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# RACAL INSTRUMENTS™

# 3161
# 300 Ms/S WAVEFORM SYNTHESIZER

**Publication No. 980811 Rev. A**

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

2. 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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# EC Declaration of Conformity

We

Astronics Test Systems
4 Goodyear St
Irvine, CA 92718

declare under sole responsibility that the

**3161 300SM/S Frequency Agile Waveform Synthesizer**
**P/N 407606-001, -002, -011, -012, -013**

They conform to the following Product Specifications:

**Safety:** EN61010-1:1993+A2:1995

**EMC:** EN61326:1997+A1:1998

**Supplementary Information:**

The above specifications are met when the product is installed in an Astronics Test Systems certified mainframe with faceplates installed over all unused slots, as applicable

The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC (modified by 93/68/EEC).

Irvine, CA, May 15, 2002 Karen L. Quinn
Engineering Director

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# Chapter 1

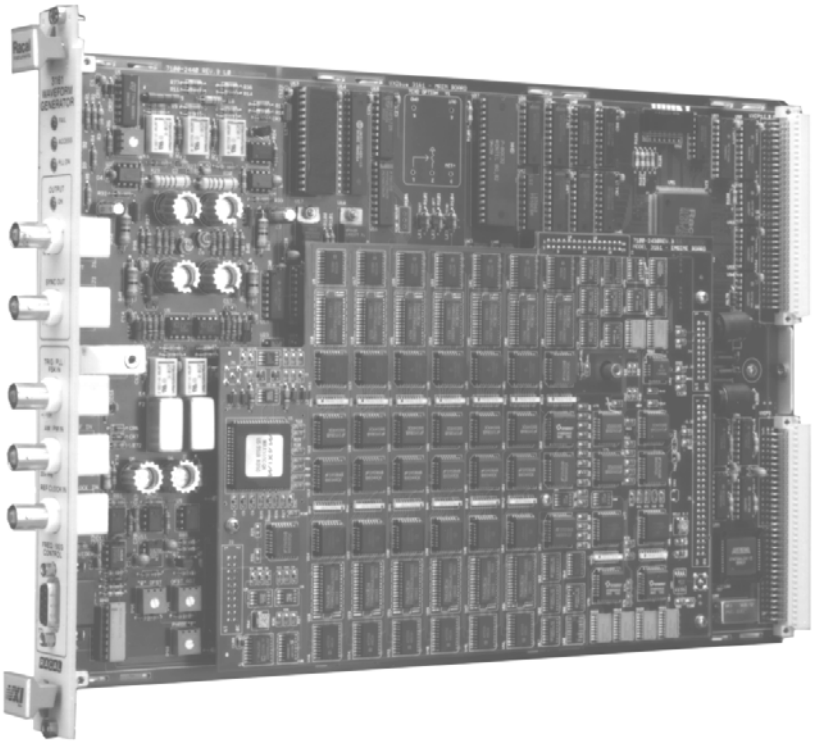
# GETTING STARTED

## What's In This Chapter

This chapter contains a general description of the VXIbus 3161 Waveform Generator and an overall functional description of the instrument. It lists and describes various options available for the 3161. It also describes the 3161 front panel connectors and indicators.

This manual provides a complete description of all features and options available with the 3161; however, some options described in the following paragraphs may not be installed in your instrument at the time of shipment.

**Figure 1-1, 3161**





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# Introduction

A detailed functional description is given following the general description of the features, functions, and options available with the 3161.

The 3161 is a VXIbus, single slot C-size synthesized Waveform Generator. It is a high performance waveform generator that combines two powerful instruments in one small package: a function generator and an arbitrary waveform generator. The instrument provides a variety of standard waveforms to be used as test stimuli for different electronic devices. The 3161 is also capable of generating arbitrary waveforms with sampling rates to 300 MHz at 12 bits of vertical resolution.

Despite its small size, the 3161 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 3161 generates standard waveforms at frequencies ranging from 100μHz to 150MHz. The instrument can also generate arbitrary waveforms with clock rates ranging from 100MHz to 300MHz. 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 a standard, CLK10 is used for the reference clock. The accuracy and stability of CLK10 is 100 ppm. An optional internal TCXO circuit provides 1ppm accuracy and stability. When the optional TCXO is installed, the output frequency can be controlled to a full seven digits of accuracy.

The output amplitude may be programmed in 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 Phase-Locked Loop (PLL) function, the 3161 can be phase locked to an external reference. An internal frequency counter detects the frequency of the external signal and adjusts the 3161 to its optimal lock-in range. After the 3161 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 3161 offers a variety of triggered modes. The output waveform may be gated, triggered, or may generate a counted burst of waveforms. The 3161's built-in trigger generator with a programmable period can replace an external trigger.



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The 3161 generates arbitrary waveforms with 12 bits of resolution. There are ten standard waveforms, which are memory-resident. Arbitrary waveforms may be generated either manually or by downloading them from the controller to the instrument using shared memory or standard data bus transfer. Waveforms may also be generated using the WaveCAD program.

The 3161 waveform generator is a digital instrument. With the exception of its standard waveforms, any waveform it generates must first be downloaded to waveform memory. The arbitrary waveform memory is a bank of 12-bit words. Each word represents a point on the waveform. Each word has a horizontal address that can range from 0 to 262120 (optionally 1048552 or 4194280) 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. 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 (repeat) up to 1 million times.

The 3161 is fully programmable using SCPI commands and syntax. There are four ways to program the 3161, 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 3161 as though it were a bench-top instrument. The third way to program the 3161 is by using either the LabVIEW or LabWindows/CVI driver. The fourth way to program the 3161 is via the WaveCAD program. The 3161 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.



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## Options

A number of options are offered for the 3161. Compare the option number with the number that is printed on the instrument to verify which of the options are installed in your instrument. Note that all 3161 options are installed in the factory. Contact your nearest Astronics representative if the number printed on the case does not reflect the correct version ordered. The list of available 3161 options is given below:

- 407606-001 - 3161, 300MS/s Waveform Generator, w/256k RAM
- 407606-002 - 3161, 300MS/s Waveform Generator, w/1Meg RAM
- 407606-003 –3161, 300MS/s Waveform Generator, w/4Meg RAM
- 407606-011 - 3161, 300MS/s Waveform Generator, w/256k RAM, 1PPM
- 407606-012 - 3161, 300MS/s Waveform Generator, w/1Meg RAM, 1PPM
- 407606-013 –3161, 300MS/s Waveform Generator, w/4Meg RAM, 1PPM

The 256k RAM option designates the memory size supplied with the standard 3161. The standard memory size is 256k (262,144 words). With the standard memory size, 261,120 point waveforms can be programmed because 1k is allocated for standard waveforms.

The 1Meg RAM option designates instruments supplied with the 1Meg memory expansion. With the 1Meg expansion, 1046552 point waveforms can be programmed. The 4Meg RAM option designates instruments with 4193280 points of waveform memory.

1ppm denotes the accuracy and stability grade of the internal 10MHz reference clock. Normally, VXI modules receive their clock reference from VXIbus CLK10. There are applications that require complete separation from VXI clocks or improved accuracy. The (1ppm) TCXO option, when installed, provides the required separation and 1ppm of accuracy.



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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 3161 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.

## Supplied Accessories

The 3161 is supplied with an Instruction Manual. The manual includes VXI*plug&play* install disks along with a WaveCAD disk. 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, front panel indicators and programming.



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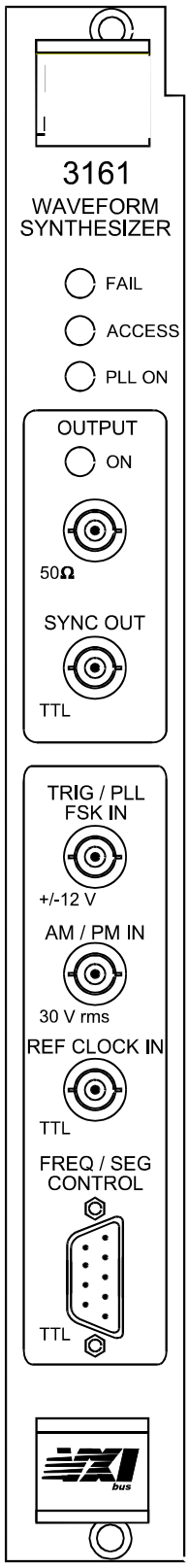



**Figure 1-2, The Front Panel**



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## Input and Output Connectors

The 3161 has 5 BNC connectors on its front panel: main output, SYNC output, TRIG/PLL/FSK input, AM/PM input, and reference clock input. It also has a 9-pin D-sub connector for frequency hop and output segment control.

## Main Output

The main output 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 double the programmed amplitude when the output impedance is above 1MΩ.

## 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 3161 to output waveforms. The trigger input is inactive when the instrument is in continuous operating mode. When placed in triggered, 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 3161. 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 3161 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 output is enabled when the logic level is high and idle when it is low.



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### AM/PM Input

The AM input accepts signals that amplitude-modulate the main output signal. The PM Input accepts signals that phase-modulate the main output frequency. The phase modulation function operates only when the PLL function is active and locked. The AM/PM input becomes active when one of these functions is selected.

### Reference Clock Input

The external reference clock input accepts a 10MHz, TTL level signal to replace the CLK10 reference. The external 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 is connected to ground. The binary combination of pins 1 through 8 may be used to control 256 different frequency divider ratios, 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

There are four operating modes that the 3161 can be programmed to operate in: continuous mode, triggered mode, gated mode and burst mode. These operating modes are described below.

### Continuous Mode

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

### Triggered Mode

In triggered mode, the 3161 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 the waveform and remains idle at the last point of the waveform. The 3161 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 circuits. These circuits cause a small delay known as system delay. System delay cannot be eliminated completely. It is, however, minimized in the 3161 to approximately 100ns 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.



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While system delay cannot be controlled, the 3161 offers a controllable trigger delay parameter. When utilized, delay from a trigger signal to output waveform may be programmed from 0 clocks to 8 Million clocks. This delay is in addition to the system delay.

## Burst Mode

Burst mode is an extension of triggered mode where the 3161 can be armed to output a counted number of waveforms following a trigger signal. Like with triggered mode, a burst can be triggered from a front panel BNC connector, a VXI backplane TTLTRG<n>, ECLTRG0 or from an internal, programmable trigger generator.

## Gated Mode

In gated mode, the 3161 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 3161 can output three types of waveforms: standard waveforms, arbitrary waveforms and sequenced waveforms. The three types of waveforms are described in the following paragraphs.

## Standard Waveforms

The 3161 generates waveforms from memory, which must be loaded before the instrument can generate them. There are 256k points of memory standard; 1Meg or 4Meg points are available as an option. 1k 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 3161 can be programmed to output ten different standard waveforms: sine wave, triangular wave, square wave, pulse, ramp, sinc (sine(x)/x), pulse, gaussian pulse, exponential pulse, noise, and DC.



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## Arbitrary Waveforms

The arbitrary waveform memory is capable of storing one or more user waveforms. There are 261120 points (1047552 or 4194280 optional) that can be allocated to one waveform that has this length. If there is no need to use the complete memory, it can be divided into smaller segments which are variable in size. Each segment can then be loaded with a different waveform and the 3161 can be programmed to output the required waveform for a specific test.

Loading data to arbitrary waveform memory can be a time-consuming task, especially if the complete 1Meg or 4Meg is loaded in one shot. The 3161 utilizes the VXIbus shared memory concept that speeds data transfer to and from the host computer. In this mode, the memory bank is disconnected from the local circuit and its bus is accessible from the VXIbus by the host computer.

## Sequenced Waveforms

The 3161 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 that one cycle of the waveforms in Figures 1-3 through 1-5 were placed in segments 1 through 3.



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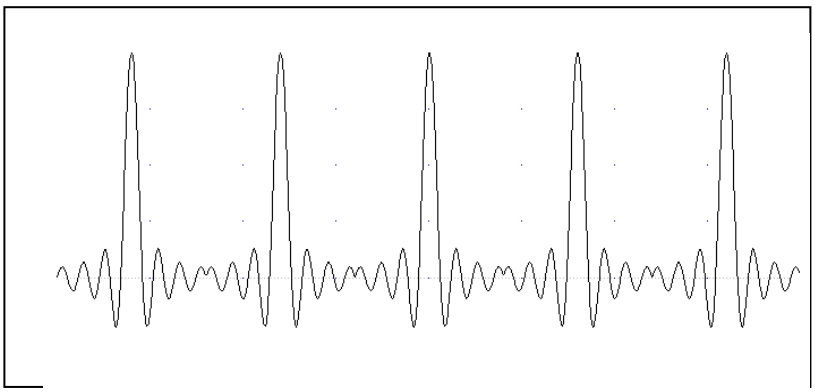


**Figure 1-3, Segment 1 – Sin (x)/x Waveform**

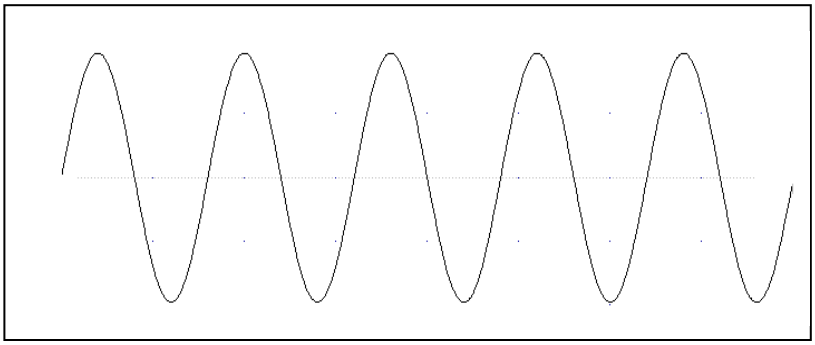


**Figure 1-4, Segment 2 – Sine Waveform**

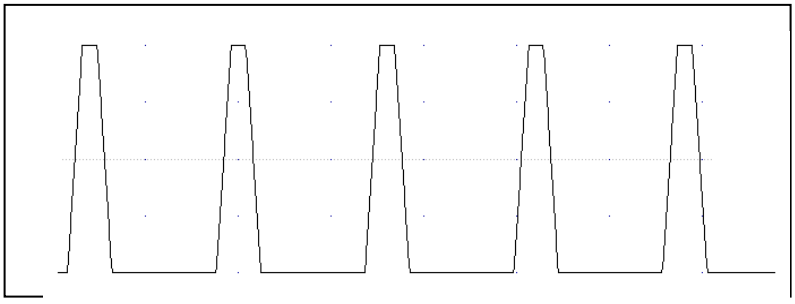


**Figure 1-5, Segment 3 – Pulse Waveform**



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

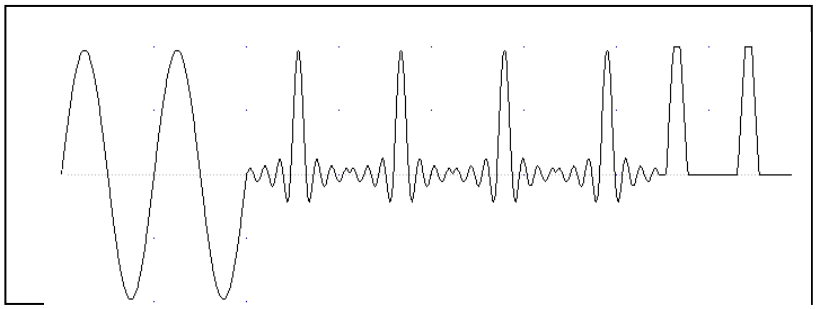


**Figure 1-6, Sequenced Waveforms**

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



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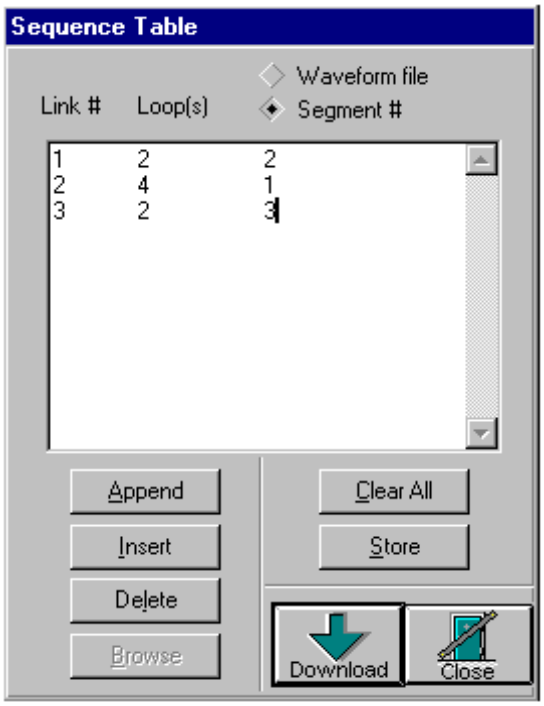



**Figure 1-7, WaveCAD Example**

## Synthesizer Agility

The 3161 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 3161 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 ratios range 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.



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## Output State

The main output can be turned on or off. The internal circuit is disconnected from the output BNC connector by a mechanical relay. This feature is useful for connecting the 3161 main output, along with other instruments, to an analog bus. For safety reasons, after power on, the main output is always off.

## Amplitude Modulation

The 3161 may be amplitude modulated by 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 can range from DC to over 1MHz.

## Front-Panel / VXIbus PLL

Multiple 3161□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. The slave modules may be configured to have phase offsets from 0° to +360°.

The reference signal is applied to the front-panel input BNC. In 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 is applied to the TRIG IN and, like the trigger input, has a programmable trigger level and slope. When placed in this mode, the 3161 scans the TRIG IN connector for a valid signal. Once sensed, the 3161 measures the signal's frequency and centers its lock-in range on this frequency. The 3161 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.

The reference source for the PLL input can also be placed onto the VXIbus backplane by one of the modules.

## Frequency Counter

The 3161 uses an auto ranging counter circuit to measure frequencies of reference signals at the trigger input. This built-in counter is made available for you in PLL mode. Thus, you can use the 3161 as a precision frequency counter, as long as the signal at the trigger input is valid and the PLL ON LED is illuminated. Frequencies are measured from 500Hz to 18.75MHz. External frequency queries return six digits with a decimal point and suffix multiplier.



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## Phase Modulation

When the 3161 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, permitting phase offset adjustments with 0.01° increments. The PM IN provides another option for changing phase offsets. Applying voltage to this input changes the start phase of the generator continuously, depending on the voltage level at the phase modulation input. The applied frequency range is from DC to 10kHz. The output frequency depends on the lock frequency and the number of waveform samples.

## Filters

Two filters are built into the 3161, each having a different cutoff frequency. These filters are available for use in various applications like the creation of high frequency sine waves. The elliptical 70MHz and 150MHz filters have very sharp cutoff frequencies. They are useful for removing the staircase effect from waveforms that are generated with high frequency clock rates.

## Front Panel Indicators

There are four LED's on the front panel. The red FAIL LED illuminates at power-up until the 3161 has passed self-test. If the 3161 self-test fails, the FAIL LED remains illuminated. The FAIL LED may illuminate during normal operation if the 3161 stops communication.

The amber ACCESS LED illuminates each time a command is received by the 3161. This light also remains on during shared memory data transfer.

The amber PLL ON LED is off during normal operation. In PLL mode, the PLL ON LED illuminates when a valid signal is available at the trigger input and the main output is locked.

When the output relay is closed, the green OUTPUT LED illuminates. It goes off when the output relay opens.



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## Programming The 3161

The 3161 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 appropriate software be installed in the Resource Manager (slot 0). The rest is a matter of practice and knowledge of the language or drivers in use. There are other system considerations like address selection that must be dealt with before programming the instrument. These are discussed in later chapters.

Low level programming of the 3161 is done using SCPI (Standard Commands for Programmable Instruments) language. Programming aspects are covered in Chapters 3 and 4.

High level software for LabVIEW, LabWindows/CVI, and operation of WaveCAD are beyond the scope of this manual. Contact your Astronics representative for more information about high level software for the 3161.



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# Chapter 2

# CONFIGURING THE INSTRUMENT

## Installation Overview

This chapter contains information and instructions necessary to prepare the 3161 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 60VDC are present.



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***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 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" 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 3161 and your equipment.**



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## Long Term Storage or Repackaging For Shipment

1. 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 Astronics Test Systems Representative or the Astronics Test Systems Customer Service Department.

2. 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.

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

4. Mark the carton with 3161 and the 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 Astronics Test Systems for calibration or repair, attach a tag to the instrument identifying the owner. Note the problem, symptoms, and service or repair desired, using the attached Repair and Calibration Request Form. 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 CUSTOMER SUPPORT BEFORE SHIPPING THE INSTRUMENT TO ASTRONICS TEST SYSTEMS.**

## Preparation For Use

Preparation for use includes removing the 3161 from the container box, 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 their addresses. 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's logical address.

To change the 3161□s 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 3161 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. Astronics Test Systems ships the 3161 with logical address 2.



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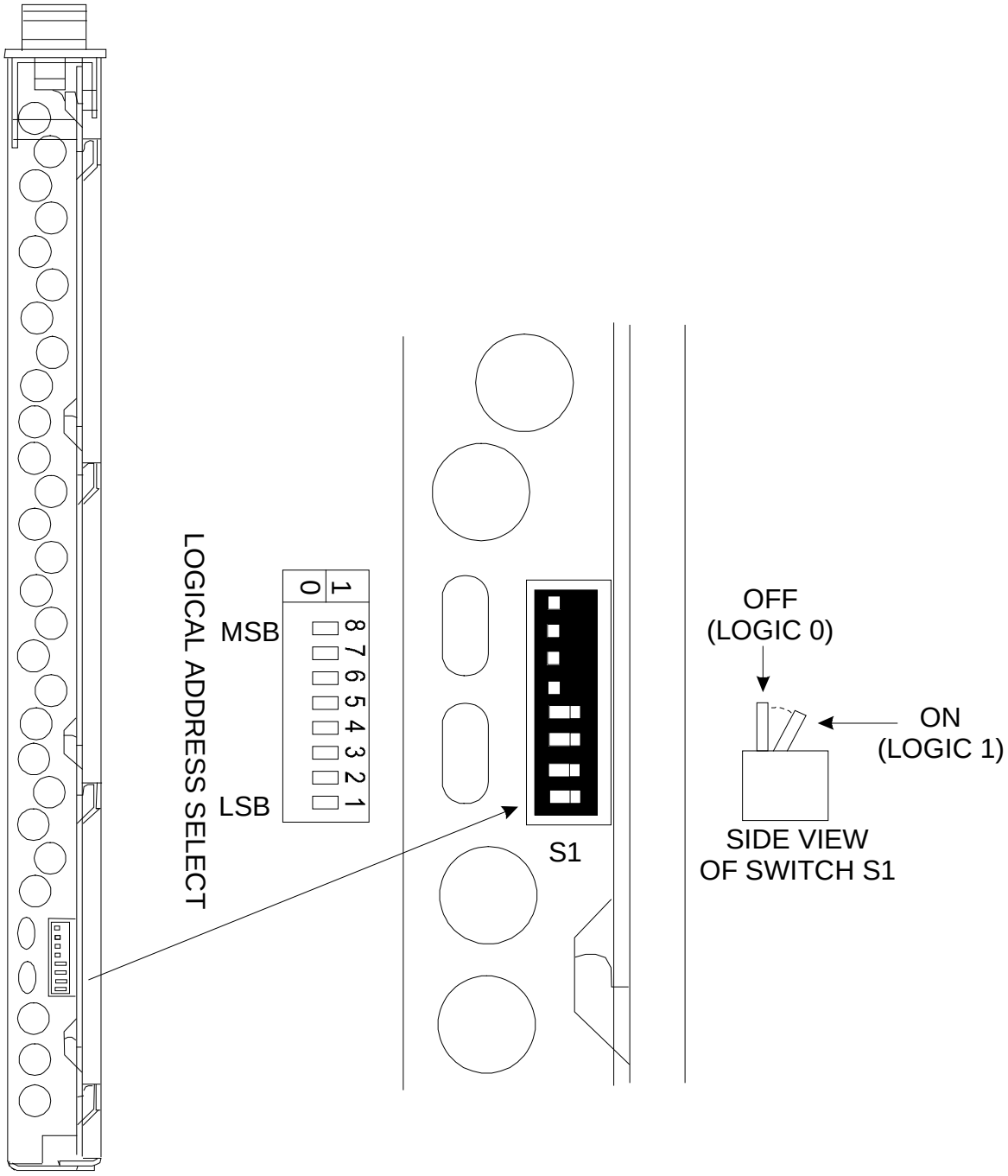



**Figure 2-1, Set Logical Address**



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## 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 the two captive screws 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 3161. Unlike bench-type instruments, the 3161 must be programmed to enable and change parameters and to configure various operating modes. The instrument is programmed using a set of SCPI commands. A list of SCPI commands for the 3161 is given in Table 4-1. The following paragraphs describe the various modes of operation and give examples of how to program the 3161.

## Output Termination

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

## Input/Output Protection

The 3161 provides protection for internal circuitry connected to input and output connectors. Refer to the specifications in Appendix A to determine 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 3161 defaults to the conditions shown in Table 3-1. A complete list of all parameters and their default 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 has the same effect.



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

| | | | |
|---|---|---|---|
| Output State: | Off | Operating Mode: | Continuous |
| SYNC State: | Off | SYNC Out Position: | Wave Start |
| Output Function: | Standard | Output Function Shape: | Sine |
| Standard Wave Frequency: | 1MHz | User Wave Sample Clock: | 1MHz |
| Amplitude: | 5V | Offset: | 0V |
| Filter State: | Off | Filter Type: | Auto |
| ECLTRG0: | Off | TTLTRG0-3: | Off |
| Trigger Slope: | Positive | Internal Trigger Period: | 100 μs |
| PLL State: | Off | AM State: | Off |
| Shared Memory State: | Off | Shared Memory Mode: | Write |

## What To Do Now

When using SCPI commands to operate the 3161, follow the instructions in this chapter to understand the meaning of each command and the response that each command generates. Examples in the following paragraphs show the basics of how to program waveforms.

**Example 1:** Program the 3161 to turn the main output on, generate a square waveform, program the frequency to 20MHz, program the amplitude to 2V and the offset to 0.5V.

/* Reset the 3161 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 since the default value after RESet is FIXed.*/

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

/* Change the frequency to 20MHz.*/

```
:FREQuency 20e6;
```

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

```
:VOLTage 2;
:VOLTage: OFFSet 0.5;
```



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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:

$$| \text{offset} | + \text{Vp-p} \div 2 \leq 5$$

/* 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 appear on your oscilloscope.

## 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 selected function. For example, the following statement outputs a 2Vp-p square wave at 1MHz 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, then you can omit the other parameters while keeping the commas. The other parameters will be set to the power-up default values:

```
APPL:SQU 10E6,,1
```

Alternatively, if only 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 then you can query the square wave parameters using the following query:



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APPL:SQU?

The generator returns a string that contains all parameters associated with the square function , for example:

"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: 1MHz, 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, 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



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default settings 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 percentage of programmed amplitude (i.e., with the VOLTage command). 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 the segment number, sampling clock rate, amplitude and offset. The default settings for these parameters are: 1, 1MHz, 2Vp-p and 0V.

The query:

APPLy:<function_shape>?



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queries parameters associated with the specified function shape.

The query:

APPLy?

queries parameters associated with the currently selected function shape. A string of values representing the parameters for the selected function shape is returned. 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:** Program the 3161 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 3161 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 appear on your oscilloscope.



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## 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 a high-level implementation of output control.

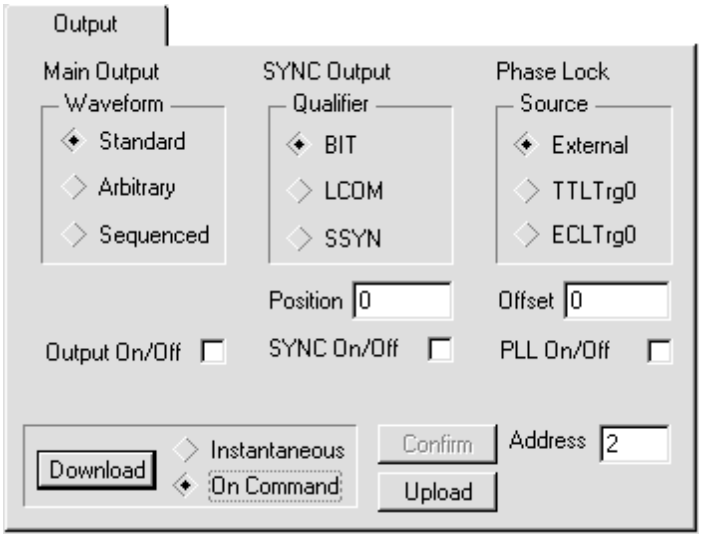



**Figure 3-1, Output Control with a WaveCAD Panel**

## 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 was 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.

**Example 1:** Program the 3161 to output a 100MHz sine wave.

```
*RST
:FUNC:MODE FIX
:FREQ 1000^6
:FUNC:SHAP SIN
:OUTP ON
```

**Example 2:** Program the 3161 to output the highest frequency triangle wave possible.

```
*RST
:FUNC:MODE FIX
:FREQ MAX
:FUNC:SHAP TRI
:OUTP ON
```

**Example 3:** Query the shape and waveform from example 2.

```
:FUNC:SHAP?
 Response: TRI

:FREQ?
Response: 1.875e7
```

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



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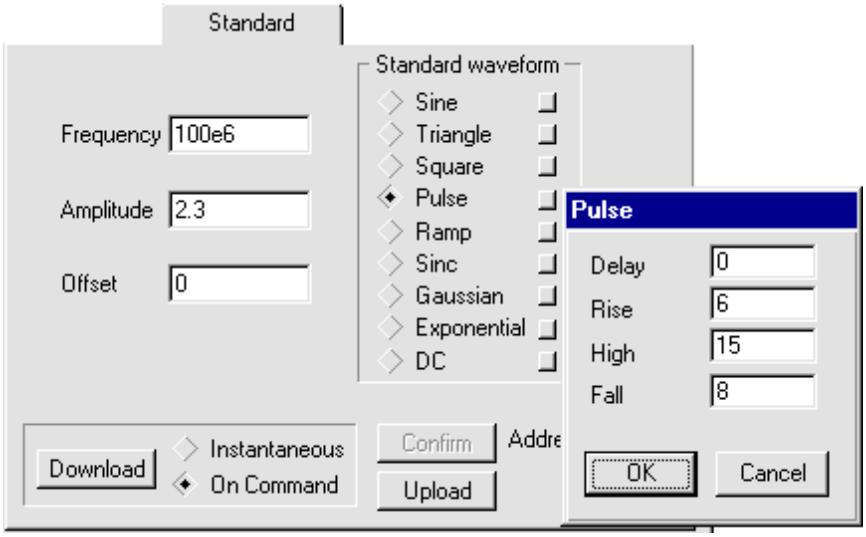



**Figure 3-2, Standard Waveform Selection Panel from WaveCAD**

## 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 1MHz for all function shapes.

**Example 1:** Program the 3161 to output a 5MHz ramp.

```
*RST
:FUNC:MODE FIX
:FREQ:5MHz
:FUNC:SHAP RAMP
:OUTP ON
```

**Example 2:** Query the ramp's frequency.

```
:FREQ?
Response: 5e6
```

The query:

FREQuency?

queries the frequency setting for the currently active built-in waveform and returns a value in Hertz.



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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 1MHz 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 3161 into frequency shift keying (FSK) mode. HOP selects frequency hopping mode, where the generator can hop between frequencies pre-programmed in the hop table.

The query:

FREQuency:MODE?

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



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## FSK Mode

In FSK mode, the generator outputs the pre-selected waveform as the carrier. Setting the FSK control line to true modifies the output frequency to a “shifted” frequency determined by a pre-programmed FSK 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 an FSK control source:

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

EXT selects the front panel TRIG IN connector as the FSK controlling source. First program the trigger level and slope of the trigger input and then apply the control signal. Information on how to program the trigger level is given later in this chapter (Page 3-28).

When a positive trigger slope is selected as 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 1.6V. This is convenient for TTL level control. You may want to change the trigger level setting if your signal is not TTL.

TTLT<n> or ECLT0 select the VXIbus backplane as the 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 frequency (or sample clock setting) which is determined by the HOP table and HOP control lines. The 3161 hops to frequencies defined in 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.

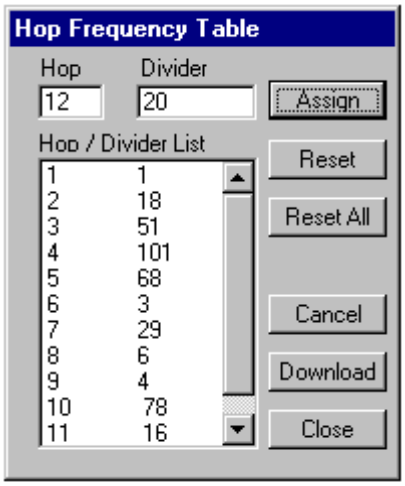



**Figure 3-3, WaveCAD Hop Table**



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If a trigger line is used as the hop advance source, the sequence will repeat itself continuously. By selecting the D-Sub connector as the hop advance source, an arbitrary 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:

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.

The front-panel D-Sub connector is selected as the hop advance source when the DSUB option is selected. This connector has 9 pins, one of which (pin 9) is connected to ground. The other 8 pins are used as 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 Hop Table entry number 3.

Table 3-2, DSUB (Digital Pattern Input) Pinout

| Pin | Description |
|---|---|
| 1 | Bit 0 (LSB) |
| 2 | Bit 1 |
| 3 | Bit 2 |
| 4 | Bit 3 |
| 5 | Bit 4 |
| 6 | Bit 5 |
| 7 | Bit 6 |
| 8 | Bit 7 (MSB) |
| 9 | Ground |



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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}

If the TCXO option is not installed, the default reference oscillator is always set to CLK10. If you have the TCXO installed in your instrument, the default reference oscillator is switched to TCXO. EXT selects the front panel reference input as the reference oscillator. The frequency of the reference oscillator is always 10MHz. However, since CLK10 is accurate to 100 ppm only, the accuracy and stability of the 3161 may be improved by installing the TCXO (1 ppm) option or by applying an external reference to the front panel input.

The query:

ROSCillator:SOURce? {CLK10 | EXTernal | TCXO}

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



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## 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 Frequency

Before selecting the filter cutoff frequency type, use the following command to activate the filter:

OUTPut:FILTer { OFF | ON}

ON enables the filter selected by the OUTP:FILT:FREQ command. The default filter state setting is OFF.



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***Note***

**The default output function of the generator is the sine waveform. Since the instrument uses the filters to generate this waveform, the state of the OUTP:FILT:FREQ 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.**

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

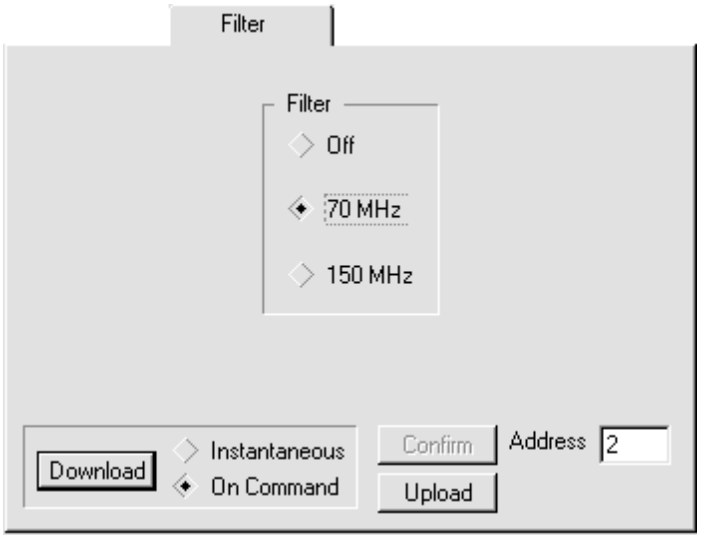



**Figure 3-4, WaveCAD FilterControl Panel**

The query:

OUTPut:FILTer?

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

The command:

OUTPut:FILTer:FREQuency {70MHz | 150MHz}

sets the filter frequency for the currently active function. The two filters have elliptical responses. The filters become active only after the OUTP:FILT ON command has been executed. The default filter setting is 70MHz. Also note that 70MHz and 150MHz designate fixed



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filter frequencies. These parameters must be programmed as selections, not as values. The filter type **cannot** be programmed using OUTP:FILT:FREQ 70e6 or OUTP:FILT:FREQ 150e6 Hz.

The query:

OUTPut:FILTer:FREQuency?

queries the currently selected filter setting and returns either 70MHz or 150MHz.

## Activating the Backplane ECLTRG and TTLTRG Lines

The 3161 can transmit and receive signals on VXIbus ECLTRG line zero and TTLTRG lines zero through three.

Use the following command to activate the ECLTRG line:

OUTPut:ECLTrg0 { OFF | ON}

ON enables ECL trigger line zero. The trigger source for this line is selected using 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.

The query:

OUTPut:ECLTrg0?

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

The TTLTRG lines zero through three can be used to transmit and receive trigger signals between the 3161 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).



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**Example 1:** Enable TTL trigger line 1

:OUTP:TTLT1 ON

**Example 2**: Query the state of ECL trigger line Zero

:OUTP:ECLT0?
Response: 1 for ON, 0 for OFF

**Example 3**: Disable TTL trigger line 3

:OUTP:TTLT3 0

## 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 3161 output state is programmed to ON.

The query:

OUTPut?

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

**Example 1**: Turn the 3161's output on

:OUTP ON

**Example 2**: Turn the 3161's output off

:OUTP OFF

**Example 3**: Query the 3161's output state

:OUTP?
Response: 1 for ON, 0 for OFF



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## 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 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 a 0 (OFF) or 1 (ON).

**Example 1:** Enable the Sync Output

:OUTP:SYNC ON

**Example 2:** Disable the Sync Output

:OUTP:SYNC OFF

**Example 3:** Query the Sync Output state

:OUTP:SYNC?

Response: 0 for OFF, 1 for ON



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## 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 selected 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 is programmed using the TRAC:SEL command. The sync position along the selected waveform is programmed using the OUTPUT:SYNC:POS command. The LCOM signal is recommended for use in Sequenced mode.

**SSYNc** Generates a sync signal at intervals 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.

**Example 1**: Set the Sync Outputs validation source to a point in a USER waveform

```
:FUNC:MODE USER
// Download a waveform
:OUTP:SYNC:SOUR BIT
```

**Example 2:** Set the Sync Output's validation source to a pre-selected point in a waveform stored in segment 4 of a sequence.

```
:FUNC:MODE SEQ
//Download the sequence
:TRAC:SEL 4
:OUTP:SYNC:SOUR LCOM
```



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**Example 3**: Use the SSYNC in the 3161's triggered mode (causing an external trigger)

```
:INIT:CONT OFF
:TRIG:SOUR:ADV EXT
:OUTP:SYNC:SOUR SSYN
```

**Example 4**: Query the 3161's SYNC source (after running example 3)

```
:OUTP:SYNC:SOUR?
:Response: SSYN
```

## Selecting the SYNC Position

The SYNC output and TTL and ECL trigger lines 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:

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.

**Example 1**: Set the SYNC output to output a pulse synchronized with the 14th point of a 32 point user-defined waveform.

```
:FUNC:MODE USER
:TRAC:DEF 1,32; SEL 1
//Download the user-defined waveform
:OUTP:SYNC 1; SOUR BIT; POS 14
```

**Example 2**: Query the SYNC position for example 1

```
:TRAC:SEL 1
:OUTP:SYNC:POS?
Response: 14
```



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## 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.

The number of points used to generate standard waveforms at various frequencies is computed as follows:

Frequency ≤ 292.9687 kHz, Points = 1024
Frequency > 292.9687 kHz, Points = N

where $N = 8 \cdot 2^{INT\left\{\log_2\left[\frac{INT\left(\frac{300}{FREQ}\right)}{8}\right]\right\}}$

**Example 1**: How many points are used in a 100kHz triangle wave?

$$N = 8 \cdot 2^{INT\left\{\log_2\left[\frac{INT\left(\frac{300}{.1}\right)}{8}\right]\right\}}$$

$$N = 8 \cdot 2^{INT\left\{\log_2\left(\frac{3000}{8}\right)\right\}}$$

$$N = 8 \cdot 2^{INT\left\{\log_2\left(375\right)\right\}}$$

$$N = 8 \cdot 2^{INT\left(8.55\right)}$$

$$N = 8 \cdot 2^{8}$$

$$N = 8 \cdot 256 = 2048$$



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

For the positive EXPonential:

$$F(m) = -\frac{A}{2} + \frac{A}{2}\left[e^{\frac{m}{7.71}} - 1\right]$$

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

For the negative EXPonential:

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

For the GAUSsian:

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

For the SINC:

$$F(m) = \frac{\mathrm{Sin}\,(2\pi \cdot \frac{m}{R})A}{2\pi \cdot \frac{m}{R}}$$

where

R = N/cyc (number of points per cycle)
cyc = Number of cycles of SINC

Standard waveforms are available at the output connector only after the FUNC:MODE FIX command has been executed. Note that changes made to parameters of a specific standard waveform do not have any effect on others.



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The command:

PULSe:DELay <value>

sets the pulse delay in percent 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 in percent 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.

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 in percent 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 in percent 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.



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The query:

PULSe:TRANsition:TRAiling?

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

## Selecting an Operating Mode

The 3161 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 3161 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.

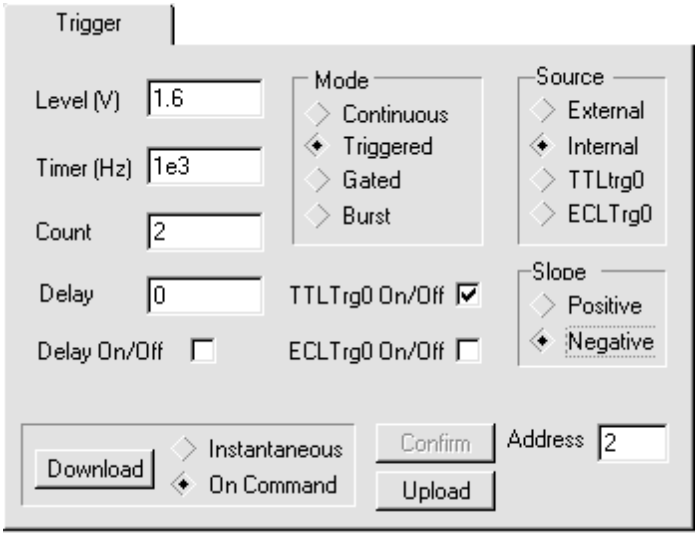



**Figure 3-5, WaveCAD Control Panel for Trigger Mode**

## 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 3161 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



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specification section of this manual (Appendix A). Note that the 3161 is limited to trigger frequencies of 18.75MHz or less. To place the 3161 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 a 0 (OFF) or 1 (ON).

## Gated Mode

The 3161 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 3161 generates output waveforms as long as the gate signal is present. When the 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 (Appendix A). To place the 3161 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 a 0 (OFF) or 1 (ON).



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## 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 3161 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 3161 cannot operate in Sequence and Burst modes simultaneously. Observe the limitations of the trigger signal as listed in the specification section of this manual (Appendix A). To place the 3161 in Burst mode, use the following commands:

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

INIT:CONT OFF places the 3161 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:

```
TRIGger:BURSt?
```

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

The query:

```
TRIGger:COUNt?
```

queries the burst count and returns an integer.



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## 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 3161. 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. See example 1 below, in the section titled "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.

**Example 1:** Use the internal trigger generator to output a 15ns rectangular pulse repeated at a 10kHz rate.

```
*RST
:FUNC:SHAP SQU
:FREQ 31.25E6     //1132ns period
:INIT:CONT OFF
:TRIG:SOUR:ADV INT
:TRIG:TIM 100e6     //1110kHz rate
:OUTP ON
```



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## Using the Trigger Delay

The trigger delay command delays the output of a triggered or burst waveform by a specified number of sample clock cycles by a value of 10 to 2 million cycles. Actual delay is calculated by $T_{delay} = D_{cycles} / f_{SCLK}$ where $D_{cycles}$ is the programmed delay and $f_{SCLK}$ is the sample clock frequency setting. Enable or disable this feature by setting the STATe:

```
TRIGger:DELay:STATe  {OFF | ON}
TRIGger:DELay        <value>
```

The queries:

```
TRIGger:DELay:STATe?
TRIGger:DELay?
```

query the state of the trigger delay feature and the delay value.

## 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 3161 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 3161 when the POS option is selected. Negative transitions will trigger the 3161 when the NEG option is selected. POS is the default slope. In Gated mode, a high level will enable the generator when the POS option is selected; a low level will enable the generator 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 1.6V, 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



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**Example 1:** Program the 3161 to trigger coincident with the falling edge of an ECL level pulse.

```
*RST
:INIT:CONT OFF
:TRIG:SLOP NEG
:TRIG:LEV –1.3
:TRIG:SOUR:ADV EXT
:OUTP ON
```

## Using the Soft Trigger

The soft trigger command allows you to write a program that can trigger the 3161 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
```

The IEEE-STD-488.2 common command *TRG has the same effect. Use either software command to trigger the 3161 in Trigger, Burst or Triggered Sequence Advance modes.

## Generating Arbitrary Waveforms

The 3161 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 256k of horizontal data points (1Meg or 4Meg optional). Each horizontal point has a unique address - the first being 00000 and the last 261120. In cases where smaller waveform lengths are required, the 3161's waveform memory can be divided into smaller segments. It is then 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 3161 provides programmable sample clock rates from 100MHz to 300MHz.



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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.

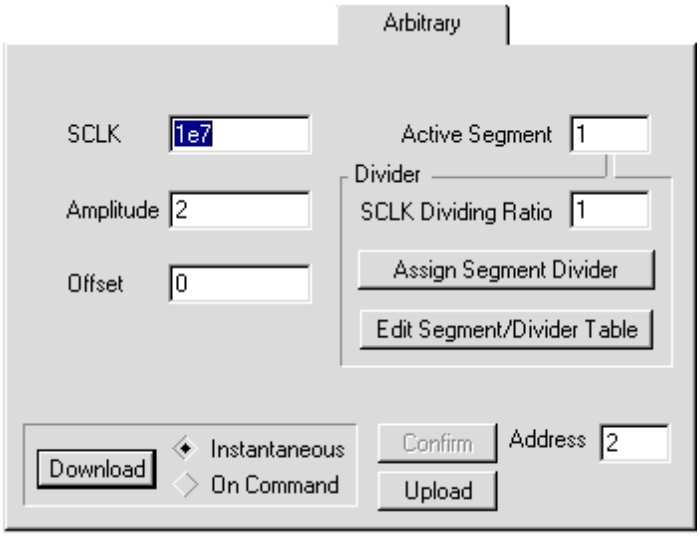



**Figure 3-6, WaveCAD's Arbitrary Waveform Control Panel**

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.

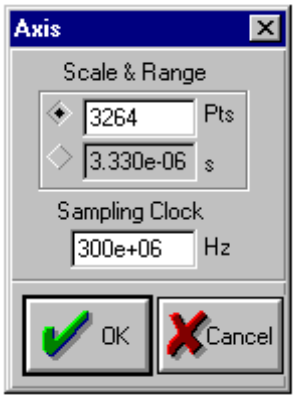



**Figure 3-7, WaveCAD's Axis Definition Panel**



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## Arbitrary Memory Management

The 3161's arbitrary memory consists of a fixed length of 262,144 words. 1k is always reserved for the built-in standard waveforms. The maximum size arbitrary waveform that can be loaded into memory is 261,120 points long. 1Meg or 4 Meg RAM is offered as an option in cases where a larger memory bank is required. For the 1M point option, the maximum waveform size is 1,047,552 points (4,194,280 for the 4Meg option). It is not necessary to use the complete 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 3161'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. The standard memory (256k) is 261,120 words long. The 1Meg optional memory is 1,047,552 words long and the 4Meg is 4,193,280.

***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 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.



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**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:

TRACe:DELete: ALL



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***CAUTION***

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

## Loading Arbitrary Waveforms

There are three ways to load waveforms into the 3161: 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 3161 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 3161 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 3161 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 byte-high, byte-low order. The FORM:SWAP command can be used to reverse this order.

When sending binary blocks to the 3161, the final byte must be



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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.

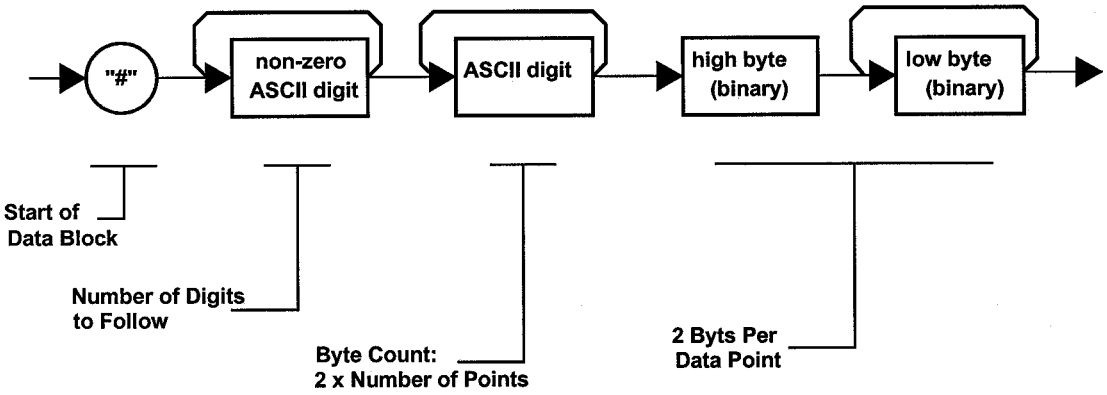



**Figure 3-8, Definite Length Arbitrary Block Data Format**

16-bits of data are sent to the 3161 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.

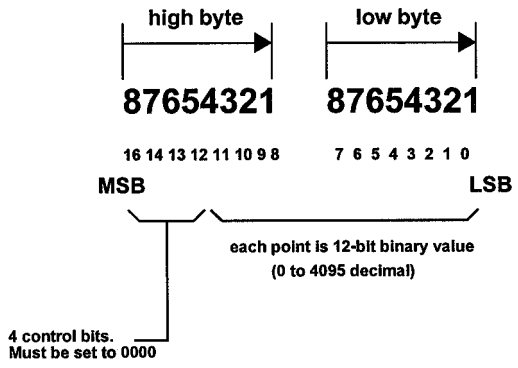



**Figure 3-9, 12-Bit Waveform Data Format**



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***Note***

**The 3161 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 binary block. 2002 is not a multiple of 8, therefore the generator will generate an error message if this segment length is used.**

## Reversing Byte Order

Binary data is sent to the 3161 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 3161. In shared memory mode, the 3161'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 3161, control is returned to the instrument.

In shared memory mode, the 3161□s memory acts like Direct Memory Access (DMA). The instrument has to be told when to receive data, send data, surrender control or gain control. The 3161 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.

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 3-33) for more information.



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The command:

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 3161 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 a 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.

4. Slot 0 sends command:

   SMEM:STATE OFF

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



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The *OPC? response is set to 1 when the 3161 has transferred memory access from the internal CPU to shared memory. This typically takes a few milliseconds.

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

### Example 1, Downloading a waveform into shared memory

```
#include <visa.h>
#include <ansi_c.h>
#include "ri3161.h"
#include <cvirte.h>    /* Needed if linking in external compiler; harmless otherwise */

/*=============================================================================*/
/* Function: Load Arbitrary Data                                               */
/* Location: ri3161.c                                                          */
/* Purpose:  This function loads arbitrary data into the specified segment */
/*=============================================================================*/
ViStatus _VI_FUNC ri3161_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 = ri3161_int_range (segment_number, RI3161_MIN_SEG_NUMBER,
                                        RI3161_MAX_SEG_NUMBER, VI_ERROR_PARAMETER2))
                return( error );

        max_size = ri3161_get_mem_size(vi);
        if (error = ri3161_int32_range (number_of_points, RI3161_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 );

        if ((error = viRead(vi, (unsigned char *) readbuf, RI3161_READ_LEN, &cnt)) < 0)
                return( error );
```



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

                if ((error = viRead(vi, (unsigned char *) readbuf, RI3161_READ_LEN,
&cnt)) < 0)
                        return( error );

                if (readbuf[0] != '1')
                        return( RI3161_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( RI3161_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( RI3161_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 3161 in slot 7 */
        ri3161_init ("VXI::7::INSTR", 1, 1, &vi);

        /* Select Arbitrary waveform mode */
        ri3161_select_waveform_mode (vi, RI3161_MODE_ARB);

        /* Turn Output on */
        ri3161_output (vi, RI3161_OUTPUT_ON);

        /* Define Segment 1 */
        ri3161_define_arb_segment (vi, 1, 24, 1);

        /* Download 24 points */
        ri3161_load_arb_data (vi, 1, data_pts, 24);
}
```



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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 (Page 3-29).

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 3161 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.



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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 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 sequence 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 3161 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.



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In SING Advance mode, the 3161 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 3161 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.

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 using 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.



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| Pin | Description |
|---|---|
| 1 | Bit 0 (LSB) |
| 2 | Bit 1 |
| 3 | Bit 2 |
| 4 | Bit 3 |
| 5 | Bit 4 |
| 6 | Bit 5 |
| 7 | Bit 6 |
| 8 | Bit 7 (MSB) |
| 9 | Ground |

**Figure 3-10, DSUB (Digital Pattern Input) Pinout**

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***

**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.



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## Front-Panel / VXIbus Phase Synchronization

The 3161 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 3161 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***

**Phase offset resolution depends on the number of waveform samples. For instance, if you have 1024 waveform samples, there is no problem adjusting the phase offset in 1° increments (360° / 1000 < 1°). As another example, if you have only 72 waveform samples, the phase offset increment is 5° (360° / 72 = 5°).**

## 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 3161 locks to the phase of the reference signal at the trigger point.

Use the following command to program the 3161 to lock to a front-panel reference signal:

PHASe:LOCK ON

This command places the 3161 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 3161 should lock and it does not, make sure that trigger level is adjusted correctly.

Make sure that the 3161'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>



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applies phase offset between the reference signal and the main output. The default value is 0E. Phase offsets can be adjusted between 0E and +360E. The resolution of this parameter is 1 waveform point, which is lowest (22.50) 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?

queries the PLL state and returns a 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.



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## Using the Frequency Counter

In PLL mode, the 3161 uses an autoranging counter circuit to measure the frequency of the reference signal. This built-in counter is made available to you, provided that the signal at the trigger input is valid and the PLL ON LED illuminates. Frequencies are measured from 100Hz to 18.75MHz with 6 digits of resolution, including decimal point and suffix multiplier.

To measure external frequencies you must first place the 3161 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 3161 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.

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 a 1 (ON) or 0 (OFF).



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## 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 a 1 (ON) or 0 (OFF).

## 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.



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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,3161,0,1.0".

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.

The query:

*OPT?

queries the waveform memory length installed in the 3161. The response is “0” for 256K, “1" for 1Meg, and “2” for 4Meg.



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# Chapter 4

# SCPI COMMAND REFERENCE

## What's In This Chapter

This chapter contains reference information for programming the 3161. Standard Commands For Programmable Instruments (SCPI) convention rules and syntax are explained in detail. Table 4-1 (Page 4-6) lists all SCPI commands used for programming the 3161. The command summary for each SCPI 3161 is also included in this chapter (Page 4-10).

This chapter teaches you how to use SCPI commands to control functions, modes, waveforms and other aspects of the instrument.

## 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 enclosed parameter |
| **Vertical Bar ( \| )** | Separate multiple parameter choices |
| **Bold Typeface Letters** | Designate factory default values |



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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.



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## 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:

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?



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## 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 values. Commands that set modes of operation can be queried for their current modes. 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.

## 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 suffixes 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>
```



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## 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 }

## Arbitrary Block Parameters

Arbitrary block parameters are used for loading waveforms into the generator's memory. Depending on which option is installed, the 3161 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 3161 SCPI Commands List Summary

| Keyword | Parameter Form (Default in Bold) | SCPI 1993.0 | Notes |
|---|---|---|---|
| :FORMat | | | |
| :BORDer | NORMal \| SWAPped | Confirmed | |
| :OUTPut | | Confirmed | |
| [:STATe] | OFF \| ON | Confirmed | |
| :FILTer | | Confirmed | |
| [:LPASs] | | Confirmed | |
| :FREQuency | 70MHz \| 150MHz | 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;262120) | Not Confirmed | 256K memory |
| [:POINt] | (0;0;1048552) | Not Confirmed | 1M memory |
| [:POINt] | (0;0;4194280) | Not Confirmed | 4M memory |
| [:SOURce] | | Confirmed | |
| :APPLy | FREQ,AMPL,OFFS | Not confirmed | |
| :SINusoid | FREQ,AMPL,OFFS,PHAS,POW | Not confirmed | |
| :TRIangle | FREQ,AMPL,OFFS,PHAS,POW | 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;150E6) \| MINimum \| MAXimum | Confirmed | |
| :RASTer | (10E6;100E-3;300E6)\| 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 3161 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 | |
| :POWer | (1;1;9) | Not Confirmed | |
| :TRIangle | | Not Confirmed | |
| :PHASe | (0;0;360) | Not Confirmed | |
| :POWer | (1;1;9) | 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 3161 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;4M points) | Confirmed | |
| :SOURCe | EXTernal \| TTLTrg<0-3> \| ECLTrg0 | 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 | |
| :DEFine | (1;1;4096),(16;106;262143) | Confirmed | Even number, 256K memory, divisible by 8 |



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## Table 4-1, VXIbus 3161 SCPI Commands List Summary (continued)

| Keyword | Parameter Form (Default in Bold) | SCPI 1993.0 | Notes |
|---|---|---|---|
| :DEFine | (1;1;4096),(16;16;1048575) | Confirmed | Even number, 1M memory, divisible by 8 |
| DEFine | (1;1;4096),(16;16;4194304) | Confirmed | Even number, 4M 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 | |
| :COUNt | (1:1:65536) | Confirmed | 4M Option |
| :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 3161 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 the output function, shape, frequency, amplitude, filter state, and synthesizer agility. 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?
:APPLy:<function_shape>?
:APPLy:DC {<percent_amplitude>}
:APPLy:EXPonential {<frequency>,[<amplitude>,[<offset>,[<exponent>]]]}
:APPLy:GAUSsian {<frequency>,[<amplitude>,[<offset>,[<exponent>]]]}
: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:SINusoid {<frequency>,[<amplitude>,[<offset>,[<phase>,[<power>]]]]}
:APPLy:SQUare {<frequency>,[<amplitude>,[<offset>,[<duty_cycle>]]]}
:APPLy:TRIangle {<frequency>,[<amplitude>,[<offset>,[<phase>,[<power>]]]]}
:APPLy:USER {<segment_number>,[<sampling_clock>,[<amplitude>,[<offset>]]]}

:ECLTrg0 {**OFF** | ON}

:FILTer:FREQuency {**70MHz** | 150MHz}
:FILTer:FREQuency?



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:FILTer {**OFF** | ON}
:FILTer?

:FREQuency?
:FREQuency {<frequency> | MINimum | MAXimum} (**1e6,**100e-6,150e6)
: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}
:FREQuency:MODE {**NORMal** | FSK | HOP}
:FREQuency:MODE?
:FREQuency:RASTer {<frequency> | MINimum | MAXimum} (**1e6,**100e-3,300e6)
:FREQuency:RASTer?

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

:OUTPut: {**OFF** | ON}

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

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

:TTLTrg<0-3> {**OFF** | ON}

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



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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] | | | |
| :DC <%_amplitude> | -100 | 100 | **100** |
| :DC? | | | |
| :EXPonential:EXPonent <value> | -100 | 100 | **-20** |
| :EXPonential:EXPonent? | | | |
| :GAUSsian:EXPonent <value> | 10 | 100 | **10** |
| :GAUSsian:EXPonent? | | | |
| :PULSe:DELay <value> | 0 | 99.9 | **10.0** |
| :PULSe:DELay? | | | |
| :PULSe:TRANsition <value> | 0 | 99.9 | **10.0** |
| :PULSe:TRANsition? | | | |
| :PULSe:TRANsition:TRAiling <value> | 0 | 99.9 | **10.0** |
| :PULSe:TRANsition:TRAiling? | | | |
| :PULSe:WIDTh <value> | 0 | 99.9 | **10.0** |
| :PULSe:WIDTh? | | | |
| :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? | | | |
| :SINusoid:PHASe <value> | 0 | 360 | **0** |
| :SINusoid:PHASe? | | | |
| :SINusoid:POWer <value> | 1 | 9 | **1** |
| :SINusoid:POWer? | | | |
| :SINC:NCYCle <value> | 4 | 100 | **10** |
| :SINC:NCYCle? | | | |
| :SQUare:DCYCle <value> | 1 | 99 | **50** |
| :SQUare:DCYCle? | | | |
| :TRIangle:PHASe <value> | 0 | 360 | **0** |
| :TRIangle:PHASe? | | | |
| :TRIangle:POWer <value> | 1 | 9 | **1** |
| :TRIangle:POWer? | | | |



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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 3161 in a special data transfer mode where the 3161'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.

**Command and Parameters**

: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}

: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



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## Modulation Command Summary

The Modulation Commands control 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 3161. The 3161 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 may be applied to a front panel connector or through one of the VXIbus trigger lines. If the 3161 is placed in PLL mode, it 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.

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? | |

## System-Related Command Summary

The system-related commands are not related directly to waveform generation but are an important part of operating the 3161. 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?



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## 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. All compatible devices must use this common set of commands and queries. 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. 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 3161.

***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, 3161□$ response to *IDN? is:

RACAL INSTRUMENTS,3161,0,1.0.

***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.



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***OPT?** - Returns the value "0" for a 3161 with 256K memory. Returns "1" for a 3161 with 1Meg memory. Returns "2" for a 3161 with 4Meg 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.

***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 affects 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 3161 functionality is tested.

0 - Selftest passed
1 - CPU to peripherals communication failure
2 - DAC control, output amplifier, amplitude & offset control failure
4 - Clock generator failure
8 - Clock divider failure
16 - Waveform memory failure
32 - Trigger & internal trigger failure
64 - Sequence advance circuit failure
128 –PLL circuit failure

More than one failure can be reported at one time. For example, the returned value "17" indicates both a CPU to peripherals communication problem and a waveform memory failure.

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



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## The SCPI Status Registers

The 3161 uses the Status Byte register group and the Standard Event register group to record various instrument conditions. Figure 4-1 (Page 4-19) 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 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.



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**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 whether 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 serial poll

**Bit 7** – Decimal value 128. Not used; always set to 0.



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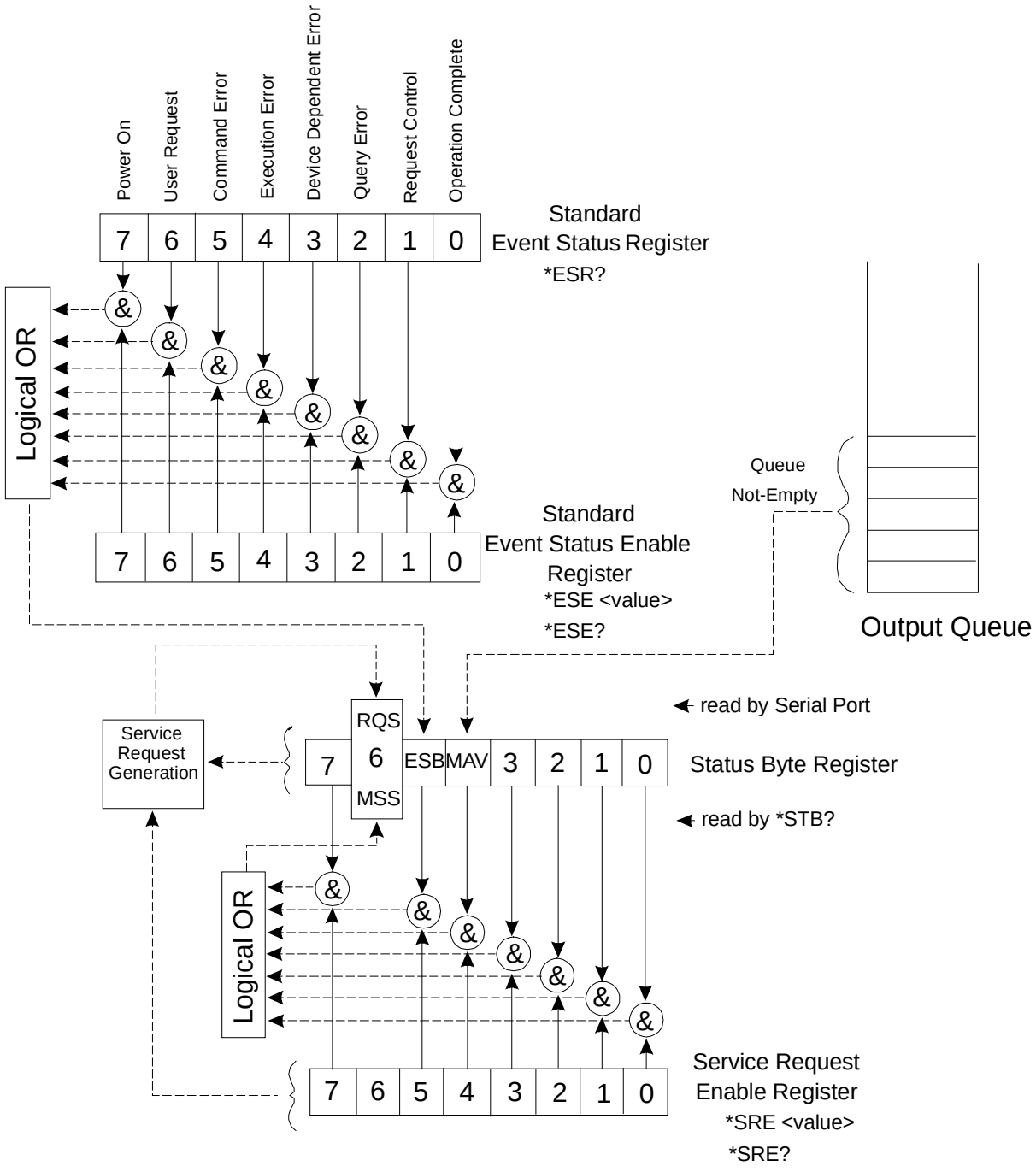



**Figure 4-1, SCPI Status Registers**



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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.



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## 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 *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 3161.

**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 that 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.



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## 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. A Summary of *ESE messages is given 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 3161 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".



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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?

A complete listing of the errors that can be detected by the generator is given below. Errors have the following format (the error string may contain up to 80 characters):

-102,"Syntax error"

-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.

-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. An execution error as defined in IEEE-488.2 has occurred.



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-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, 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 Overflow". 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.



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-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 3161 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 3161 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, service information, performance tests, and the information necessary to adjust and troubleshoot the 3161 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 precaution to avoid damaging them as described below:

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 3161 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 and caution. 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 needs to be serviced and the source of failure removed. Instructions on how to perform self-test is given later in this chapter in the **Self-Test** section.



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## 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 3161 and allow it to warm-up for at least 30 minutes before beginning the performance test procedure.

## 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 3161 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 | 200 MHz, 1 ppm accuracy |
| DMM | ACV, 0.2%; DCV, 0.1% accuracy |
| Distortion Analyzer | 10 Hz to 100 KHz |
| Spectrum Analyzer | 1 GHz bandwidth, 1 KHz resolution |
| Pulse/Function Generator | 50 MHz, 10 ns pulse width |
| Oscilloscope | 2 channels, 500 MHz analog bandwidth |
| Feedthrough termination | 50Ω, 1% |
| BNC Cables | 1 meter long, 50Ω impedance |
| 20dB feedthrough attenuator | 50Ω, 1% |
| “T” BNC Connector | 50Ω, 1% |



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## Performance Check Procedures

Use the following procedures to check the 3161 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 has to be calibrated or tested to find the source of the problem.

## Frequency Accuracy

**Accuracy Specifications:** 0.01% of reading to 150.00 MHz

**Equipment:** Counter

1. Configure the 3161 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 3161 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:

| 3161 SETTING | COUNTER READING |
|---|---|
| 10.00000 Hz | 9.999000 Hz - 10.00100 Hz |
| 100.0000 Hz | 99.99000 Hz - 100.0100 Hz |
| 1.000000 KHz | 999.9000 Hz - 1.000100 KHz |
| 10.00000 KHz | 9.999000 KHz - 10.00100 KHz |
| 100.0000 KHz | 99.99000 KHz - 100.0100 KHz |
| 1.000000 KHz | 999.9000 KHz - 1.000100 KHz |
| 10.00000 MHz | 9.999000 MHz - 10.00100 MHz |
| 150.0000 MHz | 149.9850 MHz - 150.0150 MHz |



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If TCXO option is installed in your instrument ignore the above reading and use the following table to verify readings on the counter display as follows:

| 3161 SETTING | COUNTER READING |
|---|---|
| 10.00000 Hz | 9.999990 Hz - 10.00001 Hz |
| 100.0000 Hz | 99.99990 Hz - 100.0001 Hz |
| 1.000000 KHz | 999.9990 Hz - 1.000001 KHz |
| 10.00000 KHz | 9.999990 KHz - 10.00001 KHz |
| 100.0000 KHz | 99.99990 KHz - 100.0001 KHz |
| 1.000000 KHz | 999.9990 KHz - 1.000001 KHz |
| 10.00000 MHz | 9.999990 MHz - 10.00001 MHz |
| 150.0000 MHz | 149.9980 MHz - 150.0002 MHz |

## 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 3161 as follows:

   Function: Sine
   Frequency: 1.000 KHz
   Amplitude: 5 V
   Remote Commands: :RES
   :OUTP ON
   :FUNC:SHAP SIN
   :FREQ 1e3
   :VOLT 5

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

3. Connect the 3161 output to DMM input. Terminate the output with a 50Ω feedthrough termination. Set the amplitude and verify DMM reading as follows:

| 3161 SETTING | DMM READING |
|---|---|
| 5.000 V | 1.740 V – 1.793 V |
| 500.0 mV | 173.2 mV – 180.3 mV |
| 50.0 mV | 16.79 mV – 18.55 mV |



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## DC Offset Characteristics

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

**Equipment:** DMM, 50Ω feedthrough termination

1. Configure the 3161 as follows:

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

2. Set the DMM to DCV measurements.

3. Connect the 3161 output to the DMM input. Terminate the output with a 50Ω feedthrough termination. Set the 3161 offset and verify the DMM reading as follows:

| OFFS 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 |

## 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 3161 as follows:

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



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2. Connect the 3161 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.

## Sine Characteristics

**Specified Total Harmonic Distortion:** <0.5% from 10.00 Hz to 100.0kHz, (with 4096 points waveform).

**Specified Harmonic Signals:**

-50dBc to 100kHz
-40dBc to 10MHz
-30dBc to 100MHz
-25dBc to 150kHz

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

1. Connect the 3161 output to distortion analyzer input.

2. Set the distortion analyzer to % distortion measurements, set the 3161 frequency setting, and verify the distortion reading as below.

3. Configure the 3161 as follows:

| | |
|---|---|
| Function: | User Waveform |
| Frequency: | 10.00 Hz |
| Amplitude: | 3 V |
| Remote Commands: | :RES |
| | :OUTP ON |
| | :FUNC:MODE USER |
| | :TRAC:DEF 1,4096 |
| | :TRAC:SEL 1 |
| | :FREQ:RAST 40.96e3 |
| | :VOLT 3 |

4. Load a 4096-point sine waveform. Use TRACe# command or WaveCAD to load the waveform.

| 3161 SCLK SETTING | DISTORTION READING |
|---|---|
| 40.96e3 | <0.5% |
| 409.6e3 | <0.5% |
| 4.096e6 | <0.5% |
| 40.96e6 | <0.5% |



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

6. Connect the 3161 output to spectrum analyzer input through a 20dB feedthrough attenuator. Using the command FUNC:MODE FIX;:FUNC:SHAP SIN, modify 3161 output to sine waveform.

7. Set the 3161 FREQ setting and verify the harmonic distortions levels as follows:

| FREQ SETTING | HARMONICS LEVEL |
|---|---|
| 10 MHz | <40 dBc |
| 50 MHz | <30 dBc |
| 100 MHz | <25 dBc |
| 150 MHz | <25 dBc |

## Sine Flatness

**Level Flatness:** ±5% to 10 MHz; ±10% to 150 MHz

**Equipment:** Oscilloscope

1. Configure the 3161 as follows:

| | |
|---|---|
| Function: | Sine wave |
| Frequency: | 10.00 KHz |
| Amplitude: | 3 V |
| Remote Commands: | :RES |
| | :OUTP ON |
| | :FREQ 10e3 |
| | :VOLT 3 |

2. Connect the 3161 OUTPUT to the oscilloscope, set the oscilloscope input impedance to 50 , and set oscilloscope to display the sinewave within exactly 6 vertical divisions.

3. Change the 3161 FREQ setting to 10 MHz. Verify that peak-to-peak of the displayed sinewave is within 5.7 to 6.3 divisions.

4. Change the 3161 FREQ setting to 100 MHz. Verify that peak-to-peak of the displayed sinewave is within 5.3 to 6.6 divisions.

5. Change the 3161 FREQ setting to 150 MHz. Verify that peak-to-peak of the displayed sinewave is within 5.3 to 6.6 divisions.



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## Trigger Gate & Burst Characteristics

**Triggered -** Each transition at the front panel TRIG IN connector stimulates the 3161 to generate one complete output waveform.

**Gated -** External signal at the TRIG IN connector enables the 3161 output. The last cycle of the output waveform is always completed.

**Burst -** Each transition at the front panel TRIG IN connector stimulates the 3161 to generate a burst of pre-selected number of cycles.

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

**Trigger**

1. Configure the 3161 as follows:

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

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 3161 outputs a triggered signal. Leave the external pulse generator connected to the l 3161 for the next test.

**Gate**

3. Configure the 3161 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 3161 outputs a gated signal. Leave the external pulse generator connected to the 3161 for the next test.



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### Burst

5. Configure the 3161 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 3161 outputs a burst of 10 complete output waveforms. Remove the external pulse generator connection from the 3161 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 3161 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-points waveform.

3. Connect the output from the 3161 to the oscilloscope and set the oscilloscope to display the waveform.

4. Connect the 8021 trigger output to the 3161 trigger input. Set 8021 frequency to 1 KHz.



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

**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.

1. Configure the 3161 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 HOP |
| | :HOP 1,1 |
| | :HOP 2,10 |
| | :HOP 3,100 |
| | :HOP 4,1000 |

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

3. Connect the output from the 3161 to the oscilloscope and set the oscilloscope to display the waveform. Verify that carrier frequency (73.24kHz) is displayed.

4. Connect the 8021 trigger output to the 3161 trigger input. Set 8021 frequency to 1 KHz.

5. Verify that output frequency hops with each trigger between 73.24 KHz, 7.324 KHz, 732.4 Hz, and 73.24 Hz. The hop loop repeats as long as the trigger signal is applied to the trigger input.

6. Remove the 8021 from the 3161 trigger input. Modify the hop source to DSUB using the command HOP:SOUR DSUB.

7. Pulling the DSUB pins 1 through 8 to +5 V configures hop step. You may pull the pins using an external device such as pattern generator. You may also use the + 5 V at pin 9 as pull-up source. Connect pin 1 with a short wire to pin 9 and observe that the output frequency changes to 7.324 KHz. Remove the short from pin 1 and connect pin 9 to pin 2. Observe that output frequency is now 732.4 Hz.



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## PLL Characteristics

**Accuracy:** ±(20 ns/Per [ns] x 360 + Resolution).

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

1. Configure the 3161 as follows:

   | | |
   |---|---|
   | Function: | User |
   | Mode: | PLL |
   | Sample Clock: | 300 MHz |
   | Amplitude: | 2 V |
   | Trigger Level: | 0 V |
   | Remote Commands: | :RES |
   | | :OUTP ON |
   | | :FUNC:MODE USER |
   | | :PHAS:LOCK ON |
   | | :TRIG:LEV 0 |
   | | :VOLT 2 |

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 3161 TRIG IN and the other end to the counter Channel A input.

   3. Connect the 3161 OUT to the counter Channel B input.

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

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

5. Set 8021 to output 2 Vp-p, 500 KHz square waveform.

6. Change 3161 phase offset using the command PHAS:ADJ and verify counter phase readings as shown below.

   | PHASE OFFSET | COUNTER READING |
   |---|---|
   | 0° | 0°, ±4.6° |
   | 90° | 90°, ±4.6° |
   | 180° | 180°, ±4.6° |
   | 270° | 270°, ±4.6° |



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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 3161 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.

***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.**



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***NOTE***

**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 3161 as follows:

   Function: Sine

   Frequency: 150 MHz

   Remote Commands: :RES

   :OUTP ON

   :FREQ 150e6

2. Connect the probe between U62 pin 18 and ground (on the engine board). Adjust engine board R89 for 50% duty cycle.

## Pulse Response Adjustment

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

1. Configure the 3161 as follows:

   Function: Square

   Frequency: 10 MHz

   Amplitude: 3 V

   Remote Commands: :RES

   :OUTP ON

   :FUNC:SHAP SQU

   :FREQ 10e6

   :VOLT 3

2. Connect the 3161 output through 20dB attenuator to the oscilloscope input.

3. Set oscilloscope input impedance to 50Ω.

4. Set the oscilloscope vertical gain and time base, and adjust main board C8 and C9 for best pulse response.

5. Change the 3161 frequency setting to 10.00 KHz.

6. Remove the 3161 signal from the oscilloscope and adjust the vertical position to be exactly on the center of the trace.

7. Reconnect the 3161 output to the oscilloscope and adjust R7 for best symmetry around the vertical centerline.



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## Amplitude Adjustment

**Equipment:** DMM, 50  feedthrough termination

1. Configure the 3161 as follows:

   Function: Sine
   Frequency: 1 KHz
   Amplitude: 5 V
   Remote Commands: :RES
   :OUTP ON
   :FREQ 1E3
   :VOLT 5

2. Connect the 3161 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 for DMM reading of 1.7677V, ±15 mV.

## Offset Adjustment

**Equipment:** DMM, 50Ω feedthrough termination

1. Configure the 3161 as follows:

   Function: Sine
   Frequency: 1 MHz
   Amplitude: 10 mV
   Offset: +2.250 VDC
   Remote Commands: :RES
   :OUTP ON
   :FREQ 1e6
   :VOLT 10e-3
   :VOLT:OFFS 2.25

2. Connect the 3161 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 -2.250 V and adjust R95 to have the exact reading as was recorded in the previous step (with reversed polarity).

4. Adjust R96 until the DMM reading is -4.50 V, ±30 mV.

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



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## 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 3161 are listed in the section entitled **Recommended Test Equipment** in the beginning of this chapter. Other equipment such as a logic analyzer, an in-circuit emulator, etc., could also be helpful in a difficult situation.

## Power-up Tests

Upon power-up, the 3161 performs a set of tests. If the instrument locks up after power on, proceed with the troubleshooting procedure given in the following paragraphs.

### Self-Test

An advanced feature of the 3161 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 3161 performs and their associated response, in case one of the tests fails.

0 - Selftest passed

1 - CPU to peripherals communication failure

2 - DAC control, output amplifier, amplitude & offset control failure

4 - Clock generator failure

8 - Clock divider failure

16 - Waveform memory failure

32 - Trigger & internal trigger failure

64 - Sequencer & burst circuit failure

128 - PLL circuit failure



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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.

The self-test procedure is intended to verify general operation of the 3161. It does not test for accuracy. Therefore, it should be used as a general indication that the 3161 operates correctly. The self-test procedure checks about 95% of the hardware. If the self-test procedure fails to respond correctly, troubleshooting the 3161 is suggested using the procedure given below.

The troubleshooting procedure should also be initiated whenever the generator fails to perform either completely or partially. It is also required to troubleshoot the 3161 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 were the source of the trouble is located.

## Main Board Circuits Checkout

The 3161 is made of two boards. The large board (Part Number 7100-2440) is the main board. There is a smaller board 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 board, it may be necessary to remove this board entirely. To do so, remove the four screws that tie 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 3161 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 to 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 3161 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 3161 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 3161. 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 the 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.



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**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 | |
| 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 3161 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 3161 to the factory defaults using the *RST command. Then send the command:

:OUTP ON.

**Table 5-2, Output Amplifier and Amplitude Control Checks**

| Step | 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 |



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## Clock Synthesizer Checks

Problems with the clock synthesizer circuits can be detected if the 3161 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.

**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 Circuit Checkout

As described in the paragraph **Main Board Circuit Checkout**, the 3161 is made of two boards. If the engine board is removed from the main board, reinstall it before continuing with the following checks. The following circuit checks are performed on the engine board only.

## Engine Board Checks

Problems with the engine board circuits can be detected if the 3161 accepts word serial commands and responds correctly to word serial queries however, fails to generate correct waveforms. If there is a general problem with the engine board circuits, download a 128-points square waveform, program the 3161 using the following remote commands, and proceed with the checks given in Table 5-4.

Remote Commands: :RES
:OUTP ON
:FUNC:MODE USER



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## Continuous Operation Checks

If there are general problem the shape of the output waveforms or if the output waveforms appear distorted in continuous operating mode, download a 128-points square waveform, program the 3161 using the following remote commands, and proceed with the checks given in Table 5-4.

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

| Step | Test Point | 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 | U76 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 |

## 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. Apply an external 20 KHz TTL level signal to the trigger input and program the 3161 using the following remote commands.

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



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**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)<br>Negative going TTL level pulses, 20 KHz, pulse width 15 ns |
| 2 | J4 pin 1 | Negative going TTL level pulses, 20 KHz, pulse width 15 ns |
| 2 | U81 pin 5 | Negative going TTL level pulses, 20 KHz, pulse width 12.8ns |
| 2 | U81 pin 5 | Negative going TTL level pulses, 20 KHz, pulse width 12.8ns |
| 3 | U76 pin 18 | Negative going ECL level pulses, 20 KHz, pulse width 100ns |
| 4 | U76 pin 4 | Negative going ECL level pulses, 20 KHz, pulse width 12.8ns |

## D/A, Preamplifier & Amplitude Control Checks

If there are problem with the shape of the output waveforms or if the output waveforms are not generated at all. Program the 3161 using the following remote commands.

Remote Commands: :RES
:OUTP ON
:FUNC:MODE USER

Download a 128-points square waveform and proceed with the checks given in Table 5-6.

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

| **Step** | **Test Point** | **Expected Result** |
|---|---|---|
| 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 |



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## Sequence Generator Checks

Problems with the sequence generator circuits can be detected if the 3161 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 3161 to the factory default using the *RST command. Configure the 3161 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**

| 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 3161 configured to operate in sequence mode as before however, each segment has a different clock divider number. Use the following command to configure the 3161:

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.



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## Table 5-8, Sequence Generator & Clock Divider Checks

| Step | Test Point | Expected Result |
|---|---|---|
| 1 | U84 pin 7 | 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 | 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 | U62 pin 26 | 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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# 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 | A24, D16, 256k points. Expandable to 1M points. |

## Sample Clock

| | |
|---|---|
| Range: | Internal, from internal synthesizer, 100 mHz to 300 MHz |

## Internal Synthesizer Reference Sources:

| | |
|---|---|
| Standard Reference (CLK10) | ≥0.01% (100ppm) tolerance over temperature per the VXIbus specification |
| Optional High Stability Reference | ≥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 | 100 mHz to 300 MHz, |
| Resolution | 7 digits |
| Accuracy | Same as reference |
| Stability | Same as reference |



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# 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;<br>2) Front panel TRIG IN connector;<br>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 100 mHz to 300 MHz |
| 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. |

**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 | 100 mHz to 300 MHz |

**FSK Source**

| | |
|---|---|
| External | Front panel BNC. Low level = carrier sample clock; High level = hop frequency |
| Frequency Range | From 10 MHz to DC |
| VXIbus Frequency Range | From 10 MHz 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 synchronous with the active slope of the triggering signal. Last cycle of output waveform 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. |



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| | |
|---|---|
| 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 | 2 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 + 100 ns |
| Trigger Delay Mode On | |
| Standard/Arbitrary Waveforms | 2 Sample Clock + 100 ns |

# Standard Waveforms

| | |
|---|---|
| Frequency Range | Waveform dependent |
| Source | Internal synthesizer |

**Sine**

| | |
|---|---|
| Frequency Range | 100 μHz to 150 MHz |
| Band Flatness | 5%, to 10 MHz; 10%, to 150 MHz |
| Programmable Parameters | |
| Start Phase | 0 to 360° |

**Triangle**

| | |
|---|---|
| Frequency Range: | 100 μHz to 5 MHz, usable to 18.75 MHz |
| Adjustable Parameters | |
| Start Phase | 0 to 360° |

**Square**

| | |
|---|---|
| Frequency Range | 100 μHz to 150 MHz |
| Adjustable Parameters | |
| Duty Cycle | 1% to 99% |



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**Pulse/Ramp**

| | |
|---|---|
| Frequency Range | 100 μHz to 5 MHz, usable to 18.75 MHz |
| 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 | 100 μHz to 5 MHz, usable to 18.75 MHz |
| Adjustable Parameters | |
| Cycles | 4 to 100 cycles |

**Gaussian Pulse**

| | |
|---|---|
| Frequency Range | 100 μHz to 5 MHz, usable to 18.75 MHz |
| Adjustable Parameters | |
| Time Constant | 10 to 200 |

**Exponential Decaying/Rising Pulse**

| | |
|---|---|
| Frequency Range | 100 μHz to 5 MHz, usable to 18.75 MHz |
| Adjustable Parameters | |
| Time Constant | -100 to 100 |

**Noise**

| | |
|---|---|
| Frequency Range | 100 μHz to 5 MHz, usable to 18.75 MHz |

**DC**

| | |
|---|---|
| Range | -100% to 100% of amplitude |



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# Arbitrary Waveforms

| | |
|---|---|
| Waveform Memory | 256 K (1M or 4M optional) points |
| Memory Segmentation | |
| Number of Segments | 1 to 4000 |
| Min Segment Size | 16 point |
| Vertical Resolution | 12 bits (4096 points) |
| Sinewave Total Harmonic Distortion (at 4096 vertical points and sampling rate of 300 MHz) | 0.5% |
| Harmonic Signals Below the Carrier Level (at 4096 vertical points) | |
| | >50 dBc to 100KHz |
| | >40 dBc to 10 MHz |
| | >30 dBc to 50 kHz |
| | >25 dBc to 150 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. |

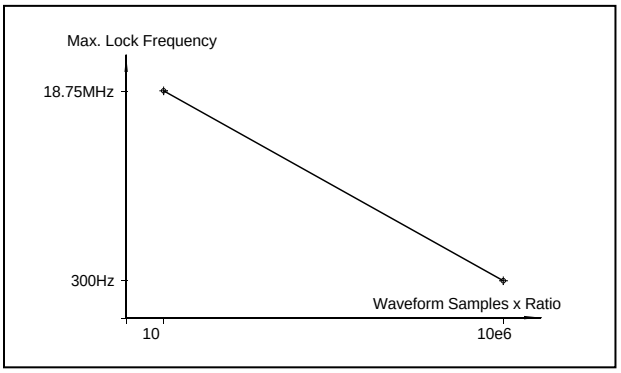


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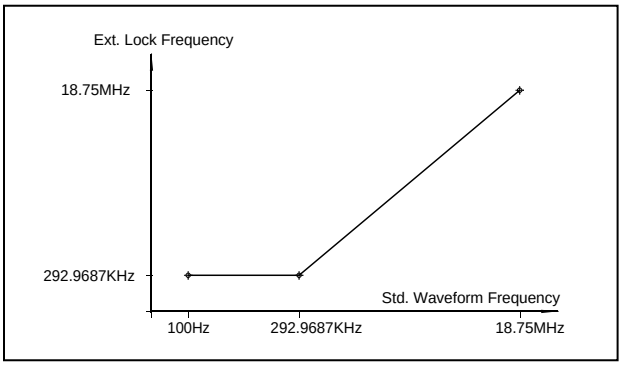
| | |
|---|---|
| Sequencer steps | From 1 to 4096 |
| Segment loops | From 1 to 1M |
| Segment Duration | Minimum 100 ns for more than one loop. |
| Sampling Clock Switching | Sample Clock is selectable per segment. |
| Ratio Between Carrier and Switched Frequencies | 1 through 65536 |
| Sampling Clock Range | To 300 MHz, Switchable Clock. |

# Phase Lock

| | |
|---|---|
| Phase lock Input | 1) Front panel BNC.<br>2) VXIbus TTLTrg0-3.<br>3) VXIbus ECLTRG0. |
| Input Frequency Range | 100 Hz to 18.75 MHz (with 16 points waveform). |
| Phase Offset | |
| Range | 0 to 360° |
| Resolution | 360°/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 | Graph below for User mode |




Graph below for 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 1 MHz |

### 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) |



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| | |
|---|---|
| Filters | 150 MHz 7-pole elliptic;<br>70 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 |

## 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 | 30 V rms, 1 KHz to DC; ±12 V dc above 1 KHz |
| 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 |



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# Power Requirements

| VXIbus Rail | Peak Current (I PM) | Dynamic Current (I DM) |
|---|---|---|
| +24 V | <50 mA | <25 mA |
| +12 V | <0.5 A | <0.25 A |
| +5 V | <3 A | <1 A |
| -5.2 V | <6 A | <2 A |
| -2 V | <0.5 A | <0.25 A |
| -12V | <0.5 A | <0.25 A |
| -24V | <50 mA | <25 mA |

Maximum Total Module Power < 60 W

# 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

| | |
|---|---|
| Dimensions | “C” size, single-slot case |
| Weight | 3 lbs. 8 oz. (1.6 kg) |
| Airflow (for 10°C rise) | 3.7 l/S |
| Pressure (for 10°C rise) | 0.5 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 | |



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| | |
|---|---|
| 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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