), and a greater accumulated error. The result is that all RESOLUTION settings have the same inherent resolution (see "Display Interpretation - Display Instability").

Note: The .1/1/.0001 RESOLUTION switch is not used in mSEC mode (k/μM/m switch pushed in). Engaging this switch causes a display of all "eights" and decimal points to appear.

OPERATING INSTRUCTIONS

7. Time interval is given by the display (1). The GATE indicator (2) lights while each measurement is in progress, and the display is updated at the end of each measurement interval. (At higher frequencies, the GATE indicator may flash too quickly to be seen.)
Note: some measurement delay and display instability may be encountered; see "Display Interpretation".
8. The OVERflow indicator (25) lights whenever the range of the display is exceeded.
9. Engaging the HOLD switch (14) "freezes" the display at the existing reading. When HOLD is released, a new measurement begins (GATE indicator lights), but the display continues to hold the old reading until the new measurement is completed.
10. Pushing the RESET switch (13) resets the display to zero. When RESET is released, a new measurement begins (GATE indicator lights), but the display remains at zero until the new measurement is complete.
11. Time interval can also be measured for "once-only" events. Select the 100/1K/.1 RESOLUTION setting (this must be used for single events, because the others are all multiple-event averaging). Set the -SL switches for the anticipated level transitions, and push RESET to prime the unit. Wk,n the event has occurred (Channel A transition followed by Channel B transition), the time interval is displayed. For each single-event measurement, the counter must again be primed by pressing RESET.

Input Controls

The following controls can be used to condition the input, to prevent mis-counting from input noise or ringing.

1. **Input Filter.** Engaging the LPF (Low Pass Filter) switch (5) routes the Channel A input through a low-pass filter (-3 dB frequency of approximately 10 kHz) before application to the counter. This helps eliminate the effects of high-frequency noise in the Channel A input.
2. **Input Attenuator.** Engaging the Channel A or Channel B X10 switch (7, 11) attenuates the Channel A or Channel B signal approximately 10:1 before application to the counter. This helps prevent mis-counting caused by noisy or improperly terminated high-amplitude signals.

TOTALIZE MEASUREMENTS

The TOTALize mode is used to count the total number of events occurring during a specific time period. This time period can be defined by front panel switch action, or, for better accuracy, by a gating signal applied to the rear panel. Events should occur at least five times per second for accurate counting.

1. Engage the TOTALize A switch (19). RESOLUTION (17) and k/ μ M/m (15) settings are ignored.
2. If the counting is to be controlled electronically, connect the gating signal to the rear panel TOTALIZE START/STOP jack. A TTL high at this input enables the totalizing process; a TTL low disables it, holding the display at the accumulated value. If no signal is connected, the jack is pulled high internally so counting occurs.
3. Depress the RESET switch (13) to zero the counter. If no gating signal is connected to the TOTALIZE START/STOP jack, the unit starts counting as soon as the RESET switch is released. If a gating signal is connected, counting starts when RESET is released and the gating signal goes high.
4. As the unit totalizes, it displays the count continually. Maximum count is 99,999,999. If this is exceeded, the OVERflow indicator (25) lights, and the count continues.

5. Counting is halted by one of three methods:
 - a. If the gating signal at the TOTALIZE START/STOP jack goes low, counting stops and the display is held at the accumulated total. Counting resumes when the gating signal again goes high.
 - b. If the HOLD switch (14) is engaged, counting stops and the display is held at the accumulated total. Counting resumes when the switch is released.
 - c. Pressing RESET at any time clears the counter and resets the display to zero.

Note: The gating signal at the TOTALIZE START/STOP jack halts totalization by inhibiting the Channel A input signal. It also blocks this signal in all other operating modes except FREQUENCY MHz. This should be kept in mind if the jack remains connected during other measurements.

6. The Channel A input controls (filter, attenuator, trigger slope and level) may be used to condition the input, to prevent mis-counting from input noise or ringing. See "Frequency Measurements - Input Controls".

DISPLAY INTERPRETATION

Display Formats

Sample displays are given in Fig. 2. In Fig. 2a, a value of 1234.567 is displayed; and the kHz/ μ SEC indicator is lit. This may represent either a frequency, period, or time interval reading; a glance at the mode switches indicates which is correct.

Assuming that Fig. 2a represents a frequency reading, the resolution displayed is .001 kHz, or 1 Hz. If the k/ μ M/m switch is now pushed in, leaving all else unchanged, the display changes to that of Fig. 2b. This is the same frequency as in Fig. 2a, but given in megahertz. Note that the resolution is now

.00001 MHz, or 10 Hz, even though a different RESOLUTION switch was not selected.

If the display of Fig. 2a is a period or time interval, depressing the k/ μ M/m switch changes the display to 1.234567 ms. Unlike the frequency example, no change in resolution occurs (resolution = .001 μ s = .000001 ms), merely a change of measurement units (decimal point shifts three places to left).

Fig. 2c shows a frequency ratio display obtained by connecting both inputs to the same signal and using the same RESOLUTION setting as in a or b. Neither units indicator is lit, since the reading displayed is a ratio.

Fig. 2d gives a typical totalize display. Totalizations have no units, and are always integers (no digits to right of decimal point). At higher totalizing frequencies, the least significant display digits tend to fade due to their rapid rate of change.

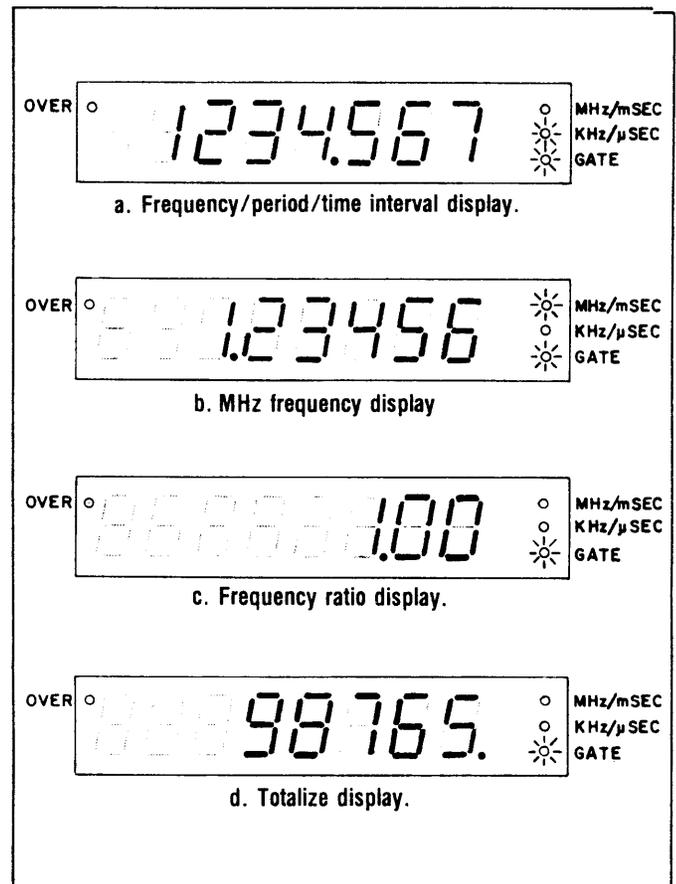


Fig. 2. Samples of various displays.

Display Instability

An uncertainty of ± 1 least significant digit is inherent in all digital measurements. However, greater display uncertainties can result from other factors, as follows:

Noise or ringing on the inputs can cause false triggering. In some cases the display may be unstable, whereas in others it may appear stable but at an incorrect reading. The input controls provided on this unit can help to achieve stable triggering from noisy inputs.

Uncertainty may be introduced by instability of the input frequency. This is common with LC oscillators; crystal-controlled oscillators are much more stable.

In period, time interval, and ratio measurements, uncertainty is introduced by trigger error (see "SPECIFICATIONS"). In period and ratio, this uncertainty can be reduced by taking the measurement over a greater number of cycles, that is, by selecting a finer RESOLUTION. In time interval, however, multi-cycle measurements are subject to a possible error of 1 count per interval. This cumulative error is increased by measuring over a greater number of intervals. The result is that all RESOLUTION settings have the same inherent resolution, and displaying more digits results in more digits being subject to jitter.

Period and frequency are reciprocals of each other. At low frequencies, more digits can be obtained (lessening the effects of instability) using PERIOD mode. Similarly, high frequency accuracy is enhanced by using FREQUENCY mode. The "crossover" point between the two modes is 10 kHz. The APPENDIX lists a number of common frequencies with their corresponding periods.

Measurement Delays

In all measurements (except TOTALize), the display is updated at the end of a finite measurement interval, which varies in length according to operating mode and resolution selected. For some conditions, the delay can

become significant. This should be kept in mind when changing resolution or operating mode, or when using HOLD or RESET, because each of these actions initiates a new measurement. Measurement delays for each mode are discussed here.

Frequency

In frequency measurements, each RESOLUTION setting establishes a set "gate time" during which the measurement is made (GATE indicator lights during this interval). Gate times for kHz and MHz modes are as follows:

Mode	RESOLUTION setting	Gate Time
kHz	100 Hz	.01 second
"	10 Hz	0.1 second
"	1 Hz	1 second
"	0.1 Hz	10 seconds
MHz	1K Hz	.02 second
"	100 Hz	0.2 second
"	10 Hz	2 seconds
"	1 Hz	20 seconds

As observed in the table, lower RESOLUTION's result in smaller gate times. They are useful when quicker updates are desired, for example, while tuning an oscillator. Better resolutions require longer update intervals.

Period/Time Interval

Period and time interval measurements are made by averaging over a set number of cycles or time intervals. That number is determined by the RESOLUTION switches as follows:

Mode	RESOLUTION setting	Number of cycles (intervals) averaged
μ SEC	.1 μ SEC	1
"	.01 μ SEC	10
"	.001 μ SEC	100
"	.0001 μ SEC	1000
mSEC ¹	.0001 mSEC	1
"	.00001 mSEC	10
"	.000001 mSEC	100

¹mSEC settings obtained by multiplying bottom row of RESOLUTION chart by .001.

The time required for a period or time interval measurement to be completed can be found by the formula:

$$\text{Time} = \left(\begin{array}{c} \text{Number of} \\ \text{cycles (intervals)} \\ \text{averaged} \end{array} \right) \times \left(\begin{array}{c} \text{Average} \\ \text{cycle (interval)} \\ \text{length} \end{array} \right)$$

where time units are same (seconds, milliseconds, etc.) on both sides.

For period measurements this is also:

$$\text{Time} = \frac{\text{Number of cycles averaged}}{\text{Input frequency (Hz)}}$$

Note that two RESOLUTION switches select 100 and 1000 cycle averaging. Because of this, significant delays may occur between display updates at low frequencies.

Frequency Ratio

To determine frequency ratio, the unit applies the input signals to two separate counters. Each counts cycles of its input until the Channel B counter reaches a specified number. Both counters then stop and the number left in the Channel A counter is applied to the display, with a proper decimal point, as the ratio. Each RESOLUTION switch specifies a particular reference number for the Channel B counter as follows:

RESOLUTION setting:	Channel B counts to:
100/1K/.1	1
10/100/.01	10
1/10/.001	100
.1/1/.0001	1000

Measurement delays are dependent on the frequency of the Channel B input and the particular resolution selected. The time required for a ratio measurement to be completed can be found by the formula:

$$\text{Time (seconds)} = \frac{\text{Channel B reference}}{\text{Input frequency (Hz)}}$$

Note that two RESOLUTION switches select 100 and 1000 as Channel B reference. Because

of this, noticeable delays may occur between display updates at low Channel B frequencies. The Channel A frequency does not affect measurement time in ratio measurements.

Inter-Measurement Interval

The time interval between measurements (GATE indicator off) is fixed at 200 milliseconds in all modes except FREQUENCY MHz, where it is 400 milliseconds, and TOTALize, in which counting is continuous. This fixed interval is independent of gate time, number of cycles, or input frequency.

GENERAL CONSIDERATIONS

Use of Attenuator Probes

Input resistance (1 M Ω) and input capacitance (40 pF max) are independent of the X10 switches. To decrease loading, a high-impedance oscilloscope probe such as the following may be used:

1. **B&K-Precision** Model PR-40 10:1 and 1:1 compensated oscilloscope probe.
2. **B&K-Precision** Model PR-37 10:1 and 1:1 compensated oscilloscope probe.

The loading effect of the PR-40 is 10 M Ω and 18 pF in the X10 mode, and 1 M Ω and 100 pF in the X1 mode. The loading effect of the PR-37 is 10 M Ω and 12.5 pF in the X10 mode, and 1 M Ω and 80 pF in the X1 mode. Use the probe in the X10 position whenever possible for less circuit loading.

Note: when using a 10:1 probe such as listed above, make certain that the signal amplitude is large enough to provide at least the minimum required signal to the counter after probe attenuation (see "Sensitivity" in "SPECIFICATIONS").

Mode or Resolution Changes

When switching resolution or operating mode, note that such a change initiates a new measurement; the display is not updated until the new measurement is completed. Even

OPERATING INSTRUCTIONS

though the decimal point and leading zeroes are adjusted immediately, appearance of the correct value may be significantly delayed depending on measurement interval (see "Display Interpretation - Measurement Delays").

Standing Waves

Standing waves are usually present on a transmission line not terminated in its characteristic impedance. These standing waves may cause damage to the signal source or produce inaccurate measurements. Therefore, when measuring radio frequencies, the transmission line characteristic impedance and the terminating impedance should each match the source impedance. For example, for a source impedance of 50 ohms, use 50 ohm coaxial cable terminated with a 50 ohm resistive load. Use a dc blocking capacitor in situations where bias voltage or other dc voltages could be affected by the termination resistor.

If additional cable is required, note that the increased cable length results in increased shunt capacitance. In addition, the effect of standing waves becomes more pronounced as the cable length approaches one-quarter wavelength of the frequency being measured. This is especially true if the cable is not terminated in its characteristic impedance. Therefore, to keep shunt capacitance and standing waves within tolerable limits, it is recommended that for radio frequency measurements, the cable be no longer than three feet (90 cm).

Duty Cycle Measurements

Time Interval mode can be used to determine the duty cycle of a digital waveform, by applying the same signal to Channel A and Channel B, and selecting proper edges for triggering.

For example, refer to Fig. 3. The duty cycle, or ratio of on-time to total period, is found by selecting positive slope for Channel A (so measurement starts at beginning of T1) and negative slope for Channel B (measurement finishes at end of T1). After this reading is taken, the period is measured, (preferably by using PERiod mode; see next para-

graph), and the duty cycle is obtained as follows:

$$\text{Duty cycle} = \frac{T1}{\text{PERIOD}} \times 100\%$$

PERiod vs. Time Interval Mode

When measuring time interval between similar edges on the same waveform (e.g. positive edge to next positive edge), it is advisable to use PERiod rather than Time Interval mode, because of the following:

1. In TI mode, the unit may tend to both trigger and stop on the same edge, resulting in erroneous readings. Waveforms with fast rise times (such as TTL signals) are less prone to this phenomenon than those with less steep slopes, such as sine and triangle waves.
2. PERiod mode affords better accuracy, especially at finer resolutions. In TI mode, the possibility of error increases with number of intervals averaged (1, 10, 100, 1000) so that more digits tend to jitter as more are selected. No actual improvement in resolution is gained. In PERiod mode the possibility of error is constant for all RESOLUTION's.

Use of TRIG LEVEL Control

When pushed in (PRESET-IN), this control sets the trigger threshold to the approximate average of the Channel A signal. While this is sufficient for many signals, it would not be adequate for the waveform of Fig. 4. The

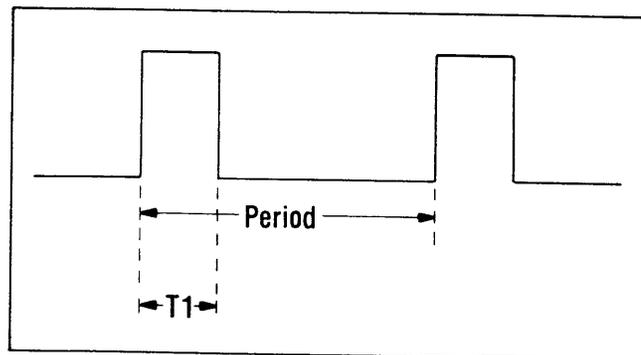


Fig. 3. Duty cycle measurement.

lower dotted line represents the trigger level set by the PRESET-IN position. This level, the average of the pulse train, is close to the level of noise present, and false triggering could occur.

By pulling the TRIG LEVEL control out and rotating it, the trigger threshold can be varied above (+) or below (-) the average. In the figure, an appropriate threshold setting would be somewhat above the noise level, as shown by the upper dotted line.

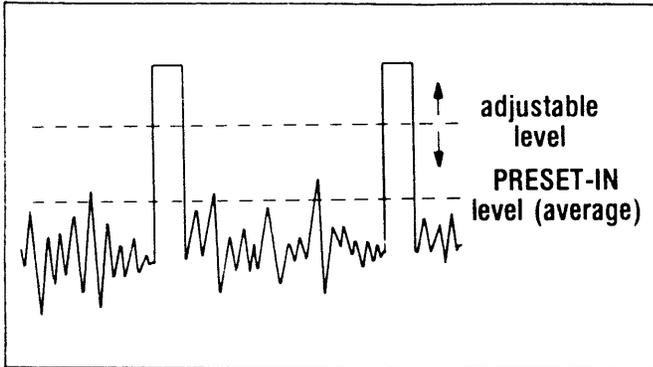


Fig. 4. Example of trigger level variation.

Line Frequency Measurement

WARNING

Use caution in measuring the line frequency of an ac outlet. Using the probe tip only, measure both sides of the line. The ground side will give a zero reading and the hot side will provide the desired measurement. Do not use the "ground" lead of the probe. Remember that the chassis of the frequency counter and the "ground" lead of the probe are already at earth ground (via the 3-wire power cord of the instrument). Touching the "ground" lead to the "hot" side of the line would place a direct short on the power line through the probe cable, resulting in possible injury and damage to the probe cable.

Use of the attenuator and/or filter is advisable when measuring line frequency, since noise is usually present and can cause miscounting.

SELF TEST

The SELF TEST mode provides a quick, general check of instrument operation. It does not check all functions of the instrument; a thorough troubleshooting procedure is given in the "MAINTENANCE AND CALIBRATION" section for that purpose.

If any of the following steps produces an incorrect result, refer to "MAINTENANCE AND CALIBRATION" for details on troubleshooting or returning for service.

1. Engage the SELF TEST switch (18). This connects the counter input internally to the time base oscillator.
2. With the k/μ-M/m switch (15) in the k/μ position (out), engage each RESOLUTION switch and check that results match the following:

RESOLUTION setting	Display reads	GATE interval ¹
100/1K/.1	10000.0 kHz	0.01 second
10/100/.01	10000.00 kHz	0.1 second
1/10/.001	10000.000 kHz	1 second
.1/1/.0001	0000.0000 kHz, OVERflow lit	10 seconds

¹GATE indicator lights during this interval; Time between measurements is 200 ms.

3. Set the k/μ-M/m switch to M/m (pushed in) and engage each of the three RESOLUTION switches listed below, checking for correct results:

RESOLUTION setting ¹	Display reads	GATE interval ²
100/1K/.1	10.0000 MHz	0.01 second
10/100/.01	10.00000 MHz	0.1 second
1/10/.001	10.000000 MHz	1 second

¹In SELF TEST mode these three RESOLUTION settings give resolutions of 100 Hz, 10 Hz, and 1 Hz, respectively.

²GATE indicator lights during this interval; time between measurements is 200 ms.

4. With the k/ μ -M/m still set to M/m, engage the .1/1/.0001 RESOLUTION switch. The display should read "88.8.8.8.8.8.", with the MHz/mSEC and OVERflow indicators lit, and the GATE indicator on for 10 second intervals.
5. For any setting in either of the above two tables, pressing HOLD should hold the display value and keep the GATE indicator off for as long as the button is pushed in. When HOLD is disengaged, GATE should resume flashing. (If a new RESOLUTION has been selected, the display is updated to its proper value after the first GATE interval).
6. For any setting in either of the two above tables, pressing RESET should clear the display. The GATE indicator should stay off as long as RESET is pushed. Upon release of the button, GATE should resume flashing and the display should be updated at the end of the first GATE interval.

CIRCUIT DESCRIPTION

BLOCK DIAGRAM ANALYSIS

Refer to the block diagram of Fig. 5 for an overall view of circuit operation. The unit can be divided into logical groupings as shown.

Analog Input Circuits

These circuits process the analog input signals in preparation for the digital circuits which follow. Input buffers provide the high impedance desired, and also selectable X10 input attenuators. The Channel A signal is passed through a selectable low-pass filter and a preamplifier which increases sensitivity and provides selectable preset or adjustable trigger level control. Signals from both channels are squared by amplifier/Schmitt trigger circuits, so that digital waveforms of appropriate levels are obtained.

Digital Input Circuits

These circuits process the now-digital signals before they reach the counter circuits.

The Channel A signal follows two different paths, according to front panel switch settings. In one case, it is applied to a divide-by-twenty prescaler which increases the frequency range of the unit. The other path channels it to a slope selector, which chooses either the signal or its complement (the Channel B signal encounters a similar circuit), and a gating circuit which either passes or blocks it in response to a control input and a switch. This Channel A signal is then applied, together with Channel B, to the Time Interval priming circuit which passes both signals unchanged (except for special instances in Time Interval mode).

The two Channel A paths converge in a selection circuit which chooses either the origi-

nal frequency or the divided-down version, in accordance with operating mode selected. This signal and that from Channel B are applied to the counter circuits.

Counter Circuits

These center around an ICM7226A Universal Counter integrated circuit, which performs all counting functions. Four control signals to the chip determine operating mode and other factors. They themselves are derived as feedback from the chip's own digit strobes (which are used as multiplex signals for the display); the feedback is selected by the front panel switches via the control logic.

Power Supply

The power supply provides regulated voltages as shown. The tapped, dual-primary transformer is universal, and can be rewired as needed for various line voltages.

SCHEMATIC DIAGRAM ANALYSIS

This discussion can best be followed by referring to the separately supplied schematic diagrams, and to the accompanying figures when directed by the text. The discussion is separated into major sections corresponding to those depicted in the main block diagram of Fig. 5.

Analog Input Circuits

Channel A Input Buffer

Refer to the schematic diagram. The input signal is capacitively coupled via C101 to the divider of R102 and R103. X10 switch S101 selects either the full voltage across the divider or only the portion across R103 (ap-

proximately one tenth of the full amount). The signal is level-clamped to a maximum of ± 1.2 volts by diodes D101-106; it is then applied to the high-impedance buffer stage consisting of Q101, used as a source follower, and Q102, which serves as a current sink and enhances response to negative signal excursions. Transistor Q103 is used as a current source for successive stages.

Channel A Filter

The signal is applied to the low-pass filter consisting of R113, R114, and C116, whose values set a -3 dB point of approximately 10 kHz. When FILTER switch S102 is pushed in (ON position on schematic), diodes D107 and D108 are biased on. This provides an ac path to ground through D108, and the filter action of R113, R114, and C116 is enabled. When S102 is released, D107 and D108 are off, isolating C116 from ground, and disabling the filter action.

Channel A Pre-amplifier

The differential amplifier of transistor array IC101 compares the input signal to a variable dc level from the TRIG LEVEL control, R125. When TRIG LEVEL is pushed in (PRESET-IN), S103 is closed, bringing the amplifier input at IC101 pin 4 to approximately ground potential. The other input, at pin 1, is taken from the output of the filter. This signal, capacitively coupled at the counter input by C101, experiences no dc offset in the buffer or filter stages. Therefore, when applied to pin 1 of IC101, its average level remains near ground potential. As a result, when TRIG LEVEL is set to PRESET-IN, the quiescent level of the diff amp is set at approximately the average level of the input. When TRIG LEVEL is pulled out, S103 is opened, and the pin 4 input level is controlled by R125, which varies the quiescent level above or below the input average.

Channel A Amplifier/Schmitt Trigger

This stage (IC102) amplifies and shapes the input to ultimately produce a digital waveform which is suitable for use in the counting circuits. The circuit makes use of a

10216 ECL triple line receiver for good response throughout the frequency range of the instrument. Two of the amps in this IC (first and third on schematic) are used to square up the signal, and a third (second on schematic) is used as a Schmitt trigger.

The chip supplies a voltage reference of 3.8 volts at pin 11; this is applied through dividers R130/R136 and R128/R129 to the inputs of the first amp (pins 9 and 10). A quiescent voltage difference of approximately 30 millivolts results between the two inputs. This defines the minimum amount of signal required at these inputs for proper "squaring" to occur.

The second amp, at pins 12 and 13, is used as a Schmitt trigger to eliminate false triggering caused by noise. Its trigger threshold is obtained from the pin 11 reference through R133. The amount of hysteresis, which provides the noise margin, is set by R134.

The third amp, at pins 4 and 5, is used to provide further "squaring" of the waveform. Inputs to this amp are the complementary outputs of the Schmitt trigger.

Transistors Q104 and Q105 are used as ECL-to-TTL level shifters. The waveform obtained across R142 is a 0 to 2.4 volt square wave with the same polarity as the input signal.

Channel B Input Buffer

The Channel B input signal is capacitively coupled via C141 to the divider of R151 and R152. X10 switch S105 selects either the full voltage across the divider or only the portion across R152 (approximately one tenth of the full amount). The signal is level-clamped to a maximum of ± 1.2 volts by diodes D111-114 and applied to the high-impedance buffer stage. This consists of FET Q111, which provides high input impedance and unity gain, and Q112, which serves as a current source for successive stages.

Channel B Amplifier/Schmitt Trigger

This stage (IC105) operates in a similar manner to its Channel A counterpart (IC102),

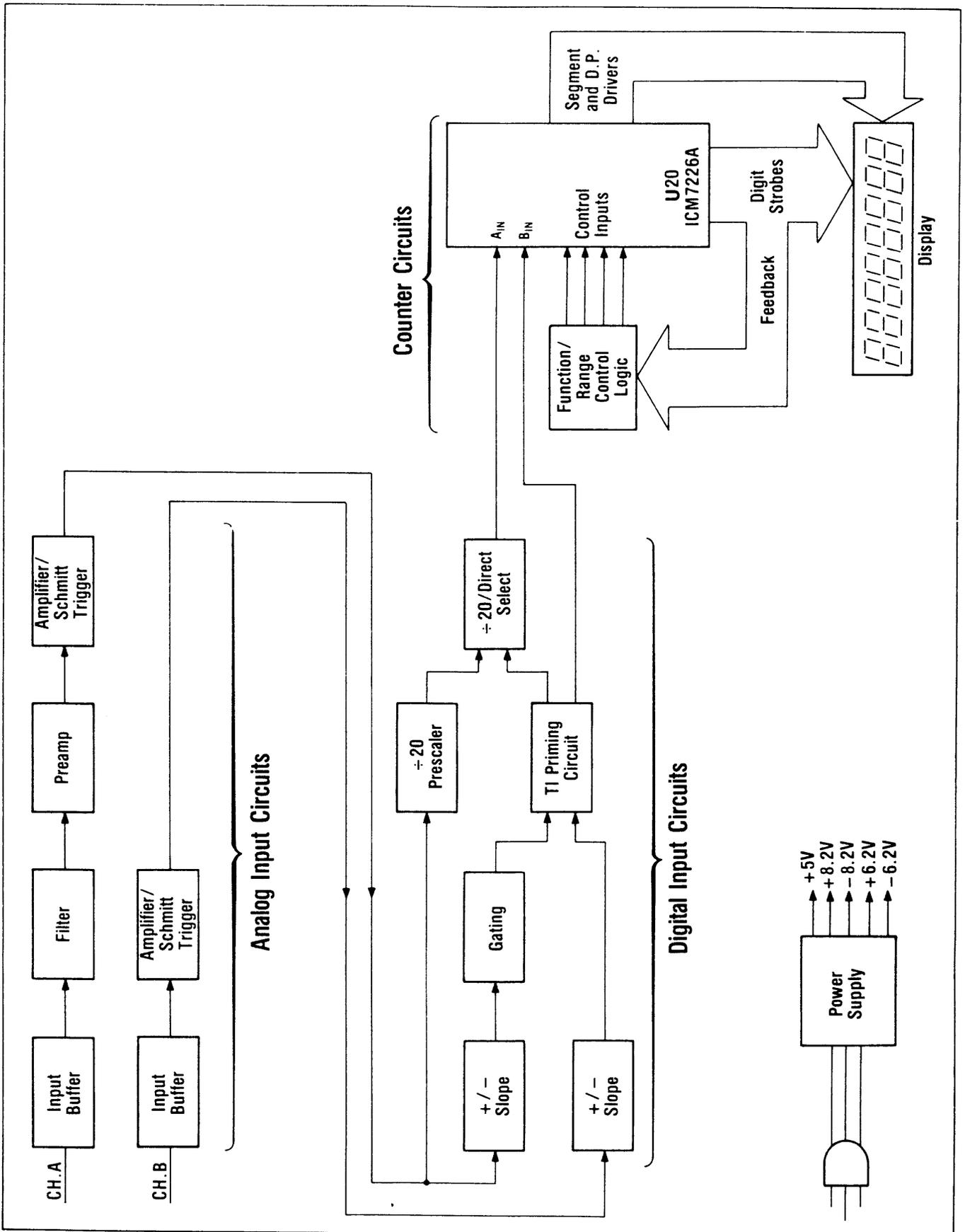


Fig. 5. Block diagram.

CIRCUIT DESCRIPTION

to square the waveform for use in the counter circuits. As in Channel A, a 10216 ECL triple line receiver (IC105) is used. The first two amps shown on the schematic are used for squaring, and the third serves as the Schmitt trigger.

The 3.8 V voltage reference from pin 11 is applied through dividers R161/162 and R159/160 to the inputs of the first amp (pins 9 and 10), defining the minimum squaring level (about 30 mV). The complementary outputs are applied to the second amp at pins 4 and 5 for further squaring of the waveform. The Schmitt trigger at pins 12 and 13 provides a noise margin; its trigger threshold is obtained from the pin 11 reference via R167, and R168 determines the amount of hysteresis.

Transistors Q113 and Q114 are the ECL-to-TTL level shifters. The R171 waveform is a 0 - 2.4 volt square wave with the same polarity as the input.

Digital Input Circuits**Channel A/Channel B Slope Select**

Positive or negative trigger slope is selected by applying the inputs through EXCLUSIVE-OR gates IC8 pins 8-13. The other input to each gate is set either high or low by the -SL (slope) switch. The result is that either the signal or its complement is fed through to IC6.

Channel A Signal Gating

The Channel A signal from IC8 pin 8 is AND'ed in IC1 (pins 1, 2, 12) with the output of the HOLD flip-flop (IC9 and HOLD switch S14) and the voltage from the TOTALIZE START/STOP jack J2 on the rear panel. This permits the input to be gated, either manually or electronically, during the TOTALize mode. When no control signal is connected to J2, the jack is pulled high by R2.

Time Interval Priming Circuit

Before any Time Interval measurement, IC6 must be primed by a high-to-low transition of input A, followed by a similar transition of

input B. In cases of repetitive input waveforms, the chip is automatically primed. However, for instances where one (and only one) time interval is to be measured, a priming circuit is used.

The circuit consists of four inverters from IC3, two EXCLUSIVE-OR's of IC8, NAND gate IC9, and RESET switch S15. The input signals, lines A1 and B1, are fed through the XOR's. Most of the time the other XOR inputs (from the priming circuit) are low, and the XOR outputs follow A1 and B1.

However, when preparing to time a single event, lines A1 and B1 are a stable high (because the inputs should be stable in anticipation of the event). Pressing RESET takes IC8 pin 1 high also (only, however, if TI mode is selected, enabling NAND gate IC9). This produces a low at IC8 pin 3. When RESET is released, IC8 pin 3 goes back high, and the inverters at IC3 pins 6-7 and 9-10 produce a momentary low at IC8 pin 6. After this priming sequence of each XOR going low and high, the priming circuit resumes its steady-state conditions, and the XOR outputs follow A1 and B1 for the time interval measurement.

Channel A Prescaler

Maximum guaranteed operating frequency of the counter chip, IC6, is 10 MHz. To extend the frequency range to 150 MHz, the Model 1822 employs a prescaler consisting of two frequency dividers in the Channel A digital input path. The first is a divide-by-ten, IC104, whose input is taken from the output of the Channel A amplifier at IC102 pin 3. This is immediately followed by IC2, a divide-by-two.

The output of IC2 is applied to a circuit consisting of the four NAND gates of IC4, which select either the frequency-divided signal or the original-frequency signal from the priming circuit. The selection circuit is governed by the output of IC1 pin 8, which goes high only during FREQ MHz mode (also discussed in the paragraphs on "Counter Circuits" below). Whenever this mode is selected, the frequency-divided version is applied to the counter circuits.

The effect of the divide-by-two operation on the input is compensated for by another divide-by-two, IC2, connected between pins 38 and 33 of the ICM7226A. As explained in the "Counter Circuits" paragraphs, whenever FREQ MHz mode is enabled, this circuit divides the counter time base by two.

The effect of the divide-by-ten on the input is compensated by shifting of the display decimal point, also discussed in the "Counter Circuits" paragraphs.

Counter Circuits

ICM7226A Counter

This integrated circuit, IC6, is the heart of the unit. It performs all counting functions and multiplexes and drives the displays. It

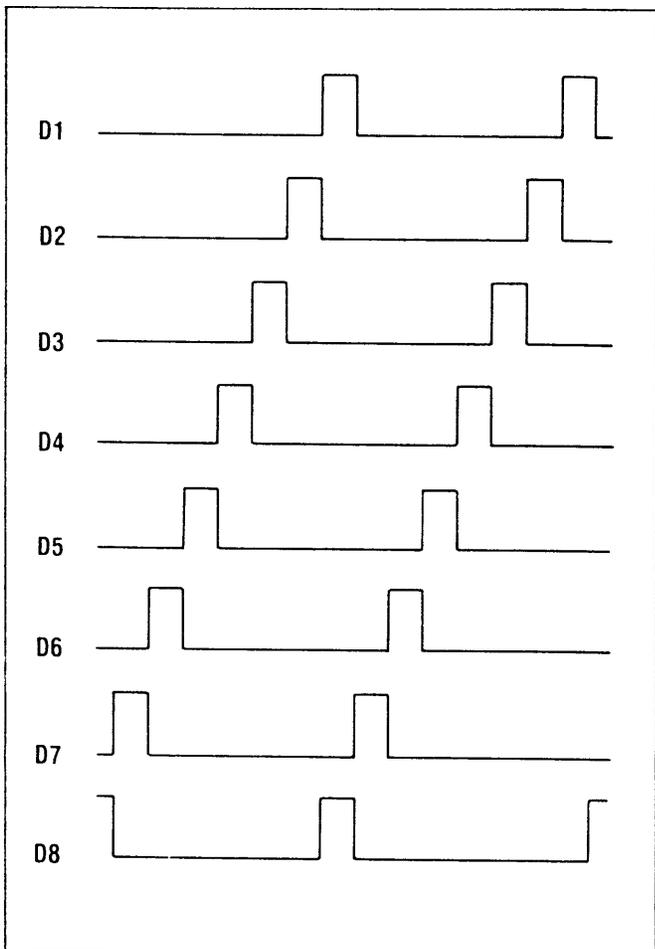


Fig. 6. IC6 digit strobes.

requires an input signal of digital logic levels, as provided by the circuits previously discussed. A crystal for the timebase oscillator is also required, as well as external connections for feedback of display digit strobes, as described below.

Digit Strobes and Feedback

The 7226A multiplexes the display by means of digit strobes D1-D8. Each strobe goes high in sequence, as in Fig. 6, turning its display digit on momentarily. As each digit is selected, the proper seven-segment and decimal point information for that digit is sent out at the same time on pins 8-11 and 13-16.

The digit strobes D1-D8 are also used to control the 7226A by selective feedback to four control pins, 1, 4, 20, and 21. Operating mode, resolution, and other parameters are determined by which strobe signal is present at each control input. Strobe feedback is controlled by the front panel settings, either directly or through logic. Each control pin and its feedback network is discussed below.

Operating Mode Selection

Operating mode selection is controlled by FUNCTION pin 4. As shown in Fig. 7, this pin is directly connected to one of digit strobes D1-D5 or D8 via mode switches S2-S7.

Resolution Selection

Resolution selection is controlled by RANGE pin 21. As shown in Fig. 8, digit strobes D1-D4 are applied directly to pin 21 via RESOLUTION switches S8-S11.

Additional Control - Pin 1

Additional control of IC6 is provided by feedback of strobes D1, D3, and D8 to CONTROL pin 1. This feedback is determined by the front panel switches via the circuits of Figs. 9 and 10. Outputs A and B in Fig. 9 are high only for the conditions listed. In Fig. 10, these outputs are used to gate the strobes to pin 1 via either a pass transistor (Q3) or bilateral switches (IC7) which provide a low-resistance path from input to output when energized.

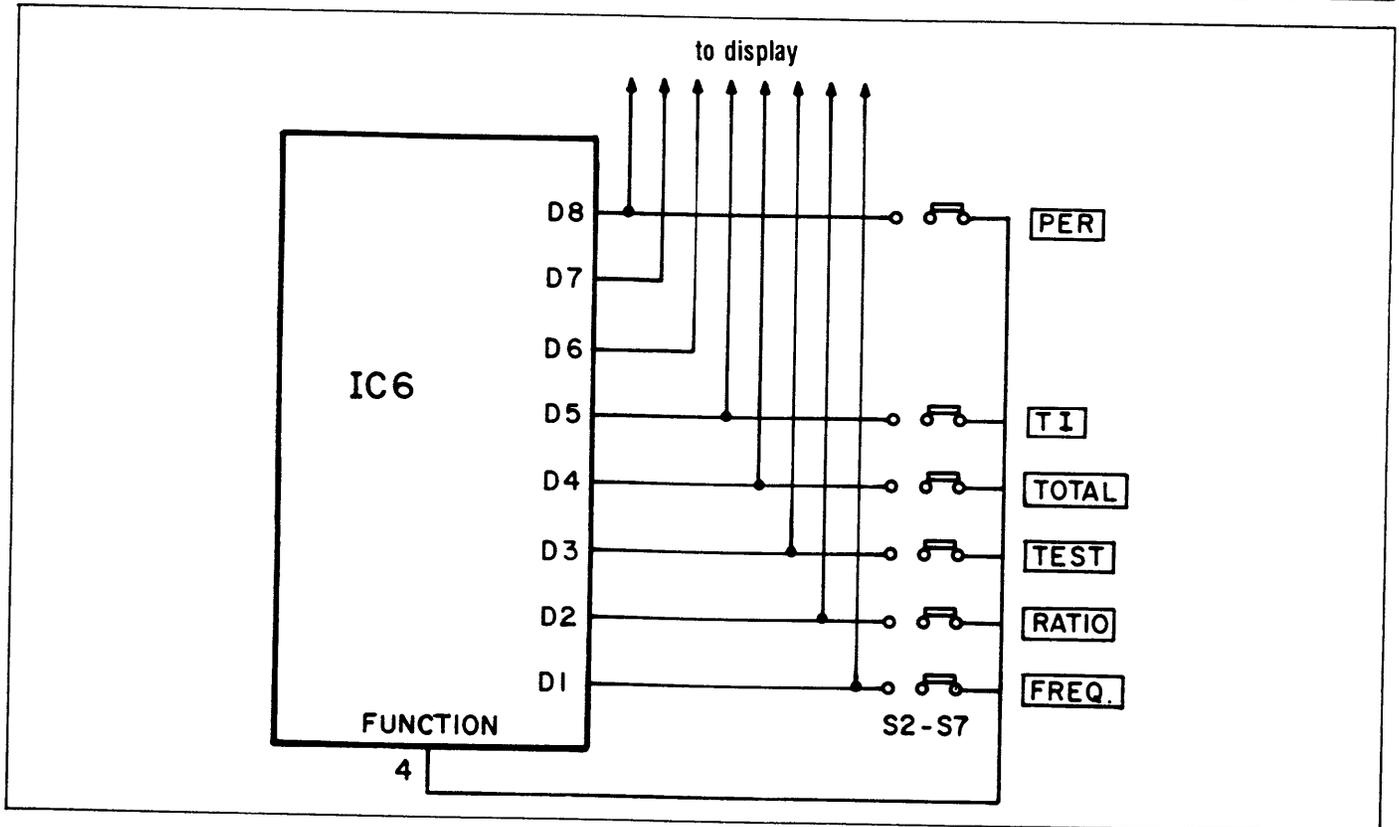


Fig. 7. Operating mode selection.

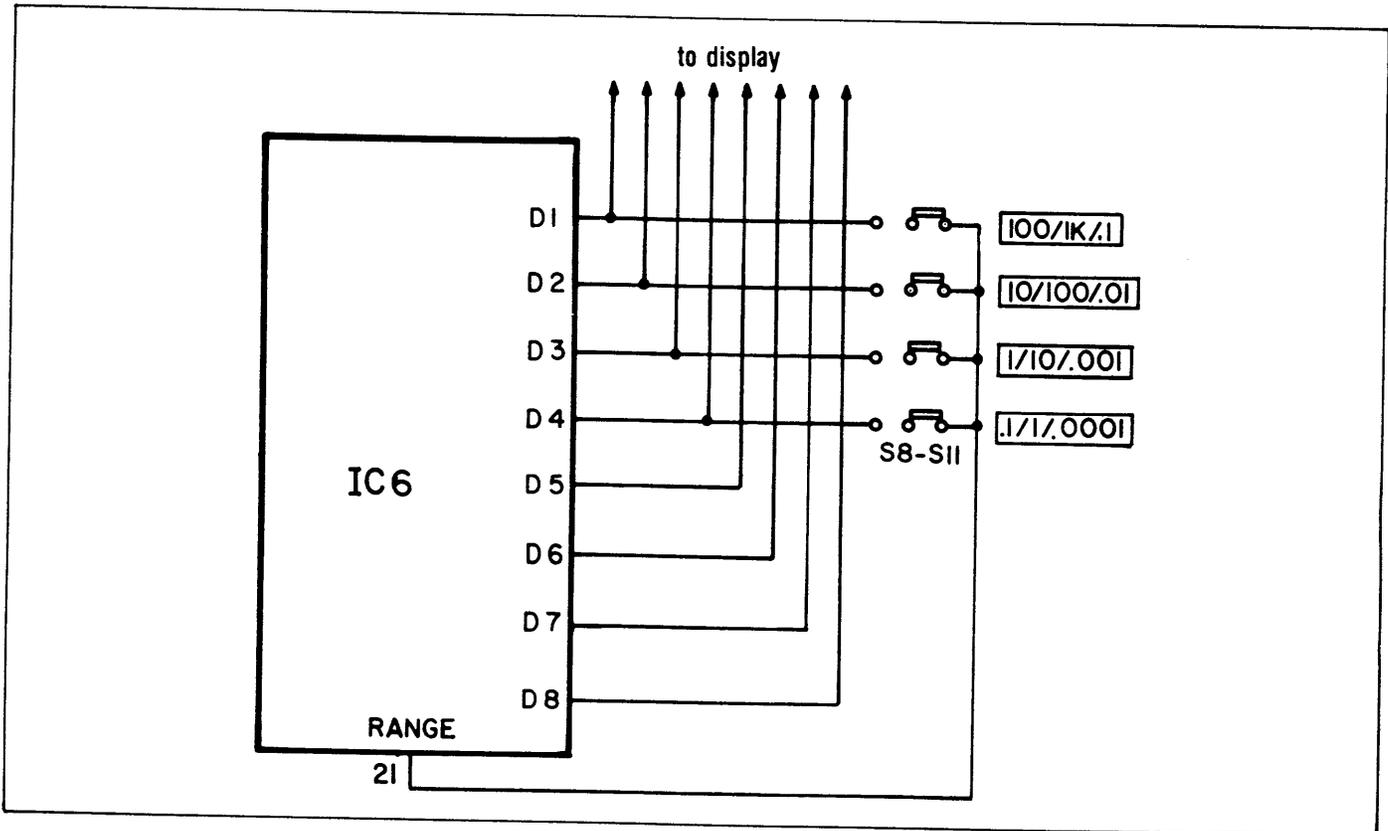


Fig. 8. Resolution selection.

D8 is applied whenever the .1/1/.0001 RESOLUTION switch S11 is engaged, the k/ μ M/m switch is pushed in, and PERIOD, Time Interval, or SELF TEST mode is selected. IC6 responds by outputting the "Display Test" condition, causing the display to read all eights and decimal points.

D1 is gated whenever the unit is in FREQ MHz mode. This instructs IC6 to use the signal at pin 33 as a time base. This is merely the output of a divide-by-two circuit whose input is the regular 10 MHz time base (made available at pin 38). Thus, whenever FREQ MHz mode is used, the time base is divided by two. This divider is included to compensate for the previously discussed divide-by-two used in the input path.

D3 is applied whenever any of the conditions listed in Fig. 9 are true. This instructs IC6 to use external decimal point control, as explained in the next section.

External Decimal Point

External decimal point placement is enabled in all of the modes listed in Fig. 9. When D3 is applied to pin 1, the 7226A disables automatic selection, and places a decimal point at the display digit whose strobe is applied to pin 20, EXT DP IN. As shown in Fig. 11, that position is determined partially by the RESOLUTION switches, and partially by the particular operating mode being used (through outputs A and B of Fig. 9).

Time Base

The 7226A provides an on-chip FET inverter oscillator. It requires the addition of a crystal (1 MHz or 10 MHz), external resistance for biasing, and external capacitance for fine adjustment. The model 1822 uses a 10 MHz crystal. As seen on the schematic, an optional TCXO (temperature-compensated crystal oscillator) may be used for increased tempera-

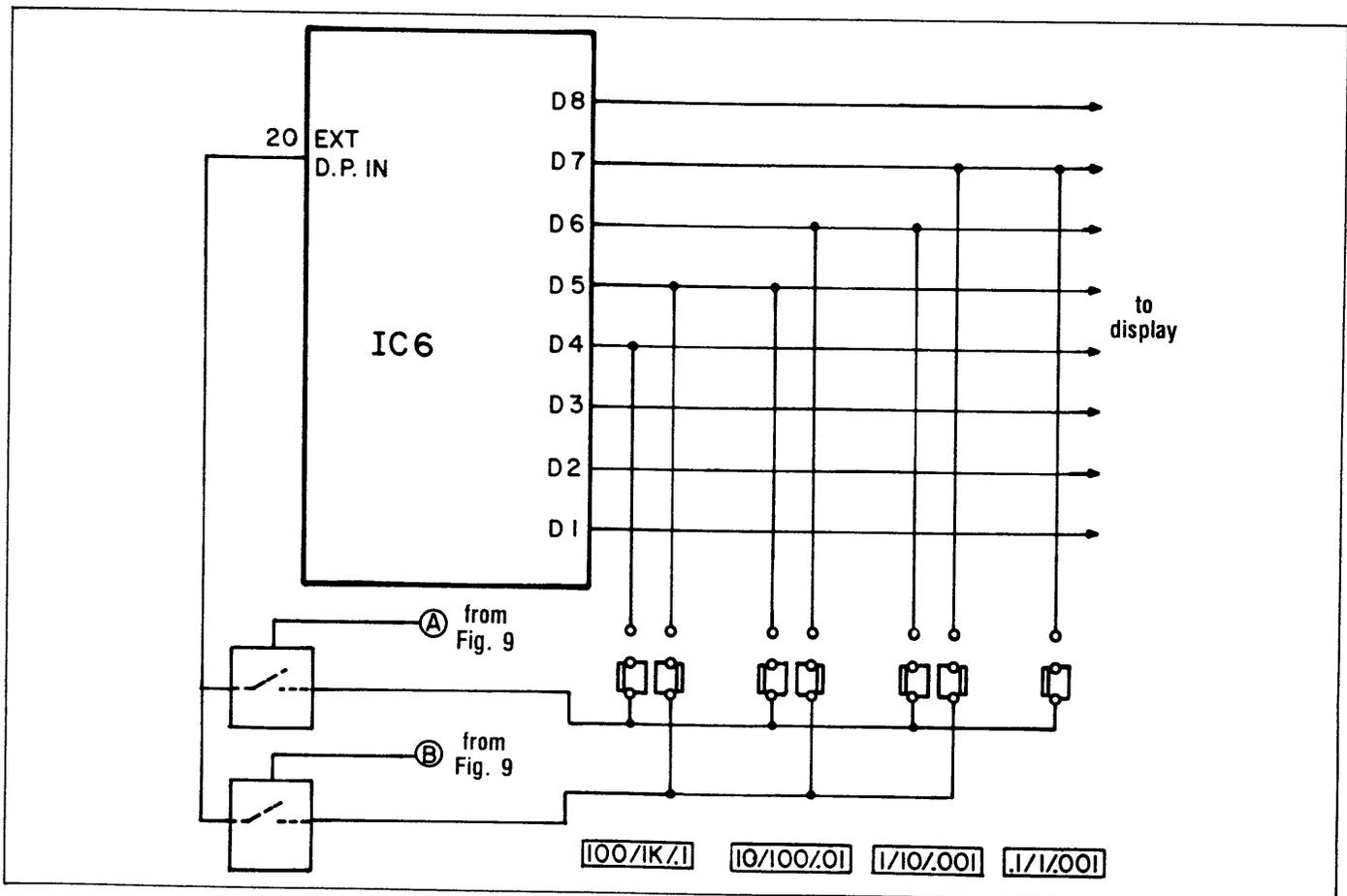


Fig. 11. External decimal point control.

ture stability. (For TCXO operation, jumpers JU6 and JU7 are disconnected, and JU8 is inserted.)

HOLD Switch

Refer to the schematic diagram. The HOLD switch, S14, is connected via IC9, which provides switch debounce, to IC6 and IC1. The connection to IC6 instructs the chip to enter the display HOLD mode whenever the switch is engaged. In TOTALize operation, however, IC6 would freeze only the display but keep on counting; this is remedied by also connecting S14 to IC1. This cuts off the input from IC6 (as does a low at the TOTALIZE START/STOP jack) and halts the counting process.

LED Indicators

The MHz/mSEC and kHz/ μ SEC indicators are connected to complementary signals which are a direct function of the setting of S12, the k/ μ M/m switch. They are, however, disabled when IC5 pin 3 goes high, in RATIO and TOTALize modes.

The GATE indicator, D18, is connected via inverter IC3 (pins 14 and 15) to IC6 pin 3. This pin goes low whenever a measurement is in progress.

Power Supply

The transformer is a universal type whose primary windings may be rewired for various line voltages by reconnecting jumpers JU1-JU5.

The output of the secondary side is rectified by bridge D4-D7 and filtered by C10 and C11. Zener diodes D10, D11, D13, and D14 provide regulated +10, -10, +6.2, and -6.2 volts, respectively.

The secondary output is also rectified by D8 and D9 and filtered by C12. +5 volts is produced by D12 and Q1, which provide good regulation and adequate power for the digital portion of the instrument.

MAINTENANCE AND CALIBRATION

WARNING

1. *The following instructions are for use by qualified personnel only. To avoid electric shock, do not perform servicing unless you are qualified to do so.*
2. *AC line voltage is present on the fuse, jumpers, and transformer circuits whenever the unit is plugged into an ac outlet, even if the PWR switch is OFF. Observe caution any time the case is removed from the instrument.*

RETURNING FOR SERVICE

If you have encountered a problem with your unit and choose to return it for service, check the following **before** returning.

1. Is the unit connected to a live power source of the proper voltage? (See "Line Voltage Conversion" in this section, if required.)
2. Is the fuse okay? Is it the proper type? (See "Fuse Replacement" in this section, if required.)

COVER REMOVAL

1. Disconnect the unit from ac power.
2. Remove the four Phillips screws (two on each side of unit) holding the rear bezel (rim) in place.
3. Remove the rear bezel.
4. Carefully slide the top or bottom cover out from the rear.
5. When replacing either cover, be sure to engage it properly in the guides, and replace with the smooth side on the inside of the unit.

CALIBRATION

There are two calibration adjustments, time base oscillator frequency, and preset trigger level. Before calibration, allow the unit one hour (fully cased) to warm up.

Time Base Adjustment

This adjustment requires a 10 MHz standard with an accuracy of at least ± 1 part in 10^6 .

1. Remove the bottom cover as directed in the previous section.
2. Connect the standard frequency source to the Channel A input.
3. Engage the FREQUENCY A switch and the 1/10/.001 RESOLUTION switch.
4. The location of the time base adjustment C1 is shown in Fig. 12. Note that C1 is adjusted from underneath the circuit board, through an access hole; the top cover is not removed. The illustration is given to provide a reference for adjustment location.
5. Using an appropriate screwdriver-type alignment tool (metal blade adequate), adjust C1 for a display of 10000.000 kHz.
6. Replace the bottom cover.

Trigger Level Adjustment

This adjustment requires a standard DVM with 0.1 mV resolution or better.

1. Remove the top cover as described previously.
2. Connect DVM ground lead to amplifier board ground and positive lead to IC101 pin 1. These points are accessible at test
3. Push in TRIG LEVEL control (PRESET-IN).
4. Set DVM to 100 millivolt range.
5. Adjust R112 (see Fig. 12 for location) for minimum reading (0 - 2 mV) on DVM.
6. Replace the top cover.

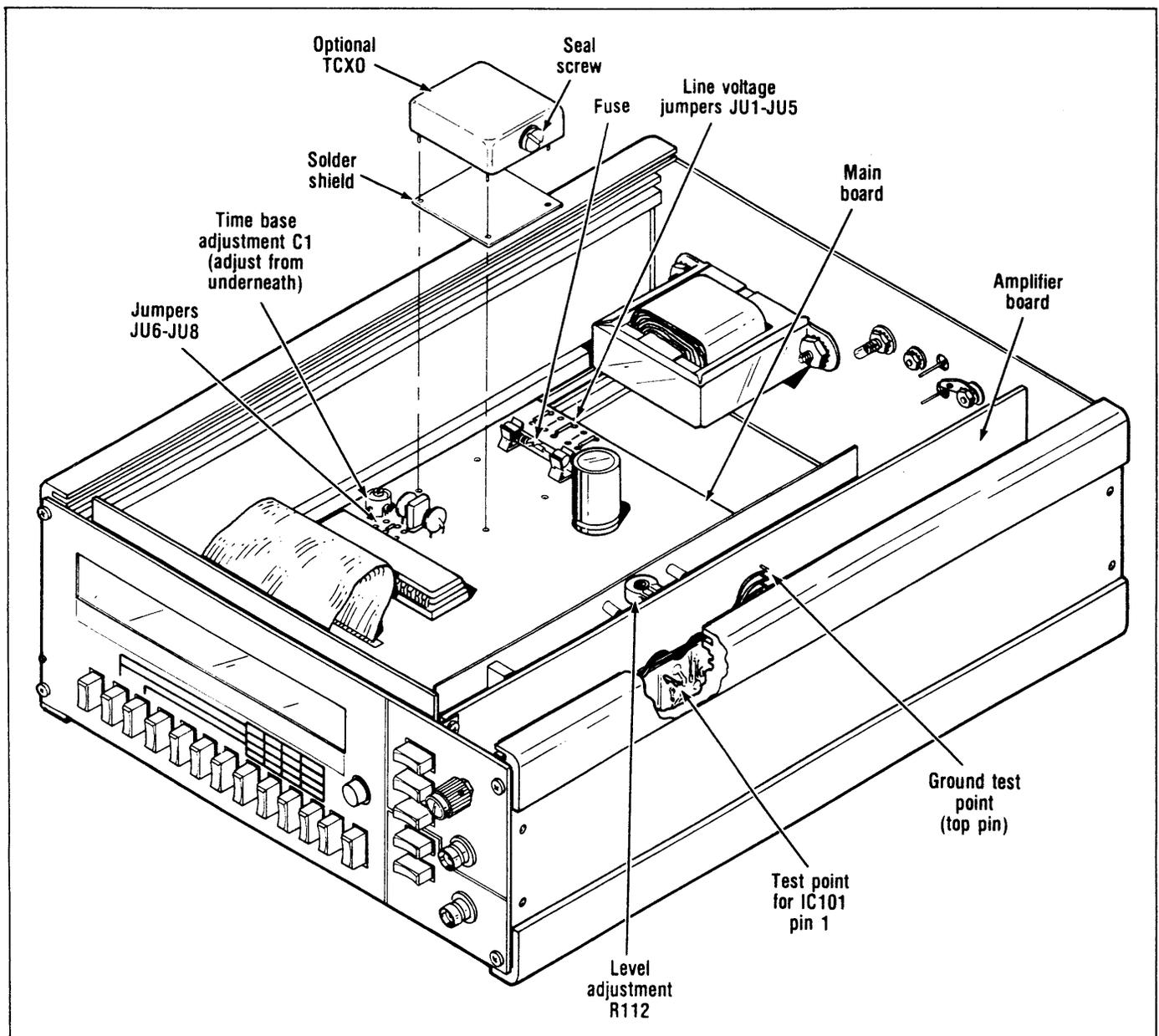


Fig. 12. Interior view showing important elements.

LINE VOLTAGE CONVERSION

The Model 1822 is equipped with a universal transformer which may be rewired appropriately for various line voltages. Domestic models are factory-wired for 108-132 VAC, 60 Hz operation, and international models are initially wired for 220 VAC, 50-60 Hz operation. Both types can be rewired as follows.

Disconnect the unit from ac power, remove the top cover as described previously, and locate jumpers JU1-JU5. These are positioned on the main circuit board, directly in front of the transformer (see Fig. 12). Connect jumpers for each line voltage as follows:

100 V: JU1, JU3, JU4

120 V: JU1, JU3, JU5

220 V: JU2, JU4

240 V: JU2, JU5

NOTE: line voltage conversion may require installation of a different fuse. See the following section.

FUSE REPLACEMENT

The fuse value required depends on the line voltage selected as follows:

100 or 120 VAC operation: 3/16 A, 250 V, 3AG Slow Blow

220 or 240 VAC operation: 0.1 A, 250 V, 3AG Slow Blow

To replace the fuse, disconnect the unit from ac power and remove the top cover as described previously. The fuse is located directly in front of the transformer, on the main circuit board (see Fig. 12).

If the fuse is blown, try to determine and correct the cause, and then replace only with a fuse of the correct value.

INSTALLATION OF OPTIONAL TCXO

An optional TCXO (temperature-compensated crystal oscillator) may be installed by the user, to provide better time base temperature stability (less than $\pm 0.0001\%$ variation from 0°C to 50°C ambient). Installation of the TCXO requires the following material, which must be purchased separately:

Description	Part No.	Qty.
TCXO - 10 MHz	523-140-9-001	1
Solder Shield	342-042-9-001	1
1 k Ω $\pm 5\%$, 1/4 W Carbon Resistor (R4)	002-104-5-102	1*

*NOTE: R4 may already be included; see step 4 below.

Installation of the TCXO is as follows:

1. Disconnect the unit from ac power.
2. Remove the top and bottom covers as described previously.
3. Locate jumpers JU6-JU8 on the main circuit board (refer to Fig. 12).
4. Remove the JU6 and JU7 wires and replace one at JU8.
5. Resistor R4 (from base of transistor Q2 to ground) may already be present in your unit. Compare the main circuit board of your unit with the circuit board map provided in this manual, to determine if R4 is included. If not, install R4 (see description above) from the base to the emitter of Q2.
6. Insert the pins of the TCXO into the appropriate holes of the solder shield and install the TCXO on the main circuit board with the seal screw facing as shown in Fig. 12.
7. Solder the four TCXO pins to the main circuit board. Check all solder connections for shorts, etc., before applying power to the unit.

TROUBLESHOOTING

The following troubleshooting steps provide a logical procedure for fault isolation. While the procedure cannot, of course, guarantee to pinpoint every possible problem, it will in most cases localize the problem to a certain area.

Most of these troubleshooting steps require removal of the top cover as described previously.

Components mentioned may be located on the circuit board by means of the CIRCUIT BOARD MAPS provided in this manual. The separately supplied schematic diagram should also be consulted in conjunction with this procedure. Finally, it should be mentioned that some insight into troubleshooting the unit may be gained by studying the CIRCUIT DESCRIPTION section of this manual.

1. Set PWR to ON and connect a 1 MHz signal source to both inputs. Frequency accuracy of the source is not critical; however, amplitude should be adequate to produce stable counter readings. Use the input controls (filter, attenuator, trigger slope and level) as necessary to obtain a stable readout. (If a stable reading cannot be obtained, follow step 5.)
2. Set the counter to each of the settings of Table 1 and check that the display shows approximately the values listed. If it does not, proceed as follows:
 - a. If no display can be obtained, follow step 3.
 - b. If display shows abnormalities such as missing decimal points or unlit segments or digits, follow step 4.
 - c. If display appears normal, but value is incorrect or unstable, follow step 5.
3. **No display.** Check supply voltage at IC6 pin 25 for approximately +5 volts. If this voltage is not present, check ac input, fuse, and +5 V power supply circuit (D8, D9, C12, D12, Q1). Otherwise proceed to step 4.
4. **Abnormal display.**
 - a. Digit strobes and time base. Check for the digit strobe waveforms of Fig. 13 at IC6 pins 22-24 and 26-30. If these are normal, proceed to step 4b. If not, check the output of the time base oscillator at pin 38 for an approximate sine wave of frequency 10 MHz and peaks of 0 and 2 V¹. If normal, proceed to step 4b; if no output is obtained, check oscillator components and IC6.
 - b. Display test. Engage the .1/1/.0001 RESOLUTION switch and select SELF TEST mode. Display should be all "eights" with all decimal points and OVERFLOW indicator on. If not, switch to PERIOD and Time Interval modes (same RESOLUTION) and check for same display in each. If the self test display appears in one mode and not in another, check mode selection circuitry as in step 5j. If it does not appear in any modes, or is incorrect in all modes, check seven-segment displays and IC6 segment driver pins 8-11 and 13-16. Waveform at each of these pins should approximate a dc level of about 1.2 V, with negative spikes of about 4 kHz.
- d. If problem is not adequately described by any of the above, start at step 3 and proceed through each step until the difficulty is isolated.

¹ Measured with oscilloscope with 1 M Ω input resistance, 28 pF input capacitance using X10 attenuator probe with 10M Ω input resistance, 18 pF input capacitance. Use of equipment with different impedance may result in significant differences in peak magnitude.

Operating Mode	RESOLUTION	Normal (Ideal) Display
FREQuency kHz	100/1K/.1 10/100/.01 1/10/.001 .1/1/.0001	1000.0 1000.00 1000.000 ¹ 1000.0000 ¹
FREQuency MHz	100/1K/.1 10/100/.01 1/10/.001 .1/1/.0001	1.000 1.0000 1.00000 1.000000 ²
PERiod μSEC	100/1K/.1 10/100/.01 1/10/.001 .1/1/.0001	1.0 1.00 1.000 1.0000
PERiod mSEC	100/1K/.1 10/100/.01 1/10/.001 .1/1/.0001	.0010 .00100 .001000 Display test ³
RATIO	100/1K/.1 10/100/.01 1/10/.001 .1/1/.0001	1. 1.0 1.00 1.000
TI μSEC (both -SL switches out, TRIG LEVEL set to PRESET IN)	100/1K/.1 10/100/.01 1/10/.001 .1/1/.0001	1.0 1.00 1.000 1.0000
TI mSEC (both -SL switches out, TRIG LEVEL set to PRESET IN)	100/1K/.1 10/100/.01 1/10/.001 .1/1/.0001	.0010 .00100 .001000 Display test ³
TOTALize	not applicable.	Display accumulates, with second digit from left changing at approximately 1 Hz.
PERiod (reduce input to less than 100 Hz)	.1/1/.0001	OVERflow lights. ¹

¹ Allow ten seconds for measurement completion.

² Allow twenty seconds for measurement completion.

³ Display is all eights, with all decimal points and OVERflow indicator lit.

Table 1. Normal displays for 1 MHz input.

- c. Decimal points. If these are abnormal in MHz or mSEC modes, check the mode selection logic as in step 5j (particularly Table 7).
- d. KHz/ μ SEC or MHz/mSEC indicators. For problems involving these, check the mode selection logic as in step 5j (particularly Table 8).
- e. GATE indicator. This LED, D18, is connected via IC3 to IC6 pin 3, which goes low whenever a measurement is being taken. Check D18, IC3, and IC6 pin 3. (If pin 3 shows no activity, it is advisable to check for proper mode selection as in step 5j.)

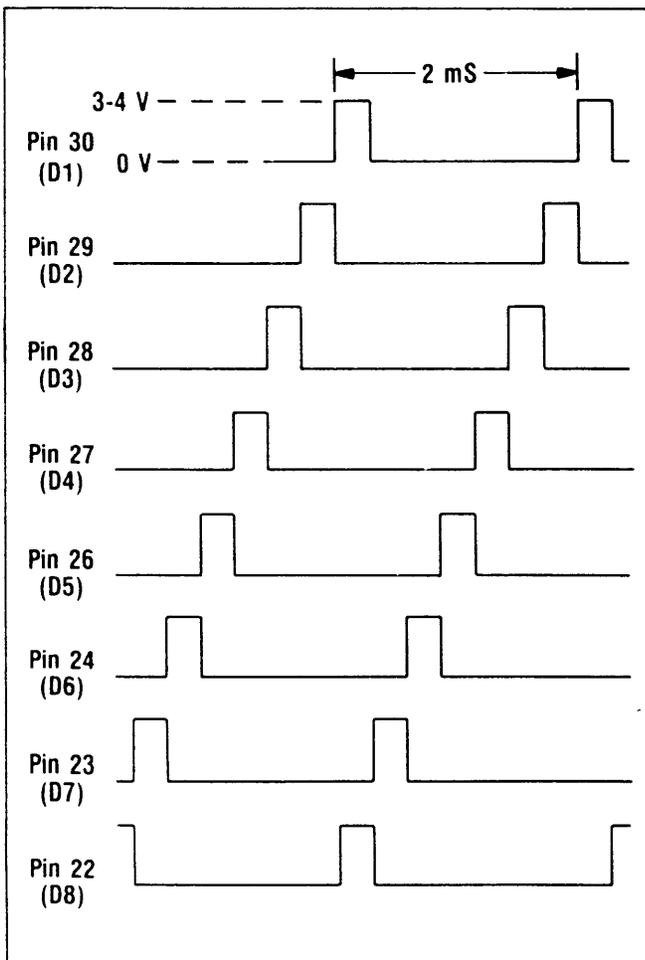


Fig. 13. Digit strobe waveforms from IC6.
(Pulse magnitude varies according to number of segments lit in a particular digit.)

5. **Incorrect or unstable display value.**

- a. Isolation by half-splitting. Check the waveform at the collector of Q104 (Channel A) and Q113 (Channel B). With a 1 MHz input to each counter channel, each of these waveforms should be a 1 MHz square wave (0-2.4 V) of same polarity as the channel input. If either waveform is abnormal, a problem may exist in the analog input circuitry for that channel; see steps 5b and 5c. Otherwise, troubleshoot the digital circuitry; see steps 5d to 5j.
- b. Analog circuitry power supply. Check for voltages of +6, -6, +10, and -10 volts in the analog circuits (appropriate points are shown on the amplifier board schematic). If these voltages are not present, check the power supply (D4-7, D10, D11, D13, D14, C10, C11).
- c. Analog input circuits. Tables 2 and 3 give waveforms for the analog input circuits for Channel A and Channel B respectively (using a 10 kHz, 1 V p-p sinusoidal input). The order of table entries is from input to output; this permits either sequential or half-splitting troubleshooting techniques, as desired by the user.
- d. Slope select gates. With the Channel A -SL switch S103 out, the TTL waveform at IC8 pin 8 should be of the opposite polarity as that at the collector of Q104 (see step 5a above). Pushing the switch in should complement the signal. Similarly, the waveform at IC8 pin 11 should be opposite to that at the collector of Q113, except when complemented by the Channel B -SL switch S106. If either waveform is abnormal, check IC8 and the -SL switches.

Test Point	Waveform ¹
A. Gate of Q101.	1 V p-p, 10 kHz sine wave, centered at 0 V.
B. Gate of Q101 (Ch. A X10 switch engaged).	0.1 V p-p, 10 kHz sine wave, centered at 0 V.
C. Base of Q103.	1 V p-p, 10 kHz sine wave, centered at +1.8 V.
D. IC101 pin 1 (LPF switch out).	0.8 V p-p, 10 kHz sine wave, centered at 0 V, in phase with input.
E. IC101 pin 1 (LPF switch pushed in).	10 kHz sine wave, approx. 0.5 V p-p, centered at 0 V, shifted by approx. 45° behind input.
F. IC101 pin 4	With TRIG LEVEL pulled out and rotated, voltage at pin 4 should vary from -1.4 V to +1.6 V. (0 V with TRIG LEVEL pushed in.)
G. IC101 pin 13 (TRIG LEVEL pushed in).	10 kHz 2.6 V p-p, rounded square wave, centered at 4.5 V. Rotation of TRIG LEVEL should have no effect.
H. IC101 pin 13 (TRIG LEVEL pulled out).	With TRIG LEVEL pulled out and centered, waveform is same as G. Rotating the control counter-clockwise increases the duty cycle toward a dc level of +6 V at extreme rotation; clockwise rotation decreases the duty cycle toward a dc level of +3 V at extreme rotation.
I. IC102 pin 11 (input disconnected).	DC level of +3.8 V.
J. IC102 pin 9 (input disconnected).	Same as I.
K. IC102 pin 10 (input disconnected).	Same as I.
L. IC102 pin 10 (input ¹ reconnected).	2.6 V p-p, 10 kHz rounded square wave, centered at +3.8 V.
M. IC102 pin 7, 13.	1 V p-p, 10 kHz square wave, centered at +3.8 V. Polarity opposite that of J; squarer edges.
N. IC102 pin 6.	Same as M, but inverted.
O. IC102 pin 4, 15.	Same as M.
P. IC102 pin 5, 14.	Same as M, but inverted.
Q. IC102 pin 2, base of Q105.	Same as M.
R. IC102 pin 3, base of Q104.	Same as M, but inverted.

¹Channel A input of 1 V p-p, 10 kHz sine wave.

Table 2. Channel A analog circuit waveforms.

Test Point	Waveform ¹
A. Gate of Q111.	1 V p-p, 10 kHz sine wave, centered at 0 V.
B. Gate of Q111 (Ch. B. X10 switch engaged).	0.1 V p-p, 10 kHz sine wave, centered at 0 V.
C. Collector of Q112.	1 V p-p, 10 kHz sine wave, centered at +3.5 V.
D. IC105 pin 11 (input disconnected).	DC level of +3.8 V.
E. IC105 pin 9 (input disconnected).	Same as D.
F. IC105 pin 10 (input disconnected).	Same as D.
G. IC105 pin 10 (input ¹ reconnected).	1 V p-p, 10 kHz sine wave, centered at +3.8 V.
H. IC105 pins 5, 6.	1 V p-p, 10 kHz rounded square wave, centered at +3.8 V.
I. IC105 pins 4, 7.	Same as H, but inverted.
J. IC105 pins 2, 13.	Same as I, with squarer corners.
K. IC105 pin 15	Same as J.
L. IC105 pin 14	Same as J, but inverted.

¹Channel B input of 1 V p-p, 10 kHz sine wave.

Table 3. Channel B analog circuit waveforms.

- e. Channel A gating. Check waveform at IC1 pin 12. With HOLD switch S14 out, TTL waveform should be the same as that at IC8 pin 8. Pushing S14 in (or applying a TTL low signal at the TOTALIZE START/STOP jack, J2) should result in a constant low at IC1 pin 12. If waveform is abnormal, check IC1, S14, HOLD flip-flop IC9, or J2 input network.
- f. TI priming circuit. Check waveforms at IC8 pins 3 and 6 (Channels A and B, respectively). With RESET switch S15 out, waveforms should be the same as those at IC1 pin 12 and IC8 pin 11, respectively. If not, check the priming circuit and RESET switch S15 as in Table 4. Also consult this table if the unit fails to properly perform single time interval measurements.
- g. Prescaler. Set counter input to 1 MHz, and check frequency of waveforms at IC104 pin 4 (should be 100 kHz, non-symmetrical wave-

Front Panel Setting	Test Point(s)	Waveform
TI switch engaged, RESET switch out	IC3 pin 3	Logic high
	IC3 pin 2	Logic low
	IC9 pin 5	Logic low
	IC9 pins 4, 6, IC3 pin 5	Logic high
	IC3 pin 4	Logic low
	IC3 pin 7	Logic high
	IC3 pin 6	Logic low
	IC3 pin 9	Logic high
	IC3 pin 10	Logic low
	IC8 pin 6	Same as IC8 pin 4
IC8 pin 3	Same as IC8 pin 2	
Press and release RESET	IC8 pin 1 should go high as long as RESET is held down. Upon release of the button, IC8 pin 1 returns low, followed by a brief high (5 ms) at IC8 pin 5.	

Table 4. Check of TI priming circuit.

form) and IC2 pin 5; (should be 50 kHz, symmetrical waveform). If either is abnormal, check IC104 or IC2.

- h. Prescale/direct selection circuit. For a 1 MHz counter input, the waveform at IC4 pin 8 should also be 1 MHz when FREQ kHz mode is selected. When FREQ MHz is selected, the frequency at IC4 pin 8 should be 50 kHz. If the waveform is abnormal, check that IC4 pin 2 is high when FREQ MHz is selected. If not, check the mode selection logic as in step 5j (particularly Table 8). Otherwise, check the gates of IC4.

- i. Time base divider. The waveform at IC2 pin 9 should be 1/2 of the frequency of that at IC2 pin 11 (10 MHz time base from IC6). If not, check IC2.
- j. Mode selection logic. Operating mode, resolution, and other factors are determined by feedback of the IC6 digit strobes D1-D8 to various control pins of this same chip. This feedback is controlled, either directly or through logic, by the front panel switches. Tables 5 - 8 give normal logic conditions in these feedback connections for each switch configuration.

Front Panel Switches Engaged	Test Point(s)	Waveform
100/1K/.1 RESOLUTION	IC6 pin 21 IC7 pin 2 IC7 pin 4	IC6 strobe D1 IC6 strobe D4 IC6 strobe D5
10/100/.01 RESOLUTION	IC6 pin 21 IC7 pin 2 IC7 pin 4	IC6 strobe D2 IC6 strobe D5 IC6 strobe D6
1/10/.001 RESOLUTION	IC6 pin 21 IC7 pin 2 IC7 pin 4	IC6 strobe D3 IC6 strobe D6 IC6 strobe D7
.1/1/.0001 RESOLUTION	IC6 pin 21 IC7 pin 2	IC6 strobe D4 IC6 strobe D7

Table 5. Check of RESOLUTION switches.

Front Panel Switches Engaged	Test Point(s)	Waveform
FREQuency A	IC6 pin 4 IC1 pin 9	IC6 strobe D1 Logic high
PERiod A	IC6 pin 4 IC5 pins 8, 10, IC1 pin 5	IC6 strobe D8 Logic high
RATIO A/B	IC6 pin 4 IC5 pins 2, 3, cathodes of D16, D17	IC6 strobe D2 Logic high
TI A → B	IC6 pin 4 IC5 pins 4, 6, 8, 9, IC1 pin 5, IC9 pin 6	IC6 strobe D5 Logic high
TOTALize A	IC6 pin 4 IC5 pins 1, 3, cathodes of D16, D17	IC6 strobe D4 Logic high
SELF TEST	IC6 pin 4 IC5 pins 5, 6, 8, 9, IC1 pin 5	IC6 strobe D3 Logic high

Table 6. Check of mode switches and related logic.

Front Panel Switches Engaged	Test Point(s)	Waveform
k/μ - M/m, FREQUENCY A	IC1 pins 8, 9, 10, IC7 ¹ pin 13 IC7 ¹ pin 1, IC6 pin 20 IC5 pins 11, 12, IC7 ¹ pin 12 IC7 ¹ pin 10, IC6 pin 1	Logic high Same as IC7 pin 2 (IC6 digit strobe selected by RESOLUTION switches; see Table 5) Logic high IC6 strobe D3 (pin 28)
k/μ - M/m, and PERIOD, TI, or SELF TEST	IC5 pin 8 IC1 pins 5, 6, IC7 ¹ pin 5 IC7 ¹ pin 3, IC6 pin 20 IC5 pins 11, 13, IC7 ¹ pin 12 IC7 ¹ pin 10, IC6 pin 1	Logic high (see Table 6) Logic high Same as IC7 pin 4 (IC6 digit strobe selected by RESOLUTION switches; see Table 5) Logic high IC6 strobe D3 (pin 28)

¹IC7 consists of four bilateral switches. Whenever the control pin (pins 5, 6, 12, 13) goes high, its corresponding switch provides a low resistance path from input to output (pins 4 to 3, 8 to 9, 11 to 10, 2 to 1, respectively).

Table 7. Check of external decimal point enable.

Front Panel Switches Engaged	Test Point(s)	Waveform
k/μ - M/m, FREQUENCY A	IC4 pins 2, 4 IC7 pin 6 IC7 pin 9, IC6 pin 1	Logic high Logic high Same as IC7 pin 8 (IC6 strobe D1, pin 30)
k/μ - M/m, .1/1/.0001 RESOLUTION, and PERIOD, TL, or SELF TEST	IC5 pin 8 IC1 pins 5, 6, IC9 pins 8, 9 IC9 pin 10, Base of Q3 Collector of Q3, IC6 pin 1	Logic high (see Table 6) Logic high Logic low Same as emitter of Q3 (IC6 strobe D8, pin 22)
k/μ-M/m engaged (no others)	IC5 pin 3 IC3 pin 11, anode of D16 IC3 pin 12, anode of D17 D16 D17	Logic low Logic high Logic low Lit Unlit
k/μ-M/m disengaged	IC5 pin 3 IC3 pin 11, anode of D16 IC3 pin 12, anode of D17 D16 D17	Logic low Logic low Logic high Unlit Lit

Table 8. Additional checks of mode selection logic.

APPENDIX

A. FREQUENCY/PERIOD TABLES

The tables in this section of the Appendix provide listings of standard audio frequencies in common use in the electronics industry. In each table the frequency and the period are given. Frequency is the reciprocal of period. Divide the period reading into 1 to get frequency.

NOTE: 1 millisecond (ms) = .001 second (s), and 1 microsecond (μ s) = .000001 second.

1. **Modem Frequencies.** There are two sets of standard audio frequencies used for data communications:
 - a. U.S. Standards.
 - b. The Consultative Committee on International Telephone and Telegraph (CCITT).

These frequencies, their periods and corresponding bit pairs are listed in Table 9.

U.S. Standard Frequency (Period)	Bit Pair	CCITT Frequency (Period)
1270 Hz (787.402 μ s)	00	980 Hz (1020.41 μ s)
1070 Hz (934.579 μ s)	01	1180 Hz (847.458 μ s)
2225 Hz (449.438 μ s)	10	1650 Hz (606.061 μ s)
2025 Hz (493.827 μ s)	11	1850 Hz (540.540 μ s)

Table 9. Modem frequencies.

2. **Telephone "Touch-Tone" Frequencies.** Each of the pushbuttons on a telephone "Touch-Tone" pad activates a pair of frequencies. These tones are used to activate the telephone terminal equipment. The digits on a telephone "Touch-Tone" pad and their respective frequency pairs are listed in Table 10.

Digit (Symbol)	Frequencies (Periods)	
1	697 Hz (1434.72 μ s)	1209 Hz (827.130 μ s)
2	697 Hz (1434.72 μ s)	1336 Hz (748.503 μ s)
3	697 Hz (1434.72 μ s)	1477 Hz (677.948 μ s)
4	770 Hz (1298.70 μ s)	1209 Hz (827.130 μ s)
5	770 Hz (1298.70 μ s)	1336 Hz (748.503 μ s)
6	770 Hz (1298.70 μ s)	1477 Hz (677.048 μ s)
7	852 Hz (1173.71 μ s)	1209 Hz (827.130 μ s)
8	852 Hz (1173.71 μ s)	1336 Hz (748.503 μ s)
9	852 Hz (1173.71 μ s)	1477 Hz (677.048 μ s)
0	941 Hz (1062.69 μ s)	1336 Hz (748.503 μ s)
*	941 Hz (1062.69 μ s)	1209 Hz (827.130 μ s)
#	941 Hz (1062.69 μ s)	1477 Hz (677.048 μ s)

Table 10. Telephone "Touch-Tone" pad digits and frequency pairs.

"Touch-Tone" is a registered trademark of A.T. & T.

NOTE/FREQ.	$C_{00}/16.351$ Hz	$C_{00}^{\#}/17.324$ Hz	$D_{00}/18.354$ Hz	$D_{00}^{\#}/19.445$ Hz	$E_{00}/20.602$ Hz	$F_{00}/21.826$ Hz	$F_{00}^{\#}/23.125$ Hz	$G_{00}/24.499$ Hz	$G_{00}^{\#}/25.956$ Hz	$A_{00}/27.500$ Hz	$A_{00}^{\#}/29.135$ Hz	$B_{00}/30.867$ Hz
PERIOD	61.1583 mS	57.7234 mS	54.4840 mS	51.4271 mS	48.5390 mS	45.8169 mS	43.2432 mS	40.8179 mS	38.5267 mS	36.3636 mS	34.3230 mS	32.3971 mS
NOTE/FREQ.	$C_0/32.703$ Hz	$C_0^{\#}/34.647$ Hz	$D_0/36.708$ Hz	$D_0^{\#}/38.890$ Hz	$E_0/41.203$ Hz	$F_0/43.653$ Hz	$F_0^{\#}/46.249$ Hz	$G_0/48.999$ Hz	$G_0^{\#}/51.913$ Hz	$A_0/55.000$ Hz	$A_0^{\#}/58.270$ Hz	$B_0/61.735$ Hz
PERIOD	30.5782 mS	28.8625 mS	27.2420 mS	25.7136 mS	24.2701 mS	22.9709 mS	21.6221 mS	20.4086 mS	19.2630 mS	18.1818 mS	17.1615 mS	16.1983 mS
NOTE/FREQ.	$C_1/65.406$ Hz	$C_1^{\#}/69.295$ Hz	$D_1/73.416$ Hz	$D_1^{\#}/77.781$ Hz	$E_1/82.406$ Hz	$F_1/87.307$ Hz	$F_1^{\#}/92.498$ Hz	$G_1/97.998$ Hz	$G_1^{\#}/103.826$ Hz	$A_1/110.000$ Hz	$A_1^{\#}/116.540$ Hz	$B_1/123.470$ Hz
PERIOD	15.2891 mS	14.4310 mS	13.6210 mS	12.8566 mS	12.1350 mS	11.4538 mS	10.8110 mS	10.2053 mS	9.6315 μ S	9.0909 μ S	8.5807 μ S	8.0991 μ S
NOTE/FREQ.	$C_2/130.812$ Hz	$C_2^{\#}/138.591$ Hz	$D_2/146.832$ Hz	$D_2^{\#}/155.563$ Hz	$E_2/164.813$ Hz	$F_2/174.614$ Hz	$F_2^{\#}/184.997$ Hz	$G_2/195.997$ Hz	$G_2^{\#}/207.652$ Hz	$A_2/220.000$ Hz	$A_2^{\#}/233.081$ Hz	$B_2/246.941$ Hz
PERIOD	7644.56 μ S	7215.48 μ S	6810.50 μ S	6428.36 μ S	6067.48 μ S	5726.92 μ S	5405.49 μ S	5102.12 μ S	4815.75 μ S	4545.45 μ S	4290.35 μ S	4049.55 μ S
NOTE/FREQ.	$C_3/261.625$ Hz	$C_3^{\#}/277.183$ Hz	$D_3/293.664$ Hz	$D_3^{\#}/311.126$ Hz	$E_3/329.627$ Hz	$F_3/349.228$ Hz	$F_3^{\#}/369.994$ Hz	$G_3/391.995$ Hz	$G_3^{\#}/415.304$ Hz	$A_3/440.000$ Hz	$A_3^{\#}/466.163$ Hz	$B_3/493.883$ Hz
PERIOD	3822.26 μ S	3607.72 μ S	3405.25 μ S	3214.13 μ S	3033.73 μ S	2863.45 μ S	2702.75 μ S	2551.05 μ S	2407.87 μ S	2272.72 μ S	2145.17 μ S	2024.77 μ S
NOTE/FREQ.	$C_4/523.251$ Hz	$C_4^{\#}/554.365$ Hz	$D_4/587.329$ Hz	$D_4^{\#}/622.253$ Hz	$E_4/659.255$ Hz	$F_4/698.456$ Hz	$F_4^{\#}/739.988$ Hz	$G_4/783.991$ Hz	$G_4^{\#}/830.609$ Hz	$A_4/880.000$ Hz	$A_4^{\#}/932.327$ Hz	$B_4/987.766$ Hz
PERIOD	1911.13 μ S	1803.86 μ S	1702.62 μ S	1607.06 μ S	1516.86 μ S	1431.73 μ S	1351.35 μ S	1275.52 μ S	1203.94 μ S	1136.36 μ S	1072.59 μ S	1012.39 μ S
NOTE/FREQ.	$C_5/1046.502$ Hz	$C_5^{\#}/1108.730$ Hz	$D_5/1174.659$ Hz	$D_5^{\#}/1244.507$ Hz	$E_5/1318.510$ Hz	$F_5/1396.912$ Hz	$F_5^{\#}/1479.976$ Hz	$G_5/1567.982$ Hz	$G_5^{\#}/1661.218$ Hz	$A_5/1760.000$ Hz	$A_5^{\#}/1864.654$ Hz	$B_5/1975.532$ Hz
PERIOD	955.564 μ S	901.933 μ S	851.311 μ S	803.531 μ S	758.432 μ S	715.865 μ S	675.687 μ S	637.762 μ S	601.968 μ S	568.182 μ S	536.293 μ S	506.193 μ S
NOTE/FREQ.	$C_6/2093.004$ Hz	$C_6^{\#}/2217.460$ Hz	$D_6/2349.318$ Hz	$D_6^{\#}/2489.014$ Hz	$E_6/2637.020$ Hz	$F_6/2793.824$ Hz	$F_6^{\#}/2959.952$ Hz	$G_6/3135.964$ Hz	$G_6^{\#}/3322.436$ Hz	$A_6/3520.000$ Hz	$A_6^{\#}/3729.308$ Hz	$B_6/3951.064$ Hz
PERIOD	477.782 μ S	450.966 μ S	425.655 μ S	401.766 μ S	379.216 μ S	357.932 μ S	337.843 μ S	318.881 μ S	300.984 μ S	284.091 μ S	268.146 μ S	253.096 μ S
NOTE/FREQ.	$C_7/4186.008$ Hz	$C_7^{\#}/4434.920$ Hz	$D_7/4699.636$ Hz	$D_7^{\#}/4978.028$ Hz	$E_7/5274.040$ Hz	$F_7/5567.648$ Hz	$F_7^{\#}/5919.904$ Hz	$G_7/6271.928$ Hz	$G_7^{\#}/6664.812$ Hz	$A_7/7040.000$ Hz	$A_7^{\#}/7456.616$ Hz	$B_7/7902.128$ Hz
PERIOD	238.891 μ S	225.483 μ S	212.782 μ S	200.883 μ S	189.608 μ S	178.966 μ S	168.922 μ S	159.441 μ S	150.493 μ S	142.046 μ S	134.073 μ S	126.548 μ S

Table 11. Scale of equal temperament.

3. **Scale of equal temperament.** Table 11 is included as a source of reference information for the frequency and period of musical notes. This table will be useful when the counter is being used to tune electronic musical instruments.
4. **Other frequencies.** Table 12 lists miscellaneous frequencies commonly encountered, along with their corresponding periods.

B. TIME INTERVAL EXAMPLE

A typical use of the Time Interval mode of the Model 1822 Universal Counter is in measuring the turn-on time of a relay. An example is given in Fig. 14. Here a relay is operated by a control voltage via a transistor switch Q1.

The relay turn-on time is the interval beginning with application of the turn-on command, and ending with relay closure. To measure this interval, Channel A is connected to the control voltage A as shown in fig. 14a. The Channel A -SL switch is left out, so as to

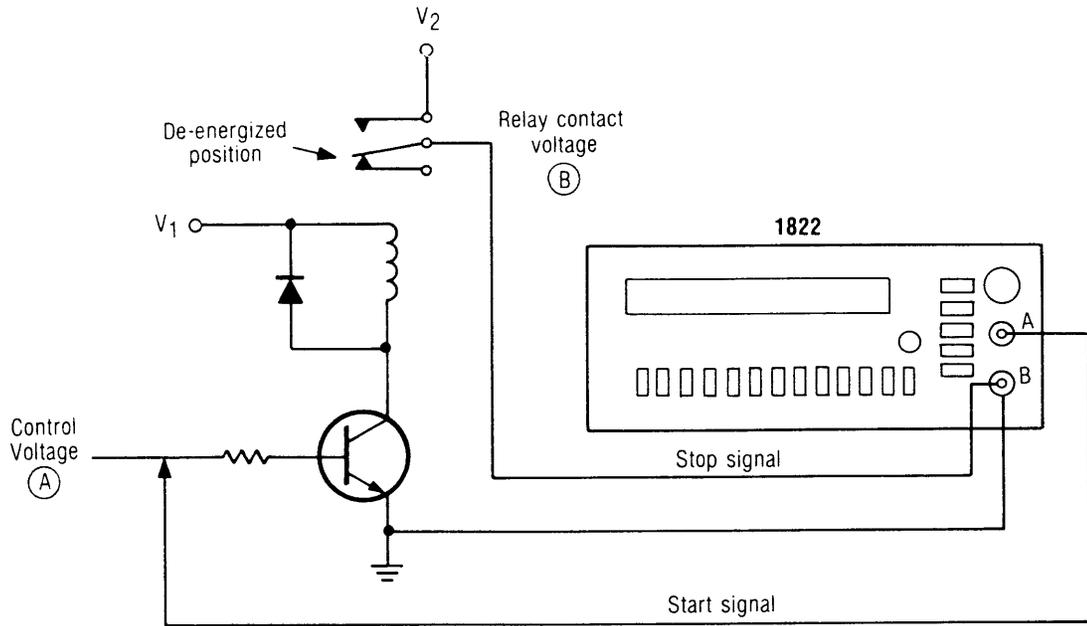
start the measurement on a positive-going voltage excursion. Channel B is connected to the moving relay contact. Since in this case relay closure results in a positive transition at the contact, the Channel B -SL switch is also left out, for positive transition. Depending on the magnitude of V_2 , the Channel B X10 attenuator may be used to reduce noise.

Assuming that relay closures occur once at a time for measurement purposes, the counter is prepared for a single-event measurement. 1-interval averaging (100/1K/.1 RESOLUTION position) is selected, and the unit is primed by pressing RESET. When the control voltage A goes high (Fig. 14b), the unit starts counting the time interval. After a delay consisting of the turn-on of Q1 and the mechanical movement of the contact, the relay contact voltage B goes to V_2 , representing the "stop" signal for Channel B. The timing then stops and the display reads the length of the delay interval.

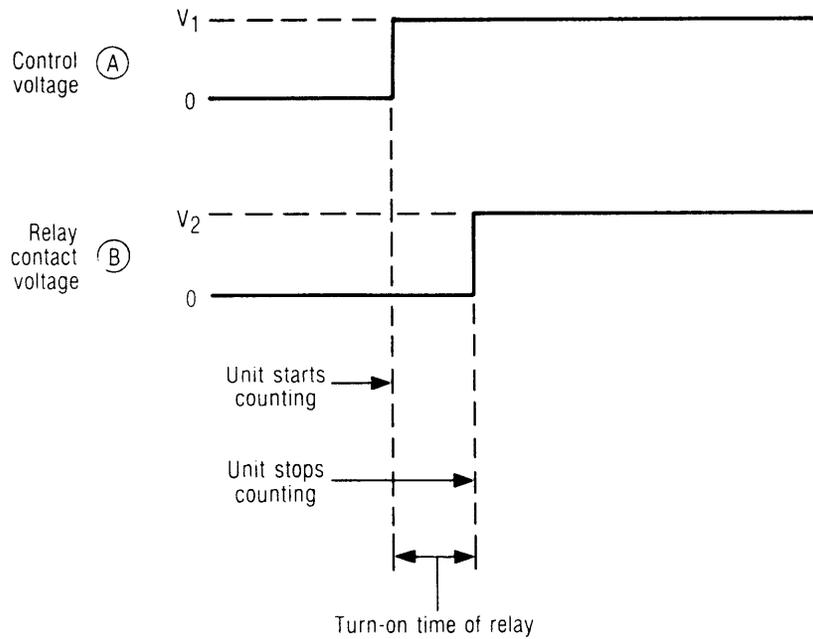
For each subsequent measurement, the unit must be primed by pushing RESET before each relay closure.

Use/Function	Frequency	Period
TV horizontal	15734.26 Hz	63.556 μ s
Stereo FM pilot carrier	19,000 Hz	52.631 μ s
Test tone	400 Hz	2500.00 μ s
Power line (and related) frequencies	60 Hz	16.6667 μ s
	50 Hz	20.0000 μ s
	30 Hz	33.3333 μ s
Kansas City standard cassette interface		
"Space"	1200 Hz	833.333 μ s
"Mark"	2400 Hz	416.667 μ s
16x Clock	4800 Hz	208.333 μ s
Amateur RTTY		
"Mark"	2125 Hz	470.588 μ s
170 Hz Shift "Space"	2295 Hz	435.730 μ s
850 Hz Shift "Space"	2975 Hz	336.134 μ s
Amateur slow-scan TV		
Sync	1200 Hz	833.333 μ s
Black	1500 Hz	666.667 μ s
White	2300 Hz	434.783 μ s

Table 12. Miscellaneous frequencies encountered.



a. Test circuit.



b. Timing waveforms.

Fig. 14. Time Interval measurement example.

C. CONTACT DEBOUNCING

The TOTALize function can be electrically controlled by a logic signal applied to the rear panel TOTALIZE START/STOP jack. In certain applications, this gating may have been provided by a contact closure such as a switch or relay. If the opening or closing of the switch or relay contacts is noisy, inaccurate readings may be obtained due to improper gating.

The problem can be reduced by using push button or toggle switches (slide switches are not recommended) and connecting a 0.22 μF

0.47 μF non-polarized capacitor across the contacts.

A better solution is to employ a TTL debounce circuit like those shown in Fig. 15. Each of the examples in the figure utilizes a flip-flop; the second circuit is in fact used in the Model 1822 to debounce the HOLD switch. Another type of debounce circuit (not shown) utilizes a 74121 one-shot. When triggered, this circuit produces a pulse (duration determined by external resistor and capacitor) which outlasts the switch chatter. Information on this chip is available in the manufacturer's literature.

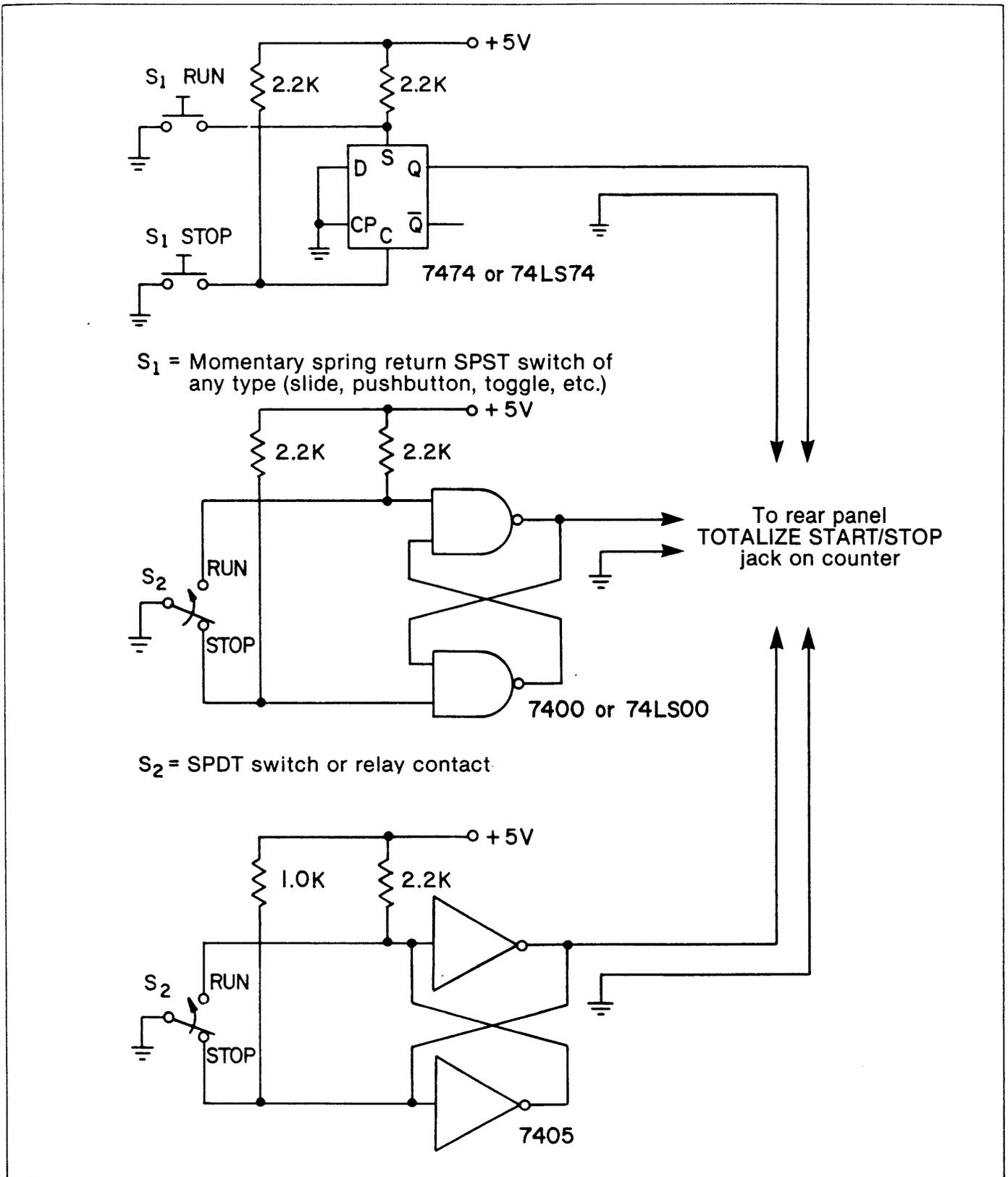
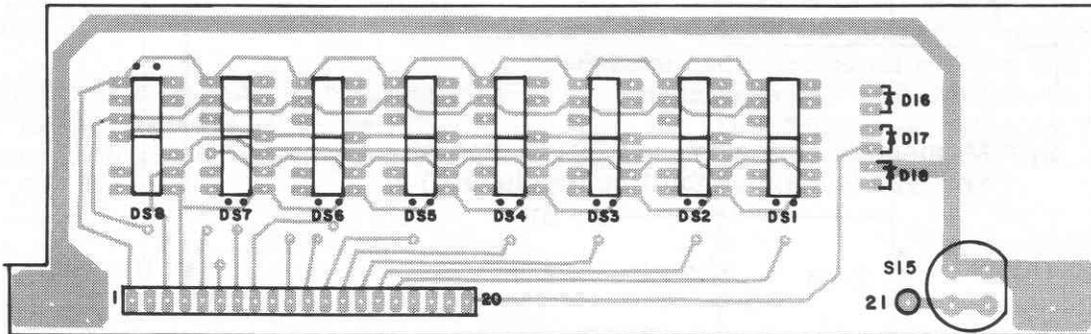


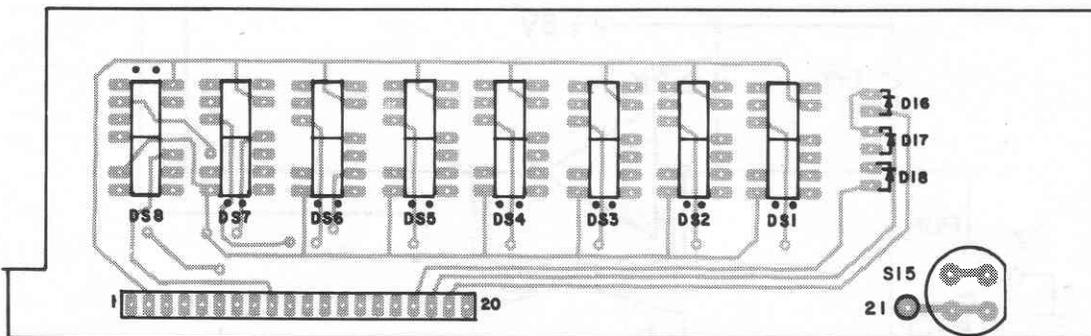
Fig. 15. Debouncing circuits.

CIRCUIT BOARD MAPS

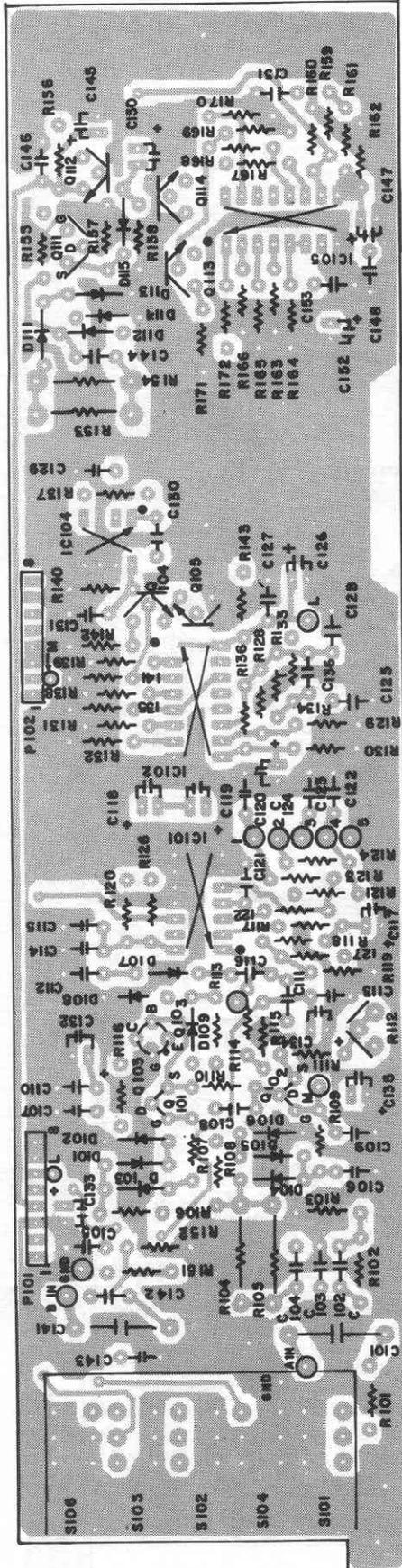
DISPLAY BOARD COMPONENT SIDE



SOLDER SIDE

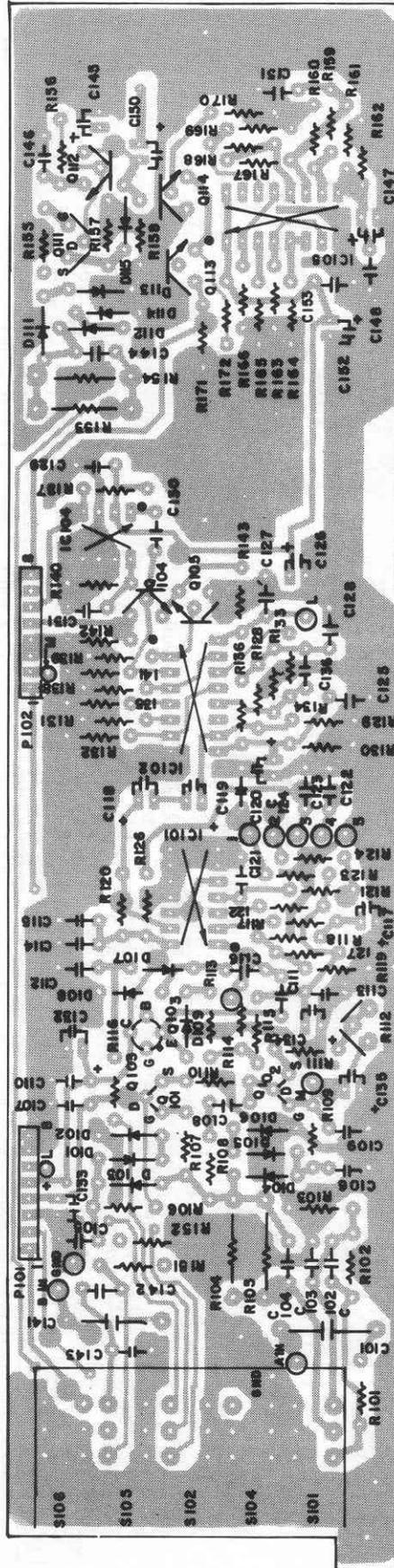


AMPLIFIER
BOARD
COMPONENT
SIDE

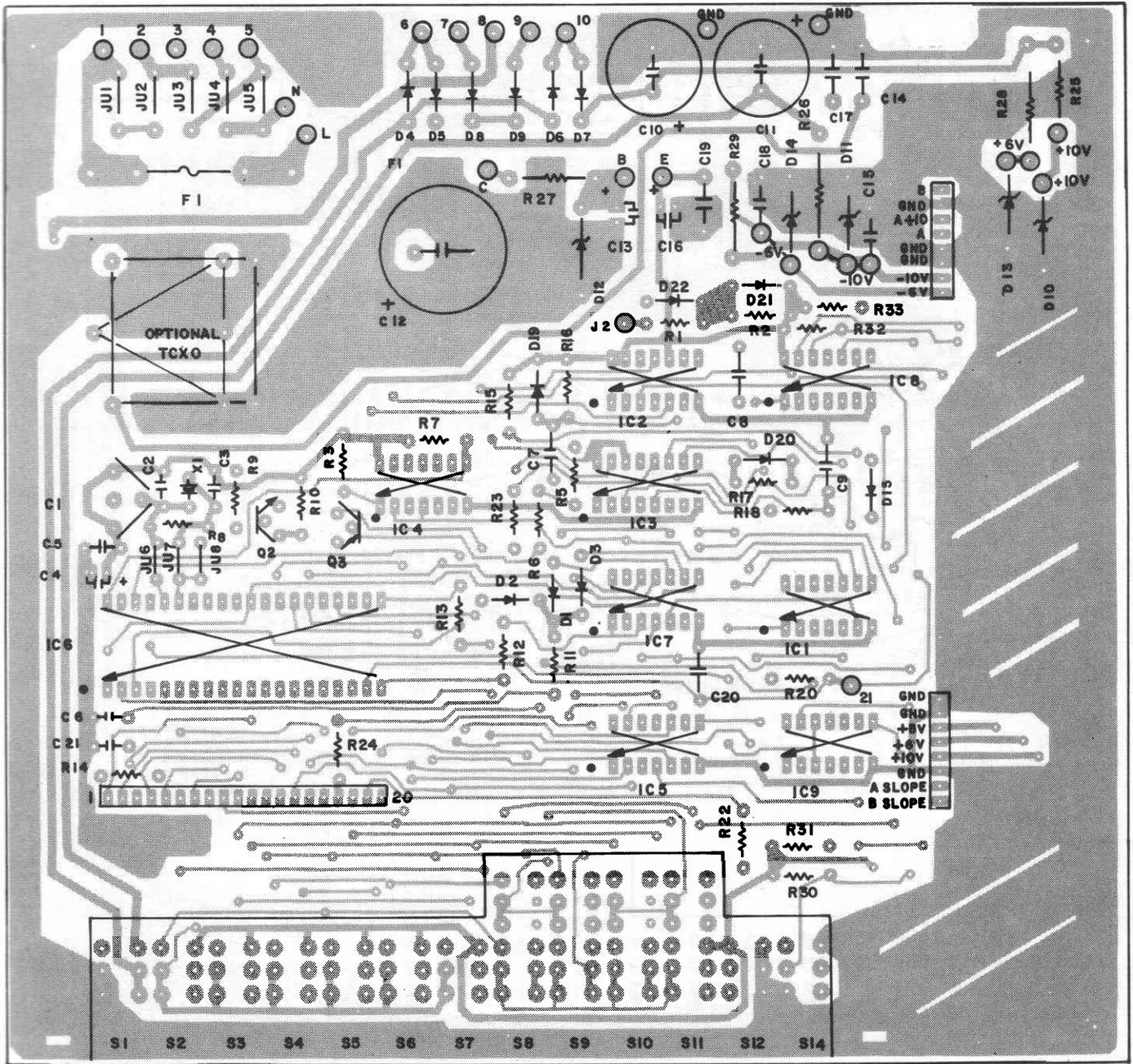


CIRCUIT BOARD MAPS

AMPLIFIER
BOARD
SOLDER
SIDE

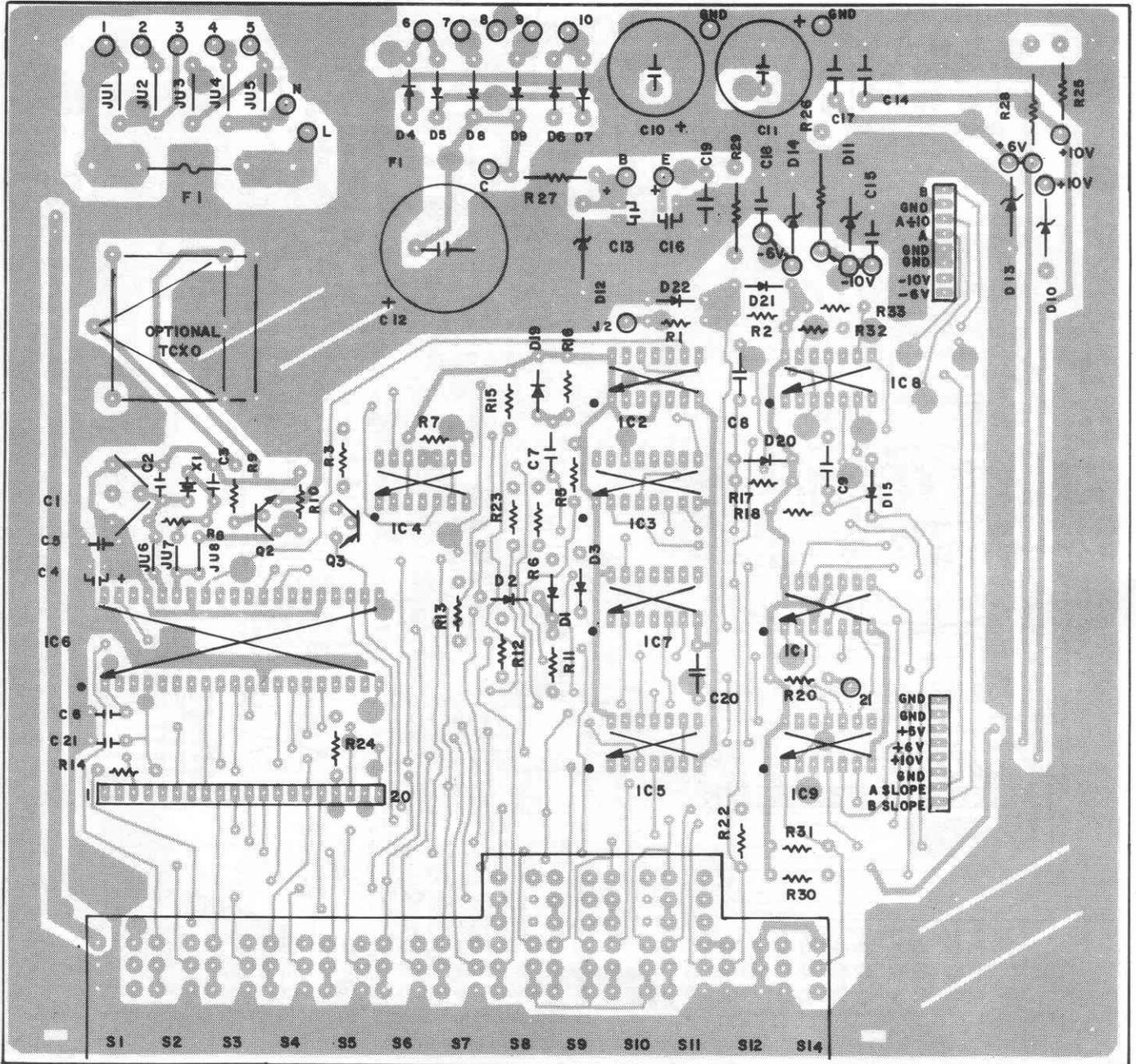


MAIN BOARD COMPONENT SIDE



CIRCUIT BOARD MAPS

MAIN BOARD SOLDER SIDE



WARRANTY INFORMATION

WARRANTY SERVICE INSTRUCTIONS (For U.S.A. and its Overseas Territories)

1. Refer to the MAINTENANCE section of your **B & K-Precision** instruction manual for adjustments that may be applicable.
2. If the above-mentioned does not correct the problem you are experiencing with your unit, pack it securely (preferably in the original carton or double-packed). Enclose a letter describing the problem and include your name and address. Deliver to, or ship PREPAID (UPS preferred in U.S.A.) to the nearest **B & K-Precision** authorized service agency (see list enclosed with unit).

If your list of authorized **B & K-Precision** service agencies has been misplaced, contact your distributor for the name of your nearest service agency, or write to:

B & K-Precision, Factory Service Operations
Maxtec International Corporation
6470 West Cortland Street
Chicago, Illinois 60635
Tel (312) 889-1448

Also use this address for technical inquiries
and replacement parts orders.

WARRANTY INFORMATION

LIMITED ONE-YEAR WARRANTY

MAXTEC INTERNATIONAL CORPORATION warrants to the original purchaser that its **B & K-Precision** product, and the component parts thereof, will be free from defects in workmanship and materials for a period of one year from the date of purchase.

MAXTEC will, without charge, repair or replace, at its option, defective product or component parts upon delivery to an authorized **B & K-Precision** service contractor or the factory service department, accompanied by proof of the purchase date in the form of a sales receipt.

To obtain warranty coverage in the U.S.A., this product must be registered by completing and mailing the enclosed warranty registration card to MAXTEC, **B & K-Precision**, 6470 West Cortland Street, Chicago, Illinois 60635 within fifteen (15) days from the date of purchase.

Exclusions: This warranty does not apply in the event of misuse or abuse of the product or as a result of unauthorized alterations or repairs. It is void if the serial number is altered, defaced or removed.

MAXTEC shall not be liable for any consequential damages, including without limitation damages resulting from loss of use. Some states do not allow limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

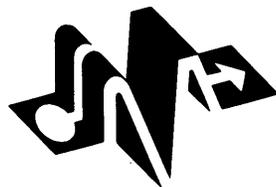
This warranty gives you specific rights and you may also have other rights which vary from state to state.

For your convenience we suggest you contact your **B & K-Precision** distributor, who may be authorized to make repairs or can refer you to the nearest service contractor. If warranty service cannot be obtained locally, please send the unit to **B & K-Precision** Service Department, 6470 West Cortland Street, Chicago, Illinois 60635, properly packaged to avoid damage in shipment.

B & K-Precision Test Instruments warrants products sold only in the U.S.A. and its overseas territories. In other countries, each distributor warrants the **B & K-Precision** products which it sells.

(continued from inside front cover)

6. Some equipment with a two-wire ac power cord, including some with a polarized power plug, is the "hot chassis" type. This includes most recent television receivers and audio equipment. A plastic or wooden cabinet insulates the chassis to protect the customer. When the cabinet is removed for servicing, a serious shock hazard exists if the chassis is touched. Not only does this present a dangerous shock hazard, but damage to test instruments or the equipment under test may result from connecting the ground lead of most test instruments to a "hot chassis". To make measurements in "hot chassis" equipment, always connect an isolation transformer between the ac outlet and the equipment under test. The **B & K-Precision** Model TR-110 Isolation Transformer, or Model 1653 or 1655 AC Power Supply is suitable for most applications. To be on the safe side, treat all two-wire ac powered equipment as "hot chassis" unless you are sure it has an isolated chassis or an earth ground chassis.
7. Servicing of this unit should be performed only by qualified electronics technicians who are trained to work safely in the presence of high voltage. AC line voltage is present on the fuse and power transformer primary circuit whenever the line cord is plugged into a live ac outlet, even if the POWER switch is off.
8. Never work alone. Someone should be nearby to render aid if necessary. Training in CPR (cardio-pulmonary resuscitation) first aid is highly recommended.



BK PRECISION

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