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User Manual

3162A/B

500 MS/s
(SINGLE OR DUAL CHANNEL)
WAVEFORM SYNTHESIZER

Publication No. 980818

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PUBLICATION DATE: May 8, 2001

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FOR YOUR SAFETY

Before undertaking any troubleshooting, maintenance or exploratory procedure, read carefully the **WARNINGS** and **CAUTION** notices.

This equipment contains voltage hazardous to human life and safety, and is capable of inflicting personal injury.

If this instrument is to be powered from the AC line (mains) through an autotransformer, ensure the common connector is connected to the neutral (earth pole) of the power supply.

Before operating the unit, ensure the conductor (green wire) is connected to the ground (earth) conductor of the power outlet. Do not use a two-conductor extension cord or a three-prong/two-prong adapter. This will defeat the protective feature of the third conductor in the power cord.

Maintenance and calibration procedures sometimes call for operation of the unit with power applied and protective covers removed. Read the procedures and heed warnings to avoid “live” circuit points.

Before operating this instrument:

1. Ensure the instrument is configured to operate on the voltage at the power source. See Installation Section.

2. Ensure the proper fuse is in place for the power source to operate.

3. Ensure all other devices connected to or in proximity to this instrument are properly grounded or connected to the protective third-wire earth ground.

If the instrument:

- fails to operate satisfactorily
- shows visible damage
- has been stored under unfavorable conditions
- has sustained stress

Do not operate until performance is checked by qualified personnel.

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Chapter 1

GETTING STARTED

What's In This Chapter

This chapter contains a general description of the VXIbus Model 3162A and 3162B Waveform Generators and an overall functional description of the instrument. It lists and describes various options available for these models. It also describes the front panel connectors and indicators.

This manual provides description of all features and options available with the instruments; however, some items described in the following paragraphs may not be installed in your instrument.



Figure 1-1, Model 3162A and 3162B

Introduction

A detailed functional description is given following the general description of the features, functions, and options available with the Model 3162A and Model 3162B.

The Model 3162A is a VXIbus, single slot, C-size synthesized Waveform Generator. It is a high performance waveform generator that combines three powerful instruments in one small package: function generator, arbitrary waveform generator and sequence generator. The instrument provides a variety of standard waveforms to be used as test stimuli for different electronic devices.

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The Model 3162B is a VXIbus, dual slot C-size, dual-channel synthesized

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Waveform Generator. It has the same performance as the Model 3162A, except it has two separate main outputs. While sample clock, frequency, trigger and sequence modes are common to the two channels, each channel has separate controls for amplitude, offset, and waveform shape.

NOTE

The Model 3162B has the same functionality as the Model 3162A. This manual describes all functions and features that are available on the Model 3162B. If you own the Model 3162A, simply ignore all references in this chapter to the second output channel.

Despite its small size, the Model 3162B offers many features and functions such as *VXIplug&play* compatibility, frequency hopping, amplitude modulation, FSK modulation, front panel or backplane PLL, phase modulation, counted burst, internal trigger-generator, and more. The instrument generates high quality, high accuracy waveforms throughout the specified frequency range, amplitude span and operating temperature.

The Model 3162B generates standard waveforms at frequencies ranging from 100µHz to 250 MHz. It can also generate arbitrary waveforms with clock rates ranging from 100mHz to 500 MHz. Clock rates and frequency may be set with 7 digits of resolution. The accuracy and the stability of the output frequency depend on the reference clock. As standard, a TCXO circuit provides 1ppm accuracy and stability. With the TCXO reference, the output frequency can be controlled to a full seven digits of resolution and accuracy.

Output amplitude may be programmed separately for each channel within the range of 20mV to 10Vp-p into an open circuit, and 10mV to 5V into 50Ω. Amplitude and offsets are programmed with 4 digits of resolution.

Using its PLL function, the generator can be phase locked to an external reference. An internal frequency counter detects the frequency of the external signal and adjusts the 3162B to its optimal lock-in range. After the instrument has locked, the phase offset between the two signals can be changed from 0° to +360°. Phase offset adjustment is controllable via SCPI commands or by using the PM input as a phase modulation control.

Besides its normal continuous mode, the Model 3162B responds to a variety of trigger modes. The output waveform may be gated, triggered, or may generate a counted burst of waveforms. A built-in trigger generator with a programmable period can be used as a replacement for an external trigger source.

The Model 3162B generates arbitrary waveforms with 12 bits of resolution. While ten standard waveforms are memory resident, up to 4096 additional waveforms may be downloaded from the controller to the instrument, using shared memory or standard data bus transfer. Waveforms may also be generated using the WaveCAD program.

The Model 3162B is a digital instrument. With the exception of standard waveforms, any waveform it generates must be first downloaded to waveform memory. The arbitrary waveform memory is a bank of 12-bit words. Each word

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represents a point on the waveform. Each word has a horizontal address that can range from 0 to 1046464, and a vertical address that can range from -2047 to +2048 (12 bits). Using a high speed clocking circuit, the digital contents of the arbitrary waveform memory are extracted and routed to the Digital to Analog Converter (DAC). The DAC converts the digital data to an analog signal, and the output amplifier completes the task by amplifying or attenuating the signal at the output connector.

There is no need to use the complete memory bank every time an arbitrary waveform is generated. Waveform memory can be divided into up to 4096 smaller segments, and different waveforms can be loaded into each segment. The various segments may then be loaded into a sequence table to generate long and complex waveforms. The sequence table can link up to 4096 segments, while each segment can loop up to 1 million times.

The Model 3162B is fully programmable using SCPI commands and syntax. There are four ways to program the Model 3162B, the first being low-level programming of each individual parameter with SCPI commands. The second alternative is to use the *VXIplug&play* driver's Soft Front Panel (SFP) for high-level programming. The *SFP* driver simulates a mechanical front panel with the necessary push buttons, displays and dials to operate the Model 3162B as a bench-top instrument. The third way to program the 3162B is by using either the LabVIEW or LabWindows/CVI driver. The fourth way to program the 3162B is via the WaveCAD program. The Model 3162B will not operate without being programmed. Therefore, it is recommended that the user become familiar with its basic features, functions and programming concepts as described in this and the following chapters.

Options

No options are offered for the generators. Compare the Model number with the number that is printed on the instrument to verify which of the instrument you received. Contact your nearest Racal representative if the number printed on the case does not reflect the correct version ordered. The list of available versions is given below:

Revision 4/18/00

- 407627-001 - Model 3162A, 500MS/s Waveform Generator, w/1Meg RAM, 1PPM
- 407627-013 - Model 3162A, 500MS/s Waveform Generator, w/4Meg RAM, 1PPM
- 407627-014 - Model 3162A, 500MS/s Waveform Generator, w/8Meg RAM, 1PPM
- 407629-001 - Model 3162B, 500MS/s Waveform Generator, w/1Meg RAM, 1PPM

1Meg RAM designates instruments supplied with the 1Meg memory. 1046464 point waveforms can be programmed. 4 Meg RAM designates 4193304 point waveforms and 8 Meg RAM designates 8387608 point waveforms can be programmed.

1ppm denotes the accuracy and stability grade of the internal 10MHz reference clock.

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Manual Changes

Technical corrections to this manual (if any) are noted on the pages themselves, with the change date shown at the bottom of the page..

Safety Considerations

The Model 3162B has been manufactured according to international safety standards. The instrument meets VDE 0411/03.81 and UL 1244 standards for safety of commercial electronic measuring and test equipment for instruments with an exposed metal chassis that is directly connected to earth via the chassis power supply cable.

WARNING

Do not remove instrument covers when operating or when the chassis power cord is connected to the mains.

Any adjustment, maintenance and repair of an opened, powered-on instrument should be avoided as much as possible, but when necessary, should be carried out only by a skilled person who is aware of the hazard involved.

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Supplied Accessories

The instrument is supplied with an Instruction Manual. The manual includes disks with VXI*plug&play* drivers along with WaveCAD for Windows 3.1X and Windows 95/NT. A Service Manual is available upon request.

Specifications

Instrument specifications are listed in Appendix A. These specifications are the performance standards or limits against which the instrument is tested. Specifications apply under the following conditions: output terminated into 50Ω after 30 minutes of warm up time, and within a temperature range of 20°C to 30°C. Specifications outside this range are degraded by 0.1% per °C.

Functional Description

A detailed functional description is given in the following paragraphs. The description is divided into logical groups: input and output connectors, operating modes, output type, output state, filters, synchronization, front panel indicators and programming.

Input and Output Connectors

The Model 3162B has 7 BNC connectors on its front panel: two main outputs, SYNC output, TRIG/PLL/FSK input, channel A AM/PM input, channel B AM input and reference clock input. It also has a 9-pin D-sub connector for frequency hop and output segment control.

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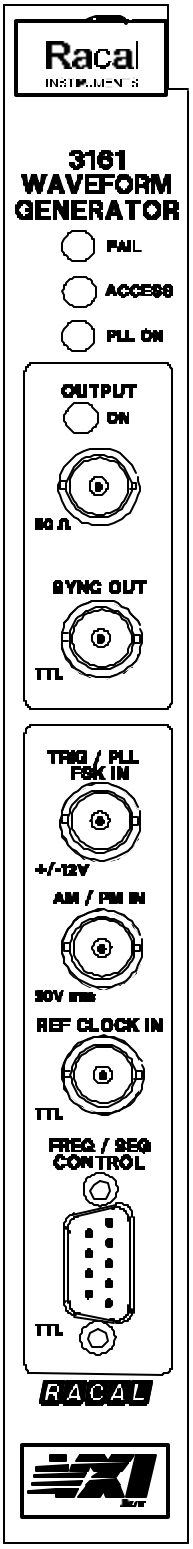


Figure 1-2, The Front Panel

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Main Output - Channel A

The main output A connector outputs standard, user, sequenced, and modulated waveforms. Output impedance is 50Ω. That is, the cable connected to this output should be terminated with 50Ω. Output amplitude accuracy is calibrated when connected to a 50Ω load. If the output is connected to a different load resistance, determine the actual amplitude from the following equation:

$$V_{out} = 2V_{prog}\left(\frac{50\Omega}{50\Omega + R_L}\right)$$

The output amplitude is doubled when the output impedance is above 1 MΩ.

Main Output - Channel B

The main output B connector outputs standard, user, sequenced, and modulated waveforms. Phase offsets, accuracy and jitter are tightly controlled between the two main outputs. Main output B impedance is 50Ω. While amplitude, offset and waveform controls are separate for each channel, all other parameters are common (i.e., sample clock, trigger mode, etc.).

SYNC Output

The SYNC output generates a single TTL pulse for synchronizing other instruments (e.g., an oscilloscope) to the output waveform. The SYNC signal always appears at a fixed point relative to the waveform. The location of the SYNC signal along the waveform is programmable.

Trigger/PLL/FSK Input

The trigger input accepts signals that stimulate the Model 3162B to output waveforms. The trigger input is inactive when the instrument is in continuous operating mode. When placed in trigger, gated or burst mode, the trigger input is made active and waits for the right condition to trigger the instrument. In trigger and burst modes, the trigger input is edge sensitive, i.e., it senses transitions from high to low or from low to high to trigger the Model 3162B. The direction of the transition is programmable. In PLL mode, the trigger input is used as a phase reference input. In FSK mode, the trigger input is used as a frequency shift control. The FSK input is level sensitive, i.e., the Model 3162B outputs carrier frequency when the level is low and shifts to a pre-programmed frequency when the level is high. Trigger level sensitivity may be programmed for the trigger input.

In gated mode, the trigger input is level sensitive, i.e., the Model 3162B is gated when the a logic level is high and idle when it is low.

AM/PM Input -

The channel A AM input accepts signals that amplitude modulate the channel A main output signal. The channel A PM Input accepts signals that phase

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Channel A

modulate the channel A main output frequency. The phase modulation function operates in conjunction with the PLL function. The AM/PM input becomes active when one of these functions is selected.

AM Input - Channel B

The channel B AM input accepts signals that amplitude modulate the channel B main output signal. The AM input becomes active when one of these functions is selected.

Reference Clock Input

The reference clock input accepts a 10 MHz, TTL level signal to replace the CLK10 reference. The reference clock input is active only when selected.

Frequency/ Segment Control Input

The frequency and segment control input is a 9-pin, D-Sub type connector. Eight pins are used as control lines and one pin (pin 9) is connected to ground. The binary combination of pins 1 through 8 may be used to control 256 different frequency dividers, or 256 different segments. A frequency divider table and/or a segment table must first be loaded into the instrument before this input can modify the output. The signal level for this connector is TTL.

Operating Modes

The Model 3162B can be programmed to operate in one of four operating modes: continuous, triggered, gated and counted burst. These modes are described below.

Continuous Mode

In normal continuous mode, the selected waveform shape is output continuously at the selected frequency, amplitude and offset.

Triggered Mode

In triggered mode, the Model 3162B circuits are armed to generate one output waveform. The trigger circuit is sensitive to transitions at the trigger input. Select between positive or negative transitions to trigger the instrument. You may also program the trigger level to the desired threshold level. When triggered, the generator outputs one waveform cycle and remains idle at the last point of the waveform. The Model 3162B can be armed to receive a trigger signal from a front panel BNC connector, a VXI backplane TTLTRG<n> or ECLTRG0, or from an internal, programmable trigger generator.

The trigger signal, whether it comes from the front panel or from the VXIbus, has to pass through some electrical circuits. These circuits cause a small delay known as system delay. System delay cannot be eliminated completely. It is, however, minimized in the Model 3162B to approximately 100 ns maximum. System delay is a factor that must be considered when applying a trigger signal. It defines how long it will take from a valid trigger edge to the moment that the output reacts.

While system delay has a fixed value that cannot be controlled, the Model 3162B offers a controllable trigger delay parameter. When operated, delay from

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a trigger signal to output waveform may be programmed from 0 clocks to 8 Million clocks. System delay factor must be added to your calculation of final delay value.

Burst Mode

The burst mode is an extension of the triggered mode where the Model 3162B can be armed to output a pre-determined number of waveforms. The source to trigger the counted burst cycle can be selected from a front panel BNC connector, VXI backplane trigger lines, or from the built-in trigger generator.

Gated Mode

In gated mode, the Model 3162B circuits are armed to generate output waveforms as long as a gating signal is true. Unlike the triggered mode, the gated mode is level sensitive. When the gating signal goes low, the waveform at the output connector is first completed and the output goes to an idle state. The idle amplitude level, after the gating signal goes low, is the last point on the waveform.

Output Type

The Model 3162B can output three types of waveforms: standard (Fixed), arbitrary (User) and sequenced waveforms. The three types of waveforms are described in the following paragraphs.

Standard (Fixed) Waveforms

The Model 3162B generates waveforms from a memory that must be loaded before the instrument can generate waveforms. There are 1Meg points available as standard. 2112 points from this memory are allocated for standard waveforms. Waveforms are loaded into this part of the memory each time that a standard function is selected.

The Model 3162B can be programmed to output ten different standard waveforms shapes: sine, triangle, square, pulse, ramp, sinc (sine(x)/x) pulse, gaussian pulse, exponential pulse, noise, and DC. There are a number of parameters associated with each waveform which modify the shape of the waveform to better suit your needs. For example, a different start phase for the sine waveform can be programmed for each channel to create phase offsets between the two output channels.

Arbitrary (User) Waveforms

The arbitrary waveform memory is capable of storing one or more user-defined waveforms. There are 1,046,464 points that can be allocated to one waveform which has this length. There is no need to use the entire memory for one waveform. The memory can be divided into smaller segments, variable in size. The segments can be loaded with different waveforms and the Model 3162B can be programmed to output one segment at a time.

Loading data to arbitrary waveform memory can be a time-consuming task, especially if the complete 1Meg is loaded in one shot. The Model 3162B utilizes the VXIbus shared memory concept that speeds data transfer from and to the host computer. In this mode, the memory bank is disconnected from the

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CPU circuit and re-routed to the bus on the backplane for direct memory access by the host computer.

The Model 3162B has separate arbitrary waveform memories for each channel. Each channel can be loaded with different waveforms. The only limitation is that if you divide channel A memory into smaller segments, the same divider is applied automatically to channel B.

Sequenced Waveforms

The Model 3162B employs a sophisticated circuit that allows dividing the memory into smaller segments, linking of the segments in user-defined order, and repeating of each linked segment up to one million times. In addition, each segment can be programmed with a unique clock rate. The sequence circuit is useful for generating long waveforms with repeated sections. The repeated waveform has to be programmed once, and the repeater will loop on this segment as many times as selected. When in sequenced mode, there is no loss of time between linked or looped segments. Figure 1-6 shows an example of a sequenced waveform. Assume the waveforms in Figures 1-3 through 1-5 were placed in segments 1 through 3.

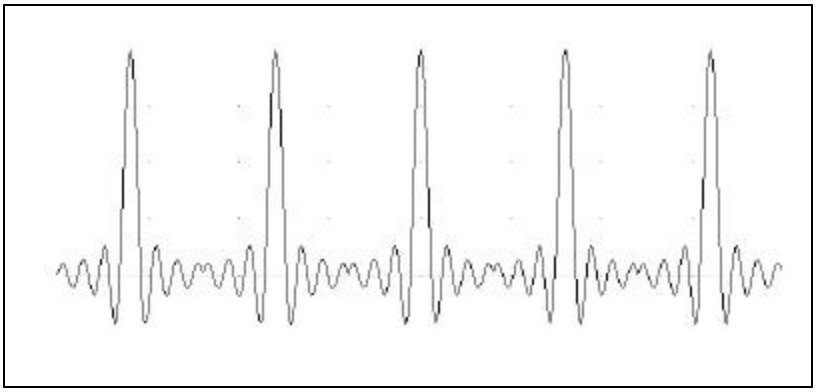
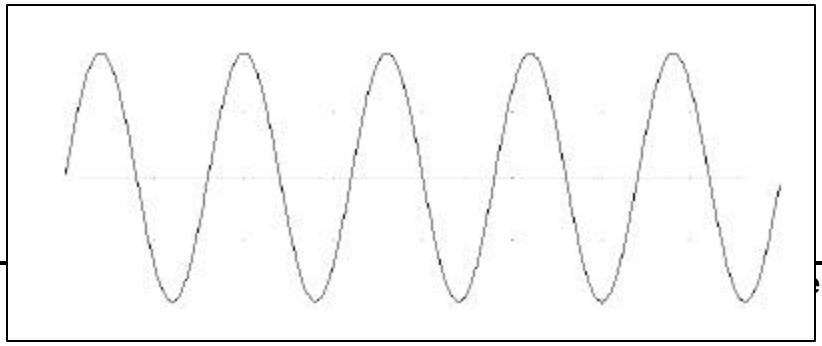


Figure 1-3, Segment 1 – Sin (x)/x Waveform



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Figure 1-4,Segment 2 – Sine Waveform

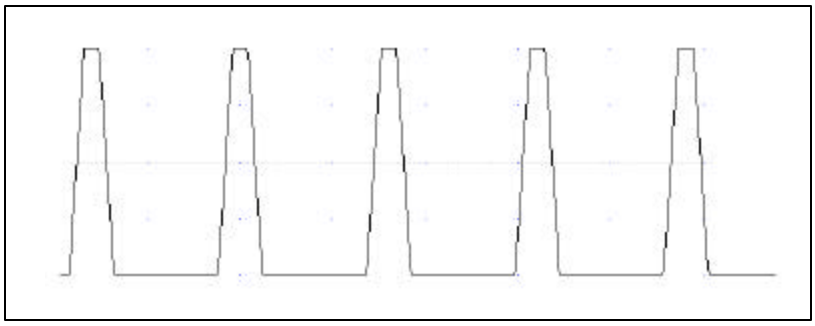


Figure 1-5. Segment 3 – Pulse Waveform

The following sequence was made of segment 2 repeated twice, segment 1 repeated four times, and segment 3 repeated two times.

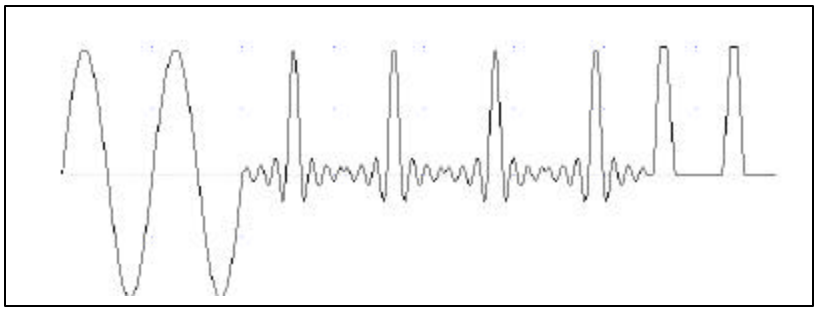


Figure 1-6. Sequenced Waveforms

The table below, from WaveCAD's Sequence Table Editor, shows how the same sequence can be defined using WaveCAD.

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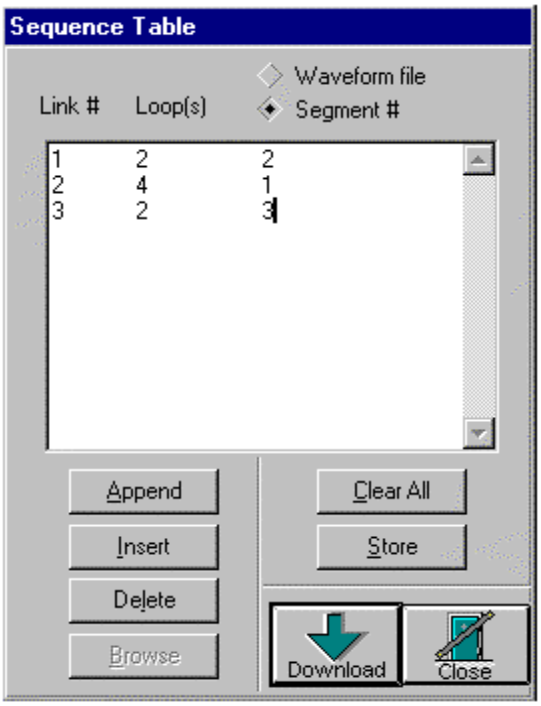


Figure 1-7, WaveCAD Example

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Synthesizer Agility

The Model 3162B is capable of frequency hopping, FSK modulation, and clock rate switching between memory segments. Frequency hopping is controlled from three different sources: front-panel 9 pin D-sub connector, front panel trigger input, and VXIbus trigger lines. The ratio between two frequencies is an integer number from 1 to 65536. The Model 3162B can hop between 256 pre-determined frequencies.

In FSK modulation mode, the instrument outputs a carrier frequency as long as the control signal remains false. When the FSK control turns true, the generator outputs a shifted frequency signal which is an integer division of the carrier frequency. Frequency divider ranges from 1 to 65536.

In sequenced mode, clock frequency dividers may be assigned to each segment. The default divider is 1, while the maximum division ratio is 65536. The division ratio is stored in the clock divider segment assignment table. Every time a sequence runs, the clock rate is switched automatically and coherently to the assigned clock divider.

Output State

The main output can be turned on or off. The internal circuit is disconnected from the output BNC connector by a mechanical switch (relay). This feature is useful for connecting the Model 3162B main output, along with other instruments, to an analog bus. For safety reasons, when power is first applied to the chassis, the main output is always off.

Amplitude Modulation

The Model 3162B may be amplitude modulated with an external signal. The amplitude modulation input accepts the envelope signal, while the carrier signal can be selected from any of the standard, user, or even sequenced waveforms. The frequency of the modulating signal ranges from DC to over 1 MHz. Each channel has separate amplitude modulation input.

Front-Panel / VXIbus PLL

Multiple Model 3162B s may be synchronized and operated together inside one VXIbus chassis. With one instrument configured as master and the rest of the instruments configured as slaves, the instruments are phase-locked to the start phase of the master module. Slave modules can be configured to have phase offsets from 0° to +360°. There is no need to install multiple Model 3162B modules into adjacent slots to phase synchronize modules.

The reference signal can be applied either to the front panel reference input or placed by one of the modules on one of the backplane trigger lines. This way, the same reference can be applied to all slave modules to generate phase-related signal patterns. The reference signal for the PLL function, when applied to the TRIG IN connector, shares the same characteristics as the trigger input: programmable trigger level and programmable slope.

When placed in PLL mode, the Model 3162B monitors the TRIG IN connector for valid signals. Once sensed, the Model 3162B measures the signal's

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frequency and centers its lock-in range on this frequency. The Model 3162B then locks automatically onto the frequency of the external signal. There is no need for manual initiation or operator intervention to lock the instrument to an external reference.

Frequency Counter

The Model 3162B uses a built-in, auto-ranging counter circuit in PLL mode to measure the frequency of the reference signal at the trigger input. Regardless of whether you want to lock the 3162B to another source or not, you can use the counter circuit to measure frequency. There are three things to be done: 1) place the generator in PLL mode, 2) adjust the trigger level, and 3) make sure that the PLL ON LED illuminates. Frequencies are measured from 500Hz to 31 MHz. An external frequency query returns six digits with a decimal point and suffix multiplier.

Phase Modulation

When the Model 3162B is placed in PLL mode, there are two ways to control the phase offset. The first option is to modify the phase-offset setting using SCPI commands. This method is extremely accurate while permitting phase offset adjustments with 0.01° increments. The PM IN provides another option for changing phase offsets. This input is voltage sensitive. Applying voltage to this input changes the start phase of the generator. The bandwidth of the PM input is DC to 10kHz.

Filters

Two filters are built into the Model 3162B, one for each channel. These filters are available for use in various applications like the creation of high frequency sine waves. The elliptical 150 MHz filter has very sharp cutoff frequency. It is very useful for removing the staircase effect from waveforms that are generated with high frequency clock rates.

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Front Panel Indicators

There are five LED's on the front panel. The FAIL LED (Red) illuminates at power-up until the Model 3162B has passed self-test. If the Model 3162B self-test fails, the FAIL LED remains on.

The ACCESS LED (Amber) illuminates each time a command has been received by the Model 3162B. This light remains on during shared memory data transfer.

The PLL ON LED (Amber) is off during normal operation. In PLL mode, the PLL ON LED illuminates when a valid signal is available at the trigger input and lock frequency is available at the main output connector.

When the output state is on, the OUTPUT LED (Green) light illuminates. It goes off when the output state is changed to off. There is a separate LED for each channel.

Programming The Model 3162B

The Model 3162B has no controls on its front panel. Instrument functions, parameters, and modes can only be accessed through VXIbus commands. There are a number of ways to talk to the instrument. They all require that an appropriate software driver be installed in the Resource Manager (slot 0). The rest is a matter of practice and knowledge of the language in use. There are other system considerations like address selection that have to be settled before programming the instrument. These topics are discussed in later chapters.

Low level programming of the Model 3162B is done using SCPI (Standard Commands for Programmable Instruments) language. Programming aspects are covered in Chapters 3 and 4.

High level drivers like VXI*plug&play* and WaveCAD are beyond the scope of this manual. Contact your Racal representative for more information about high level drivers for the Model 3162B.

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Chapter 2

CONFIGURING The INSTRUMENT

Installation Overview

This chapter contains information and instructions necessary to prepare the Model 3162A/B for operation. Details are provided for initial inspection, grounding safety requirements, repackaging instructions for storage or shipment, logical address selection and installation information.

Unpacking and Initial Inspection

Unpacking and handling of the generator requires normal precautions and procedures applicable to the handling of sensitive electronic equipment. The contents of all shipping containers should be checked for included accessories and certified against the packing slip to determine that the shipment is complete.

Safety Precautions

The following safety precautions should be observed before using this product and associated computer. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified persons who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cables, connector jacks, or test fixtures. The American National Standard Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak or 60 VDC are present.

WARNING

For maximum safety, do not touch the product, test cables, or any other instrument parts while power is applied to the circuit under test. ALWAYS remove power from the entire

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test system before connecting cables or jumpers, installing or removing cards from the computer, or making internal changes such as changing the module address.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always keep your hands dry while handling the instrument.

When using test fixtures, keep the lid closed while power is applied to the device under test. Carefully read the Safety Precautions instructions that are supplied with your test fixtures.

Before performing any maintenance, disconnect the line cord and all test cables. Only qualified service personnel should perform maintenance.

Performance Checks

The instrument has been inspected for mechanical and electrical performance before shipment from the factory. It is free of physical defects and in perfect electrical order. Check the instrument for damage in transit and perform the procedures outlined in the section entitled **Unpacking and Initial Inspection.**

Grounding Requirements

To ensure the safety of operating personnel, the U.S. O.S.H.A. (Occupational Safety and Health Administration) requirement and good engineering practice mandate that the instrument panel and enclosure be "earth" grounded. Although BNC housings are isolated from the front panel, the metal part is connected to earth ground.

WARNING

Do not attempt to float the output from ground, as it may damage the Model 3162A/B and your equipment.

Long Term Storage or Repackaging For Shipment

If the instrument is to be stored for a long period of time or shipped immediately, proceed as directed below. If you have any questions, contact your local Racal Instruments Representative or the Racal Instruments Customer Service Department.

1. Repack the instrument using the wrappings, packing material and accessories originally shipped with the unit. If the original container is not available, purchase replacement materials.

2. Be sure the carton is well sealed with strong tape or metal straps.

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3. Mark the carton with the model and serial number. If it is to be shipped, show sending and return address on two sides of the box.

NOTE

If the instrument is to be shipped to Racal Instruments for calibration or repair, attach a tag to the instrument identifying the owner. Note the problem, symptoms, and service or repair desired. Record the model and serial number of the instrument. Show the work authorization order as well as the date and method of shipment. ALWAYS OBTAIN A RETURN AUTHORIZATION NUMBER FROM THE FACTORY BEFORE SHIPPING THE INSTRUMENT TO RACAL INSTRUMENTS.

Preparation For Use

Preparation for use includes removing the instrument from the container, selecting the required logical address and installing the module in a VXIbus chassis.

Logical Address Selection

The VXIbus Resource Manager identifies modules in the system by the module s address. VXIbus logical addresses can range from 0 to 255, however, addresses 1 to 254 **only** are reserved for VXIbus modules. Logical address 0 is reserved for the Resource Manager. Logical address 255 permits the Resource Manager to dynamically configure the module logical address.

To change the logical address, use the 8-position DIP switch accessible from the top side of the module near the rear end of the case (switch S1). Figure 2-1 shows the location of the logical address switch. The switches are marked with numbers 1 to 8. The Model 3162A/B uses binary values (2^0 to 2^7) to set the logical address using the active low address switch. A switch is active when its arm is placed in the ON position.

Racal Instruments ships the Model 3162A/B with logical address 2.

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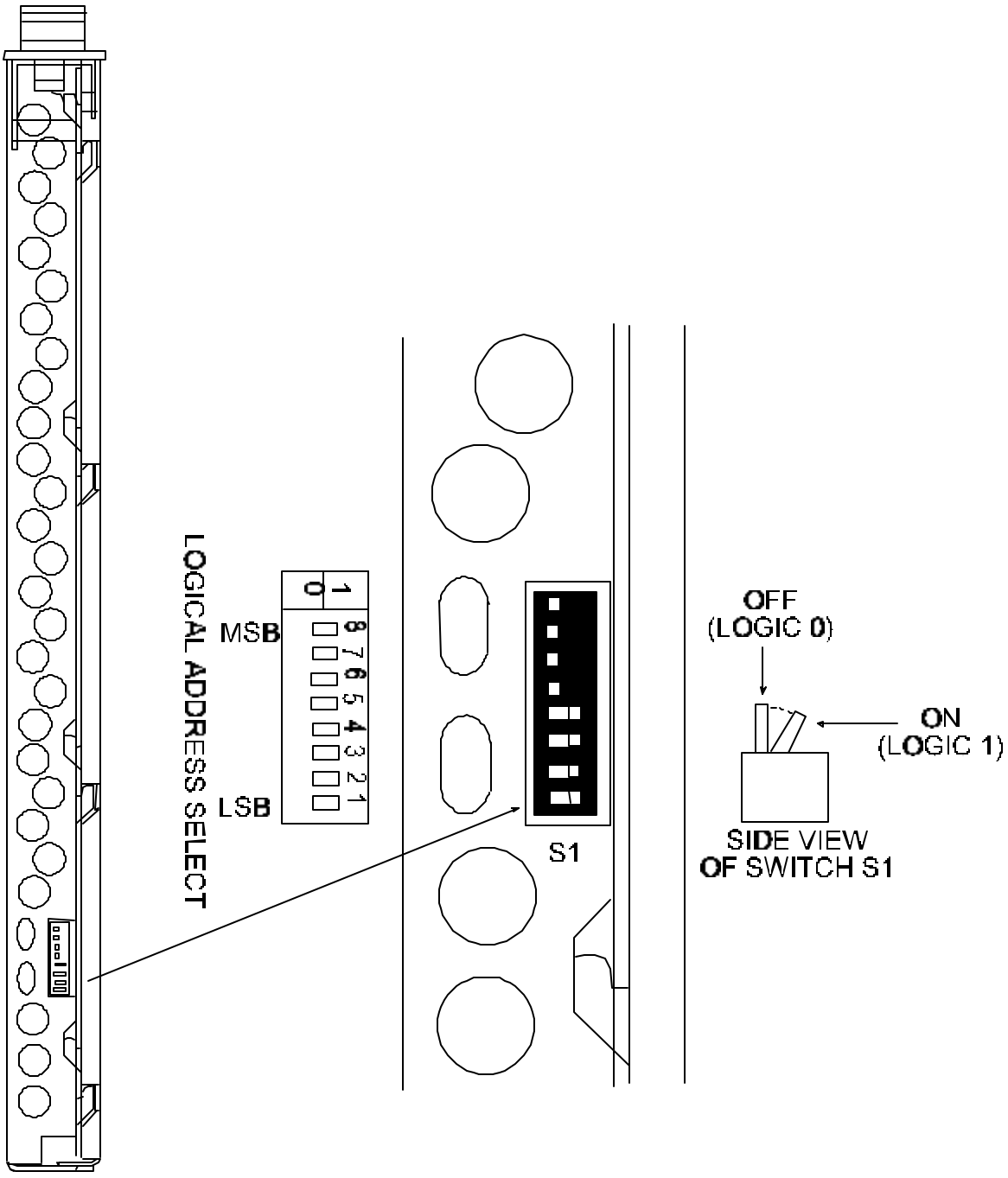


Figure 2-1, Set Logical Address

Installation

The instrument can be installed in any slot except slot 0 in a VXIbus mainframe. When inserting the instrument into the mainframe, it should be gently rocked back and forth to seat the connectors into the backplane receptacle. The ejectors will be at right angles to the front panel when the instrument is properly seated into the backplane. Use two captive screws

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above and below the ejectors to secure the instrument into the chassis.

After installation, perform an initial checkout and operational verification.

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Chapter 3
USING THE INSTRUMENT

Overview

This chapter contains information about how to operate the Model 3162A/B. Unlike bench-type instruments, the Model 3162A/B must be programmed to turn on functions, change parameters and configure various operating modes. Two graphical interfaces are available for programming the instrument: VXIbus*plug&play* and WaveCAD. LabWindows/CVI drivers and a set of SCPI commands are available for experienced programmers. SCPI (Standard Commands for Programmable Instruments) commands for the Model 3162A/B are listed in Table 4-1. This manual provides information on low-level programming using SCPI commands only. The following paragraphs describe the various modes of operation and give examples of how to program the Model 3162A/B.

NOTE

The Model 3162B has the same functionality as the Model 3162A. This manual describes all functions and feature that are available on the Model 3162B. If you own the Model 3162A, simply ignore all references in this chapter to the second output channel.

Inter-Channel Dependency

The Model 3162B has two output channels. Although this is a two-channel instrument, most of the commands that set parameters and functions are common for both channels. For example, sample clock and trigger modes cannot be set separately for each channel. On the other hand, you may program each channel to have a different function shape, amplitude and offset. Table 3-1 lists the functions and parameters and their related inter-channel dependency.

Output Termination

During use, output connectors must be properly terminated to minimize signal reflection or power loss due to an impedance mismatch. Proper termination is also required for an accurate amplitude level at the main output connector. Use 50Ω cables and terminate the main and SYNC cables with terminating resistors. Always place the 50Ω termination at the far end of each cable.

Input/Output

The Model 3162B provides protection for internal circuitry connected to input and output connectors. Refer to the specifications in Appendix A to determine

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Protection

the level of protection associated with each input or output connector.

Power On/Reset Defaults

At Power On or as a result of a software reset, the Model 3162B defaults to the conditions shown in Table 3-1. Also listed in this table are parameters that are common or separate for each channel. A complete list of all parameters, their default values, as well as their maximum and minimum values is given in Chapter 4.

Use the following command to place the instrument in its default state:

```
RESet;
```

Using the IEEE-STD-488.2 common command *RST will have the same result.

Function / Parameter	Default	Inter-Channel Dependency
Output State:	Off	Separate
Operating Mode:	Continuous	Common
SYNC State:	Off	Common
SYNC Out Position:	Wave Start	Common
Output Function:	Standard	Separate
Output Function Shape:	Sine	Separate
Standard Wave Frequency:	1MHz	Common
User Wave Sample Clock:	1MHz	Common
Amplitude:	2V	Separate
Offset:	0V	Separate
Filter State:	Off	Separate
Filter Type:	Auto	Separate
ECLTRG0:	Off	Common
TTLTRG0-3:	Off	Common

Table 3-1, Default Conditions After Power On or After *RST

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Function / Parameter	Default	Inter-Channel Dependency
Trigger Slope:	Positive	Common
Trigger Level:	1.6 V	Common
Internal Trigger Period:	100 µs	Common
PLL State:	Off	Common
AM State:	Off	Separate
Shared Memory State:	Off	Separate
Shared Memory Mode:	Write	Separate

Table 3-1, Default Conditions After Power On or After *RST (continued)

What To Do Now

When writing low level code to operate the Model 3162B, follow the instructions in this chapter to understand the meaning and response that each command generates. Examples contained in the following paragraphs show basic techniques of how to program output waveforms.

Example 1

The following example programs the Model 3162B to turn on the main outputs and program the waveform frequency to 20 MHz. It programs channel A to output a square waveform with an amplitude of 2V and offset of 0.5V, and programs channel B to output a triangular waveform with an amplitude of 1V and offset of 0.5V.

/* Reset the Model 3162B to its default condition as listed in Table 3-1. */

```
:RESet;
```

/* Change the output waveform to square. Note that there is no need to use the FUNC:MODE command as the default value after RESet is FIXed. */

```
:FUNCtion:SHAPe SQUare;
```

/* Change the frequency to 20MHz. Note that the frequency setting is common for both channels. */

```
:FREQuency 20e6;
```

/* Change channel A amplitude to 2V and the offset to 0.5V. */

```
:VOLTage 2;

:VOLTage: OFFSet 0.5;
```

Note that output peak voltage may never exceed ±2.5V. Amplitude and offset may be set freely within a 5V window, as long as the following limits are kept:

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| offset | + Vp-p ÷ 2 ≤ 5

/* Turn on channel A main output. */

:OUTPut ON;

/* Turn on the SYNC output, if required. */

:OUTPut:SYNC ON;

If the above commands are executed correctly, a square waveform will be seen on your oscilloscope at the channel A output connector.

So far, there was no need to specify which of the channels is receiving commands for two reasons: 1) channel A is the default channel and 2) the frequency parameter is common to both channels. Common parameters affect the two channels the same way. For example, changing the frequency for channel A will automatically change the frequency for channel B. This example will now continue with programming the channel B parameters.

/* The following command changes control to the B channel. */

:INSTrument:SELect B;

/* Change channel B amplitude to 1V and the offset to 0.5V. */

:VOLTage 1;

:VOLTage: OFFSet 0.5;

/* Turn on channel B main output. */

:OUTPut ON;

/* Turn on the SYNC output, if required. */

:OUTPut:SYNC ON;

If the above commands are executed correctly, a square waveform will be seen on your oscilloscope at channel B output connector.

Using the APPLy Command

The APPLy command provides a high level method of programming the generator. Selection can be made for function, frequency, amplitude, offset and other parameters which are associated with the applied function. For example, the following statement outputs a 2Vp-p square wave at 1 MHz with a 0V offset and 10% duty cycle using APPLy:

APPL:SQU 1E6, 2, 0, 10

It is not necessary to enter every parameter with the APPLy command. If only the frequency and offset need to be changed, omit the other parameters while keeping the commas. The other parameters will be set to the power-up default

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values:

APPL:SQU 10E6,,1

Alternatively, if just the first parameters need to be changed, omit the commas. The other parameters will be set to the power-up default values:

APPL:SQU 4e6,2

Queries can also be made on all parameters associated with a standard function using the APPL: <function_shape>? query. For example, if the generator was programmed using the above APPLy:SQU command, query the square wave parameters using the following query:

APPL:SQU?

The generator returns a string that contains all the parameters associated with the square function similar to the following string:

"1.000000e+6,2.000,0.000,50"

The command:

APPLy:SINusoid
{<frequency>,<amplitude>,<offset>,<phase>,<power>}

programs the generator to output a sine waveform with frequency, amplitude, offset, start phase and power parameters. Parameters are not optional if the above APPLy command is used. Include all other parameters in the command. The default settings for these parameters are: 1MHz, 2Vp-p, 0V, 0 and 1.

The command:

APPLy:TRIangle
{<frequency>,<amplitude>,<offset>,<phase>,<power>}

programs the generator to output a triangle waveform with frequency, amplitude, offset, start phase, and power parameters. The default settings for these parameters are: 1 MHz, 2Vp-p, 0V, 0 and 1.

The command:

APPLy:SQUare {<frequency>,<amplitude>,<offset>,<duty_cycle>}

programs the generator to output a square waveform with frequency, amplitude, offset and duty cycle parameters. The default settings for these parameters are: 1MHz, 2Vp-p, 0V, and 50%.

The command:

APPLy:PULSe{<frequency>,<amplitude>,<offset>,<delay>,
<high_time>,<rise_time>,<fall_time>}

programs the generator to output a pulse waveform with frequency, amplitude,

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offset, delay, high time, rise time, and fall time parameters. The default settings for these parameters are: 1MHz, 2Vp-p, 0V, 0%, 10%, 10% and 10%.

The command:

APPLy:RAMP {<frequency>,<amplitude>,<offset>,<delay>,
<rise_time>,<fall_time>}

programs the generator to output a ramp waveform with frequency, amplitude, offset, delay, rise time, and fall time parameters. The default settings for these parameters are: 1MHz, 2Vp-p, 0V, 0%, 10% and 10%.

The command:

APPLy:SINC {<frequency>,<amplitude>,<offset>,<number_cycles>}

programs the generator to output a sine(x)/x waveform with frequency, amplitude, offset, and number of cycles parameters. The default settings for these parameters are: 1MHz, 2Vp-p, 0V and 10.

The command:

APPLy:EXPonential <frequency>,<amplitude>,<offset>,<exponent>}

programs the generator to output an exponential waveform with frequency, amplitude, offset, and exponent parameters. The default settings for these parameters are: 1MHz, 2Vp-p, 0V and -10.

The command:

APPLy:GAUSsian {<frequency>,<amplitude>,<offset>,<exponent>}

programs the generator to output a gaussian waveform with frequency, amplitude, offset, and exponent parameters. The default settings for these parameters are: 1MHz, 2Vp-p, 0V and 10.

The command:

APPLy:DC {<percent_amplitude>}

programs the generator to output a DC level. The DC level is set as a percent of programmed amplitude. The default setting for this function is 100%.

The command:

APPLy:USER
{<segment_number>,<sampling_clock>,<amplitude>,<offset>}

programs the generator to output an arbitrary waveform. The specified segment number must be loaded with an arbitrary waveform before the generator can execute this command successfully. This command lets you specify segment number, sampling clock rate, amplitude and offset. The default settings for these parameters are: 1, 1MHz, 2Vp-p and 0V.

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The query:

APPLy:<function_shape>?

queries parameters associated with the specified function shape, and returns a string of values depending on the parameters that are available for the selected function shape.

The query:

APPLy?

queries parameters associated with the currently selected function shape and returns a string of values depending on the parameters available for the selected function shape. For example, if the generator is programmed to output a ramp waveform, the APPL? command returns: "1e+6, 2, 0 , 0, 10, 10, 10".

Example 2

The following example programs the Model 3162B using the APPLy command. This example turns on the main output, generates a square waveform, programs frequency to 2MHz, programs amplitude to 1V and offset to 1V. It also changes the square wave duty cycle parameter to 25%.

/* Reset the Model 3162B to its default condition as listed in Table 3-1. */

:RESet;

/* Change the output waveform to square, frequency to 2MHz, amplitude to 1V, offset to 1V and duty cycle to 25%. Note that there is no need to use the FUNC:MODE command because the default value after RESet is FIXed. */

:APPLy:SQUare 2e6,1,1,25

/* Turn the main output on. */

:OUTPut ON

/*Turn the SYNC output on, if required. */

:OUTPut:SYNC ON

If the above commands are executed correctly, a square waveform will be seen on your oscilloscope.

Selecting the Active Channel

Use the following command to select the active channel:

INSTrument:SELect {A | B}

When “A” is selected, commands will control parameters that are unique for the channel A output. Selecting “B”, modifies the control of channel B parameters. The default option is “A”. Parameters that are common to both

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channels may be programmed from either path.

The query:

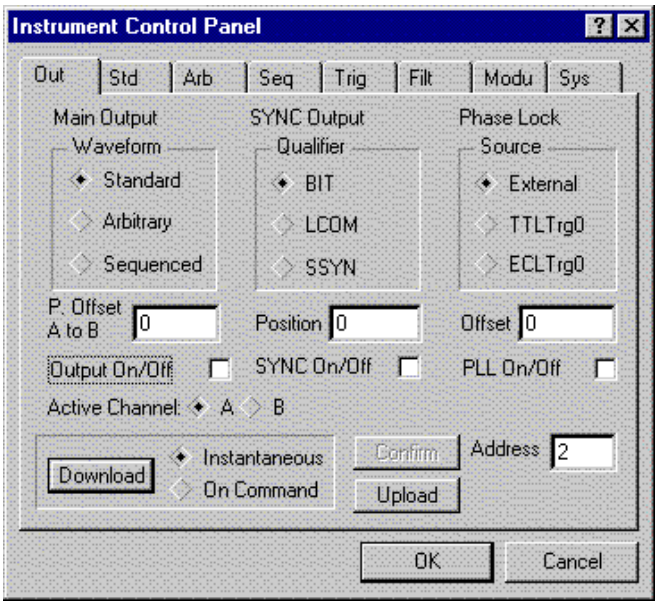
INSTrument:SELect?

queries the active channel and returns A or B.

Output Configuration Commands

The output configuration commands control the output function, shape, frequency, amplitude, filter and state. Optional modes are omitted from these commands. The Output Instrument Control Panel from WaveCAD is shown below as an example of high-level implementation of output control.

Figure 3-1, Output Control with a WaveCAD Panel



Selecting an Output Function Type

Use the following command to select the output function type:

FUNCtion:MODE {FIXed | USER | SEQuence}

When “FIXed” is selected, the generator outputs the standard waveform currently selected by the FUNC:SHAP command. When “USER” is selected, the generator outputs the arbitrary waveform currently selected by the TRAC:SEL command. When “SEQuence” is selected, the generator outputs the sequence that is programmed using the SEQ:DEF command.

The query:

FUNCtion:MODE?

queries the output function type and returns FIX, USER or SEQ.

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Selecting a Standard Function Shape

Use the following command to select a standard output function:

FUNCtion:SHAPe {SINusoid | TRIangle | SQUare | PULSe | RAMP | SINC | EXPonential | GAUSsian | NOISe | DC}

The selected waveform is output using the previously selected frequency, amplitude, offset, and other relevant settings. The standard waveform will be output only after the FUNC:MODE:FIX command is selected.

The query:

FUNCtion:SHAPe?

queries the standard function shape and returns either SIN, TRI, SQU, PULS, RAMP, SINC, EXP, GAUS, NOIS or DC.

The Standard Waveform Instrument Control Panel from WaveCAD is shown below as an example of a high-level implementation of Standard Waveform Selection.

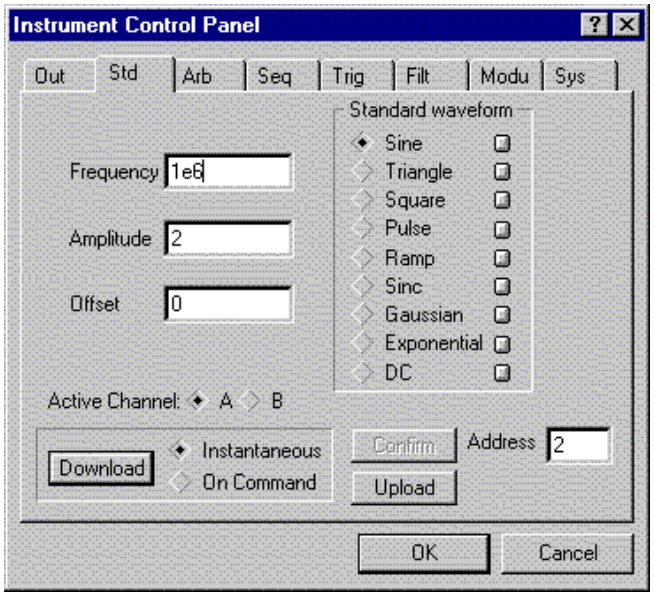


Figure 3-2, Standard Waveform Selection Panel from WaveCAD

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Changing the Frequency and Sample Clock

Use the following command to change the frequency for standard waveforms:

FREQuency {<frequency> | MINimum | MAXimum}

MIN selects the lowest frequency allowed for the currently active function. MAX selects the highest frequency allowed for the currently active function. The default frequency setting is 1 MHz for all parameters.

The query:

FREQuency?

queries the frequency setting for the standard function currently active and returns a value in hertz.

The command:

FREQuency:RASTer {<frequency> | MINimum |MAXimum}

sets the sample clock frequency for the user and sequenced mode parameters. MIN selects the lowest frequency allowed for the currently active segment or sequence. MAX selects the highest frequency allowed for the currently active segment or sequence. The default sample clock frequency setting is 1 MHz for all parameters.

Note that the output frequency depends on the number of points specified in the waveform. The output frequency can be computed using the following formula: Output Frequency = Sample Clock / Number of points in the active segment.

The query:

FREQuency:RASTer?

queries the sample clock frequency setting for the arbitrary segment or sequence currently active and returns a value in Hertz.

Controlling Synthesizer Agility

Use the following commands to select the control mode for the frequency synthesizer:

FREQuency:MODE {NORMal | FSK | HOP}

In NORM mode, the selected output function is generated continuously with the programmed frequency parameter. FSK places the Model 3162B in frequency shift keying FSK mode. HOP selects frequency-hopping mode, where the generator can hop between various frequencies, as programmed in the hop table.

The query:

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FREQuency:MODE?

queries the frequency mode setting and returns NORM, FSK or HOP.

FSK Mode

In FSK mode, the generator outputs a pre-selected waveform with the frequency or sample clock setting as carrier frequency, as long as the controlling line remains false (logic zero). Toggling the controlling line true (logic one) modifies the output frequency to another frequency, which is determined by a pre-programmed dividing ratio. Use the following command to program the FSK dividing ratio:

FREQ:FSK<dividing_ratio>

The dividing ratio must be an integer number from 1 to 65536. The default value is 1.

The query:

FREQ:FSK?

queries the FSK dividing ratio and returns an integer value.

FSK control is available from a number of sources. Use the following command to select FSK control source:

FREQ:FSK:SOURce {EXTernal | TTLTrg<0-3> | ECLTrg0}

EXT selects the front panel TRIG IN connector as the FSK control source. First program the trigger level and slope of the trigger input, then apply the control signal. Information on how to program the trigger level is given later in this chapter.

When a positive trigger slope is selected for the trigger level input (default), signal levels below the programmed trigger level are false (carrier frequency). Signal levels above the programmed trigger level are true and shift the carrier frequency to the modulated frequency. Changing the trigger slope to negative inverts the above conditions.

The default trigger level is 1.6 V. This is convenient for TTL level control. You may change the trigger level setting if your signal is not TTL.

TTLT<n> or ECLT0 select the VXIbus backplane as FSK control source. For TTLT<n> or ECLT0, a logic low generates the carrier frequency. A logic high level at these lines generates the shifted frequency.

The query:

FREQ:FSK:SOURce?

queries the FSK control source and returns EXT, TTLT<n> or ECLT0.

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HOP Mode

In HOP mode, the generator outputs a pre-selected waveform whose frequency (or sample clock setting) is determined by the HOP table and HOP control lines. The Model 3162B hops from frequency to frequency according to a pre-determined table. The hop table contains hop numbers and their associated dividing ratios. The hop table holds up to 256 hop settings.

The WaveCAD Hop Table editor (shown below) is an example of a graphical interface for defining a hop table.

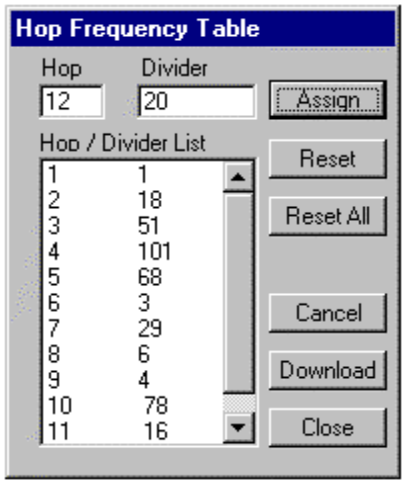


Figure 3-3, WaveCAD Hop Table

The following low-level commands programs a five-step hop table:

```
FREQ:HOP 1,50
FREQ:HOP 2,500
FREQ:HOP 3,5000
FREQ:HOP 4,50000
```

Each trigger advances the output to the next frequency. In the above example, setting the sample clock to 200MHz generates the following hop frequencies: 200MHz, 40MHz, 4MHz, 400kHz, and 40kHz. If the trigger lines are used as the hop advance sources, the sequence will repeat itself continuously. By selecting the D-Sub connector as the hop advance source, any external hop pattern may be used. Undefined hop table entries have a dividing ratio of 1.

Note that the hop command does not have a query.

The command:

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FREQ:HOP:SOURce {EXTernal | TTLTrg<0-3> | ECLTrg0 | DSUB}

selects the hop advance source. EXT selects the front-panel TRIG IN connector. Every valid trigger signal increments the table to the next step. TTLT<n> or ECLT0 select the corresponding VXIbus backplane trigger line.

A front-panel D-Sub connector is selected as the hop advance source when the DSUB option is selected. This connector has 9 pins, of which one (pin 9) is connected to ground and the other 8 pins are used as advance control lines. The binary value of these 8 lines determines the next hop step. For example, when none of the pins are connected to an external +5V signal, the generator outputs its carrier frequency. If pins 1 and 2 are connected to an external +5V signal, the output hops to the frequency set by step Hop Table entry number 3.

The query:

FREQ:HOP:SOURce?

queries the hop frequency advance source and returns either EXT, TTLT<n>, ECLT0 or DSUB.

The command:

FREQ:HOP:DELete<n>

deletes the specified hop steps from the hop table.

The command:

FREQ:HOP:DELete:ALL

deletes all hop steps and resets the hop table.

Selecting the Reference Oscillator

Use the following command to select the reference oscillator for the synthesizer circuit:

ROSCillator:SOURce {CLK10 | EXTernal | TCXO}

TCXO is the standard reference oscillator for the Model 3162B. The default reference oscillator is set to TCXO. Regardless, you can still select and use other reference sources. CLK10 accuracy is 100ppm and TCXO accuracy is 1ppm. If you have a 10MHz signal that is either more stable or is shared with other system modules, you can apply it to the front panel reference input. CLK10 connects the VXIbus backplane clock to the internal synthesizer circuit. EXT connects the front panel TTLreference input to the main clock circuit.

The query:

ROSCillator:SOURce? {CLK10 | EXTernal | TCXO}

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queries the reference oscillator source and returns either CLK10, EXT or TCXO.

Programming the Output Amplitude and Offset

Use the following command to program the peak-to-peak amplitude of the generated waveform:

VOLTage {<amplitude>|MINimum|MAXimum}.

MIN selects the smallest possible amplitude. MAX selects the largest possible amplitude. The default amplitude is 2.00V (into 50Ω).

The query:

VOLTage?

queries the output amplitude and returns a value in volts.

The command:

VOLTage:OFFSet <offset>

sets the offset. The default offset is 0V.

The query:

VOLTage:OFFSet?

queries the output offset and returns a value in volts.

Selecting the Filter

Use the following command to activate the filter:

OUTPut:FILTer { OFF | ON}

The 3162B has a seven-pole, built-in 150MHz filter, with elliptical characteristic and very sharp cutoff frequency. This filter is used for generating the sine waveforms and, when in other output functions, can be used for other filtering tasks. ON enables the filter. The default filter state setting is OFF.

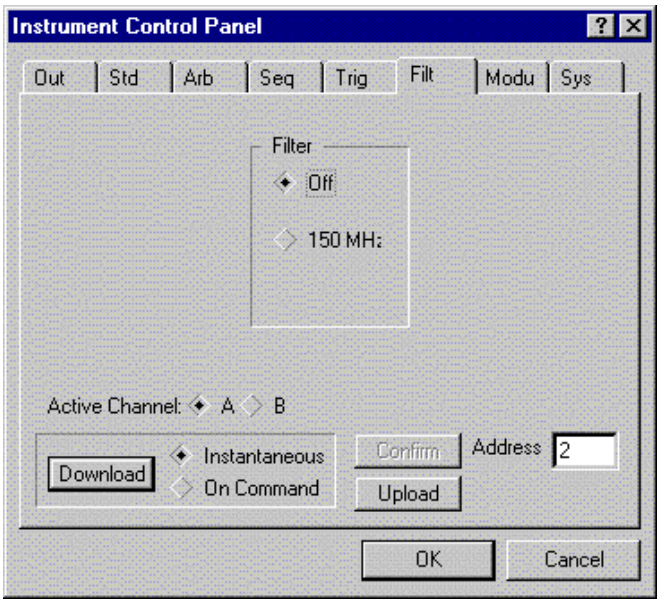
Note

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The default output function of the generator is the sine waveform. Since the instrument uses the filter to generate this waveform, the state of the OUTP:FILT cannot be changed until another output function is selected. A setting conflict error will occur if one attempts to change the filter state before changing to another output function or mode.

The WaveCAD Filter Control Panel is shown below as a graphical implementation of the filter setting.

Figure 3-4, WaveCAD FilterControl Panel



The query:

OUTPut:FILTer?

queries the output filter state and returns "0" (OFF) or "1" (ON).

Activating the Backplane ECLTRG and TTLTRG Lines

The Model 3162B can transmit and receive signals on VXIbus ECLTRG line zero and TTLTRG lines zero through three.

Use the following command to activate one of two backplane ECLTRG lines:

OUTPut:ECLTrg0 { OFF | ON}

ON enables the ECL trigger line. The trigger source for this line can be selected with the TRIG:SOUR command. The default ECLTrg0 state is OFF. Note that the trigger validation source for ECLT0 is exactly as was set for the SYNC output.

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The query:

OUTPut:ECLTrg0?

queries the ECLTrg0 state and returns "0,0" (OFF) or "0,1" (ON).

TTLTRG lines zero through three can be used to transmit and receive trigger signals between the Model 3162B and other VXIbus modules.

Use the following command to activate one of the four backplane TTLTRG lines:

OUTPut:TTLTrg<n> { OFF | ON}

where <n> designates the activated trigger line and 0 through 3 are available. ON enables the selected trigger line. Note that the trigger validation source for TTLT<n> is exactly as was set for the SYNC output.

The query:

OUTPut:TTLTrg<n>?

queries the TTLTRG<n> state and returns "<n>,0" (OFF) or "<n>,1" (ON).

Enabling the Main Output

For safety reasons, the main output default setting is OFF. Disable or enable the main output using the following command:

OUTPut {OFF | ON}

When the main output state is programmed to ON, the output connector is connected to the output amplifier through a 50Ω resistor. In the OFF position, the output connector is disconnected from the output amplifier by means of a mechanical relay. Ensure that voltage is **not** applied to the main output connector when the Model 3162B output state is programmed to ON.

The query:

OUTPut?

queries the state of the main output and returns "0" (OFF) or "1" (ON).

Enabling the SYNC Output

For safety reasons, the SYNC output default setting is OFF. Disable or enable the SYNC output using the following command:

OUTPut:SYNC {OFF | ON}

When the SYNC output state is programmed to ON, the SYNC output

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connector generates signals which are triggered by signals selected using the SYNC:SOUR command. In the OFF position, the SYNC connector has no output. It is connected electrically to internal circuitry at all times. Ensure that voltage is **not** applied to the SYNC outputs connector at any time. The default SYNC position is the 6th point from the end of the waveform. The position of the SYNC signal can be programmed using the OUTPUT:SYNC:POS:POIN command.

The query:

OUTPut:SYNC?

queries the state of the SYNC OUTPUT and returns "0" (OFF) or "1" (ON).

Assigning the Source For The SYNC Output

The SYNC output generates a synchronized signal at the beginning of the waveform or at any position on the waveform as may be programmed by the OUTP:SYNC:POS command. The validation source for this command is selectable from a number of options. Use the following command to select the source for validating the SYNC output:

OUTPut:SYNC:SOURce {BIT | LCOMplete | SSYNc}

BIT Generates a sync signal every time the segment is output in User mode and in Sequenced mode. The sync position along the waveform can be programmed using the OUTPUT:SYNC:POS command. The BIT signal is recommended for use in continuous mode.

LCOMplete Generates a sync signal in SEQ mode only once when the selected segment appears for the first time in the sequence. The identity of the segment can be programmed using the TRAC:SEL command. The sync position along the selected waveform can be programmed using the OUTPUT:SYNC:POS command. The LCOM signal is recommended for use in Sequenced mode.

SSYNc Generates a sync signal at intervals that are synchronized with the internal clock generator. This option is useful for minimizing jitter when using an oscilloscope. The SSYNc signal is recommended for use in Triggered mode.

The query:

OUTPut:SYNC:SOURce?

queries the signal source for the SYNC output and returns BIT, LCOM or SSYN.

Selecting the SYNC Position

The SYNC output can be programmed to output the SYNC signal at any point along the output waveform. This function is available in USER and SEQ modes only. Use the following command to select the SYNC output position:

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OUTPut:SYNC:POSition <value>

The SYNC position can be selected from point 0 to the last point of the active waveform. SYNC position has to be programmed for each segment. The default SYNC position is at the beginning of the segment or waveform.

The query:

OUTPut:SYNC:POSition?

queries the output SYNC position and returns an integer value.

Using the Built-In Standard Waveforms

The Standard Waveform commands control the various parameters of the active standard waveform. Standard waveform commands operate in a similar fashion for each of the standard waveforms.

To simplify the description of this set of commands, only the standard waveform commands for the PULSe function are described below. Use the same procedure to program parameters for the SINusoid, TRIangle, RAMP, SQUare, SINC, GAUSsian, EXPonential, NOISe, and DC waveforms.

The number of points used to define each standard waveform is the same. Thus, some parameters may not have any effect on the waveform because too few points are available to generate the waveform. The number of points for each standard waveform at various frequencies is given below. The mathematical expressions for the positive exponential pulse, negative exponential pulse, gaussian pulse, and sinc pulse are given.

All standard parameters use the same computation. Therefore, you should expect that at some frequencies, for instance 50MHz, the sinc pulse would not appear as it should because there are only ten points available to generate it.

The equations used for generating EXPonential, GAUSsian and SINC parameters are as follows:

For the positive EXPonential:

$$F(m)=-A+A[e^{\frac{m}{0.63t}}-1]-A$$

Where A = Amplitude
m = Current point (1..N)
N = Total number of points
t = Time constant set by user

For the negative EXPonential:

$$F(m)=2Ae^{\frac{-m}{t}}-A$$

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For the GAUSsian:

$$F(m)=2Ae^{\frac{-(m-n/2)^2}{t}}-A$$

For the SINC:

$$F(m)=\frac{A\cdot\sin(2\pi\cdot\frac{m}{Nt}-\pi t)}{(2\pi\cdot\frac{m}{Nt}-\pi t)}$$

where

m = Current point (I..N)
N = Total number of points
t = Number of minima

The standard waveform will be available at the output connector only after the FUNC:MODE FIX command has been executed. Select the FUNC:SHAP PULS command. Parameters for the PULSe function shape can now be modified and will cause an effect on the output waveform. Note that changes made to parameters for a specific function do not have any effect on other parameters.

The command:

PULSe:DELay <value>

sets the pulse delay as a percentage of the pulse period. For example, if the pulse period is 100 ms, 10% will delay the first transition of the pulse by 10 ms. Delay is measured from trigger to the first turning point.

The query:

PULSe:DELay?

queries the pulse delay setting and returns a value in percent.

The command:

PULSe:TRANsition <value>

sets the pulse rise time as a percentage of the pulse period. For example, if the pulse period is 100 ms, 5% rise time equals 5 ms. Pulse rise time is measured between the two turning points of the first transition.

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The query:

PULSe:TRANsition?

queries the pulse rise time setting and returns a value in percent.

The command:

PULSe:WIDTh <value>

sets the pulse width as a percentage of the pulse period. For example, if the pulse period is 100 ms, 20% pulse width equals 20 ms. Pulse width is measured between the two turning points on the top of the pulse.

The query:

PULSe:WIDTh?

queries the pulse width setting and returns a value in percent.

The command:

PULSe:TRANsition:TRAiling <value>

sets the pulse fall time as a percentage of the pulse period. For example, if the pulse period is 100 ms, 15% fall time equals 15 ms. Pulse fall time is measured between the two turning points of the second transition.

The query:

PULSe:TRANsition:TRAiling?

queries the pulse fall time setting and returns a value in percent.

Selecting an Operating Mode

The Model 3162B offers four operating modes: Continuous, Triggered, Gated and Burst. The selected waveform is repeated continuously when the instrument is set to operate in continuous mode. In this mode, the Model 3162B does not require a trigger source to stimulate output cycles. The default operating mode of the instrument is continuous.

Triggered, Gated, and Burst modes require an external signal to initiate output cycles. Information on how to trigger gate output a burst of waveforms is given in the following paragraphs. The WaveCAD Trigger control panel (shown below) shows a high-level example of selecting the trigger mode.

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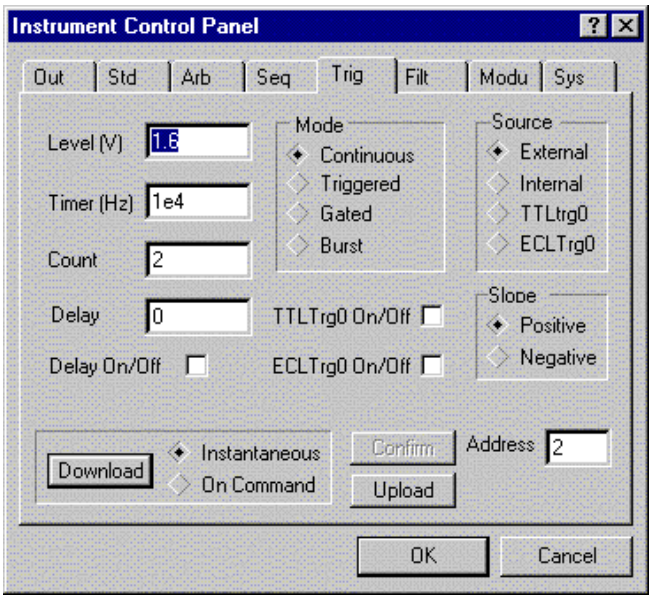


Figure 3-5, WaveCAD Control Panel for Trigger Mode

Triggered Mode

In Triggered mode, the output remains at a DC level as long as the TRIG IN signal from the front panel remains inactive. The trigger input is sensitive to either a rising edge or a falling edge. Each time a transition at the trigger input occurs, the Model 3162B generates one complete output waveform. At the end of the output cycle, the output resumes position at a DC level equal to the last point of the waveform.

The Triggered mode operates on standard waveforms and arbitrary waveforms. Observe the limitations of the trigger signal as listed in the specification section of this manual. Note that the Model 3162B is limited to trigger frequencies of 18.75 MHz or less. To place the Model 3162B in Triggered mode, use the following command:

INITitiate:CONTinuous {OFF | ON}

OFF places the instrument in Triggered mode. ON restores continuous operation.

The query:

INITitiate:CONTinuous?

queries the instrument operating mode parameter and returns "0" (OFF) or "1" (ON).

Gated Mode

The Model 3162B can be set to operate in Gated mode only after the INIT:CONT OFF command has been received. The output remains at a DC level as long as the TRIG IN signal from the front panel remains inactive. The gating signal can be programmed to be either active high or active low. Each time the proper level is present at the trigger input connector, the Model 3162B generates output waveforms as long as the gate signal is present. When the

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gate signal is de-asserted, the output completes the last cycle and resumes position at a DC level equal to the last point of the waveform.

Gated mode operates on standard waveforms, arbitrary waveforms, and on sequences of waveforms. Observe the limitations of the gating signal as listed in the specification section of this manual. To place the Model 3162B in Gated mode, use the following commands:

```
INIT:CONT OFF
TRIGger:GATE {OFF | ON}
```

The default state for the Gated mode is OFF. Turning Gated mode ON automatically turns Burst mode off.

The query:

```
TRIGger:GATE?
```

queries the gate state and returns "0" (OFF) or "1" (ON).

Burst Mode

Burst mode is very similar to Triggered mode with the exception that only one trigger signal is needed to generate a counted number of output waveforms. In Burst mode, the output remains at a DC level as long as the TRIG IN signal from the front panel remains inactive. The trigger input is sensitive to either the rising edge or the falling edge. Each time a transition at the trigger input occurs, the Model 3162B generates the number of output cycles that have been programmed in the burst count parameter. At the end of the burst, the output resumes position at a DC level equal to the last point of the waveform. The burst count is programmable from 1 to 10^6. The default burst value is 1.

Burst mode operates on standard waveforms and arbitrary waveforms. Note that the Model 3162B cannot operate in Sequence and Burst modes simultaneously. Observe the limitations of the trigger signal as listed in the specification section of this manual. To place the Model 3162B in Burst mode, use the following commands:

```
INITitiate:CONTinuous OFF
TRIGger:BURSt  ON
TRIGger:COUNt <counts>
```

INIT:CONT OFF places the Model 3162B in a non-continuous mode. TRIG:BURS ON turns the burst function on. The TRIG:COUN specifies the number of waveforms output after a qualified trigger signal. To ensure proper operation, enable Burst mode after setting up the burst parameters. When Burst mode is enabled, previously programmed trigger or gate modes turn off automatically.

The query:

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TRIGger:BURSt?

queries the state of Burst mode and returns "0" (OFF) or "1" (ON).

The query:

TRIGger:COUNt?

queries the burst count and returns an integer.

Selecting the Trigger Source

When an external source is not available, the operator has the option of using either the built-in trigger generator or a TTLTRG<n> signal to stimulate its output. Use the following command to select the trigger source for the instrument:

TRIGger:SOURce:ADVance {EXTernal | INTernal | TTLTrg<n>}

EXT is the default trigger source for the Model 3162B. Select the TTLT<n> option with <n> ranging from 0 to 3 to use one of the TTLTRG lines available on the backplane. Select INT to use the internal trigger generator. Remember to program the period of the internal generator as discussed in the section, “Using the Internal Trigger Generator”.

The query:

TRIGger:SOURce:ADVance?

queries the trigger source and returns EXT, INT or TTLT<n>.

Using the Internal Trigger Generator

The internal trigger generator is a free-running generator which is asynchronous with the main output generator. When the internal trigger source is selected, the front panel TRIG IN signal is inactive. The internal trigger generator is also usable in Burst mode, but has no effect in Gated mode. To use the internal trigger generator, place the instrument in triggered mode, but select the internal trigger generator as the trigger source. Then use the following command to program an internal trigger period:

TRIGger:TIMer <value>

The period of the internal trigger generator can be programmed from 20 µs to 1000 s. The default period is 100 µs. The internal trigger generator is ignored when either an external or TTLT source is enabled.

The query:

TRIGger:TIMer?

queries the period of the internal trigger generator and returns a value in seconds.

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Selecting the Trigger Slope

The trigger slope command selects the sensitive edge of the trigger signal that is applied to the TRIG IN connector. The Model 3162B can be made sensitive to either positive or negative transitions. Use the following command to select the sensitive edge for the trigger signal:

TRIGger:SLOPe {POSitive | NEGative}

Positive going transitions will trigger the Model 3162B when the POS option is selected. Negative transitions will trigger the Model 3162B when the NEG option is selected. POS is the default slope. In Gated mode, a high level will gate the generator when the POS option is selected; a low level will when NEG is selected.

The query:

TRIGger:SLOPe?

queries the trigger slope and returns POS or NEG.

Selecting the Trigger Level

The trigger level command sets the threshold level at the trigger input connector. Trigger levels are adjustable from -10 V to +10 V with up to 4 digits of resolution. Trigger level resolution is always 10 mV. Use the following command to set the trigger level for the trigger signal:

TRIGger:LEVel <value>

This sets the trigger level for the signal, which is applied at the TRIG IN connector. The default value is 1.6 V, so there is no need to modify this value if you apply a TTL level signal to the trigger input.

The query:

TRIGger:LEVel?

queries the trigger level and returns a value in Volts.

Using the Soft Trigger

The soft trigger command allows you to write a program that can trigger the 3162B directly. To use the soft trigger command, place the instrument in the TRIG:SOUR EXT mode. Soft triggers are ignored in the internal and TTLTrg<n> modes. Use the following SCPI commands to trigger the instrument:

TRIGger

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The IEEE-STD-488.2 common command *TRG has the same effect. Use either software command to trigger the Model 3162B in Trigger, Burst or Triggered Sequence Advance modes.

Generating Arbitrary Waveforms

The Model 3162B cannot generate arbitrary waveforms without first loading them into memory. A description of the arbitrary waveform function and an explanation of how to load waveforms into memory are given in the following paragraphs.

What Are Arbitrary Waveforms?

Arbitrary waveforms are generated from digital data points, which are stored in memory. Each data point has a vertical resolution of 12 bits (4096 points), i.e., each sample is placed on the vertical axis with a precision of 1/4096.

Arbitrary waveform memory has the capacity to store up to 1Meg of horizontal data points. Each horizontal point has a unique address - the first being 00000 and the last 1046464. In cases where smaller waveform lengths are required, the Model 3162B's waveform memory can be divided into smaller segments. Then it is possible to select which segment is sampled, how many times, and in what sequence.

When the instrument is programmed to output arbitrary waveforms, the clock samples the data points (one at a time) from address 0 to the last address. The rate at which each sample is replayed is defined by the sample clock rate parameter. The Model 3162B provides programmable sample clock rates from 100 mHz to 500 MHz.

The Arbitrary Waveform Control Panel (Figure 3-6) and the Axis Control Panel (Figure 3-7) in WaveCAD allow arbitrary waveforms to be created graphically.

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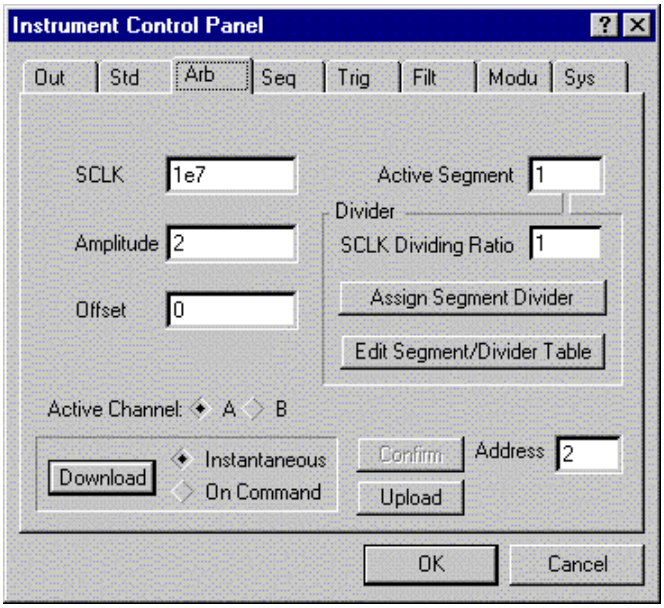


Figure 3-6, WaveCAD's Arbitrary Waveform Control Panel

Unlike the built-in standard waveforms, arbitrary waveforms must first be loaded into the instrument's memory. Correct memory management is required for best utilization of the arbitrary memory. An explanation of how to manage the arbitrary waveform memory is given in the following paragraphs.

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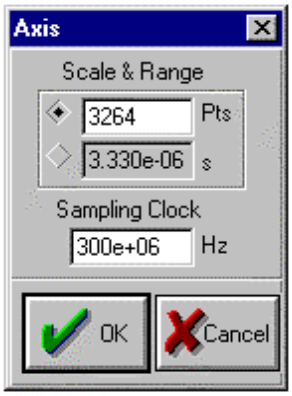


Figure 3-7, WaveCAD's Axis Definition Panel

Arbitrary Memory Management

The Model 3162B's arbitrary memory consists of a fixed length of 1,048,576 points. 2112 points are always reserved for the built-in standard waveforms. The maximum size arbitrary waveform that can be loaded into memory is 1,046,464 points long.

It is not necessary to use the entire length of this memory. The memory can be partitioned into smaller segments, and different waveforms can be loaded into each segment. The memory can be partitioned into 4096 segments, each having a unique length and sample rate. Minimum segment length is 16 points. Information on how to partition the memory is given in the following paragraphs.

Memory Management Commands

Arbitrary memory can be divided into smaller segments. Up to 4096 different arbitrary waveforms can be stored in the Model 3162B's memory. The length of each segment and its associated sample clock rate are left to the user's discretion. To partition the arbitrary waveform memory, use the following command:

TRACe:DEFine <segment_number>,<length>,<divider>

Note that numbers, not names, are assigned to segments that are defined. Segment numbers can range from 1 through 4096. The order of assignment is not important as long as the sizes of the segments, having already been defined, are not changed.

The length of any segment may be programmed from a minimum of 16 points to the maximum memory size, which is 1,046,464 words long.

Note

Minimum segment length is 16 points. Segment size may be set from 16 points to the maximum memory size in increments of 8 points. A size of 1002 is not a valid

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segment length, since it is not evenly divisible by 8. An error will occur if 1002 points are assigned to a segment.

A sample rate clock divider must be assigned to each segment. The division factor must be an integer number ranging from 1 to 65536. When the segment is selected, the sample clock rate will automatically be divided by its associated dividing ratio.

Note

The clock divider must be set to 1 for frequencies above 300 MHz.

Example 1

The following example defines segment number 1 with a length of 1048 points and no sample clock divider.

TRACe:DEFine 1,1048,1

In this example, the frequency of the output waveform is equal to the sample clock rate divided by the number of points. If the sample clock frequency was set to 104.8MHz, the output frequency will be 100kHz.

Example 2

The following example defines segment number 2 with a length of 1048 points and sample clock divided by 10.

TRACe:DEFine 2,1048,10

In this example, the frequency of the output waveform is equal to the sample clock rate divided by the number of points. If the sample clock frequency is set to 104.8MHz, the output frequency would then be 10kHz.

You cannot query the TRAC:DEF command so you must keep good track if you intend to partition the memory into many segments.

If a mistake is made and removal of one or more segments from the active directory is needed, use the following command:

TRACe:DELete <n>

where <n> is the segment number to be removed from memory. Note that if a segment is deleted, the memory portion that belonged to this segment is no longer accessible. The next segment that is defined will be placed after the last defined memory segment. However, if the last segment is deleted, the next downloaded segment will be written on top of the deleted one. There is danger that by using the TRAC:DEL command often, large portions of memory will remain unused. It is, therefore, suggested that you periodically clear the entire memory and only reload waveforms that will be used.

To partition the memory from the beginning, use the following command:

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TRACe:DELete: ALL

CAUTION

This command will destroy waveforms that were previously loaded into memory. After using this command, waveform segments will line up from address 0 upwards.

Loading Arbitrary Waveforms

There are three ways to load waveforms into the Model 3162B: by using a graphical user interface, i.e., WaveCAD, a LabWindows/CVI or LabVIEW driver, or by low-level programming. When using WaveCAD, disregard most of this chapter as WaveCAD does the work for you. When writing your own program or instrument driver, use the following commands to load data into a specific memory segment.

First, define the work area. Define the segment number, its associated length and sample clock divider. The segment length must be divisible by eight or an error will occur. For example, to use segment number 8, give it a length of 1048 points and a sample clock divider of 1, use this command:

TRACe:DEFine 8,1048,1

Next, make segment 8 the active segment. The active segment must be selected because as waveforms are loaded, the Model 3162B must be notified as to where to place the data it receives. Select the active segment using the following command:

TRACe:SELect 8

The next step is to transfer data to the active segment. Data is loaded into the Model 3162B using high-speed binary transfer. A special command is defined by IEEE-STD-488.2 for this purpose. High-speed binary transfer allows any 8-bit bytes (including extended ASCII code) to be transmitted in a message. This command is particularly useful for sending large quantities of data. The Model 3162B uses this command to receive waveforms from the controller:

TRACe #42096<binary_block>

This command causes the transfer of 2096 bytes of data (1048) points into the active memory segment. The ASCII "#" ($23) is the start of the binary data block. "4" designates the number of digits that follow. "2096" is the even number of bytes to follow. The generator represents binary data as 12-bit integers, which are sent as two bytes. Therefore, the total number of bytes is always twice the number of data points in the waveform. For example, 2096 bytes are required to download a waveform with 1048 points. Bytes are sent in

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byte-high, byte-low order. The FORM:SWAP command can be used to reverse this order.

When sending binary blocks to the Model 3162B, the final byte must be transmitted with the EOI bit set. Carriage Return and Line Feed will not be detected as terminators. This permits the values ODH and OAH to be used as data points.

The IEEE-STD-488.2 definition of Definite Length Arbitrary Block Data Format is demonstrated in Figure 3-8.

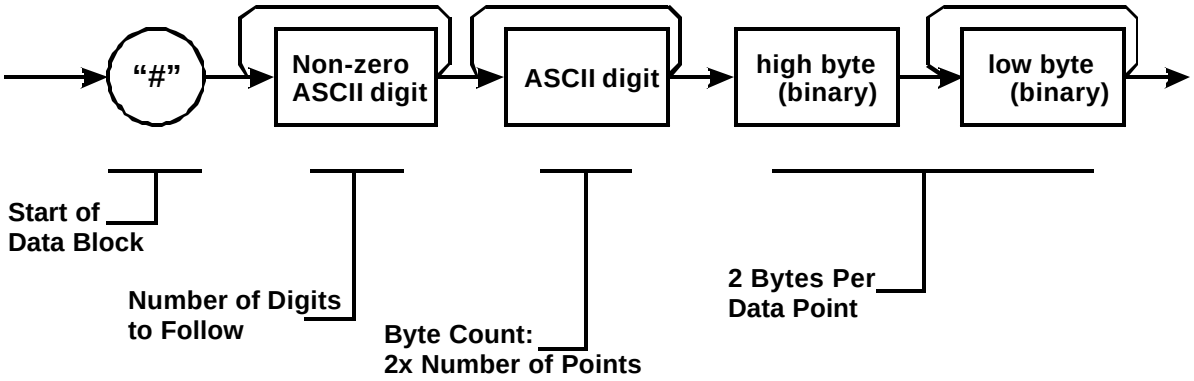


Figure 3-8, Definite Length Arbitrary Block Data Format

16-bits of data are sent to the Model 3162B even though only 12 bits are required to generate the waveform. The order of bytes and bits and their values are shown in Figure 3-9.

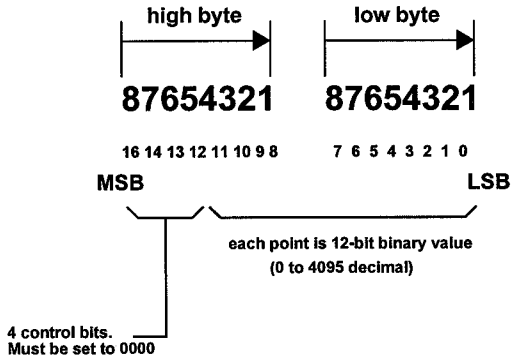


Figure 3-9, 12-Bit Waveform Data Format

Note

The Model 3162B operates in interlaced mode where eight memory cells generate one byte of data. Segment size can be programmed in numbers evenly divisible by eight only. For example, 2096 bytes is an acceptable length for a

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binary block. 2002 is not a multiple of 8, therefore the generator will generate an error message if this segment length is used.

The following program fragment shows an example of programming the 3162A or the 3162B's channel A.

```
#include <visa.h>
#include <ansi_c.h>
#include "ri3162.h"
#include <cvirte.h>    /* Needed if linking in external compiler; harmless otherwise */


/*============================================================================*/
/* Function: Load Arbitrary Data
                     */
/* Location: ri3162.c
                                        */
/* Purpose:  This function loads arbitrary data into the specified segment */
/*============================================================================*/
ViStatus _VI_FUNC ri3162_load_arb_data (ViSession vi,
ViInt16 segment_number,
ViInt16 *data_pts,
ViInt32 number_of_points)
{
          ViInt32 max_size;
          ViStatus error;
          ViUInt32 cnt;

          ViJobId job;
          ViEventType etype;
          ViEvent event;


          /* range check the parameters */
          if (error = ri3162_int_range (segment_number, RI3162_MIN_SEG_NUMBER,
                    RI3162_MAX_SEG_NUMBER, VI_ERROR_PARAMETER2))
                    return( error );


          max_size = ri3162_get_mem_size(vi);
          if (error = ri3162_int32_range (number_of_points, RI3162_MIN_SEGMENT_SIZE,
                    max_size, VI_ERROR_PARAMETER4))
                    return( error );


          /* select the arbitrary waveform segment */
          if ((error = viPrintf(vi, "TRAC:SEL %d\n", segment_number)) < 0)
                    return( error );

          if ((error = viPrintf(vi, ":SMEM:STATE OFF\n")) < 0)
                    return( error );

          /* get the device ready to download via A24 space */
          if ((error = viPrintf(vi, ":SMEM:MODE WRITE\n")) < 0)
                    return( error );

          if ((error = viPrintf(vi, ":SMEM:STATE ON\n")) < 0)
                    return( error );

          if ((error = viPrintf(vi, "*OPC?\n")) < 0)
                    return( error );
```


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```
          if ((error = viRead(vi, (unsigned char *) readbuf, RI3162_READ_LEN, &cnt)) < 0)
                    return( error );

          /* try again */
          if (readbuf[0] != '1')
                    {
          if ((error = viPrintf(vi, "*OPC?\n")) < 0)
                    return( error );

          if ((error = viRead(vi, (unsigned char *) readbuf, RI3162_READ_LEN, &cnt)) < 0)
                    return( error );

          if (readbuf[0] != '1')
                    return( RI3162_BINARY_DOWNLOAD_FAILED );
                    }

          error = viEnableEvent(vi, VI_EVENT_IO_COMPLETION, VI_QUEUE, VI_NULL);
error = viMoveAsync (vi, VI_LOCAL_SPACE, (ViBusAddress)data_pts, VI_WIDTH_16,
VI_A24_SPACE, 0L, VI_WIDTH_16, number_of_points, &job);
if (error < 0) {
          viPrintf(vi, ":SMEM:STATE OFF\n");
          return( RI3162_INVALID_FILE_DATA );
          }
error = viWaitOnEvent (vi, VI_EVENT_IO_COMPLETION, 10000, &etype, &event);
if (error < 0) {
          viTerminate( vi, VI_NULL, job );
          viWaitOnEvent( vi, VI_EVENT_IO_COMPLETION, 0, &etype, &event );
          viDiscardEvents( vi, etype, VI_ALL_MECH );
          viPrintf(vi, ":SMEM:STATE OFF\n");
          return( RI3162_INVALID_FILE_DATA );
          }
          viDiscardEvents( vi, etype, VI_ALL_MECH );

return( viPrintf(vi, ":SMEM:STATE OFF\n") );
}

int main (int argc, char *argv[]) {
          /* Define a 24-point square wave */
          ViInt16 data_pts[24] = {
                    4095, 4095, 4095, 4095,
                    4095, 4095, 4095, 4095,
                    4095, 4095, 4095, 4095,
                       0,    0,    0,    0,
                       0,    0,    0,    0,
                       0,    0,    0,    0
          };
          ViSession vi;

          if (InitCVIRTE (0, argv, 0) == 0)    /* Needed if linking in external compiler; harmless otherwise */
                    return -1;    /* out of memory */

          /* Initialize 3162 in slot 7 */
          ri3162_init ("VXI::7::INSTR", 1, 1, &vi);

          /* Select Arbitrary waveform mode */
          ri3162_select_waveform_mode (vi, RI3162_MODE_ARB);

          /* Turn Output on */
          ri3162_output (vi, RI3162_OUTPUT_ON);

          /* Define Segment 1 */
          ri3162_define_arb_segment (vi, 1, 24, 1);
```


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```
        /* Download 24 points */
        ri3162B_load_arb_data (vi, 1, data_pts, 24);
}
```

The above program uses the VISA I/O library and the LABWindows/CVI driver.

Reversing Byte Order

Binary data is sent to the Model 3162B in byte-high byte-low order. This order can be reversed using the following command:

FORMat:BORDer {NORMal | SWAPped}

The default is NORM. This command is useful only for binary block transfers. The query:

FORMat:BORDer?

queries the byte order configuration and returns "NORM" or "SWAP".

Using Shared Memory

Shared memory transfer is the fastest way to get waveforms into the Model 3162B. In shared memory mode, the Model 3162B's CPU disconnects from the waveform memory and passes access to the VXIbus. The internal data bus is connected directly to the VXIbus, and data is downloaded into the memory in binary blocks using A24 memory space. Byte and bit order are the same as with the Arbitrary Block transfers as shown in Figures 3-1 and 3-2. After the data is loaded into the Model 3162B, control is returned to the instrument.

In shared memory mode, the Model 3162B s memory acts like Direct Memory Access (DMA). The instrument must be told when to receive data, send data, surrender control or gain control. The Model 3162B has an auto-increment address counter. The Slot 0 Controller need only select the base address for both write and read cycles. Shared Memory commands are explained below.

The maximum block of shared memory that can be downloaded in a single transfer is 2Meg (2097152) words. If segments greater than 2Meg are needed, then multiple segments must first be defined. Then loaded with up to 2Meg of data, and then re-defined as a single segment of the desired size. For the example of a 3Meg segment, segments 1 and 2 can be defined as 2Meg and 1Meg, respectively. Two downloads are then required of 2Meg and 1Meg to these segments. Then segment 1 is redefined as 3Meg and the process is complete.

Revised 5/7/01

To write to or read from a segment, the user must first define the segment using the TRACe:DEFine command. The trace must then be selected using the TRACe:SELect command. Refer to Loading Arbitrary Waveforms (Page 3-31) for more information.

The command:

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SMEMory:MODE {READ | WRITe}

sets the instrument to receive (WRITE) data from or send (READ) data to the VXIbus.

The query:

SMEMory:MODE?

queries the shared memory mode and returns “READ” or “WRITE”.

The command:

SMEMory:STATe {OFF | ON}

places the Model 3162B in the shared memory state when ON is selected. After this, the instrument cannot accept normal commands. Data must be sent to the generator using shared memory access. Normal command mode is resumed when the SMEMory:STATe is changed to OFF.

The query:

SMEMory:STATe?

queries the shared memory state and returns "0" (OFF) or "1" (ON).

The following sequence should be used for shared memory transfers:

1. Slot 0 sends commands:

   TRAC:DEF (n),(m) (Shared Memory write only)
   TRAC:SEL <n>
   SMEM:MODE {READ * WRITE}
   SMEM:STATE ON

2. Slot 0 repeatedly sends:

   *OPC?

   When response is 1, shared memory transfers may start.

3. Use an I/O routine such as ViMoveAsync (from the VISA I/O library) to transfer the data (See previous example).

4. Slot 0 sends command:

   SMEM:STATE OFF

   once data transfer is complete (the ViMoveAsync command completion information).

The *OPC? response is set to 1 when the Model 3162B has transferred memory access from the internal CPU to shared memory. This typically takes a few milliseconds.

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Generating Sequenced Waveforms

What Are Sequenced Waveforms?

Sequenced waveforms are made of a number of arbitrary waveforms, which can be linked and repeated in user-programmable order. Sequenced waveforms are generated from waveforms stored in a library of memory segments. Before using a sequence of waveforms, load arbitrary memory with the required waveforms. Use TRAC# or shared memory methods to load waveforms into memory. Information on how to partition the memory and load waveforms is given in the section entitled **Generating Arbitrary Waveforms**.

An example of how sequenced waveforms work is demonstrated in figure 1-6. The sequence generator lets you link segments in user-defined order and repeat each segment up to 1 million times. Figure 1-6 shows a sequence of waveforms that were stored in three different memory segments.

Sequence Commands

The following is an overview of how to define and program a sequence of arbitrary waveforms.

A sequence is made of steps. A step can stand on its own or link to another step. It is possible to have only one step in a sequence but the output will look like a continuous waveform. If only one step is specified and the Model 3162B is placed in Triggered mode, the output will behave as it would in Burst mode, where the repeat number replaces the burst count parameter.

Aside from step numbers, each step has two other parameters: segment number and repeat counter. The segment number specifies which segment will be linked, and the repeat counter specifies how many times the segment will repeat. Use the following command to generate a sequence:

SEQuence:DEFine {<step_number>,<segment_number>,<repeat>}

Use this command up to 4095 times, each time for a different step and for a different segment number and repeat combination. Note that the same segment number can be used for different sequence steps. The SEQ:DEF command does not change the FUNC:MODE setting. Unless the FUNC:MODE SEQ command is used, the SEQ:DEF command has no immediate effect on the output waveform or function.

The sequence generator goes through its steps in descending order. In the continuous operating mode, the sequence is repeated automatically after the last step has been completed. When the generator is set to operate in Triggered mode, the output stops at the last point of the last waveform in the sequence. In Gated mode, the sequence is always completed after the gate

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stop signal.

If removal of a step from the sequence is required, use the following command:

SEQuence:DELete <n>

where <n> is the step number to be removed from the sequence.

To delete all sequence steps, use the following command:

SEQuence:DELete:ALL

CAUTION

The above command will destroy all sequence steps previously loaded into memory.

Sequence Advance Commands

The way the instrument advances through the sequence links and loops, and the source of the event causing sequence advance, can be specified by the user. Use the following commands to control how the instrument advances through the sequence:

SEQuence:ADVance {AUTO | STEP | SINGle}

AUTO specifies continuous advance, where the generator steps continuously to the end of the sequence table and repeats the sequence from the start. For example, if a sequence is made of three segments – 1, 2, and 3, and AUTO mode is used, the sequence will generate an infinite number of 1,2,3,1,2,3,1,2,3…waveforms. Of course, each link (segment) can be programmed with its associated loop (repeat) number and each segment can be programmed with a unique sample clock rate divider. AUTO is the default sequence advance mode.

In STEP advance mode, the sequence is advanced to the next waveform only when a valid trigger is received. The output of the model 3162B generates the first segment continuously until a trigger signal advances the sequence to the next segment. In this mode, after programming the number of loops for each segment, each trigger advances n times per step until n loops have been completed.

In SING advance mode, the Model 3162B idles between steps until a valid trigger signal is sensed. This mode operates with trigger mode only. An attempt to select the SING advance mode when the Model 3162B is in continuous operating mode will generate an error. After trigger, the generator outputs one waveform cycle. Then, the output level idles at a DC level equal to the last point of the last generated waveform. If loops (repeats) were programmed, the output will repeat this segment every time a trigger is received. Only after executing all of the programmed loops will the sequence step to the next assigned segment.

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The query:

SEQuence:ADVance?

queries sequence advance mode and returns “AUTO”, “STEP” or “SING”.

Sequence Advance Source Commands

The user can program the event, causing the sequence generator to advance to best match his application needs. In AUTO mode, the sequence is repeated continuously and there is no need to specify an advance source. In STEP and SING modes, the user must specify an advance source. Use the following commands to select the advance source.

SEQuence:ADVance:SOURce {INTernal | EXTernal | DSUB | TTLTrg<n> | ECLTrg0}

EXT is the default trigger source where triggers are applied to the front-panel trigger input. This input may be used as a stimulant for all sequence advance modes. Before you start using this input, make sure that the trigger level and trigger slope are programmed correctly to match your external trigger signal.

INT specifies the internal trigger generator as the sequence advance source. The internal trigger generator produces repetitive, continuous, and asynchronous trigger signals at intervals set by the user. This source can be selected if an external source is not available. Trigger intervals are programmable from 20µs to 1000s. The internal trigger source may be used to advance all sequence advance modes.

TTLT<n> or ECLT0 select the VXIbus backplane as a sequence advance source. In this case, another VXIbus module must source the trigger signals on one of the VXIbus trigger lines.

DSUB selects the front panel D-subminiature connector as the advance source. The DSUB option works only in stepped sequence advance mode. Pin 9 is connected to ground. All other pins (1 through 8) are pulled to ground internally through pull-down resistors.

Each pin from 1 to 8 has a binary value of 2^0, 2^1, 2^2, etc. The binary combination of the pins that are tied to +5 V determines the segment at the output connector.

Note

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There is a shift of 1 between the sequence table and the D-sub connector. With no pins pulled up, the binary value sensed by the generator is "0". The sequence table for the DSUB option ranges from 1 to 256.

Examples:

1. **If no pin is pulled up (binary value "0"), the instrument generates segment 1.**

2. **If pin 1 is pulled (binary value "1"), the instrument generates segment 2.**

3. **Pulling up pins 1 and 3 (binary value "5") generates segment 6.**

The query:

SEQuence:ADVance:SOURce?

queries the sequence advance source and returns "INT", "EXT", "DSUB", "TTLT<n>" or "ECLT0".

Front-Panel / VXIbus Phase Synchronization

The Model 3162B can phase lock to a reference signal which is applied to either the front-panel trigger input or one of the VXIbus backplane trigger lines. The phase locking process is done automatically by the generator. There is no need for the user to manually set the generator's lock-in range for this mode. A front-panel LED illuminates when the reference signal is valid and the Model 3162B locks onto the reference signal. After lock has been achieved, the frequency and the start phase of the reference signal and the main output are identical. The phasing between the two signals may be shifted from 0E to +360E.

Note

Minimum phase offset resolution is 8 points. It also depends on the number of waveform samples. For instance, if you have minimum 2880 waveform samples, there is no problem adjusting the phase offset in 1° increments (360° x 8/2880=1°). As another example, if you have only 1024 waveform samples, the phase offset increment is 2.81° (2880° /1024 = 2.81°).

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PLL Commands

To operate the PLL, set the trigger level and trigger slope and apply your reference signal to the trigger input. Trigger level and trigger slope settings are extremely important, especially if your reference signal has a slow slew rate. This is because the Model 3162B locks to the phase of the reference signal at the trigger point.

Use the following command to program the Model 3162B to lock to a front-panel reference signal:

PHASe:LOCK ON

This command places the Model 3162B in PLL mode. If no valid reference signal is applied to the trigger input, the PLL ON LED remains off. If you feel that the 3162B should lock and it does not, make sure that trigger level is adjusted correctly.

Make sure that the 3162B's frequency setting permits phase lock in the required range. Two graphs, one for fixed mode and the other for user mode are given in Appendix A. The graphs show the lock range relationship between the reference and the internal frequency settings.

The command:

PHASe:ADJust <value>

applies phase offset between the reference signal and the main output. The default value is 0E. Phase offsets can be adjusted between 0Œ and +360E. The resolution of this parameter is 1 waveform point, which is lowest (22.5°) with 16 point waveforms.

The command:

PHASe:STEP {POINt | DEGRee}

sets the phase offset adjustment units to either waveform points or degrees. The default option is DEGR. The advantage of using units of POINts is that phase offset of long waveforms may be adjusted with extremely fine resolution limited only by the number of waveform points.

The command:

PHASe:SOURce {EXTernal | TTLTrg<0-3> | ECLTrg0}

selects the reference source for the PLL function. EXT selects the front-panel trigger input. If you select this option, make sure that you also set the trigger level and trigger slope. TTLT<n> and ECLT0 are the options to use if your reference signal can be routed through the VXIbus backplane trigger lines. Trigger level and trigger slope cannot be adjusted for these trigger lines.

The query:

PHASe:LOCK?

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queries the PLL state and returns “0” (OFF) or “1” (ON)

The query:

PHASe:ADJust?

queries the PLL offset and returns value in degrees or points depending on the setting of PHASe:STEP.

The query:

PHASe:SOURce?

queries the PLL reference source and returns “EXT”, “TTLT<n>” or “ECLT0”.

Using the Frequency Counter

In PLL mode, the Model 3162B uses an autoranging counter circuit to measure the frequency of the reference signal. This built-in counter is available to you, provided that the signal at the trigger input is valid and the PLL ON LED illuminates. Frequencies are measured from 100 Hz to 18.75 MHz with 6 digits of resolution, including decimal point and suffix multiplier.

To measure external frequencies you must first place the model 3162B into PLL mode and then use the PLL command as described below.

The command:

FREQuency:EXTernal?

queries external frequency and returns a frequency in Hz. A 0.00000e0 reading indicates that no valid signal is available at the trigger input.

Using the Phase Modulation Input

The Phase Modulation (PM) function operates in conjunction with the PLL function. The PM Input accepts signals that phase modulate the main output frequency (carrier) after it has locked to an external reference.

When the Model 3162B is placed in PLL mode, the phase of the main output signal may be shifted from the reference phase using the phase modulation input. Although not very accurate, the phase modulation input provides a way of phase offsetting the main output to 360E or more.

The PM IN is sensitive to voltage levels. Applying 1V to this input generates a phase offset of 24°. Likewise, applying -1V to this input generates a phase offset of -24°. You may apply up to 20V to this input and, depending on the frequency and number of waveform points, generate a phase offset of 480°. The applied frequency range is DC to 10kHz, depending on the lock frequency and the number of waveform samples. See Appendix A for a graph of waveform points vs. maximum PM frequencies.

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Use the following command to control the PM input:

PM {OFF | ON}

ON activates the PM input and OFF is the default.

The query:

PM?

queries the PM input state and returns “1” (ON) or “0” (OFF).

Inter-Channel Phase Control

The Model 3162B has two output channels. These two outputs generate waveforms that have a common clock and waveform start mechanism. Common clock reference allows tight control over the phase relationship between the two channels. Besides an unavoidable initial skew between the channels (<1 ns typically), you can program any phase offset between the two channels.

The command:

PHASe:OFFSet <value>

Controls the phase offset between the two main outputs. Offset is applied to the B channel in reference to the rising edge of the A channel. Phase offset between the two channels can be programmed from 0E to 360E. The default value is 0E.

The query:

PHASe:OFFSet?

queries the phase offset value.

Amplitude Modulation Commands

The AM input is used for modulating the amplitude at the main output connector. The carrier signal is any continuous waveform which was programmed for the output. The envelope signal is supplied from an external source to the AM input.

The command:

AM {OFF | ON}

controls the AM input where ON enables AM and OFF is the default.

The query:

AM?

queries the AM input state and returns “1” (ON) or “0” (OFF).

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System-Related Commands

System-related commands are used to place the instrument in a known state, clear the instrument to its defaults, or query the generator for system errors or identification. The following is an overview of the system-related commands.

The query:

SYSTem:ERRor?

reads one error from the error queue. Up to 30 errors can be stored in the generator's error queue. Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. When all errors have been read from the queue, the generator returns +0, "No error".

If more than 30 errors have occurred, the last error stored in the queue (the most current error) is replaced with -350,"Too many errors". No additional errors are stored until all errors have been removed from the queue. The error queue is cleared only when power is cycled off or after the execution of a *CLS command. The *RST command does not clear the error queue.

The query:

SYST:ERRor?

queries the system error queue and returns a string with the following format: -102,"Syntax error". A complete list of errors that can be detected by the generator is given in Chapter 4.

The query:

SYSTem:VERSion?

queries the generator to determine the present SCPI revision and returns a string similar to "1993.0"

The query:

*IDN?

reads the generator's identification string. The generator returns four fields separated by commas. The first field is the manufacturer's name, the second field is the model number, the third field is not used (always "0") and the fourth field is the firmware revision number. The command returns "Racal Instruments,3162B,0,1.0".

The commands:

RESet
*RST

reset the generator to its default state. The *RST and RES commands have no effect on status registers, VXIbus states, or SCPI command set.

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The query:

*OPT?

queries the waveform memory length installed in the 3162B. The response is 1" for 1Meg memory.

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Chapter 4

SCPI COMMAND REFERENCE

What's In This Chapter

This chapter contains reference information for programming the Model 3162A/B. Standard Commands For Programmable Instruments (SCPI) convention rules and syntax are explained in detail. Table 4-1 lists all SCPI commands used for programming the Model 3162A/B. The command summary for each SCPI model is also included in this chapter.

This chapter teaches you how to use SCPI commands to control functions, modes, waveforms and other aspects of the instrument. Prior understanding of SCPI programming is necessary for low level programming of the Model 3162A/B.

NOTE

The Model 3162B has the same functionality as the Model 3162A. This manual describes all functions and feature that are available on the Model 3162B. If you own the Model 3162A, simply ignore all references in this chapter to the second output channel.

Introduction To SCPI Language

Commands to program the instrument over the MXI interface bus are defined by the SCPI 1993.0 standard. The SCPI standard defines a common language protocol. It goes one step further than IEEE-STD-488.2 and defines a standard set of commands to control every programmable aspect of the instrument. It also defines the format of command parameters and the format of values returned by the instrument.

SCPI is an ASCII-based instrument command language designed for test and measurement instruments. SCPI commands are based on a hierarchical structure known as a tree system. In this system, associated commands are grouped together under a common mode or root, thus forming subsystems. Throughout this manual, the following conventions are used for SCPI command syntax.

Square Brackets ([ ]) Enclose optional keywords or parameters

Braces ({ }) Enclose parameters within a command string

Triangle Brackets (< >) Substitute a value for the

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enclosed parameter

Vertical Bar (|) Separate multiple parameter choices

Bold Typeface Letters Designate factory default values

Part of the OUTPut subsystem is shown below to illustrate the tree system:

```
OUTPut
    :FILTer
        [:LPASs]
            :FREQuency {70MHz | 150MHz}
             [:STATe] OFF|ON
```

OUTPut is the root keyword of the command; FILTer and STATe are second level keywords. FREQuency and STATe are third level keywords. A colon (:) separates a command keyword from a lower level keyword.

Command Format

The format used to show commands in this manual is shown below:

```
FREQuency {<frequency>|MINimum|MAXimum}
```

The command syntax shows most commands (and some parameters) as a mixture of upper and lowercase letters. The uppercase letters indicate the abbreviated spelling for the command. For shorter program lines, send the abbreviated form. For better program readability, use the long form.

For example, in the above syntax statement, FREQ and FREQUENCY are both acceptable forms. Use upper or lowercase letters. Therefore, FREQ, FREQUENCY, freq, and Freq are all acceptable. Other forms such as FRE and FREQUEN will generate an error.

The above syntax statement shows the frequency parameter enclosed in triangular brackets. The brackets are not sent with the command string. A value for the frequency parameter (such as "FREQ 50e+6) must be specified.

Some parameters are enclosed in square brackets ([]). The brackets indicate that the parameter is optional and can be omitted. The brackets are not sent with the command string. If an optional parameter is not specified, the generator uses a default value.

Command Separator

A colon (:) is used to separate a command keyword from a lower level keyword as shown below:

```
SOUR:FUNC:SHAP SIN
```

A semicolon (;) is used to separate commands within the same subsystem, and can also minimize typing. For example, sending the following command string:

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TRIG:SOUR:ADV INT;BURS ON;INT:RATE 5e-3

is the same as sending the following three commands:

TRIG:SOUR:ADV INT
TRIG:BURS ON
TRIG:INT:RATE 5e-3

Use the colon and semicolon to link commands from different subsystems. For example, in the following command string, an error is generated if both the colon and the semicolon are not used.

OUTP:STATE ON;:TRIG:STAT ON

The MIN and MAX Parameters

Substitute MINimum or MAXimum in place of a parameter for some commands. For example, consider the following command:

FREQuency {<frequency>|MINimum|MAXimum}

Instead of selecting a specific frequency, substitute MIN to set the frequency to its minimum value or MAX to set the frequency to its maximum value.

Querying Parameter Setting

Query the current value of most parameters by adding a question mark (?) to the command. For example, the following command sets the output function to square:

SOUR:FUNC:SHAP SQR

Query the output function by executing:

SOUR:FUNC:SHAP?

Query Response Format

The response to a query depends on the format of the command. In general, a response to a query contains current values or settings of the generator. Commands that set values can be queried for their current value. Commands that set modes of operation can be queried for their current mode. IEEE-STD-488.2 common queries generate responses which are common to all IEEE-STD-488.2 compatible instruments.

SCPI Command Terminator

A command string sent to the function generator must terminate with a <new line> character. The IEEE-STD-488 EOI message is a <new line> character. A <carriage return> followed by a <new line> is also accepted. Command string termination always resets the current SCPI command path to the root level.

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IEEE-STD-488.2 Common Commands

The IEEE-STD-488.2 standard defines a set of common commands that perform functions like reset, trigger and status operations. Common commands begin with an asterisk (*), are four to five characters in length, and may include one or more parameters. The command keyword is separated from the first parameter by a blank space. Use a semicolon (;) to separate multiple commands as shown below:

```
*RST; *STB?; *IDN?
```

SCPI Parameter Type

The SCPI language defines four different data formats to be used in program messages and response messages: numeric, discrete, boolean, and arbitrary block.

Numeric Parameters

Commands that require numeric parameters will accept all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation. Special values for numeric parameters like MINimum and MAXimum are also accepted.

Engineering unit suffices with numeric parameters (e.g., MHz or kHz) can also be sent. If only specific numeric values are accepted, the function generator will ignore values which are not allowed and will generate an error message. The following command is an example of a command that uses a numeric parameter:

```
VOLT:AMPL <amplitude>
```

Discrete Parameters

Discrete parameters are used to program settings that have a limited number of values (i.e., FIXed, USER and SEQuence). They have short and long form command keywords. Upper and lowercase letters can be mixed. Query responses always return the short form in all uppercase letters. The following command uses discrete parameters:

```
SOUR:FUNC:MODE {FIXed | USER | SEQuence}
```

Boolean Parameters

Boolean parameters represent a single binary condition that is either true or false. The generator accepts "OFF" or "0" for a false condition. The generator accepts "ON" or "1" for a true condition. The instrument always returns "0" or "1" when a boolean setting is queried. The following command uses a boolean parameter:

```
OUTP:FILT { OFF | ON }
```

The same command can also be written as follows:

```
OUTP:FILT {0 | 1 }
```


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Arbitrary Block Parameters

Arbitrary block parameters are used for loading waveforms into the generator's memory. Depending on which option is installed, the Model 3162B can accept binary blocks up to 1M bytes. The following command uses an arbitrary block parameter that is loaded as binary data:

TRAC:DATA#564000<binary_block>

SCPI Command Summary

Table 4-1 summarizes the complete SCPI command tree available to program the generator over the GPIB. Refer to earlier sections in this manual for more complete details on each command.

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Table 4-1. VXIbus Model 3162B SCPI Commands List Summary

Keyword	Parameter Form (Default in Bold)	SCPI 1993.0	Notes
:FORMat			
:BORDer	NORMal | SWAPped	Confirmed	
:INSTrument		Confirmed	
:SELect	A | B	Confirmed	
:OUTPut		Confirmed	
[:STATe]	OFF | ON	Confirmed	
:FILTer		Confirmed	
[:LPASs]		Confirmed	
[:STATe]	OFF | ON	Confirmed	
:ECLTrg0		Confirmed	
[:STATe]	OFF | ON	Confirmed	
:TTLTrg<n>	(0;0;3)	Confirmed	(default;min;max)
[:STATe]	OFF | ON	Confirmed	
:SYNC		Not confirmed	
:SOURce	BIT | LCOMplete | SSYNc	Not confirmed	
[:STATe]	OFF | ON	Not confirmed	SYNC output inactive
:POSition		Not Confirmed	
[:POINt]	(0;0;1046464)	Not Confirmed	1Meg memory
[:SOURce]		Confirmed	
:APPLy	FREQ,AMPL,OFFS	Not confirmed	
:SINusoid	FREQ,AMPL,OFFS,PHAS	Not confirmed	
:TRIangle	FREQ,AMPL,OFFS,PHAS	Not confirmed	
:SQUare	FREQ,AMPL,OFFS,DCYC	Not confirmed	
:PULSe	FREQ,AMPL,OFFS,DEL,WIDT,LEAD,TRA	Not confirmed	
:RAMP	FREQ,AMPL,OFFS,DEL,LEAD,TRA	Not confirmed	
:SINC	FREQ,AMPL,OFFS,NCYC	Not confirmed	
:GAUSsian	FREQ,AMPL,OFFS,EXP	Not confirmed	
:EXPonential	FREQ,AMPL,OFFS,EXP	Not confirmed	
:DC	DC_AMPL	Not confirmed	
:USER	SEG<n>,SCLK,AMPL,OFFS	Not confirmed	
:FREQuency		Confirmed	
:MODE	NORMal | FSK | HOP	Not confirmed	
[:CW]	(1E6;100E-6;250E6) | MINimum | MAXimum	Confirmed	
:RASTer	(10E6;100E-3;500E6)| MINimum | MAXimum	Not confirmed	
:FSK	(1;1;65535)	Not confirmed	
:SOURce	EXTernal | TTLTrg<0-3> | ECLTrg0	Not confirmed	

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Table 4-1. VXIbus Model 3162B SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	SCPI 1993.0	Notes
:HOP	(1;1;256),(1;1;65535)	Not confirmed	
:SOURce	EXTernal | TTLTrg<0-3> | ECLTrg0 |DSUB	Not confirmed	
:EXTernal?		Not confirmed	
:ROSCillator		Confirmed	
:SOURce	**CLK10** | EXTernal | TCXO	Confirmed	
:VOLTage		Confirmed	
[:LEVel]		Confirmed	
[:IMMediate]		Confirmed	
[:AMPLitude]	(2.000;10E-3;5.000)	Confirmed	
:OFFSet	(0;-2.495;+2.495)	Confirmed	
:FUNCtion		Confirmed	
:MODE	**FIXed** | USER | SEQuence	Confirmed	
:SHAPe	**SIN** | TRI | SQU | PULS | RAMP | SINC | GAUS | EXP | NOISe | DC	Confirmed	
:SINusoid		Not Confirmed	
:PHASe	(0;0;360)	Not Confirmed	
:TRIangle		Not Confirmed	
:PHASe	(0;0;360)	Not Confirmed	
:SQUare		Not Confirmed	
:DCYCle	(50;1;99)	Not Confirmed	
:PULSe		Confirmed	
:DELay	(10;0;99.9)	Confirmed	
:WIDTh	(10;0;99.9)	Confirmed	
:TRANsition		Confirmed	
[:LEADing]	(10;0;99.9)	Confirmed	
:TRAiling	(10;0;99.9)	Confirmed	
:RAMP		Not Confirmed	
:DELay	(0;0;99.9)	Not Confirmed	
:TRANsition		Not Confirmed	
[:LEADing]	(60;0;99.9)	Not Confirmed	
:TRAiling	(30;0;99.9)	Not Confirmed	
:SINC		Not Confirmed	
:NCYCle	(10;4;100)	Not Confirmed	

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Table 4-1. VXIbus Model 3162B SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	SCPI 1993.0	Notes
:GAUSsian		Not Confirmed	
:EXPonent	(20;10;200)	Not Confirmed	
:EXPonential		Not Confirmed	
:EXPonent	(-20;-100;100)	Not Confirmed	
:NOISe		Not Confirmed	
:DC		Not Confirmed	
[:VOLTage]		Not Confirmed	
[:IMMediate]		Not Confirmed	
[:AMPLitude]	(100;-100;100)	Not Confirmed	
:AM		Confirmed	
[:STATe]	**OFF** | ON	Confirmed	
:PM		Confirmed	
[:STATe]	**OFF** | ON	Confirmed	
:PHASe		Confirmed	
:LOCK		Confirmed	
[:STATe]	**OFF** | ON	Not Confirmed	
:STEP	POINt | **DEGRee**	Not Confirmed	
:ADJust	(0;0;360°)(0;0;1M points)	Confirmed	
:SOURCe	EXTernal | TTLTrg<0-3> | ECLTrg0	Confirmed	
:OFFSet	(0;0;360°)(0;0;1M points)	Confirmed	
:SEQuence		Not Confirmed	
:ADVance	**AUTOmatic** | STEP | SINGle	Not Confirmed	
:SOURce	**EXTernal** | INTernal | TTLTrg<0-3> | EECLTrg0 | DSUB	Not Confirmed	
:DEFine	(1;1;4096),(1;1;4096),(1;1;1E6)	Not Confirmed	
:DELete		Not Confirmed	
[:NAME]	(1;1;4096)	Not Confirmed	
:ALL		Not Confirmed	
:RESet		Confirmed	
:SYSTem		Confirmed	
:ERRor?		Confirmed	
:VERSion?		Confirmed	
:TRACe		Confirmed	
[:DATA]		Confirmed	

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Table 4-1. VXIbus Model 3162B SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	SCPI 1993.0	Notes
:DEFine	(1;1;4096),(16;16;1046464)	Confirmed	Even number, 1M memory, divisible by 8
:DELete		Confirmed	
[:NAME]	(1;1;4096)	Confirmed	
:ALL		Confirmed	
:DIVider	(1;1;4096),(1;1;65535)	Not Confirmed	
:DELete		Not Confirmed	
:ALL		Not Confirmed	
:SELect	(1;1;4096)	Confirmed	
:INITiate		Confirmed	
[:IMMediately]		Confirmed	
:CONTinuous	OFF | **ON**	Confirmed	
:TRIGger		Confirmed	
:BURSt		Not Confirmed	
[:STATe]	**OFF** | ON	Not Confirmed	
:COUNt	(1;1;1E6)	Confirmed	
:DELay	(0;10;2E6)	Confirmed	
:STATe	**OFF** | ON	Confirmed	
:LEVel	(1.6;-10.00;+10.00)	Confirmed	
:SOURce		Not Confirmed	
:ADVance	**EXTernal** | INTernal | TTLTrg<0-3> | ECLTrg0	Not Confirmed	
:GATE		Not Confirmed	
[:STATe]	**OFF** | ON | 0 | 1	Not Confirmed	
:SLOPe	**POSitive** | NEGative	Confirmed	
:TIMer	(100e-6;20e-6;1000)	Confirmed	
[:IMMediate]		Confirmed	
:SMEMory		Not Confirmed	
:MODE	**READ** | WRITe	Not Confirmed	
[:STATe]	**OFF** | ON	Not Confirmed	
:TEST		Confirmed	
[:ALL]?		Confirmed	

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Table 4-1. VXIbus Model 3162B SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	SCPI 1993.0	Notes
*CLS		Confirmed	
*ESE	(0;0;255)	Confirmed	
*OPC		Confirmed	
*RST		Confirmed	
*SRE	(0;0;255)	Confirmed	
*TRG		Confirmed	
*ESE?		Confirmed	
*ESR?		Confirmed	
*IDN?		Confirmed	
*OPC?		Confirmed	
*SRE?		Confirmed	
*STB?		Confirmed	
*TST?		Confirmed	

Output Configuration Command Summary

Output Configuration commands control output functions, shape, frequency, amplitude, filter state, synthesizer agility and active (read) channel. Optional modes may be omitted from these commands. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable. Use the Standard Waveform parameters as described in **Using The APPLy Command**.

Commands and Parameters **(Default,** Low Limit, High Limit**)**

[:SOURce]
:APPLy:SINusoid {<frequency>,[<amplitude>,[<offset>,[<phase>]]]}
:APPLy:TRIangle {<frequency>,[<amplitude>,[<offset>,[<phase>]]]}
:APPLy:SQUare {<frequency>,[<amplitude>,[<offset>,[<duty_cycle>]]]}
:APPLy:PULSe {<freq.>,[<amp.>,[<offset>,[<delay>,[<high_time> ,[<rise_time>, [<fall_time>]]]]]]}
:APPLy:RAMP {<frequency>,[<amplitude>,[<offset>,[<delay>,[<rise_time>,[<fall_time>]]]]]}
:APPLy:SINC {<frequency>,[<amplitude>,[<offset>,[<number_cycles>]]]}
:APPLy:EXPonential {<frequency>,[<amplitude>,[<offset>,[<exponent>]]]}
:APPLy:GAUSsian {<frequency>,[<amplitude>,[<offset>,[<exponent>]]]}
:APPLy:DC {<percent_amplitude>}
:APPLy:USER {<segment_number>,[<sampling_clock>,[<amplitude>,[<offset>]]]}
:APPLy:<function_shape>?
:APPLy?

:FUNCTion:MODE {**FIXed** | USER | SEQuence}
:FUNCTion:MODE?
:FUNCtion:SHAPe {**SINusoid** | TRIangle | SQUare | PULSe | RAMP | SINC
:EXPonential | GAUSsian | NOISe | DC }
:FUNCtion:SHAPe?

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:FREQuency:MODE {**NORMal** | FSK | HOP}
:FREQuency:MODE?
:FREQuency {<frequency> | MINimum | MAXimum} (**1e6,**100e-6,250e6)
:FREQuency?
:FREQuency:RASTer {<frequency> | MINimum | MAXimum} (**1e6,**100e-3,500e6)
:FREQuency:RASTer?
:FREQuency:EXTernal?

:FREQuency:FSK <FSK_divider> (**1**,1,65535)
:FREQuency:FSK?
:FREQuency:FSK:SOURce (**EXTernal** | TTLTrg<0-3> | ECLTreg0}
:FREQuency:HOP <HOP_number>,<HOP_divider> (**1**,1,256),(**1**,1,65535)
:FREQuency:HOP?
:FREQuency:HOP:SOURce (**EXTernal** | TTLTrg<0-3> | ECLTreg0}

:ROSCillator:SOURce {CLK10 | EXTernal | **TCXO**}
:ROSCillator:SOURce?

:VOLTage {<amplitude>| MINimum | MAXimum} (**2**,10e-3,5)
:VOLTage?
:VOLTage:OFFSet <offset> (**0**,-2.495,2.495)
:VOLTage:OFFSet?

:OUTPut: {**OFF** | ON}
:FILTer {**OFF** | ON}
:FILTer?
:SYNC {**OFF** | ON}
:SYNC?
:SYNC:SOURce {**BIT** | LCOMplete | SSYNc }
:SYNC:SOURce?
:SYNC:POSition <value> (**0,**0,256K/1M, /4M)
:ECLTrg0 {**OFF** | ON}
:TTLTrg<0-3> {**OFF** | ON}

:INSTrument:SELect {**A** | B}
:INSTrument:SELect?

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Standard Waveform Command Summary

The Standard Waveform Commands control the various parameters of the standard output functions. Optional modes are omitted from these commands. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable. The Standard Waveforms parameters could be used for the APPLy command.

Command and Parameters	Low Limit	High Limit	Default
[:SOURce]			
:SINusoid:PHASe <value>	0	360	**0**
:SINusoid:PHASe?			
:TRIangle:PHASe <value>	0	360	**0**
:TRIangle:PHASe?			
:SQUare:DCYCle <value>	1	99	**50**
:SQUare:DCYCle?			
:PULSe:DELay <value>	0	99.9	**10.0**
:PULSe:DELay?			
:PULSe:WIDTh <value>	0	99.9	**10.0**
:PULSe:WIDTh?			
:PULSe:TRANsition <value>	0	99.9	**10.0**
:PULSe:TRANsition?			
:PULSe:TRANsition:TRAiling <value>	0	99.9	**10.0**
:PULSe:TRANsition:TRAiling?			
:RAMP:DELay <value>	0	99.9	**0.0**
:RAMP:DELay?			
:RAMP:TRANsition <value>	0	99.9	**60.0**
:RAMP:TRANsition?			
:RAMP:TRANsition:TRAiling <value>	0	99.9	**30.0**
:RAMP:TRANsition:TRAiling?			
:SINC:NCYCle <value>	4	100	**10**
:SINC:NCYCle?			
:GAUSsian:EXPonent <value>	10	100	**10**
:GAUSsian:EXPonent?			
:EXPonential:EXPonent <value>	-100	100	**-20**
:EXPonential:EXPonent?			
:DC <%_amplitude>	-100	100	**100**
:DC?			

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Arbitrary Waveform, Sequence, and Shared Memory Command Summary

Arbitrary Waveform commands allow the definition of segments and their corresponding lengths, addition and deletion of segments, and the loading of waveform data. Sequence commands control which segments are linked and the number of times each segment is repeated. The shared memory commands place the Model 3162B in a special data transfer mode where the Model 3162B's message-based interface is bypassed and data is loaded directly from the VXIbus. Optional modes are omitted from these commands. Defaults are shown in bold. Note that channel B is shared memory read only.

Command and Parameters

:TRACe #<binary_block>

:TRACe:DEFine <segment_number>,<length>

:TRACe:DELete <segment_number>

:TRACe:DELete:ALL

:TRACe:SELect <segment_number>

:TRACe:DIVider <segment_number>,<clock_divider>

:TRACe:DIVider:DELete:ALL

:FORMat:BORDer {**NORMal** | SWAPped}

:FORMat:BORDer?

:SEQuence:ADVance {**AUTOmatic** | STEP | SINGle}

:SEQuence:ADVance?

:SEQuence:ADVance:SOURce {**EXTernal** | INTernal | TTLTrg<0-3> | ECLTrg0}

:SEQuence:ADVance:SOURce?

:SEQuence:DEFine <step_number>,<segment_number>,<#_repeat>

:SEQuence:DELete <sequence_number>

:SEQuence:DELete:ALL

:SMEMory:MODE {READ | WRITe}

:SMEMory {OFF | ON}

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Modulation Command Summary

The Modulation Commands controls amplitude and phase modulation parameters. Optional modes may be omitted from these commands. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable.

Command and Parameters

[SOURce:]

AM {**OFF** | ON}

AM?

PM {**OFF** | ON}

PM?

Trigger Command Summary

The Trigger commands control the trigger modes of the Model 3162B. The Model 3162B can be placed in Triggered, Gated or Burst mode. Trigger source is selectable from an external source, internal trigger generator, backplane TTLTrg 0-3, ECLTrg0, or a software trigger. Optional modes are omitted from these commands. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable.

Command and Parameters	**(Default,**Low Limit,High Limit**)**
:INITiate:CONTinuous {OFF | **ON**}	
:TRIGger:BURSt {**OFF** | ON}	
:TRIGger:COUNt <value>	(**1**,1,1e6)
:TRIGger:DELay <value>	(**0**,0,8e6)
:TRIGger:DELay:STATe {**OFF** | ON}	
:TRIGger:GATE {**OFF** | ON}	
:TRIGger:LEVel <value>	(**1.6**,-10,10)
:TRIGger:SLOPe {**POSitive** | NEGative}	
:TRIGger:SOURce:ADVance {**EXTernal** | INTernal | TTLTrg<n> | ECLTrg0}	
:TRIGger:TIMer: <value>	(**100e-6**,20e-6,1000)
:TRIGger:IMMediate	
*TRG	

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PLL Command Summary

PLL commands control the PLL mode and the phase offsets versus another reference. The reference signal is applied either to a front panel connector or through one of the VXIbus trigger lines. The Model 3162B in PLL mode, can be used as a slave only. After lock, the generator's output frequency is exactly equal to the frequency of the reference signal. Note that the PLL lock range depends on the number of waveform samples, sampling frequency and external reference frequency. The relationship between these parameters is shown in Appendix A. Also included in this section are phase offset command. The

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phase offset commands control inter-channel phase offsets.

The commands are presented exactly as they should be typed in your program. Factory defaults after *RST or front panel reset are shown in bold typeface. Parameter low and high limits are given where applicable.

Command and Parameters	(Default,Low Limit,High Limit)
:PHASe:LOCK {**OFF** | ON}	
:PHASe:LOCK?	
:PHASe:STEP {POINt | **DEGRee**}	
:PHASe:STEP?	
:PHASe:ADJust <value>	(**0**,0,360°)(0,0,4M points)
:PHASe:ADJust?	
:PHASe:SOURCe {**EXTernal** | TTLTrg<0-3> | ECLTrg0}	
:PHASe:SOURCe?	
:PHASe:OFFSet <value>	
:PHASe:OFFSet?	

System-Related Command Summary

The system-related commands are not related directly to waveform generation but are an important part of operating the Model 3162B. These commands can reset or test the instrument, or query the instrument for system information.

Command and Parameters
SYSTem:ERRor?
SYSTem:VERSion?
RESet
*RST
TEST?
*TST?
*IDN?
*OPT?

IEEE-STD-488.2 Common Commands and Queries

Since most instruments and devices in an ATE system use similar commands, which perform similar functions, the IEEE-STD-488.2 document has specified a common set of commands and queries, which all compatible devices must use. This avoids situations where devices from various manufacturers use different sets of commands to enable functions and report status. The IEEE-STD-488.2 treats common commands and queries as device dependent commands. For example, *TRG is sent over the bus to trigger the instrument.

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Some common commands and queries are optional, but most of them are mandatory.

The following is a complete listing of all common commands and queries, which are used in the Model 3162B.

***CLS** - Clear the Status Byte summary register and all event registers.

***ESE** <enable_value> - Enable bits in the Standard Event enable register. The selected bits are then reported to the status byte.

***ESE?** - Query the Standard Event enable register. The generator returns a decimal value, which corresponds to the binary-weighted sum of all bits, set in the register.

***ESR?** - Query the Standard Event register. The generator returns a decimal value, which corresponds to the binary-weighted sum of all bits, set in the register.

***IDN?** - Query the generator's identity. The returned data is organized into four fields, separated by commas. The generator responds with its manufacturer and model number in the first two fields, and may also report its serial number and options in fields three and four. If the latter information is not available, the device must return an ASCII 0 for each. For example, Model 3162B s response to *IDN? is:

RACAL INSTRUMENTS,3162B,0,1.0.

***OPC** - Set the "operation complete" bit (bit 0) in the Standard Event register after the previous commands have been executed.

***OPC?** - Returns "1" to the output buffer after all the previous commands have been executed. *OPC? is used for synchronization between a controller and the instrument using the MAV bit in the Status Byte or a read of the Output Queue. The *OPC? query does not affect the OPC Event bit in the Standard Event Status Register (ESR). Reading the response to the ***OPC?** query has the advantage of removing the complication of dealing with service requests and multiple polls to the instrument. However, both the system bus and the controller handshake are in a temporary hold-off state while the controller is waiting to read the *OPC? query response.

***OPT?** - Returns the value 1 for a Model 3162B with 1Meg memory.

***RST** - Resets the generator to its default state. Default values are listed in Table 4-1.

***SRE** <enable_value> - Enables bits in the Status Byte enable register.

***SRE?** - Query the Status Byte enable register. The generator returns a decimal value in the range of 0 to 63 or 128 to 191 since bit 6 (RSQ) cannot be set. The binary-weighted sum of the number represents the value of the bits of the Service Request enable register.

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***STB?** - Query the Status Byte summary register. The *STB? command is similar to a serial poll but is processed like any other instrument command. The *STB? command returns the same result as a serial poll, but the "request service" bit (bit 6) is not cleared if a serial poll has occurred.

***TRG** - Triggers the generator from the remote interface. This command effects the generator if it is first placed in the Trigger or Burst mode of operation and the trigger source is set to "BUS".

***TST?** - Implements an internal self-test and returns a value as described below. Approximately 90% of the Model 3162B functionality is tested.

0 - Selftest passed

1 - CPU to peripherals communication failure

2 - DAC control, output amplifier, amplitude & offset control failure – Channel A

4 - DAC control, output amplifier, amplitude & offset control failure – Channel B

8 - Waveform memory failure - Channel A

16 - Waveform memory failure - Channel A

32 - Clock divider failure

64 - Clock generator failure

128 - Trigger & internal trigger failure

256 - Sequence advance circuit failure

512 - PLL circuit failure

More than one failure can be reported at one time. For example, the returned value 17" indicates both a DAC/Output Amplifier problem and a sequence/burst generator problem exist.

***WAI** – Wait for all pending operations to complete before executing any additional commands over the interface.

The SCPI Status Registers

The Model 3162B uses the Status Byte register group and the Standard Event register group to record various instrument conditions. Figure 4-1 shows the SCPI status system.

An Event Register is a read-only register that reports defined conditions within the generator. Bits in an event register are latched. When an event bit is set, subsequent state changes are ignored. Bits in an event register are automatically cleared by a query of that register or by sending the *CLS command. The *RST command or device clear does not clear bits in an event register. Querying an event register returns a decimal value, which corresponds to the binary-weighted sum of all bits, set in the register.

An Event Register defines which bits in the corresponding event register are logically ORed together to form a single summary bit. The user can read from

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and write to an Enable Register. Querying an Enable Register will not clear it. The *CLS command does not clear Enable Registers but it does clear bits in the event registers. To enable bits in an enable register, write a decimal value that corresponds to the binary-weighted sum of the bits required to enable in the register.

The Status Byte Register (STB)

The Status Byte summary register contains conditions from the other registers. Query data waiting in the generator's output buffer is immediately reported through the Message Available bit (bit 4). Bits in the summary register are not latched. Clearing an event register will clear the corresponding bits in the Status Byte summary register. Description of the various bits within the Status Byte summary register is given in the following:

Bit 0 - Decimal value 1. Not used, always set to 0.
Bit 1 - Decimal value 2. Not used, always set to 0.
Bit 2 - Decimal value 4. Not used, always set to 0.
Bit 3 - Decimal value 8. Not used, always set to 0.
Bit 4 - Decimal value 16. Message Available Queue Summary Message (MAV). The state of this bit indicates whether or not the output queue is empty. The MAV summary message is true when the output queue is not empty. This message is used to synchronize information exchange with the controller. The controller can, for example, send a query command to the device and then wait for MAV to become true. If an application program begins a read operation of the output queue without first checking for MAV, all system bus activity is held up until the device responds.
Bit 5 - Decimal value 32. Standard Event Status Bit (ESB) Summary Message. This bit indicates whether or not one or more of the enabled ESB events have occurred since the last reading or clearing of the Standard Event Status Register.
Bit 6 - Decimal value 64. Master Summary Status (MSS)/Request Service (RQS) Bit.

This bit indicates if the device has at least one condition to request service. The MSS bit is not part of the IEEE-STD-488.1 status byte and will not be sent in response to a serial poll. However, the RQS bit, if set, will be sent in response to a serial poll.
Bit 7 - Decimal value 128. Not used, always set to 0.

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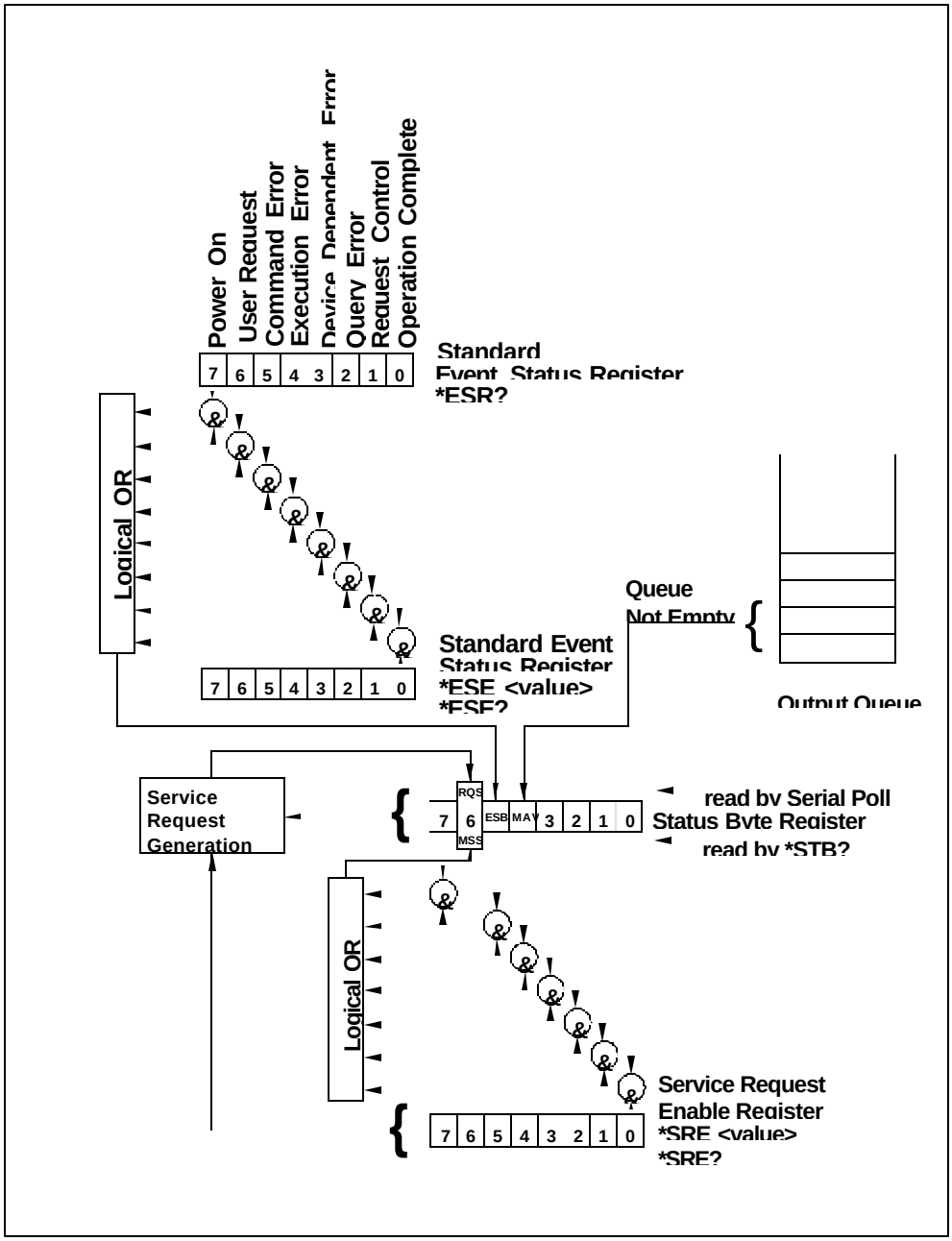


Figure 4-1 SCPI Status Registers

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Reading the Status Byte Register

The Status Byte summary register can be read with the *STB? common query. The *STB? common query causes the generator to send the contents of the Status Byte register and the MSS (Master Summary Status) summary message as a single <NR1 Numeric Response Message> element. The response represents the sum of the binary-weighted values of the Status Byte Register. The *STB? common query does not alter the status byte.

Clearing the Status Byte Register

Removing the reasons for service from Auxiliary Status registers can clear the entire Status Byte register. Sending the *CLS command to the device after a SCPI command terminator and before a Query clears the Standard Event Status Register and clears the output queue of any unread messages. With the output queue empty, the MAV summary message is set to FALSE. Methods of clearing other auxiliary status registers are discussed in the following paragraphs.

Service Request Enable Register (SRE)

The Service Request enable register is an 8-bit register that enables corresponding summary messages in the Status Byte Register. Thus, the application programmer can select reasons for the generator to issue a service request by altering the contents of the Service Request Enable Register.

The Service Request Enable Register is read with the *SRE? common query. The response to this query is a number that represents the sum of the binary-weighted value of the Service Request Enable Register. The value of the unused bit 6 is always zero.

The Service Request Enable Register is written using the *SRE command followed by a decimal value representing the bit values of the Register. A bit value of 1 indicates an enabled condition. Consequently, a bit value of zero indicates a disabled condition. The Service Request Enable Register is cleared by sending *SRE0. The generator always ignores the value of bit 6. Summary of *SRE commands is given in the following.

***SRE0** - Clears all bits in the register.

***SRE1** - Not used.

***SRE2** - Not used.

***SRE4** - Not used.

***SRE8** - Not used.

***SRE16** - Service request on MAV.

***SRE32** - Service request on ESB summary bit.

***SRE128** - Not used.

Standard Event Status Register (ESR)

The Standard Event Status Register reports status for special applications. The 8 bits of the ESR have been defined by the IEEE-STD-488.2 as specific conditions, which can be monitored and reported back to the user upon request. The Standard Event Status Register is destructively read with the *ESR? common query. The Standard Event Status Register is cleared with a

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*CLS common command, with a power-on and when read by *ESR?.

The arrangement of the various bits within the register is firm and is required by all GPIB instruments that implement the IEEE-STD-488.2. Description of the various bits is given in the following:

Bit 0 - Operation Complete. Generated in response to the *OPC command. It indicates that the device has completed all selected and pending operations and is ready for a new command.

Bit 1 - Request Control. This bit operation is disabled on the Model 3162B.

Bit 2 - Query Error. This bit indicates that an attempt is being made to read data from the output queue when no output is either present or pending.

Bit 3 - Device Dependent Error. This bit is set when an error in a device function occurs. For example, the following command will cause a DDE error:

VOLTage 4.25;:VOLTage:OFFSet 2

Both of the above parameters are legal and within the specified limits, however, the generator is unable to generate such an amplitude and offset combination.

Bit 4 - Execution Error. This bit is generated if the parameter following the command is outside of the legal input range of the generator.

Bit 5 - Command Error. This bit indicates the generator received a command that was a syntax error or a command that the device does not implement.

Bit 6 - User Request. This event bit indicates that one of a set of local controls had been activated. This event bit occurs regardless of the remote or local state of the device.

Bit 7 - Power On. This bit indicates that the device's power source was cycled since the last time the register was read.

Standard Event Status Enable Register (ESE)

The Standard Event Status Enable Register allows one or more events in the Standard Event Status Register to be reflected in the ESB summary message bit. The Standard Event Status Enable Register is an 8-bit register that enables corresponding summary messages in the Standard Event Status Register. Thus, the application programmer can select reasons for the generator to issue an ESB summary message bit by altering the contents of the ESE Register.

The Standard Event Status Enable Register is read with the *ESE? Common query. The response to this query is a number that represents the sum of the binary-weighted value of the Standard Event Status Enable Register.

The Standard Event Status Enable Register is written using the *ESE command followed by a decimal value representing the bit values of the Register. A bit value one indicates an enabled condition. Consequently, a bit value of zero indicates a disabled condition. The Standard Event Status Enable Register is cleared by setting *ESE0. Summary of *ESE messages is given

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in the following.

***ESE0** – No mask. Clears all bits in the register.

***ESE1** – ESB on Operation Complete.

***ESE2** – ESB on Request Control.

***ESE4** – ESB on Query Error.

***ESE8** – ESB on Device Dependent Error.

***ESE16** – ESB on Execution Error.

***ESE32** – ESB on Command Error.

***ESE64** – ESB on User Request.

***ESE128** – ESB Power on.

Error Messages

In general, whenever the Model 3162B receives an invalid SCPI command, it automatically generates an error. Errors are stored in a special error queue and may be retrieved from this buffer one at a time. Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. When you have read all errors from the queue, the generator responds with a 0,"No error" message.

If more than 30 errors have occurred, the last error stored in the queue is replaced with -350, “Queue Overflow”. No additional errors are stored until you remove errors from the queue. If no errors have occurred when you read the error queue, the generator responds with 0,"No error".

The error queue is cleared when power has been shut off or after a *CLS command has been executed. The *RST command does not clear the error queue. Use the following command to read the error queue:

SYSTem:ERRor?

Errors have the following format (the error string may contain up to 80 characters):

-102,"Syntax error"

A complete listing of the errors that can be detected by the generator is given below.

-100,"Command error". When the generator cannot detect more specific errors, this is the generic syntax error used.

-101,"Invalid Character". A syntactic element contains a character, which is invalid for that type.

-102,"Syntax error". Invalid syntax found in the command string.

-103,"Invalid separator". An invalid separator was found in the command string. A comma may have been used instead of a colon or a semicolon. In some cases where the generator cannot detect a specific separator, it may return error -100 instead of this error.

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-104,"Data type error". The parser recognized a data element different than allowed.

-108,"Parameter not allowed". More parameters were received than expected for the header.

-109,"Missing parameter". Too few parameters were received for the command. One or more parameters that were required for the command were omitted.

-128."Numeric data not allowed". A legal numeric data element was received, but the instrument does not accept one in this position.

-131,"Invalid suffix". A suffix was incorrectly specified for a numeric parameter. The suffix may have been misspelled.

-148,"Character data not allowed". A character data element was encountered where prohibited by the instrument.

-200,"Execution error". This is the generic syntax error for the instrument when it cannot detect more specific errors. Execution error as defined in IEEE-488.2 has occurred.

-221,"Setting conflict". Two conflicting parameters were received which cannot be executed without generating an error. Listed below are events causing setting conflicts.

1. INIT:CONT ON
FSK ON & HOP ON
PHAS ON & FSK ON
PHAS ON & HOP ON

2. INIT:CONT OFF
FSK ON
HOP ON
PHAS ON

3. SEQ ON
INIT:CONT ON & SEQ:ADV:SING
INIT:CONT OFF & SEQ:ADV:STEP
INIT:CONT OFF;:TRIG:GATE ON & SEQ:ADV STEP
INIT:CONT OFF;:TRIG:GATE ON & SEQ:ADV SING
INIT:CONT OFF;:TRIG:BURS ON

4. FUNC:MODE FIX;:FUNC:SHAP SIN
OUTP:FILT:ON
OUTP:FILT OFF
OUTP:FILT:FREQ 70MHz | 150MHz

5. ANY FUNCTION OR MODE
(VOLT/2 + |VOLT:OFFS|) > 2.5
Σ Pulse Parameters > 100%
Σ Ramp Parameters > 100%

-222,"Data out of range". Parameter data, which followed a specific header,

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could not be used because its value is outside the valid range defined by the generator.

-224,"Illegal parameter value". A discrete parameter was received which was not a valid choice for the command. An invalid parameter choice may have been used.

-300,"Device-specific-error". This is the generic device-dependent error for the instrument when it cannot detect more specific errors. A device- specific error as defined in IEEE-488.2 has occurred.

-311,"Memory error". Indicates that an error was detected in the instrument's memory.

-350,"Queue Oveflow". The error queue is full because more than 30 errors have occurred. No additional errors are stored until the errors from the queue are removed. The error queue is cleared when power has been shut off, or after a *CLS command has been executed.

-410,"Query INTERRUPTED". A command was received which sends data to the output buffer, but the output buffer contained data from a previous command (the previous data is not overwritten). The output buffer is cleared when power is shut off or after a device clear has been executed.

Device-Specific Commands

The Model 3162B conforms to the 1993.0 version of the SCPI standard. Some of the commands used are not included in the 1993.0 version. However, these commands are designed with the SCPI standard in mind and they follow all of the command syntax rules defined by the standard. Table 4-1 lists all device-specific commands that were designed specifically for the Model 3162B as not confirmed SCPI 1993.0 commands.

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Chapter 5

MAINTENANCE AND PERFORMANCE CHECKS

What's in This Chapter

This chapter provides maintenance and service information, performance tests, and the procedures necessary to adjust and troubleshoot the Model 3162A/B Waveform Generator.

WARNING

The procedures described in this section are for use only by qualified service personnel. Many of the steps covered in this section may expose the individual to potentially lethal voltages that could result in personal injury or death if normal safety precautions are not observed.



CAUTION

ALWAYS PERFORM DISASSEMBLY, REPAIR AND CLEANING AT A STATIC SAFE WORKSTATION.

Disassembly Instructions

If it is necessary to troubleshoot the instrument or replace a component, use the following procedure to remove the side panels:

1. Using a Phillips head screwdriver, remove the two screws on each side of the instrument, and one screw at the rear of the instrument that secures the side panels.

2. Grasp one side panel and carefully slide and lift it off the instrument. Use the same procedure to remove the other side panel. After removing the side panels from the instrument, access the component side for calibration and checks, and the solder side when replacing components.

3. When replacing the side panels, reverse the above procedure.

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Special Handling of Static Sensitive Devices

CMOS devices are designed to operate at very high impedance levels for low power consumption. As a result, any normal static charge that builds up on your person or clothing may be sufficient to destroy these devices if they are not handled properly. When handling such devices, use the precautions described below to avoid damaging them:

1. CMOS IC's should be transported and handled only in containers specially designed to prevent static build-up. Typically, these parts are received in static-protected containers of plastic or foam. Keep these devices in their original containers until ready for installation.

2. Ground yourself with a suitable wrist strap. Remove the devices from the protective containers only at a properly grounded workstation.

3. Remove a device by grasping the body; do not touch the pins.

4. Any printed circuit board into which the device is to be inserted must also be grounded to the bench or table.

5. Use only anti-static type solder suckers.

6. Use only grounded soldering irons.

Once the device is installed on the PC board, the device is adequately protected and normal handling may resume.

Cleaning

The Model 3162A/B should be cleaned as often as operating conditions require. To clean the instrument, use the following procedure:

1. Thoroughly clean the inside and outside of the instrument.

2. When cleaning inaccessible areas, remove dust with low-pressure compressed air or a vacuum cleaner.

3. Use alcohol applied with a cleaning brush to remove accumulation of dirt or grease from connector contacts and component terminals.

4. Clean the exterior of the instrument and the front panel with a mild detergent mixed with water, applying the solution with a soft, lint-free cloth.

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Repair and Replacement

Repair and replacement of electrical and mechanical parts must be accomplished with great care. Printed circuit boards can become warped, cracked or burnt from excessive heat or mechanical stress. The following repair techniques are suggested to avoid inadvertent destruction or degradation of parts and assemblies:

1. Use a 60/40 solder and temperature-controlled 35 - 40 watt pencil-type soldering iron on the circuit board. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the circuit from the base material.

2. Keep the soldering iron in contact with the PC board for a minimum time to avoid damage to the components or printed conductors.

3. To desolder components, use a commercial "solder sucker" or a solder-removing SOLDER - WICK, size 3.

4. Always replace a component with an exact duplicate as specified in the parts list.

Performance Checks

The following performance checks verify proper operation of the instrument and should normally be used:

1. As a part of the incoming inspection of the instrument specifications;

2. As part of the troubleshooting procedure;

3. After any repair or adjustment before returning the instrument to regular service.

Environmental Conditions

Tests should be performed under laboratory conditions having an ambient temperature of 25°C, ±5°C and at relative humidity of less than 80%. If the instrument has been subjected to conditions outside these ranges, allow at least one additional hour for the instrument to stabilize before beginning the adjustment procedure. Always perform a self-test sequence before commencing with the performance checks. The self-test, if executed without any failure, ensures proper operation of the generator. If self-test failures have been encountered, the instrument first must be serviced and the source of failure removed. Instructions on how to perform self-test are given later in this chapter in the **Self-Test** section.

Warm-up Period

Most equipment is subject to a small amount of drift when it is first turned on. To ensure accuracy, turn on the power to the Model 3162A/B and allow it to warm-up for at least 30 minutes before beginning the performance test procedure.

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Initial Instrument Setting

To avoid confusion as to which initial setting is to be used for each test, it is required that the instrument be reset to factory default values prior to each test. To reset the Model 3162A/B to factory defaults, send either of the following commands:

RESet, or *RST.

Recommended Test Equipment

Recommended test equipment for troubleshooting, calibration and performance checking is listed below. Test instruments other than those listed may be used only if their specifications equal or exceed the required characteristics.

Test Instrument & Accessories	Minimum Specification
Universal Counter	300MHz, 1 ppm accuracy
DMM accuracy	ACV, 0.2%; DCV, 0.1%
Distortion Analyzer	10Hz to 100kHz
Spectrum Analyzer resolution	1 GHz bandwidth, 1kHz
Pulse/Function Generator	50MHz, 10ns pulse width
Oscilloscope	2 channels, 500MHz analog bandwidth
Feedthrough termination	50Ω, 0.1%
BNC Cables	1 meter long, 50Ω impedance
20dB feedthrough attenuator	50Ω, 1%
"T" BNC Connector	50Ω, 1%

Performance Check Procedures

Use the following procedures to check the Model 3162A and the 3162B against the specifications. A complete set of specifications is listed in Appendix A. The following paragraphs show how to set up the instrument for the test, what the specifications for the tested function are, and what acceptable limits for the test are. If the instrument fails to perform within the specified limits, the instrument must be calibrated or tested to find the source of the problem.

In the following, 3162B tests refer to both 3162A and 3162B models. If you own the Model 3162A, simply ignore tests that pertain to the B channel operation.

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Frequency Accuracy

Accuracy Specifications: 1 ppm of reading to 200.00 MHz

Equipment: Counter

1. Configure the Model 3162B as follows:

   Function: Square
   Frequency: 10 Hz
   Amplitude: 1 V
   Remote Commands: :RES
   :OUTP ON
   :FUNC:SHAP SQU
   :FREQ 10
   :VOLT 1

2. Set the counter to frequency measurement.

3. Connect the Model 3162B output to the counter's input. Change the frequency setting as required for the test and verify the reading on the counter display as follows:

3162B Setting	Counter Reading
10.00000 Hz	9.999999 Hz - 10.00001 Hz
100.0000 Hz	99.99999 Hz - 100.0001 Hz
1.000000 kHz	999.9999 Hz - 1.000001 kHz
10.00000 kHz	9.999999 kHz - 10.00001 kHz
100.0000 kHz	99.99999 kHz - 100.0001 kHz
1.000000 MHz	999.9999 kHz - 1.000001 MHz
10.00000 MHz	9.999999 MHz - 10.00001 MHz
150.0000 MHz	149.9998 MHz - 150.0002 MHz
200.0000 MHz	199.9998 MHz - 200.0002 MHz

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Amplitude Accuracy

Accuracy Specifications (1 kHz):

±(1% of reading +25 mV), 1 V to 5 V

±(1% of reading +5 mV), 100 mV to 999.9 mV

±(1% of reading +2 mV), 10 mV to 99.99 mV

Equipment: DMM, 50Ω feedthrough termination

1. Configure the Model 3162B as follows:

   Function: Sine
   Frequency: 1.000 kHz
   Amplitude: 5 V
   Remote Commands: :RES
   :FREQ 1e3
   :OUTP ON
   :VOLT 5
   :INST:SEL B
   :OUTP ON
   :VOLT 5

2. Set the DMM to ACV measurements (RMS).

3. Connect the A channel output to the DMM input. Terminate the output with a 50Ω feedthrough termination. Set the amplitude and verify DMM reading as follows:

A Channel Setting	DMM Reading
5.000 V	1.725 V – 1.809 V
500.0 mV	170.0 mV – 183.4 mV
50.0 mV	15.50mV – 19.84mV

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4. Configure Channel B using the following commands:

   Remote Commands: :INST:SEL B
   :OUTP ON
   :VOLT 5

5. Connect the B channel output to the DMM input. Terminate the output with a 50Ω feedthrough termination. Set the amplitude and verify DMM reading as follows:

B Channel Setting	DMM Reading
5.000 V	1.725 V – 1.809 V
500.0 mV	170.0 mV – 183.4 mV
50.0 mV	15.50 mV – 19.84 mV

DC Offset Characteristics

Accuracy Specifications: ± (2% of reading +10 mV)

Equipment: DMM, 50 feedthrough termination

1. Configure the Model 3162B as follows:

   Function: Sine
   Frequency: 1.000 MHz
   Amplitude: 10 mV
   Remote Commands: :RES
   :FREQ 1e6
   :VOLT 10e-3
   :VOLT:OFFS 2.495
   :OUTP ON

2. Set the DMM to DCV measurements.

3. Connect the A channel output to the DMM input. Terminate the output with a 50Ω feedthrough termination. Set the A channel offset and verify the DMM reading as follows:

A Channel Offset Setting	DMM Reading
+2.495 V	+2.435 V to +2.555 V
+1.000 V	+0.980 V to +1.020 V
-1.000 V	-0.980 V to -1.020 V
-2.495 V	-2.435 V to –2.555 V

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4. Configure Channel B using the following commands:

   Remote Commands: :INST:SEL B
   :VOLT 10e-3
   :VOLT:OFFS 2.495
   :OUTP ON

5. Connect the B channel output to the DMM input. Terminate the output with a 50Ω feedthrough termination. Set the B channel offset and verify DMM reading as follows:

B Channel Offset Setting	DMM Reading
+2.495 V	+2.435 V to +2.555 V
+1.000 V	+0.980 V to +1.020 V
-1.000 V	-0.980 V to -1.020 V
-2.495 V	-2.435 V to –2.555 V

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Square Wave Characteristics

Specified Transition Time: <2.5 ns typical (10% to 90% of amplitude)

Specified Aberration: <5% of amplitude +10 mV

Equipment: Oscilloscope, 20dB attenuator

1. Configure the Model 3162B as follows:

   Function: Square wave
   Frequency: 10 MHz
   Amplitude: 3 V
   Remote Commands: :RES
   :FUNC:SHAP SQU
   :FREQ 10e6
   :VOLT 3
   :OUTP ON

2. Connect the A channel output to the oscilloscope input. Use the 20dB attenuator and set oscilloscope input impedance to 50Ω.

3. Set the oscilloscope and verify that the rise and fall times are less than 2.5 ns. Verify that overshoot and ringing are less than 5% of amplitude.

4. Configure Channel B using the following commands:

   Remote Commands: :INST:SEL B
   :FUNC:SHAP SQU
   :VOLT 3
   :OUTP ON

5. Connect the B channel output to the oscilloscope input. Use the 20dB attenuator and set oscilloscope input impedance to 50Ω.

6. Set the oscilloscope and verify that the rise and fall times are less than 2.5 ns. Verify that overshoot and ringing are less than 5% of amplitude.

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Sine Characteristics

Specified Total Harmonic Distortion: <0.5% from 10.00 Hz to 100.0 kHz, (measured with minimum 4096 horizontal points and sampling rate of 500 MS/s).

Specified Harmonic Signals:

-50dBc to 100 kHz

-40dBc to 10 MHz

-25dBc to 200 MHz

Equipment: Distortion Analyzer, Spectrum Analyzer, 50Ω feedthrough termination and 20dB attenuator.

1. Configure the Model 3162B as follows:

   Function: User Waveform
   Frequency: 100 kHz
   Amplitude: 3 V
   Remote Commands: :RES
   :FUNC:MODE USER
   :TRAC:DEF 1,5000
   :TRAC:SEL 1
   :FREQ:RAST 500e6
   :VOLT 3
   :OUTP ON
   :INST:SEL B
   :FUNC:MODE USER
   :TRAC:DEF 1,5000
   :TRAC:SEL 1
   :VOLT 3
   :OUTP ON

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2. Connect the A channel output to the distortion analyzer input.

3. Load a 5000-point sine waveform to both A and B channels. Use TRACe# command or WaveCAD to load the waveform.

4. Set the distortion analyzer to % distortion measurements, set the Model 3162B sample clock setting, and verify the distortion reading for both channels as below.

3162B SCLK Setting	Distortion Reading
500e6	<0.5%
50e6	<0.5%
5e6	<0.5%
500e3	<0.5%
50e3	<0.5%

5. Tune the spectrum analyzer to the carrier frequency and adjust the gain so the fundamental corresponds to 0 dB.

6. Connect the Model 3162B output to spectrum analyzer input through a 20dB feedthrough attenuator. Using the command FUNC:MODE FIX, modify both channels to output sine waveforms.

7. Set the Model 3162B FREQ setting and verify the harmonic distortion levels for both channels as follows:

FREQ Setting	Harmonic Level
10 MHz	<40 dBc
50 MHz	<25 dBc
100 MHz	<25 dBc
200 MHz	<25 dBc

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Sine Flatness

Level Flatness: ±10% to 10 MHz; ±30% to 200 MHz

Equipment: Oscilloscope

1. Configure the Model 3162B as follows:

   Function: Sine wave
   Frequency: 10.00 kHz
   Amplitude: 3 V
   Remote Commands: :RES
   :FREQ 10e3
   :VOLT 3
   :OUTP ON
   :INST:SEL B
   :VOLT 3
   :OUTP ON

2. Connect the Model 3162B OUTPUT to the oscilloscope, set the oscilloscope input impedance to 50Ω, and set oscilloscope to display the sinewave within exactly 6 vertical divisions. Repeat this step for channel B.

3. Change the Model 3162B FREQ setting to 100 MHz. Verify that peak-to-peak of the displayed sinewave is within 5.4 to 6.6 divisions. Repeat this step for channel B.

4. Change the Model 3162B FREQ setting to 200 MHz. Verify that peak-to-peak of the displayed sinewave is within 4.2 to 7.8 divisions. Repeat this step for channel B.

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Trigger Gate & Burst Characteristics

Triggered - Each transition at the front panel TRIG IN connector stimulates the Model 3162B to generate one complete output waveform.

Gated - External signal at the TRIG IN connector enables the Model 3162B output. The last cycle of the output waveform is always completed.

Burst - Each transition at the front panel TRIG IN connector stimulates the Model 3162B to generate a burst of pre-selected number of cycles.

Equipment: Pulse/function generator (8021), oscilloscope.

Trigger

1. Configure the Model 3162B as follows:

   Function: Sine wave
   Frequency: 1 MHz
   Operating Mode: Triggered
   Remote Commands: :RES
   :FREQ 1e6
   :INIT:CONT OFF
   :OUTP ON

2. Set the external pulse/function generator frequency to 10 kHz and connect its SYNC connector. Set the oscilloscope and verify on the oscilloscope that the Model 3162B outputs a triggered signal. Leave the external pulse generator connected to the Model 3162B for the next test.

Gate

3. Configure the Model 3162B as follows:

   Function: Sine wave
   Frequency: 1 MHz
   Operating Mode: Gated
   Remote Commands: :RES
   :OUTP ON
   :FREQ 1e6
   :INIT:CONT OFF
   :GATE:STAT ON

4. Set the oscilloscope and verify that the Model 3162B outputs a gated signal. Leave the external pulse generator connected to the Model 3162B for the next test.

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Burst

5. Configure the Model 3162B as follows:

   Function: Sine wave
   Frequency: 1 MHz
   Operating Mode: Burst
   Remote Commands: :RES
   :OUTP ON
   :FREQ 1e6
   :INIT:CONT OFF
   :BURST:STAT ON
   :TRIG:COUN 10

6. Set oscilloscope and verify that the Model 3162B outputs a burst of 10 complete output waveforms. Remove the external pulse generator connection from the Model 3162B for the next test.

Synthesizer Agility Characteristics

FSK

Operation: Trigger high modifies carrier frequency to FSK.

Equipment: Pulse/Function Generator (8021), Oscilloscope

1. Configure the Model 3162B as follows:

   Function: USER
   Sample Clock: 300 MHz
   Amplitude: 3 V
   Remote Commands: :RES
   :OUTP ON
   :FUNC:MODE USER
   :FREQ 300e6
   :VOLT 3
   :FREQ:MODE FSK
   :FSK 10

2. Using WaveCAD, or any other waveform generation program, load segment 1 with a 4096-point waveform.

3. Connect the output from the Model 3162B to the oscilloscope and set the oscilloscope to display the waveform.

4. Connect the 8021 trigger output to the 3162B trigger input. Set 8021 frequency to 1 kHz.

5. Verify that carrier frequency (73.24 kHz) is displayed when the trigger signal is low and FSK frequency (7.324 kHz) when trigger signal is high.

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HOP

Operation: Hop table contains 256 hop frequencies. Hop advance source may be selected from front panel, VXIbus triggers and front-panel D-sub connector.

6. Configure the Model 3162B as follows:

Function:		USER
Sample Clock:		300 MHz
Amplitude:	3 V	
Remote Commands:		:RES
		:OUTP ON
		:FUNC:MODE USER
		:INIT:CONT OFF
		:FREQ 300e6
		:VOLT 3
		:FREQ:MODE HOP
		:HOP 1,1
		:HOP 2,10
		:HOP 3,100
		:HOP 4,1000

7. Using WaveCAD, or any other waveform generation program, load segment 1 with a 32-point waveform.

8. Connect the output from the Model 3162B to the oscilloscope and set the oscilloscope to display the waveform. Verify that carrier frequency of 9.375 MHz is displayed.

9. Connect the 8021 trigger output to the 3162B trigger input. Set 8021 frequency to 1 Hz.

10. Verify that output frequency hops with each trigger between 9.375 MHz, 937.5 kHz, 93.75 kHz, and 9.375 kHz. The hop loop repeats as long as the trigger signal is applied to the trigger input.

11. Remove the 8021 from the 3162B trigger input. Modify the hop source to DSUB using the command HOP:SOUR DSUB.

12. Pulling the DSUB pins 1 through 8 to +5 V configures the hop step. You may pull the pins using an external device such as a pattern generator. Connect pin 1 to +5 V and verify that the output frequency changes to 937.5 kHz. Move the +5 V from pin 1 to pin 2. Observe that output frequency is now 93.75 kHz.

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PLL Characteristics

Accuracy: ±(2880/n [points] + 20 ns/Period [ns] x 360).

Equipment: Counter, Pulse/Function Generator, Feedthrough Terminator, 3 each BNC Cables, 50 "T" Connector

1. Configure the Model 3162B as follows:

   Function: User
   Mode: PLL
   Sample Clock: 500 MHz
   Amplitude: 2 V
   Trigger Level: 0 V
   Remote Commands: :RES
   :FUNC:MODE USER
   :PHAS:LOCK ON
   :TRIG:LEV 0
   :VOLT 2
   :OUTP ON

2. Make the following connections:

   1. Connect function generator output to the input of the 50Ω "T" Connector.

   2. Connect one end of the 50Ω "T" connector to the 3162B TRIG IN and the other end to the counter Channel A input.

   3. Connect the 3162B OUT to the counter Channel B input.

3. Using WaveCAD, or any other waveform generation program, load segment 1 with a 360-point square waveform.

4. Set counter to phase measurements. Terminate counter inputs by 50Ω.

5. Set the 8021 to output a 2 V p-p, 500 kHz square waveform.

6. Change 3162B phase offset using the command PHAS:ADJ and verify counter phase readings as shown below:

Phase Offset	Counter Reading
0°	0°, ±11.6°
90°	90°, ±11.6°
180°	180°, ±11.6°
270°	270°, ±11.6°

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Adjustments

Environmental Conditions

Adjustments should be performed under laboratory conditions having an ambient temperature of 24°C, ±2°C and relative humidity of less than 70%. If the instrument has been outside this range, allow at least one additional hour for the instrument to stabilize before beginning the adjustment procedure. Between adjustments, always leave the side panel on the unit to keep the internal temperature as stable as possible.

Warm-up Period

Most equipment is subject to a small amount of drift when first turned on. To ensure long-term calibration accuracy, turn on the power to the Model 3162A/B and allow it to warm up for at least 30 minutes before beginning the adjustment procedure.

Recommended Test Equipment

Recommended test equipment for calibration is listed at the beginning of this chapter in the section entitled **Recommend Test Equipment**. Test instruments other than those listed may be used only if their specifications equal or exceed the required characteristics.

Adjustment Procedures

All adjustments are performed with the POWER ON. The side covers should be removed to allow access to test points and adjustments. If channel B is installed, adjustments must be made on the A channel first. Remove the B channel board, perform the adjustments on the first channel, then replace the second channel and proceed with the adjustment procedure on the B channel.

WARNING

Special care should be taken to prevent contact with live circuits or the power line area. This could cause an electrical shock resulting in serious injury or death. Use an isolated tool when making adjustments.

When necessary, refer to the component layouts for determining adjustment points. Follow the procedure in the sequence indicated as some adjustments are interrelated and dependent on the proceeding steps.

Verify that the waveform generator is functioning according to the performance checks. Ensure that all results are within or close to the range of the required specifications; otherwise, refer to the troubleshooting procedures given later in this section.

Perform the following adjustment procedure. If an adjustment cannot be made to obtain a specific result, refer to the troubleshooting procedures.

NOTE

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If not otherwise specified, configure the instrument to factory defaults before each adjustment by sending the *RST command. Always connect the output BNC connector through a 50Ω feedthrough termination.

Sample Clock Duty Cycle Adjustment

Equipment: Oscilloscope (HP 64616B), 10/1 Probe

1. Configure the Model 3162B as follows:

   Function: Sine
   Frequency: 200 MHz
   Remote Commands: :RES
   :OUTP ON
   :FREQ 200e6

2. Connect the probe between U62 pin 2 and ground (on the A channel engine board). Adjust R28 for 50% duty cycle.

Pulse Response Adjustment

Equipment: Oscilloscope (HP 64616B), 20dB Attenuator

1. Configure the Model 3162B as follows:

   Function: Square
   Frequency: 10 MHz
   Amplitude: 3 V
   Remote Commands: :RES
   :FREQ 10e6
   :FUNC:SHAP SQU
   :VOLT 3
   :OUTP ON

Channel A Adjustment

2. Connect the A channel output through 20dB attenuator to the oscilloscope input.

3. Set oscilloscope input impedance to 50Ω. Set the oscilloscope vertical gain and time base, and adjust main board C8 for best pulse response.

4. Change the Model 3162B frequency setting to 10 kHz.

5. Remove the 3162B signal from the oscilloscope and adjust the vertical position to be exactly on the center of the trace.

6. Reconnect the 3162B output to the oscilloscope and adjust R7 for best symmetry around the vertical centerline.

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Channel B Adjustment

7. Change the Model 3162B settings using the following remote commands:

```
                    :FREQ 10 e6.
:INST:SEL B
:FUNC:SHAP SQU
:VOLT 3
:OUTP ON
```

8. Connect the B channel output through 20dB attenuator to the oscilloscope input.

9. Set oscilloscope input impedance to 50Ω. Set the oscilloscope vertical gain and time base, and adjust C9 on engine board B for best pulse response.

10. Change the Model 3162B frequency setting to 10 kHz.

11. Remove the 3162B signal from the oscilloscope and adjust the vertical position to be exactly on the center of the trace.

12. Reconnect the 3162B output to the oscilloscope and adjust R5 on engine board B for best symmetry around the vertical centerline.

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Amplitude Adjustment

Equipment: DMM, 50 Ω feedthrough termination

1. Configure the Model 3162B as follows:

   Function: Sine
   Frequency: 1 kHz
   Amplitude: 5 V
   Remote Commands: :RES
   :FREQ 1e3
   :VOLT 5
   :OUTP ON

Channel A Adjustment

2. Connect the Model 3162B output to the DMM input through the 50Ω feedthrough termination. Set the DMM to AC volt measurements and 2 V range.

3. Adjust R34 on the engine board A for DMM reading of 1.7677V, ±15 mV.

Channel B Adjustment

4. Change the Model 3162B settings using the following remote commands:

   :INST:SEL B
   :VOLT 5
   :OUTP ON

5. Connect the Model 3162B output to the DMM input through the 50Ω feedthrough termination. Set the DMM to AC volt measurements and 2 V range.

6. Adjust R78 on the engine board B for DMM reading of 1.7677V, ±15 mV.

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Offset Adjustment

Equipment: DMM, 50Ω feedthrough termination

1. Configure the Model 3162B as follows:

   Function: Sine
   Frequency: 1 MHz
   Amplitude: 10 mV
   Offset: +4.500 V
   Remote Commands: :RES
   :FREQ 1e6
   :VOLT 10e-3
   :VOLT:OFFS 4.5
   :OUTP ON

Channel A Adjustment

2. Connect the Model 3162B output to the DMM input through the 50Ω feedthrough termination. Set the DMM to DCV measurements and 10 V range. Record this reading.

3. Change the offset setting to -4.50 V and adjust R95 on the main board to have the exact reading as was recorded in the previous step (with reversed polarity).

4. Adjust R96 on the main board for a DMM reading of -4.500 V, ±30 mV.

5. Repeat Steps 3 and 4 until the best result is obtained in both steps.

Channel B Adjustment

6. Change the Model 3162B settings using the following remote commands:

   :INST:SEL B
   :VOLT 10e-3
   :VOLT:OFFS 4.5
   :OUTP ON

7. Connect the Model 3162B output to the DMM input through the 50Ω feedthrough termination. Set the DMM to DCV measurements and 10 V range. Record this reading.

8. Change the offset setting to -4.50 V and adjust R77 on the B channel engine board to have the exact reading as was recorded in the previous step (with reversed polarity).

9. Adjust engine board B R76 until the DMM reading is -4.500 V, ±30 mV.

10. Repeat steps 3 and 4 until the best result is obtained in both steps.

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PLL Adjustment

Equipment: Counter, Pulse/Function Generator, 3 BNC cables, 2 50Ω feedthrough termination, "T" BNC connector

1. Configure the Model 3162B as follows:

   Function: Square
   Frequency: 10 kHz
   Amplitude: 3 V
   PLL Mode: ON
   Phase Offset 16
   Remote Commands: :RES
   :FREQ 10e3
   :VOLT 3
   :PHAS:LOCK ON
   :PHAS:ADJ 16
   :OUTP ON

2. Using the "T" BNC connector, connect one BNC from the pulse/function generator SYNC output to the counter (channel A). and the other BNC to the 3162B trigger input. Set pulse/function generator frequency to 5 kHz.

3. Connect the 3162B channel A output to the counter (channel B). Observe that the front-panel PLL LED illuminates.

4. Set counter to phase measurements and adjust R98 on the main board for a phase reading of 16° ±1°.

Troubleshooting

The troubleshooting instructions contained in this section are intended for qualified personnel having basic understanding of analog and digital circuitry. The individual should also be experienced at using typical test equipment as well as ordinary troubleshooting procedures. The information presented here has been written to assist in isolating a defective circuit or circuit section. Isolation to a specific component is left to the technician.

Recommended Test Equipment

Recommended test equipment for troubleshooting and adjustment of the Model 3162A/B is listed in the section entitled **Recommended Test Equipment** in the beginning of this chapter. Other equipment such as a logic analyzer, in-circuit emulator, etc., could also be helpful in a difficult situation.

Power-up Tests

Upon power-up, the Model 3162A/B performs a set of tests. If the instrument locks up after power on, proceed with the troubleshooting procedure given in the following paragraphs.

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Self-Test

An advanced feature of the Model 3162B is its self-test capability. This feature helps in reducing troubleshooting time of faulty circuits to the minimum. If the instrument fails its self-test procedure, it will generate an error bit. *TST? initiates the self-test procedure. If the instrument executes its self-test without errors, 0 is placed at the output queue. Non-zero indicates self-test failure. The following is a list of tests that the 3162B performs and their associated response, in case one of the tests fails.

0 - Selftest passed
1 - CPU to peripherals communication failure
2 - DAC A control, output amplifier, amplitude & offset control failure
4 - DAC B control, output amplifier, amplitude & offset control failure
8 - Clock generator failure
16 - Clock divider failure
32 - Channel A waveform memory failure
64 - Channel B waveform memory failure
128 - Trigger & internal trigger failure
256 - Sequencer & burst circuit failure
512 - PLL circuit failure

More than one failure can be reported at one time. For example, the returned value “258" indicates both a channel A DAC/output amplifier problem and a sequence/burst generator problem exist.

The self-test procedure is intended to verify general operation of the Model 3162A/B. It does not test for accuracy. Therefore, it should be used as a general indication that the Model 3162A/B operates correctly. The self-test procedure checks about 95% of the hardware. If the self-test procedure fails to respond correctly, troubleshooting the Model 3162A/B is suggested using the procedure given below.

The troubleshooting procedure should be initiated whenever the generator fails to perform either completely or partially. It is also required to troubleshoot the Model 3162A/B whenever the instrument fails to fully comply with its published specifications. The information given in the following does not intend to replace full scale troubleshooting, but merely to direct the Service Technician to the area where the source of the trouble is located.

Main Board Circuits Checkout

The Model 3162B is made of three boards. The large board (Part Number 7100-2440) is the main board. There are two smaller boards mounted on the main board with three connectors (Part Number 7100-2430). This smaller board is called the “engine board”. The following checks are made on the main board. To gain access to components below the engine boards, it may be necessary to remove one or both boards entirely. To do so, remove the four screws that secure the engine board to the main board, grasp the engine board from both sides and pull away from the main board.

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Power Supply Checks

It is suggested that the first step in troubleshooting the Model 3162B would be to check the power supply rails. If the various supply voltages within the instrument are not within the required limits, troubleshooting the remaining circuits can be very difficult.

The supply voltages are supplied to the instrument through the backplane. In case of a "dead short" between one of the supplies and the common ground, disconnect the entire supply section from the remaining circuitry, and then determine whether the problem is in the power supply or in the remaining circuits.

A few preliminary checks could help here. First remove the Model 3162B from the VXI chassis. Turn on the VXI chassis and verify that the supply voltages are available directly on the backplane sockets. Check the following supplies: +24 V, -24 V, +12 V, -12 V, +5 V, -5.2 V, and –2 V. Check the ripple on these lines using an oscilloscope.

Plug an extension card into one of the slots and plug the Model 3162B into the extension card. Turn the chassis power on and repeat the supply voltage tests as above. If one of the voltages is missing or not within the specified range, it is possible that one of the supply lines is shorted inside the Model 3162B. Remove the filter chokes L2 and L3 if there are problems on the +12 V or –12 V lines; remove L1 or L4 if there are problems on the +5 V or -5.2 V lines.

CPU and VXI ASIC Checks

The most important section to be verified after power supply checkout is the CPU and VXI ASIC section with its various clocks, address, data lines, and chip select serial data communication components. Problems with the digital part could cause erratic operation or erroneous response to word serial commands.

Problems in the CPU and the digital circuit may cause a complete malfunction of the entire instrument. The CPU would not start generating control signals. This makes it impossible to troubleshoot the remaining circuits. Check the various components associated with the CPU circuitry, its clocks, and the components associated with the VXI ASIC using the information given in Table 5-1.

Table 5-1, CPU and VXI Interface Checks

Step	Test Point	Expected Result
1	CPU Clock – U37 pin 19	16 MHz TTL level clock
2	VXI Clock - U91 pin 159	16 MHz TTL level clock
3	ALE – U15 pin 11	Positive going pulses; period 375 ns, pulse width 120 ns
4	PSEN – U16 pin 19	2.67 MHz TTL level pulses
5	Load a 16000-point wave and perform the following tests during load time	

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6	RD – U37 pin 16	Negative going 400 ns width pulses
7	WR – U37 pin 17	Negative going 400 ns width pulses
8	LDACK – U37 pin 5	Negative going 6.5 µs width pulses
9	ASIC LCS – U91 pin 26	Negative going 6.5 µs width pulses
10	LR/W - U91 pin 18	Negative going 60 µs width pulses

Output Amplifier and Amplitude Control Checks

Problems with the output amplifier and amplitude control circuits can be detected if the Model 3162B accepts word serial commands and responds correctly to word serial queries, but fails to output the correct waveform with correct amplitude and offset levels. If there is a problem with the output amplifier or with the amplitude control circuit, proceed with the checkout procedure given in Table 5-2.

Before starting the following procedure, reset the Model 3162B to the factory defaults using the *RST command. Then send the command:

: :OUTP ON.
:INST:SEL B
:OUTP ON

Table 5-2, Output Amplifier and Amplitude Control Checks

Step	Engine Board A Test Point	Expected Result
1	P1 connector (output amplifier input)	600 mVp-p sinewave, 1 MHz
2	U5, pin 6	Approximately 1 Vp-p sinewave, +6 V offset
3	U6, pin 6	Approximately 1 Vp-p sinewave, -6 V offset
4	U4, pin 2	-7 V dc
5	U2, pin 2	+7 V dc
	Engine Board B Test Point	
6	U13, pin 6	1.2 Vp-p sinewave, 1 MHz
7	U4, pin 6	Approximately 1 Vp-p sinewave, +6 V offset
8	U5, pin 6	Approximately 1 Vp-p sinewave, -6 V offset
9	U3, pin 2	-7 V dc
10	U1, pin 2	+7 V dc

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Clock Synthesizer Checks

Problems with the clock synthesizer circuits can be detected if the Model 3162B accepts word serial commands and responds correctly to word serial queries, but fails to output the correct waveform frequency. If there is a problem with the clock synthesizer circuit, proceed with the checkout procedure given in Table 5-3.

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Table 5-3 Clock Synthesizer Checks

Step	Test Point	Expected Result
1	P6 (Sample clock input)	256 MHz ECL level clock
2	U87 pin 9	256 MHz ECL level clock
3	U99pin 5	2 MHz TTL level square pulse
4	U30 pin 7	2 MHz TTL level square pulse
5	U30 pin 2	2 MHz sinewave
6	U80 pin1 and 2	2 MHz ECL level clock
7	U24 pin 5	10 MHz TTL level clock
8	U87 pin 26	32 MHz ECL level clock
9	U97 pin 12	32 MHz TTL level clock

Engine Board A/B Circuit Checkout

As described in the paragraph **Main Board Circuit Checkout**, the Model 3162B is made of three boards. If one of the engine boards is removed from the main board, reinstall it before continuing with the following checks. The following circuit checks are performed on the engine boards A and B only.

Engine Board A/B Checks

Problems with the engine board circuits can be detected if the Model 3162B accepts word serial commands and responds correctly to word serial queries but fails to generate correct waveforms. If there is a general problem with the engine board circuits, download a 128-point square waveform to both channels A and B, program the Model 3162B using the following remote commands, and proceed with the checks given in Table 5-4.

Remote Commands: :RES
:FUNC:MODE USER
:OUTP ON
:INST:SEL B
:OUTP ON

Continuous Operation Checks

If there are problems with the shape of the output waveforms or if the output waveforms are not generated at all, program the Model 3162B using the following remote commands:

Remote Commands: :RES
:FUNC:MODE USER
:OUTP ON
:INST:SEL B
:FUNC:MODE USER
:OUTP ON

Download 128-point square waveforms to both channels A and B and proceed with the checks given in Table 5-4.

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Table 5-4 Engine Board Checkout – Continuous Operating Mode Checks

Step	Engine Board A Test Points	Expected Result
1	U12, U13, U20, U21, U28, U29, U36, U37, U44, U45, U52, U53 Pins 9, 10, 11, 12, 18, 19, 20, 21, and 24	78.125 KHz ECL level clock
2	U85 pin 5	Negative going ECL level pulses, period 800 ns, pulse width 100 ns
3	U63, U65 – U73 pin 2	Negative going TTL level pulses, period 800 ns, pulse width 200 ns
4	U63, U65 – U73 pin 9	Negative going TTL level pulses, period 12.8 µs, pulse width 800 ns
5	J6	10 MHz ECL level square waveform
6	U12, U13, U20, U21, U28, U29, U36, U37, U44, U45, U52, U53 Pin 13	10 MHz ECL level square waveform
7	U12, U13, U20, U21, U28, U29, U36, U37, U44, U45, U52, U53 Pin 17	Negative going ECL level pulses, period 800 ns, pulse width 100 ns
	Engine Board B Test Points	
8	U23, U24, U31, U32, U39, U40, U47, U48, U55, U56, U63, U64 Pins 9, 10, 11, 12, 18, 19, 20, 21, and 24	78.125 kHz ECL level clock
9	U70 – U79 pin 2	Negative going TTL level pulses, period 800 ns, pulse width 200 ns
10	U70 – U79 pin 9	Negative going TTL level pulses, period 12.8 µs, pulse width 800 ns
11	U23, U24, U31, U32, U39, U40, U47, U48, U55, U56, U63, U64 Pin 13	10 MHz ECL level square waveform
12	U23, U24, U31, U32, U39, U40, U47, U48, U55, U56, U63, U64 Pin 17	Negative going ECL level pulses, period 800 ns, pulse width 100 ns

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Triggered Operation Checks

If there are general problems with the shape of the output waveforms or if the output waveforms appear distorted in triggered operating mode, proceed with the checks given in Table 5-5. Checks in this table are performed on engine board A only. Apply an external 20 kHz TTL level signal to the trigger input and program the Model 3162B using the following remote commands:

Remote Commands: :RES
:OUTP ON
:INIT:CONT OFF

Table 5-5 Engine Board Checkout – Triggered Operating Mode Checks

Step	Test Point	Expected Result
1	U10, Pins 7 and 8	(This check made on the main board) TTL level square waves, 20 KHz
2	J4A pin 1	Negative going TTL level pulses, 20 KHz, pulse width 15 ns
3	U81 pin 5	Negative going TTL level pulses, 20 KHz, pulse width 12.8ns
4	U85 pin 25	Positive going ECL level pulses, 20 KHz, pulse width 100ns
5	U85 pin 26	Negative going ECL level pulses, 20 KHz, pulse width 12.8ns

D/A, Preamplifier & Amplitude Control Checks

If there are problems with the shape of the output waveforms or if the output waveforms are not generated at all, program the Model 3162B using the following remote commands:

Remote Commands: :RES
:FUNC:MODE USER
:OUTP ON
:INST:SEL B
:FUNC:MODE USER
:OUTP ON

Download 128-point square waveforms to both channels A and B and proceed with the checks given in Table 5-6.

Table 5-6 Engine Board Checkout – D/A, Preamplifier and Amplitude Control Checks

Step	Engine Board A Test Point	Expected Result

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1	U1 pins 13, 14, 17 and 18	78.125 kHz, 0 to – 1 V square waveform
2	U1 pins 38 and 39	+1 V dc
3	U5 pin 1	-1 V dc
4	U5 pin 7	Approximately +330 mV dc
5	U1 pins 2 and 3	10 MHz ECL level square waveform
6	U3 pin 6	78.125 kHz ±600 mV level square waveform
	Engine Board B Test Point	
7	U15 pins 13, 14, 17 and 18	78.125 kHz, 0 to – 1 V square waveform
8	U15 pins 38 and 39	+1 V dc
9	U17 pin 1	-1 V dc
10	U17 pin 7	Approximately +330 mV dc
11	U15 pins 2 and 3	10 MHz ECL level square waveform
12	U13 pin 6	78.125 kHz ±600 mV level square waveform

Sequence Generator Checks

Problems with the sequence generator circuits can be detected if the Model 3162B accepts word serial commands and responds correctly to word serial queries, but fails to output sequences or bursts. If there is a problem with the sequence generator circuits, proceed with the checks given in Table 5-7.

Before starting the following procedure, reset the Model 3162B to the factory default using the *RST command. Configure the Model 3162B to sequenced output mode and load three different waveforms, each 32 points long, to segments 1, 2, and 3, respectively. Program each step to repeat once. Use the following commands after loading the waveforms.

Remote Commands:
```
:FUNC:MODE SEQ
:SEQ:DEF 1,1,1
:SEQ:DEF 2,2,1
:SEQ:DEF 3,3,1
:OUTP ON
```

Table 5-7 Sequence Generator Checks

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Step	Test Point	Expected Result
1	J4 pin 6	Positive going TTL level pulses, 312.5 kHz, pulse width 800 ns
2	U81 pin 9	Negative going TTL level pulses, 312.5 kHz, pulse width 800 ns
3	U63, U73 pins 5 and 6	Positive going TTL level pulses, 104.2 kHz, pulse width 3.2µs

The next check is done on the Model 3162B configured to operate in sequence mode as before, however each segment has a different clock divider number. Use the following commands to configure the Model 3162B:

Remote Commands:
```
:FUNC:MODE SEQ
:SEQ:DEF 1,1,1
:SEQ:DEF 2,2,2
:SEQ:DEF 3,3,4
:OUTP ON
```

Proceed with the checks given in Table 5-8.

Table 5-8 Sequence Generator & Clock Divider Checks

Step	Test Point	Expected Result
1	U59 pin 24	Negative going ECL level pulses. Each sequence cycle is 22.4 µs. Three pulses in each cycle: 800 ns, 1.6 µs, and 3.2 µs
2	U78 pin 13, U87 pin 13	Positive going ECL level pulses. Each sequence cycle is comprised of 12 cycles. Cycle 1 through 4, period = 800 ns, pulse width 100 ns. Cycle 5 through 8, period = 1600 ns, pulse width 200 ns. Cycle 9 through 12, period = 3.2 µs, pulse width 400 ns
3	U95 pin 7	ECL level pulses, 3.2 µs low level, 32 each 5 MHz clocks (6.4 µs duration), and 32 each 2.5 MHz clocks (12.8 µs duration)

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Chapter 6

PRODUCT SUPPORT

Product Support

Racal Instruments has a complete Service and Parts Department. If you need technical assistance or should it be necessary to return your product for repair or calibration, call 1-800-722-3262 or 949-859-8999 and ask for Customer Support. You may also contact Customer Support via E-Mail at:

Helpdesk@racalate.com

If parts are required to repair the product at your facility, call 1-800-722-3262 or 1-949-859-8999 and ask for the Parts Department.

When sending your instrument in for repair, complete the form in the back of this manual

Reshipment Instructions

Use the original packing material when returning the 3162A/B to Racal Instruments for calibration or servicing. The original shipping carton and internal packing will provide the necessary support for safe reshipment.

If the original packing material is unavailable, wrap the switching module in ESD barrier material and use foam to surround and protect the instrument.

Re-ship in either the original or a new shipping carton.

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Support Offices

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4 Goodyear St., Irvine, CA 92618-2002
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Appendix A

SPECIFICATIONS

VXIbus General Information

Module Form	Single slot VXIbus C-size module
Connectors	P1, P2
Protocol	A16/A24/D16 Slave, Message-Based
VXIbus Revision	1.4
SCPI Revision	1993.0
Logical Address Settings	1 - 255, configured via DIP switches
Interrupt Level Settings	1 - 7, configured dynamically (no DIP switch)
Shared Memory	A32, D16, 1Meg

Sample Clock

Range:	Internal, from internal synthesizer, 100mHz to 500MHz

Internal Synthesizer Reference Sources:

Standard	≥0.0001% (1ppm) initial tolerance over a 19°C to 29°C temperature range; 1ppm/°C below 19°C and above 29°C; 1ppm/year aging rate
External	From Front Panel BNC, 10 MHz Nominal

Other Synthesizer Specifications

Range	100mHz to 500MHz,
Resolution	7 digits
Accuracy	Same as reference
Stability	Same as reference

Internal Synthesizer Agility

Frequency hopping

Operation	Permits the selection of sample clock (carrier sample clock) dividing ratio. Sample clock hops between 256 pre-determined steps
Hop Control Source	1) Front panel 9 pin D-Sub connector; 2) Front panel TRIG IN connector; 3) VXIbus TTLTrg0-3, ECLTrg0
Sample Clock Selection	D-Sub - binary combination of 8 lines determines the next division ratio; Trigger - determines the next division ratio.
Carrier Sample Clock	Range 100mHz to 300MHz
Ratio Between Carrier and Hop Frequencies	1 through 65536
Hop Table	256 hop frequencies
Hop Delay	Next frequency delayed until last cycle is completed + 100ns.

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FSK Modulation

Operation	Current segment is sampled continuously. External low level (below trigger level) programs carrier sample clock, external high level (above trigger level) programs shifted frequency. Sample clock changes coherently between frequencies.
Carrier Sample Clock Range	100mHz to 300MHz

FSK Source

External	Front panel BNC. Low level = carrier sample clock; High level = hop frequency
Frequency Range	From 10MHz to DC
VXIbus Frequency Range	From 10MHz to DC
Ratio Between Carrier and Hop Frequencies	1 through 65536
FSK Delay	Minimum 1 waveform cycle

Operating Modes

Normal	Continuous waveform is generated.
Triggered	Each input cycle generates a single output cycle.
Internal Trigger	An internal timer repeatedly generates a single output cycle.
Gated	External signal enables generator. First output cycle is synchronous with the active slope of the triggering signal. Last cycle of output waveform is always completed.
External Burst	Preset number of up to 1M cycles stimulated by an internal, external, or manual trigger. This mode is available in FIXed and USER modes only.
Internal Burst	An internal timer repeatedly generates a burst of up to 1M counted output cycles. This mode is available in FIXed and USER modes only.
Delayed Trigger	1 to 8 M clock cycles
Resolution	1 sample clock period
Accuracy	2 sample clock periods + system delay
Jitter	1 sample clock

Trigger Sources

Internal		Internal programmable rate generator
	Period	From 20 µs to 1000 s
	Accuracy	±(1% + 0.5 µs)
External		
	Input	1) Front panel BNC 2) VXIbus (TTLTRG 0-3) 3) VXIbus ECLTRG0
	Frequency	15 MHz to DC
	Software	IEEE 488.2 *TRG, VXI Word Serial trigger command

System Delay (trigger to waveform output)

Trigger Delay Mode Off	
Standard/Arbitrary Waveforms	1 Sample Clock + 150 ns
Trigger Delay Mode On	
Standard/Arbitrary Waveforms	2 Sample Clock + 150 ns

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Standard Waveforms

Frequency Range	Waveform dependent
Source	Internal synthesizer
Sine	
Frequency Range	100µHz to 200MHz, usable to 250MHz
Band Flatness	10%, to 100MHz; 30%, to 200MHz
Programmable Parameters	
Start Phase	0 to 360°
Triangle	
Frequency Range:	100µHz to 5MHz, usable to 50MHz
Adjustable Parameters	
Start Phase	0 to 360°
Square	
Frequency Range	100µHz to 200MHz, usable to 250MHz
Adjustable Parameters	
Duty Cycle	1% to 99%
Pulse/Ramp	
Frequency Range	100µHz to 5MHz, usable to 50MHz
Adjustable Parameters	
Delay	0% to 99.9% of period
Rise Time	0% to 99.9% of period
High Time	0% to 99.9% of period
Fall Time	0% to 99.9% of period
Sinc (Sine(x)/x)	
Frequency Range	100µHz to 5MHz, usable to 50MHz
Adjustable Parameters	
Cycles	4 to 100 cycles
Gaussian Pulse	
Frequency Range	100µHz to 5MHz, usable to 50MHz
Adjustable Parameters	
Time Constant	10 to 200
Exponential Decaying/Rising Pulse	
Frequency Range	100µHz to 5MHz, usable to 50MHz
Adjustable Parameters	
Time Constant	-100 to 100
Noise	
Frequency Range	100µHz to 5MHz, usable to 50MHz
DC	
Range	-100% to 100% of amplitude

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Arbitrary Waveforms

Waveform Memory	1Meg points
Memory Segmentation	
Number of Segments	1 to 4096
Min Segment Size	16 point
Vertical Resolution	12 bits (4096 points)
Sinewave Total Harmonic Distortion (at 4096 vertical points and sampling rate of 500 MHz)	0.5%

Harmonic Signals Below the Carrier Level (at 4096 vertical points)

>50 dBc to 100KHz
>40 dBc to 10 MHz
>25 dBc to 200 MHz

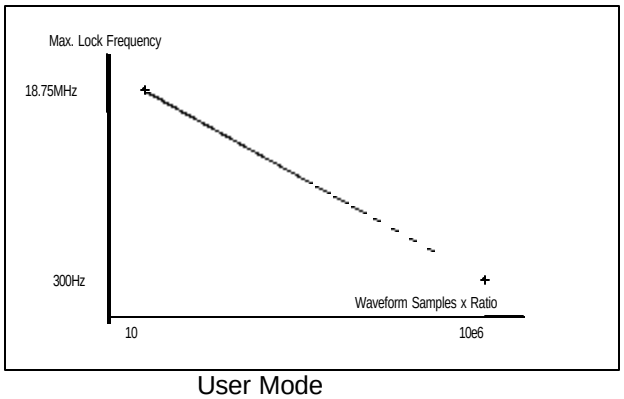
Sequenced Arbitrary Waveforms

Operation	Permits division of the memory bank into smaller segments. Segments may be linked, and repeated in user-selectable fashion to generate extremely long waveforms. Sample clock is selectable per segment. Sample clock changes coherently between steps.
Advance Modes	
Automatic Sequence Advance	No triggers required to step from one segment to the next. Sequence is repeated continuously per a pre-programmed sequence table.
Stepped Sequence Advance	Current segment is sampled continuously, external trigger advances to next programmed segment. Segment is switched with its attached sample clock. Control input is TRIG IN connector.
Single Sequence Advance	Current segment is sampled to the end of the segment and idles there. Next trigger advances to next segment. Control input is TRIG IN connector.
Advance Sources	
Internal	Internal programmable rate generator
External	
Input	1) Front panel BNC. 2) VXIbus TTLTRG 0-3 3) VXIbus ECLTRG0 4) Front panel D-Sub connector. User can control active segments in real time. Control input is 8-pin “D connector”. Binary combination of 8 lines determines the next active segment. Binary word at the connector controls the active segment.
Sequencer steps	From 1 to 4096
Segment loops	From 1 to 1M
Segment Duration	Minimum 100 ns for more than one loop.
Sampling Clock Switching	Sample Clock is selectable per segment.
Ratio Between Carrier and Switched Frequencies	1 through 65536
Sampling Clock Range	To 300 MHz, Switchable Clock

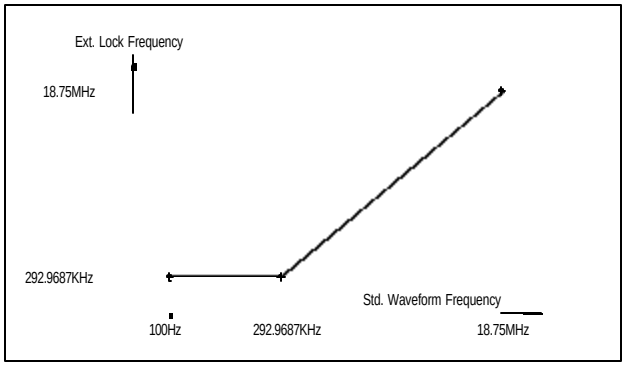
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Phase Lock

Phase lock Input	1) Front panel BNC. 2) VXIbus TTLTrg0-3. 3) VXIbus ECLTRG0.
Input Frequency Range	100Hz to 18.75MHz (with 16 point waveform)
Phase Offset	
Range	0 to 360°
Resolution	2880/n (n = number of points in waveform)
Programming	In degrees and in number of points
Mode	Automatic lock to external reference frequency and phase
Maximum Lock Frequency Range	See graphs below



User Mode



Fixed Mode

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Modulation

Amplitude Modulation (AM)

Modulation Input	Front panel BNC
Impedance	1 MΩ, ±5%
Max Input Voltage	±12 V
Sensitivity	0 V to -2 V (2 Vp-p) produce 100% modulation
	0 V to -4 V (4 Vp-p) produce 200% modulation
Source	External
Modulation Range	0 to 200%
Bandwidth	DC to 1MHz

Phase Modulation (PM)

Modulation Input	Front panel BNC
Impedance	1 MΩ, ±5%
Max Input Voltage	±12 V
Sensitivity	24°/V, typical
Accuracy	±10%

FSK Modulation

See description under Synthesizer Agility above.

Outputs

Main Output

Connector	Front panel BNC
Stand-by	Output Off or Normal
Impedance	50Ω, ±1%
Protection	Protected against short to case ground
Glitch Energy	100 pV-s at 5 Vp-p
Amplitude	
Range	10 mV to 5 Vp-p, into 50Ω
Resolution	3.5 digits
Accuracy (1 KHz)	±(1% + 25 mV), 1.000 V to 5 Vp-p
	±(1% + 5 mV), 100 mV to 999.9 mVp-p
	±(1% + 2 mV), 10 mV to 99.99 mVp-p
Offset	
Range	0 to ±2.495 V
Resolution	5 mV
Accuracy	±(2%+10 mV)
Filters	150 MHz 7-pole elliptic
Square Wave, Pulse	
Rise/Fall time	<2.5 ns, 10% to 90% of amplitude
Aberration	<5% + 10 mV

SYNC Output

Connector	Front panel BNC
Impedance	50Ω, ±10%
Level	> 2 V into 50Ω, 5V nominal into 10KΩ
Protection	Protected against temporary short to case ground
Validations	BIT, LCOM, SSYN

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Inputs

TRIG/FSK/PLL Input

Connector	Front panel BNC
Impedance	10 KΩ, ±5%
Threshold Range	Programmable from -10 V to +10 V
Threshold Resolution	50 mV
Sensitivity	0.2 Vp-p
Max Input Voltage	±12 V dc
Min Pulse Width	20 ns
Slope	Positive or negative going edge

External Reference Input

Connector	Front panel BNC
Impedance	10 KΩ, ±5%
Threshold	TTL
Min Pulse Width	20 ns

General

Front Panel Indicator LED's

Fail	Red - Power-up selftest failure
Access	Amber - Module addressed on VXIbus
PLL Lock	Amber - Module locked to external source
Output On	Green - Output on / off

Power Requirements 3162A

VXIbus Rail	Peak Current (I PM)	Dynamic Current (I DM)
+24 V	<100 mA	<25 mA
+12 V	<0.5 A	<0.25 A
+5 V	<4 A	<1 A
-5.2 V	<6 A	<2 A
-2 V	<1 A	<0.25 A
-12V	<0.5 A	<0.25 A
-24V	<100 mA	<25 mA

Maximum Total Module Power < 70 W

Power Requirements 3162B

VXIbus Rail	Peak Current (I PM)	Dynamic Current (I DM)
+24 V	<150 mA	<25 mA
+12 V	<1 A	<0.25 A
+5 V	<6 A	<1 A
-5.2 V	<11 A	<2 A
-2 V	<2 A	<0.25 A
-12V	<1 A	<0.25 A
-24V	<150 mA	<25 mA

Maximum Total Module Power <123 W

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EMC

Radiated Emissions (Close Field)	VXIbus B.8.6.3 (Rev 1.4, Page 85)
Radiated Susceptibility	VXIbus B.8.6.4 (Rev 1.4, Page 94)
Conducted Emissions	VXIbus B.8.7.3 (Rev 1.4, Page 94)
Conducted Susceptibility	VXIbus B.8.7.4 (Rev 1.4, Page 95)

Certification — CE marked for safety and EMC

Mechanical

3162A

Dimensions	"C" size, single-slot case
Weight	3 lbs. 8 oz. (1.6 kg)
Airflow (for 10°C rise)	5.6 l/s
Pressure (for 10°C rise)	0.54 mm H_20

3162B

Dimensions	"C" size, dual-slot case
Weight	4.8 lbs. (2.2 kg)
Airflow (for 10°C rise)	4.9 l/s
Pressure (for 10°C rise)	0.14 mm H_20

Environmental

Operating temperature	0 °C - 50 °C
Humidity (non-condensing)	11 °C - 30 °C 95% +5%
	31 °C - 40 °C 75% +5%
	41 °C - 50 °C 45% +5%
Altitude	
Operating	10000 ft
Storage	15000ft
Vibration	5 - 55 Hz sine (2g at 55 Hz), non-operating
Shock	30g 11 ms half-sine pulse, non-operating
Bench Handling	4", any face, wooden surface, non-operating

Reliability — MTBF per MIL-HDBK-217E, 25 °C, Ground Benign

Safety — Designed to meet IEC 1010-1, UL 3111-1, CSA 22.2 #1010

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