SERIAL No. GC812O2E

Global 5002
175MHz Universal Counter
Operator's Manual

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INTRODUCTION

The Global Model 5002 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 5002 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 "onceonly" 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 X 10 attenuators for A channel, 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).

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).
Plastic Case.	Selectable Trigger Slope (Ch. A & Ch. B).
Dual Input.	
CHA. Attenuator	
Soft touch switch (Function & Gate)	

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 ± time base error.
Display:	kHz or MHz with decimal point.

PERIOD A

Range:	0.5 μs to 200,000 μs.
Freq. Range:	5 Hz to 2 MHz sine wave.
Resolution:	100 ps to 100 ns in decade steps.
Accuracy:	±1 count ± time base error ± trigger error[1]
Display:	ms or μs with decimal point.
Minimum Pulse Width:	250 ns.
Average:	1, 10, 100, or 1000 cycles averaged, depending on RESOLUTION setting.

[1] NOTE: Trigger error is typically ±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.

RATIO A/B

Freq. Range A:	5 Hz to 10 MHz sine wave.
Freq. Range B:	5 Hz to 2 MHz sine wave.
Resolution:	$\pm \frac{\text{Freq B}}{\text{Freq A x N}}$ where N = 1, 10, 100, or 1000.
Accuracy:	$\pm$ (Freq B + Freq (A x N)) $\pm \frac{\text{(Freq B x Trigger Error}^1\text{)}}{\text{N}}$
Display:	Numerical ratio with decimal point.

TIME INTERVAL A TO B

Range:	0.5 μs to 200,000 μs.
Freq. Range:	5 Hz to 2 MHz, sine wave.
Resolution:	100 ps to 100 ns in decade steps.
Accuracy:	± 1 count ± time base error ± trigger error[1] ± N, where N = intervals averaged.
Minimum Pulse Interval (A to B):	250 ns.
Display:	msec or μsec with decimal point.
Average:	1, 10, 100, or 1000 intervals averaged.
Single Event Capability:	Pressing RESET primes unit for measurement of "onceonly" event.

TOTALIZE A

Range:	5 Hz to 10 MHz sine wave.
Count Capability:	0 to 99,999,999 before OVER flow.
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 FRE Quency mode:	MHz FRE Quency mode:,
20 mV rms, 5 Hz to 5 MHz.	150mV rms, 150 MHz to 175 MHz
———	100mV rms, 125 MHz to 150 MHz.
———	50 mV rms, 5 MHz to 125 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.
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.
Stability:	±0.1 ppm (±1 Hz).
Line Voltage Stability:	Less than ±1 ppm with ±10% line voltage variation.
Temperature Stability:	Less than ± .001% (±10 ppm) from 0°C to 50°C ambient.
Maximum aging rate:	± 10 ppm/yr.

DISPLAY CHARACTERISTICS

Display:	Eight .43" seven-segment digits with kHz/μSEC, MHz/mSEC, GATE and OVER flow indicators.
OVER flow Indication:	LED indicator lights when count exceeds 99999999 during any selected gate time.
Display Update Time:	1. kHz FRE Quency and SELF TEST modes: userselected 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: userselected 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:	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. 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.
Power Requirements:	115/230 VAC 50/60 Hz; 20 VA (all ±10%) with adapter
Dimensions: (HWD)	6.4 x 24 x 19 (CM)
Weight:	1.17 Kg.

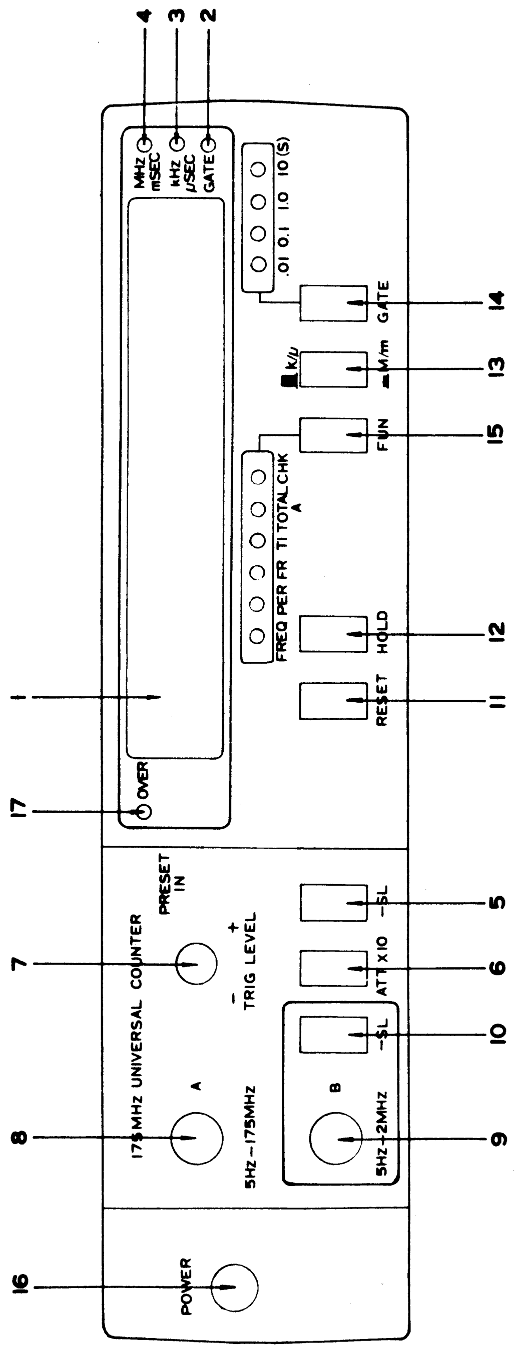


Fig 1. CONTROLS AND INDICATORS

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 take.

3. kHz/μSEC 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 8 apply to Channel A only.

5. -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.

6. 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.

7. 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.

8. Channel A input Jack. Female BNC connector terminated in a 1 megohm input resistance, shunted by < 40 pF capacitance.

Items 9 through 10 apply to Channel B only.

9. Channel B Input Jack. Female BNC connector terminated in a 1 megohm input resistance, shunted by < 40 pF capacitance.

10. -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.

11. RESET Switch. In all modes, pushing this momentary switch resets the counter to zero. When it is released, the measurement starts again.

12. 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 is high (or jack is open).

13. k/μM/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.

14. RESOLUTION Switches. This switch select the degree of display resolution in all modes except TOTALize. In PERiod μSEC and both FREQuency modes.

15. FUNCTION Switch
    Select the desired operating mode.

    1. SELF TEST When this mode is selected, the unit displays the frequency of the internal time base, providing a general check of performance.

    2. TOTALize A Switch. When this mode is engaged, the unit counts cycles of the Chnnnel A input and continuously displays that count. Totalization can be controlled by a gate signal at the rear panel TOTALize START/STOP jack (26).

    3. TI (Time Interval) A → B Switch. When this mode is selected, 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 (5, 10). Display is in μs or ms, as selected by the k/μM/m switch (13), and as indicated by the kHz/μSEC or MHz/mSEC indicators (3,4). Resolution is selected by the RESOLUTION switches (14).

    4. RATIO A/B Switch. When this mode is selected, the unit measures the ratio of the Channel A frequency to the Channel B frequency. Resolution is selected by the RESOLUTION switches (14).

    5. PERiod A Switch. When this mode is selected, the unit displays the period of one cycle of the Channel A signal. Readings are in μs or ms as selected by the k/μ-M/m switch (13), and as indicated by the kHz/μSEC or MHz/mSEC indicators (3, 4). Resolution is selected by the RESOLUTION switches.

    6. FREQuency A Switch. This mode 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 (13), and as indicated by the kHz/μSEC or MHz/mSEC indicators (3, 4). Resolution is selected by the RESOLUTION switches (14).

    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: 50mV rms, 5 MHz to 125 MHz,100 mV rms, 125 MHz to 150 MHz, 150 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.

16. PWR Switch. Turns the unit ON and OFF.

17. OVERflow Indicator. Lights whenever the range of the display is exceeded. One or more most significant digits are not displayed.

18. 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

CAUTION

Before connecting unit to ac power, check adapter label to be certain that the unit is wired correctly for your particular line voltage.

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 (16) to ON (pushed in). If no other front panel buttons have been engaged, the display is blank except for the lit kHz/μSEC 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 X 10 switches (6) 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 (8).
2. Engage the FREQuency A of function switch (15).
3. Select measurement units with the k/μ-M/m switch (13): in for megahertz, out for kilohertz. The kHz/μSEC 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: 50 mV rms, 5 MHz to 125 MHz, 100mV rms, 125 MHz to 150 MHz, 150 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 (14).
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 OVER flow indicator (17) lights whenever the range of the display is exceeded.
7. Engaging the HOLD switch (12) "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 (11) 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. Imput Attenuator. Engaging the Channel A X10 switch (6) 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.
2. Slope Selection. The Channel A -SL (Slope) switch (5) 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.

3. Trigger Level Adjustment. Channel A trigger threshold can be varied by the TRIG LEVEL control (7) 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 (8).
2. Engage the PERiod A of function switch (15).
3. Select measurement units with the k/μ-M/m switch (13): in for milliseconds, out for microse-microseconds. The kHz/μSEC or MHz/mSEC indicator (3, 4) lights accordingly.
4. Select the degree of resolution desired, using the RESOLUTION switches (14). In μSEC 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 OVER flow indicator (17) lights whenever the range of the display is exceeded.
7. Engaging the HOLD switch (12) "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 (11) resets the display tó zero. When RESET is released, a new measurement begins (GATE indicator lights), but the display remains at zero until the new measurement is completed.
9. The Channel A input controls (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 (8, 9).

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

2. Engage the RATIO A/B of function switch (15).

3. Both the kHz/μSEC and MHz/mSEC indicators (3, 4) are off because the reading displayed is a ratio.

4. Select the resolution desired using the RESOLUTION switches (14). 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 (13) 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 OVER flow indicator (17) lights whenever the range of the display is exceeded.

7. Engaging the HOLD switch (12) "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 (11) 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 (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 (trigger slope selector, 10), 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 waverform.

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 (8, 9).

2. Engage the TI A → B of function switch (15) 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 (5, 10). 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 (7) 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/μ-M/m switch (13): 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 switch (14).

   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/μ-M/m switch pushed in). Engaging this switch causes a display of all "eights" and decimal points to appear.

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 (17) lights whenever the range of the display is exceeded.

9. Engaging the HOLD switch (12) "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 (11) 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. When 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.

Input Attenuator. Engaging the Channel A X10 switch attenuates the Channel A signal approximately 10:1 before application to the counter. This helps prevent mis-counting caused by noisy or improperly terminated highamplitude 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 of function switch (15). RESOLUTION (14) and K/μ-M/m (13) 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 (11) 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 (17) 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 (12) 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 (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/μSEC 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 = .0001 μs = .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.

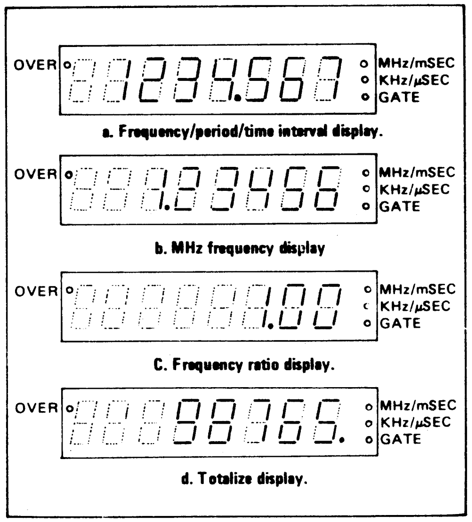


Fig. 2. Samples of various displays.

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.

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
kHz	10 Hz	0.1 second
kHz	1 Hz	1 second
kHz	0.1 Hz	10 seconds
MHz	1K Hz	0.02 second
MHz	100 Hz	0.2 second
MHz	10 Hz	2 seconds
MHz	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
μSEC	.1 μSEC	1
μSEC	.01 μSEC	10
μSEC	.001 μSEC	100
μSEC	.0001 μSEC	1000
mSEC[1]	.0001 mSEC	1
mSEC	.00001 mSEC	10
mSEC	.000001mSEC	100

[1] mSEC 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:

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

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 MΩ) and input capacitance (40 pF max) are independent of the X10 switches. To decrease loading, a high-impedance oscilloscope probe may be used:

Use the probe in the X10 position whenever possible for less circuit loading.

Note: when using a 10:1 probe 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 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 shount 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 TI) and negative slope for Channel B (measurement finishes at end of TI). After this reading is taken, the period is measured, (preferably by using PERiod mode; see next paragraph), and the duty cycle is obtained as follows:

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

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.

OPERATING INSTRUCTIONS

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 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.

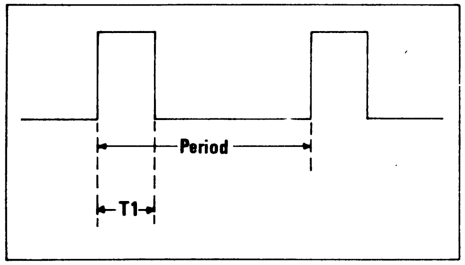


Fig. 3. Duty cycle measurement.

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.

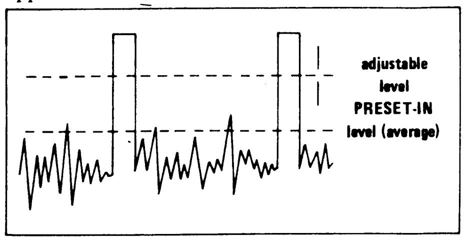


Fig. 4. Example of trigger level variation.

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 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.

1. Engage the SELF TEST of function switch (14). This connects the counter input internally to the time base oscillator.

2. With the k/μ-M/m switch (13) 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, OVER flow lit	10 seconds

[1] GATE 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

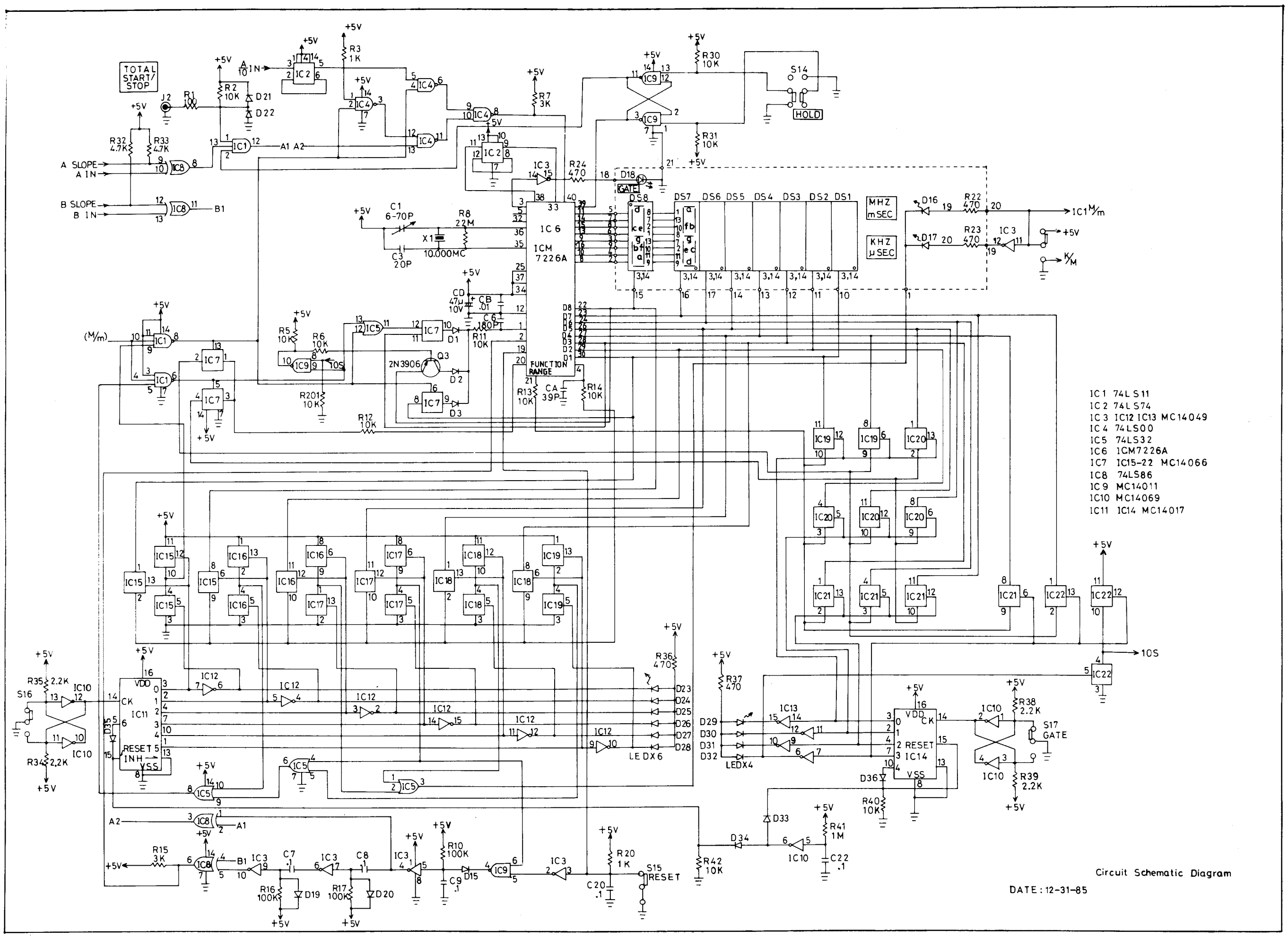
[1] In SELF TEST mode these three RESOLUTION settings give resolutions of 100 Hz, 10 Hz, and 1 Hz, respectively.

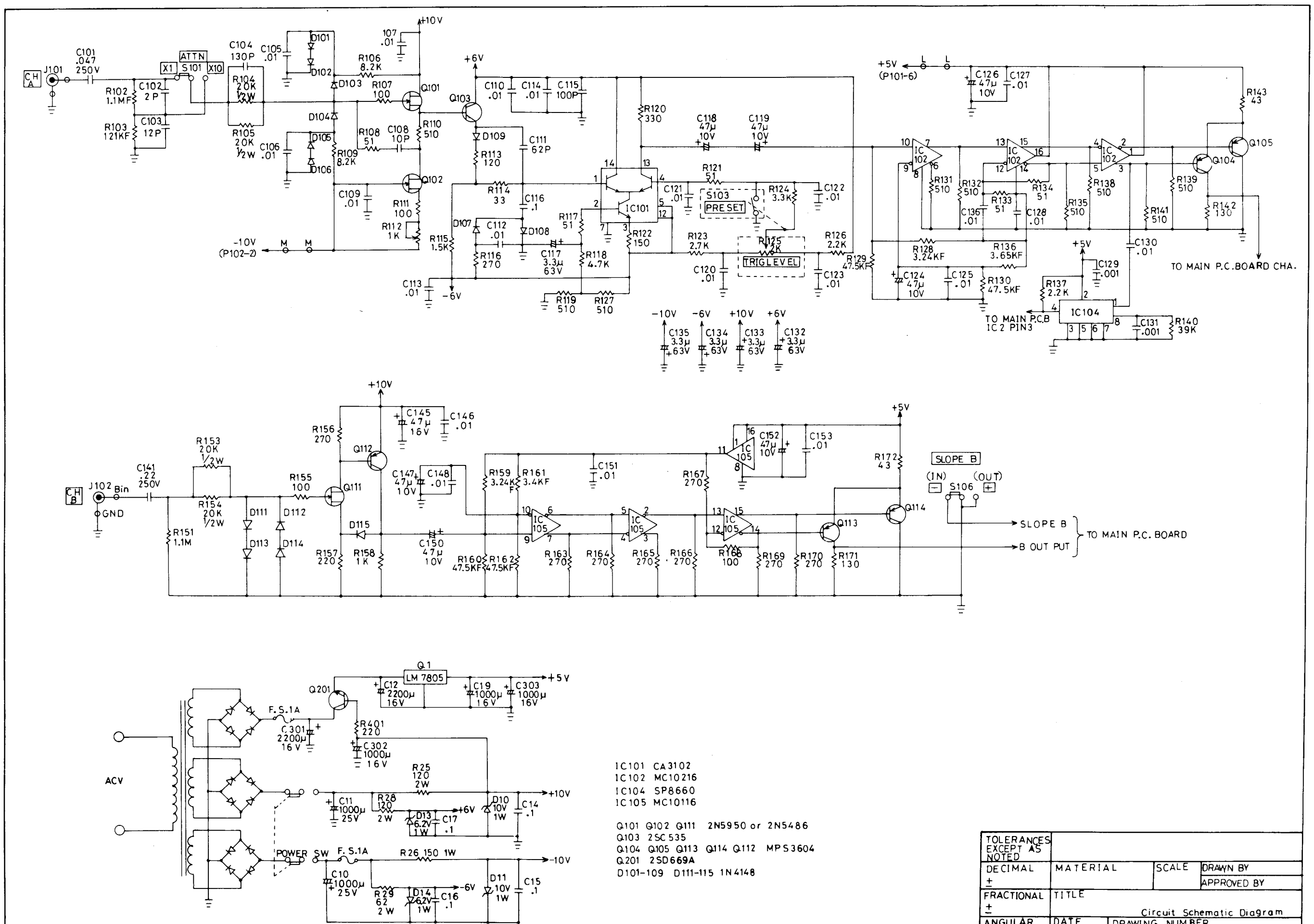
[2] GATE indicator lights during this interval; time between measurements is 200 ms.

4. With the k/μ-M/m still set to M/m, engage the .1/1/.0001 RESOLUTION switch. The display should read "88.8.8.8.8.8.8", 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.


TOTAL START/ STOP
A SLOPE
A IN
B SLOPE
B IN
ICM 7226A
10.000MC
FUNCTION RANGE
MHZ mSEC
KHZ μSEC
HOLD
RESET
GATE
LEDX6
LEDX4
IC1 74LS11
IC2 74LS74
IC3 IC12 IC13 MC14049
IC4 74LS00
IC5 74LS32
IC6 ICM7226A
IC7 IC15-22 MC14066
IC8 74LS86
IC9 MC14011
IC10 MC14069
IC11 IC14 MC14017
Circuit Schematic Diagram
DATE: 12-31-85


CH A
ATTN
PRESET
TRIG LEVEL
TO MAIN P.C. BOARD CHA.
TO MAIN P.C.B IC2 PIN3
CH B
SLOPE B
(IN) (OUT)
SLOPE B
B OUT PUT
TO MAIN P.C. BOARD
LM 7805
ACV
POWER SW
IC101 CA3102
IC102 MC10216
IC104 SP8660
IC105 MC10116
Q101 Q102 Q111 2N5950 or 2N5486
Q103 2SC535
Q104 Q105 Q113 Q114 Q112 MPS3604
Q201 2SD669A
D101-109 D111-115 1N4148
TOLERANCES EXCEPT AS NOTED
DECIMAL ±
FRACTIONAL ±
ANGULAR ±
MATERIAL
SCALE
DRAWN BY
APPROVED BY
TITLE
Circuit Schematic Diagram
DATE 12-31-85
DRAWING NUMBER