HIOKI

3601 UNIVERSAL COUNTER

INSTRUCTION MANUAL

PREFACE

We would like to express our appreciation for your purchase of the Hioki 3601 Universal Counter. To ensure that you get the most out of your new 3601, we recommend that you read this manual carefully before use.

Table of Contents

1. GENERAL

The 3601 is a multifunction universal counter that provides a wide range of functions at a reasonable price. Features include:

- Three types of frequency measurement--prescaled counting, direct counting, and reciprocal--permitting selection of the optimum measurement function for the frequency under measurement.

- Automatic switching of the B input (to COM. A), and selection of the trigger slope and other parameters according to the measurement function, which greatly simplifies setup for pulse width and duty cycle measurements.

- An averaging function that improves measurement resolution and stability by repeating the measurement within a designated time (0.1s, 1s, or 10s) and performing statistical processing.

- A difference function that calculates the difference from a base value, so that changes can be read directly.

- Simultaneous measurement and calculation of period and pulse width, so that single pulses can be measured, plus a duty ratio measurement function with reduced measurement error.

- An rpm measurement function that displays the rpm value of the input frequency.

- A masking function that masks the stop-trigger for an appropriate time interval, so that signals including noise or chattering from mechanical switches can be measured.

- A power supply circuit that runs on 85V to 250V, with no need for switching according to the line voltage.

- An optional GP-IB unit for use in measurement systems and automated measurement.

2. SPECIFICATIONS

2.1 Electrical Specifications

Frequency Measurement	INPUT A prescale FREQ Apre
Measurement range	2MHz to 160MHz
Gate time	1ms, 10ms, 0.1s, 1s, 10s
Unit display	MHz
Measurement accuracy	±1 count ± timebase accuracy
Frequency Measurement	INPUT A FREQ A
Measurement range	10Hz to 20MHz
Gate time	1ms, 10ms, 0.1s, 1s, 10s
Units display	Hz, kHz, MHz
Measurement accuracy	±1 count ± timebase accuracy
Frequency Measurement	INPUT B(A) FREQ B(A)
Measurement range	1mHz to 20MHz
Gate time	
1ms	100Hz or greater: 1ms to 10ms Less than 100Hz: One period of the input frequency Four or more digits displayed
10ms	10Hz or greater: 10ms to 100ms Less than 10Hz: One period of the input frequency Five or more digits displayed
0.1s	1Hz or greater: 0.1s to 1s

	Less than 1Hz: One period of the input frequency Six or more digits displayed
1s	0.1Hz or greater: 1s to 10s Less than 0.1Hz: One period of the input frequency Seven or more digits displayed
10s	10mHz or greater: 10s to 100s Less than 10mHz: One period of the input frequency
Units display	mHz, Hz, kHz, MHz
Measurement accuracy	$\pm$(trigger error/measured frequency · gate time) $\pm$1 count $\pm$ timebase accuracy
Period Measurement	INPUT B(A) PERIOD B(A)
Measurement range	50ns to 999.99999s
Multiplier	10^0, 10^1, 10^2, 10^3, 10^4
Time unit	100ns
Units display	ns, µs, ms, s
Measurement accuracy	$\pm$(trigger error/multiplier) $\pm$1count $\pm$ timebase accuracy
Frequency Ratio Measurement	INPUT A, B RATIO A/B
Measurement range	DC to 20MHz
Multiplier	10^0 Display: 1 to 99999999 10^1 Display: 0.1 to 99999999 10^2 Display: 0.01 to 99999999 10^3 Display: 0.001 to 9999999.9 10^4 Display: 0.0001 to 999999.99

Measurement accuracy	±(B input trigger error/ multiplier) ±1count ± A input accuracy
Time Interval Measurement	INPUT A, B T. I. A B
Measurement range	100ns to 999.99999s
Multiplier	10^0, 10^1, 10^2, 10^3, 10^4
Time unit	100ns
Units display	μs, ms, s
Measurement accuracy	± (Trigger error/N) ±1 count ± timebase accuracy N: Square root of the multiplier, but 1 for an extremely stable signal synchronized with the timebase
Pulse Width Measurement	INPUT A P.W. A
Measurement range	100ns to 999.99999s
Multiplier	10^0, 10^1, 10^2, 10^3, 10^4
Time unit	100ns
Units display	μs, ms, s
Measurement accuracy	± (Trigger error/N) ± 1 count ± timebase accuracy N: Square root of the multiplier, but 1 for an extremely stable signal synchronized with the timebase
Duty Cycle Measurement	INPUT A DUTY A
Measurement range	1mHz to 1MHz
Multiplier	10^0, 10^1, 10^2, 10^3, 10^4
Time unit	100ns
Units display	None (% display instead)

Measurement accuracy	± (Trigger error/N) ±1 count ± arithmetic error N: Square root of the multiplier, but 1 for an extremely stable signal synchronized with the timebase Arithmetic error: 1
Totalization	INPUT B TOT. B
Maximum counting frequency	20MHz
Maximum display	99999999
RPM Measurement	INPUT B rpm B
Measurement range	0.06 to 60000000rpm
Gate time	1ms, 10ms, 0.1s, 10s (or until the next input, if the above times are exceeded)

Input Specifications

INPUT A and INPUT B

Input sensitivity	25mVrms: DC to 20MHz;10MHz to 150MHz (prescaled) 50mVrms: 2MHz to 10MHz (prescaled); 150MHz to 160MHz (prescaled)
Sensitivity ranges	x1, x10, x100
Input voltage	25mVrms to 1Vrms
Damage threshold	200V (DC + AC peak)
Input coupling modes	DC, AC, AUTO (AC)
Input impedance	Approx. 1M paralleled by 30pF
Trigger level	DC or AC mode: Approx. -1V to 1V. Triggering may be repeated.

	AUTO mode: Automatically set to approximately half the input signal peak value
Trigger slope	Positive or negative (switchable)
Masking	Approx. 100µs to 100ms (INPUT B)
High-frequency noise rejection	Approx. 100kHz lowpass filter
Timebase	
Internal timebase frequency	10MHz
Temperature characteristic	$\pm 3 \times 10^{-6}$ (0°C to 40°C)
Aging rate	$\pm 1 \times 10^{-6}$ per year
Internal timebase output voltage	Approx. $2V_{p-p}$ (Output impedance approx. 100 Ω)
External Timebase Input	
Input frequency	10MHz
Input voltage	$1V_{p-p}$ to $10V_{p-p}$

2.2 General Specifications

Display	8-digit
Display device	7-segment LEDs
Arithmetic functions	
Difference (DIFF)	The value when the DIFF key is pressed becomes the base value. Thereafter the measured value minus the base value is displayed.
Average (AV)	o When the gate selection is 10^2, 10^3 or 10^4, measurements are aver-

	aged for 0.1s, 1s or 10s, respectively, and the result is displayed. (Frequency Ratio, period, time internal, pulse width, duty cycle)
Hold	The next sample after the HOLD key is pressed is held.
Sample rate	40ms or less, or hold
Operating temperature and humidity	0°C to +40°C, max. 85% RH (No condensation)
Storage temperature and humidity	-20°C to +70°C, max. 90% RH (No condensation)
Line voltage	85V to 250V, no switching required
Line frequency	47Hz to 66Hz
Power consumption	25VA max.
Outside dimensions	Approx. 92(H) x 217(W) x 255(D)mm excluding handle and knobs.
Weight	Approx. 2.2kg

2.3 Options and Accessories

2.3.1 GP-IB Option (3601, with 9505)

Specifications	Conforms to IEEE 488-1978 standard
Interface functions	o Source-acceptor handshaking o Talker/listener o Service request, serial poll

	o Remote/local o Device clear, device trigger
Code	ASCII

Remote Programmable Functions

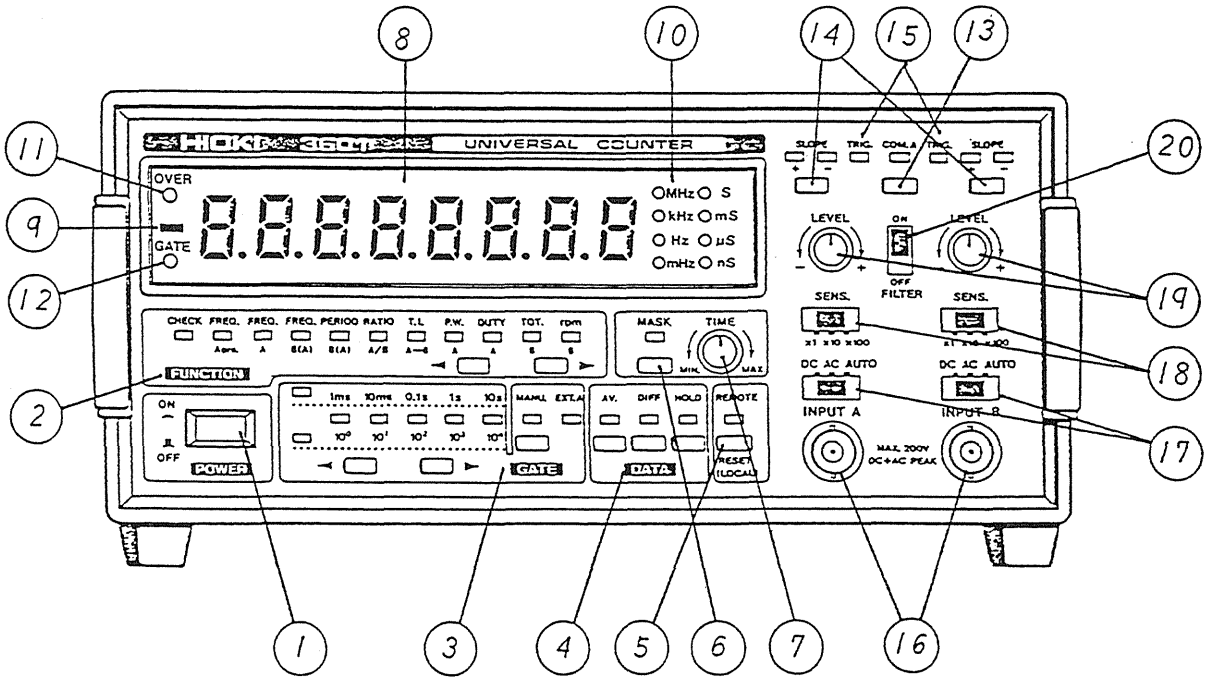
Functions	Gate time or count
Trigger slope	COM. A
Average	DIFF calculation
Hold	Masking
Manual gate	

2.3.2 Accessories

Power cable	1
Input cables	
(BNC-BNC)	1
(BNC-alligator clip)	1
Fuse	1
Instruction manual	1

3. DESCRIPTION OF PARTS

3.1 Front Panel



1 POWER

Power switch. When turned ON, the 3601 is powered and ready for measurement.

2 FUNCTION

A lamp lights to indicate the selected function. The two selector keys change the selection.

3 GATE

Press the selector keys to select the gate time, multiplier, or totalization time.

4 DATA

These keys select the average, difference, and hold functions.

5 RESET (LOCAL)

Initializes the measurement conditions. If the REMOTE lamp is lighted to indicate that the 3601 is under GP-IB control, pressing the RESET (LOCAL) switch returns the 3601 to local control and initializes the measurement conditions.

6 MASK

When the lamp is on, the signal under measurement is masked.

7 TIME

This rotary control sets the masking time. The masking time is displayed when the MASK key is pressed in the CHECK mode.

8 Measurement Display

The measurement value is displayed on an 8-digit LED display.

9 Minus Sign Display

The minus sign is displayed in difference measurement.

10 Units Display

The measurement unit is displayed.

11 OVER

This lamp lights when the capacity of the counter is exceeded.

12 GATE

This lamp lights when the gate is open and the counter is counting.

13 COM. A

This control enables frequency B and period measurement to be performed with input still connected to INPUT A. Waveshaping is performed, so the input impedance does not change.

14 SLOPE

These controls select triggering on the positive (+) or negative (-) slope.

15 TRIG

These lamps indicate when the input wave-shaping trigger is active.

16 INPUT

These are the input terminals of signal.(BNC)

17 AC DC AUTO

These switches select the input coupling.

18 SENS.

These switches select the input sensitivity.

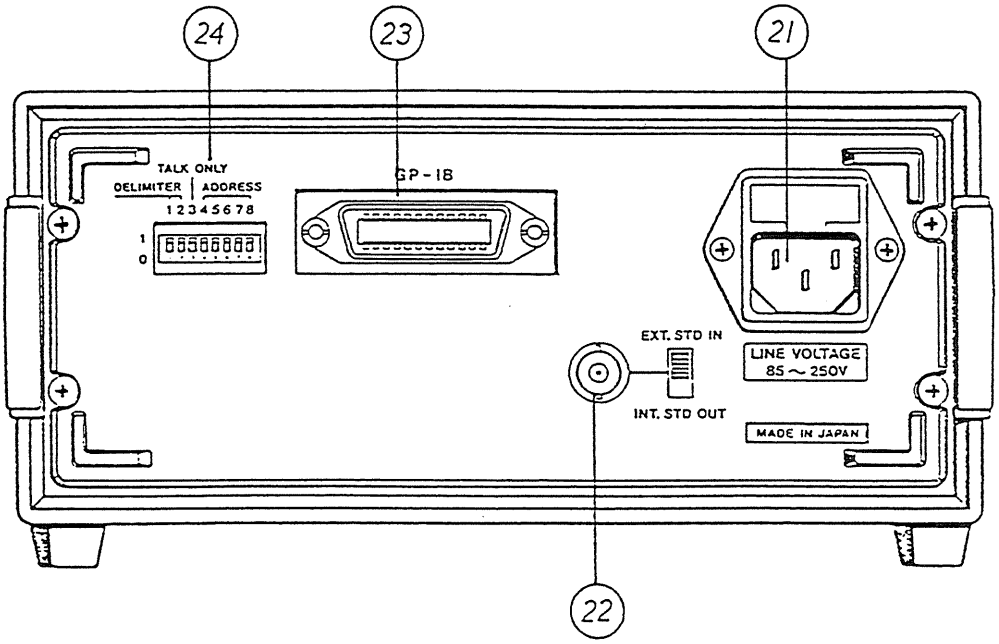
19 LEVEL

These switches select the input signal trigger voltage.

20 FILTER

This control routes the input through an approximate 100kHz lowpass filter.

3.2 Rear Panel



21 Power Cable Inlet

22 When switched to EXT. STD IN, this connector is for external timebase input.
When switched to INT. STD OUT, this connector is for internal timebase output.

23 GP-IB (Option) Connector

24 GP-IB (Option) Address Switches

4. OPERATING PROCEDURES

4.1 General Precautions

4.1.1 Power

The 3601 operates on line voltages from 85V to 250V (47Hz to 66Hz). Use a power supply within this range.

4.1.2 Ambient Conditions

The 3601 should be used in an ambient temperature of 0°C to 40°C and relative humidity of 85% maximum. Avoid using it in locations where it is exposed to direct sunlight, dust, vibration or corrosive fumes.

4.1.3 Impact

The 3601 contains a crystal oscillator. Handle it carefully to avoid strong impact.

4.1.4 Warmup Time

All functions are operative as soon as power is switched on, but the timebase frequency may drift slightly, so a warmup time of at least 30 minutes is recommended.

4.1.5 Input

The input circuit of the 3601 is not floating, so pay attention to the grounding of the equipment under measurement.

The damage thresholds of the A and B inputs are both 200V (DC + AC peak). Do not input higher voltages.

4.2 Preparations

(1) Use the accessory power cable to connect the 3601 to a power outlet.

(2) Turn the POWER switch ON and check that all lamps except the GATE and TRIG. lamps come on.

(3) Next set the front panel to the following initial conditions.

FUNCTION	CHECK
GATE	1s
SLOPE A	+
SLOPE B	-
All other controls	OFF

The display should indicate the internal timebase frequency of 10.0000000MHz.

If Err is indicated, the 3601 is set to external timebase input but no external timebase is connected. Set the switch on the rear panel to INT. STD OUT, or leave it set to EXT. STD IN and check the external clock signal generator connected to the input connector.

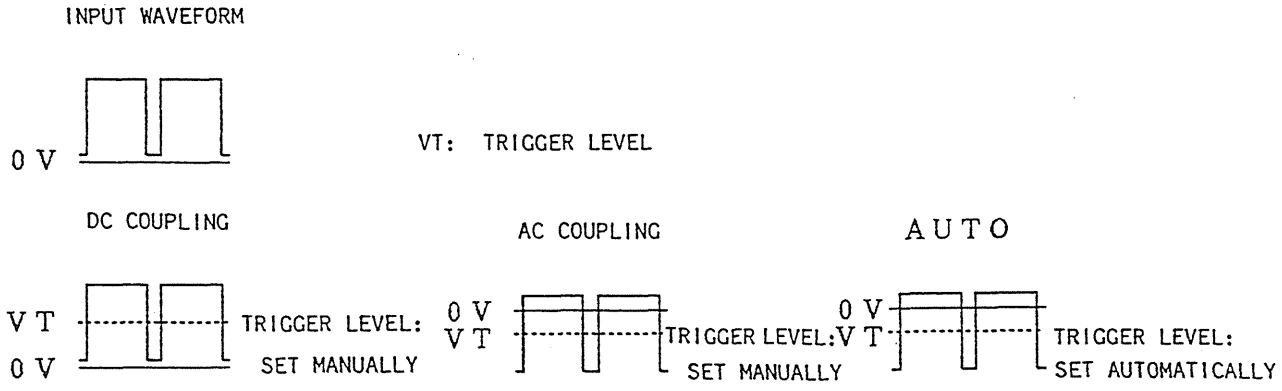
4.3 Input Settings

4.3.1 Input Coupling: DC, AC, AUTO

DC The 3601 is set for DC coupling. This coupling is used mainly for signals with frequencies below 10Hz, and with the time interval (T.I.), pulse width (P.W.), and duty cycle (DUTY) functions.

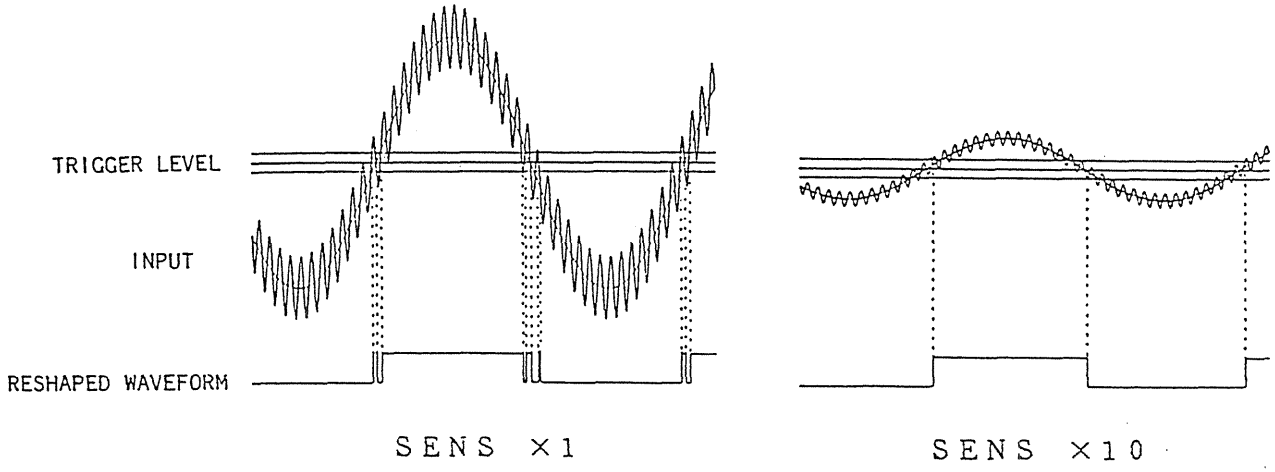
AC The 3601 is set for AC coupling with the DC component removed. This coupling is used mainly for signals with frequencies above 10Hz, or for signals with DC components.

AUTO The 3601 is set for AC coupling, with the trigger level set at approximately half the peak-to-peak input voltage. This coupling is used in normal frequency measurement at 10Hz and above.



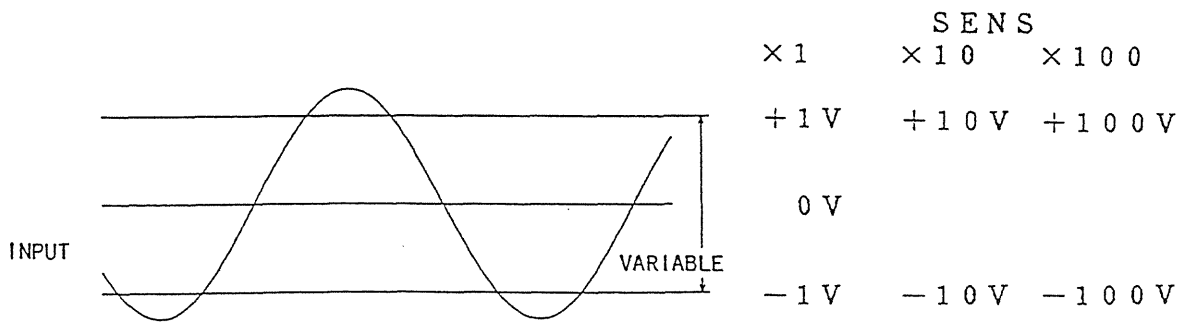
4.3.2 SENS. (Sensitivity)

This switch is used to adjust so that the input signal level is above the sensitivity threshold but below the maximum input voltage. If the sensitivity is set incorrectly, the trigger may fail to be activated (if the sensitivity voltage is too high), or false counts may be produced (if the input is higher than the maximum input voltage). Sensitivity also applies to any noise components present in the input signal, so this control can be used to reject noise.



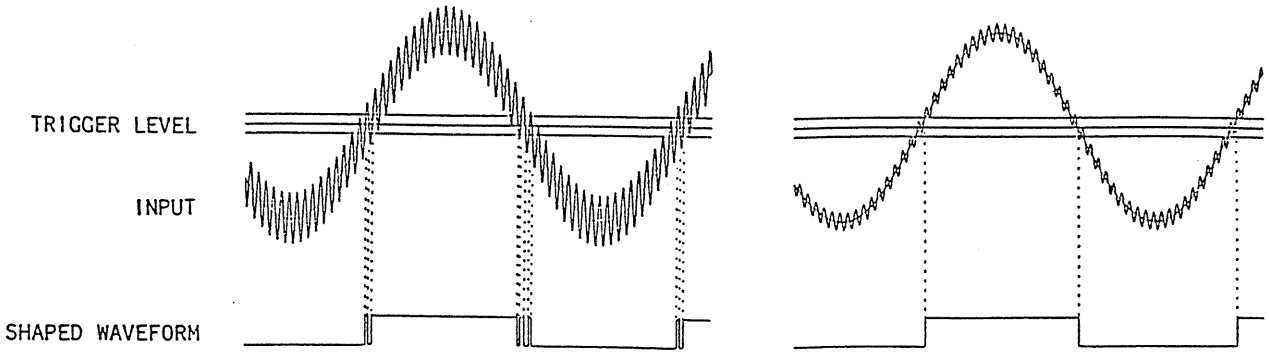
4.3.3 LEVEL (Trigger Level)

The trigger level may be set from approximately +1V to -1V. In the x10 sensitivity (SENS.) range this becomes approximately +10V to -10V, and in the x100 sensitivity range it becomes +100V to -100V. If AUTO input coupling is selected, the trigger level setting is disregarded, and the trigger is automatically set to approximately half the input level.



4.3.4 FILTER

This control switches on an approximately 100kHz lowpass filter. Use it to remove high-frequency noise from the input signal.



FILTER OFF FILTER ON

4.3.5 COM. A (Common A)

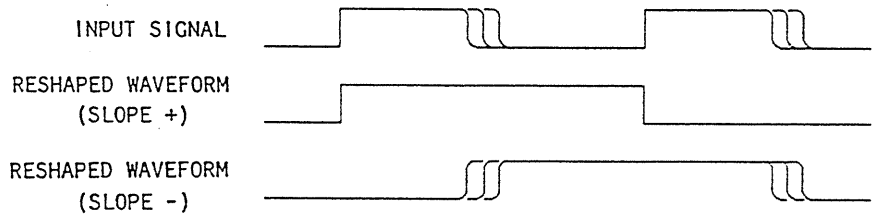
Although there are separate input connectors for input A and input B, the A connector can be used for B input by pressing the COM. A switch to the ON position. The slope of this common input is set by the B control, but sensitivity and level are set by the A controls.

The COM. A switch is operative in the frequency B and period measurement function modes. Common input is used automatically in the pulse width (P.W.) and duty cycle (DUTY) modes, although the COM. A lamp does not light.

4.3.6 SLOPE

This control selects whether to trigger on the rising edge (+) or falling edge (-). In the pulse width (P.W.) and duty ratio (DUTY) modes, the positive trigger slope is automatically selected for positive-going pulses, and the negative trigger slope for negative-going pulses.

This control is normally not used in frequency and period measurement, but when the signal includes jitter, selection of the proper slope can stabilize the measurement.



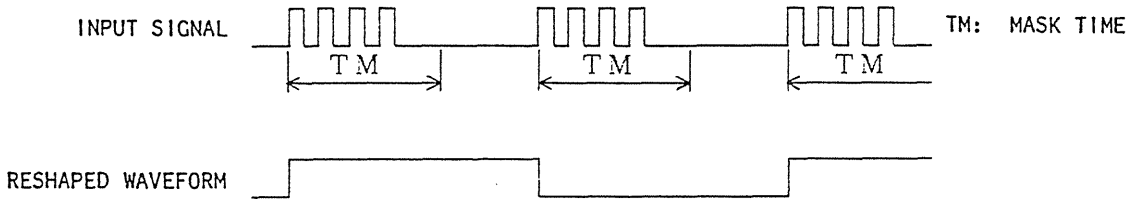
4.3.7 MASK (Stop Trigger Mask)

When this control is on, stop-trigger events are ignored for a certain time (the mask time) after each start-trigger event. The measurement gate is closed by the first stop-trigger event after the mask time.

The function may be used to measure signals that include relay chattering or noise.

It is operable in the frequency B, frequency ratio (RATIO), and time interval (T.I.) measurement modes, and in the totalization (TOT.) mode with B input.

The mask time can be read by turning the mask switch on in the CHECK mode.



4.4 Measurement Functions

4.4.1 Frequency Measurement

(a) FREQ. Apre. (2MHz to 160MHz)

The input frequency is divided by 10 and counted directly. Compared with direct counting, one digit of resolution is lost. Although frequencies from 2MHz to 160MHz can be measured in this way, frequencies up to 20MHz should be measured by direct counting, to avoid loss of resolution.

Procedure

(1) Prepare for measurement (see Section 4.2).

(2) Select the FREQ. Apre. function.

(3) Set the input section according to the input signal. (See Section 4.3.) The LEVEL control is inoperative, so set the input coupling to AUTO. Check that the filter switch is OFF.

(4) Connect the input to INPUT A.

(5) Check that the trigger (TRIG.) lamp is on. If it is not on, check the input settings, particularly the sensitivity (SENS.) setting.

(6) Set an appropriate GATE time (the optimum time for the measurement).

(7) Measurement now begins.

(b) FREQ. A (10Hz to 20MHz)

The input signal is converted to a series of pulses, which are counted for a precise interval of time (the gate time). The result is converted to a frequency and displayed. The higher the frequency is, the higher the resolution is, but counting capacity is limited. The 3601 has the highest resolution in the range from 1MHz to 20MHz.

Procedure

(1) Prepare for measurement (see Section 4.2).

(2) Select the FREQ. A function.

(3) Set the input section according to the input signal (see Section 4.3).

(4) Connect the input to INPUT A.

(5) Check that the trigger (TRIG.) lamp is on. If it is not on, check the input settings, particularly the sensitivity (SENS.) and the LEVEL settings.

(6) Set an appropriate GATE time (the optimum time for the measurement).

(7) Measurement now begins.

(c) FREQ. B (1mHz to 20MHz)

The period is measured, and the reciprocal is calculated and displayed as the frequency value. With direct counting, the resolution for a 1s gate time is 1Hz, but the reciprocal method provides a 7-digit display at 1s gate time, because the 3601 contains a 10MHz

internal timebase. The reciprocal method should be used to obtain high resolution at low frequencies. The highest resolution is obtained at frequencies below 10MHz.

The measurement is started and stopped by the input signal, so even if the signal period is longer than the gate time, the measurement does not end at the gate time. Measurement continues until the next signal is input.

Procedure

(1) Prepare for measurement (see Section 4.2).

(2) Select the FREQ. B function.

(3) Set the input section according to the input signal (see Section 4.3).

(4) Connect the input to INPUT B, or connect the input to INPUT A and turn on the COM. A switch (see Section 4.3.5).

(5) Check that the trigger (TRIG.) lamp is on. If it is not on, check the input settings, particularly the sensitivity (SENS.) and LEVEL settings.

(6) Set an appropriate GATE time (the optimum time for the measurement).

(7) Measurement begins when triggered by the input signal.

4.4.2 Period Measurement (50ns to 999.99999s)

At the first input pulse, the gate opens and counting of timebase clock pulses begins. The gate remains open for the number of input pulses set by the GATE control, then closes. The timebase count at this instant is converted to a time value and displayed.

If averaging is selected, when the gate closes, if the averaging time has not been reached, the measurement is performed again. The measurement is repeated until the averaging time is reached or passed, and the average of the measured values is calculated and displayed. The gate multiplier selection takes priority over the averaging time. For example, if a signal with a

period of 10ms is measured with a gate multiplier selection of 10^3 and hence averaging time of 1s, the measurement will take 10s. The averaging function can be used advantageously to measure high-frequency input signals.

Procedure

(1) Prepare for measurement (see Section 4.2).

(2) Select the PERIOD function.

(3) Set the input section according to the input signal (see Section 4.3).

(4) Connect the input to INPUT B, or connect it to INPUT A and turn the COM. A switch on (see Section 4.3.5).

(5) Check that the trigger (TRIG.) lamp is on. If it is not on, check the input settings, particularly the sensitivity (SENS.) and LEVEL settings.

(6) Set an appropriate GATE multiplier (the optimum multiplier for the measurement).

(7) Measurement begins when triggered by the input signal.

4.4.3 Frequency Ratio Measurement (1mHz to 20MHz)

The gate for counting input A is triggered by input B. The gate remains open for the number of input B pulses set by the GATE control, then closes. The ratio of A pulses to B pulses at this instant is calculated and displayed.

If averaging is selected, the same averaging procedure as for period measurement is applied to the B input. Averaging can be used advantageously when the B input frequency is high.

Procedure

(1) Prepare for measurement (see Section 4.2).

(2) Select the RATIO function.

(3) Set the input section according to the input signal (see Section 4.3).

(4) Connect the dividend signal to INPUT A and the divisor signal to INPUT B. COM. A cannot be used.

(5) Check that the trigger (TRIG.) lamp is on. If it is not, check the input settings, particularly the sensitivity (SENS.) and LEVEL settings.

(6) Set an appropriate GATE multiplier (the optimum multiplier for the measurement).

(7) Measurement begins when triggered by the input signal.

4.4.4 Time Interval Measurement (100ns to 999.99999s)

The gate for counting timebase clock signals is opened by input A and closed by input B. The gate open-close cycle is repeated the number of times set by the GATE control, then the count is converted to a time value and displayed.

If averaging is selected, the above procedure is repeated until the averaging time is reached or exceeded. (Example: 10^3 gate multiplier measurement is repeated for 1s.) Statistical processing is performed to determine the resolution and display the result. Averaging may or may not improve the resolution.

Procedure

(1) Prepare for measurement (see Section 4.2).

(2) Select the time interval (T.I.) function.

(3) Set the input section according to the input signal (see Section 4.3).

(4) Connect the start signal to INPUT A and the stop signal to INPUT B. COM. A cannot be used.

(5) Check that the trigger (TRIG.) lamp is on. If it is not on, check the input settings, particularly the sensitivity (SENS.) and LEVEL settings.

(6) Set an appropriate GATE multiplier (the optimum multiplier for the measurement).

(7) Measurement begins when triggered by the input signal.

Note:

There is a dead time of 50ns from when the start signal is input until the stop signal is input.

4.4.5 Pulse Width Measurement (100ns to 999.99999s)

The gate for counting timebase clock pulse opens on the positive-going edge of the input A signal, and closes on the negative-going edge. This open-close cycle is repeated the number of times set by the GATE control, and the result is converted to a time value and displayed. If the A SLOPE control is set to negative (-), the gate opens on the negative-going edge and closes on the positive-going edge, so that negative-going pulses can be measured.

If averaging is selected, it is performed in the same way as in time interval measurement. Averaging can be used advantageously to measure high-frequency input signals.

Procedure

(1) Prepare for measurement (see Section 4.2).

(2) Select the pulse width (P.W.) function.

(3) Set the input section according to the input signal (see Section 4.3).

(4) Connect the input to INPUT A.

(5) Check that the trigger (TRIG.) lamp is on. if it is not on, check the input settings, particularly the sensitivity (SENS.) and LEVEL settings.

(6) Set an appropriate GATE multiplier (the optimum multiplier for the measurement).

(7) Measurement begins when triggered by the input signal.

4.4.6 Duty Cycle Measurement (1mHz to 1MHz)

The gate is triggered by the input signal. Internal counter A counts timebase pulses to measure the signal pulse width, and internal counter B counts timebase pulses to measure the signal period. The gate closes when the number of signals set by the GATE control have been input, and the ratio of the A and B counts is calculated and converted to a percent value and displayed. (The % unit is not displayed.) If the A SLOPE control is set to negative (-), the duty ratio of negative-going pulses can be measured.

If averaging is selected, it is performed in the same way as in time interval measurement. Averaging can be used advantageously to measure high-frequency input signals.

Procedure

(1) Prepare for measurement (see Section 4.2).

(2) Select the DUTY function.

(3) Set the input section according to the input signal (see Section 4.3).

(4) Connect the input to INPUT A.

(5) Check that the trigger (TRIG.) lamp is on. If it is not on, check the input settings, particularly the sensitivity (SENS.) and LEVEL settings.

(6) Set an appropriate GATE (the optimum multiplier for the measurement).

(7) Measurement begins when triggered by the input signal.

4.4.7 Totalization (DC to 20MHz)

(a) Manual Gate

Press the gate switch marked MANU. The GATE lamp lights and input B signals are counted. The MANU. switch is a momentary switch.

Procedure

(1) Prepare for measurement (see Section 4.2).

(2) Select the totalization (TOT.) function.

(3) Set the input section according to the input signal (see Section 4.3).

(4) Connect the input to INPUT B.

(5) Check that the trigger (TRIG.) lamp is on. If it is not on, check the input settings, particularly the sensitivity (SENS.) and LEVEL settings.

(6) Press the MANU. switch. The GATE lamp lights, the gate opens, and counting is enabled. Signals input from this point onward are counted.

(7) To close the gate, press the MANU. switch again. Closing the gate does not clear the counter, so if the switch is pressed again to reopen the gate, the count resumes from the previous value.

(8) To clear the counter, press the RESET switch.

(b) External Gate (DC to 20MHz)

The gate for counting the B input is controlled by the A input. If the A SLOPE control is set to positive (+), the gate opens on the positive-going edge and closes on the negative-going edge of the A signal.

Procedure

(1) Prepare for measurement (see Section 4.2).

(2) Select the totalization (TOT.) function.

(3) Press the EXT. A gate switch.

(4) Connect the input to INPUT B, and the gate signal to INPUT A.

(5) The gate opens on a positive-going pulse if A SLOPE is positive (+), and on a negative-going pulse if A SLOPE is negative (-).

(6) Check that the trigger (TRIG.) lamp is on. If it is not on, check the input settings, particularly the sensitivity (SENS.) and LEVEL settings.

(7) The measurement is performed with the gate controlled by the input A signal.

(8) To clear the counter, press the RESET switch.

4.4.8 Rpm (0.06 to 60,000,000rpm)

The frequency of the input B signal is measured, converted to an rpm value, and displayed.

Procedure

(1) Prepare for measurement (see Section 4.2).

(2) Select the rpm function.

(3) Set the input section according to the input signal (see Section 4.3).

(4) Connect the input to INPUT B.

(5) Check that the trigger (TRIG.) lamp is on. If it is not on, check the input settings, particularly the sensitivity (SENS.) and LEVEL settings.

(6) Set an appropriate GATE time (the optimum time for the measurement).

(7) Measurement begins when triggered by the input signal.

4.5 Data Functions

4.5.1 Averaging (AV.)

The measurement is repeated for the time corresponding to the gate multiplier selection (example: 1s if the gate multiplier selection is 10^3), and statistical processing is performed on the data for this period to determine the resolution and display the result. The gate multipliers and corresponding measurement times

for which averaging can be selected are 10^2 and 0.1s, 10^3 and 1s, and 10^4 and 10s.

Averaging can be selected for period, ratio, time interval (T.I.), pulse width (P.W.) and duty ratio (DUTY) measurements.

The averaging mode can be selected both to improve the resolution and to obtain easier readout.

When the AV. switch is pressed, the lamp lights and the averaging mode is entered. The averaging mode is discontinued when the AV. switch is pressed again.

4.5.2 Difference (DIFF)

The value at the instant the DIFF switch is pressed to turn the difference function on is subtracted from the subsequent measurement results, and the difference is displayed. The difference data function is operable in all measurement functions except totalization (TOT.).

To exit from the difference mode, press the DIFF switch again. The lamp will go off.

4.5.3 Hold (HOLD)

After the HOLD switch is pressed, the measurement is performed just once and the result is held. In the hold state, the RESET switch can be pressed to repeat the measurement, holding the new result each time.

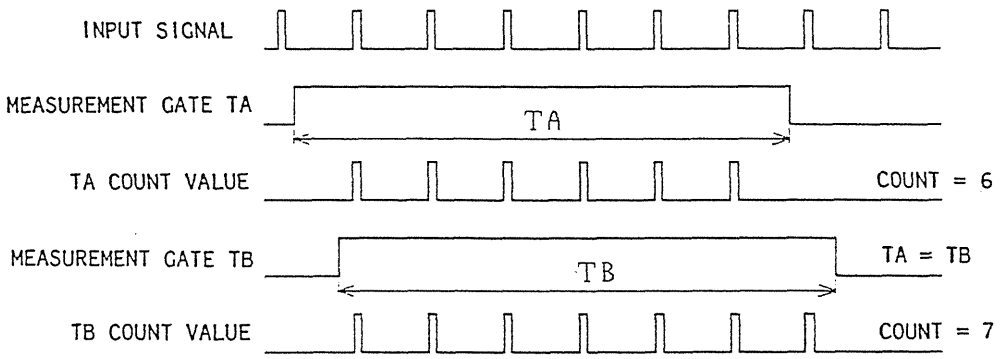
To exit from the hold state and resume normal measurement, press the HOLD switch again. The HOLD lamp will go off.

4.6 Accuracy

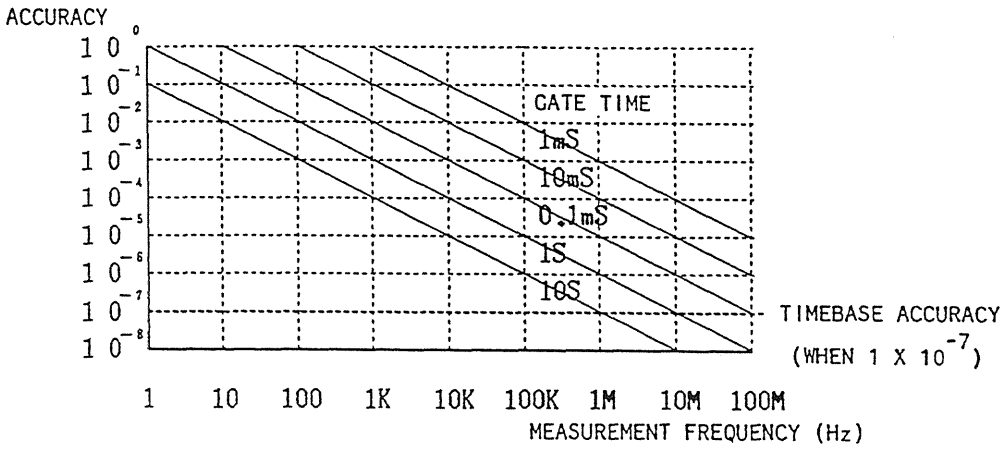
4.6.1 Direct Counting

Inaccuracy arises from the timebase oscillator error and the ±1-count quantization error. Fig. 4.6.1 shows how a ±1-count difference can occur for the same signal measured with identical gate times.

When 1/10 prescaling is performed, the prescaling is done before quantization, so accuracy is degraded by a factor of 10.



Quantization Error

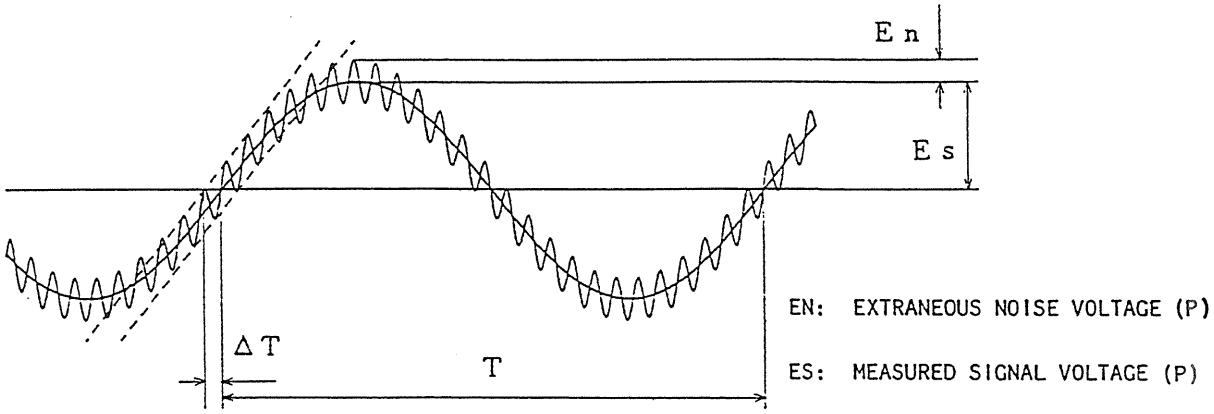


Direct Counting Accuracy

4.6.2 Reciprocal Measurement

The signal period is measured, so if noise is superimposed on the input signal, there may be an additional trigger error. If the input signal is a sine wave:

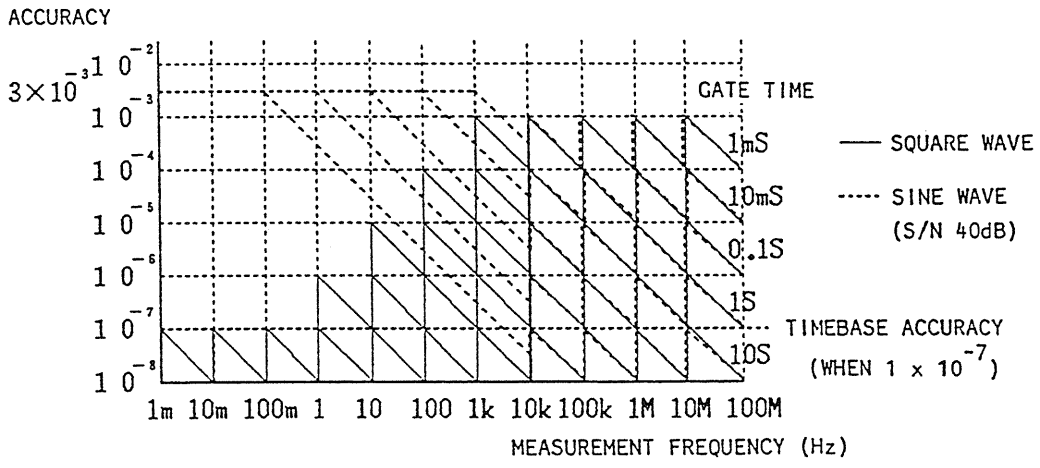
$$\text{Trigger error} = \frac{2 \cdot \Delta T}{T} = \frac{En}{\pi Es} \quad (s)$$



Trigger Error

The trigger error occurs twice--when the gate is opened and when it is closed--so if N periods are measured, the trigger error is:

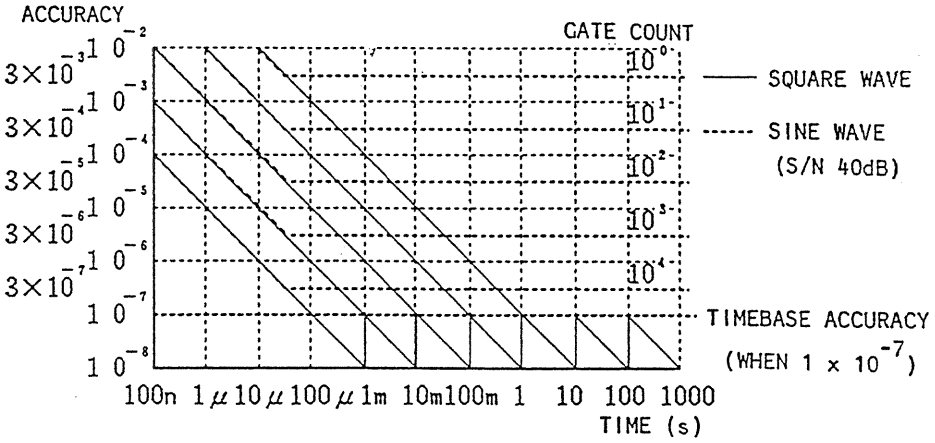
$$\text{Trigger error} = \frac{1}{N} \cdot \frac{En}{\pi Es} \quad (s)$$



Reciprocal Measurement Accuracy

4.6.3 Period Measurement

The principle is the same as for reciprocal measurement, but the value of N used for averaging depends on the gate selection.



Period Measurement Accuracy

4.6.4 Time Interval, Pulse Width and Duty Ratio Measurement

Trigger error is the same as for period measurement, but when the input signal is a pulse it is easier to give the formula in terms of the slew rate.

$$\text{Trigger error} = \frac{\text{Noise}}{\text{Slew rate}} \quad \text{(s)}$$

In the averaging mode, when the averaging time is set, the measurement is repeated until the set time is reached or exceeded, then statistical processing is performed, the resolution is calculated, and the result is displayed. When the input signal is extremely stable, as when it is synchronized with the timebase, averaging is not performed.

5. CALIBRATION

5.1 General

The deciding factor in the accuracy of a counter is the accuracy of its internal timebase. The 3601 uses a highly accurate, stable crystal oscillator. To maintain measurement accuracy, however, it is still advisable to calibrate the 3601 periodically with a frequency standard.

5.2 Preparations

Obtain a frequency standard generator (that generates a frequency of 10MHz with an accuracy of 1×10^{-9} or better) and let it warm up.

To calibrate the 3601 with its internal timebase in a stable condition, also let the 3601 warm up for at least 30 minutes.

5.3 Procedure

(1) Remove the four screws on the top of the 3601 and lift off the upper part of the case.

(2) Set the front panel as follows.

FUNCTION ..... FREQ. A

GATE	1s	DATA	OFF
MASK	OFF	FILTER	OFF
SENS	x1	Input coupling ...	AUTO

(3) Connect the frequency standard generator to INPUT A.

(4) Adjust the timebase of the 3601 so that a reading of 10.000000 is obtained.

(5) Replace the upper case and tighten the screws. This procedure calibrates the 3601 with an accuracy of 1×10^{-7}.

6. MAINTENANCE

6.1 Installation Location

The 3601 should be installed and handled carefully. Avoid installing it in places where it will be exposed to:

- o Direct sunlight
- o High temperature or humidity
- o Extreme temperature variations
- o Vibration
- o Salt spray or corrosive fumes
- o Excessive dust or dirt
- o Excessive electrical noise

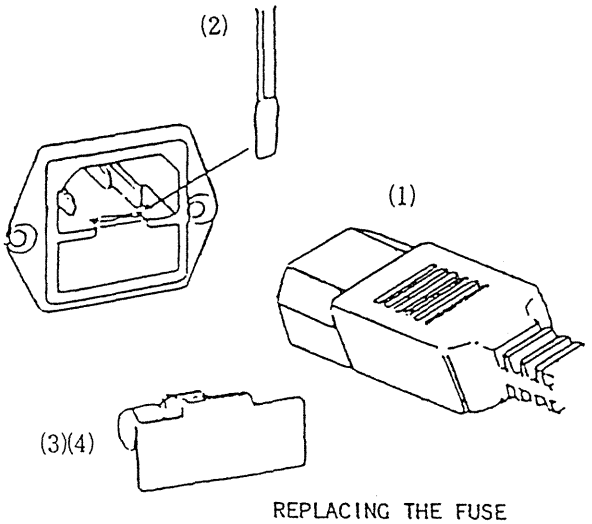
6.2 Fuse Replacement

(1) Remove the power cable.

(2) Use a flatblade screwdriver to remove the fuse holder.

(3) If the fuse has blown, replace it. (Use a midget fuse rated at 250V, 0.5A.)

(4) Remount the fuse holder and connect the power cable.



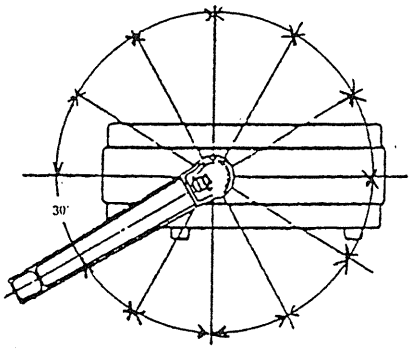
REPLACING THE FUSE

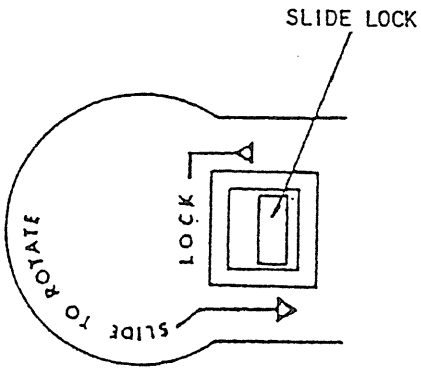
6.3 Moving the Handle

If the slide locks on both sides of the handle are moved in the direction marked SLIDE TO ROTATE, the handle can be rotated one full turn in 30° steps.

To lock the handle, push the slide switches in the direction marked LOCK at one of the 30° steps.

The handle can be locked at a convenient angle and used as a stand, but it will not support a heavy weight.





7. 3601 GP-IB INTERFACE

7.1 GP-IB Subset

SH1	All SH functions
AH1	All AH functions
T5	Basic talker, serial poll, talk only, talker cleared when MLA is received
L4	Basic listener, listener cleared when MTA is received
SR1	Serial poll function
RL1	All RL functions
PP0	No parallel poll functions
DC1	All DC functions
DT1	All DT functions
C0	No controller functions

7.2 Talker Data Format

7-bit ASCII code

AAAODDDDDDDDDDEEEXX

AAA ..... Header (Function status)

CKF	Frequency check
CKM	Mask time check
FAP	Frequency A prescaled measurement
FA*	Frequency A measurement
FB*	Frequency B measurement
PRD	Period measurement
TI*	Time interval measurement
PWH	High pulse width measurement
PWL	Low pulse width measurement

FR*	Frequency ratio measurement
DRH	High duty cycle measurement
DRL	Low duty cycle measurement
TCM	Count (gated by manual control)
TCA	Count (gated by A input)
RPM	Revolutions-per-minute measurement
*	An asterisk designates a space

O ..... Overflow flag

O	Overflow
" " (space)	Not overflow

DDDDDDDDDD Mantissa

Sign	" " (space) or "-"
Digits	Maximum 8
Decimal point	Maximum 1

When the mantissa consists of less than 10 characters, spaces are padded on the right.

EEE ..... Exponent

From E-9 to E+6 in steps of 10^3

XX ..... Delimiter

Two-digit binary code, specified by talker data or DIP switch setting

7.3 Listener Data Format

ASCII 7-bit code. Asterisks designate initial values

Function Data

*F0	Check
F1	Frequency A prescaled measurement
F2	Frequency A measurement
F3	Frequency B measurement
F4	Period measurement
F5	Frequency ratio measurement
F6	Time interval measurement
F7	Pulse width measurement
F8	Duty cycle measurement
F9	Count measurement
F:	Rpm measurement

Gate Data

G0	10^0, 1ms
G1	10^1, 10ms
G2	10^2, 100ms
*G3	10^3, 1s
G4	10^4, 10s
G5	Count measurement, gated manually
G6	Count measurement, gated by A input

Trigger Data

*T0	Trigger A +
T1	Trigger A -
T2	Trigger B +

*T3 Trigger B -

*T4 COM. A off

T5 COM. A on

Averaging Data

*A0 Averaging not performed

A1 Averaging performed

Difference Data

*D0 Difference not calculated

D1 Difference calculated

Hold Data

*H0 Hold off

H1 Hold on

Mask Data

*M0 Mask off

M1 Mask on

Manual Gate Data

*O0 Manual gate closed

O1 Manual gate open

Service Data

S0 Service request is sent

*S1 Service request is not sent

Header Data

HD0 Header and overflow flag not sent when talker

*HD1 Header and overflow flag sent when talker

Delimiter Data

*DL0 Delimiter when talker: CR-LF + EOI

DL1 Delimiter when talker: LF + EOI

DL2 Delimiter when talker: CR + EOI

DL3 Delimiter when talker: EOI only

Other Data

C Initialize

E Begin measurement

7.4 GP-IB Commands

ASCII 7-bit code

GTL:	Go to local	"01H"
SDC:	Selected device clear	"04H"
GET:	Group execute trigger	"08H"
LLO:	Local lockout	"11H"
DCL:	Device clear	"14H"
SPE:	Serial poll enable	"18H"
SPD:	Serial poll disable	"19H"
MLA:	My listener address	"20H" - "3EH"
UNL:	Unlisten	"3FH"
MTA:	My talker address	"40H" - "5EH"
UNT:	Untalk	"5FH"

7.5 Listener Data Recognition

In general, data are classified according to the first alphabetic character received, and recognized when the first numeric digit is received subsequently. Data should be programmed according to the listener data format.

If the recognized data cannot be set in the current function, they are ignored.

The delimiters recognized in the listener mode are EOI and LF. If CR-only is used, reception ends at the end of the listener active state.

7.6 Data Transmission

Data are sent once when the unit is designated as a talker after the end of the measurement. If a service request is not sent and the unit is not designated as a talker, the data are updated at the end of each measurement. If a service request is sent, the data are updated after being transmitted once, then a new service request is sent.

If the unit is designated as a talker when there are no data to send, the unit waits for the current measurement to end, then sends the resulting data once. When the unit is designated as a talker during a count measurement, however, it sends the current data immediately.

If the DATA function is set to HOLD, the same data can be sent any number of times.

7.7 Service Request

If service requests are sent, they are sent at the end of a measurement. Sending of the service request stops when the controller issues a serial poll or data are transmitted.

The status byte sent in response to polling is:

D8	D7	D6	D5	D4	D3	D2	D1
0	1	0	0	0	0	0	1

D7 is in the same state as the service request.

D0 is set at the end of a measurement and reset when the data are transmitted.

7.8 Remote and Local Modes

Changing from remote to local does not change the function setting.

Changing from local to remote restores the function settings that were valid in the preceding remote state.

The function settings are initialized at power-on and by the clear command or clear data.

7.9 Address Switch

A DIP switch on the rear panel sets the GP-IB address, the talk-only mode, and the talker delimiter. The DIP switch is read when power is switched on.

Positions 4-5-6-7-8: Address setting. Cannot be 11111
Postion 3: 1--Talk-only mode
Positions 1-2: Talker delimiter

45678	Address	ASCII	Listener	ASCII	Talker
00000	00	"SP"	20H	"@"	40H
00001	01	"!"	21H	"A"	41H
00010	02	"""	22H	"B"	42H
00011	03	"#"	23H	"C"	43H
00100	04	"$"	24H	"D"	44H
00101	05	"%"	25H	"E"	45H
00110	06	"&"	26H	"F"	46H
00111	07	"'"	27H	"G"	47H
01000	08	"("	28H	"H"	48H
01001	09	")"	29H	"I"	49H
01010	10	"*"	2AH	"J"	4AH
01011	11	"+"	2BH	"K"	4BH
01100	12	","	2CH	"L"	4CH
01101	13	"-"	2DH	"M"	4DH
01110	14	"."	2EH	"N"	4EH
01111	15	"/"	2FH	"O"	4FH
10000	16	"0"	30H	"P"	50H
10001	17	"1"	31H	"Q"	51H
10010	18	"2"	32H	"R"	52H
10011	19	"3"	33H	"S"	53H
10100	20	"4"	34H	"T"	54H
10101	21	"5"	35H	"U"	55H
10110	22	"6"	36H	"V"	56H
10111	23	"7"	37H	"W"	57H
11000	24	"8"	38H	"X"	58H

11001	25	"9"	39H	"Y"	59H
11010	26	":"	3AH	"Z"	5AH
11011	27	";"	3BH	"["	5BH
11100	28	"<"	3CH	"\"	5CH
11101	29	"="	3DH	"]"	5DH
11110	30	">"	3EH	"^"	5EH

Position 3

1: Talk-only mode. Address setting is ignored.

0: Addressable mode

Positions 1-2

00: Talker delimiter is CR + LF + EOI

01: Talker delimiter is LF + EOI

10: Talker delimiter is CR + EOI

11: Talker delimiter is EOI only

7.10 Sample Programs

These sample programs are for HP9816 and PC9801 controllers.

An HP3314A function generator is used as the signal source. The OUT connector of the HP3314A is connected to INPUT A of the 3601-01.

The input section of the 3601-01 is set as follows: SENS. x1, AUTO, FILTER OFF.

The sample programs measure frequency A, frequency B, period, negative-going pulse width, and duty cycle twice.

The comments in the HP9801 program apply to the same lines in the PC9801 program.

Lines 510 and 520 in the PC9801 program reset the PC9801's SRQ flag.

7.11 Caution

If the GP-IB address of the 3601-01 is set to 31 (binary 11111), the GP-IB interface will function incorrectly, and even measurements performed without using the GP-IB will not be performed correctly.

```
10 '*****  3601  GP-IB  Sample Program  *****
20 '                    ---   For PC 9801   ---
30 '          Address   3601-01  --  1
40 '                    HP 3314A --  7
50 '
60 '
70 '
80  ISET IFC  :ISET REN :GOSUB *RS98
90  WBYTE &H14;
100 PRINT @1;"S1"
110 F$="OFF"
120 ON SRQ GOSUB *SRI
130 *REST:    N=N+1
140 PRINT @7;"AP100MV FR12.34MZ"
150 SRQ ON
160 PRINT @1;"F2 S0E"
170 IF F$="OFF" THEN 170
180 F$="OFF"
190 PRINT @7;"FR 123.4HZ"
200 SRQ ON
210 PRINT @1;"F3 T5 S0E"
220 IF F$="OFF" THEN 220
230 F$="OFF"
240 SRQ ON
250 PRINT @1;"F4 T5 S0E"
260 IF F$="OFF" THEN 260
270 F$="OFF"
280 PRINT @7;"FU2 SY20PC"
290 SRQ ON
300 PRINT @1;"F7 G2 T1 S0E"
310 IF F$="OFF" THEN 310
320 F$="OFF"
330 SRQ ON
340 PRINT @1;"F8 G2 T0 S0E"
350 IF F$="OFF" THEN 350
360 F$="OFF"
370 PRINT @7;"SY50PC FU1"
380 IF N=2 THEN *ED
390 GOTO *REST
400 *SRI: POLL 1,S
410       PRINT @1;"S1"
420       IF S<>65 THEN *ER
430       INPUT @1;A$
440       PRINT A$
450       F$="ON"   :GOSUB *RS98
460       RETURN
470 *ER: PRINT "SRQ ERROR !!!",S
480 *ED:       PRINT "END    !!"
490            WBYTE &H14;
500            END
510 *RS98 :DEF SEG=&H60 :A%=PEEK(&H9F3)
520   A%=A% AND &HBF :POKE &H9F3,A% :RETURN
```

```
Do   !
FA    12.340278E+6
FB     123.4147E+0
PRD      8.1054E-3
PWL      6.4585E-3
DRH      20.056E+0
FA    12.340294E+6
FB     123.4158E+0
PRD      8.1059E-3
PWL      6.4579E-3
DRH      20.056E+0
END    !!
```

```
10     !*****  3601-01  GP-IB  Sample Program  *****
20     !                      ---   For HP 9816   ---
30     !              Address   3601-01  --  1
40     !                        HP 3314A --  7
50     !
60     ASSIN @Uc TO 701              !@Uc=3601-1 Address 1
70     ASSIN @Fg TO 707              !@Fg=3314A  Address 7
80     ABORT 7                       !IFC REN ATN
90     CLEAR 7                       !ATN DCL
100    OUTPUT @Uc;"S1"               !3601 SRQ"OFF"
110    F$="OFF"                      !Flag Init.
120    ON INTR 7 GOSUB Srq           !SRQ Man. Address
130 Re_st:   N=N+1                   !How many Times
140    OUTPUT @Fg;"AP100.0MV FR12.34MZ" !3314A .1V 12.34MHz
150    ENABLE INTR 7;2               !9816 Intr. Enable
160    OUTPUT @Uc;"F2 S0E"           !3601 Function FA SRQ
170    IF F$="OFF" THEN 170          !SRQ Wait
180    F$="OFF"                      !Flag Init.
190    OUTPUT @Fg;"FR 123.4HZ"       !3314A FR123.4Hz
200    ENABLE INTR 7;2               !9816 Intr. Enable
210    OUTPUT @Uc;"F3 T5 S0E"        !3601 Func. FB COM A
220    IF F$="OFF" THEN 220          !SRQ Wait
230    F$="OFF"                      !Flag Init.
240    ENABLE INTR 7;2               !9816 Intr. Enable
250    OUTPUT @Uc;"F4 T5 S0E"        !3601 Func. PERIOD
260    IF F$="OFF" THEN 260          !SRQ Wait
270    F$="OFF"                      !Flag Init.
280    OUTPUT @Fg;"FU2 SY20PC"       !3314A Squar Duty20%
290    ENABLE INTR 7;2               !9816 Intr. Enable
300    OUTPUT @Uc;"F7 G2 T1 S0E"     !3601 Pulse Width Low
310    IF F$="OFF" THEN 310          !SRQ Wait
320    F$="OFF"                      !Flag Init.
330    ENABLE INTR 7;2               !9816 Intr. Enable
340    OUTPUT @Uc;"F8 G2 T0 S0E"     !3601 Func. DUTY
350    IF F$="OFF" THEN 350          !SRQ Wait
360    F$="OFF"                      !Flag Init.
370    OUTPUT @Fg;"SY50PC FU1"       !3314A D50% Sin
380    IF N=2 THEN End_e             !2 Times
390    GOTO Re_st                    !Re start
400 Srq:    S=SPOLL(@Uc)             !Serial Poll Sub.
410         OUTPUT @Uc;"S1"          !3601 SRQ"OFF"
420         IF S<>65 THEN Err        !Status Check
430         ENTER @Uc;A$             !Measure Data In
440         PRINT A$                 !Data Print Out
450         F$="ON"                  !Flag Set
460         RETURN                   !Sub End Return
470 Err:    PRINT "Srq Error !!!"    !Status Error
480 End_e:    CLEAR 7                !ATN DCL
490           PRINT "END !!"         !PRINT END
500           END                    !End
```

```
Do  !
FA   12.340283E+6
FB    123.4085E+0
PRD     8.1030E-3
PWL     6.4776E-3
DRH     20.056E+0
FA   12.340296E+6
FB    123.4089E+0
PRD     8.1041E-3
PWL     6.4776E-3
DRH     20.056E+0
END !!
```

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