
RACAL-DANA SERIES 9500
UNIVERSAL TIMER/COUNTER
FUNCTION
N/RESOLUTION
INPUT CONTROLS
A START
B STOP
AUTO TRIGGER
RANGE
SAMPLE RATE
HOLD
START /STOP
RESET
SRQ
TALK
LISTEN
REMOTE
GATE
MHz
KHz
Hz
SEC
ms
µs
ns
0-100 MHz
50Ω
10.000


RACAL-DANA SERIES 9500
UNIVERSAL TIMER/COUNTER
10999.46

PUBLICATION NO. 980512

OPERATORS MANUAL

SERIES

9500

UNIVERSAL TIMER/COUNTERS

INCLUDES MODELS: 9510, 9512, 9514 & 9515

RACAL-DANA

RACAL-DANA INSTRUMENTS INC.
4 Goodyear Street, P.O. Box C-19541, Irvine, CA 92713
Telephone: 714/859-8999, TWX: 910-595-1136, TLX: 67-8341

RACAL-DANA INSTRUMENTS LTD.
Duke Street, Windsor, Berkshire SL4 1SB, United Kingdom
Telephone: Windsor (0753) 868101, TLX: 847013

RACAL-DANA INSTRUMENTS S.A.
18 Avenue Dutartre, 78150 Le Chesnay, France
Telephone: (1) 3-955-8888, TLX: 697 215

RACAL-DANA INSTRUMENTS GmbH.
Hermannstrasse 29, D-6078 Neu Isenburg, Federal Republic of Germany
Telephone: 06102-2861/2, TLX: 412896

RACAL-DANA INSTRUMENTS ITALIA srl.
Via Mecenate 84/A, 20138 Milano MI, Italy
Telephone: (02) 5062767, (02) 5062686, (02) 503444; TLX: 315697

RACAL

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WARRANTY

Within one year of purchase, Racal-Dana will repair or replace your instrument, at our option, if in any way it is defective in material or workmanship. The instrument must be returned to the country of purchase, unless prior arrangement has been made, and Racal-Dana Instruments will pay all parts and labor charges. Just call Racal-Dana Customer Service at (714) 859-8999 in U.S.A., Windsor (0753) 868101 in England, (1) 3-955-8888 in France, 06102-2861/2 in Germany or (02) 5062767, 5062686, or 503444 in Italy for assistance. We will advise you of the proper shipping address for your prepaid shipment. Your instrument will be returned to you freight prepaid.

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FOR YOUR SAFETY

Before undertaking any maintenance procedure, whether it be a specific troubleshooting or maintenance procedure described herein or an exploratory procedure aimed at determining whether there has been a malfunction, read the applicable section of this manual and note carefully the **WARNING** and **CAUTION** notices contained therein.

The equipment described in this manual contains voltage hazardous to human life and safety and which is capable of inflicting personal injury. The cautionary and warning notes are included in this manual to alert operator and maintenance personnel to the electrical hazards and thus prevent personal injury and damage to equipment.

If this instrument is to be powered from the AC line (mains) through an autotransformer (such as a Variac or equivalent) ensure that the common connector is connected to the neutral (earthed pole) of the power supply.

Before operating the unit ensure that the protective conductor (green wire) is connected to the ground (earth) protective conductor of the power outlet. Do not defeat the protective feature of the third protective conductor in the power cord by using a two conductor extension cord or a three-prong/two-prong adaptor.

Maintenance and calibration procedures contained in this manual sometimes call for operation of the unit with power applied and protective covers removed. Read the procedures carefully and heed Warnings to avoid "live" circuit points to ensure your personal safety.

Before operating this instrument:

1. Ensure that the instrument is configured to operate on the voltage available at the power source. See Installation Section.
2. Ensure that the proper fuse is in place in the instrument for the power source on which the instrument is to be operated.
3. Ensure that all other devices connected to or in proximity to this instrument are properly grounded or connected to the protective third-wire earth ground.

If at any time the instrument:

- Fails to operate satisfactorily
- Shows visible damage
- Has been stored under unfavorable conditions
- Has sustained stress

It should not be used until its performance has been checked by qualified personnel.

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1.1 INTRODUCTION.

1.1.1 This manual contains, in addition to the general description and specifications, installation, interface, operation and applications instructions for the Racal-Dana Series 9500 Timer-Counters. The installation and interface section includes mechanical and electrical information required to prepare the instrument for bench operation or for incorporating the instrument into a system.

1.1.2 Operating instructions presented in Section 3 include a description of all operating controls and indicators, a calibration check procedure, and operating procedures for each mode and feature of the instrument. Operating procedures are provided for both bench and system operation.

1.1.3 Typical applications are explained in Section 4 along with software examples, equipment interconnections and operating tips.

1.2 GENERAL DESCRIPTION.

1.2.1 The Series 9500 Timer/Counters include the Models 9510, 9512, 9514 and 9515. The description presented in the following paragraphs refer generally to these instruments; specific differences are noted in appropriate paragraphs for clarity.

1.3 MEASUREMENT CAPABILITIES.

1.3.1 The Series 9500 Timer/Counters are designed to perform five basic measurements; frequency, period, time interval, frequency ratio and totalize. The function and capabilities of the instruments for each of these basic measurements is described in the following paragraphs.

1.3.2 Frequency Measurement.

1.3.2.1 The instrument is normally equipped with two input channels for the measurement of frequency between 0 and 100 megahertz. The general input is designed for synchronous operation; when this channel is used, the instrument will measure only a signal of sufficient amplitude. Channel B is designed for continuous arm operation; the instrument measurement cycle is continuous regardless of the amplitude of the incoming signal. Options are available for direct measurement of frequencies to 512 megahertz or for prescaled measurement of 1.25 GHz. These high frequency options operate with the channel C input.

1.3.3 Period Measurement.

1.3.3.1 Period Measurement function is designed to measure the period of time required for one complete cycle of an input signal. The instrument is also equipped with a period average function which permits the measurement of repetitive waveforms to higher resolution than can be obtained using the period function.

1.3.4 Time Interval Measurement.

1.3.4.1 Two methods of Time Interval Measurement are provided; time interval and time interval average. The Time Interval function is used to measure the elapsed time between two electrical events. The Time Interval Average function provides greater resolution when measuring repetitive inputs.

1.3.5 Frequency Ratio Measurement.

1.3.5.1 This function provides the capability to measure directly the ratio between two frequencies with complete control of the slope, range, coupling and trigger level of both the signal input and reference inputs. The instrument is also capable of measuring the ratio of a high frequency signal (up to 1.25 GHz) to a signal with a frequency between 0 and 10 megahertz.

1.3.6 Totalize.

1.3.6.1 This function of the instrument provides the capability to count a series of input pulses or electrical events over a period of time controlled by the operator. The count may be stopped and started again repeatedly through use of a front panel pushbutton.

1.3.7 Special Features.

1.3.7.1 The Series 9500 Timer/Counters include a wide variety of measurement control capabilities, unique operating features and automatic functions not found in most electronic counters. These features and capabilities are described in the following paragraphs.

1.3.8 Automatic Triggering.

1.3.8.1 It is often necessary to measure signals of unknown magnitude. For simplicity of operation, the Model 9514 and Model 9515 are equipped with an automatic triggering circuit which measures the amplitude of the incoming measurement waveform and automatically sets the triggering level to the optimum point. This minimizes false counting due to noise and ringing on the input signal during frequency and period measurements. Further, it saves operating time usually required for adjustment of a trigger level control.

1.3.9 Measurement Gate Control.

1.3.9.1 To provide a wide variety of measurement application capabilities, the Series 9500 Timer/Counters are equipped with special circuits which allow control of the measurement gate start and stop time by external means. In normal operation the measurement gate control is a function of the measurement mode and input channel selection. When the channel A input is used, the measurement gate will not open until the measurement signal applied to the channel A input is of sufficient magnitude to trigger the instrument. Channel B, on the other hand, is designed for continuous arming and the measurement cycle is under control of the sample rate control on the front panel. Control of the measurement gate may be accomplished by an external control signal applied to a connector on the rear panel of the instrument. Selection of the measurement gate control mode is accomplished by setting a switch on the rear panel of the instrument. When the Models 9514 and 9515 are operated in the system mode, selection of the measurement gate control may be done by system commands via the general purpose interface bus. The description of the measurement gate control operation in the various modes is presented in the following paragraphs.

1.3.9.2 SELECTIVE GATE CONTROL. (A ⎍ B)

1.3.9.2.1 It is often necessary to measure the period of a train of pulses or electrical events as opposed to the period of a single event. This is easily accomplished with the Selective Gate Control. By applying a positive going TTL pulse to the gate control input, the counter's measurement gate can be controlled so that the measurement encompasses the desired period. The rising edge of the TTL pulse arms the counter to trigger at the first correct trigger point to begin the measurement. The high level of the TTL pulse inhibits the measurement gate from closing. Thus, the measurement gate is held open until the external gate control signal goes low. The falling edge of the external gate control signal then enables the counter to terminate the measurement when the next correct point occurs.

1.3.9.3 SYNCHRONOUS WINDOW CONTROL. (A&B ⎍)

1.3.9.3.1 The Synchronous Window feature is used to isolate a pulse or a period of time during which the 9500 is to make a timing measurement. By moving the time position of the synchronous window control pulse and by varying the width of the pulse, a selective measurement window is created which defines the area of time during which the 9500 will make its measurement. This feature is also used to isolate a pulse or part of the input signal for automatic triggering.

1.3.9.3.2 In the time interval average measurement mode, an externally applied pulse controls the arming of channels A and B. The rising edge of the positive going TTL pulse enables both channels to trigger at the next set of correct trigger points. The falling edge disables both channels. Consequently, the measurement window is created during which time the 9500 can make a measurement.

1.3.9.4 GATE DELAY.

1.3.9.4.1 This mode of measurement is very similar to the selective gate mode except that the counter does not arm at the rising edge of the control waveform. The counter is prevented from finishing a measurement whenever the control waveform is at a high level. A typical application of this mode is the measurement of time between RF bursts when a control signal is not available (i.e., the selective gate mode cannot be used). In such a case the time interval mode is selected, the gate output signal from the counter is used to trigger a pulse generator and the pulse generator is adjusted to provide the control waveform whose duration is longer than the RF burst. Thus, the incoming RF measurement burst signal will trigger the counter and the control waveform from the pulse generator will prevent the counters measurement gate from closing until the arrival of the next RF burst.

1.3.9.5 EXTERNAL ARM.

1.3.9.5.1 The instrument may be externally armed by use of a control signal applied to the gate control connector on the rear panel when operating on the standard interface bus. This allows the controller or system to control the trigger arming remotely while in the system mode of operation. This feature is available on the Model 9514 and 9515 instruments only and is not available for bench operation. In this mode of operation, a rising edge at the gate control input will arm the counter.

1.3.9.6 GATE CONTROL VERSUS INSTRUMENT FUNCTION.

1.3.9.6.1 The Gate Control features operate with many of the instrument functions. There are, however, some restrictions to the use of the gate control functions with the various operating modes of the instrument. Refer to Table 3.25 to determine functional compatibility with gate control modes.

1.3.10 High Resolution (2 Nanoseconds) Single Shot Time Interval Measurement.

1.3.10.1 The 9500 offers a measurement mode (C/A→B) which counts the RF channel input during the time between triggers of the start and stop channels A and B. This capability provides 2 nanosecond resolution for single shot time interval measurements. With a 500 megahertz signal applied to channel C, the instrument performs as a timer/counter with a 500 megahertz reference clock. A typical application and operating example of this mode of operation is shown in the operation section, Table 3.15.

1.3.11 General Purpose Interface Bus.

1.3.11.1 Models 9514 and 9515 are equipped with a IEEE-STD-488 - 1978 interface. The instrument may be remotely controlled via the interface bus. The instrument's bus message repertoire is complete in that it may be commanded to perform all functions on all ranges that it performs in the bench operation mode. Operation, addressing and bus protocol are explained in subsection 3.3 of the operating section of this manual. The instrument address assignment is illustrated in Table 3.26, while the interface message repertoire is listed in Table 3.28. The device dependent messages used to assemble operating programs are shown in Table 3.29. The IEEE-STD-488-1978 Interface Subset Capability is presented in Table 3.25.

1.3.12 Parallel BCD Interface.

1.3.12.1 The Model 9512 employs the 8-4-2-1 binary coded digits (BCD) to interface with remote automatic controllers. The remote interface through connector J210 enables the programming of all functions on all ranges performed in bench operation mode. Subsection 3.4, the operation section of this manual, explains the operation, addressing and protol. Recorder bus interface, through J209 supplies the instrument measurements format to peripheral devices.

1.4 OPTIONS.

1.4.1 There are a number of options available for the 9500 series counter-timer. The options are described in the following paragraphs.

1.4.2 Master Oscillator (Options 22A and 24A).

1.4.2.1 Three master oscillators are available. The standard oscillator has an aging rate of less than $3x10^{-7}$ per month. (See specifications section.) Two options are also available. The Option 22A oven oscillator replaces the standard oscillator and provides an aging rate of less than $3x10^{-9}$ per day. The Option 24A oven oscillator provides an aging rate of less than $5x10^{-10}$per day.

1.4.3 External Reference Multiplier (Option 10).

1.4.3.1 An optional external reference multiplier (Option 10) may be added to use an external reference frequency of 1 MHz or 5 MHz. The external reference multiplier will use the external 1 MHz or 5 MHz signal to produce a 10 MHz reference signal.

1.4.4 512 MHz Direct Count Channel C (Option 41).

1.4.4.1 For measuring signals between 50 MHz and 512 MHz a signal conditioner is available. This option is used in the channel C position. The specifications for the high frequency channel C option are included in the general specifications Table 1.1.

1.4.5 1.25 GHz Prescaled Channel C (Option 42).

1.4.5.1 For measuring signals between 50 MHz and 1.25 GHz a prescaler and signal conditioner is available. The specifications for Option 42 are in the general specifications Table 1.1.

1.4.6 Extended Programming Capability (Option 55E For 9514 & 9515)

1.4.6.1 This option adds remotely programmable 50 ohm input impedance feature for channels A and B. In addition it provides for program control of the Gate Control features of the instrument.

1.4.7 Analog Trigger Output (Option 70)

1.4.7.1 This option provides a DC voltage available at the rear panel which corresponds to the triggering level of the input. It has a range of - 3.2 V to + 3.2 V. It will mirror either the analog setting, or DAC setting (on 9512, 9514, or 9515 only) depending on which type of trigger level selection is in control. The output trigger level is independent of the input attenuators, for example, if the trigger level output reads 1.5 V and the X100 attenuator is in use, the internal trigger level is (1.5 x 100) V or 150 V.

1.5 ELECTRICAL DESCRIPTION.

1.5.1 A simplified block diagram of the Series 9500 Universal Counter-Timer is shown in Figure 1.1. Note that the diagram shows the interface circuits contained in the Models 9512, 9514 and 9515. The basic difference between the 9510 and 9512 and the other instruments is the GPIB interface capability and microprocessor-controller auto trigger feature. For simplicity, the block diagram shows the relationship of the instrument measurement circuits to the interface circuits. The phase-locked-loop frequency multiplier feature of the 9515 increases the resolution using 100 MHz reference signal.

1.5.2 Input channels A and B are identical through the signal conditioning circuits. The high frequency channel C circuit is an optional plug-in board which includes a signal conditioner for the 50 MHz to 512 MHz measurement input signal. The signal conditioning circuits contain the

AC/DC coupling circuits, the attenuator, the signal conditioning amplifiers and schmitt trigger circuits to condition and convert the measurement signal to a pulse suitable for application to the steering and sync circuits. The conditioned measurement signals are routed to the steering and synchronization circuits which in turn route them to the gate control or to the main gate depending on the function and mode selected. As shown on the diagram, the selected measurement signal may be used as the count signal while the gate control signals control the flow of the count to the accumulator. For example, when measuring frequency in the FA mode the selected measurement signals are applied to the main gate and the start/stop signals from the time base generator through the steering and synchronization logic produce the gate which allows the count signals to reach the accumulator. In this situation the count signal is the FA selected measurement and the gate signal is the time base generator.

1.5.3 The converse is true in some functions such as time interval measurement. In time interval mode, the conditioned measurement signals are used to produce the START/STOP signal for the gate control and thus the gate control produces the gate signal to control the main gate. The count signal is a clock signal derived from the master oscillator.

1.5.4 The conditioned measurement signals are also routed from the signal conditioning circuits to the marker generator. The marker generator circuit produces an external marker useful for observing the measurement time on an oscilloscope. The marker signal starts when channel A triggers and terminates when channel B triggers. The marker pulse represents the precise measurement of the time between channel A and channel B triggering. The trigger levels can be adjusted very accurately with the use of an oscilloscope and the external marker. The oscilloscope trace displays the point where the time measurement starts and terminates.

1.5.5 The counter uses an internal master oscillator which produces a 10 MHz clock signal for a measurement reference. There are 3 choices of master oscillator for the instrument, as described in the general description. The specifications for the optional oscillators are listed in the specifications section. There are occasions when it is desirable to use the master oscillator frequency for external purposes. For this reason, the output of the master oscillator can be routed to the reference connector through appropriate switching on the rear panel of the instrument. See Figure 3.2.

1.5.6 In some applications it is desirable to use an outside reference frequency for the master reference of the 9500 timer-counter. In this application, the external reference frequency is applied to the connector on the rear panel and the instrument then uses the external reference as a substitute for the internal master oscillator. An external signal should not be connected to the connector when the instrument is operating on the internal reference oscillator.

1.5.7 Some users of the instrument may wish to connect a 1 MHz or a 5 MHz external reference signal to the instrument and for this purpose an optional reference multiplier is available (see Figure 3.2). The reference multiplier will multiply the 1 MHz or 5 MHz signal and produce the 10 MHz reference frequency for use as the timebase clock.

1.5.8 As previously described, an external gate control signal may be applied to the rear panel connector to condition the timing of the main gate. This is useful when it is desired to select a particular pulse in a train of pulses or to control the opening and closing of the main gate through use of an external gate signal. The external gate control signal is applied to the rear panel connector and is routed to the gate control to accomplish this external synchronization of the main gate.

1.5.9 The function, range and mode of the instrument is controlled through front panel switches which apply control signals to the control logic. The control logic applies the appropriate control codes to the synchronization and steering logic and gate control circuits causing the instrument to perform the desired function.

1.5.10 During the measurement cycle, the gated count is applied to the accumulator for the measurement gate period. After the main gate is closed, the contents of the accumulator are displayed on the front panel display.

1.5.11 Models 9514 and 9515 include a general purpose interface bus (GPIB). This is shown on the block diagram below the dotted line. When the GPIB is used, control signals from the interface bus applied to the program input section of the GPIB circuits generate control signals as substitutes for the control signals from the front panel switches. Thus, the system, or external controller, is enabled to operate the instrument remotely.

1.5.12 The Model 9512 instrument is configured for remote control parallel BCD output, data is routed out to the system through the rear panel connectors illustrated in Figures 3.11 and 3.12. This illustration shows the pin signal assignments for the parallel BCD program input connector and parallel output connector.

1.5.13 Measurement information from the accumulator is routed to the GPIB circuits for transmission over the interface bus to the controller or system. Specific information on the GPIB interface is contained in Section 2 and includes such information as the interface connector pin/signal assignments, control messages and measurement information format. The operation section contains reference information for assembling the necessary GPIB control messages for remote control of the instrument. Section 4 contains remote programming examples for various applications. The programming examples include sample programs developed for the Hewlett Packard 9825 calculator along with explanations for each line of the various programs and the printed tape of the program and measurement result.

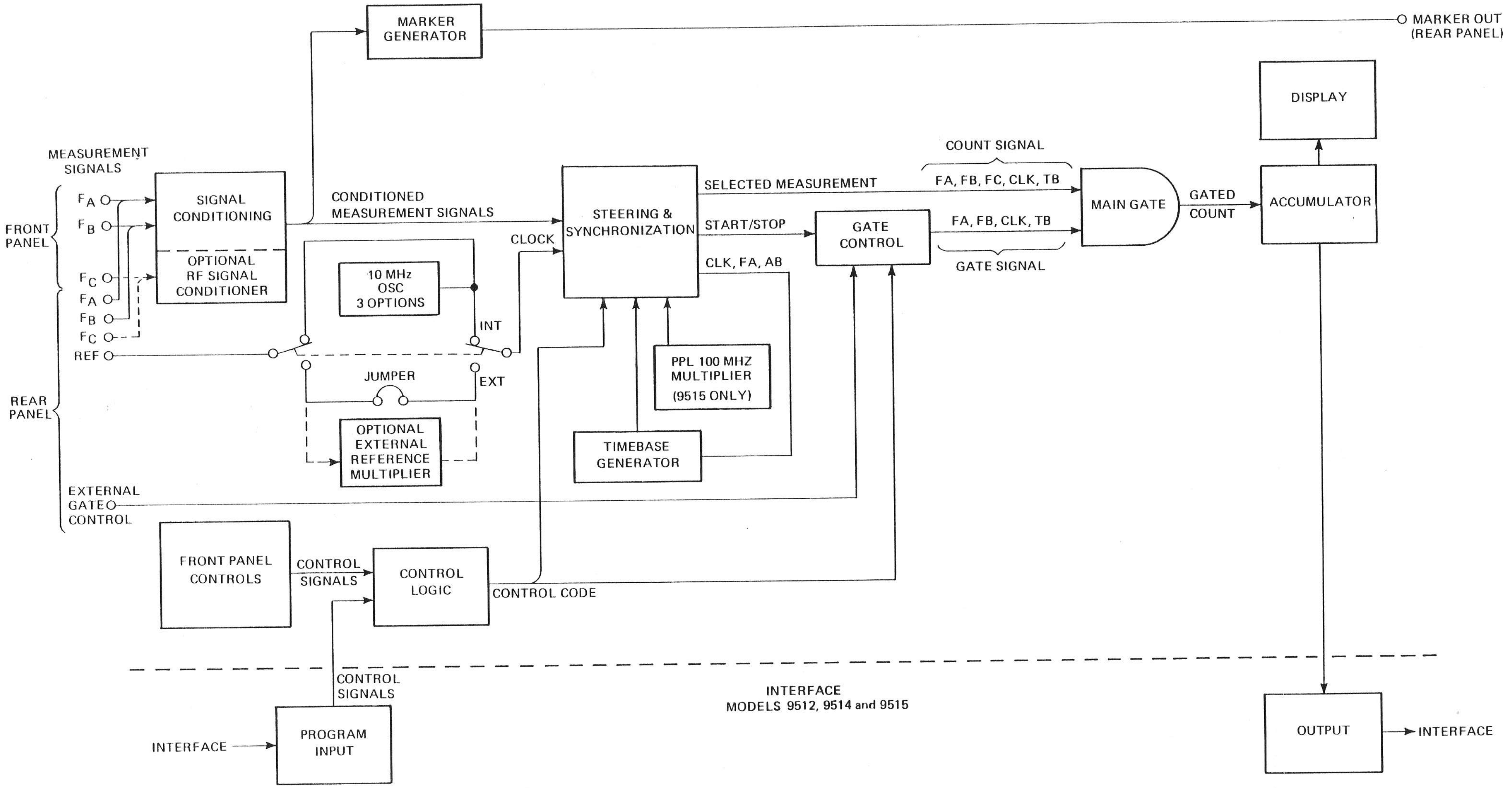


Figure 1.1 - Functional Block Diagram

1.6 MECHANICAL DESCRIPTION.

1.6.1 The Series 9500 instruments are completely enclosed in standard rack width aluminum cases, and are designed for either rack or bench type operation (Figure 1.2)

1.6.2 The Models 9512, 9514 and 9515 contain five printed circuit boards; the mainframe or motherboard, the interface board, the switching board, the display board and the I/O buffer board. Three additional printed circuit boards may be added; the channel C high frequency signal conditioner or prescaler for options 41 and 42, the options 22A and 24A oscillator power supply board, and the external reference multiplier board, option 10. The 9512, 9514, and 9515 use a rotary fan for cooling while the 9510 uses a large heat sink mounted on the rear panel and the front panel contains the auto trigger pushbuttons, which are not used on the Model 9510. The microprocessor controlled interface board plugs into the display panel through an edge connector and is also connected to the motherboard through three dip connectors and flat style cables. The I/O Buffer printed circuit board plugs into the rear edge of the microprocessor controlled interface board and fastens mechanically to the rear panel, providing connection to the interface bus. The Model 9510 instrument without options contains only the motherboard, display board, and switching board.

Table 1.1 - Specifications For Series 9500 Counter/Timers

INPUT CHARACTERISTICS	
Channel A & B	
Frequency Range	
DC Coupled:	0 to 100MHz
AC Coupled:	20Hz to 100MHz
Coupling:	DC or AC, switch selectable
Sensitivity	
Sinewave:	25mV rms to 1MHz 50mV rms to 30MHz 100mV rms to 100MHz
Pulse:	150mV p-p; 10nsec minimum width
Input Impedance:	1Mohm shunted by less than 25pF
Maximum Input: (without damage)	X1: 0-20 KHz; 250 Vrms 20 KHz - 1 MHz; $5X10^6/f$ 1 MHz - 100 MHz; 5 Vrms X10, X100: 0 to 5.5 MHz; 250 Vrms 5.5 - 100 MHz; $1.38X10^9/f$
Attenuator Ranges:	1, 10, 100; switch selectable or automatically selected (9514 only) (9514 & 9515 only)
Trigger Level:	Adjustable to ± 300% of voltage range
Preset Condition:	Zero trigger level
Channel C (Option 41)	
Frequency Range:	50MHz to 512MHz direct count
Sensitivity	
Sinewave:	15mV rms, 50MHz - 512MHz
Input Impedance	50 ohms nominal
Maximum Operating Input:	1V rms
Maximum Input Without Damage:	5V rms (fuse protected)
Resolution:	1Hz in 1 second
Channel C (Option 42)	
Frequency Range:	50MHz to 1.25GHz
Sensitivity	
Sinewave:	30mV rms
Scaling Factor:	÷ 4
Input Impedance:	50Ω nominal
Maximum Operating Input:	1V rms
Maximum Input Without Damage:	5V rms (fuse protected)

1.7 SPECIFICATIONS.

1.7.1 The specifications for the 9500 Series Timer/Counters are presented in Table 1.1.

General Input Characteristics	
Automatic Ranging: (Model 9510 Excepted)	Channels A and B voltage ranges are automatically selected as a function of the input signals' voltage levels.
Manual Ranging:	Channels A and B voltage ranges are selected by front panel switch.
Automatic Trigger Level: (Models 9510 and 9512 Excepted)*	The counter measures the maximum and minimum peak of the input signal, calculates the arithmetic mean, and automatically sets the trigger level at the mean. Standard on both Channels A and B. For inputs ≧ 400Hz, ≧ 50mV rms. (Optional 40Hz)

*This feature also sets to a DC level and may be used to measure DC voltage.

FREQUENCY MEASUREMENT TO 100MHz	
Frequency Range	
DC Coupled:	0 to 100MHz
AC Coupled:	20Hz to 100MHz
Accuracy:	± 1 count ± reference error
Inputs:	Channel A and Channel B
Measurement Time	
Standard Mode:	1 μsec to 10 seconds, selectable in decade steps
Display:	9 digits; Hz, KHz or MHz
Self Test:	
(10^{-1} sec time base)	10.00000MHz

FREQUENCY MEASUREMENT TO 512MHz	
(Option 41)	
Frequency Range:	50MHz to 512MHz
Accuracy:	± 1 count ± reference error
Input:	Channel C
Measurement Time:	1 μsec to 10 sec, selectable in decade steps
Display:	9 digits, MHz

Table 1.1 - Specifications For 9500 Series Counter/Timers continued

TOTALIZE MEASUREMENTS

Frequency Range:	0 to 100MHz
Count Range:	0 to 10^9
Accuracy:	± 1 count per gate
Input:	Channel A

FREQUENCY MEASUREMENT TO 1.25GHz (Option 42)

Frequency Range:	50MHz to 1.25GHz
Accuracy:	± 1 count ± reference error
Input:	Channel C
Measurement Time:	4 μsec to 40 seconds
Display:	9 digits, MHz

TIME INTERVAL MEASUREMENTS

Range:	100nsec to 10^9 sec 10nsec to 10^8 sec (9515 only)
Resolution:	100nsec (10nsec on 9515)
Accuracy:	± 1 count ± reference error ± trigger error*
Input	
Separate Mode:	Channel A start and Channel B stop
Common Mode:	Channel A start and stop
Display:	μsec, msec, sec

TIME INTERVAL AVERAGE MEASUREMENTS

Range:	100psec to 10 sec (1sec on 9515)
Accuracy:	± reference error ± 2nsec $\pm \frac{\text{(trigger error* + 100nsec†)}}{\sqrt{\text{No. of Intervals Averaged}}}$
Intervals Averaged:	1 to 10^7, selectable in decade steps
Dead Time:	Minimum time between stop and start: 200nsec (50 nsec for 9515)
Input	
Separate Mode:	Channel A start and Channel B stop
Common Mode:	Channel A start and stop
Display:	nsec, μsec

PERIOD MEASUREMENTS

Range:	100nsec to 10^9 sec 10nsec to 10^8 sec (9515 only)
Resolution:	100nsec (10nsec on 9515)
Accuracy:	± 1 count ± reference error ± trigger error**
Input:	Channel A
Display:	μsec, msec, sec

PERIOD AVERAGE MEASUREMENTS

Range:	100nsec to 100 sec 10nsec to 10sec (9515 only)
Accuracy:	± reference error ± 1 count $\pm \frac{\text{trigger error**}}{\text{No. of Periods Averaged}}$
Periods Averaged:	1 to 10^7, selectable in decade steps
Input:	Channel A
Display:	nsec, μsec

*trigger error = $\frac{\leq 0.0025\mu\text{sec}}{\text{signal slope (in V/}\mu\text{sec)}}$

†10ns on 9515

**trigger error = $\frac{\leq 0.3}{(S/N)\, f_A}$
where S/N equals signal to noise ratio in volts and f_A equals input frequency.

FREQUENCY RATIO MEASUREMENTS

Frequency Range	
Channel A:	0 - 10MHz
Channel B:	0 - 100MHz
Channel C	
Direct:	50Hz to 512MHz (Option 41)
Prescaled:	50Hz to 1.25GHz (Option 42)
Ratio Modes:	B/A C/A
Ratio:	10^{-7} to 10^9
Multiplier:	f_A scaled by 1 to 10^7 selectable in decade steps
Accuracy:	$\frac{\pm 1 \text{ count} \pm \text{trigger error of } f_A}{\text{multiplier}}$

EVENTS C, A TO B

Frequency Range	
Channel A:	DC to 10MHz
Channel B:	DC to 10MHz
Channel C:	50MHz to 512MHz (direct) (Option 41) 50MHz to 1.25GHz (÷4) (Option 42)
Range:	0 to 10^9
Resolution	
Direct Count (Option 41):	1 cycle of Channel C input
Prescaled (Option 42):	4 cycles of Channel C input

GENERAL SPECIFICATIONS

Gate Control Input	
Maximum Voltage Input:	−5V to +12V
Low Level:	−5V to +0.5V
High Level:	+1V to +12V
Rear Input (Model 9514 & 9515 onlv): (Option 01)	Sensitivity reduced by 6dB above 50MHz. Sensitivity at front inputs not specified with this option installed.
Internal Reference Oscillator	
Aging Rate:	$<3 \times 10^{-7}$ per month
Temperature Stability:	$<5 \times 10^{-6}$ 0°C to +50°C
Voltage Stability:	$<1 \times 10^{-7}$ with 10% line voltage variation
Internal Reference Output:	10MHz square wave, buffered, TTL compatible.
External Reference Input Standard:	10MHz; 1V rms into 1Kohm, switch selectable.
Optional: (Option 10)	1, 5, or 10MHz; 1V rms into 1Kohm, switch selectable.
Marker Output:	Negative-going pulse (TTL levels) available on a rear panel BNC, with duration equal to Channel A trigger point to Channel B trigger point.
Display	
Numeric:	Nine 11mm (.43 inch) yellow LED's. Leading zeros suppressed.
Status Indicators:	Trigger lights status. Display overflow. Gate indicator. Units indicators. Model 9514 & 9515 only – GPIB status indicators Talk (addressed to talk) Listen (addressed to listen) Remote SRQ (service request)
Display Time:	Adjustable 25msec to 5 seconds and hold.
Input/Output Connectors:	BNC
Operating Temperature, Humidity:	0°C to +50°C, 75% R.H.
Storage Temperature, Humidity:	−40°C to +70°C, 75% R.H.
Line Voltage:	50 to 400Hz (50-60Hz - Model 9514 & 9515); 100, 120, 220, or 240V ±10%
Power Requirement:	80 watts maximum
Weight:	Net 6.8 kg (15 lb.); shipping 9.5 kg (21 lb.)

Table 1.1 - Specifications continued

GENERAL PURPOSE INTERFACE BUS (GPIB)

(Models 9514 and 9515 only)

Models 9514 and 9515 contain a GPIB compatible interface. This interface is compliant with IEEE-Std-488-1975. It provides subsets AH1, DC1, DT1, L4, PP0, RL1, SH1, SR1 and T5 of this standard to assure ease of use. The Model 9514 makes programming easy by the use of an expandable program string. For simple measurements you need only program those functions, ranges, and controls that affect the measurement. For more complex measurement requirements, "high level" controls may be programmed. Use of the expanded programming option (Option 55E) further expands the 9514 to allow arming mode and input impedance to be programmed.

PROGRAMABILITY: all front panel controls except line power and sample rate.

DATA OUTPUT FORMAT: .XXXXXXXXXE±XXCRLF

PROGRAMMING FORMAT: 7 bit ASCII Code

MAXIMUM ADDRESSING TIME: less than 350µS

MAXIMUM READING RATE: (3.3msec + gate time) per Reading

IEEE-STD-488 SUBSET CAPABILITY

GPIB Subset	Description	Applicable Capability
AH1	Acceptor Handshake	Complete Capability
DC1	Device Clear	(1) DCL = Device Clear (2) SDC = Selected Device Clear
DT1	Device Trigger	GET = Group Execute-Trigger
L4	Listener	(1) Basic Listener (2) Unaddress if MTA
PP0	Parallel Poll	No Capability
RL1	Remote/Local	(1) REN — Remote Enable (2) LLO — Local Lockout (3) GTL — Go to Local (4) MLA — My Listen Address
SH1	Source Handshake	Complete Capability
SR1	Service Request	Complete Capability
T5	Talker	(1) Basic Talker (2) Serial Poll (3) Talk only Mode (4) Unaddress if MLA

PROGRAMMING CAPABILITY

Command Group	Description	ASCII Program Code	
Function:	Frequency, Channel A	F0	
	Frequency, Channel C	F1	
	Ratio B/A	F2	
	Ratio C/A	F3	
	Period - Channel A	F4	
	Time Interval	F5	
	Period Average - Channel A	F6	
	Time Interval Average	F7	
	Frequency, Channel B	F8	
	Events C, (A→B)	F9	
	Totalize	F:	
(Continued)			
Range:	0	G0	
	1	G1	
	2	G2	
	3	G3	
	4	G4	
	5	G5	
	6	G6	
	7	G7	
Input Controls:		**Channel A**	**Channel B**
	Slope:		
	Positive	A0	B0
	Negative	A1	B1
	Coupling:		
	DC	A2	B2
	AC	A3	B3
	Attenuation:		
	X1	A4	B4
	X10	A5	B5
	X100	A6	B6
	Trigger Level:		
	Automatic	LAA	LBA
	Programmed	LA± DDD	LB± DDD
	Input Configuration:		
	Separate	C0	
	Common - Channel A	C1	
	Test	C2	
Measurement Mode:	Single Reading/No SRQ	S0	
	Single Reading and SRQ	S1	
	Multiple Readings/No SRQ	S2	
	Multiple Readings with SRQ	S3	
Trigger Controls:	Start/Stop - Totalize mode	P	
	Software Trigger - Single Reading Mode	T	
	Reset	R	
Output Requests:	Channel A Signal Levels:		
	Trigger setting	H0	
	+ Peak of input signal*	H2	
	— Peak of input signal*	H4	
	Channel B Signal Levels:		
	Trigger setting	H1	
	+ Peak of input signal*	H3	
	— Peak of input signal*	H5	
	In-Process Measurement Data	V	
	Measurement Data	H6	
	*Available only after auto-trigger		

EXTENDED PROGRAMMING (Option 55E)

Arming Mode:	Automatic Arming/ Continuous Arming	U0
	External Arming/No Hold-Off	U1
	External Arming/ External Hold-Off	U2
	Synchronous Window	U3
	Automatic or Continuous Arming/ External Hold-Off	U4
Input Impedance:	50 OHM	U5
	1 Meg OHM	U6

Table 1.1 - Specifications continued

OSCILLATORS

Internal Reference Oscillator	Aging Rate	Temperature Stability	Voltage Stability
Standard	$< 3x10^{-7}$/mo.	$< 5x10^{-6}$ $0^{o}C$ to $+50^{o}C$	$< 1x10^{-7}$ with 10% line V variation
Option 22A	$< 3x10^{-9}$/day*	$< 3x10^{-9}/^{o}C$ $0^{o}C$ to $+50^{o}C$	$< 2x10^{-8}$ with 10% line V variation
Option 24A	$< 5x10^{-10}$/day*	$< 6x10^{-10}/^{o}C$ $0^{o}C$ to $+50^{o}C$	$< 1.5x10^{-9}$ with 10% line V variation

*After 3 months operation

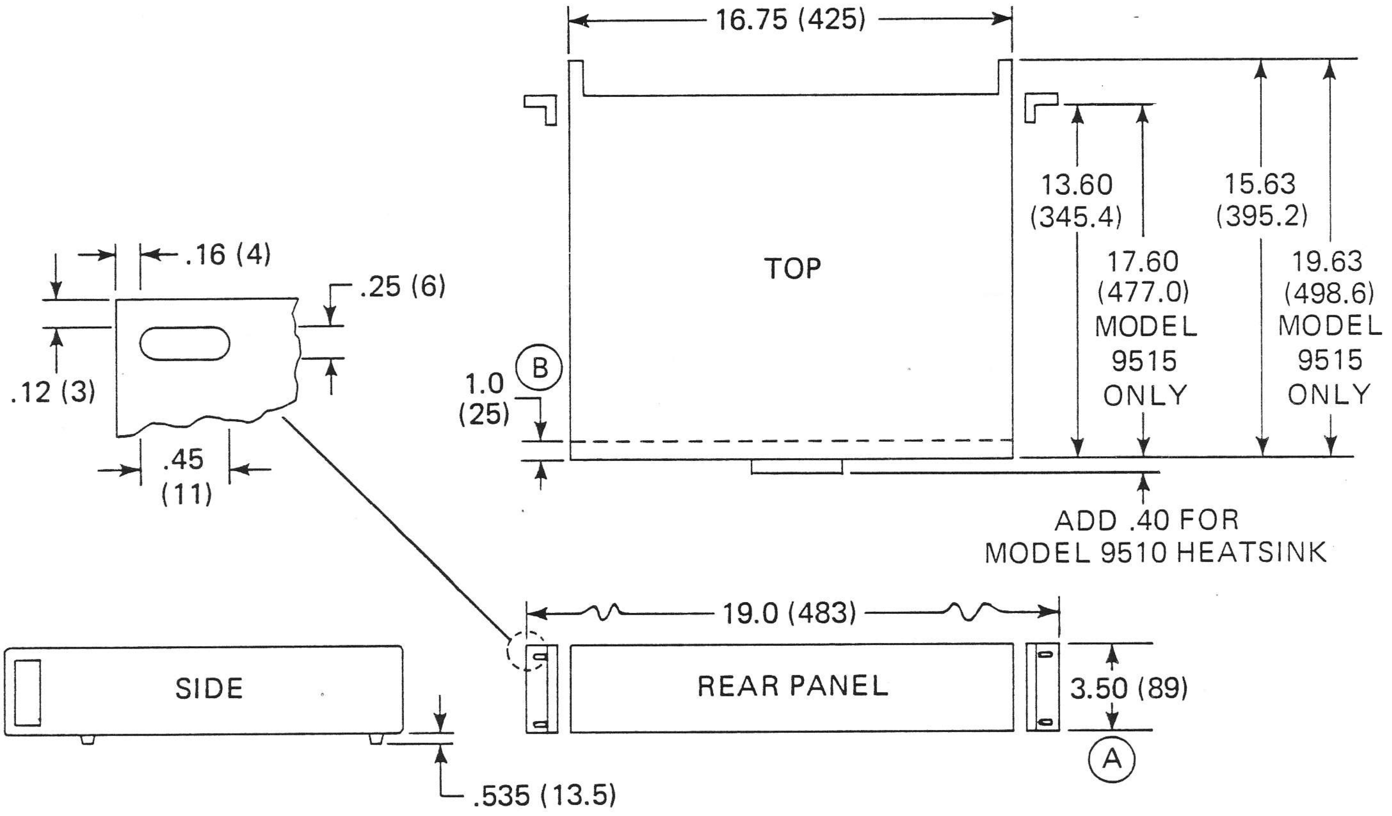
PARALLEL BCD SYSTEM INTERFACE (Model 9512 only)

The Model 9512 BCD logic accepts TTL, 74LS series parameters where positive true logic equals "1" and zero or false equals "0". Command lines are biased at logic "1" level permitting control settings to pull the appropriate control lines to ground. Remote trigger levels accepted are BCD or analog control voltages, and each 0.1 volt of input voltage adjusts the trigger level 1% of the selected range.

Data Output Information:	All BCD outputs of display, 4-Bit Range code, function flags, polarity flags, special flags, and logic form the recoder drive signals.
Logic Type:	Low power Schottky TTL levels 8-4-2-1 BCD
Remote Programming Input Information:	Provides programming of all functions and ranges.
Program Code:	The control lines terminal J210 is the remote access for the BCD code
Peripheral:	Connector J209 provides parallel BCD display code to drive recorder device

Table 1.2 - Maximum Input Voltages Without Damage

Channel	Attenuator Setting	Frequency	Maximum Input Voltage
A and B	X1	0-20 KHz 20 KHz - 1 MHz 1 MHz - 100 MHz	250 VRMS $5X10^{6}/f$ 5 VRMS
A and B	X10, X100	0 - 5.5 MHz 5.5 - 100 MHz	250 VRMS $38X10^{9}/f$
C(512 MHz option)	No atten on chan C	50 to 500 MHz	5 Vrms
C(1.25 GHz option)	No atten on chan C	50 MHz to 1.25 GHz	5 Vrms



DIMENSIONS IN INCHES (mm)

Ⓐ E. I. A. RACK HEIGHT

FOR CABINET HEIGHT ADD FEET HEIGHT

Ⓑ REAR PANEL ACCESS

Figure 1.2 - Dimensional Outline

2.1 UNPACKING AND INSPECTION.

2.1.1 The Series 9500 Counter is packed in plastic-foam within a cardboard carton for shipment. The plastic foam holds the Counter securely in the carton and absorbs any reasonable external shock normally encountered in transit. Prior to unpacking, examine the exterior of the shipping carton for any signs of damage. Carefully remove the Counter from the carton and inspect the exterior of the instrument for any signs of damage. If damage is found, notify the carrier immediately.

2.1.2 Included with the Counter packed in the container are the instruction manual, Racal-Dana Part Number 980-505, and power cord.

2.2 BENCH OPERATION.

2.2.1 Each Counter is equipped with a tilt bail or "kickstand" to enable the front of the instrument to be elevated for convenient bench use. The tilt bail is attached to the two front supporting "feet" at the bottom of the instrument. For use, the bail is pulled down to its supporting position.

2.3 POWER CONNECTIONS.

WARNING

Disconnect the instrument from the AC power source before attempting to change power connections. Potentially lethal voltages are exposed when covers are removed.

2.3.1 Power requirements for domestic units are 115V ± 10%, 50 to 400 Hz for Model 9510 and 50 Hz - 60 Hz for all other instruments. Power consumption is 80 watts maximum. The Series 9500 counters are adaptable for 230V operation. The instrument may be set to operate on any one of four line voltages.

2.3.2 Line voltage selection is accomplished by inserting a small printer-circuit-board into its jack in one of four positions. The PCB contains jumpers that configure the power transformer primary connections for the desired line voltage. To select the line voltage proceed as follows:

a. Remove the top cover from the instrument.

b. Remove the plastic safety guard labeled "HIGH VOLTAGE" to gain access to the line voltage selection PCB and remove the board.

c. Insert the board so that the number corresponding to the desired line voltage appears in the window in the rear panel.

d. Instruments equipped with the option 22 or option 24 high stability reference oscillator have included an additional power supply. This supply provides power to the option as long as the power cord is connected, regardless of the position of the front panel power switch. The supply, located at the mid-rear left on the motherboard, has a line select switch which must be set to correspond to the line voltage.

e. Replace the safety guard and instrument cover.

2.3.3 Power Cable.

2.3.3.1 A standard power cable having a three-pin plug is supplied with the counter. The cord connects to the power connector reference ④ figure 3.2. The ground pin (round) is attached to the main frame of the counter. It is important that this pin be connected to a good quality earth ground.

2.4 GROUNDING REQUIREMENTS.

2.4.1 To protect equipment operators from possible injury in the event of shorts or fault currents, the front panel and case of this instrument are grounded in accordance with MIL-T-28800A. A low impedance ground is maintained through one conductor of the three conductor power cable supplied with the instrument, when the cable is plugged into an appropriate, properly wired, receptacle.

2.5 FUSE.

2.5.1 The power fuse holder is located on the rear panel of the counter. A 1 amp 3 AG fuse is used for 100/120 volt operation while a .5 amp fuse is used for 220/240 volt operation.

2.6 REMOTE PROGRAMMING.

2.6.1 Information on remote control and programming for Models 9512, 9514 and 9515 appears in Section 3 and 4 of this manual. Interface address assignments and operation covering GPIB and BCD are explained in detail.

2.7 OPERATING PROCEDURES.

2.7.1 Tables 3.1, 3.2 and 3.3 describe the function of each operating control and each connector on the instrument. Tables 3.5 through 3.23 describe procedures for operating the instrument in each of the measurement modes. Remote operation is described in paragraphs 3.3 and 3.4.

2.8 RACK MOUNTING.

2.8.1 The instrument can be mounted in a standard 19-inch rack with the option 60 rack-mounting flanges. To install the flanges, proceed as follows:

a. With instrument on its side, loosen the four captive Phillips head screws holding the bottom cover and remove cover. Remove screws holding feet (and bail) in place. Replace bottom cover.

b. Place one of the supplied screws through each of the two holes in the mounting flange (figure 2.1). Thread a securing nut onto each screw just enough to attach it to the screw (approximately one turn).

c. Place the mounting flange onto the mounting slot in the instrument side panel so that the securing nuts fit entirely into the slot. Be sure the rack-mount slots on the flange are toward the front of the instrument.

d. Tighten screws. The securing nuts will rotate and hold the flange securely in place.

2.9 STORAGE REQUIREMENTS.

2.9.1 The instrument can be stored at temperatures ranging from –40°C to +70°C at 75% relative humidity without adversely affecting PCB's or components. The instrument must be brought up to within the specified operating range (0°C to +50°C) before power is applied.

2.10 RESHIPMENT PACKAGING REQUIREMENTS.

2.10.1 The shipping carton with its molded plastic foam forms and plastic dust cover is specifically designed to provide the required support necessary for safe shipment. Whenever possible, these should be used for reshipment.

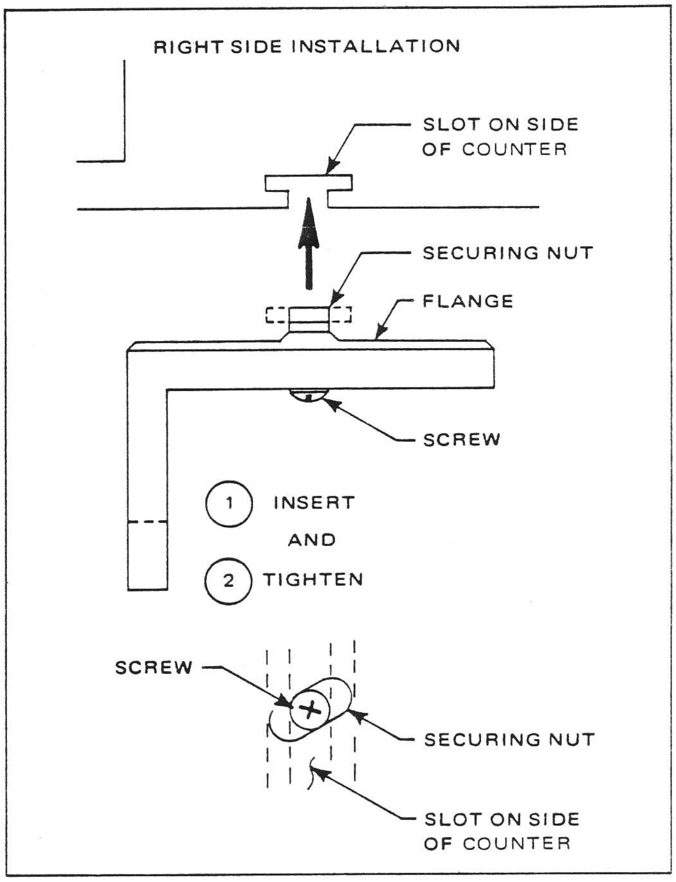


Figure 2.1 - Rack Mount Installation

2.10.2 If the original packing materials are not available, proceed as follows:

a. Wrap instrument in plastic or heavy paper.

b. Place packing material around all sides of instrument and pack in cardboard box.

c. Place instrument and inner container in sturdy cardboard or wooden box. Mark box with appropriate precautionary labels.

SECTION 3 OPERATION

3.1 INTRODUCTION.

3.1.1 This section contains instructions for operation of the model 9510, 9512, 9514 and 9515 timer/counter. Subsection 3.2 contains operating information for the controls and indicators on the front and rear panels of both instruments. In addition, line voltage configuration instructions are provided to enable the user to set the instrument for operation on any one of four operating line voltages.

3.1.2 Refer to the Model 9500 Maintenance Manual (Racal-Dana Publication No. 980515) for information covering calibration check procedures and adjustments. Material for Series 9500 is found in subsections 6.2 and 6.3 as well as an addendum in the front of the manual. This information may be used any time to check the calibration of the instrument as well as for incoming specification validation or acceptance test inspection.

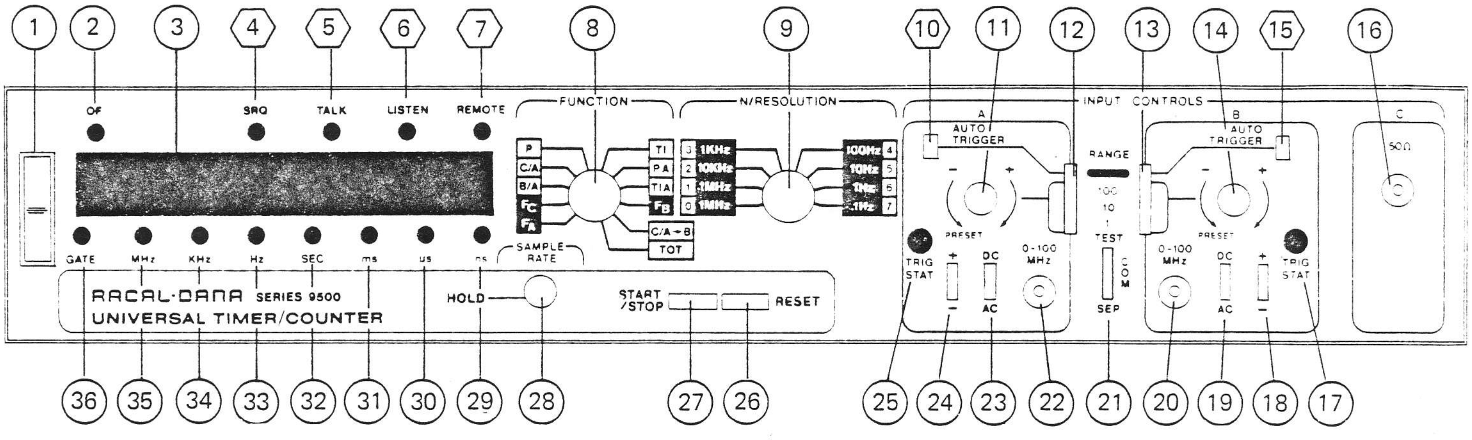
3.1.3 A general operating troubleshooting procedure or checklist is also included to help the operator avoid malfunctions stemming from cockpit error.

3.1.4 The bench operation section contains an operating procedure for every function of the instrument along with an applications example. The subsection on system operation, paragraph 3.3 and 3.4 contain a description of the system interface bus, instrument bus address instructions, a detailed description of the interface handshake cycle and a complete description of the sequence of bus operation illustrating the transmission of the device dependent message program string and the subsequent measurement data transmission by the counter.

3.1.5 The subsection on software organization illustrates the counter programming subroutines and their relationship to the users overall software package or operating system. A simple program is assembled and the sequence of its operation is explained in detail.

3.2 BENCH OPERATION.

3.2.1 This subsection contains the operating instructions for using the Series 9500 timer/counter as a bench instrument. Operation of all controls, connectors and indicators is described in Figures 3.1 through 3.3 and Tables 3.1 through 3.3.



Hex shaped reference symbol indicates control or indicator included on Model 9514 and 9515 only.

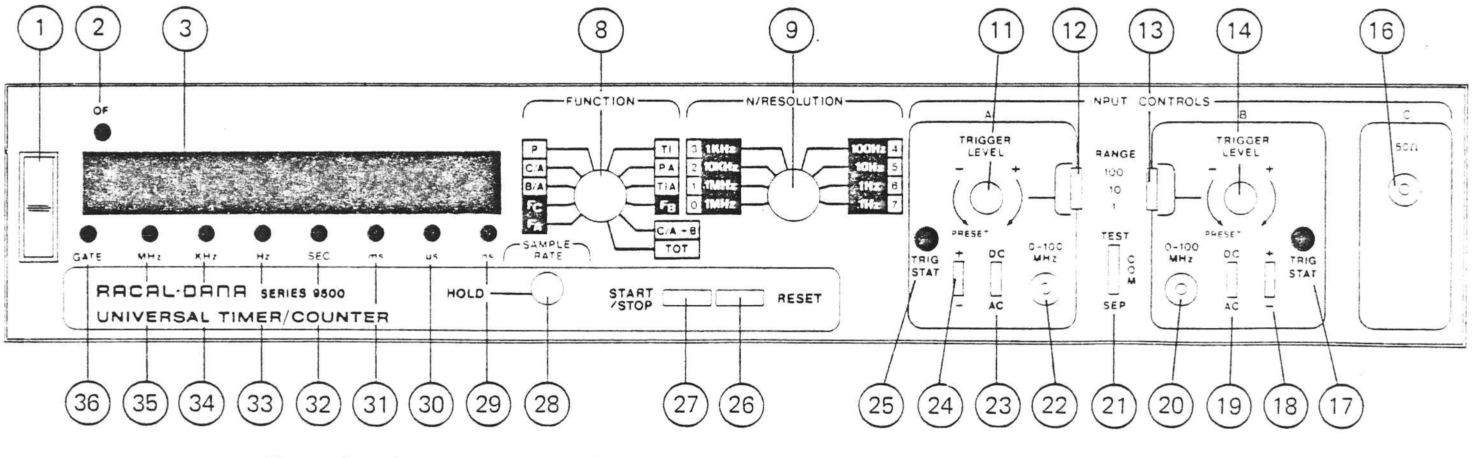


Figure 3.1 - Series 9500 Timer/Counter Front Panel Controls, Connectors and Indicators

Table 3.1 - Controls, Indicators and Connectors, Front Panel

Reference	Item/Position	Function
Figure 3.1		
①	Power switch/ indicator	Applies main AC line power to the instrument when set to the on position.
②	OF annunciator	Indicates that the accumulator passed the 999999999 count before the measurement gate closed.
③	Display	Measurement display composed of nine LED 7-Segment indicators.
⟨4⟩	SRQ annunciator	Indicates that the instrument is transmitting a service request on the interface bus.
⟨5⟩	TALK annunciator	Indicates that the instrument is a "Talker" on the interface bus.
⟨6⟩	LISTEN annunciator	Indicates that the instrument is a "Listener" on the interface bus.
⟨7⟩	REMOTE annunciator	Indicates that the instrument is under control of a remote controller via the interface bus.
⑧	FUNCTION switch	Selects the function the instrument is to perform. The functions for each switch position are shown below.
	F_A	Measures the frequency of the signal applied to channel A.
	F_C	Measures the frequency of the signal applied to channel C.
	B/A	Measures the ratio of the frequency of the signal applied to channel B to the frequency of the signal applied to channel A.
	C/A	Measures the ratio of the frequency of the signal applied to channel C to the frequency of the signal applied to channel A.
	P	Measures the period of one cycle of the input waveform (channel A).
	TI	Measures time between two electrical events. The start point is controlled by the channel A trigger and the stop point is controlled by the channel B trigger.

*Hex shaped reference symbol indicates control, indicator or connector is included on model 9514 only.

Table 3.1 - Controls, Indicators and Connectors, Front Panel continued

Reference	Item/Position	Function
	PA	The period of a number of input waveforms are measured and then averaged. The number of period measurements is determined by the setting of the N/RESOLUTION control; 10^N is the number of periods. See reference ⑨.
	TIA	The time interval between two electrical events is measured a number of times and then averaged. The number of time interval measurements is determined by the setting of the N/RESOLUTION control; 10^N is the number of time interval measurements. See reference ⑨.
	F_B	Measures the frequency of the signal applied to the channel B input connector.
	C/A➤B	In this position the instrument is in the gated count mode. In the gated count mode of operation the instrument will count the number of cycles of the measurement signal applied to the channel C input connector for the time period beginning when the channel A triggers and ending when channel B triggers. In this mode channels A and B provide the start and stop points for the channel C measurement.
	TOT	Measures the total number of cycles of the signal applied to channel A.
⑨	N/RESOLUTION switch	Selects the resolution or range of the instrument for the various functions. The resolution possible for each of the various functions of the instrument is shown below.

Models 9510, 9512, 9514

Sw Pos	Resolution in F_A, F_B, F_C	No. of Periods of Ch. A Signal PA, C/A, B/A.TIA	Resolution in P, TI	F_A, F_B, F_C Gate Time
0	1 MHz	$10^0=1$	.1 usec	1 usec
1	.1 MHz	$10^1=10$	1 usec	10 usec
2	10 KHz	$10^2=100$	10 usec	100 usec
3	1 KHz	$10^3=1,000$	.1 msec	1 ms
4	.1 KHz	$10^4=10,000$	1 msec	10 ms
5	10 Hz	$10^5=100,000$	10 msec	100 ms
6	1 Hz	$10^6=1,000,000$	.1 sec	1 sec
7	.1 Hz	$10^7=10,000,000$	1 sec	10 sec

Model 9515

Sw Pos	Resolution in F_A, F_B, F_C	No. of Periods of Ch. A Signal PA, C/A, B/A.TIA	Resolution in P, TI	F_A, F_B, F_C Gate Time
0	1 MHz	$10^0 = 1$	.01 usec	1 usec
1	.1 MHz	$10^1 = 10$	.1 usec	10 usec
2	10 KHz	$10^2 = 100$	1 usec	100 usec
3	1 KHz	$10^3 = 1,000$	10 usec	1 ms
4	.1 KHz	$10^4 = 10,000$	.1 msec	10 ms
5	10 Hz	$10^5 = 100,000$	1 msec	100 ms
6	1 Hz	$10^6 = 1,000,000$	10 msec	1 sec
7	.1 Hz	$10^7 = 10,000,000$	.1 sec	10 sec

Table 3.1 - Controls, Indicators and Connectors, Front Panel continued

Reference	Item/Position	Function
⟨10⟩	Auto Trigger Switch	When depressed this switch causes an auto trigger for channel A if the attenuator switch is in the auto position.
⑪	Trigger Level Control, Channel A	Adjust the voltage level which channel A input circuit triggers if the range switch is in the 1, 10, or 100 position.
⑫	Attenuator Range Channel A	Selects the trigger level range for the channel A input circuits. When set to the 1 position, the triggering for channel A may be adjusted to trigger at some point between –3 and 3 volts, depending on the setting of the variable trigger level control reference number 11.
⑬	Attenuator Range Channel B	Selects the trigger level range for the channel B input circuits. When set to the 1 position, the triggering for channel B may be adjusted to trigger at some point between –3 and +3 volts, depending on the setting of the variable trigger level control reference number 11.
⑭	Trigger Level Control, Channel B	Adjust the voltage level which channel B input circuit triggers if the trigger range switch is in the 1, 10, or 100 position.
⟨15⟩	Auto Trigger Switch	When depressed this switch causes an auto trigger for channel B if the range switch is in the auto position.
⑯	Channel C Input	BNC connector for applications of 50 to 512 megahertz signals to the channel C input circuits. The channel C input connector contains a fuse. The fuse blows when the input to channel C exceeds maximum limits (5 volts). The fuse may be replaced by unscrewing the front of the BNC connector from the front panel. This may be done from the outside of the instrument and it may be accomplished with power on the instrument with no damage to the instrument.
⑰	Trigger Status Indicator	Indicates, when flashing, that channel B is triggering. If the indicator remains off or remains lit it is an indication that channel B is not triggering.
⑱	± Switch (Channel B Trigger Slope Switch)	When set to the plus (+) position causes channel B to trigger on the positive slope of the input signal; when set to the minus (–) position causes channel B to trigger on the negative slope of the measurement signal.
⑲	AC/DC Coupling Switch, Channel B	Selects the coupling mode for channel B.

Table 3.1 - Controls, Indicators and Connectors, Front Panel continued

Reference	Item/Position	Function
⑳	Channel B Input Connector	Used in conjunction with channel A for making ratio and time interval measurements. May be used alone for frequency measurements. See table 1.5 in Section 1 for maximum voltage inputs.
㉑	TEST/COM/SEP Switch	Input configuration switch for channels A and B. In the test position 10 MHz is applied to the inputs of both channel A and channel B. In the Com position the channel B input ⑳ is disconnected and the channel A input ㉒ is connected internally to channel B as well as channel A (in this position the measurement signal is applied to the channel A input connector). In the Sep position the inputs to channels A and B are not connected and the instrument operates normally, e.g., separate channel A and B inputs.
㉒	Channel A Input Connector	Used for each function except F_B and F_C (512 MHz). It accepts the maximum input voltages shown in table 1.5 of Section 1.
㉓	AC/DC Coupling Switch, Channel A	Selects the AC or DC coupling mode for channel A.
㉔	± Switch (Channel A Trigger Slope Switch)	When set to the plus (+) position causes channel A to trigger on the positive slope of the input signal; when set to the minus (–) position causes channel A to trigger on the negative slope of the measurement signal.
㉕	Trigger Status Indicator	Indicates, when flashing, that channel A is triggering. If the indicator remains off or remains lit it is an indication that channel A is not triggering.
㉖	RESET Switch	This is a spring return switch which serves two functions. When depressed and released it resets the counter circuits and starts a new measurement. This is most commonly used in the totalize mode but will reset the counter in any mode. When depressed and held this switch serves as a test switch and all the LED indicators of the display are lit indicating all eight's. In addition, this control causes the instrument to return to local mode unless the Local Lock Out (LLO) command has been previously transmitted by the controller (9514/9515 only)
㉗	START/STOP Switch	Used only in the totalize function and when depressed starts the count; stops the count when depressed the second time.
㉘	SAMPLE RATE/HOLD CONTROL	When set to the hold position max. ccw, the instrument is in the idle state and does not make measurement cycles. When turned in a clockwise direction from the hold position the control varies the rate at which measurement cycles are taken. Measurement cycle may be set to any repetitive rate from approximately one measurement every 5 seconds to 40 measurements per second.

Table 3.1 - Controls, Indicators and Connectors, Front Panel continued

Reference	Item/Position	Function
㉙	ns annunciator	Indicates that the display value is in nanoseconds.
㉚	μs annunciator	Indicates that the display value is in microseconds.
㉛	ms annunciator	Indicates that the display value is in milliseconds.
㉜	SEC annunciator	Indicates that the display value is in seconds.
㉝	Hz annunciator	Indicates that the display value is in Hertz.
㉞	KHz annunciator	Indicates that the display value is in kilohertz.
㉟	MHz annunciator	Indicates that the display value is in megahertz.
㊱	GATE annunciator	Indicates that the measurement gate is open.

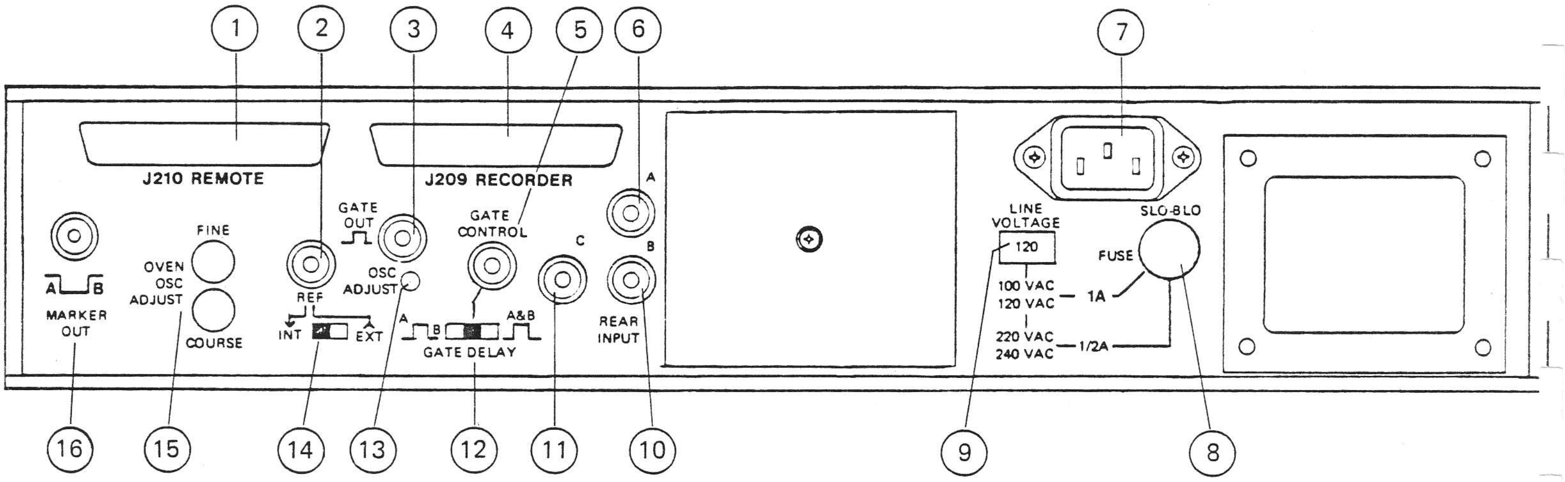


Figure 3.2 - 9512 Rear Panel Controls, Connectors and Indicators

Table 3.2 - 9512 Rear Panel Controls

Reference	Item/Position	Function
①	J210 Connector	Remote peripheral input connector.
②	REFERENCE Connector	Provides connection for external reference signal as a master clock for time base or for output of internal oscillator.
③	GATE OUT Connector	Used to sync a scope or other instrument. The signal available at this connector is a positive-going TTL pulse that is high when measurement gate is open.
④	J209 Connector	Recorder peripheral output connector.
⑤	GATE CONTROL Connector	Used to apply external gate signal to the instrument. Reference 12 below covers details of this operation.
⑥	REAR INPUT A Connector (Option 01)	Input connector for channel A, 0 to 100 MHz measurement signal.
⑦	POWER Connector	Accepts removable AC line cord.
⑧	SLO-BLO-FUSE	Holds AC line fuse, 1 amp for 110 - 120 volt operation, 1/2 amp for 220 - 240 volt operation.
⑨	LINE VOLTAGE Selector/Indicator PCB	Used to select operating line voltage and to provide external indication of the voltage selected.
⑩	REAR INPUT B Connector (Option 01)	Input connector for channel B, 0 to 100 MHz measurement signal.
⑪	REAR INPUT C Connector (Option 01)	Input connector for channel C, 50 to 512 MHz measurement signal.
⑫ See Table 3-25 for FUNCTION/GATE CONTROL COMPATIBILITY	ARMING MODE SWITCH SELECTIVE GATE POSITION A⎍B (Left Position)	A three position switch used to select the external control mode of operation. A⎍B or Selective Gate position causes the counter to arm channel A on the leading edge of the external gate signal and to arm channel B on the trailing edge of the external gate signal. The counter main gate opens on the first selected transition of the channel A input signal following the leading edge of the external gate signal. The main gate closes on the first selected transition of the channel B input signal following the trailing edge of the external gate signal.

Table 3.2 - 9512 Rear Panel Controls continued

Reference	Item/Position	Function
⑫ Continued	GATE DELAY Position (Center)	Gate Delay (center) position causes the counter main gate, once it has opened, to remain open until the external control gate has gone low.
	Synchronous Window Position A&B ⎍ (Right Position)	A&B ⎍ Synchronous Window position is used when it is desired to select a portion of a waveform to analyze. It is only used with the Time Interval Average function or Auto Trigger and it causes the counter to see only the part of the input signal which is bracketed by the control waveform.
⑬	OSC ADJUST Control	Used to adjust the frequency of the master oscillator when the instrument is not equipped with an oscillator option (see Reference 15 below).
⑭	REF Switch	Connects the internal oscillator or external reference signal to the time base circuits.
	INT Position	Connects internal oscillator to time base circuits and to the REF connector (see Description Section).
	EXT Position	Connects REF connector to time base circuits and to the REF connector (see Description Section).
⑮	FINE and COARSE OVEN OSC ADJUST	Used to adjust oven oscillator frequency if instrument is equipped with an option 22 or 24 oscillator.
⑯	MARKER OUT Connector	Provides an output signal that goes low when channel A triggers and which goes high when channel B triggers. This signal's useful for synchronizing an oscilloscope to view the waveform under measurement.

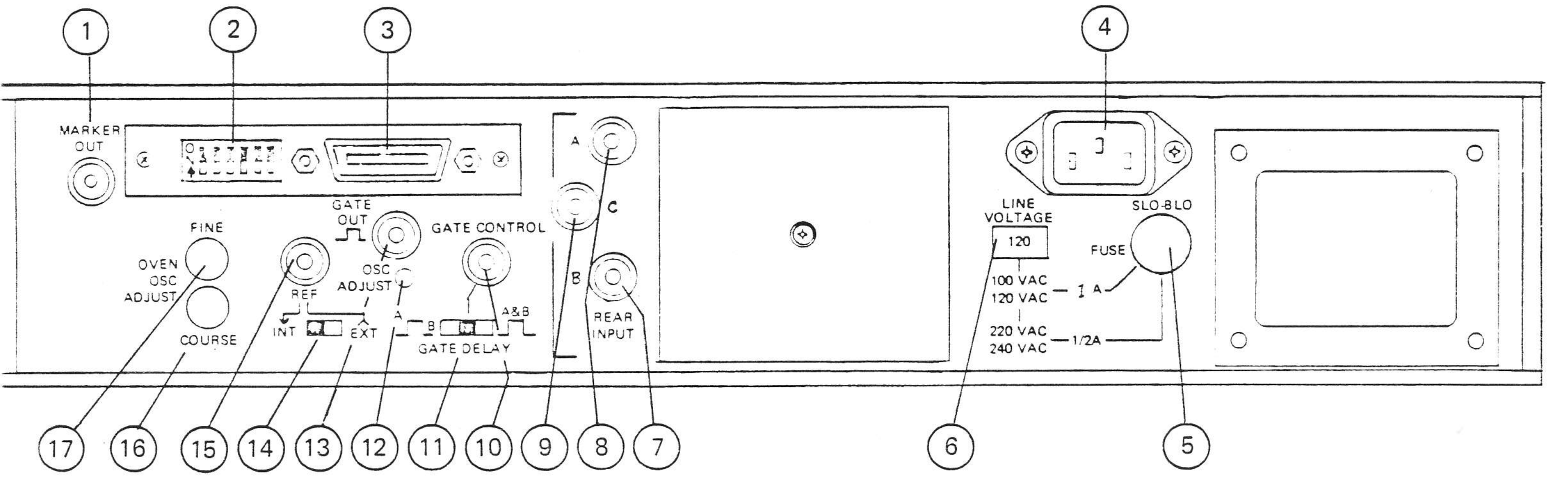


Figure 3.3 - 9514-9515 Rear Panel Controls, Connectors and Indicators

Table 3.3 - 9514-9515 Rear Panel Controls, Connectors and Indicators

Reference	Item/Position	Function
①	MARKER OUT Connector	Provides an output signal that goes low when channel A triggers and which goes high when channel B triggers. This signal's useful for synchronizing an oscilloscope to view the waveform under measurement.
②	Address Switch	Used to assign the bus address to the instrument and to control the "Talk Only" function when the instrument is used with a printer.
③	Interface Connector	Used for connecting the instrument to the IEEE-488-1975 GPIB for system operation.
④	Power Connector	Accepts removeable AC line cord.
⑤	SLO-BLO FUSE	Holds AC line fuse, 1 amp for 110-120 volt operation, 1/2 amp for 220-240 volt operation.
⑥	Line Voltage Selector/Indicator PCB	Used to select operating line voltage and to provide an external indication of the voltage selected.
⑦	Rear Input B Connector (Option 01)	Input connector for channel B, 0 to 100 MHz measurement signal.
⑧	Rear Input A Connector (Option 01)	Input connector for channel A, 0 to 100 MHz measurement signal.
⑨	Rear Input C Connector (Option 01)	Input connector for channel C, 50 to 512 MHz measurement signal.
⑩	GATE CONTROL Connector	Used to apply external gate signal to the instrument. See Reference 11 for details of operation.
⑪ See Table 3-24 for FUNCTION/GATE CONTROL COMPATIBILITY	Arming Mode Switch	A three position switch used to select the external gate control mode of operation.
	Selective Gate Position A⎍B	A⎍B or Selective Gate position causes the counter to arm channel A on the leading edge of the external gate signal and to arm channel B on the trailing edge of the external gate signal. The counter main gate opens on the first selected transition of the channel A input signal following the leading edge of the external gate signal. The main gate closes on the first selected transition of the channel B input signal following the trailing edge of the external gate signal.

Table 3.3 - 9514 - 9515 Rear Panel Controls, Connectors and Indicators continued

Reference	Item/Position	Function
See Table 3-24 for FUNCTION/GATE CONTROL COMPATIBILITY	GATE DELAY Position	Gate Delay (center) position causes the counter main gate, once it has opened, to remain open until the external control gate has gone low.
	Synchronous Window Position A & B	A & B Synchronous Window position is used when it is desired to select a portion of a waveform to analyze. It is only used with the Time Interval Average function or Auto Trigger and it causes the counter to see only the part of the input signal which is bracketed by the control waveform.
⑫	OSC ADJUST Control	Used to adjust the frequency of the master oscillator when the instrument is not equipped with an oscillator option (see Reference 16 and 17 below).
⑬	GATE OUT Connector	Used to sync a scope or other instrument. The signal available at this connector is a positive-going TTL pulse that is high when the measurement gate is open.
⑭	REF Switch	Connects the internal oscillator or external reference signal to the timebase circuits.
	INT Position	Connects internal oscillator to timebase circuits and to the REF connector (see Description Section).
	EXT Position	Connects REF connector to timebase circuits and to the REF connector (see Description Section).
⑮	REF Connector	Provides connection for external reference signal as master clock for timebase or for output of internal oscillator. See Reference 14 above.
⑯ ⑰	FINE and COARSE OVEN OSC ADJUST	Used to adjust oven oscillator frequency if instrument is equipped with an option 22 or 24 oscillator.

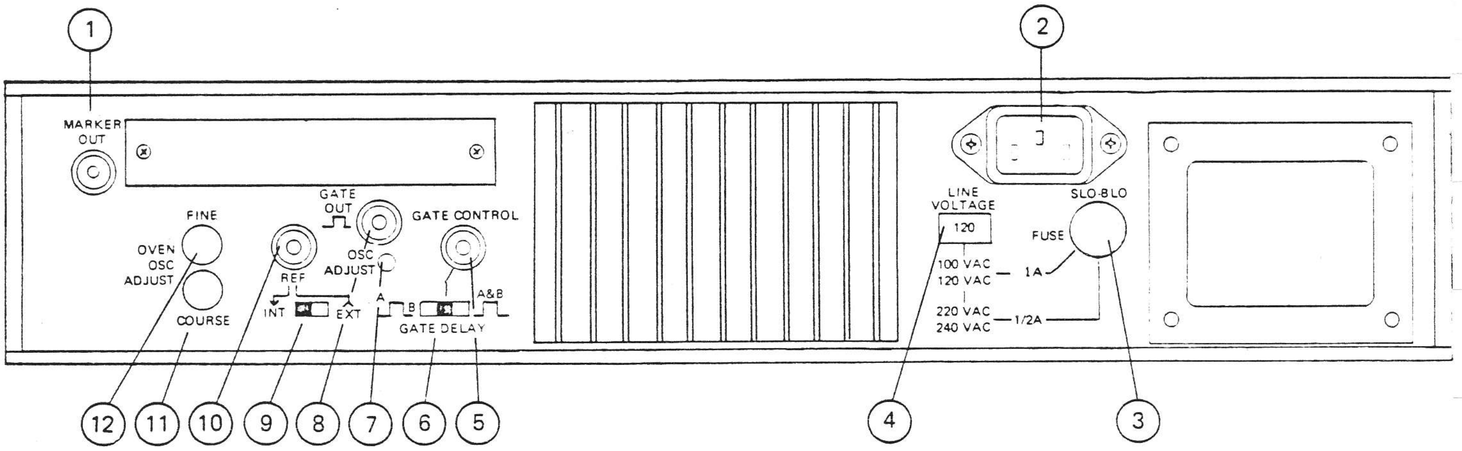


Figure 3.4 - 9510 Rear Panel Controls, Connectors and Indicators

Table 3.4 - 9510 Rear Panel Controls, Connectors and Indicators

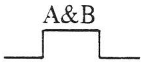
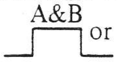
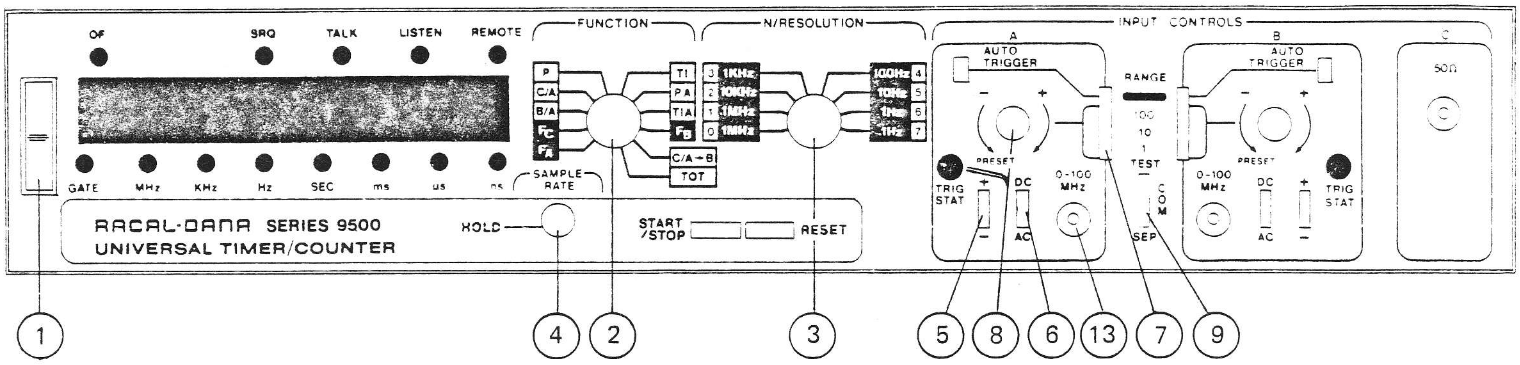
Reference	Item/Position	Function
①	MARKER OUT Connector	Provides an output signal that goes true when channel A triggers and which goes false when channel B triggers. This signal's useful for synchronizing an oscilloscope to view the waveform under measurement.
②	Power Connector	Accepts removeable AC line cord.
③	SLO-BLO FUSE	Holds AC line fuse, 1 amp for 110-120 volt operation, 1/2 amp for 220-240 volt operation.
④	Line Voltage Selector/Indicator PCB	Used to select operating line voltage and to provide an external indication of the voltage selected.
⑤	GATE CONTROL Connector	Used to apply external gate signal to the instrument. See Reference 6 for details of operation.
⑥ See Table 3-24 for FUNCTION/GATE CONTROL COMPATIBILITY	Arming Mode Switch	A three position switch used to select the external gate control mode of operation.
	Selective Gate 	 or Selective Gate position causes the counter to arm channel A on the leading edge of the external gate signal and to arm channel B on the trailing edge of the external gate signal. The counter main gate opens on the first selected transition of the channel A input signal following the leading edge of the external gate signal. The main gate closes on the first selected transition of the channel B input signal following the trailing edge of the external gate signal.
	GATE DELAY Position	Gate Delay (center) position causes the counter main gate, once it has opened, to remain open until the external control gate has gone low.
	Synchronous Window Position 	 or Synchronous Window position is used when it is desired to select a portion of a waveform to analyze. It is only used with the Time Interval Average function, and it causes the counter to see only the part of the input signal which is bracketed by the control waveform.
⑦	OSC ADJUST Control	Used to adjust the frequency of the master oscillator when the instrument is not equipped with an oscillator option (see Reference 16 and 17 below).
⑧	GATE OUT Connector	Used to sync a scope or other instrument. The signal available at this connector is a positive-going TTL pulse that is high when the measurement gate is open.
⑨	REF Switch	Connects the internal oscillator or external reference signal to the timebase circuits.
	INT Position	Connects internal oscillator to timebase circuits and to the REF connector (see Description Section).

Table 3.4 - 9510 Rear Panel Controls, Connectors and Indicators continued

Reference	Item/Position	Function
	EXT Position	Connects external REF connector to timebase circuits and disconnects internal oscillator (see Description Section).
⑩	REF Connector	Provides connection for external reference signal as master clock for timebase or for output of internal oscillator. See Reference 14 above.
⑪⑫	FINE and COARSE OVEN OSC ADJUST	Used to adjust oven oscillator frequency if instrument is equipped with an option 22A or 24A oscillator.

Table 3.5 - Calibration Check



① Connect AC power and set power switch to the on position.

② Set FUNCTION switch to FA.

③ Set N/RESOLUTION switch to .1 Hz.

④ Set SAMPLE RATE control to the maximum ccw position that can be attained without setting it to the hold position.

⑤ Set the channel A slope switch to the + position.

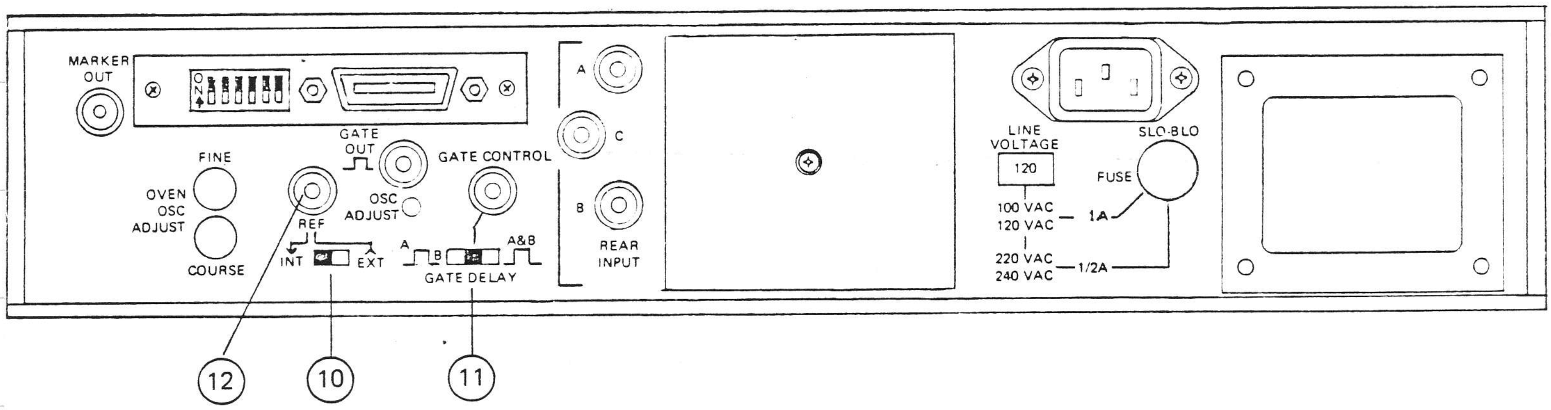
⑥ Set the channel A coupling switch to the AC position.

⑦ Set the channel A trigger RANGE switch to the 1 position.

⑧ Set the channel A trigger level control to the PRESET (full ccw) position.

⑨ Set the input configuration switch to the SEP position.

Table 3.5 - Calibration Check continued



⑩ Set the REF switch to the INT position.

⑪ Set the GATE DELAY switch to the gate delay (center) position.

⑫ Connect an oscilloscope to the REF connector and observe the internal reference oscillator waveform. It should be a TTL compatible square wave with a frequency of 10 MHz.

⑬ Apply a 10 MHz, 1 Vrms reference standard signal to the channel A input connector.

NOTE

If a 10 MHz reference standard signal is not available and option 10 is not installed in the instrument, a 5 MHz or 1 MHz signal may be substituted. The display reading must be multiplied by 2 or by 10 before comparison with the performance standards shown below. (Models 9510, 9512 and 9514 only).

The difference between the Internal Counter Reference oscillator and the 10 MHz Frequency Standard can be determined by the following formula (20 000 000.–Display Reading) = the Internal oscillator frequency in hertz.

Typical Counter Reference Oscillator Difference for Standard Oscillator

Display	Internal Reference Oscillator	Frequency Error
9999995.0	10000.0050	5.0 Hz high
9999997.5	10000.0025	2.5 Hz high
10000000.0	10000.0000	on Frequency
10000002.5	9999.9975	2.5 Hz low
10000005.0	9999.9950	5.0 Hz low

3.2.9 General Operation Troubleshooting And Pretest Procedure.

3.2.9.1 The following paragraphs contain troubleshooting procedures for use in the event an instrument appears to be operating improperly. The troubleshooting procedures are organized in three general catagories; (1) general operation, (2) bench operation and (3) remote operation. If an instrument appears to be operating abnormally or fails to operate refer to the appropriate troubleshooting procedure to check control settings and input signals. To perform the general operations troubleshooting procedure, proceed as follows:

1. Verify that the line voltage select card is set to the desired line voltage position.
2. Verify that the AC power fuse has not been blown.
3. Check to see that the AC line cord is properly connected.
4. Verify that the power switch is set to the ON position and that the power indicator is lit.
5. Verify that the SAMPLE RATE control is <u>not</u> in the hold position.
6. Verify that the arming mode switch on the rear panel is set to the GATE DELAY position (center position).
7. Verify that the REF switch on the rear panel is set to the INT position.
8. Depress the reset push button and verify that the display shows all 8's.
9. Perform the F_A one-second test as follows:
   a. Set the function switch to F_A.
   b. Set the range to 1 Hz.
   c. Set the input configuration switch on the front panel (Reference (21) in Figure 3.1) to the test position.
   d. Verify that the display indicates 10000000 hertz.

3.2.9.2 BENCH OPERATION TROUBLESHOOTING.

1. Perform General Operation Troubleshooting and Pretest Procedure.
2. <u>Main gate not operating in F_A Function</u> but gate operates properly when the instrument is placed in F_B function. This can result from insufficient channel A input signal. The 9500 Series counter/timers utilize a "Positive Arm" Trigger technique for channel A; the main gate operates only when channel A is triggered.

   Conversely, the counter gate operates continuously in F_B function even though channel B has no signal input. Check the setting of the channel A TRIGGER LEVEL and RANGE controls. If the symptoms appear when using the Model 9514 or 9515 in Autotrigger mode, observe the input signal on a scope to verify that there is sufficient signal amplitude to trigger the instrument. Input sensitivity varies depending on the function, input signal frequency and waveform. Refer to Table following paragraph 3.2.9.3, 3b for sensitivity specifications.
3. <u>Channel C inoperative.</u> The channel C input connector contains a fuse to protect the signal conditioning circuits. If an over voltage input signal has blown this fuse the channel will not operate. To replace the channel C fuse proceed as follows:
   a. Remove the channel C BNC input connector from the front or rear panel, depending on which input is inoperative. The BNC connector is equipped with a 7/16" hex shoulder and may be unscrewed (in ccw direction) with a wrench. The fuse, part number 920364 is located inside the shell of the connector.
   b. Remove the fuse and check it for continuity. Replace if defective and reinstall the connector.

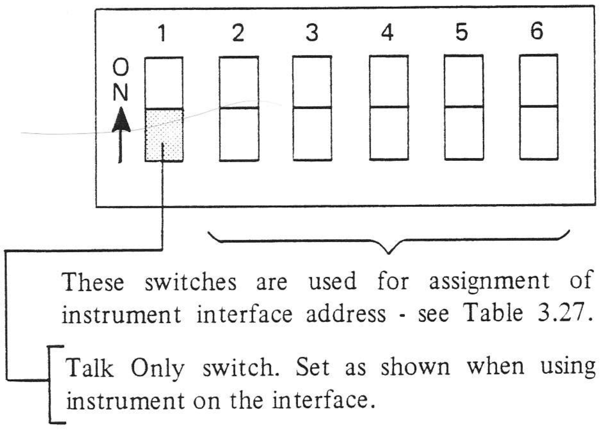
3.2.9.3 REMOTE OPERATING TROUBLESHOOTING, MODEL 9514 AND 9515.

1. Perform the General Operation Troubleshooting and Pretest Procedure.
2. <u>TALK annunciator lit continuously.</u> This can result from setting the Talk Only switch to the "1" position. Check the setting of this switch.

3. Instrument will not respond to bus commands sent by controller. Check the following:

   a. Verify that the correct bus address has been set on the address switch which is located on the rear panel of the instrument. Refer to Table 3.27 for the appropriate switch setting for any given decimal address.

   b. Verify that the "Talk Only" switch is set to the "0" position as shown below.



These switches are used for assignment of instrument interface address - see Table 3.27.

Talk Only switch. Set as shown when using instrument on the interface.

   c. Verify that the interface bus connector is properly seated in the rear panel bus connector (Ref. ③ , Figure 3.3, Table 3.3).

   d. Verify that the LISTEN annunciator is active.

   e. Verify that the REMOTE annunciator is active (lit or lites periodically) indicating receipt of the listen address when remote enable (REN) is asserted by the controller.

   f. If the controller program includes a "Talker" mode, verify that the TALK annunciator is active.

   g. If the controller program includes an interrupt or service request (SRQ) mode, verify that the SRQ annunciator is active.

3.2.10 Frequency Measurement.

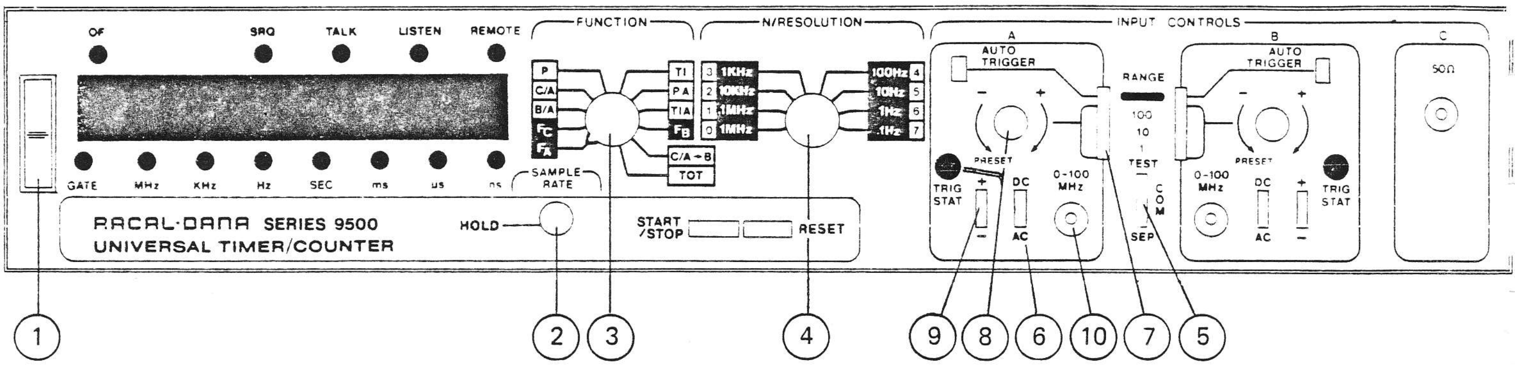
3.2.10.1 The instrument will measure the frequency of a signal applied to channel A, B or C. If the frequency is between zero and 100 MHz, channel A should normally be used. Channel A is designed for Positive Arm operation; it will not trigger the measurement gate unless a measurement signal of sufficient amplitude is applied. Operating instructions and an application example are presented in Table 3.6.

3.2.10.2 Channel B is designed for Continuous Arm measurement regardless of the input amplitude. Thus, in F_B mode if a signal of insufficient amplitude is applied the instrument may produce innaccurate measurements or the display might indicate all zeros. An application example and operating instructions are provided in Table 3.7.

3.2.10.3 Channel C is used, if Option 41 is installed, for frequencies between 50 MHz and 512 MHz or, for frequencies to 1.25 GHz if Option 42 is installed. Channel C is designed for Positive Arm measurement operation. Channel C operating instructions are shown in Table 3.8.

3.2.10.4 Channel C may be used for Gated Count measurements for measuring a selected burst of RF by using the C/A→B function. In this mode the opening and closing of the measurement gate is controlled by the channel A and channel B triggering. An example of Gated Count operation is presented in Table 3.16.

Table 3.6 - Frequency A Operating Instructions



① Connect AC power and set the power switch to the on position.

② Set SAMPLE RATE control to a convenient display interval (see Table 3.1).

③ Set the FUNCTION switch to F_A.

④ Set the N/RESOLUTION switch to desired gate time (0.1 Hz = 10 sec, 1 Hz = 1 sec, etc., see Table 3.1).

⑤ Set the input configuration switch to SEP.

⑥ Set AC/DC coupling to AC or DC. Use DC coupling for bursts or pulse trains with a DC offset and for frequencies less than 20 Hz. Use AC coupling for other waveforms, including CW at frequencies above 20 Hz.

⑦ Set INPUT CONTROL range switch to be compatible with the input signal amplitude (1, 10 or 100 volt range, see Table 3.1). On model 9514 set the switch to the auto trigger position and press AUTO TRIGGER pushbutton after connecting input signal. See Table 3.24.

⑧ Set channel A level control to desired trigger level or to PRESET to trigger at zero volts.

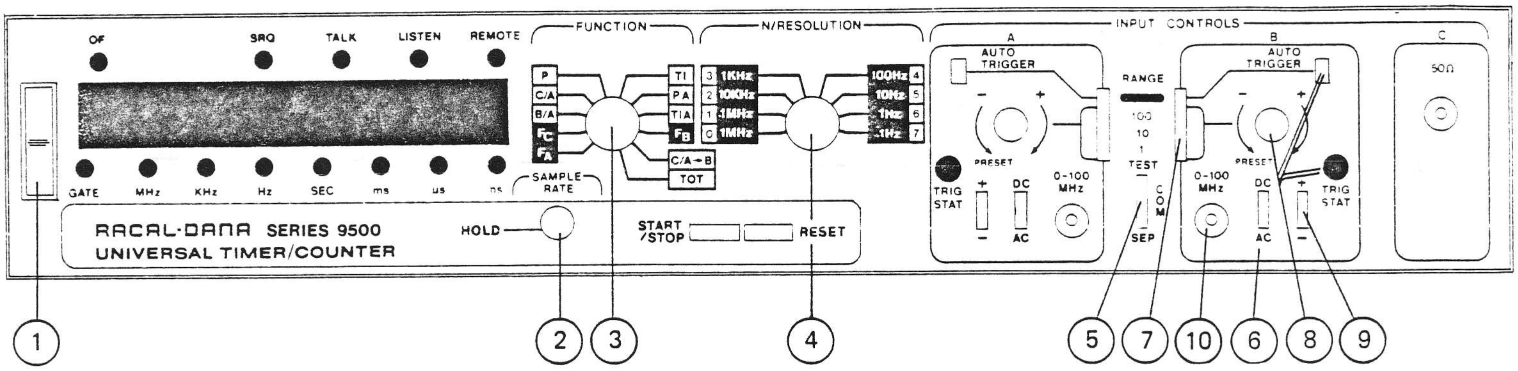
⑨ Set the A slope to (+) plus.

⑩ Connect input signal (0 to 100 MHz) to channel A input connector. Note: Max. inputs are shown in Table 1.4. Do not exceed.

Example. Input frequency to be measured is 600 hertz at 8 volts peak to peak. The N/RESOLUTION is set to 1 Hz. Input voltage range is set to 10 volts, trigger level to PRESET, slope to plus and AC/DC to AC. Display will be 600 Hz with 1 hertz resolution. Change the RESOLUTION to .1 Hz, the display will be 600.0 Hz.

NOTE: A much faster measurement technique would be to use the PERIOD mode and measure the period of the signal.

Table 3.7 - Frequency B Operating Instructions



① Connect AC power and set the power switch to the on position.

② Set SAMPLE RATE control to a convenient display interval (see Table 3.1).

③ Set the FUNCTION switch to F_B.

④ Set the N/RESOLUTION switch to desired gate time (0.1 Hz = 10 sec, 1 Hz = 1 sec, etc., see Table 3.1).

⑤ Set the input configuration switch to SEP.

⑥ Set AC/DC coupling to AC or DC. Use DC coupling for bursts or pulse trains with a DC offset and for frequencies below 20 Hz. Use AC coupling for other waveforms, including CW at frequencies above 20 Hz.

⑦ Set INPUT CONTROL range switch to be compatible with the input signal amplitude (1, 10 or 100 volt range, see Table 3.1).

⑧ Set channel B level control to desired trigger level or to PRESET to trigger at zero volts. On model 9514 the AUTO TRIGGER feature may be used as described in Table 3.24.

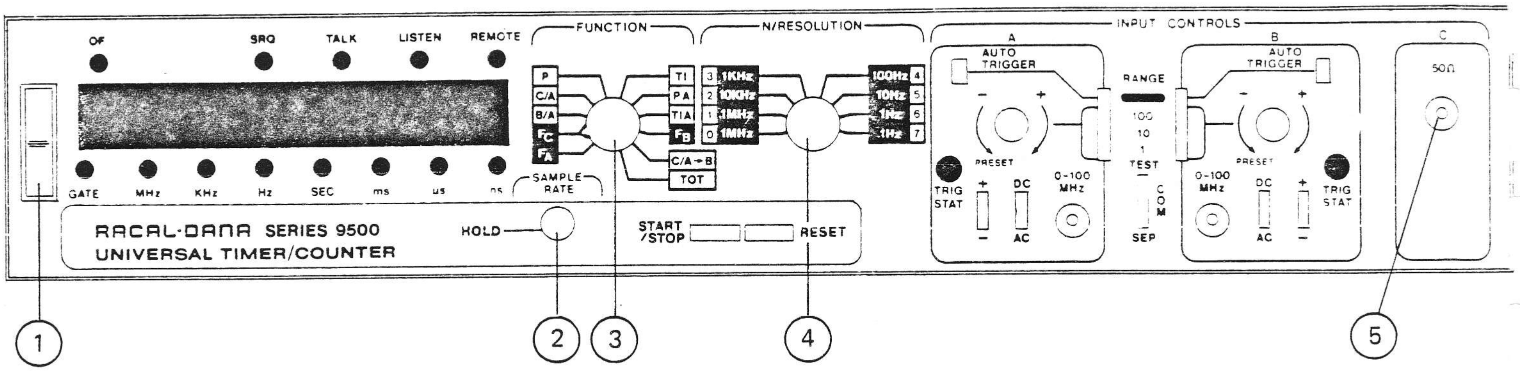
⑨ Set the B slope to (+) plus.

⑩ Connect input signal (0 to 100 MHz) to channel B input connector. Note: Max. inputs are shown in Table 1.4. Do not exceed.

Example. Input frequency to be measured is 600 hertz at 8 volts peak to peak. The N/RESOLUTION is set to 1 Hz. Input attenuator range is set to 10 volts, trigger level to PRESET, slope to plus and AC/DC to AC. Display will be 600 Hz with 1 hertz resolution. Change the RESOLUTION to .1 Hz, the display will be 600.0 Hz.

NOTE: A much faster measurement technique would be to use the PERIOD mode and measure the period of the signal.

Table 3.8 - Frequency C Operating Instructions



① Connect AC power and set the power switch to the on position.

② Set the SAMPLE RATE control for desired display interval.

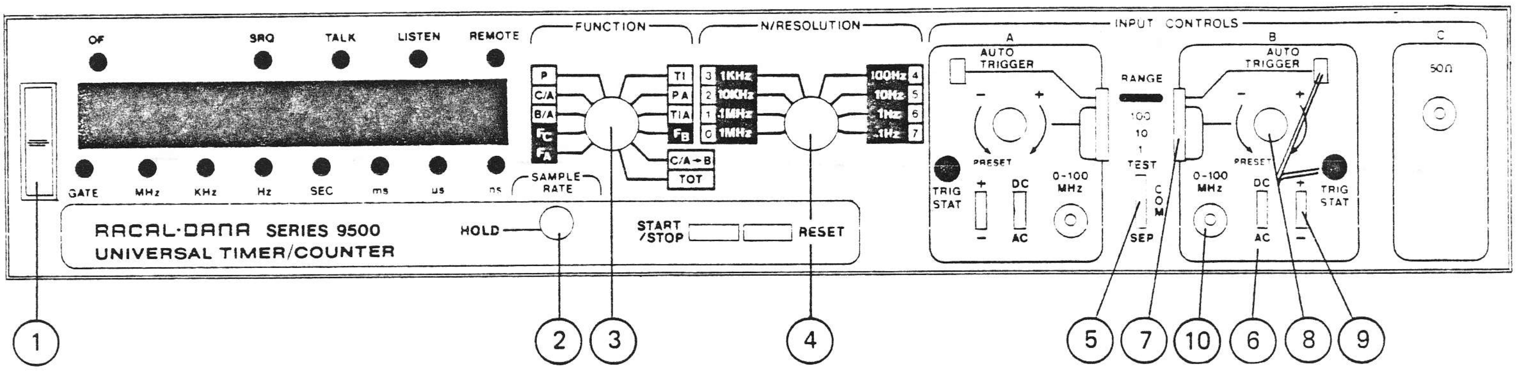
③ Set the FUNCTION switch to the F_C position.

④ Set the N/RESOLUTION switch to the desired gate time or resolution (see Table 3.1).

⑤ Connect the input signal from 50 to 512 MHz in frequency to channel C input. Note: Max. input operating input is 1V rms. Max. input without damage is 5V rms. When Option 42 is installed the upper frequency limit is 1.25 GHz.

Example: Input frequency to be measured is 200 MHz at .5Vrms. The N/RESOLUTION is set to 10 Hz. The trigger level setting is automatic in F_C function. The display will be 200000.00 KHz with 10 Hz resolution.

Table 3.7 - Frequency B Operating Instructions



① Connect AC power and set the power switch to the on position.

② Set SAMPLE RATE control to a convenient.display interval (see Table 3.1).

③ Set the FUNCTION switch to F_B.

④ Set the N/RESOLUTION switch to desired gate time (0.1 Hz = 10 sec, 1 Hz = 1 sec, etc., see Table 3.1).

⑤ Set the input configuration switch to SEP.

⑥ Set AC/DC coupling to AC or DC. Use DC coupling for bursts or pulse trains with a DC offset and for frequencies below 20 Hz. Use AC coupling for other waveforms, including CW at frequencies above 20 Hz.

⑦ Set INPUT CONTROL range switch to be compatible with the input signal amplitude (1, 10 or 100 volt range, see Table 3.1).

⑧ Set channel B level control to desired trigger level or to PRESET to trigger at zero volts. On model 9514 the AUTO TRIGGER feature may be used as described in Table 3.24.

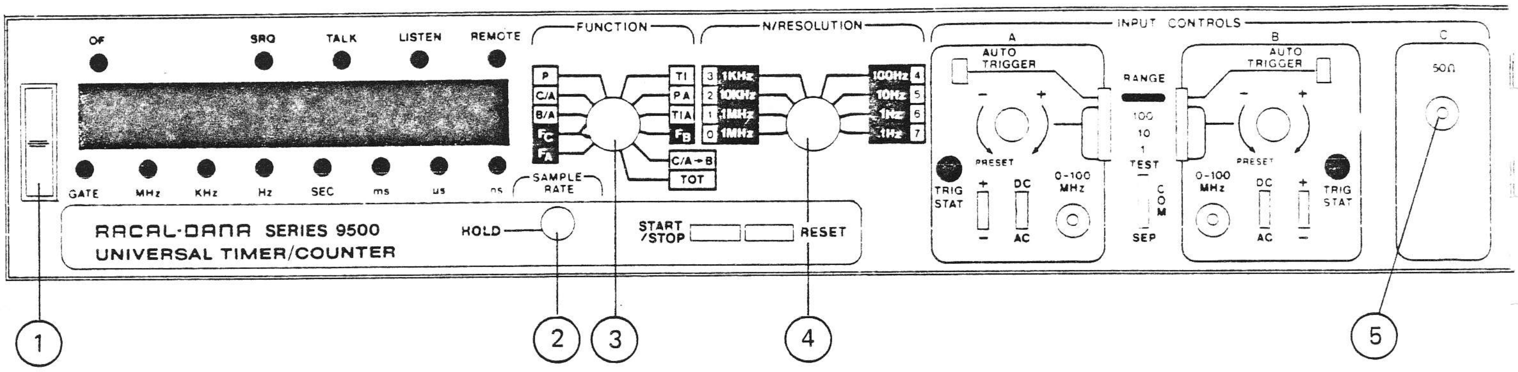
⑨ Set the B slope to (+) plus.

⑩ Connect input signal (0 to 100 MHz) to channel B input connector. Note: Max. inputs are shown in Table 1.4. Do not exceed.

Example. Input frequency to be measured is 600 hertz at 8 volts peak to peak. The N/RESOLUTION is set to 1 Hz. Input attenuator range is set to 10 volts, trigger level to PRESET, slope to plus and AC/DC to AC. Display will be 600 Hz with 1 hertz resolution. Change the RESOLUTION to .1 Hz, the display will be 600.0 Hz.

NOTE: A much faster measurement technique would be to use the PERIOD mode and measure the period of the signal.

Table 3.8 - Frequency C Operating Instructions



① Connect AC power and set the power switch to the on position.

② Set the SAMPLE RATE control for desired display interval.

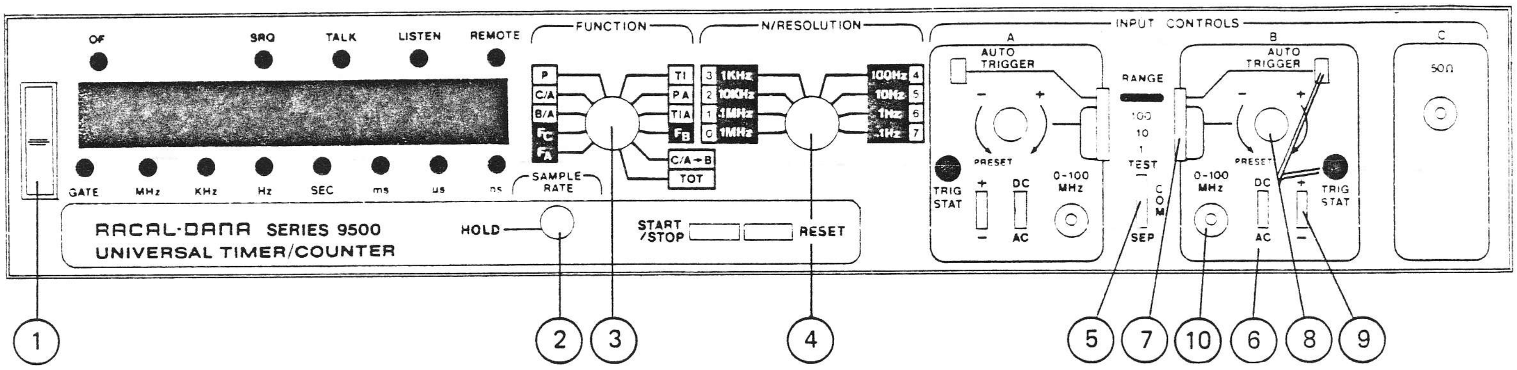
③ Set the FUNCTION switch to the F_C position.

④ Set the N/RESOLUTION switch to the desired gate time or resolution (see Table 3.1).

⑤ Connect the input signal from 50 to 512 MHz in frequency to channel C input. Note: Max. input operating input is 1V rms. Max. input without damage is 5V rms. When Option 42 is installed the upper frequency limit is 1.25 GHz.

Example: Input frequency to be measured is 200 MHz at .5Vrms. The N/RESOLUTION is set to 10 Hz. The trigger level setting is automatic in F_C function. The display will be 200000.00 KHz with 10 Hz resolution.

Table 3.7 - Frequency B Operating Instructions



① Connect AC power and set the power switch to the on position.

② Set SAMPLE RATE control to a convenient display interval (see Table 3.1).

③ Set the FUNCTION switch to F_B.

④ Set the N/RESOLUTION switch to desired gate time (0.1 Hz = 10 sec, 1 Hz = 1 sec, etc., see Table 3.1).

⑤ Set the input configuration switch to SEP.

⑥ Set AC/DC coupling to AC or DC. Use DC coupling for bursts or pulse trains with a DC offset and for frequencies below 20 Hz. Use AC coupling for other waveforms, including CW at frequencies above 20 Hz.

⑦ Set INPUT CONTROL range switch to be compatible with the input signal amplitude (1, 10 or 100 volt range, see Table 3.1).

⑧ Set channel B level control to desired trigger level or to PRESET to trigger at zero volts. On model 9514 the AUTO TRIGGER feature may be used as described in Table 3.24.

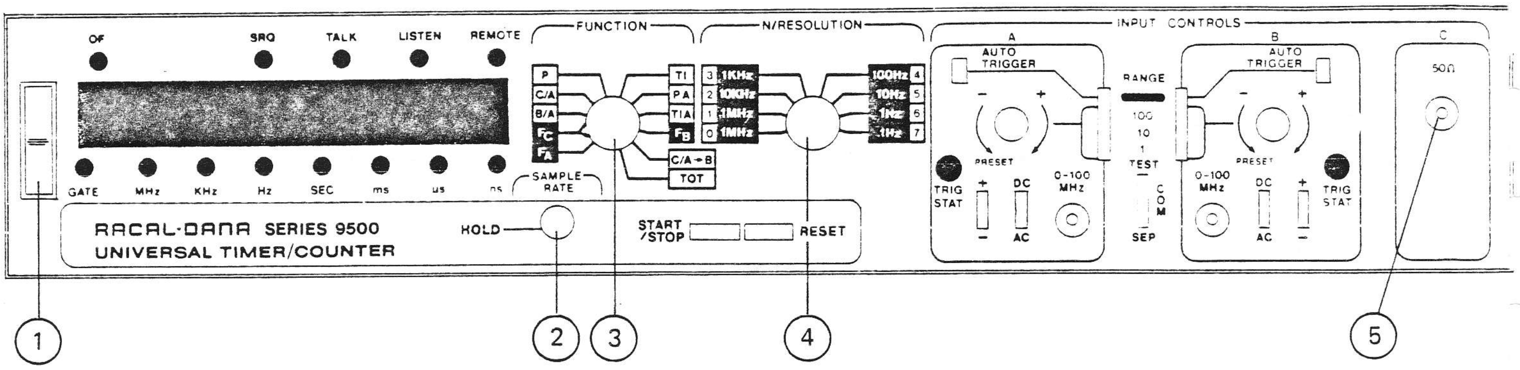
⑨ Set the B slope to (+) plus.

⑩ Connect input signal (0 to 100 MHz) to channel B input connector. Note: Max. inputs are shown in Table 1.4. Do not exceed.

Example. Input frequency to be measured is 600 hertz at 8 volts peak to peak. The N/RESOLUTION is set to 1 Hz. Input attenuator range is set to 10 volts, trigger level to PRESET, slope to plus and AC/DC to AC. Display will be 600 Hz with 1 hertz resolution. Change the RESOLUTION to .1 Hz, the display will be 600.0 Hz.

NOTE: A much faster measurement technique would be to use the PERIOD mode and measure the period of the signal.

Table 3.8 - Frequency C Operating Instructions



① Connect AC power and set the power switch to the on position.

② Set the SAMPLE RATE control for desired display interval.

③ Set the FUNCTION switch to the F_C position.

④ Set the N/RESOLUTION switch to the desired gate time or resolution (see Table 3.1).

⑤ Connect the input signal from 50 to 512 MHz in frequency to channel C input. Note: Max. input operating input is 1V rms. Max. input without damage is 5V rms. When Option 42 is installed the upper frequency limit is 1.25 GHz.

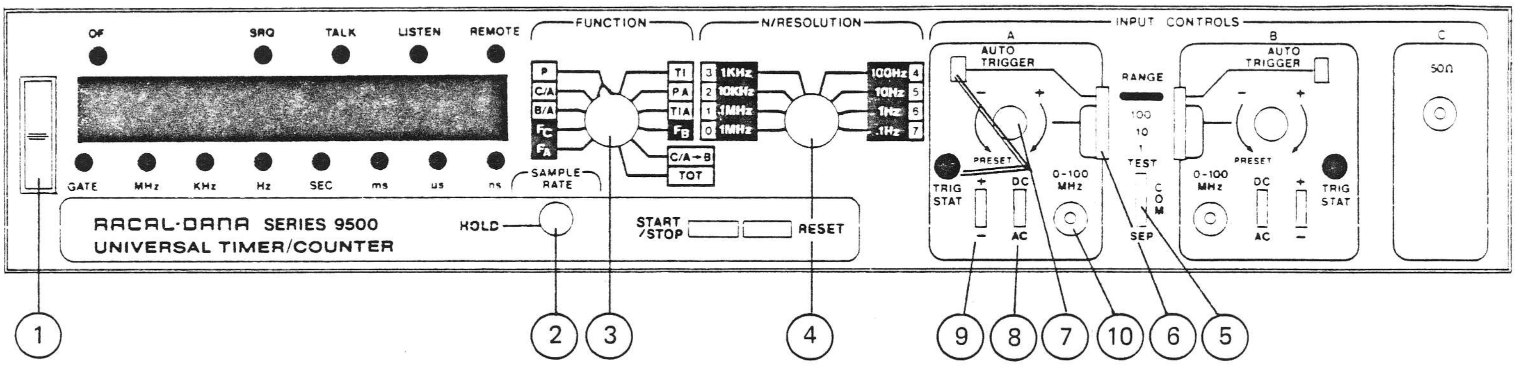
Example: Input frequency to be measured is 200 MHz at .5Vrms. The N/RESOLUTION is set to 10 Hz. The trigger level setting is automatic in F_C function. The display will be 200000.00 KHz with 10 Hz resolution.

3.2.11 Period Measurement.

3.2.11.1 The Period function is used to measure the period of time required for one complete cycle of an input signal and is the reciprocal of the frequency of the input signal. For low frequency measurements ($\leq$ 10 KHz) more resolution can be obtained in a reasonable time by measuring the period of the signal and arithmatically deriving the reciprocal (1/f). Operating instructions for the period measurement function and an example are presented in Table 3.9.

3.2.11.2 The Period Average function permits the measurement of repetitive waveforms to higher resolution than can be obtained using the Period mode. Table 3.10 presents operating instructions and a typical measurement example.

Table 3.9 - Period Operating Instructions



① Connect AC power and set the power switch to the on position.

② Set SAMPLE RATE control to a convenient display interval.

③ Set the FUNCTION switch to P.

④ Set the N switch to the desired time units to be counted. See Table 3.1.

⑤ Set the SEP/COM to SEP.

⑥ Set the channel A INPUT RANGE switch to be compatible with the input signal amplitude or to Auto (9514-9515). See Table 3.24.

⑦ Set the channel A trigger level control to the desired trigger level or to PRESET to trigger at ≅ (0) zero volts and verify that the TRIG STAT indicator is active. On the model 9514 or 9515 the AUTO TRIGGER feature may be used as described in Table 3.24.

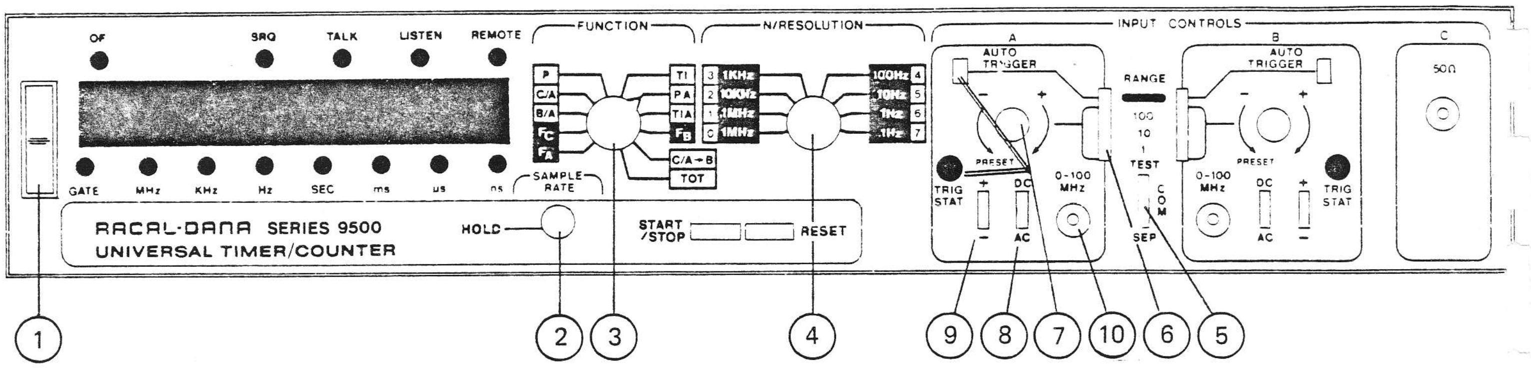
⑧ Set the AC/DC coupling to AC or DC on channel A.

⑨ Set the A slope to (+) plus or (−) minus.

⑩ Connect the input signal to channel A input jack.

Example: Input PERIOD to be measured is 1 millisecond at 1V peak. The N switch is set to 0. The channel A INPUT RANGE switch is set to the 1-volt range, trigger level is set to the PRESET position and AC/DC is set to AC. The display will read 1000.0 microseconds with 100 nanoseconds resolution on the 9514 Model, or 1000.00 microseconds with 10 nanoseconds resolution on the 9515 Model.

Table 3.10 - Period Average Operating Instructions



① Connect the AC power and set the power switch to the on position.

② Set SAMPLE RATE control to a convenient display interval.

③ Set the FUNCTION switch to PA.

④ Set the N/RESOLUTION switch to the desired time multiplier position (see Table 3.1).

⑤ Set the SEP/COM switch to SEP.

⑥ Set the channel A INPUT RANGE switch to match the input signal amplitude. On model 9514 and 9515 the AUTO TRIGGER feature may be used as described in Table 3.24.

⑦ Set the channel A level control to the desired trigger level or to PRESET to trigger at ≅ (0) zero volts.

⑧ Set the AC/DC coupling to AC or DC on channel A.

⑨ Set the channel A slope to (+) or (–) minus.

⑩ Connect the input signal to channel A input jack.

Example: Input period to be measured is 1 millisecond at 1V peak. The N is set to 0. The channel A input range switch is set to the 1 volt range, the trigger level is set to the PRESET position and AC/DC is set to AC. The display is 1000.0 microseconds with 100 nanoseconds resolution. Turn the N multiplier switch to 1. The display will be 1000.00 microseconds with 10 nanosecond resolution, or one nanosecond on the 9515 Model.

3.2.12 Time Interval Measurement.

3.2.12.1 The Time Interval function is used to measure the elapsed time between two separate electrical events. The events may be on separate signals applied to channels (A and B) or they may be on the same signal and applied to channel A with the channel inputs in common mode configuration. An example of time interval measurement application and operating instructions are presented in Table 3.10.

3.2.12.2 The Time Interval Average function provides greater resolution than the TI mode, when measuring repetitive inputs that are asynchronous with the counters internal reference oscillator (10 MHz). If the input signal approaches a sub-harmonic of the reference frequency, a greater number of time intervals will have to be averaged to achieve good accuracy. The accuracy is found by use of the following equation for Models 9510, 9512 and 9514.

$$\pm \text{Reference error} \pm 2 \text{ nsec} \pm \frac{(\text{Trigger error} \pm 100 \text{ nsec})}{\sqrt{\text{No. of Intervals Averaged}}}$$

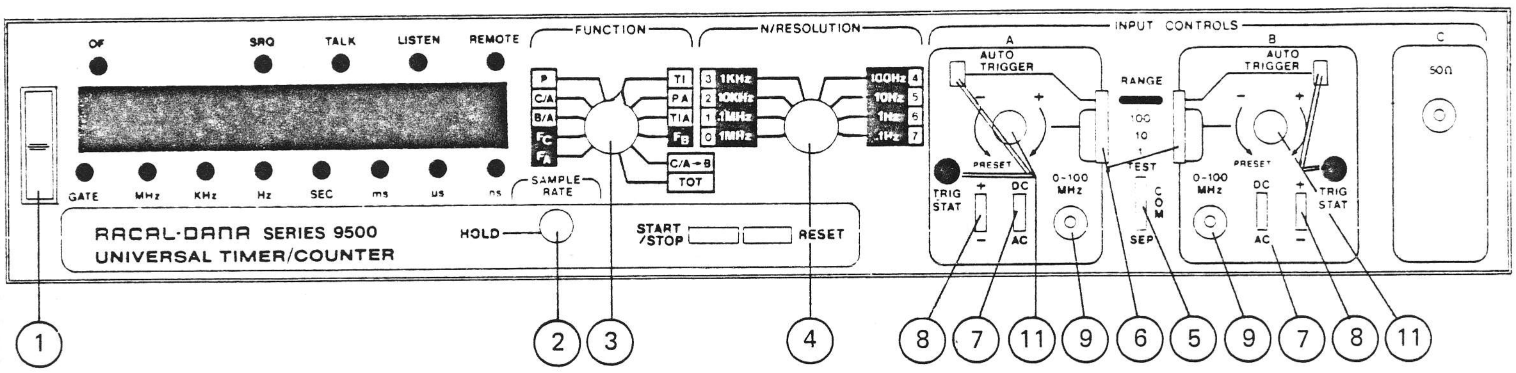
For Model 9515, the reference oscillator is 100 MHz, the formula becomes;

$$\frac{\text{Trigger error} \pm 10 \text{ nsec}}{\text{No. of Intervals Averaged}}$$

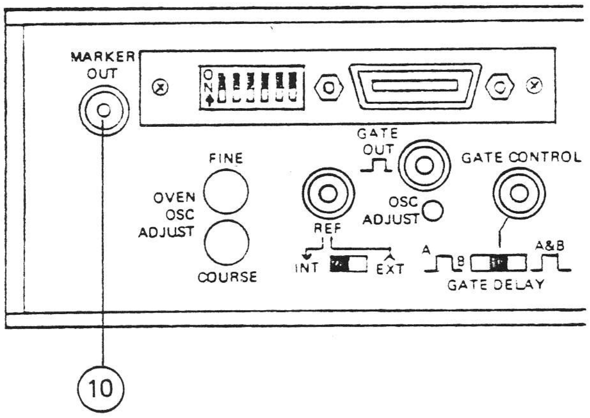
$$\text{where} \qquad \text{Trigger error} = \frac{\leq 0.0025\ \mu\text{sec}}{\text{Signal slope (V/}\mu\text{sec)}}$$

Operating instructions and a measurement example are presented in Table 3.12.

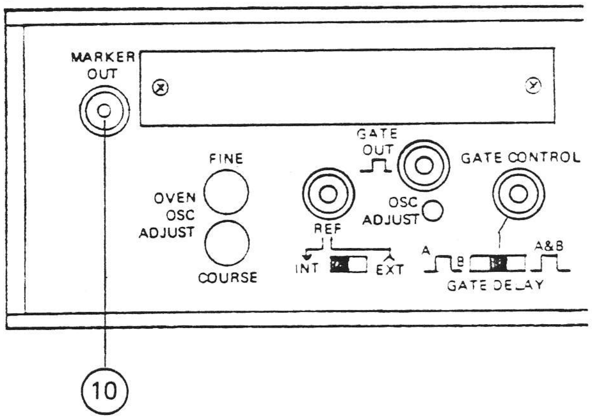
Table 3.11 - Time Interval Operating Instructions



9514 Rear Panel



9510 Rear Panel



① Connect the AC power and set the power switch to the on position.

② Set SAMPLE RATE potentiometer to a convenient display interval.

③ Set the FUNCTION switch to the TI position.

④ Set the N/RESOLUTION switch to the desired position. See Table 3.1.

⑤ Set the input configuration switch to the appropriate position for the measurement to be performed. Use SEP when "start" and "stop" points are on two different signals. Use COM when "start" and "stop" points are both on one signal.

⑥ Set the channels A and B INPUT CONTROL range switches to be compatible with the input signal amplitude. On 9514 the AUTO TRIGGER feature may be used as described in Table 3.24.

⑦ Set channel A and B coupling switches to desired setting.

⑧ Set +/– slope switches to desired setting.

⑨ Connect input signal to channel A input. If two input signals are used connect the second signal to channel B input.

⑩ To use the MARKER of the counter, tee-off the input signal of channel A input and connect to oscilloscope. Use the MARKER OUT signal to trigger channel B of the scope.

⑪ Adjust channel A and B trigger level controls to desired "start" and "stop" trigger voltages. To Auto Trigger 9514, just push the Auto Trigger button (see Table 3.24).

Example: The input waveform is a TTL level pulse train with a 20% duty cycle and a repetition rate of 1 KHz. To measure the pulse width of the positive pulse: set the N/RESOLUTION switch to 1, A + B coupling to DC, channel A slope +, triggering range of channels A + B to 1, channel B slope –, input configuration to SEP and adjust both TRIGGER LEVEL controls for stable triggering. The display should read approximately 200 μ sec.

Table 3.12 - Time Interval Average Operating Instructions

To use the Time Interval Average function of the instrument proceed as follows:

① Set the controls as shown in Table 3.11 with the exception of the FUNCTION control (Step 3), the N/RESOLUTION control (Step 4) and the use of the MARKER OUT signal (Step 10).

② Set the FUNCTION control to TIA.

③ Set the N/RESOLUTION control for the desired number of intervals to be averaged (see table 3.1).

NOTE

The maximum TI function resolution for Models 9510, 9512 and 9514 is 100 nsec and 10 nsec for Model 9515. The TIA function increases resolution to 100 Psec for Model 9515.

NOTE

Dead time of 200 nsec occurs between channel B trigger and channel A trigger. No TIA measurements can be made on events closer in time than 200 nsec apart. This limitation refers to the stop-to-start time. The dead time is 50 nSec for Model 9515.

Example: The propagation delay in a length of coax cable is to be measured. A 1 MHz square wave (with at least 1V amplitude and less than 10 ns rise time) is connected to the channel A input through a 50 Ω tee. One end of the cable to be measured is connected to that tee and the other end is connected to the channel B input. Set the input configuration switch to SEP. On each channel, set the coupling switch to AC, the slope switch to +, range to 1, and trigger level to preset. The N/RESOLUTION switch should be set to 6 or 7 for best accuracy.

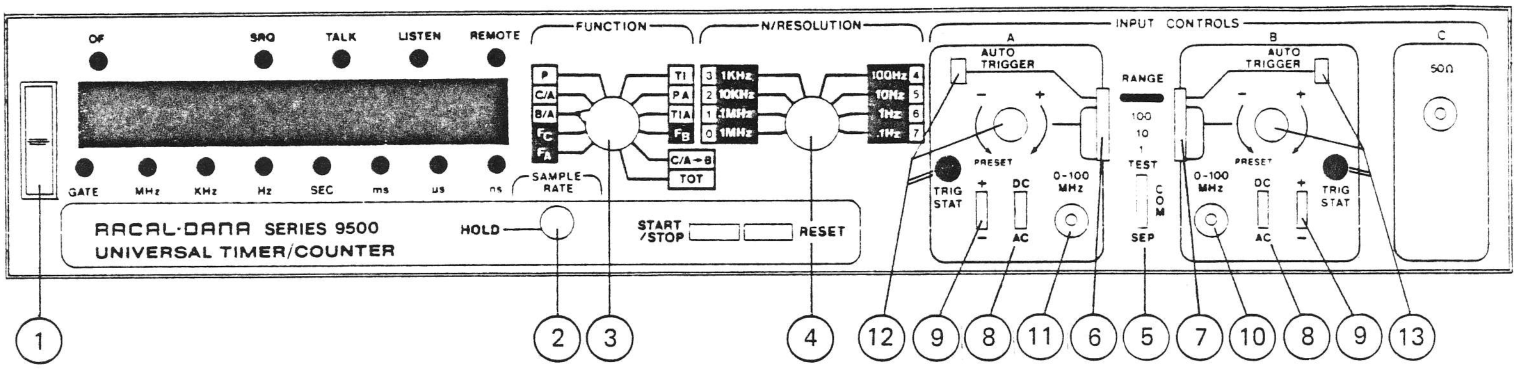
For best results, the cable and the tee should be terminated where they connect to channels A and B. A cable five feet long should measure approximately 2.4 nsec.

3.2.13 Ratio Measurement.

3.2.13.1 The ratio B/A function enable the user to measure directly the ratio between two frequencies with total slope, range, coupling and trigger level control of both the signal and reference input. For an application example and operating instructions for the Ratio B/A mode refer to Table 3.13.

3.2.13.2 The ratio C/A provides capability for measuring the ratio of a high frequency signal (50 MHz to 512 MHz or 50 MHz to 1.25 GHz, depending on which high frequency option is installed) to a signal with a frequency between zero and 10 MHz. Unlike the B/A mode, the channel C input does not provide for control of slope, range, coupling or trigger level. Operating instructions and an application example are presented in Table 3.14.

Table 3.13 - Ratio B/A Operating Instructions



① Connect AC power and set the power switch to the on position.

② Set the SAMPLE RATE control for the desired display interval.

③ Set the FUNCTION switch to B/A.

④ Set the N/RESOLUTION switch to the desired resolution (see Table 3.1).

⑤ Set the input configuration switch to SEP.

⑥ Set the channel A INPUT CONTROL range switch to match the input signal amplitude. On Model 9514 the AUTO TRIGGER feature may be used as described in Table 3.24.

⑦ Set the channel B INPUT CONTROL range switch to match the input signal amplitude.

⑧ Set channels A and B couplings to AC or DC.

⑨ Set channels A and B slopes to (+) plus or (–) minus.

⑩ Connect the higher frequency input (0 - 100 MHz) to channel B.

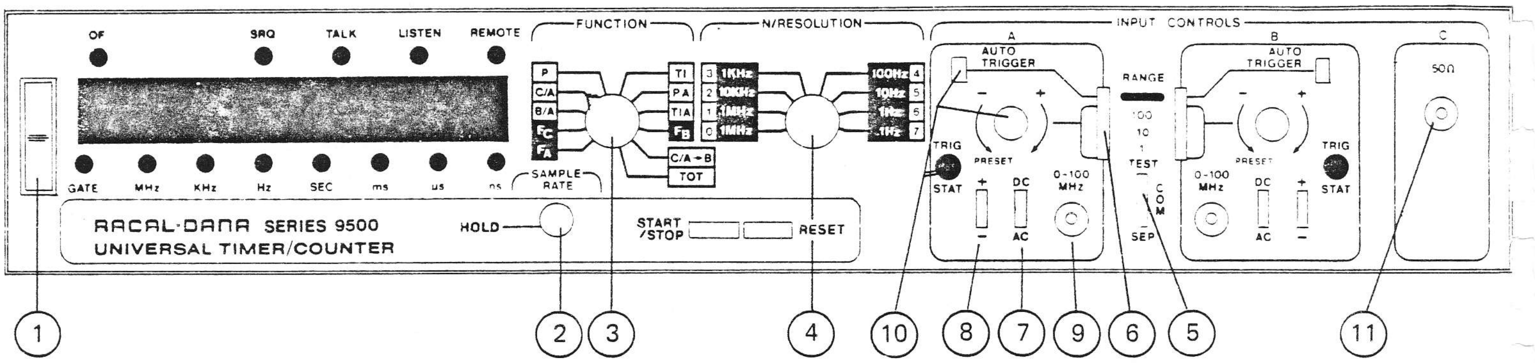
⑪ Connect the lower frequency input (0 - 10 MHz) to channel A.

⑫ Set the channel A trigger level control to the desired trigger level or to the PRESET to trigger at ≅ (0) zero volts.

⑬ Set the channel B trigger level control to the desired trigger level or to PRESET to trigger at ≅ (0) zero volts.

Example: The ratio of two frequencies, 100 kHz and 1 kHz is to be measured. The 100 kHz signal is applied to channel B. The 1 kHz signal is applied to channel A. The N/RESOLUTION switch is set to 0. Both A and B trigger levels are set to PRESET position. The display indicates ratio directly. Ratio equals frequency B divided by frequency A. The display reads 100. Set the N/RESOLUTION switch to 1. The display reads 100.0.

Table 3.14 - Ratio C/A Operating Instructions



① Connect AC power and set the power switch to the on position.

② Set the SAMPLE RATE control for the desired display interval.

③ Set the FUNCTION switch to C/A.

④ Set the N/RESOLUTION switch to the desired resolution (see Table 3.1).

⑤ Set the input configuration switch to SEP.

⑥ Set the channel A INPUT CONTROL range switch to match the input signal amplitude (see Table 3.1). On Models 9512 and 9514 the AUTO TRIGGER feature may be used as described in Table 3.24.

⑦ Set channel A coupling to AC or DC.

⑧ Set channel A slope to (+) plus or (−) minus.

⑨ Connect the lower frequency input (0-10 MHz) to channel A.

⑩ Set the channel A trigger level control to the desired trigger level or to PRESET to trigger at ~ (0) zero volts.

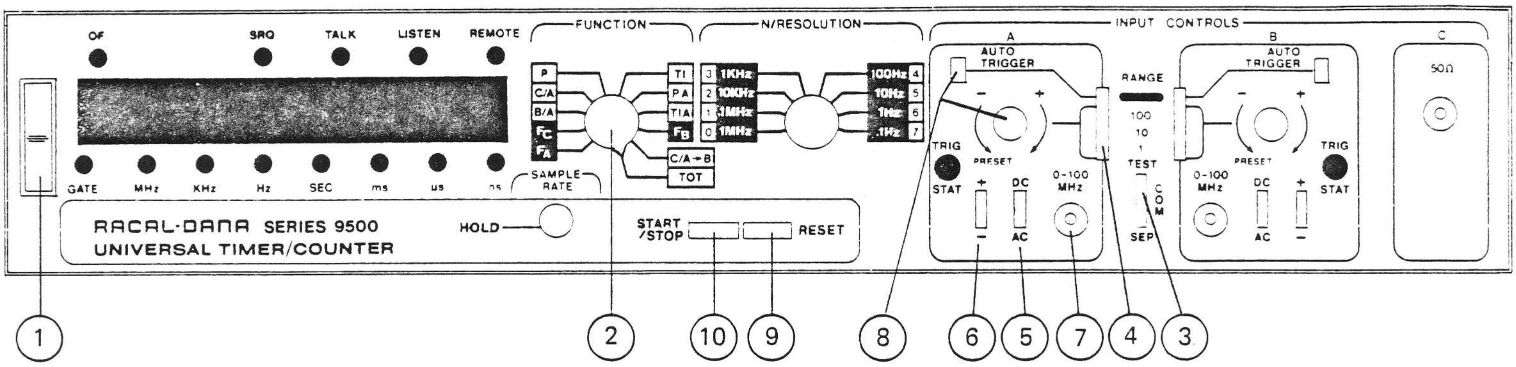
⑪ Connect the higher frequency input (50-512 MHz) to the channel C input. Note: Max. operating input is 1V rms. Max. input without damage is 5V rms. When Option 42 is installed the upper frequency limit is 1.25 GHz.

Example: The ratio of two frequencies, 5 MHz and 250 MHz is to be measured. The 5 MHz signal is applied to channel A. The 250 MHz signal is applied to channel C. The N/RESOLUTION switch is set to 0. A trigger level is set to the PRESET position and A coupling is set to AC. The display indicates ratio (frequency C divided by frequency A) directly. The displayed ratio is 50. Set the N/RESOLUTION switch to 2. The display now reads 50.00. Resolution is one hundred times better than with the N/RESOLUTION switch set to 0.

3.2.14 Totalizing.

3.2.14.1 In the Totalize mode, the instrument registers the aggregate of a series of input pulses or events over a time period controlled by the user. The time period is controlled manually by the START/STOP pushbutton on the front panel. Totalize mode is used with channel A only. The other channels are not functional in TOT function. Operating instructions and an application example are presented in Table 3.15.

Table 3.15 - TOTALIZE Operating Instructions



① Connect AC power and set the power switch to the on position.

② Set the FUNCTION switch to TOT.

③ Set the input configuration switch to SEP.

④ Set the channel A INPUT CONTROL range switch to match the input signal amplitude (see Table 3.1), and on 9514 or 9515 set switch to Auto (see Table 3.24).

⑤ Set channel A coupling to AC or DC.

⑥ Set channel A slope to (+) plus or (–) minus.

⑦ Connect input signal (0-100 MHz) to channel A input connector.

⑧ Set channel A level control to desired trigger level or to PRESET to trigger at ~ (0) zero volts. On Models 9510, 9514 or 9515 the AUTO TRIGGER feature may be used as described in Table 3.24.

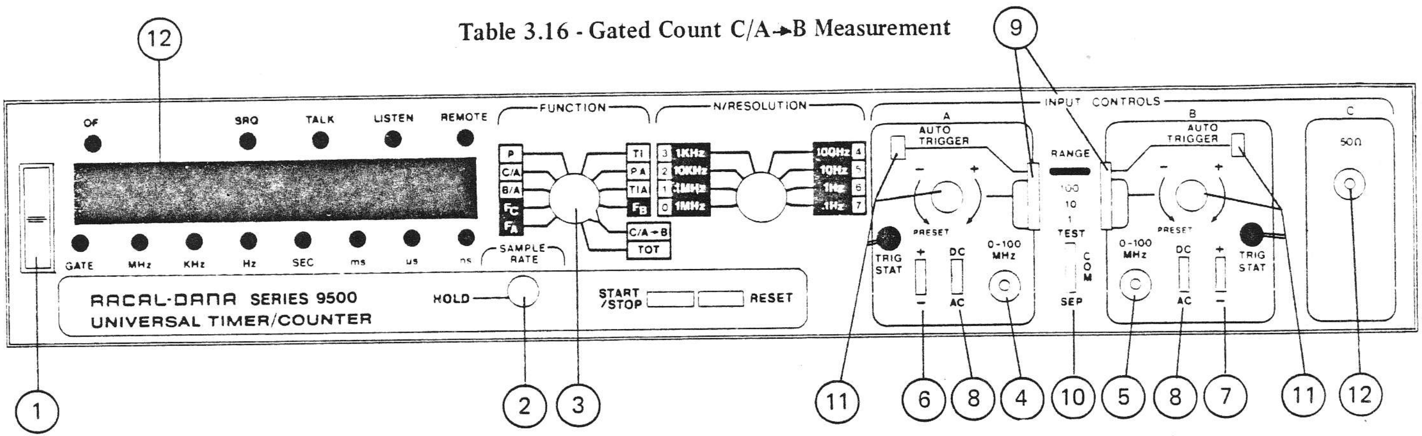
⑨ Press the RESET button to clear the display.

⑩ To start totalizing, press the START/STOP button once. Press once more to stop the count. These steps may be repeated to accumulate more counts in the display.

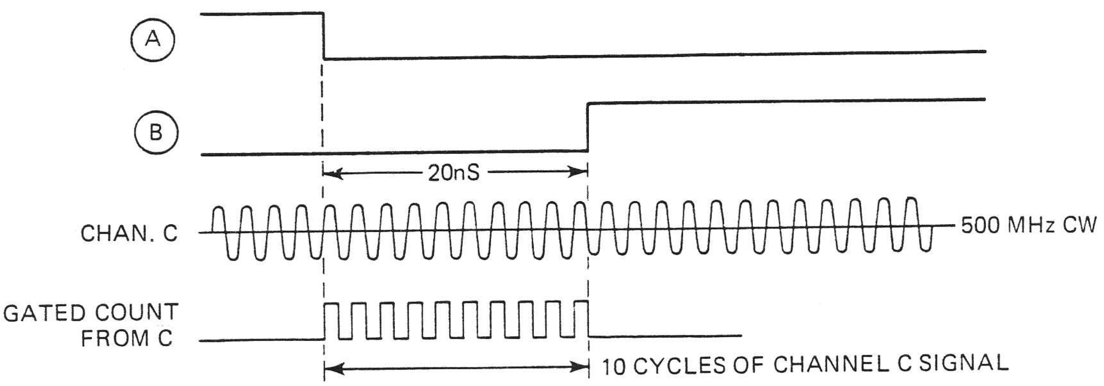
Example: The number of cycles in a 2V p-p, 50 MHz burst of 100 μs width is to be counted. Channel A RANGE is set to 10, coupling is set to AC, slope is set to (+) plus, and level is set to PRESET. Connect the signal to the channel A input connector. If the signal source can drive 50 Ω, use a 50 Ω termination at the channel A input.

Press the RESET button to clear the display. Press the START/STOP button once to start the measurement, then trigger the 50 MHz burst. Press the START/STOP button once to stop the measurement. Display will read 5000, the total number of cycles in the burst.

Table 3.16 - Gated Count C/A→B Measurement



The Series 9500 timer counters can be used to measure extremely short time intervals. The following procedure illustrates a method of measuring the time between two electrical events on separate signals. The signals have the time relationship shown in the diagram below.



In this example, the A and B signals which define the time interval to be measured are input to the counter (steps 4-11). A 500 MHz signal from an oscillator or signal generator is connected to the channel C input (step 12).

① Connect AC power and set the power switch to the on position.

② Set the SAMPLE RATE control to a convenient display interval (See Table 3.1).

③ Set the Function switch to the C/A-B position.

④ Connect signal A to channel A input connector.

⑤ Connect signal B to channel B input connector.

⑥ Set the channel A slope control to –.

⑦ Set the channel B slope control to +.

⑧ Set the channel A and B coupling controls to DC.

⑨ Set the channel A and B trigger range controls to 10. On Model 9514 and 9515 the AUTO TRIGGER feature may be used as described in Table 3.24.

⑩ Set input configuration switch to SEP.

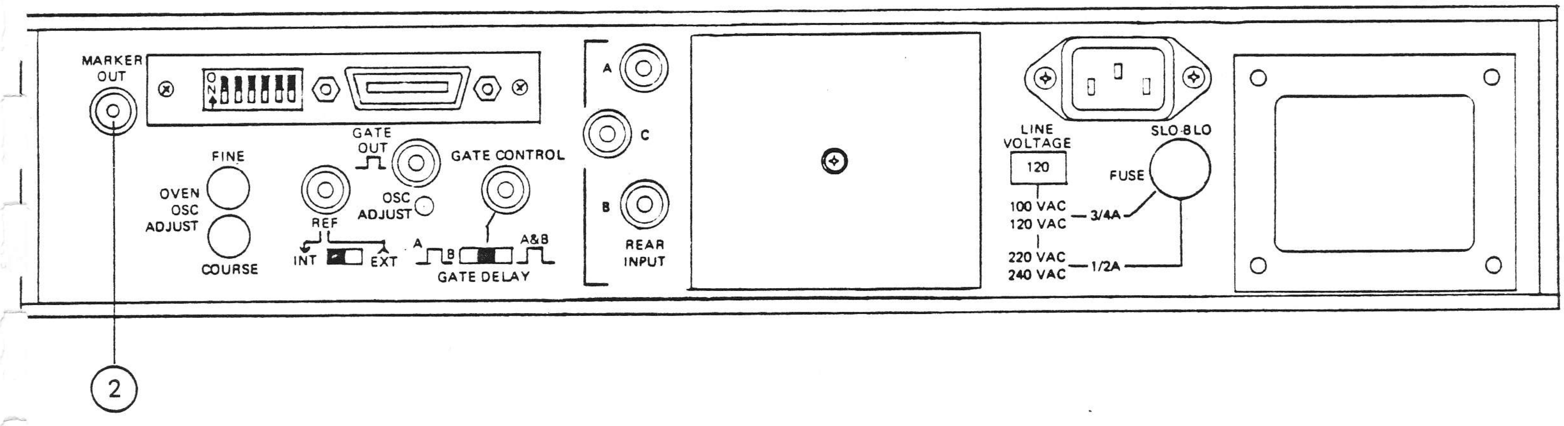
⑪ Set the channel A and B trigger level controls so that the instrument triggers at the 50% point of the signals. (Refer to Table 3.17 for use of the MARKER OUT signal in monitoring trigger levels with a scope.)

⑫ Connect the 500 MHz signal to channel C input (See Table 1.1 for amplitude and frequency range). Verify that gate opens when A & B signals are present.

⑬ After the gate closes, the display will show the number of cycles of the channel C signal accumulated during the time interval set by the A & B signals. To convert this count to time, multiply by 2 nS (the period of the 500 MHz signal) if Option 41 is installed.

If Option 42 is installed, it will prescale the channel C signal by 4, so the displayed count must be multiplied by 8 nS to get the time between the channel A and channel B events.

Table 3.17 - Marker Output



① Set the controls as shown in Table 3.11 then tee-connect the input signal to the oscilloscope vertical input.

CAUTION

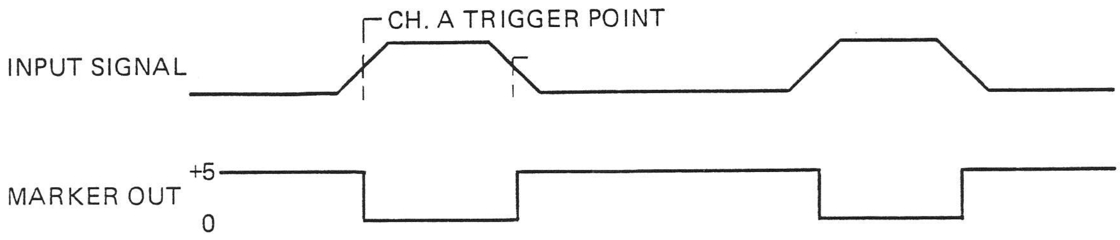
Do not use 50Ω termination.

② Connect MARKER OUT to the second vertical input of the oscilloscope. MARKER output voltage swing is TTL compatible, from +5V to 0V.

The MARKER OUT signal falling edge occurs at the Channel A trigger point and the rising edge occurs at the Channel B trigger point, as shown below.

NOTE

MARKER OUT signal may be connected to Z-axis or intensity input of some oscilloscopes (check oscilloscope manual to see if MARKER output voltage swing is compatible with oscilloscope model). However, using the oscilloscope vertical input will give better accuracy in most cases.



Marker Out Signal Timing

Example: To measure the width of a 3 volt pulse with a repetition rate of 100 Hz and approximately 1 ms wide:

Set the front panel controls as shown in Table 3.10 and connect the signal to the Ch. A input connector. Set the input configuration switch to COMMON, Ch. A and Ch. B coupling to DC, and Ch. A and Ch. B RANGE to 1.

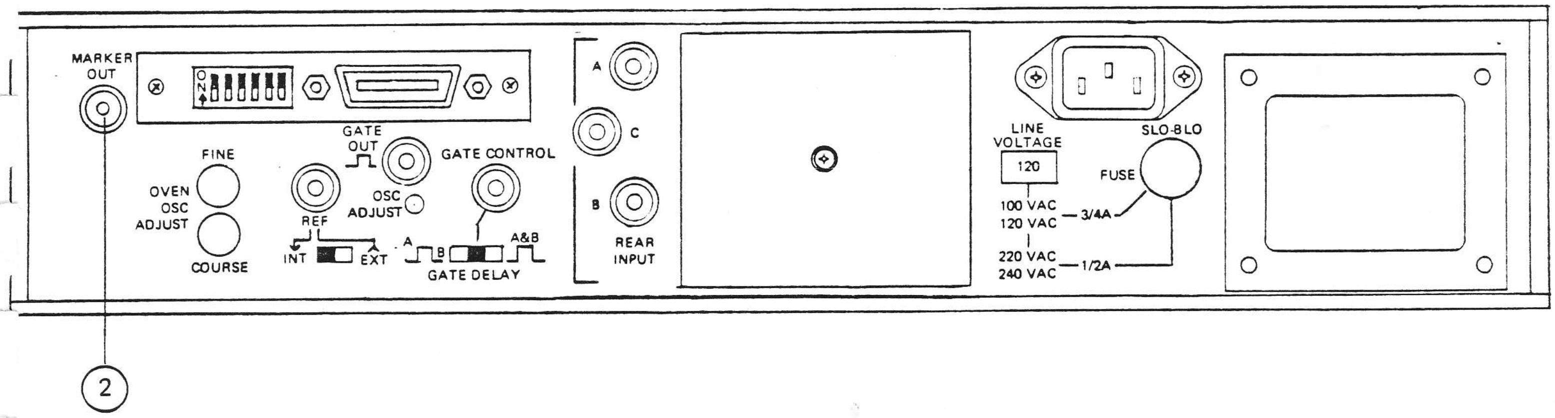
Set Ch. A slope to +, Ch. B slope to –, and adjust each trigger level control so that the trigger status LEDs are active.

Tee-connect the input pulse signal to one vertical input of the oscilloscope and connect the MARKER OUT BNC to the other vertical input. Trigger both scope channels on the rising edge of the 1 ms input pulse and set the scope controls so that both the input pulse and the MARKER signal are visible on the screen.

Set the counter Ch. A trigger level control to line up the MARKER signal falling edge with the 50% point of the input pulse rising edge. Set the counter Ch. B trigger level control to line up the MARKER signal rising edge with the 50% point of the input pulse falling edge.

The counter will then display the pulse width. Set the N/RESOLUTION control for the desired resolution.

Table 3.18 - Gate Output



① Set up counter function and input configuration (see instruction tables for each function).

CAUTION

Do not use a 50Ω termination with the GATE output.

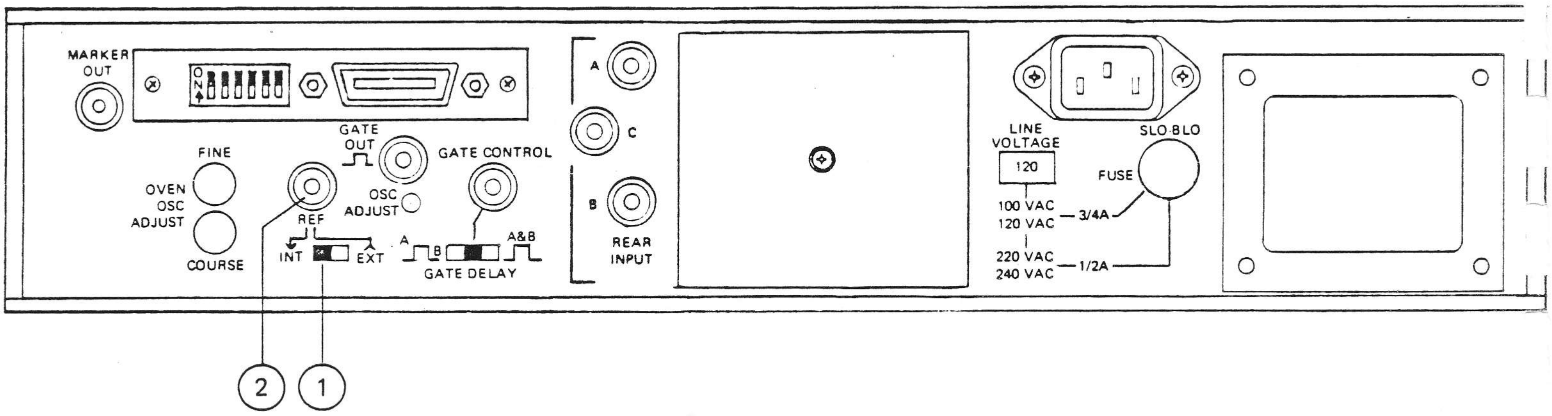
② Connect GATE OUT BNC to oscilloscope or other instrument. The GATE output signal is TTL compatible, with a high level when the counter measurement gate is open and a low level at all other times.

Example: A burst frequency measurement using F_A is to be monitored. By displaying the GATE output signal alongside the counter input signal, it can be verified that the burst length is long enough for a valid measurement.

The counter input signal is a 100 MHz burst, 2μs long, with a repetition rate of 1 KHz. Set up the counter for Frequency A operation (Table 3.6) with the N/RESOLUTION switch in the 1 MHz (1μs gate time) position and sample rate control at maximum.

Now tee-connect the signal from the counter channel A input and connect to one channel of oscilloscope (for best results terminate the signal at the oscilloscope rather than at the counter). Connect the GATE output to another channel on the scope. Adjust the oscilloscope controls so that both the RF burst and the GATE OUT signal are visible and synchronized to the burst. Observe that the high-level part of the GATE OUT signal is entirely within the 100 MHz burst. This shows that no counts are being lost (thus giving an inaccurate reading) because of insufficient burst length.

Table 3.19 - Reference Output Operating Instructions



① Set INT/EXT reference switch to INT (left hand position). The counter is now using its internal 10 MHz reference oscillator.

② The REF connector produces the internal 10 MHz reference (TTL levels) when switch① is set to INT. Connect this BNC connector to the external system or instrument that will be using the 10 MHz reference signal.

CAUTION

Do not use a 50Ω termination with the REF connector output.

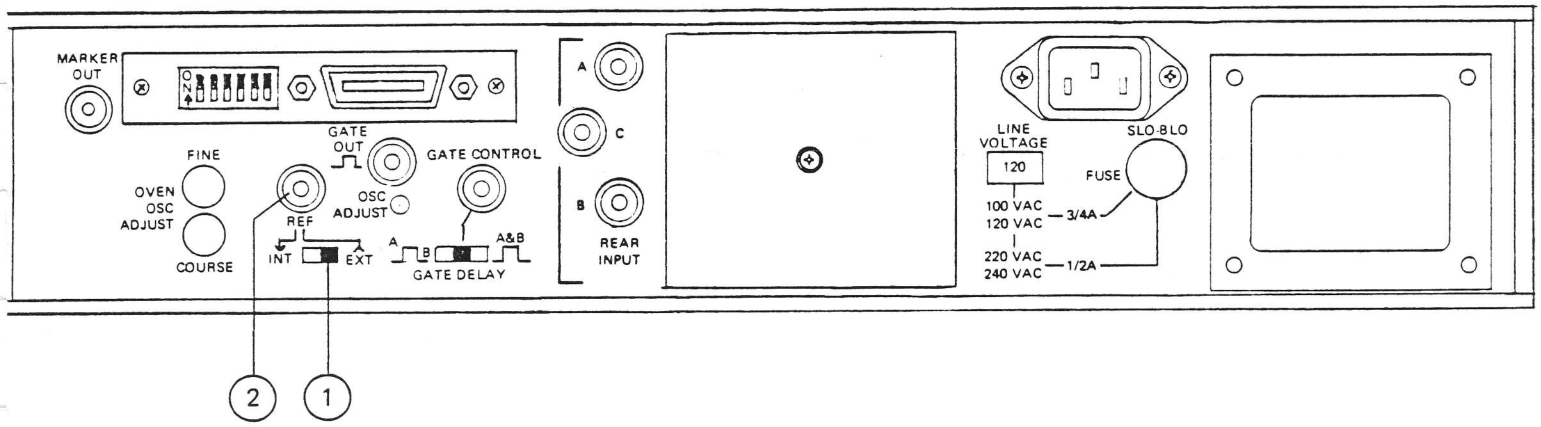
Example: A 9514 or 9515 with Option 24A (high stability oven oscillator) is to be used as a reference source for a digital frequency synthesizer.

Set up the 9514 or 9515 for reference output as outlined above. Connect the REF BNC on the 9514 or 9515 to the "external standard" or "external reference" input of the digital frequency synthesizer.

NOTE

Check the synthesizer specification to ensure that its input frequency and amplitude requirements are compatible with the counter output.

Table 3.20 - Reference Input Operating Instructions



① Set INT/EXT reference switch to EXT (right hand position). The counter logic is now disconnected from its internal 10 MHz reference oscillator.

② The REF connector accepts an external 10MHz standard frequency (1Vrms min. into 1KΩ) when switch ① is set to EXT. Connect this BNC connector ② to the standard frequency source that the counter is to operate from.

OPTION 10:

Frequencies less than 10 MHz may be used for Models 9510, 9512 and 9514 without option 10, but the displayed readings must then be scaled to correct for the difference between the source frequency and the 10 MHz counter clock.

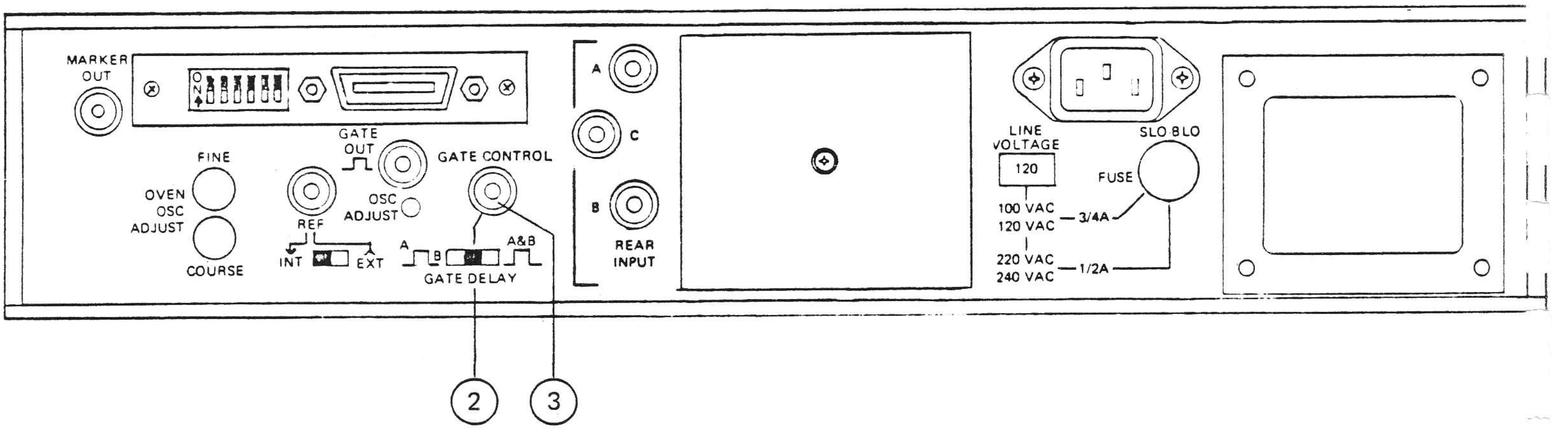
The option accepts 1, 5, or 10 MHz EXT REF input at the BNC connector marked two above. The REF switch is placed in the external position.

Example: A 9510 with Option 10 is to be used in a system with a 5 MHz, 1 V rms house standard. Set the reference switch as in ① above, then connect the 5 MHz standard to the REF BNC. The counter will now be operating on the house standard.

3.2.15 External Gate Control.

3.2.15.1 This feature of the counter offers the user a choice of three methods of external gate control; gate delay, selective gate or synchronous window. The operational features are described in Section 1 of this manual. Operating procedures and applications examples are provided in Tables 3.21, 3.22 and 3.23 of this section. The external gate control modes and their compatibility with the various functions of the instruments are correlated in Table 3.25.

Table 3.21 - Gate Delay Operating Instructions



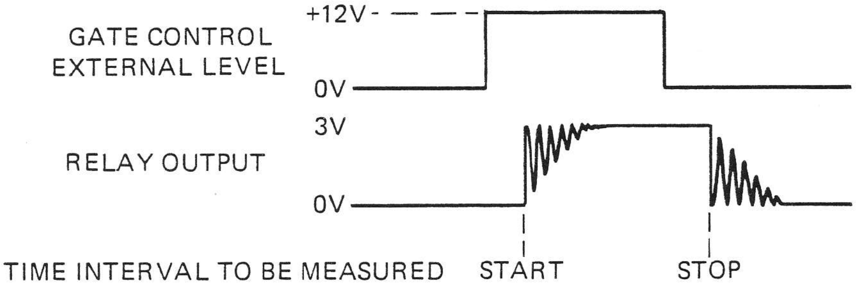
① Set up counter for desired measurement (TI, F_A, etc.). Check Table 3.25 for function compatibility with Gate Delay mode.

② Set Arming Mode switch to GATE DELAY (center position).

③ Connect external control level to the GATE CONTROL BNC. When this external level is low (–5V to +0.5V) the counter operates normally. When the external control level is high (+1V to +12V) the closing of the counter measurement gate is inhibited until the external level goes low.

> **CAUTION**
>
> Do not use external control levels outside the range of –5V to +12V as it may cause damage to the counter.

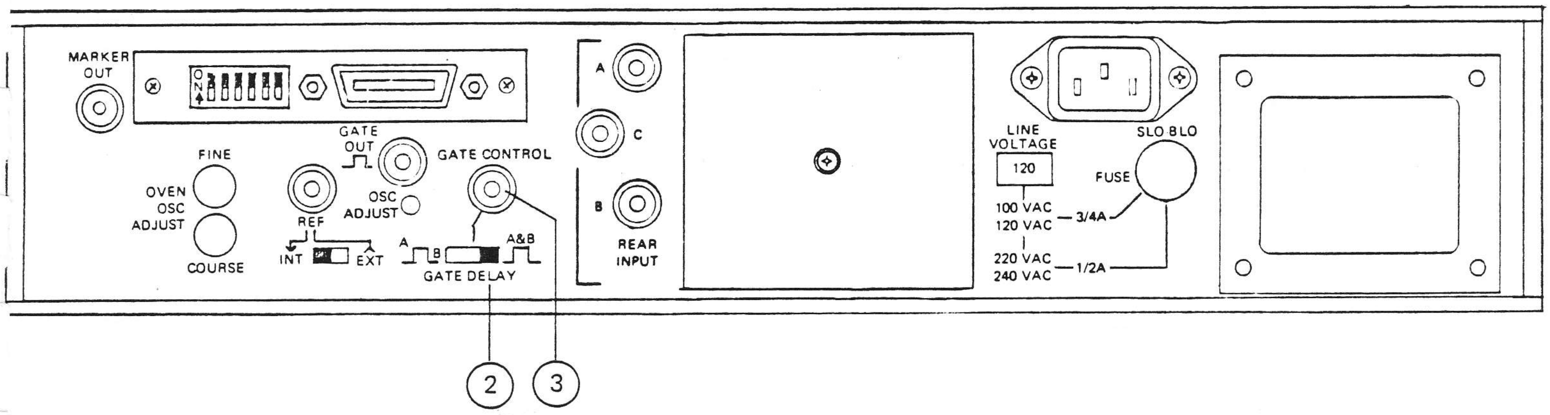
Example: The time between the first open and the first close of a low-level relay is to be measured The relay output is +3 volts when open and 0V when closed.



The counter is set up for TI measurement with resolution as needed. Ch. A is + slope, x1 RANGE, DC coupled; Ch. B is – slope, x1 RANGE, DC coupled. Input configuration is COM, and Ch. A and Ch. B trigger level is set to ~ +2V.

With a gate control level as shown applied to the BNC, the counter gate close is inhibited during the relay bounce and the correct measurement is made.

Table 3.22 - Synchronous Window Operating Instructions



① Set up front panel controls for TIA (see Table 3.12) measurement if Synchronous Window mode will be used for TIA. If Synchronous Window mode is being used only for Auto Trigger Level setting, just set the RANGE switch(es) to AUTO (see Table 3.24).

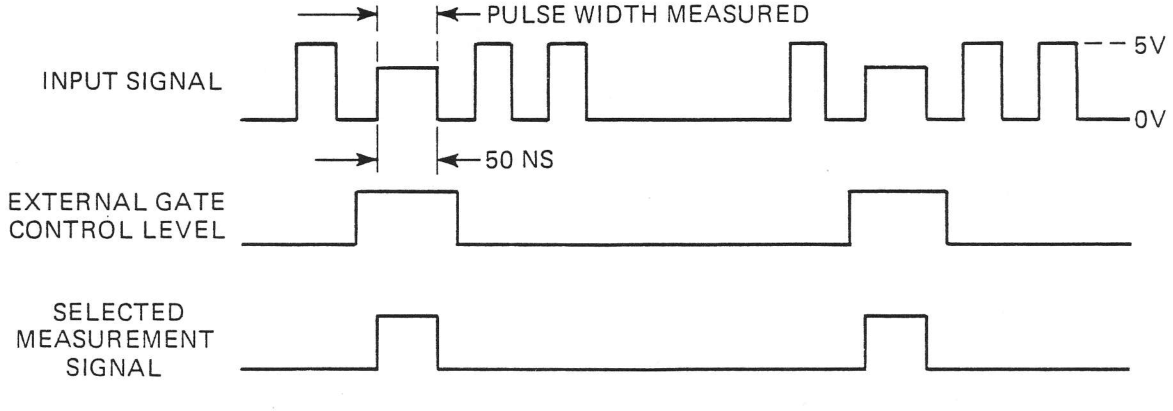
② Set the Arming Mode Switch to Synchronous Window, right hand position ($\overset{\text{A\&B}}{\sqcap}$).

③ Connect an external control level to the GATE CONTROL BNC. A low level (–5V to +0.5V) at this input inhibits the TIA measurement or the Auto Trigger. A high level (+1V to +12V) at the GATE CONTROL input enables the TIA measurement or the Auto Trigger.

NOTE

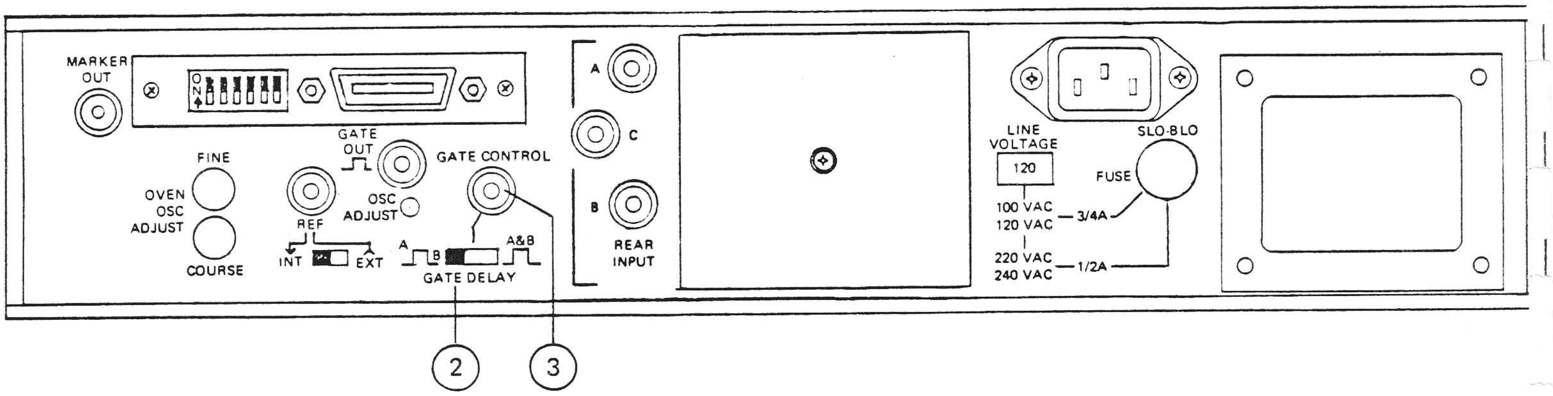
The use of external control levels outside a range of –5V to +12V is not recommended as it may cause damage to the counter.

Example: Synchronous Window can be used to measure the width of one pulse out of a group of pulses in a periodic waveform. The figure below shows the timing of the GATE CONTROL level vs. the input signal.



Set up the counter for TIA measurement with sample rate at max. and N/RESOLUTION at 4. Set the input configuration switch to COM, both RANGE switches to 1, both coupling switches to DC, Ch. A slope to +, Ch. B slope to –, and both trigger levels to ~2V. Now connect the external control level to the GATE CONTROL BNC. The counter will display the width of the selected pulse.

Table 3.23 - Selective Gate Operating Instructions



① Set up counter for desired function. Check Table 3.25 for function compatibility with Selective Gate mode.

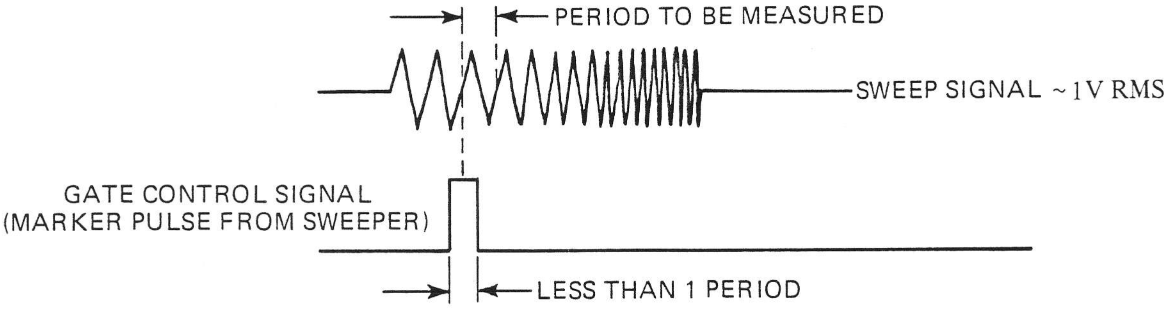
② Set the Arming Mode switch to Selective Gate, left hand position (A⎍B).

③ Connect an external control signal to the GATE CONTROL BNC. A rising edge (low to high level change) at this input arms the counter for the measurement function selected on the front panel. A high level (+1V to +12V) inhibits the closing of the measurement gate. When the control signal returns to a low level (–5V to +0.5V) the gate closing is no longer inhibited.

NOTE

The use of external control levels outside a range of –5V to +12V is not recommended as it may cause damage to the counter.

Example: The waveform period at a selected point of an audio frequency sweep is to be measured, as shown below.

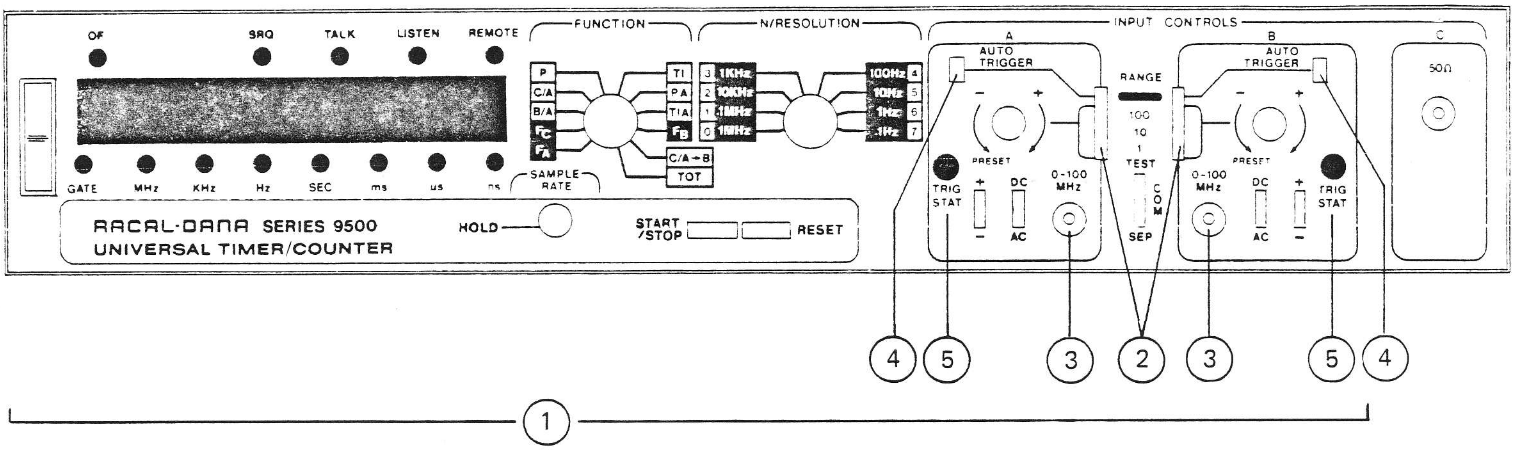


Set the counter controls for the Period function (Table 3.9). Set N/RESOLUTION to 0, Ch. A coupling to AC, Ch. A slope to +, RANGE to 1, trigger level to PRESET, and SAMPLE to max.

To designate at what point on the sweep the measurement will be made, connect to the GATE CONTROL input a marker pulse signal synchronized with that point of sweep signal (see Figure above).

The counter will then measure and display the selected period.

Table 3.24 - Auto Trigger Operating Instructions (9514 and 9515 only)



① Set all controls and switches (except RANGE and trigger level) as necessary for function being performed.

② Set RANGE switch to AUTO (top) position. Note that Ch. A and Ch. B are independent, i.e., Ch. A trigger level may be set manually while auto-trigger is used with Ch. B.

③ Connect the input signal. The input signal frequency or repetition rate must be at least 400 Hz. Auto trigger will also work correctly with stable DC voltage inputs.

④ Press the AUTO TRIGGER pushbutton.

⑤ Check that the trigger status LED is active (if input is not a DC level). If LED is steadily on or off, input amplitude and/or frequency may be too low.

Table 3.25 - Series 9500 Function Compatability With Gate Control Modes

ALLOWABLE ARMING MODE/FUNCTION COMBINATIONS

ARMING MODE FUNCTION	AUTOMATIC ARMING (BURST)	AUTOMATIC/CONTINUOUS ARMING EXTERNAL HOLD-OFF	EXTERNAL ARMING (NO HOLD-OFF)	EXTERNAL ARMING EXTERNAL HOLD-OFF (SELECTIVE GATE)	SYNCHRONOUS WINDOW	CONTINUOUS ARMING
Frequency A	X	X	X	X		
Frequency B			X	X		X
Frequency C	X		X			
Period		X	X	X		X
Time-Interval		X	X	X		X
TI Average				X	X	X
Period Average		X	X	X		X
Events C, (A to B)		X	X	X		
Totalize						X
Ratio B/A C/A		X	X	X		X

3.3 SYSTEM OPERATION: 9514 AND 9515.

3.3.1 This subsection presents information on the operation of the 9514 and 9515 on the system interface.

3.3.2 General Purpose Interface Bus.

3.3.2.1 The Interface Board provides remote programming of all controls and digital output data defining all front panel indicators. Inputs and outputs for the option are on a bi-directional bus via a 24 pin connector on the rear panel. The pin location, line identification, and operation of the option are in compliance with IEEE standard 488-1975, "IEEE STANDARD DIGITAL INTERFACE FOR PROGRAMMABLE INSTRUMENTATION". The Interface Board provides interface capability with other instruments and a controller also utilizing the "interface bus" structure. Connector contact assignments are shown in Figure 3.5. The IEEE-488-1975 subsets available in the Model 9514/9515 timer counter are listed in Table 3.26.

3.3.2.2 By assigning an available address to the 9514/9515, it can be "called up" by the controller or another device on the bus without interfering with any other unit on the bus. Switches located on the rear panel of the 9514 or 9515 permit the programming of the instrument address. The coding used for the address on the option board is ASCII (hexadecimal). Any one of 31 codes can be used for the address of an instrument but a total of 15 is the maximum number of devices that can be used on one bus.

3.3.3 Bus Description.

3.3.3.1 Of the twenty-four lines available at the connector (shown in Table 1.3), seven are grounds, one is a shield, and the remaining 16 lines are the signal lines. All of the signal lines are either input or output lines and have the following characteristics:

Logic Levels:	1 = Low = $\leq$ .8V 0 = Hi = $\geq$ 2.0V
Input Loading:	Each input = one TTL load
Output:	The output is capable of driving 15 interface bus loads. It consists of an open collector driver and is capable of sinking 48 mA with a maximum voltage drop of 0.4 volts. See IEEE 488 Electrical Specifications.

3.3.3.2 The signal lines as shown in Figure 3.5 consists of three functionally separate sets: Data, Handshake and Interface.

3.3.3.3 *Data.* The data lines consist of lines DIO-1 through DIO-8. These lines are the lines over which data flows between all instruments on the bus in bit parallel, byte serial form.

3.3.3.4 *Handshake.* The transfer lines consist of: DAV (data valid), NDAC (not data accepted), and NRFD (not ready for data). These lines provide communication between the instrument that is talking and the instruments that are listening to synchronize the flow of information across the eight data lines. These lines derive their nomenclature from their meaning in the low or one state, e.g., when NRFD is low the device is Not Ready For Data.

a. DAV. Signifies that valid information is available on the data lines.

b. NRFD. Signifies instrument not ready to accept information.

c. NDAC. Signifies information is not accepted by the acceptor.

3.3.3.5 *Interface.* The five interface lines coordinate the flow of information on the bus.

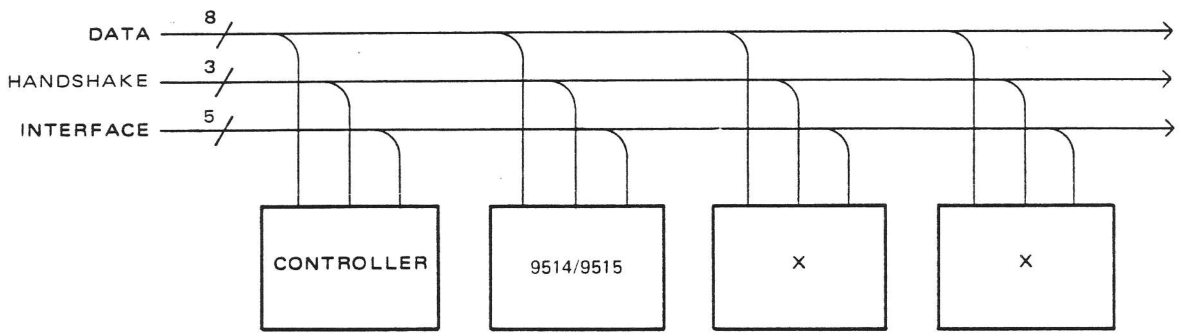
a. IFC. Places the instrument in the IDLE state. (Untalk, Unlisten).

b. ATN. Indicates the nature of information on data lines during a handshake transfer sequence. Low indicates data lines carry interface commands; high indicates that the data lines carry data.

c. REN. Arms instrument to select Remote operation when its LISTEN ADDRESS is received (Low for Remote).

d. SRQ. Service request signal line that signals the controller that a peripheral or bus member wants attention for such purposes as transmitting measurement, status or condition information to the bus controller.

e. EOI. End or Identify signal. Used for two purposes: (1) to signify the end of a message and (2) to signal bus peripherals to set the I/O bit assigned for parallel poll identification process.



PIN		
1	DIO-1 Data In/Out Bit 1 (LSB)	DATA LINES ARE USED TO TRANSFER DATA FROM ONE INSTRUMENT TO ANOTHER
2	DIO-2 Data In/Out Bit 2	
3	DIO-3 Data In/Out Bit 3	
4	DIO-4 Data In/Out Bit 4	
13	DIO-5 Data In/Out Bit 5	
14	DIO-6 Date In/Out Bit 6	
15	DIO-7 Data In/Out Bit 7	
16	DIO-8 † Data In/Out Bit 8	
6	DAV (DATA VALID)	HANDSHAKE LINES OPERATE IN A PROPER TIME SEQUENCE FOR COMPLETE COMMUNICATION BETWEEN INSTRUMENTS
7	NRFD (NOT READY FOR DATA)	
8	NDAC (NOT DATA ACCEPTED)	
5	EOI (END OR IDENTIFY)	INTERFACE LINES ARE USED TO PROVIDE AN ORDERLY FLOW OF INFORMATION BETWEEN UNITS
9	IFC (INTERFACE CLEAR)	
10	SRQ (SERVICE REQUEST)	
11	ATN (ATTENTION)	
17	REN (REMOTE ENABLE)	

†NOT USED WITH MODEL 9514/9515

Figure 3.5 - Data Bus Lines and Interface Signal Pin Assignments

Table 3.26 - IEEE 488 1975 Standard Interface Subset Capability

Subset Mnemonic	Function	Capability
SH1	Source Handshake	Complete
AH1	Acceptor Handshake	Complete
T5	Talker	Complete
TE0	Extended Talker	None
L4	Listener	All except listen only
LE0	Extended Listener	None
SR1	Service Request	Complete
RL1	Remote/Local	Complete
PP0	Parallel Poll	None
DC1	Device Clear	Complete
DT1	Device Trigger	Complete
C0	Controller	None

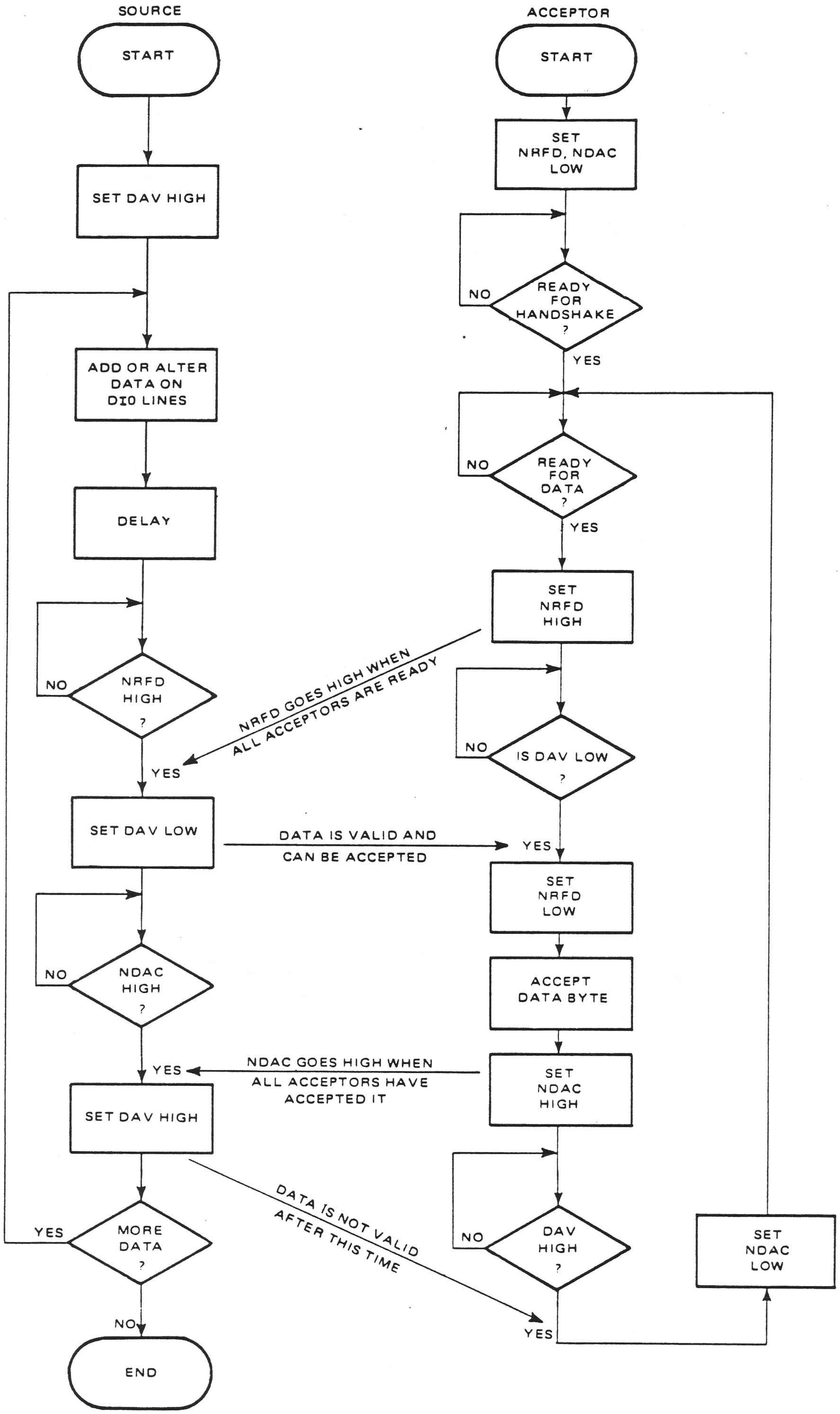
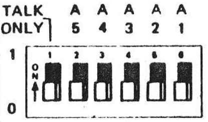


Figure 3.6 - Handshake Flow Chart

Table 3.27 - Model 9514-9515 Interface Addressing

ASCII CHARACTERS		DATA LINES							ADDRESS SWITCH SETTING	DECIMAL ADDRESS
		D_7	D_6	D_5	D_4	D_3	D_2	D_1		
TALK	LISTEN	TALK	LISTEN	ADDRESS 16	8	4	2	1		
	SP	0	1	0	0	0	0	0		00
@		1	0	0	0	0	0	0		
	!	0	1	0	0	0	0	1		01
A		1	0	0	0	0	0	1		
	"	0	1	0	0	0	1	0		02
B		1	0	0	0	0	1	0		
	#	0	1	0	0	0	1	1		03
C		1	0	0	0	0	1	1		
	$	0	1	0	0	1	0	0		04
D		1	0	0	0	1	0	0		
	%	0	1	0	0	1	0	1		05
E		1	0	0	0	1	0	1		
	&	0	1	0	0	1	1	0		06
F		1	0	0	0	1	1	0		
	' (APOSTROPHE)	0	1	0	0	1	1	1		07
G		1	0	0	0	1	1	1		
	(	0	1	0	1	0	0	0		08
H		1	0	0	1	0	0	0		
	)	0	1	0	1	0	0	1		09
I		1	0	0	1	0	0	1		
	*	0	1	0	1	0	1	0		10
J		1	0	0	1	0	1	0		
	+	0	1	0	1	0	1	1		11
K		1	0	0	1	0	1	1		
	,	0	1	0	1	1	0	0		12
L		1	0	0	1	1	0	0		
	-	0	1	0	1	1	0	1		13
M		1	0	0	1	1	0	1		
	.	0	1	0	1	1	1	0		14
N		1	0	0	1	1	1	0		
	/	0	1	0	1	1	1	1		15
O		1	0	0	1	1	1	1		

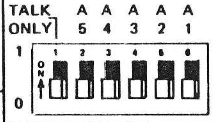
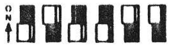
ASCII CHARACTERS		DATA LINES							ADDRESS SWITCH SETTING	DECIMAL ADDRESS
		D_7	D_6	D_5	D_4	D_3	D_2	D_1		
TALK	LISTEN	TALK	LISTEN	ADDRESS 16	8	4	2	1		
	0	0	1	1	0	0	0	0		16
P		1	0	1	0	0	0	0		
	1	0	1	1	0	0	0	1		17
Q		1	0	1	0	0	0	1		
	2	0	1	1	0	0	1	0		18
R		1	0	1	0	0	1	0		
	3	0	1	1	0	0	1	1		19
S		1	0	1	0	0	1	1		
	4	0	1	1	0	1	0	0		20
T		1	0	1	0	1	0	0		
	5	0	1	1	0	1	0	1		21
U		1	0	1	0	1	0	1		
	6	0	1	1	0	1	1	0		22
V		1	0	1	0	1	1	0		
	7	0	1	1	0	1	1	1		23
W		1	0	1	0	1	1	1		
	8	0	1	1	1	0	0	0		24
X		1	0	1	1	0	0	0		
	9	0	1	1	1	0	0	1		25
Y		1	0	1	1	0	0	1		
	:	0	1	1	1	0	1	0		26
Z		1	0	1	1	0	1	0		
	;	0	1	1	1	0	1	1		27
[		1	0	1	1	0	1	1		
	<	0	1	1	1	1	0	0		28
\		1	0	1	1	1	0	0		
	=	0	1	1	1	1	0	1		29
]		1	0	1	1	1	0	1		
	>	0	1	1	1	1	1	0		30
^		1	0	1	1	1	1	0		
NONE		ILLEGAL							NONE	31

Table 3.28 - Bus Operation Sequence

	HANDSHAKE LINES	INTERFACE LINES	DATA LINES	MEANING OR FUNCTION
1		REN Lo		Arms bus peripherals to go to remote mode.
2		IFC		Stops activity on the bus.
3		ATN Lo		Signifies that data byte will be a "Bus Message".
4	NRFD Hi			Counter says ready for data.
5			?	UNL (Unlisten) message (ASCII character ?) on data bus by controller means "all bus peripherals unlisten.
6	DAV Lo			Controller says data is now valid.
7	NRFD Lo			Counter says its not ready for new data; do not change data lines while counter is accepting data.
8				Counter reads data lines.
9	NDAC Hi			Counter says it has read data.
10	DAV Hi		?	Controller says data no longer valid.
11	NDAC Lo			Counter removes data accepted flag.
12	NRFD Hi			Counter says it's ready for next data byte.
13				Controller removes or changes data on bus.
14			U	"I talk", controller becomes talker (HP9825 talker address).
15			"	"You listen", addressed peripheral becomes talker (In this case it is the 9514/9515 Counter set to decimal address 02; see table 3.27). Remote operation is enabled
16		ATN Hi		Signifies that data byte will be a "Device Dependent Message" as opposed to a "Bus Message".
17			F	Function
18			0	Frequency A
19			G	Range
20			5	5
21			A	Channel A
22			2	DC coupling
23			C	Configuration of input
24			0	Separate channels
25			L	Level of triggering
26			A	Channel A
27			A	Automatic
28			CR	End of transmission by HP9825. This is ignored by the 9514/9515 counter.
29			LF	
30		ATN Lo		Byte to follow is a "Bus Message".
31			?	UNL (unlisten) bus message.
32			B	"You talk", 9514/9515 talk address (Decimal Address 02).
33			5	"I listen", HP9825 listen address.
34		ATN Hi		Message is to be transmitted by counter.
35			0	Measurement data transmitted by counter. Data Format: 0.DDDDDDDDDE± DD CR LF
36			.	
37			0	
38			0	
39			2	
40			7	
41			1	
42			3	
43			5	
44			3	
45			4	
46			E	Exponent Indicator means X 10^N
47			+	Sign of exponent.
48			1	Exponent. Here it indicates 10^{10}.
49			0	
50			CR	End of 9514/9515 data message.
51		EOI	LF	

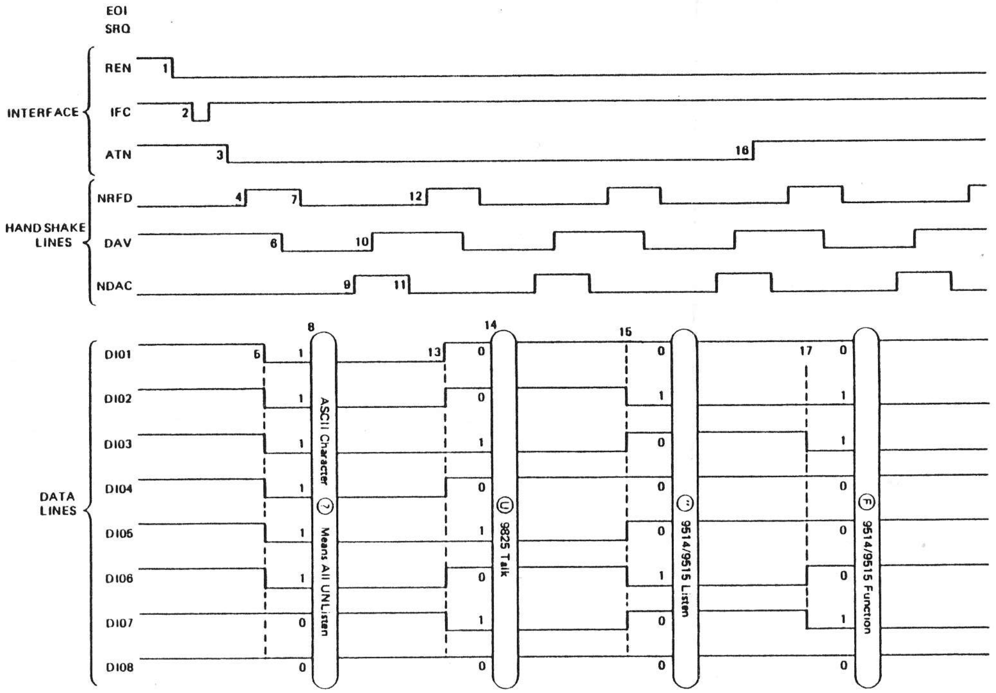


Figure 3.7 - Handshake Timing

3.3.4 Handshake.

3.3.4.1 The handshake is the process by which each data byte is transferred from the source to the acceptor.

3.3.4.2 Shown in Figure 3.7 is the sequential relationship between the DAV, NRFD, and NDAC lines, used to transfer data bytes. Figure 3.6 illustrates the handshake flow chart.

3.3.5 Address Assignment.

3.3.5.1 Model 9514/9515 counter/timer, when used as a system instrument must be assigned an address as a bus member. The instrument is equipped with an address switch located on the rear panel which enables the user to assign it one of 31 decimal addresses. The decimal addresses available are the numbers 00 through 30.

3.3.5.2 Table 3.27 contains all of the information required for setting the instruments address and determining the talk and listen address codes for use in programming the controller. The use of this information is described in the following paragraphs.

3.3.5.3 Refer to Table 3.27 and note that the right hand column shows the decimal addresses available for assignment to the 9514 and 9515. The column titled "Address Switch Setting" illustrates the positions of the switches for each decimal address. To set the address on the instrument, select the desired decimal address, refer to Table 3.27, and set the switches on the address switch to the pattern shown in the "address switch" column of the table.

3.3.5.4 Once the instrument has been assigned an address and the address switch has been set, the controller may address the instrument as a talker or as a listener by transmitting the appropriate ASCII character on the data lines. The "Data Lines" column shows the 7 bit binary code required for each talk and listen address assigned to the instrument. These are the codes the controller must transmit to establish the talker-listener condition of the counter. Note that there are 2 address codes used for each decimal address. Each of these address codes constitutes a different ASCII character. For example, if it is desired to use the decimal address 02 the address switch on the rear panel of the instrument is set to the pattern shown in Table 3.27 and as shown in the table, the talk address is the ASCII character B and the listen address is the ASCII character ". Note that the only difference in the binary code in each case is the state of data lines D6 and D7.

3.3.5.5 Table 3.27 illustrates the data line code in binary form for each decimal address. Again using the example for decimal address 02 note that bits D1 through D5 are the same for both talk and listen address and that the only difference is in bits D6 and D7.

3.3.6 Bus Operation Sequence.

3.3.6.1 The transmission of programming instructions to the instrument and the subsequent transmission of measurement data to the controller is accomplished by transmitting programming instructions as outlined in the bus operation sequence in Table 3.28. Table 3.28 and the accompanying timing chart (Figure 3.7) illustrates the sequence of the transmission of device dependent messages to the counter to cause it to measure the frequency of a measurement signal applied to channel A and transmit the resultant measurement data to the controller by the interface bus.

3.3.6.2 Note that the left hand column of the table contains line numbers. These are used for reference purposes throughout the following description of the bus operation sequence. The column titled "Handshake Lines" indicates the high/low condition of the handshake lines at various points throughout the two-way transmission of information over the bus. In a similar fashion the columns titled "Interface Lines" and "Data Lines" contain entries reflecting the state of the interface lines and data lines during operation. The column titled "Meaning or Function" contains entries explaining the purpose of each operational step during the data transfer.

3.3.6.3 A timing chart is included to illustrate the condition of each individual bus line at each stage of the data transfer operation. Note that the timing chart includes numbers adjacent to each level change; these numbers refer to the individual line entries of the table. The command programming and subsequent data transfer operation are described in the following paragraphs.

3.3.6.4 The measurement operation used for the example of bus operation in Table 3.28 is a simple frequency measurement using channel A of the Model 9514/9515 counter. The measurement parameters are as follows: Function: Frequency A; resolution: 10 hertz, channel A coupling: DC, input configuration: Separate, channel A triggering: Automatic. Note that lines 17 through 27 of the table contain the Device Dependent Messages required to program the instrument for this operation and that the program string is F0G5A2C0LAA.

3.3.6.5 For purposes of this example, it is assumed that the Model 9514/9515 has been assigned the decimal address 02 and that the controller is a Hewlett-Packard 9825 calculator with the talk address U. It is further assumed that both the controller and the counter are a system connected, turned on and operational.

3.3.6.6 Table 3.28 shows the sequence of bus operation. Lines 1 through 13 show the detailed operation of the bus for one handshake cycle; the transmission of one ASCII character as a bus message. Lines 14 through 50 do not indicate the detail of each handshake cycle. They indicate only the transmission of the characters required for the programming commands and the subsequent transmission of the data by the counter. Each transmission by the controller or the counter shown in lines 14 through 50 requires the handshake cycle illustrated by the line entries 1 through 13 of the table.

3.3.6.7 Refer to Table 3.28, line 1, and note that the first operation performed is the setting of the Remote Enable (REN) line to the low state. As explained in the table, this operation arms the bus members to go to the remote mode. The controller then transmits the interface clear (IFC) signal which stops bus activity and the attention (ATN) line is set low indicating that the next data byte placed on the bus by the controller will be a Bus Message. Note in the timing chart that when the ATN line is set low (3) that the counter responds by setting the NRFD line high (4). This response by the counter indicates that it is now ready to accept data.

3.3.6.8 When the counter transmits the ready for data signal by setting the NRFD line high (line 4 of Table 3.28), the controller puts the bus message UNL on the data lines. As shown in line 5 of the table this is the ASCII character ?. The unlisten message is a universal message understood by all bus members as the command "unlisten". Having placed the data character on the lines, the controller now says the data is valid by setting the DAV line low (6). The counter then says "I'm going to accept the data now on the data lines; don't change the data lines". The counter then reads the data lines (8) and acknowledges acceptance of the data by setting the NDAC line high (9). The controller then removes the data valid signal (10) and the counter removes the data accepted signal from the bus (11). At this point one ASCII character has been transmitted by the controller to the counter and the counter is now ready to accept a new data byte. It indicates this (12) by setting the NRFD line high. The controller now puts the next character on the data line and the handshake cycle for the transfer of the character is repeated. The next character transmitted by the controller is the ASCII character U which is the talk address of the Hewlett-Packard 9825 calculator. As indicated in Table 3.28, by transmission of this character, the calculator is making itself a talker. The next character transmitted is the quotation mark which is the listen address of the 9514/9515 counter when it has been assigned the decimal address 02.

3.3.6.9 Lines 16 through 27 of the table illustrate the sequence of transmission of the program string which instructs the counter to make the channel A frequency measurement. Lines 28 and 29 of the table indicate the end of transmission characters CR (carriage return) and LF (line feed). Note that at line 16 of the table the controller sets the ATN line high indicating that the program string to follow in lines 17 through 29 are device dependent messages.

3.3.6.10 Having transmitted the program string of device dependent messages to the counter, the controller then sets the ATN line low indicating that the characters to follow in lines 31 through 33 are bus messages. These bus messages change the talker/listener relationship of the controller and counter; the counter is made a talker and the controller becomes a listener.

3.3.6.11 Lines 35 through 51 illustrate the sequence of the transmission of data by the counter. The handshake sequence is the same when the counter is transmitting data as that outlined in lines 1 through 13 of the table, except that the counter is controlling the handshake lines.

3.3.6.12 Upon completion of the data transmission, the model 9514 transmits a carriage return (CR) and line feed (LF) to indicate the end of the data transmission. In addition, the counter pulls the EOI line low with the transmission of the line feed character as an additional indication of the end of the data message.

3.3.7 Interface Message Repertoire.

3.3.7.1 The Model 9514/9515 counter/timer is equipped with a standard GPIB interface which conforms to the specifications contained in IEEE-488-1975. The specification includes the definition of multi-line interface messages and this definition divides the messages into two groups; the primary command group and the secondary command group. The 9514/9515 includes none of the secondary command group in its interface message repertoire.

3.3.7.2 The primary command group of interface messages is further broken down into four lower categories: (1) the listen address group, (2) the talk address group, (3) the universal command group and (4) the addressed command group. The model 9514 is designed to include in its interface message repertoire 31 listen addresses and 31 talk

Table 3.29 - Interface Messages Used With Model 9514/9515 Counter-Timer

Message	Meaning	HEX CODE	Decimal Equiv.	DATA LINE CODE						
				7	6	5	4	3	2	1
GTL	Go To Local	01	1	0	0	0	0	0	0	1
SDC	Selected Device Clear	04	4	0	0	0	0	1	0	0
GET	Group Execute Trigger	08	8	0	0	0	1	0	0	0
LLO	Local Lock Out	11	17	0	0	1	0	0	0	1
DCL	Device Clear	14	20	0	0	1	0	1	0	0
SPE	Serial Poll Enable	18	24	0	0	1	1	0	0	0
SPD	Serial Poll Disable	19	25	0	0	1	1	0	0	1
UNL	Unlisten	3F	63	0	1	1	1	1	1	1
UNT	Untalk	5F	95	1	0	1	1	1	1	1

addresses. The listen and talk address group to which the instrument may be configured by its address switch to respond are listed in Table 3.27. An explanation of the use of this table is included in an accompanying paragraph.

3.3.7.3 The interface messages to which the 9514/9515 timer/counter is designed to respond are listed in Table 3.29 along with their decimal equivalent, hex equivalent, meaning and data line code. The function of the 9514/9515 in response to each of these commands is described in the following paragraphs.

3.3.7.4 GO TO LOCAL (GTL).

3.3.7.4.1 As shown in Table 3.29, the GTL command means go to local and the decimal and hex equivalent are both 01. Upon on receipt of this interface message the 9514, if previously programmed for remote, will return to its local operational state. This means that the instrument will then perform the function according to the settings of the front panel controls on the instrument until such time as it returns to remote control. The Model 9514/9515 must be in its listener addressed state to execute this command.

3.3.7.5 SELECTED DEVICE CLEAR (SDC).

3.3.7.5.1 Upon receipt of the SDC command the model 9514/9515 will go to the home state which is defined in Table 3.31. The decimal and hex equivalent are both 04. The instrument must be in its addressed listener state to execute this command.

3.3.7.6 GROUP EXECUTE TRIGGER (GET).

3.3.7.6.1 As shown in Table 3.29, the decimal and hex equivalents of the GET command are both 08. Upon receipt of the GET interface message the Model 9514/9515 will execute a measurement in the function for which it has been previously programmed. The use of the group execute trigger command is to cause the simultaneous execution of a number of functions by a number of bus members at the same time. To use this command, two or more bus members are programmed to perform a function on receiving the GET interface message or a trigger command. Subsequently the controller will transmit the GET command and all bus members previously programmed will begin execution on receipt of the command.

3.3.7.7 LOCAL LOCK OUT (LLO).

3.3.7.7.1 After the Model 9514/9515 has gone into remote operation it will stay in remote operation under control of the bus controller until either the bus controller gives the command go to local (GTL) or until the reset button on the front panel of the instrument is depressed. When the reset button is actuated, the instrument illuminates all seven bars of each of the display LEDs and returns to local operation. Return-to-local (RTL) operation via the front panel reset button may be prevented by the bus controller by the transmission of the interface message LLO.

3.3.7.8 DEVICE CLEAR (DCL).

3.3.7.8.1 The decimal equivalent of the DCL command as shown in Table 3.29 is 20, the hex 14. This command is identical in operation to the SDC command except that the counter does not need to be in its listener addressed state. When this command is transmitted on the bus all devices on the bus which respond to the DCL will clear.

3.3.7.9 SERIAL POLL ENABLE (SPE).

3.3.7.9.1 As shown in Table 3.29, the decimal equivalent of this interface command is 24; the hex equivalent 18. The function of this command is to cause all bus members responding to the SPE command to ready their status word. Thus, when a bus member has transmitted a service request (SRQ), the bus controller can transmit the serial poll enable command, sequentially command each bus member to transmit its status byte and thus identify the bus member requesting attention. The Model 9514/9515, upon receipt of the SPE interface message, immediately prepares to respond to a status request from the controller. If the 9514/9515 has previously transmitted an SRQ, it will set bit 7 of the status byte to 1. The Model 9514/9515 makes a service request whenever it has data ready for the controller (S1 or S3). In the case of the overflow the status byte, bit 1 will be set to the 1 state; if data is ready, bit 2 of the status byte will be set to the 1 state. Thus the serial poll allows a bus member to set the service request line to the 1 state indicating to the controller that it wants attention and the controller may sequentially interrogate each bus member to determine which bus member has requested service and the purpose for the request.

3.3.7.10 SERIAL POLL DISABLE (SPD).

3.3.7.10.1 As shown in Table 3.29 the decimal equivalent to the SPD command is 25; the hex equivalent is 19. The function of this command is to signal that the serial poll transaction has been completed.

3.3.7.11 UNLISTEN (UNL).

3.3.7.11.1 As shown in Table 3.29 the decimal equivalent of this command is 63; the hex equivalent is 3F. This command is also a universal interface message understood by all members of the bus as a command to go to the unlisten state. When this command is transmitted all bus members previously in the listen state will return to the unlisten state.

3.3.8 Device Dependent Messages.

3.3.8.1 The messages which control the operation of the Model 9514/9515 counter/timer, when in system operation, are referred to as device dependent messages. These messages are simply combinations of ASCII characters which the instrument recognizes as specific instructions. To program the instrument for a specific operation, the operator programs the controller to transmit a sequence of these messages, referred to as a program string. The program string is variable in length and has no fixed format. The only format requirements are that an individual command be transmitted as a pair of characters or, in some cases, three characters. Individual commands may be transmitted in any order and require no delineators or spacing for the instrument to understand.

3.3.8.2 The device dependent messages are listed in Table 3.30 along with the 9514/9515 operation and any special notes that apply. The device dependent messages applicable to the 9514/9515 are divided into subcategories of Function Commands, Range Commands, Input Configuration, Trigger Control, Mode Control, and Trigger Status Messages. In general, the various commands cause the instrument to perform the same functions as the front panel control settings do, as outlined in the section on bench operation. There are special cases however, where there are extra functions available under remote control which are not available in the bench operation mode. Further, there are some special situations requiring special attention to the operation sequence used with the Model 9514/9515. The following paragraphs describe the function of each of the device dependent messages and the presentation of any special considerations applicable to the various individual messages.

3.3.8.3 FUNCTION COMMANDS.

3.3.8.3.1 There is a function command equivalent to each position of the function switch on the front panel of the instrument. Note that the 9514/9515 operation column of Table 3.30 lists the eleven functions available on the instrument and that the bus message column shows the pair of ASCII characters required to program the instrument for each of these functions. To program a function, the controller need transmit only the two ASCII characters required for the desired function, e.g., to program the measurement function frequency A, the controller simply transmits the two ASCII characters F and 0 over the bus to the 9514/9515.

Table 3.30 - Model 9514/9515 Device Dependent Messages

FUNCTION COMMANDS

9514/9515 Operation	Program Code	Special Notes
FA	F0	The counting logic is cleared whenever a Function Command is received via the interface bus. Refer to Table 3.1, Reference ⑧ for the explanation of instrument operation in each function.
FC	F1	
B/A	F2	
C/A	F3	
P	F4	
TI	F5	
PA	F6	
TIA	F7	
FB	F8	
C/A→B	F9	
TOT	F:	Suggested Mode: Single measurement, next reading on the fly.

RANGE COMMANDS

9514/9515 Operation	Program Code	Special Notes
Range 0	G0	The counting logic is cleared whenever a Range Command is received via the interface bus. Refer to Table 3.1, Reference ⑨ for the resolution/gate time for each range.
1	G1	
2	G2	
3	G3	
4	G4	
5	G5	
6	G6	
7	G7	

INPUT CONFIGURATION

9514/9515 Operation	Program Code		Special Notes
	Ch. A	Ch. B	
Pos slope	A0	B0	These commands perform the operation controlled by front panel controls shown in Figure 3.1, Reference ⑫ ⑬ ⑱ ⑲ ㉓ and ㉔ .
Neg slope	A1	B1	
DC	A2	B2	
AC	A3	B3	
X1	A4	B4	
X10	A5	B5	
X100	A6	B6	

Sep	C0	Refer to Table 3.1, Reference ㉑ for an explanation of the function of these commands.
Com.	C1	
Test	C2	

Table 3.30 - Model 9514/9515 Device Dependent Messages continued

TRIGGER CONTROL

9514/9515 Operation	Program Code		Special Notes
	Ch. A	Ch. B	
Auto trigger	LAA	LBA	Refer to paragraph 3.3.8.6.
Set trig. level	LA ± DDD	LB ± DDD	Range: –300 to +300

TRIGGER STATUS (Data Output)

9514/9515 Operation	Program Code	Special Notes
Level A trig.	H0	Paragraph 3.3.8.7 presents a detailed description of these commands and the associated output message transmitted by the instrument. Commands H0 through H5 are "single shot" in function; i.e., once the output message is transmitted by counter, the instrument reverts to measurement output mode (H6).
Level B trig.	H1	
Level A + Peak	H2	
Level B + Peak	H3	
Level A – Peak	H4	
Level B – Peak	H5	
Measurement	H6	

MODE CONTROL

9514/9515 Operation	Program Code	Special Notes
Single measure no SRQ	S0	} Use 'T' or group execute trigger to start measurement.
Single measure SRQ	S1	
Multiple measure no SRQ	S2	
Multiple measure SRQ	S3	
Next reading on the fly	V	
Internal Arm	U0	Mode control commands U0 through U6 are Extended Program Option 55E.
External Arm	U1	
Selective Gate	U2	
Sync. Window	U3	
Gate Delay	U4	
50Ω Input Impedence	U5	
High Impedence Input	U6	
Start/Stop	P	Toggle command.
Trigger	T	Used to start a measurement (especially with S0 or S1).
Reset	R	See section 3.3.8.23 and table 3.31.

3.3.8.4 RANGE COMMANDS.

3.3.8.4.1 Like the function commands, the range commands are interface messages equivalent to the various positions of the range switch on the front panel of the instrument. For example, to program the instrument to range zero or 1 MHz resolution, the controller transmits the two ASCII characters G and 0.

3.3.8.5 INPUT CONFIGURATION.

3.3.8.5.1 The input configuration commands are the remote messages which perform the same instrument control function as the setting of the slope control, coupling control and trigger range controls on the front panels of the instrument. Like the function and range commands described above, the commands are simply pairs of ASCII characters. There is one difference, however, and that is the fact that there are different commands for channel A and for channel B. Note that the input configuration portion of Table 3.30, the bus message column contains a column for channel A and another column for channel B. As shown in the table to program channel A for positive slope, the controller transmits the ASCII characters A and 0. If it were desired to program channel B for positive slope, the controller must transmit the ASCII characters B and 0.

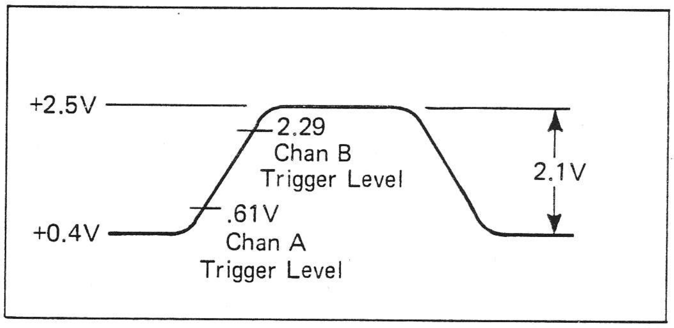
3.3.8.5.2 The input configuration may be set to SEPARATE channel, COMMON channels or to TEST by the transmission of the ASCII characters C0, C1 or C2. These command messages perform the same function as the setting of the input configuration switch located on the front panel of the instrument.

3.3.8.6 TRIGGER CONTROL.

3.3.8.6.1 Just as in the bench operation mode, the model 9514/9515 may be set to set its own trigger levels automatically or the trigger levels may be set to some specific desired level before the instrument is put into operation. Further, the trigger levels may be changed while the instrument is in operation by transmitting additional trigger control commands.

3.3.8.6.2 The simplest method of operation, of course, is to use the auto trigger mode. Like the input configuration, the trigger levels must be programmed for each channel. To set the channel A into auto trigger mode, the controller transmits the ASCII characters LAA. This mnemonic comes from the words Level A Auto. There is a similar command for channel B; LBA from the words Level B Auto.

3.3.8.6.3 It is sometimes useful to have the instrument trigger at predetermined signal levels. For example, in making a rise time measurement, the peaks of the signal can be measured through the use of a scope or the 9514/9515 counter. The trigger levels can then be set to any desired level to measure the time interval between the two channel triggers. The figure shown below illustrates a waveform and the voltage levels used for a sample rise time measurement.



3.3.8.6.4 Assume that it is desired to measure the trigger level of the pulse shown. Note that the pulse starts at .4 volts and rises to a peak of 2.5 volts. Assume further that it is desired to measure the time that it takes for the level to rise from the 10 percent to the 90 percent point of the pulse. Channel A trigger level would be programmed for 0.61 volts; while channel B would be programmed to trigger at 2.29 volts.

3.3.8.6.5 To transmit specific fixed trigger levels, the controller must transmit the channel identification, the polarity, and a 3-digit number indicating the value of the desired trigger level. In the example given above to program channel A to trigger at .61 volts, the controller would transmit the ASCII characters LA+061. In this example, the channel A attenuator would have been previously programmed in the times 1 range by the transmission of the ASCII characters A4, and thus the instrument would understand the 061 to be .61 volts.

3.3.8.6.6 In a similar fashion, the channel B attenuator would have been programmed to the times 1 range by the transmission of the ASCII characters B4 and to set the trigger level B, the controller would transmit the ASCII characters LB+229.

3.3.8.6.7 If the particular controller with which the 9514/9515 is being used happens to transmit a decimal point somewhere in the trigger level string, the operation of the 9514/9515 will be unaffected in that when the trigger level command message is received; any decimal point is ignored. In this command sequence the instrument recognizes only numeric ASCII characters after the first three characters.

3.3.8.6.8 Some high level language controllers will not allow output of leading zeroes; in this case, one or two digits may be transmitted as long as they are followed by the ASCII character X, which will act as a terminator for the trigger level entry sequence.

3.3.8.7 TRIGGER STATUS (DATA OUTPUT).

3.3.8.7.1 There are occasions when it is necessary for the controller to obtain the trigger status; as in the case where the instrument has been programmed to use the auto trigger mode, has made a measurement and has established the levels required for triggering. In this case the controller can transmit a message requesting that the 9514/9515 transmit the trigger status. For example, if the controller wants to know the trigger status for channel A it should transmit the ASCII characters H0. In response to this, the instrument will transmit a polarity sign followed by three decimal characters, a carriage return, a line feed and will lower the End Or Identify (EOI) line to signify the end of the transmission. The trigger status message contains a decimal point.

3.3.8.7.2 Note that there are six parameters for the two channel trigger level; it requires three parameters to describe each of the input signal levels.

3.3.8.7.3 When the Model 9514/9515 is commanded to use the auto trigger mode it determines the positive peak of the measurement signal and the negative peak of the measurement signal. The midpoint between the positive and negative point is then assigned as the triggering level. This function is described in paragraph 3.3.8.6.2.

3.3.8.8 MODE CONTROL.

3.3.8.8.1 The mode control commands determine the signal transfer timing between the 9514/9515 and the controller. A description of the mode control command functions is presented in the following paragraphs.

3.3.8.9 SINGLE MEASUREMENT NO SRQ.

3.3.8.9.1 As shown in Table 3.30 the message for this command is S0. When this command is transmitted as a part of an overall program string the instrument sets up internally to the function and range commanded and waits until it receives a trigger command (T or GET). When the trigger command is transmitted by the controller the counter will make one measurement, store it and wait until it receives a talk command before transmitting the measurement data on the bus. The controller is not informed when the measurement is complete and the data is ready.

3.3.8.10 SINGLE MEASUREMENT WITH SRQ.

3.3.8.10.1 Upon receipt of the S1 message the counter sets up the internal circuits to perform the function previously programmed by the program string and waits for the T or GET trigger command. Upon receipt of the trigger command the counter will make a measurement, set the SRQ bit and data ready bit of the status word and set the SRQ line low. This informs the controller that the counter has data ready and is making a service request. After the controller has accepted the data from the instrument, the instrument will wait for another trigger before taking another single measurement.

3.3.8.11 MULTIPLE MEASUREMENTS NO SRQ.

3.3.8.11.1 Upon receipt of the S2 message the instrument takes a measurement and waits for the controller to take the data by making the 9514/9515 a talker. As soon as the controller takes the measurement data from the counter in the multiple measurement mode, the counter immediately makes a new measurement and again waits for the controller to take the data.

3.3.8.12 MULTIPLE MEASUREMENTS WITH SRQ.

3.3.8.12.1 Upon receipt of the S3 message the counter makes a measurement, sets the SRQ bit and data ready bit of the status byte and sets the SRQ line low. After the controller takes the data from the counter the counter will immediately make another measurement and transmit another service request.

3.3.8.13 NEXT READING ON THE FLY.

3.3.8.13.1 Upon receipt of the V message, the counter prepares to take an "on the fly" reading. When the next talk command is received, the instrument immediately outputs the data in the accumulator without waiting for the end of the current measurement. A V message must be transmitted for each "on the fly" reading.

3.3.8.14 CONTINUOUS ARM.

3.3.8.14.1 Upon receipt of the U0 message, the instrument operates normally in that the gate operates in the normal unmodified manner. For example, an input signal applied to channel A in the FA mode causes the instrument to trigger in the automatic arm mode; the main gate is under control of the channel A trigger controls rather than an external control signal.

3.3.8.15 EXTERNAL ARM.

3.3.8.15.1 Upon receipt of the U1 message, the instrument goes into the external arm mode. In this mode the main gate is under control of an external signal applied to the gate control BNC connector on the rear panel. See paragraph 1.3.9.5.

BIT NO.	8	7	6	5	4	3	2	1
	▨	SRQ	▨	▨	▨	▨	DATA READY	OVER-FLOW

Figure 3.8 - Status Byte

3.3.8.16 SELECTIVE GATE.

3.3.8.16.1 Upon receipt of the U2 message the instrument goes into the selective gate mode which is described in Table 3.4, Reference ⑥.

3.3.8.17 SYNCHRONOUS WINDOW.

3.3.8.17.1 Upon receipt of the U4 message the instrument goes into the synchronous window mode which is described in Table 3.4, Reference ⑥.

3.3.8.18 GATE DELAY.

3.3.8.18.1 Upon receipt of the U4 message the instrument goes into the gate delay mode. This mode of operation is described in Table 3.4, Reference ⑥.

3.3.8.19 HIGH IMPEDANCE INPUT.

3.3.8.19.1 Upon receipt of the U6 message the input impedance of channels A and B will be approximately 1 megohm.

3.3.8.20 50 OHM INPUT IMPEDANCE.

3.3.8.20.1 Upon receipt of the U5 message the input impedance of channels A and B will be approximately 50 ohms.

3.3.8.21 START/STOP.

3.3.8.21.1 Upon receipt of the P message the instrument reacts as though the start/stop pushbutton on the front panel had been pressed. The operation of the start/stop function is described in Table 3-1, Reference ㉘. This mode is used only with the totalize function.

3.3.8.22 TRIGGER.

3.3.8.22.1 Upon receipt of the T message the instrument immediately performs a measurement in the function for which it has been programmed by a previously transmitted program string.

3.3.8.23 RESET.

3.3.8.23.1 Upon receipt of the R message the instrument immediately goes to its home state. The condition of the various internal circuits of the instrument in the home state is shown in Table 3.31.

Table 3.31 - Home State Condition

Operating Parameter	Home State Condition
Trigger Level A	Zero (LA + 000)
Trigger Level B	Zero (LB + 000)
Level A + Peak	Zero
Level A – Peak	Zero
Level B + Peak	Zero
Level B – Peak	Zero
On-the-Fly	Inactive
Trigger Required	No
Mode	Multiple Measurement, No SRQ (S2)
Channel A+B Slope	(A0, B1)
Channel A+B Coupling	DC (A2, B2)
Channel A+B Trigger Range	100 (A6, B6)
Input Configuration	Common (C1)
Function	Time Interval (F5)
Range	0
Arming	Normal (U0)
Data Output	Measurement (H6)

3.3.8.24 STATUS MESSAGES.

3.3.8.24.1 To inform the controller of its status the model 9514/9515 assembles and transmits a status message, referred to as the status byte. The status byte is transmitted in response to the controller's serial poll enable message. The controller generates the serial poll enable cycle in order to find out which bus member has requested service. When the instrument becomes a talker after it receives the serial poll enable command, it transmits the status byte to the controller.

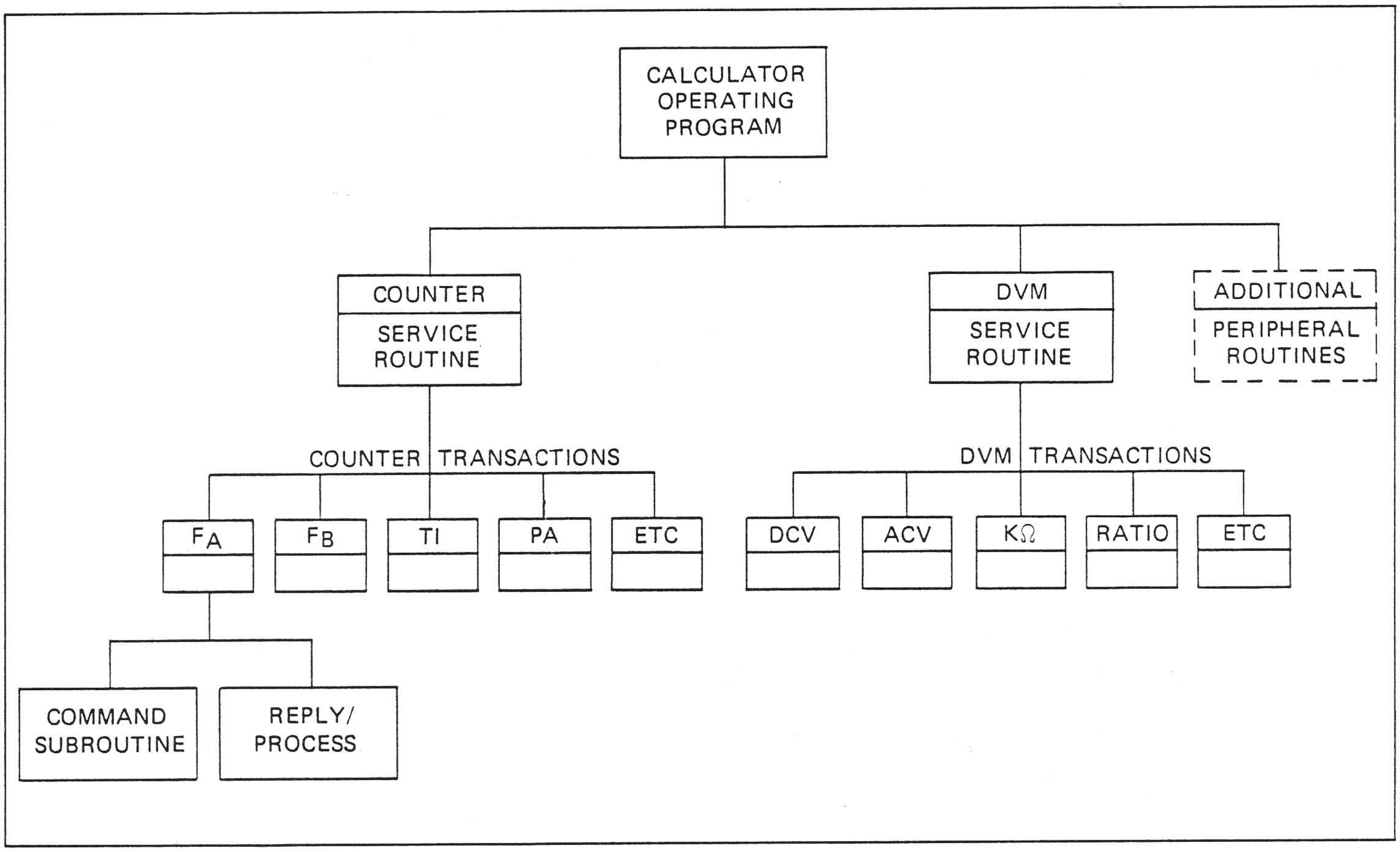


Figure 3.9 - Software Organization

3.3.8.24.2 The status byte is shown in Figure 3.8. Note that it contains 3 bits that convey specific information. Bit 1 when set to a 1 indicates that the instrument has overflowed. Bit 2 when set to the 1 state indicates that the instrument has completed a measurement and has data ready for transmission on the bus to the controller. Bit 7 indicates that the Model 9514/9515 has transmitted a service request (SRQ).

3.3.8.24.3 It should be noted that more than one bus member can transmit a service request at a time and that another bus member may have instigated the transmission of the serial poll enable command. If the Model 9514/9515 has no data ready, has not overflowed and has not transmitted the SRQ it will transmit the status byte when polled, but the status byte will contain all zeros.

3.3.8.25 TRIGGER LEVEL OUTPUT FORMAT.

3.3.8.25.1 In response to device commands H0 through H5, the Model 9514/9515 counter will transmit seven ASCII characters representing trigger level data in the following format:

± D.DD CR LF

The decimal point may appear after the first, second or third digit and its position indicates that the input attenuator is in the X1, X10 or X100 condition.

3.3.8.26 MEASUREMENT DATA OUTPUT FORMAT.

3.3.8.26.1 After the Model 9514/9515 counter makes a measurement, it transmits it, upon request, in the form of seventeen ASCII characters in the following format:

0.DDDDDDDDDE± DD CR LF

In case of overflow condition, the exponent will be set to ± 99.

3.3.9 SOFTWARE ORGANIZATION.

3.3.9.1 The following paragraphs are presented to acquaint the reader with the device messages used when operating Model 9514/9515 counter/timer and to explain the relationship of these device dependent messages to the user's overall software package.

Bus Action or Message	Active Unit	Transaction	
IFC		Interface Message	COMMAND Subroutine
ATN			
UNLISTEN	C		
I TALK	C		
YOU LISTEN	C		
F0	C	Device Dependent Message Command Characters	
G5	C		
A2C0	C		
ATN		Interface Message	REPLY Subroutine
UNLISTEN	C		
YOU TALK	C		
I LISTEN	C		
0		Peripheral Message Reply (Data, Status) Characters	
•			
1	9514/9515		
2			
3			
4			
5			
6			
7			
8			
9			
E			
+			
0			
7			
CR			
LF	↓		
EOI	9514/9515		

Figure 3.10 - 9514 Counter Transaction For Frequency Measurement, Channel A

3.3.9.2 A calculator, computer or other controller device software package usually includes a collection of transactions, service routines and subroutines for controlling all of the elements of a system. The relationship of the various parts of a typical software operating system are illustrated in Figure 3.9. A complete operating system may include the main executive program, the keyboard monitor program, some form of statistical routine, an arithmetic or decision making routine and a set of peripheral servicing routines. Figure 3.9 illustrates a portion of a software package referred to as an operating system. The portion illustrated is a typical collection of peripheral service routines. These peripheral service routines are groups of subroutines known as transactions. Note that the illustration shows a service routine for a counter, a digital voltmeter and a number of additional peripheral equipments. A counter service routine for the Model 9514/9515 counter might include a number of transactions, depending on the application of the instrument in the system. Each transaction will include the bus commands and device messages necessary to accomplish the specific function for each transaction. Note that the transactions shown are for FA (Frequency A), FB (Frequency B), TI (Time Interval), PA (Period Average) and any number of other transactions necessary for the particular counter application. Note that under the FA transaction block a further breakdown is illustrated: that of the command subroutine and the reply or process subroutine. This is the point in the overall software structure that the 9514/9515 device messages appear.

3.3.9.3. COUNTER TRANSACTIONS.

3.3.9.3.1 Figure 3.10 illustrates a typical counter transaction designed to operate the Model 9514/9515. The left-hand column of the illustration titled "Bus Action or Message" contains a sequence of bus control line titles and device characters. The second column of the illustration indicates whether the controller or the counter is controlling the bus or transmitting the characters. This column is titled "Active Unit or Talker". The boxes to the right of the second column identify the portion of the transaction as the command subroutine or the reply subroutine. Note that the command portion of the transaction includes an interface message which establishes the talker/listener relationship and the device dependent message which instructs the counter to perform a specific operation. Once the peripheral, in this case the 9514/9515 counter/timer, has been programmed to perform a function, the controller transmits the second interface message to reestablish the listener/talker relationship and the counter makes the measurement and transmits a series of characters over the interface bus which represents the measurement data.

3.4 PARALLEL BCD SYSTEMS INTERFACE.

3.4.1 This subsection presents the 9512 Systems Interface. The following paragraphs describe the programming portion of the BCD module.

3.4.1.1 By design, the Function and the N/Resolution switches develop BCD codes that are read by the Timer/Counter circuitry to execute the instructions selected. When remote operation to control the instrument in an automatic system is designed, the remote device through the interface board, must supply the identical codes to the Timer/Counter.

3.4.2 Parallel BCD Interface.

3.4.2.1 The BCD board provides remote programming for all counter controls and control data for the recorder. Input and output connections are through two 50 pin jacks secured to the rear panel. Figures 3.11 and 3.12 depict the Remote and Recorder jacks. The BCD provides interface capabilities with other instruments and controllers.

3.4.3 Interface Description.

3.4.3.1 The control lines terminate at the 50 pin Remote jack J210, but the 50 output line terminated at Recorder connector jack J209, transfers pulse transitions required to initiate the peripheral functions. With the exception of trigger levels, the pulse levels required to execute the circuit logic are:

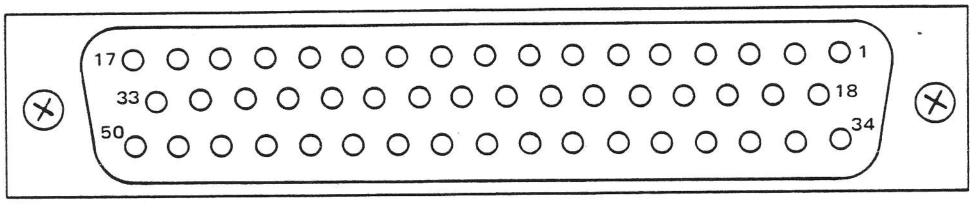
True, High or 1:	$\geq$ 2.5V positive-going
False, Low or 0:	$\leq$ 0.8V

The remote trigger voltage levels required for F_A and F_B channels are described in paragraph 3.4.4.13.

3.4.3.2 In Figure 3.11 and 3.12, each line number identifies the function and the address code, either BCD or single line digital. The following Peripheral Operation paragraphs address the Remote and Recorder functions. A "Low" pulse state is required when a bar appears over the label or mnemonic.

3.4.4 Peripheral Operation.

3.4.4.1 Numeric Readout: The numeric readout lines have the designations V1 through V9. The designators represent the corresponding readout "Window" with V1 to the right,



Pin Out	Label	Pin Out	Label
1	OF - Annunciator	26	V5-1 - Numeric Read-out Lines
2	DP-8	27	V5-8
3	MHz	28	V4-1
4	Hz	29	V4-8
5	PRT: Print Pulse	30	V3-1
6	V8-8	31	V2-1
7	V7-8	32	V2-8
8	DP-2	33	V1-1
9	V8-4 - Numeric Read-out Lines	34	DP-7
10	V7-4	35	V9-4
11	V6-4	36	V9-8
12	V5-4	37	V9-1
13	V4-4	38	KHz
14	V3-8	39	DP-1
15	V2-2	40	DP-3
16	V1-2	41	DP-5
17	V1-4	42	V8-2
18	V9-2	43	V7-2
19	DP-4	44	V6-2
20	DP-6	45	V5-2
21	Sec	46	V4-2
22	V8-1	47	V3-2
23	V7-1	48	V3-4
24	V6-1	49	V2-4
25	V6-8	50	V1-8

Figure 3.11 - J209 Recorder Jack

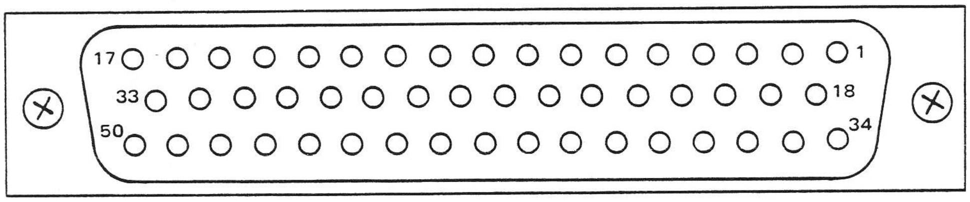
the least-significant bit. Refer to Figure 3.13. For example, a seven in the most-significant bit is shown as:

V9-8	logic 0
V9-4	logic 1
V9-2	logic 1
V9-1	logic 1

These lines are accessible at J209, the recorder output jack, and Table 3.32, the Recorder Cabling Guide lists the line numbers.

3.4.4.2 Annunciator: Designator "OF" is the annunciator label which terminates at J209 - pin 1.

3.4.4.3 Decimal: Eight lines provide the decimal (designators "DP-1" through "DP-8", refer to Figure 3.13) that describe the number of places to the left of the least-significant digit the decimal is located. These lines are accessible at J209, the recorder output jack. Table 3.32, the recorder Cabling Guide, lists the line numbers.



Pin Out	Label	Pin Out	Label
1	One Ref	26	Not Used
2	$\overline{\text{DCA}}$	27	Fb FUNCTION
3	$\overline{\text{COM}}$	28	Fd FUNCTION
4	$\overline{\text{X100–A}}$	29	B3
5	$\overline{\text{DCB}}$	30	B1
6	$\overline{\text{X10–B}}$	31	B6
7	$\overline{\text{X100–B}}$	32	B8
8	PSB - B Slope	33	A3
9	$\overline{\text{SYS CONTROL}}$	34	PSA - A Slope
10	ZERO - ▽	35	$\overline{\text{X10–A}}$
11	Fc FUNCTION	36	$\overline{\text{EXT GATE}}$
12	B4	37	μ Sec
13	B2	38	mSec
14	B5	39	$\overline{\text{TEST}}$
15	B7	40	$\overline{\text{RESET}}$
16	B9	41	$\overline{\text{HOLD}}$
17	A2	42	A ANALOG TRIGGER LEVEL INPUT
18	ZERO - ▽	43	B ANALOG TRIGGER LEVEL
19	ZERO - ▽	44	A9
20	nSec	45	A8
21	Fa FUNCTION	46	A7
22	Ra - RANGE	47	A6
23	Rb - RANGE	48	A5
24	Rc - RANGE	49	A4
25	Rd - RANGE	50	A1

Figure 3.12 - J210 Remote Jack

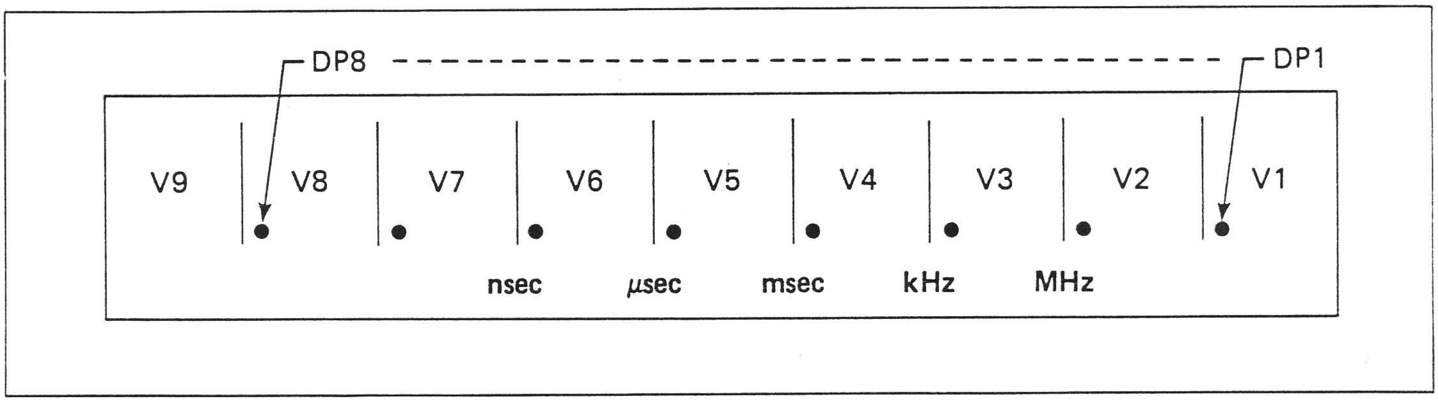


Figure 3.13 - Decimal Point Position

Table 3.32 - Recorder Cabling Guide: 9512 - J209

Output	Designator	Connector	Pin No.
Numeric	V1-1	J209	33
	V1-2		16
	V1-4		17
	V1-8		50
	V2-1		31
	V2-2		15
	V2-4		49
	V2-8		32
	V3-1		30
	V3-2		47
	V3-4		48
	V3-8		14
	V4-1		28
	V4-2		46
	V4-4		13
	V4-8		29
	V5-1		26
	V5-2		45
	V5-4		12
	V5-8		27
	V6-1		24
	V6-2		44
	V6-4		11
	V6-8		25
	V7-1		23
	V7-2		43
	V7-4		10
	V7-8		7
Numeric	V8-1	J209	22
	V8-2		42
	V8-4		9
	V8-8		6
	V9-1		37
	V9-2		18
	V9-4		35
	V9-8		36
Decimal	DP-1		39
	DP-2		8
	DP-3		40
	DP-4		19
	DP-5		41
	DP-6		20
	DP-7		34
	DP-8		2
Unit	MHz		3
	KHz		38
	Hz		4
	SEC		21
	mSec	J210	38
	nSec	J210	20
	μSEC	J210	37
Other	PRINT	J209	5
	ONE REF	J210	1
	ZERO REF	J210	10,18,19
	OVERFLOW	J209	1

Table 3.33 - Programming Cabling Guide: 9512 - J210

Input	Designator	J210 Pin No.	Mode
Function	Fa	21	4-Line
	Fb	27	
	Fc	11	
	Fd	28	
Range	Ra	22	
	Rb	23	
	Rc	24	
	Rd	25	
Sep/Com	$\overline{\text{COM}}$	3	Single Line
A Range	$\overline{\text{X10A}}$	35	2-Line
	$\overline{\text{X100A}}$	4	
A Slope	PSA	34	Single Line
A AC/DC	$\overline{\text{DC A}}$	2	
A Trigger (Binary)	A1	50	9-Line
	A2	17	
	A3	33	
	A4	49	
	A5	48	
	A6	47	
	A7	46	
	A8	45	
	A9	44	

Input	Designator	J210 Pin No.	Mode
A Trig Analog	A Analog	42	Analog
B Range	$\overline{\text{X10B}}$	6	2-Line
	$\overline{\text{X100B}}$	7	
B Slope	PSB	8	Single Line
B AC/DC	$\overline{\text{DC B}}$	5	
B Trigger (Binary)	B1	30	9-Line
	B2	13	
	B3	29	
	B4	12	
	B5	14	
	B6	31	
	B7	15	
	B8	32	
	B9	16	
B Trig Analog	B Analog	43	Analog
Other	$\overline{\text{RESET}}$	40	Single Line
	$\overline{\text{HOLD}}$	41	
	$\overline{\text{Sys Contrl}}$	9	
	$\overline{\text{Ext Gate}}$	36	
	$\overline{\text{Test}}$	39	
	GROUND	10, 18, 19	

3.4.4.4 PRT: This designator is the mnemonic for "Print Pulse". This command at J209-5 indicates that data is available for recording. The print pulse is a 0 to 1 pulse of 5 microseconds duration.

3.4.4.5 One Ref: One Reference is provided for those recorders requiring a reference voltage. This line at J209-1 jack, supplies approximately +2.5 volts with an impedance of 1 kilohm ± 5%. Refer to Table 3.32.

3.4.4.6 Zero: Zero Reference is the recorder common line to which all of the other output lines are referenced. Pins 10, 18 and 19 on J209 are common. Refer to Figure 3.32.

3.4.4.7 Sys Control: The Systems Control line (pin 9 on connector J210) programs remote operation when placed at logic "0". All front panel controls are inhibited when system control is enabled. Refer to Table 3.33.

3.4.4.8 Fa, Fb, Fc, Fd: The four function control lines; pin no. 28, 11, 27 and 21 located on J210, enables remote selection by applying the BCD code for a specific function as charted in the Function Program Guide. Refer to Table 3-33.

FUNCTION PROGRAM CHART

FUNCTION	J210 PIN NO.				BCD WEIGHT
	28	11	27	21	
CHECK	0	0	0	0	0
PERIOD	0	0	0	1	1
PERIOD AVG.	0	0	1	0	2
FREQUENCY A	0	0	1	1	3
FREQUENCY C	0	1	0	0	4
TOTALIZE	0	1	0	1	5
TIME INTERVAL	0	1	1	0	6
B/A RATIO	0	1	1	1	7
TIME INTERVAL AVG.	1	0	0	0	8
C/A	1	0	0	1	9
FREQUENCY B	1	0	1	0	10
C/A—B	1	0	1	1	11

3.4.4.9 Multiplier Time Base: The remote selection of the multiplier time base is made by applying a binary code to the four time base command lines located on J210. The remote selection duplicates the operation of the front panel pushbuttons. Coding for each time base is shown below.

Frequency Function Timebase Programming	J210 Pin No.				BCD Weight
	25	24	23	22	
1 MHz	0	0	0	1	1
0.1 MHz	0	0	1	0	2
10 KHz	0	0	1	1	3
1 KHz	0	1	0	0	4
100 Hz	0	1	0	1	5
10 Hz	0	1	1	0	6
1 Hz	0	1	1	1	7
0.1 Hz	1	0	0	0	8

The basic formulas to derive the frequency or resolution time base are listed for the N/RESOLUTION function switch.

A. Resolution:

$$\frac{107}{10K} \text{ Hz}$$

Where $1 \leq K \leq 8$ and K = BCD weight

B. Period or Time Interval:

Resolution: 10^{-7} X 10^{N} = Seconds
Where $1 \leq K \leq 8$ and K = BCD weight

C. Period Avg.
Time Interval Avg.:

$$\text{Resolution} = \frac{10\text{-}7}{10N} \text{ Sec.}$$

Where $0 \leq N \leq 7$ and N = BCD weight

D. Ratio; B/A, C/A:

$\frac{f_C}{f_A}$ X 10N or $\frac{f_B}{f_A}$ X 10^N and N = BCD weight

TIME BASE PROGRAMMING ALL FUNCTIONS EXCEPT FREQUENCY					
N/RESOLUTION NUMBER	J210 PIN NO.				BCD WEIGHT
	25	24	23	22	
0	0	0	0	0	0
1	0	0	0	1	1
2	0	0	1	0	2
3	0	0	1	1	3
4	0	1	0	0	4
5	0	1	0	1	5
6	0	1	1	0	6
7	0	1	1	1	7

3.4.4.10 Input Controls: The remote operation of input controls for channels A and B consists of both single line and binary coded inputs. Coding for the input controls is provided below.

	J210 Pin No.
Separate/Common	3
Separate	1
Common	0

Channel A Range	4	35	BCD Weight
X100	0	1	1
X10	1	0	2
X1	1	1	3

Channel A Slope	J210 Pin No.
	34
+	1
–	0

Channel A AC/DC	J210 Pin No.
	2
AC	1
DC	0

Channel A Trigger Level	J210 Pin No.								
	44*	45	46	47	48	49	33	17	50

*Most Significant Bit

Channel B Range	7	6	BCD Weight
X100	0	1	1
X10	1	0	2
X1	1	1	3

Channel B Slope	J210 Pin No.
	8
+	1
–	0

Channel B AC/DC	J210 Pin No.
	5
AC	1
DC	0

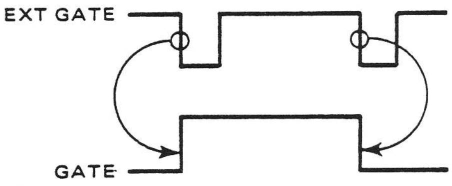
Channel B Trigger Level	J210 Pin No.								
	16*	32	15	31	14	12	29	13	30

*Most Significant Bit

3.4.4.11 Hold: The Hold line, pin 41 of J210, corresponds to the full clockwise position of the DISPLAY TIME control on the front panel. When the Hold line is at logic 0, the counter takes one reading and holds the measurement until the Reset is activated.

3.4.4.12 Reset: The reset corresponds to the front panel RESET switch. This is a single line control (pin 40 of J210) and is activated when set to logic 0. The line must be held at logic 0 for a minimum of 10 microseconds. During power up and $\overline{\text{reset}}$, BCD Data Registers are not cleared to zero.

3.4.4.13 External Gate: The external gate line (pin 36 of J210) is used in the Totalize mode to externally establish a gate time during which channel A signal is counted. The external gate command must be greater than 100 nanoseconds. Two commands are required per gate time or measurement. The gate is initiated in less than 50 nanoseconds after the following edge of the first command. The next command terminates the gate and holds the accumulated reading. The count may be cleared by pulling the Reset line to logic 0.



3.4.4.14 $\overline{\text{TEST}}$. In the test position, a 10 MHz signal (Low) is applied to the inputs of both channel A and channel B.

3.4.4.15 Trigger Level:

A. The trigger levels of channels A and B are capable of being independently set by external control with either an analog voltage level or a binary coded input.

B. Analog control of channel A is through pin 42 and control of channel B is through pin 43 of connector J210. To program channels to a desired level, multiply the input voltage by .085.

Example: $V_{IN} = 11.75$, Trigger = 1.00 V

C. The Trigger Level (T.L.) voltages vary from a maximum 3.1875 volts positive to a minimum of 3.2 volts negative. To find the binary number (BN) for a specific trigger level, apply the formula:

$$BN = \frac{3.1875 - \text{Required T.L.}}{12.5 \text{ X } 10^{-3}}$$ (decimal equivalent of BN: convert to BN)

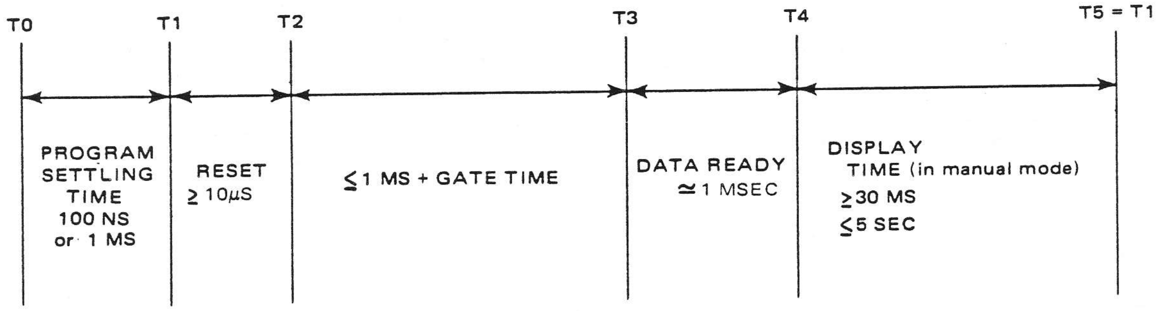
Example: Require a T.L. of –2.18 volts, find BN

$$BN = \frac{3.1875 - (-2.18)}{12.5 \text{ X } 10^{-3}} = 429$$ decimal BN equivalent rounded off

429 = binary 1 1 0 1 0 1 1 0 1

Relating to Channel A; pin numbers on J-210

BN -	1	1	0	1	0	1	1	0	1
	A9	A8	A7	A6	A5	A4	A3	A2	A1
Pin No.	44	45	46	47	48	49	33	17	50



T0 - T1	TIME FOR INPUTS TO SETTLE ≤100 NS. IF PROGRAMMING OF TRIGGER LEVEL OR SIGNAL CONDITIONING WAS CHANGED, SETTLING TIME WILL BE 1 MS.
T1 - T2	RESET ≥ 10µS
T2 - T3	≤1 MS + GATE TIME, GATE OPENS, COUNTS ACCUMULATE IN THE COUNTER, GATE CLOSES, DISPLAY FLIP-FLOP IS RESET.
T3 - T4	DATA READY FLAG. (PRINT PULSE)
T4 - T5	DISPLAY TIME ELAPSES (≥30 MS TO ≤5 SEC SELECTABLE ON FRONT PANEL WHEN COUNTER IS IN MANUAL MODE).

Figure 3.14 - Simplified Timing Diagram

4.1 INTRODUCTION.

4.1.1 This section contains system operating examples for the Model 9514/9515 timer/counter. Each example contains a statement of purpose, a sample program string and the device dependent message required to program the instrument for the particular application. These examples were prepared using a Hewlett-Packard 9825 calculator connected to the Racal-Dana Model 9514/9515 through the IEEE 488-1975 Standard Interface. Each example contains a program listing as printed by the calculator along with an explanation for each line of the program. If the 9514/9515 is to be used with a Hewlett-Packard Model 9825 calculator, the programming presented in this section may be used directly and/or further modified to suit the users needs. Because the Model 9514/9515 may be used with any controller which operates on the standard interface bus, the user may wish to prepare equivalent software for another controller device. In such a case the user should review the remote operating instructions contained in Section 3 of this manual to select and assemble appropriate operating statements for his controller, which cause the transmission of the required interface messages and device dependent messages.

4.1.2 For example, in the first program sample in this section, line zero of the program is `rem 7` and the accompanying explanation indicates that this statement on the Hewlett Packard 9825 calculator sends the remote message to all devices on the bus. This statement causes the calculator to lower the REN line thus arming the counter for remote operation.

4.1.3 Referring again to the first example note that line 1 of the program printout contains the statement `flt 6` and that the accompanying explanation indicates that this sets the floating decimal format. This may or may not be a feature or function of the controller in use and since it is not an interface or device dependent message, use of an equivalent is at the discretion of the user. Line 2 of the program shows the statement `wrt 702;`.The explanation indicates that this transmits the device listen address 02. The user should select the statement for his controller which causes it to transmit the listen address assigned to the counter. Instructions for the address assignment of the Model 9514/9515 are presented in paragraph 3.3.5. Table 3.26 shows the address switch setting, the talk and listen address characters and data line binary code for each available decimal address of the instrument.

4.1.4 Line 2 of the example also contains the program string which is composed of the device dependent messages. The device dependent message is the primary subject to which this section of the manual addresses itself. The examples contained in this section are presented primarily to show the various combinations of device dependent messages used to accomplish the various remotely controlled measurement operations. Note that the program printout indicates the string of device dependent messages presented in the table directly above the program tape. This format is maintained throughout the section and thus the user may use this section conveniently by referring to the device dependent message string shown for each system operation example.

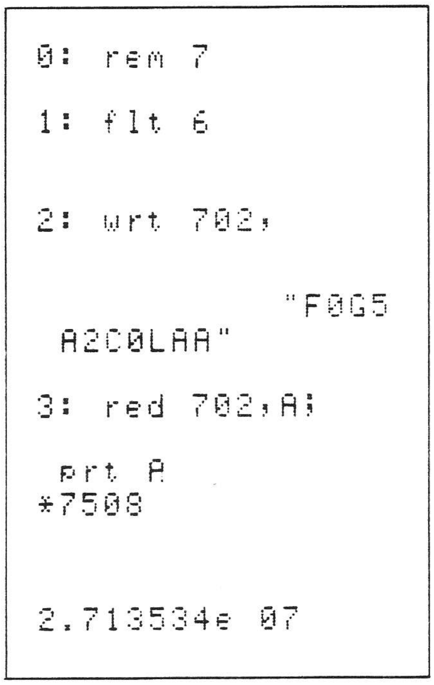
4.1.5 Line 3 of the program, shown in the example, is the reply subroutine of the program and instructs the counter to become a talker and transmit the measurement data. Line 3 also instructs the calculator to store the measurement data transmitted by the counter in a storage register known as "Variable A" and, subsequentially, to print the value in Variable A on the program tape. The final line on the program printout is the measurement value `2.713534e 07` the answer 27.13534 MHz.

Purpose: Remotely program the FA function to measure 27.135 MHz transmitter frequency

9514/9515 Program String: F0G5A2C0LAA

Device Dependent Messages

Device Code	Parameter
F0	Frequency A
G5	Range 5 (10 Hz)
A2	A DC Coupling
C0	Separate inputs
LAA	Channel A Auto Trigger



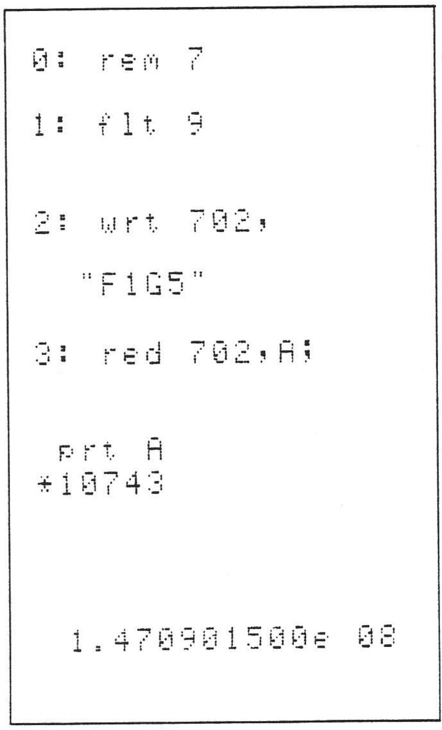
`0: rem 7`	Sends Remote message to all devices on the bus.
`1: flt 6`	Sets floating decimal (scientific notation) format. Six places to the right of the decimal. i.e. X.XXXXXXeXX
`2: wrt 702,`	Address device 02 (9514/9515) as a listener.
`"F0G5 A2C0LAA"`	Writes a device dependent message followed by a Carriage Return (CR) and Line Feed (LF) to device 02 (9514/9515).
`3: red 702,A;`	Address device 02 (9514/9515) as a talker. Reads values into variable A from device 02 (9514/9515).
`prt A` `*7508`	Prints the value stored in variable A.
`2.713534e 07`	Answer: 27.13534 MHz

Purpose: Remotely program the FC function to measure a 147.09 MHz transmitter frequency.

9514/9515 Program string F1G5

Device Dependent Messages

Device Code	Parameter
F1 G5	Frequency C 10 Hz Resolution



```
0: rem 7

1: flt 9


2: wrt 702,
     "F1G5"

3: red 702,A;


  prt A
*10743




  1.470901500e 08
```

——— Send Remote message to all devices on the bus

——— Sets floating decimal point (scientific notation) nine places to the right of the decimal. i.e. X.XXXXXXXXXeXX

——— Address device 02 (9514/9515) as a listener.

——— Writes a device dependent message, 9514/9515 program string, followed by a (CR) Carriage Return and (LF) Line Feed to device 02(9514/9515).

——— Address device 02 (9514/9515) as a talker. Reads values into specified variable (A) from device 02 (9514/9515).

——— Prints the value stored in variable A.

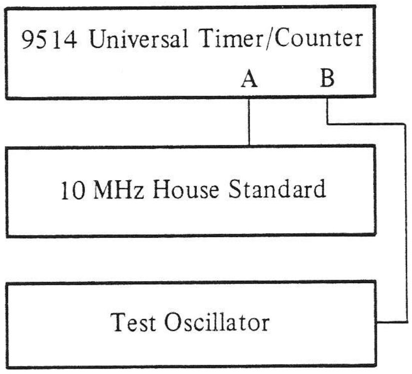
——— Answer: Transmitter frequency 147.09015 MHz.

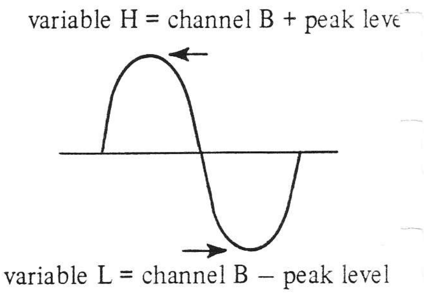
Purpose: Remotely program the B/A Ratio function to check the calibration of a test oscillator against a 10 MHz house standard.

9514/9515 Program String F2G6A3B3C0LAALBAH3
H5

Device Dependent Messages

Device Code	Parameter
F2	B/A Ratio Function
G6	Range 6
A3	AC Coupling channel A
B3	AC Coupling channel B
C0	Separate inputs
LAA	Auto trigger A
LBA	Auto trigger B
H3	Channel B + peak level
H5	Channel B – peak level





```
0: rem 7
```

Sends Remote message to all devices on the bus.

```
1: conv 13,32,
 10,44
```

Cancels any previously sent conversion table and converts CR (Carriage Return) to a SP (Space) and LF (Line Feed) to a , (Comma).

```
2: wrt 702,
```

Address device 02 (9514/9515) as a listener.

```
                  "F2G6
 A3B3C0LAALBAH3"
```

Writes a device dependent message (9514/9515 program string) followed by a CR (Carriage Return) and LF (Line Feed) to device 02 (9514/9515).

```
3: red 702,H,M;
```

Address device 02 (9514/9515) as a talker. Reads channel B positive peak i o variable H, and the ratio measurement into variable M.

```
 wrt 702,"H5";
```

Address device 02 (9514/9515) as a listener. Write a device dependent message (9514/9515 program string) followed by a CR (Carriage Return) and LF (Line Feed) to device 02 (9514/9515).

```
 red 702,L
```

Address device 02 (9514/9515) as a talker. Reads values into variable C from device 02 (9514/9515).

```
4: H-L→D;
```

Subtracts the value stored in variable L (channel B – peak) from the value stored in variable H (channel B + peak). Places result in variable D(Peak to Peak value).

```
 D*.3535→D;
```

Multiplies the value in variable D by .3535 and stores value in variable D (Peak to peak x .3535= RMS).

```
 fxd 2;
```

Sets fixed decimal format, 2 places after the decimal.

```
 prt "RMS=",D;
```

Prints the characters RMS= and the value stored in variable D.

```
 fxd 6;prt "B/
 A=",M
```

Sets fixed decimal format, 6 places after the decimal. Prints the characters B/A (RATIO) and the value stored in variable M.

```
5: B*1e7→E;
```

Multiplies the value stored in variable M (ratio of channel A and B) by 1e7 (10 MHz house standard) to obtain frequency of test oscillator and stores that value in variable E.

```
  flt 4;
```

Sets floating decimal point (scientific notation) format, 4 places to the right of the decimal. i.e. X.XXXXeXX

```
  prt "F=",E
  *20663
```

Prints the characters F= and the value stored in variable E.

```
RMS=          8.50
```

Answer: RMS value = 8.50V

```
B/A=      0.050928
```

Ratio of the oscillators = 0.050928

```
F=     5.0928e 05
```

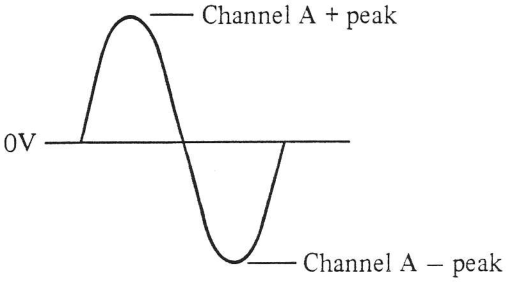
Frequency of the test oscillator = 509.28 KHz.

Purpose: Measure the period of a 450 Hz sine wave. Display the period, frequency and Peak to Peak value.

9514/9515 Program String: F4G0A0A2C0LAAH2
H4

Device Dependent Messages

Device Codes	Parameter
F4	Period
G0	Range 0 (1 period)
A0	Channel A + Slope
A2	Channel A DC coupling
C0	Separate inputs
LAA	Auto trigger channel A
H2	Channel A + Peak Level
H4	Channel A – Peak Level



`0: rem 7`	Send Remote message to all devices on the bus.
`1: conv 13,32,10,44`	Cancels any previously sent conversion tables. Converts Carriage Return (CR) to Space (SP) and Line Feed (LF) to Comma (,) for input data.
`2: wrt 702,`	Address device 02 (9514/9515) as a listener.
`"F4G0A0A2C0LAAH2"`	Writes a device dependent message followed by a Carriage Return (CR) and Line Feed (LF) to device 02 (9514/9515).
`3: red 702,A,B;`	Address device 02 (9514/9515) as a talker. Read values into variables A and B from device 02 (9514/9515).
`wrt 702,"H4";`	Address device 02 (9514/9515) as a listener. Writes a device dependent message followed by a Carriage Return (CR) and Line Feed (LF) to device 02 (9514/9515).
`red 702,C`	Address device 02 (9514/9515) as a talker. Reads values into variable C from device 02 (9514/9515).
`4: A-C→D;`	Subtracts the value stored in variable C (channel A – peak level) from the value stored in variable A (channel A + peak level). Stores the result in variable D.
`fxd 2;`	Sets fixed decimal format, 2 places to the right of the decimal.

`prt "P-P=",D;`	Prints the characters P–P= and the value stored in variable D (peak to peak).
`flt 3;`	Sets floating decimal (scientific notation) format three places to the right of the decimal. i.e. X.XXXeXX
`prt "P=",B;`	Prints the characters P= and the value stored in variable B (Period).
`fxd 3;`	Sets fixed decimal 3 format, three places to the right of the decimal.
`1/B→E;`	Divides 1 by the value stored in variable B and stores the result in variable E (reciprocal of period).
`prt "F=",E` `*11662`	Prints the characters F= and the value stored in variable E.
`P-P=          8.90`	Answer: Peak to Peak value 8.90 Volts
`P=     2.218e-03`	Period 2.218 ms
`F=       450.836`	Frequency 450.836 Hz

Purpose: Remotely program the Time Interval function to measure the pulse width of a T^2L 1 Hz clock at the two volt level.

9514/9515 Program: F5G1A0B1A2B2A4B4C1LA+200LB+200

Device Dependent Messages

Device Code	Parameter
F5	Time interval
G1	Range 1
A0	Channel A + Slope
B1	Channel B – Slope
A2	Channel A DC coupling
B2	Channel B DC coupling
A4	A 1 volt range
B4	B 1 volt range
C1	common input
LA+200	Trigger level A+2.00V
LB+200	Trigger level B+2.00V

```
0: rem 7

1: flt 5


2: wrt 702,

              "F5G1
  A0B1A2B2A4B4C1L
  A+200LB+200"

3: red 702,A;

  prt "TI=",A
*19358



TI=   4.98662e-01
```

Sends Remote message to all devices on the bus.

Sets floating decimal (scientific notation) format. Five places to the right of the decimal. i.e. X.XXXXXeXX

Address device 02 (9514/9515) as a listener.

Writes a device dependent message (9514/9515 program string) followed by a Carriage Return (CR) and Line Feed (LF) to device 02 (9514/9515).

Address device 02 (9514/9515) as a talker. Reads values into specified variables (A) from device 02 (9514/9515).

Prints the characters TI= and the value stored in variable A.

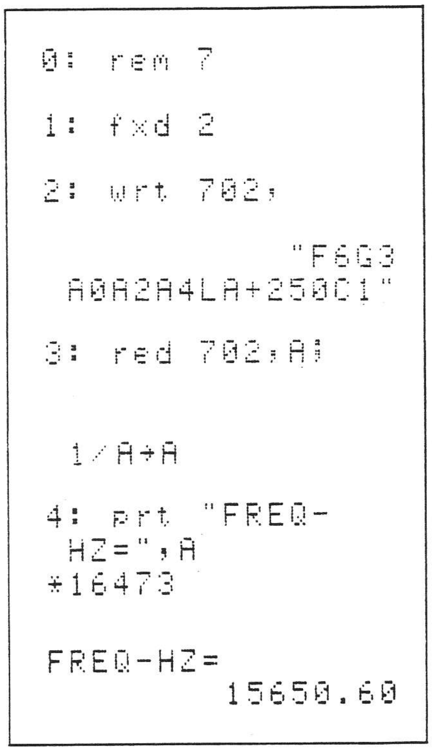
Answer: Time interval = .498662 sec.

Purpose: Measure the period, using period average for greater resolution, of a 5 volt 15.6 KHz sine wave from a hybrid oscillator and convert to frequency.

9514/9515 Program String: F6G3A0A2A4LA+250

Device Dependent Messages

Device Codes	Parameter
F6	Period average
G3	Range 3(10K periods)
A0	Channel A + Slope
A2	Channel A DC coupling
A4	Channel A 1V Range
LA+250	Trigger level A 2.50V
C1	Common inputs 1



```
0: rem 7

1: fxd 2

2: wrt 702,
          "F6G3
 A0A2A4LA+250C1"

3: red 702,A;


 1/A→A

4: prt "FREQ-
 HZ=",A
*16473

FREQ-HZ=
          15650.60
```

Sends Remote message to all devices on the bus.

Sets fixed decimal 2 format, two places to the right of the decimal.

Address device 02 (9514/9515) as a listener.

Writes a device dependent message followed by a Carriage Return (CR) and Line Feed (LF) to device 02 (9514/9515).

Address device 02 (9514/9515) as a talker. Reads values into variable A from device 02 9514/9515.

Divides 1 by the value stored in variable A and places that new value (Reciprocal of Period) in variable A.

Prints the characters FREQ-HZ= and the value stored in variable A.

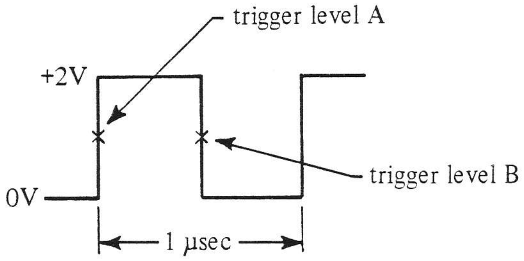
Answer 15.6506 KHz

Purpose: Measure the Pulse Width of a 2V 1 MHz clock @ the 50% point using time interval average for greater resolution.

9514/9515 Program String: F7G6A0B1A2B2A4B4LA+100LB+100C1

Device Dependent Messages

Device Codes	Parameter
F7	Time Interval Average
G6	Range 6
A0	Channel A + Slope
B1	Channel B – Slope
A2	Channel A DC coupling
B2	Channel B DC coupling
A4	Channel A 1V Range
B4	Channel B 1V Range
LA+100	Trigger level A + 1.00V
LB+100	Trigger level B + 1.00V
C1	Common inputs



```
0:  rem  7

1:  flt  6

2:  wrt  702,

                "F7G6
  A0B1A2B2A4B4LA+
  100LB+100C1"

3:  red  702,A;

    prt  A
   *16101


          4.733907e-07
```

Sends Remote message to all devices on the bus.

Sets floating decimal (scientific notation) format. Five places to the right of the decimal. i.e. X.XXXXXeXX

Address device 02 (9514/9515) as a listener.

Writes a device dependent message followed by a Carriage Return (CR) and Line Feed (LF) to device 02 (9514/9515).

Address device 02 (9514/9515) as a talker. Reads values into variable A fro device 02 (9514/9515).

Prints the value stored in variable A.

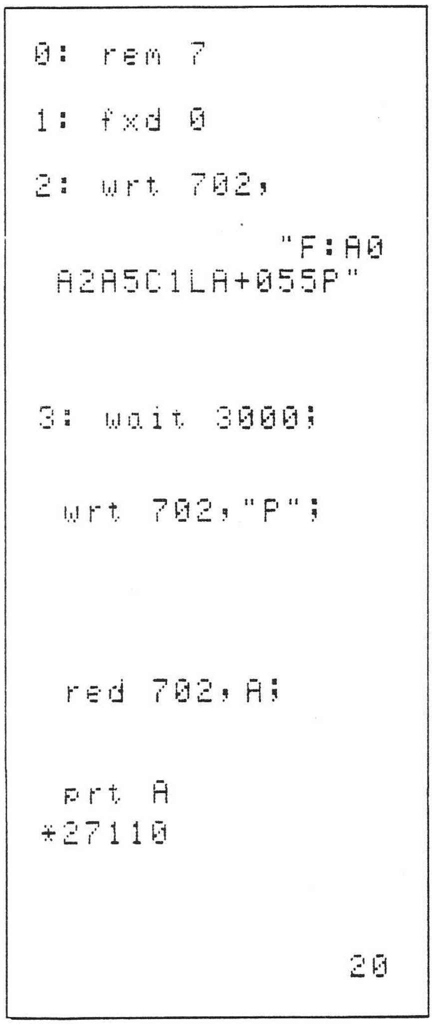
Answer: .4733907 µsec

Purpose: Measure number of noise spikes occuring on a 5 volt power supply line over a 3 second interval

9514/9515 Program String: F: A0A2A5C1LA+055P
P

Device Dependent Messages

Device Codes	Parameter
F:	Totalize
A0	Channel A + Slope
A2	Channel A DC coupling
A5	Channel A 10V Range
C1	Common input
LA+055	Trigger level A + 5.5V
P	Start/Stop



```
0: rem 7
```

Send Remote message to all devices on the bus

```
1: fxd 0
```

Sets fixed decimal format (no trailing decimals).

```
2: wrt 702,
```

Address device 02 (9514/9515) as a listener.

```
              "F:A0
 A2A5C1LA+055P"
```

Writes a device dependent message, followed by a Carriage Return (CR) and Line Feed (LF) to device 02 (9514/9515).

NOTE: The first P opens the measurement gate.

```
3: wait 3000;
```

Commands the controller to wait 3 sec before proceeding to the next step.

```
 wrt 702,"P";
```

Address device 02 (9514/9515) as a listener and writes a device dependent message followed by a Carriage Return (CR) and Line Feed (LF) to device 02 (9514/9515).

NOTE: The second P closes the measurement gate.

```
 red 702,A;
```

Address device 02 (9514/9515) as a talker. Reads values into variable A from device 02 (9514/9515).

```
 prt A
*27110
```

Prints the value stored in variable A.

```
                   20
```

Answer: 20 noise spikes

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Upstate New York
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CANADA
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British Columbia
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Ottawa
(613) 726-8888
Montreal
(514) 336-0392

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RACAL-DANA Instruments Inc.

U. S. AND CANADIAN SERVICE CENTERS

FACTORY SERVICE

A RACAL-DANA INSTRUMENTS INC.
4 Goodyear Street
Irvine, California 92718
Telephone: (714) 859-8999

PRODUCT SERVICE TWX 910-595-1136

REGIONAL SERVICE CENTER

B RACAL-DANA INSTRUMENTS INC.
5101 "D" Blacklick Road
Annandale, Virginia 22003
Telephone: (703) 941-0525

INTERNATIONAL SERVICE CENTERS

RACAL-DANA INSTRUMENTS LTD.

Duke Street, Windsor,
Berkshire SL4 1SB, United Kingdom
Telephone: Windsor (0753) 868101, TLX: 847013

RACAL-DANA INSTRUMENTS GmbH.

Hermannstrasse 29, D-6078 Neu Isenburg,
Federal Republic of Germany
Telephone: 06102-2861/2, TLX: 412896

RACAL-DANA INSTRUMENTS S.A.

18 Avenue Dutartre, 78150 Le Chesnay, France
Telephone: (1) 3-955-8888, TLX: 697 215

RACAL-DANA INSTRUMENTS ITALIA srl.

Via Mecenate 84/A, 20138 Milano MI, Italy
Telephone: (02) 5062767/5062686, TLX: 315697

REPAIR REQUEST FORM

To allow us to better understand your repair requests, we suggest you use the following outline and include a copy with your instrument to be sent to your local Racal-Dana repair facility.

Model Number ____________________ Options ____________________ Date ______________

Serial Number ________________________ P. O.# ________________________________

Company Name ____

Address ____

City __________________________________ State __________ Zip Code _____________

Contact ___________________________ Phone Number ______________________________

1. Describe, in detail, the problem and symptoms you are having.

____

____

2. If you are using your unit on the bus, please list the program strings used and the controller type, if possible. ____

____

3. List all input levels, and frequencies this failure occurs.

____

____

4. Indicate any repair work previously performed.

____

____

5. Please give any additional information you feel would be beneficial in facilitating a faster repair time. (I. E., modifications, etc.)

____

____