

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.

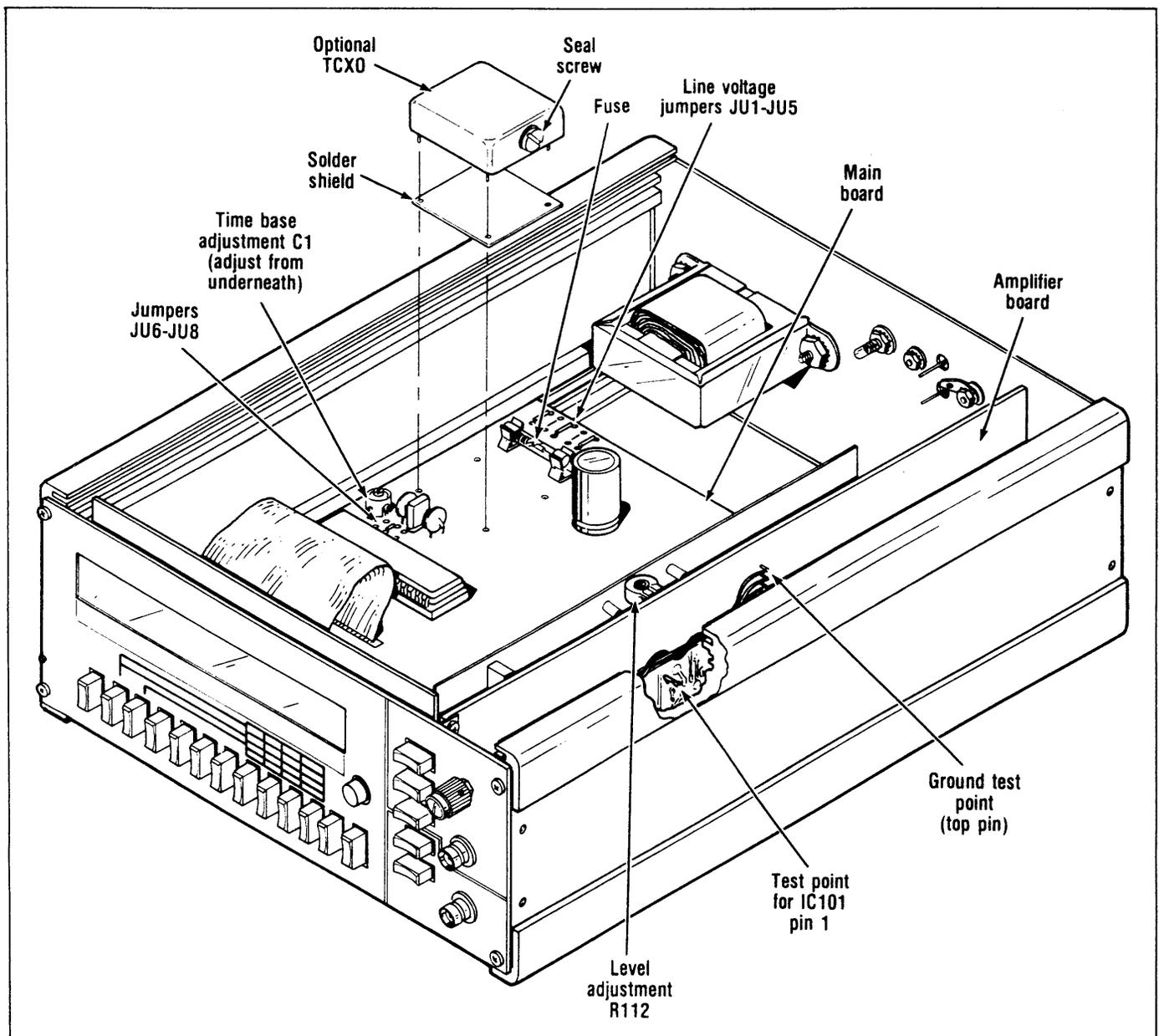


Fig. 12. Interior view showing important elements.

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 μ SEC | 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 μ SEC (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.)

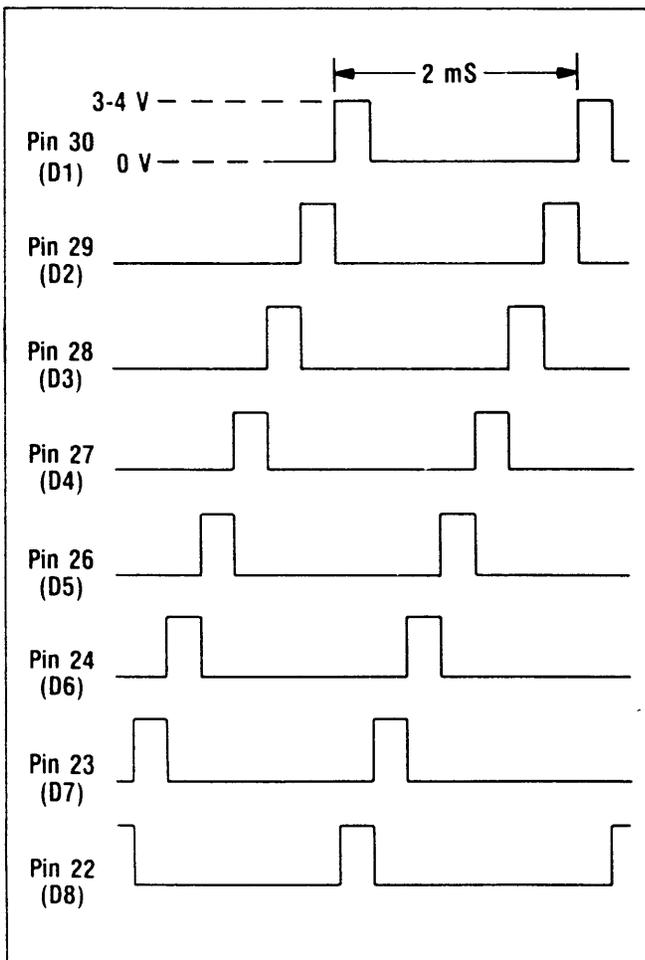


Fig. 13. Digit strobe waveforms from IC6.
(Pulse magnitude varies according to number of segments lit in a particular digit.)

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

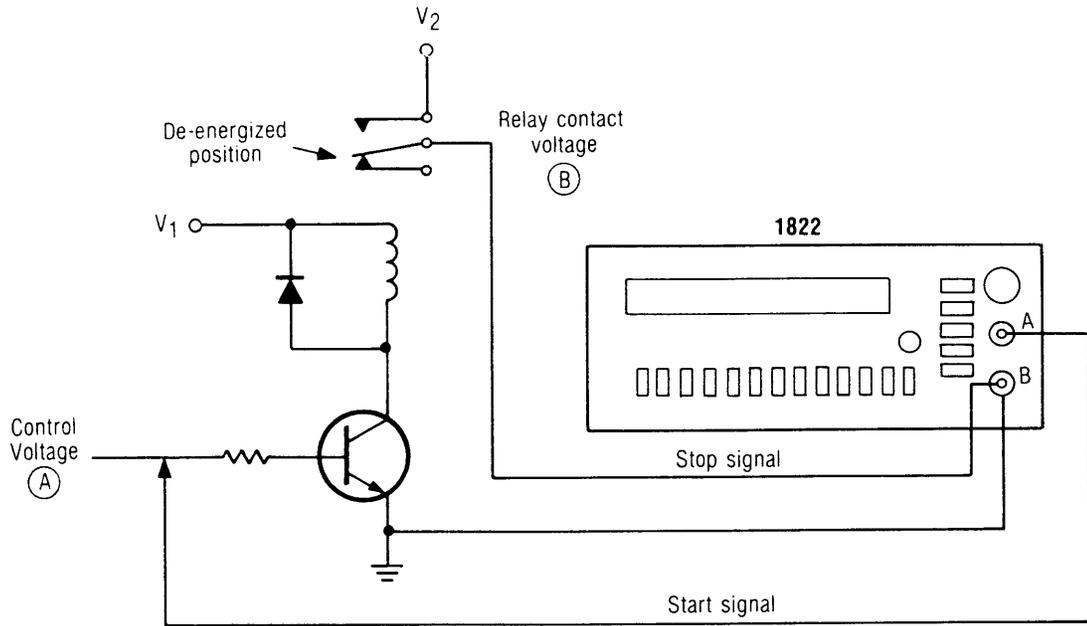
start the measurement on a positive-going voltage excursion. Channel B is connected to the moving relay contact. Since in this case relay closure results in a positive transition at the contact, the Channel B -SL switch is also left out, for positive transition. Depending on the magnitude of V_2 , the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

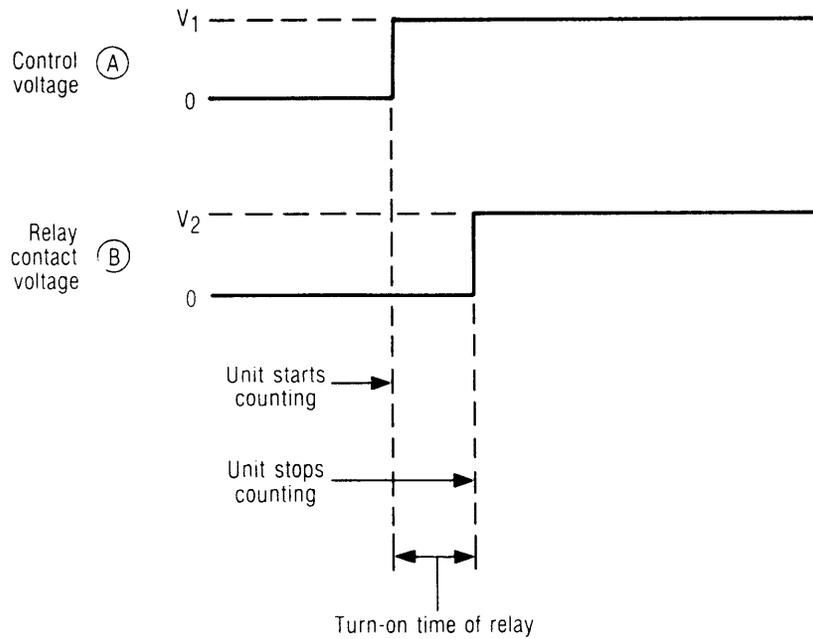
For each subsequent measurement, the unit must be primed by pushing RESET before each relay closure.

| 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.

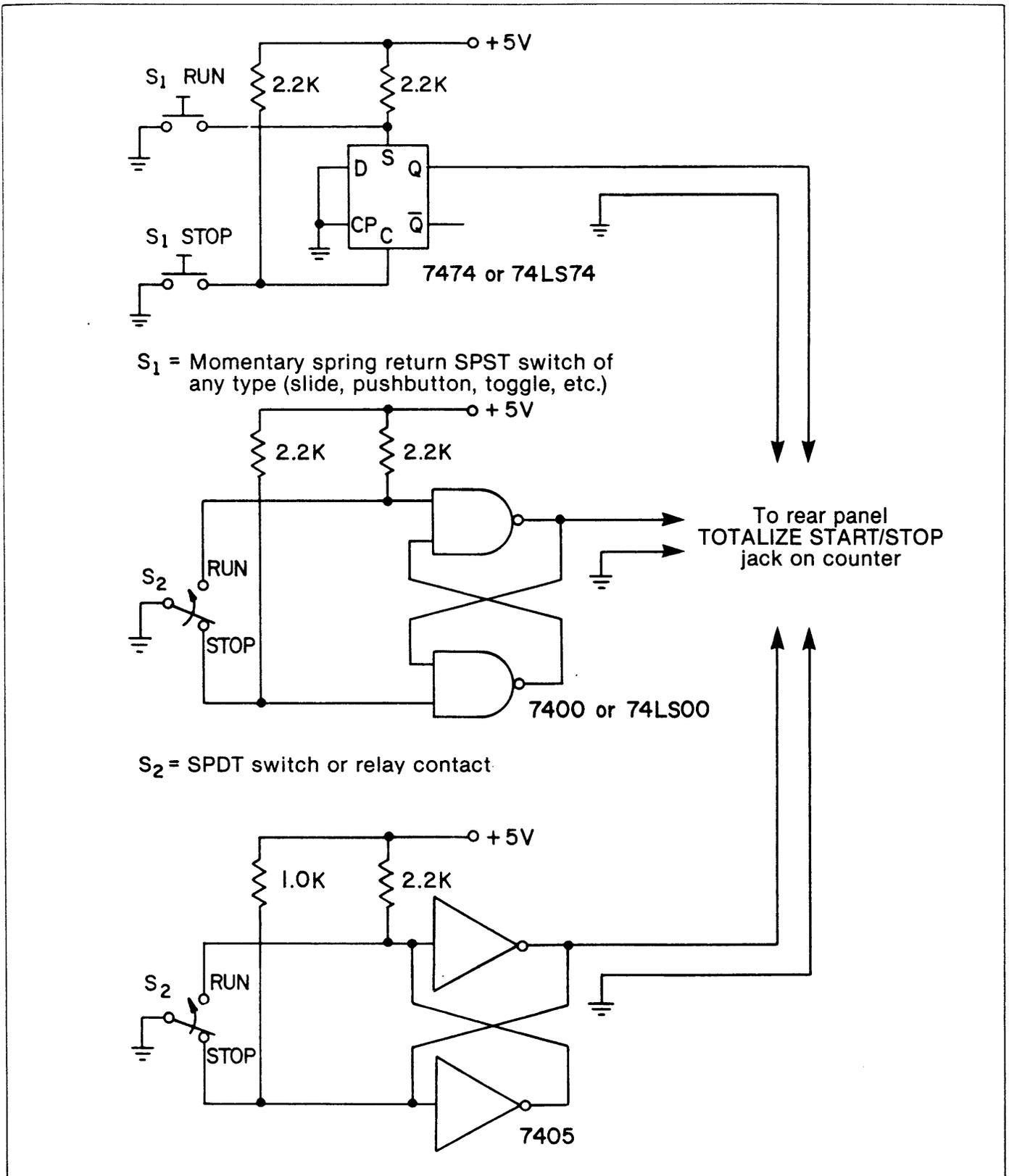
C. CONTACT DEBOUNCING

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.



S_1 = Momentary spring return SPST switch of any type (slide, pushbutton, toggle, etc.)

S_2 = SPDT switch or relay contact

Fig. 15. Debouncing circuits.