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User Manual

3153

100/50 MHz (THREE CHANNEL) WAVEFORM SYNTHESIZER

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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.



and calibration procedures sometimes call for operation of the unit with power applied and ıvers 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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Chapter 1

GETTING STARTED

What's In This Chapter

This chapter contains a general description of the VXIbus Model 3153 Waveform Generator and an overall functional description of the instrument. It lists and describes various options available. It also describes the front panel connectors and indicators.

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



Figure 1-1, Model 3153

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Introduction

A detailed functional description is given following the general description of the features, functions, and options available with the Model 3153.

The Model 3153 is a VXIbus, single slot C-size 3-channel synthesized Waveform Generator. It is a high performance waveform generator that combines three separate and powerful waveform generators in one small package. Each of the three channels can operate as a separate waveform generator; having its own independent sample clock, trigger input, waveform memory and sequence generator. In applications where two or more channels must output synchronized waveforms, channel 1 takes control over slave channels 2, 3 or both.

In master-slave configuration, all three channels generate waveforms from one sample clock source and start from one trigger source. The master-slave mode ensures that all waveforms that are generated by the three channels are fully synchronized in terms of frequency and start phase of the output waveforms. In master-slave mode, the start phase of each channel may be adjusted relative to the master channel.

The Model 3153 has three output channels. Each channel is completely independent with its own set of input and output connectors. The instrument connects through a common VXI ASIC device to the VXIbus backplane from which it receives commands and waveform data. The information that is downloaded from the backplane is distributed to the various channels using 16-bit data and A32 address space. After loading waveform data and controlling commands to the generator, each channel can start generating waveforms.

The architecture of the 3153 is such that only channel 1 is allowed to be programmed as master. Channels 2 and 3 can only be slaves. There are 4 combinations of which the three channels can operate:

1) Each channel operates as an independent generator;
2) Channel 1 master, channel 2 slave;
3) Channel 1 master, channel 3 slave;
4) Channel 1 master, channels 2 and 3 slaves.

Being a master, channel 1 has a few features that are not available in the slave units. Channel 1 can output waveforms with up to a 100 MSa/s clock rate maximum, while the slave channels output waveforms at up to 50 MSa/s. The trigger level input for channel 1 may be programmed, while the other two channels are sensitive to TTL levels only. Also, memory options are not the same for all channels. The various memory options are discussed later in this chapter. The generator, if not ordered with special memory option, is shipped with the following memory configuration: channel 1 with 512k, channels 2 and 3 with 2 Meg. Other memory options are listed below.

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Note:

Field upgrades for larger memory banks are not available.

Aside from the differences above, all channels have the same frequency bandwidth, the same output power and the same operational flexibility and performance.

The Model 3153 is completely digital. There are no analog functions resident in its hardware circuits. Data has to be downloaded to the instrument for it to start generating waveforms. The instrument can generate nine different standard functions such as sine wave, square wave plus seven other functions. Each time that a standard function is required, the instrument has to calculate its coordinates and place them in the waveform memory. Therefore, every time a standard function is recalled, minimal time is required for the controller to compute the function and load its data to the waveform memory.

The frequency accuracy of the output waveform is determined by the clock reference. Using CLK10 as the reference oscillator provides 100 ppm accuracy and stability over time and temperature. If higher accuracy and/or stability are required, one may connect one's own reference oscillator to a front panel input and use this input as the reference for the three sample clock generators of the 3153. Frequency may be is programmed with up to 9 digits, so using an external reference is recommended, if you intend to utilize the full resolution provided by the instrument.

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

Besides its normal continuous mode, the Model 3153 responds to a variety of trigger sources. The output waveform may be gated, triggered, or may generate a counted burst of waveforms. A built-in trigger generator with a programmable period can be used as a replacement of an external trigger source. As was discussed above, the channels can operate separately from each other. Each channel has its own set of output and input connectors. The trigger inputs are separate for each channel as well. In master-slave configuration, the trigger input of the slave channels are disabled and channel 1 trigger input is the only active trigger input. The VXIbus TTLTrg0 through TTLTrg4 and ECLTrg0 may be routed to any channel. However, in master-slave configuration, active trigger signal is that which is applied to channel 1.

The Model 3153 generates arbitrary waveforms with 12 bits of vertical resolution. Any waveform it generates must first be downloaded to waveform memory.

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The arbitrary waveform memory is a bank of 12-bit words. Each word represents a point on the horizontal (or time) waveform scale. Each word has a horizontal address that can range from 0 to 8388560 (with the 8 Meg option only) and a vertical address (or voltage level) that can range from -2047 to +2048 (12 bits). Using a high speed clocking circuit, the digital contents of the arbitrary waveform memory are extracted and routed to the Digital to Analog Converter (DAC). The DAC converts the digital data to an analog signal, and the output amplifier completes the task by amplifying or attenuating the signal at the output connector.

There is no need to use the complete memory bank every time an arbitrary waveform is generated. Waveform memory can be divided into up to 4096 smaller segments and different waveforms can be loaded into each segment. The various segments may then be loaded into a sequence table to generate long and complex waveforms. The sequence table can link up to 4096 segments, while each segment can loop up to 1 million times. Note that sequence generators are separate for each channel. The separation exists also in master-slave mode.

The Model 3153 is fully programmable using SCPI commands and syntax. There are four ways to program the Model 3153, the first being low-level programming of each individual parameter using SCPI commands. The second alternative is to use the *VXIplug&play* driver's Soft Front Panel (SFP) for high-level programming. The *SFP* driver simulates a mechanical front panel with the necessary push buttons, displays and dials to operate the Model 3153 in a similar way to using a bench-top instrument. The third way to program the 3153 is by using either the LabVIEW or LabWindows/CVI drivers. The fourth way to program the 3153 is via the WaveCAD program. The Model 3153 will not operate without being programmed. Therefore, it is recommended that the user become familiar with its basic features, functions and programming concepts as described in this and the following chapters.

Options

A number of options are offered for the model 3153. Compare the option number with the number that is printed on the instrument to verify which of the options is installed in your instrument. Note that all Model 3153 options are only installed in the factory. Contact your nearest Racal representative if the number printed on the case does not reflect the correct version ordered. The list of available options is given below:

1. 407677-001 – Model 3153, Waveform Generator, channel 1 - 512k RAM, channels 2/3 – 2Meg
2. 407677-002 – Model 3153, Waveform Generator, channel 1 – 2Meg, channels 2/3 – 4Meg
3. 407677-003 – Model 3153, Waveform Generator, channel 1- 2Meg, channels 2/3 – 8Meg

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The 512k RAM option designates the memory size supplied with the standard Model 3153. The standard memory size is 512k (524288 words). With the standard memory size, 524288 point waveforms can be programmed on channel 1. The 2Meg, 4Meg and 8Meg RAM options designate instruments supplied with memory expansions. With the 2Meg memory expansion, 2097152 point waveforms can be programmed on channel 1. The 4Meg RAM option designates channels 2 & 3 with 4194304 points of waveform memory. The 8Meg RAM option designates channels 2 & 3 with 8388608 points of waveform memory.

Manual Updates

Technical corrections to this manual (if any) are noted on change pages within the manual. Dates of the changes are stated on the change pages.

Safety Considerations

The Model 3153 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 AC Line (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 instrument is supplied with an Instruction Manual. The manual includes disks with VXI*plug&play* drivers along with WaveCAD for Windows 95/NT. A Service Manual is available upon request.

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Specifications

Instrument specifications are listed in Appendix A. 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 (from 0° to 50°C) are degraded by 0.1% per °C.

Functional Description

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

Input and Output Connectors

The Model 3153 has 15 SMB connectors and 1 BNC connector on its front panel: three main outputs, two low outputs, three SYNC outputs, three TRIG inputs, one set of Start/Stop inputs, two SCLK inputs and one reference clock input.

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Figure 1-2, The Front Panel

Output - Channel 1

The channel 1 output connector outputs fixed (standard) waveforms to 50 MHz, user (arbitrary) and sequenced waveforms with sampling clock to 100 MSa/s. Output impedance is 50Ω, therefore, for best performance, 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 using the following equation:

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

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

High Output - Channel 2

The channel 2, high output connector outputs fixed (standard) waveforms to 25 MHz, user (arbitrary) and sequenced waveforms with sampling clock to 50 MSa/s. Output impedance is 50Ω, therefore, for best performance, 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 using the equation above.

High Output - Channel 3

The channel 3, high output connector outputs fixed (standard) waveforms to 25 MHz, user (arbitrary) and sequenced waveforms with sampling clock to 50 MSa/s. Output impedance is 50Ω, therefore, for best performance, 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 using the equation above.

Low Output - Channel 2

The channel 2, low output connector outputs exactly the same waveforms as the channel 2 high output connector. The only difference is that the low output has fixed amplitude of 2 Vp-p into 50Ω. Either the high or low output connectors are active. The generator defaults to the high output connector therefore, a command must be sent to the instrument to activate the low output connector. The main application for this output is for I & Q modulation.

Low Output - Channel 3

The channel 3, low output connector outputs exactly the same waveforms as the channel 3 high output connector. The only difference is that the low output has a fixed amplitude of 2 Vp-p into 50Ω. Either the high or low output connectors are active. The generator defaults to the high output connector therefore, a command must be sent to the instrument to activate the low output connector. The main application for this output is for I & Q modulation.

SYNC 1 Output

The SYNC1 output generates a single TTL pulse for synchronizing other instruments (i.e., an oscilloscope) to the output waveform. The SYNC1 signal always appears at a fixed point relative to the waveform. The location of the signal along the waveform is programmable.

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SYNC 2 Output

The SYNC2 output generates a single TTL pulse for synchronizing other instruments to the output waveform. The SYNC2 signal always appears at a fixed point relative to the waveform. The location of the signal along the waveform is programmable.

SYNC 3 Output

The SYNC3 output generates a single TTL pulse for synchronizing other instruments to the output waveform. The SYNC3 signal always appears at a fixed point relative to the waveform. The location of the signal along the waveform is programmable.

Trigger 1 Input

In general, the trigger inputs accept signals that stimulate the output waveforms. The trigger input is inactive when channel 1 is in continuous operating mode. When placed in trigger, gated or burst mode, the trigger input is made active and waits for the right condition to trigger the instrument. In *trigger and burst* modes, the trigger input is *edge sensitive*, i.e., it senses transitions from high to low or from low to high to trigger the Model 3153. The direction of the transition is programmable. In *gated mode*, the trigger input is *level sensitive*, i.e., the Model 3153 is gated when the logic level is high and idle when the level is logic low. Trigger level for this input is programmable.

In master-slave mode, the trigger 1 input is also used as the master trigger for the whole generator. When other channels are coupled to channel 1, all other trigger inputs are disabled.

Trigger 2 Input

The trigger 2 input is inactive when channel 2 is in continuous operating mode. When placed in trigger, gated or burst mode, the trigger input is made active and waits for the right condition to trigger the instrument. In *trigger and burst* modes, the trigger input is *edge sensitive*, i.e., it senses transitions from high to low or from low to high to trigger the Model 3153. The direction of the transition is programmable. In *gated mode*, the trigger input is *level sensitive*, i.e., the Model 3153 is gated when the logic level is high and idle when the level is logic low. Trigger 2 input accepts TTL level signals only.

If channel 2 is coupled to channel 1, this input is disabled and channel 1 triggers override the state of this input.

Trigger 3 Input

The trigger 3 input is inactive when channel 3 is in continuous operating mode. When placed in trigger, gated or burst mode, the trigger input is made active and waits for the right condition to trigger the instrument. In *trigger and burst* modes, the trigger input is *edge sensitive*, i.e., it senses transitions from high to low or from low to high to trigger the Model 3153. The direction of the transition is programmable. In *gated mode*, the trigger input is *level sensitive*, i.e., the Model 3153 is gated when the logic level is high and idle when the level is logic low. Trigger 3 input accepts TTL level signals only.

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If channel 3 is coupled to channel 1, this input is disabled and channel 1 triggers override the state of this input.

Stop Input

The stop input operates in conjunction with the trigger (1, 2 or 3) and the start input. The stop input is sensitive to TTL level transitions. Slope sensitivity is programmable for positive or negative edge. The stop signal arms the 3153 to stop at the next breakpoint. When applied, the sample clock is removed and the output waveform stops. A consequent start signal at the start input resumes the generation of the output waveform from the last point it has stopped.

The stop input is active in all operating modes, i.e. continuous, trigger gated, etc., The stop input controls all three channels simultaneously. Typical waveform which, has resulted from the use of the stop, start and trigger inputs is shown in Figure 1-3.

Start Input

The start input operates in conjunction with the stop input. The start input is sensitive to TTL level transitions. Slope sensitivity is programmable for positive or negative edge. Transitions at the start input cause the generator to continue the waveform from the last point it has stopped. The start input is active only after a valid stop signal. Following a stop signal at the stop input, the only signal that will unlock this break is the signal at the start input.

The start input is active in all operating modes, i.e. continuous, trigger gated, etc., The start input controls all three channels simultaneously. Typical waveform which, has resulted from the use of the stop, start and trigger inputs is shown in Figure 1-3.

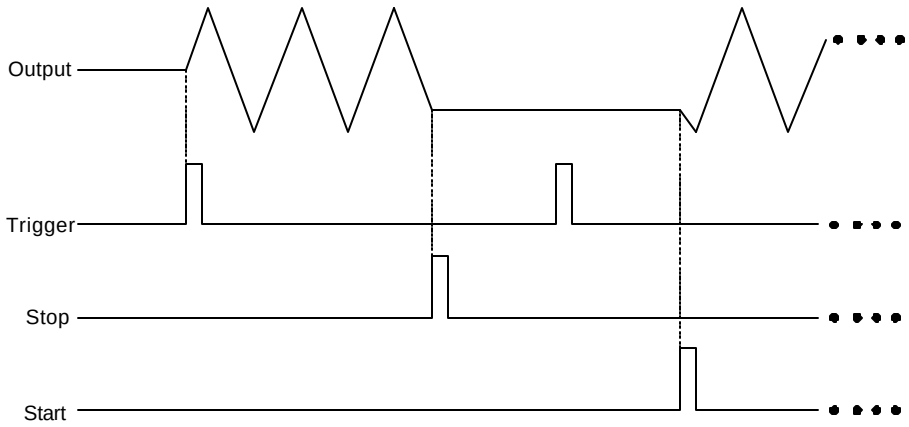


Figure 1-3, Start/Stop Operation in Trigger Mode

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Reference Clock Input

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

Operating Modes

Each of the three channels can be programmed to operate in one of four operating modes: continuous, triggered, gated, and counted burst. These modes are described below. These modes are identical for each channel.

In master-slave mode, the master overrides the operating modes of the slave channels. For example, channel 1 was in triggered mode and channel 2 is in continuous mode. Coupling channel 2 as slave, modifies its operating mode to triggered mode because channel 1 was in triggered mode when channel 2 was made slave.

As was discussed above, when channel 1 is in triggered mode, all other channels are modified automatically to operate in triggered mode. In this case, all channels will start generating waveforms when a valid trigger signal is received at the channel 1 trigger. Note that synchronization in master-slave mode does not require that all waveforms be equal in length. All waveforms will start at exactly the same time and will wait for the longest waveform to complete.

Continuous Mode

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

Triggered Mode

In triggered mode, the Model 3153 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 (channel 1 only) to the desired threshold level. When triggered, the generator outputs one waveform cycle and remains idle at the last point of the waveform. The Model 3153 can be armed to receive a trigger signal from a front panel connector, a VXI backplane TTLTRG<n> or ECLTRG0, or from an internal, programmable trigger generator.

The trigger signal, whether it comes from the front panel or from the VXIbus, has to pass through some electrical circuits. These circuits cause a small delay known as system delay. System delay cannot be eliminated completely. It is, however, minimized in the Model 3153 to approximately 100 ns maximum. System delay is a factor that must be considered when applying a trigger signal. It defines how long it will take from a valid trigger edge to the moment that the output reacts.

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Burst Mode

The burst mode is an extension of the triggered mode where the Model 3153 can be programmed to output a pre-determined number of waveforms. The source to trigger the counted burst cycle can be selected from a front panel connector, VXI backplane trigger lines, or from the built-in trigger generator.

Gated Mode

In gated mode, the Model 3153 circuits are armed to generate output waveforms as long as a gating signal is present. Unlike the triggered mode, the gated mode is level sensitive. When the gating signal goes low, the waveform at the output connector is first completed and the output goes to an idle state. The idle amplitude level, after the gating signal goes low, is the last point on the waveform.

Output Type

The Model 3153 can output three types of waveforms: standard (Fixed), arbitrary (User) and sequenced waveforms. Different waveform types may be assigned to each channel. Waveform type assignments for each channel are retained in separate mode as well as in master-slave mode. Descriptions of the various waveform types that the Model 3153 can generate are provided below.

Standard (Fixed) Waveforms

The Model 3153 generates waveforms from a memory that has to be loaded before the instrument can generate waveforms. There are a number of memory options that are available with the instrument. Memory option must be specified at the time of purchase. **Field upgrade of memory options is not available**. On power up, the waveform memory has no specific data. The sine waveform, being the default waveform on power on, is computed and loaded to the waveform memory as part of the reset procedure. From this moment on, every time that another standard waveform is selected, it is being computed and loaded to the waveform memory.

Waveforms are written from the same start address. Therefore, every time that a new waveform is selected, there is some minimal time for the processor to compute and download the data to the memory.

The Model 3153 can be programmed to output nine different standard waveforms shapes: sine, triangle, square, pulse, ramp, sinc (sine(x)/x) pulse, pulse, gaussian pulse, exponential pulse, and DC. There are number of parameters associated with each waveform which, modify the shape of the waveform to better suite your needs. For example, different start phase for the sine waveform can be programmed for each channel to create phase offsets between two or three output channels.

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Arbitrary (User) Waveforms

The arbitrary waveform memory is capable of storing one or more user-defined waveforms. As was discussed before, and unless ordered differently, the Model 3153 is supplied with 512k, 2 Meg and 2 Meg memory banks with channels 1, 2 and 3, respectively. With the 8 Meg option, there are up to 8 Meg points that can be allocated to one single waveform. On the other hand, there is no need to use the entire memory for only one waveform. The memory can be divided into smaller segments loaded with different waveforms. The instrument can be programmed to output one segment at a time.

Loading data to arbitrary waveform memory can be a time-consuming task, especially if all 8 Meg points are loaded in one shot. The Model 3153 utilizes the VXIbus shared memory concept that speeds data transfer from host computer. In this mode, the memory bank is disconnected from the CPU circuit and re-routed to the bus on the back plane for direct memory accessing by the host computer.

The Model 3153 has separate arbitrary waveform memories for each channel. Each channel can be loaded with different waveforms. Channels are not limited by the number of segments and by the shape of the waveforms regardless if the channels operate separately or in master-slave mode.

Sequenced Waveforms

The sequence generator is a very powerful tool that lets you link and loop segments in any way you desire. As a simple example of a sequenced waveform, look at Figures 1-3 through 1-5. The waveforms shown in these figures were placed in memory segments 1, 2 and 3, respectively. The sequence generator takes these three waveforms links and loops them in a predefined order to generate the waveform shown in Figure 1-6.

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.

The Model 3153 has three separate sequence generators – one for each channel. Each sequence generator is dedicated to its own channel, even in master-slave mode.

Sequence tables must be loaded to the generator before sequenced waveforms can be generated. The data for the sequence table is first prepared on external platforms, then downloaded to the generator. Downloading long sequence table may take some time therefore, such table can be downloaded to the instrument using direct memory access (DMA) routines. Figure 1-7 shows an example how to define a sequence using WaveCAD.

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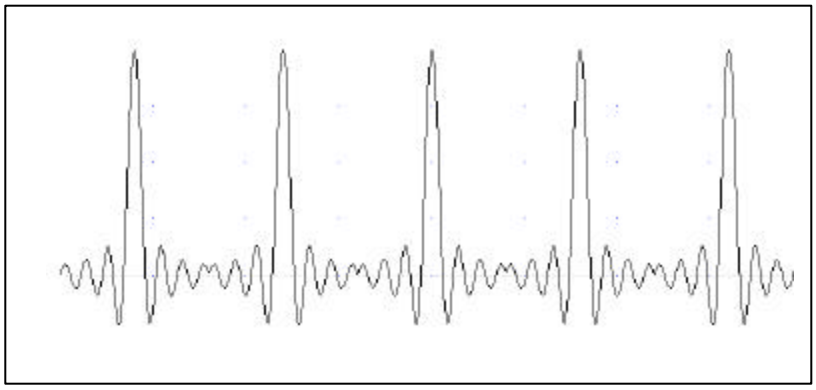


Figure 1- 4, Segment 1 – Sin (x)/x Waveform

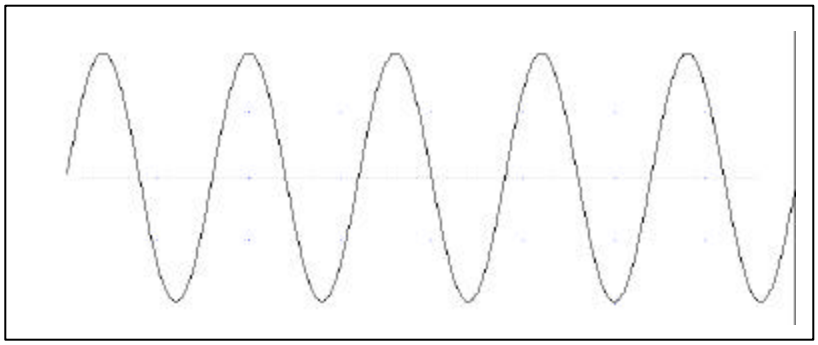


Figure 1- 5,Segment 2 – Sine Waveform

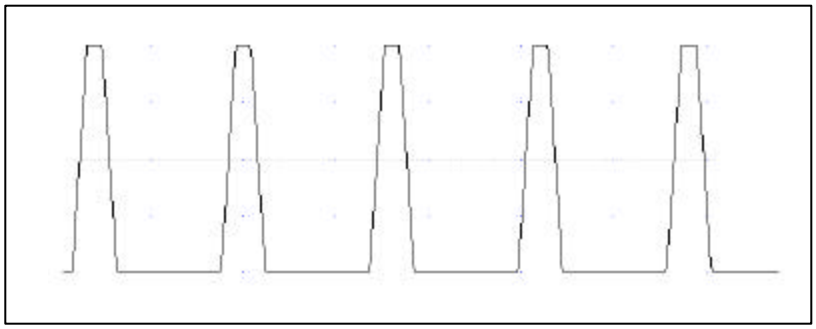


Figure 1- 6. Segment 3 – Pulse Waveform

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

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Figure 1- 7. Sequenced Waveforms

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

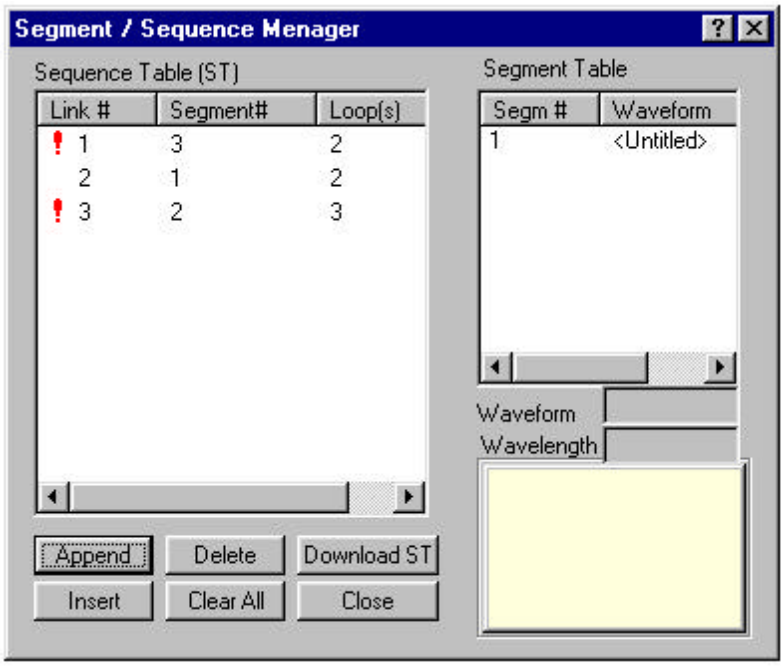


Figure 1- 8, WaveCAD Example

Output State

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

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Filters

Six filters are built into the Model 3153, two for each channel. These filters are available for use in various applications such as the creation of high frequency sine waves and removing the staircase effect from waveforms that are generated with high frequency clock rates.

Front Panel Indicators

There are seven LED's on the front panel. The FAIL LED (Red) illuminates at power-up until the Model 3153 has passed self-test. The FAIL LED remains on if the self-test fails.

The ACCESS LED (Amber) illuminates each time a command has been received by the Model 3153. This light remains on during shared memory data transfer.

When the output state is on, the OUTPUT LED (Green) light illuminates. There are three LED's, one for each channel. Note that the LED's are part of the high output. The signal is always on at the low output connector.

The SCLK1 AND SCLK 2/3 LED's (Green) are off during normal operation. If an external sample clock input is selected, the LED that is associated with the selected connector turns on.

Programming The Model 3153

The Model 3153 has no controls on its front panel. Instrument functions, parameters, and modes can only be accessed through VXIbus commands. There are a number of ways to "talk" to the instrument. They all require that an appropriate software driver be installed in the Resource Manager (slot 0). The rest is a matter of practice and knowledge of the language in use. There are other system considerations like address selection that have to be settled before programming the instrument. These topics are discussed in later chapters.

Low level programming of the Model 3153 is done using SCPI (Standard Commands for Programmable Instruments) language. Programming aspects are covered in Chapters 3 and 4.

High level drivers like VXI*plug&play* and WaveCAD are beyond the scope of this manual. Contact your Racal representative for more information about high level drivers for the Model 3153.

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Chapter 2

CONFIGURING The INSTRUMENT

Installation Overview

This chapter contains information and instructions necessary to prepare the Model 3153 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 handling of sensitive electronic equipment. The contents of all shipping containers should be checked for included accessories and certified against the packing slip to determine that the shipment is complete.

Safety Precautions

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

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

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

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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**" instructions that are supplied with your test fixtures.

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

Performance Checks

The instrument has been inspected for mechanical and electrical performance before shipment from the factory. It is free of physical defects and in perfect electrical order. Check the instrument for any damage sustained in transit and perform the electrical 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) 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 of the BNC connector is connected to earth ground.

WARNING

Do not attempt to float the output(s) from ground as it may damage the Model 3153 and your equipment.

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Long Term Storage or Repackaging For Shipment

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

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

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

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

NOTE

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

Preparation For Use

Preparation for use includes removing the Model instrument 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 the module's address. VXIbus logical addresses can range from 0 to 255, however, addresses 1 to 254 **only** are reserved for VXIbus modules. Logical address 0 is reserved for the Resource Manager. Logical address 255 permits the Resource Manager to dynamically configure the module logical address.

To change the logical address, use the 8-position DIP switch accessible from the top right side of the module near the rear end of the case (switch S1). The switches are marked with numbers 1 to 8. The Model 3153 uses binary values (2^0 to 2^7) to set the logical address using the active low address switch. A switch is active when its arm is placed in the ON position.

Racal Instruments ships the Model 3153 with the logical address set to 2.

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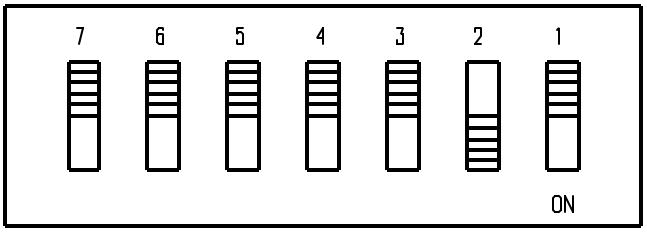


Figure 2-1, Logical Address Set to "2"

Installation

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

After installation, perform an initial checkout and operational verification.

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Chapter 3
USING The INSTRUMENT

Overview

This chapter contains information about how to operate the Model 3153. Unlike bench-type instruments, the Model 3153 must be programmed to turn on functions, change parameters and configure various operating modes. Two graphical interfaces are available for programming the instrument: VXIbus Plug&Play and WaveCAD. LabWindows/CVI drivers and a set of SCPI commands are available for the experienced programmers. SCPI (standard commands for programmable instruments) commands for the Model 3153 are listed in Table 4-1. This manual provides information on low-level programming using SCPI commands only. The following paragraphs describe the various modes of operation and give examples of how to program the Model 3153 using SCPI commands.

Inter-Channel Dependency

The Model 3153 has three output channels. The parameters for each channel may be set separately and each channel may be operated as an independent instrument. Alternatively, two or more channels may be linked and synchronized to operate from one master sample clock, or to start generating waveform from one trigger input. Parameters, waveforms and operating modes are totally independent for each channel. However, in places where inter-channel dependency (synchronization) is required, channel 1 must be programmed as master, while channels 2 and/or 3 may become slaves.

Inter-channel dependency is available in one of these configurations:

1) Channel 1 master, channel 2 slave, channel 3 free-running;

2) Channel 1 master, channel 3 slave, channel 2 free-running;

3) Channel 1 master, channels 2 and 3 slaves

Programming the 3153 for one of the above configurations does not mean that all channels will start generating the same functions and waveforms. The idea is that, in this mode, all channels will a) start generating waveforms when one flag is set true (master trigger) and b) will advance waveforms from one clock source (master clock). Aside from common trigger advance and clock source, the rest of the parameters can be programmed independently for each channel.

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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 cables and terminate the main and SYNC cables with terminating resistors. Always place the 50Ω termination at the far end of the cables.

Input / Output Protection

The Model 3153 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 instrument defaults to some factory pre-selected conditions. A complete list of all parameters, their default values, as well as their maximum and minimum values is given in Chapter 4.

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

```
RESet;
```

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

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What To Do Now

When writing low level code to operate the Model 3153, follow the instructions in this chapter to understand the meaning and response that each command generates. Examples contained in the following paragraphs show basic techniques of how to program output waveforms.

Example 1

The following example programs the Model 3153 to turn on channel 1 and programs the waveform frequency to 10MHz. Then, it programs channel 1 to output a square waveform with amplitude of 2V and offset of 0.5V. Next, it programs channel 2 to output a triangular waveform with amplitude of 1V and offset of 0.5V.

```
/* Reset the Model 3153 to its default state as listed in Table 3-1. */

    :RESet;

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

    :FUNCtion:SHAPe SQUare;

/* Change the frequency to 10MHz. */

    :FREQuency 10e6;

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

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

Note that output peak voltage may never exceed ±5V. Amplitude and offset may be set freely within a 10V window, as long as the following limits are kept:

$$| \text{offset} | + V_{pk\text{-}pk} \div 2 \leq 10$$

```
/* Turn on the channel 1 output. */

    :OUTPut ON;

/* The following command changes control to channel 2. */

    :INSTrument:SELect 2;

/* Set channel 2 amplitude to 1V and the offset to 0.5 V. */

     :VOLTage 1;
    :VOLTage:OFFSet 0.5;
```


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/* Change the output waveform to triangle. */

:FUNCtion:SHAPe TRIangle;

/* Turn on the channel 2 high output. */

:OUTPut ON;

/* Turn on the channel 2 SYNC output, if required. */

:OUTPut:SYNC ON;

If the above commands are executed correctly, a square waveform will be seen on your oscilloscope on channel 1 and a triangle waveform will be seen on channel 2.

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 apply function. For example, the following statement outputs a 5Vpk-pk square wave at 1MHz with a 0V offset and 10% duty cycle using APPLy:

APPL:SQU 1E6, 5, 0, 10

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

APPL:SQU 10E6,,1

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

APPL:SQU 4e6,2

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

APPL:SQU?

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

"1.000000e+6,5.000,0.000,50"

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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, 5Vpk-pk, 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, 5Vpk-pk, 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, 5Vpk-pk, 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, and delay, rise time, high time and fall time parameters. The default settings for these parameters are: 1MHz, 5Vpk-pk, 0V, 0%, 10%, 10% and 10%.

The command:

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

programs the generator to output a ramp waveform with frequency, amplitude, offset, delay, rise time, and fall time parameters. The default settings for these parameters are: 1MHz, 5Vpk-pk, 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, 5Vpk-pk, 0V and 10.

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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, 5Vpk-pk, 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, 5Vpk-pk, 0V and 10.

The command:

APPLy:DC {<percent_amplitude>}

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

The command:

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

programs the generator to output an arbitrary waveform. The specified segment number must be loaded with an arbitrary waveform before the generator can execute this command successfully. This command lets you specify segment number, sampling clock rate, amplitude and offset. The default settings for these parameters are: 1, 1MHz, 5Vpk-pk and 0V.

The query:

APPLy:<function_shape>?

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

The query:

APPLy?

queries parameters associated with the currently selected function shape and returns a string of values depending on the parameters available for the selected function shape. For example, if the generator is programmed to output a ramp waveform, the APPL? command returns: "1e+6, 5, 0 , 0, 10, 10, 10".

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Example 2

The following example programs the Model 3153 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 Model 3153 to its default condition as listed in Table 3-1. */

```
:RESet;
```

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

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

/* Turn the main output on. */

```
:OUTPut ON
```

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

```
:OUTPut:SYNC ON
```

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

Selecting the Active Channel

On power up, the instrument defaults to channel 1. That means that each command sent to the generator affects channel 1 parameters. If you want to send commands to other channels, you must switch the input to other channels. Proceeding channel selection, all command will affect the selected channel only. Use the following command to select the channel you want to program:

```
INSTrument:SELect {1 | 2 | 3}
```

When “1” is selected, commands will control parameters that are unique for the channel 1 output. Selecting “2”, modifies the control to channel 2 parameter. Similarly. Selecting “3”, modifies the control to channel 3 parameter The default option is “1”. Parameters that are common to all three channels may be programmed from either path.

The query:

```
INSTrument:SELect?
```

queries the active channel and returns 1, 2, or 3.

The Control Panel from WaveCAD is shown in Figure 3-1 demonstrates high-level implementation of channel control.

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Enabling the Main (High) Outputs

3153 waveforms are generated using data points that are downloaded to a waveform memory. Using the sample clock generator, the data is clocked to the digital to analog converter (DAC) which, in turn, generates the waveform shape that was downloaded to the arbitrary waveform memory.

The DAC itself can not be connected directly to the main output because it does not have sufficient drive capabilities, nor does it have the amplitude and offset control, which is required at the output connector. To overcome this problem, a high-power output amplifier circuit is installed directly after the DAC. The amplifier circuit includes gain, offset, attenuation and stand-by control. The output amplifier is the circuit that connects to the output connector.

For safety reasons, 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 and an LED near the output connector illuminates. In the OFF position, the output connector is disconnected from the output amplifier by means of a mechanical relay.

CAUTION

Ensure that voltage is not applied to the main output connector when the Model 3153 output state is programmed to ON.

The query:

OUTPut?

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

Enabling the Low Outputs

The Model 3153 has three high-level output connectors that have amplitude and offset control. Channels 2 and 3 also have low-level output connectors. The low-level outputs are connected directly from the DAC through a buffer amplifier. Amplitude from these connectors is fixed at 2Vpk-pk into 50Ω.

The low-level outputs are used in applications where signal purity and high signal-to-noise ratio are crucial. The signal at the output of the DAC circuit predominantly has these signal qualities. To minimize damage that may be caused by external misuse of this output, the signal from the DAC is buffered before it is applied to the low-level output connector.

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Waveforms from the high and low level outputs are not available at the same time. Either the low-level outputs or the high-level outputs can be made active at a time. If turned on, the high level outputs are active first. For safety reasons, the low-level outputs are turned off when the generator is first turned on.

Use the following command to enable the low-level output:

OUTPut:TYPE {HIGH | LOW}

The default state is **HIGH**. This means that when the output is turned on (OUTP ON), the signal will be available from the high-level output connector. Use the **LOW** option to route the DAC circuit to the low-level output.

The query:

OUTPut:TYPE?

queries the output type and returns HIGH or LOW.

Output Configuration Commands

The output configuration commands control the output function, shape, frequency, amplitude, filter and state. The Instrument Control Panel from WaveCAD below demonstrates high-level implementation of output control.

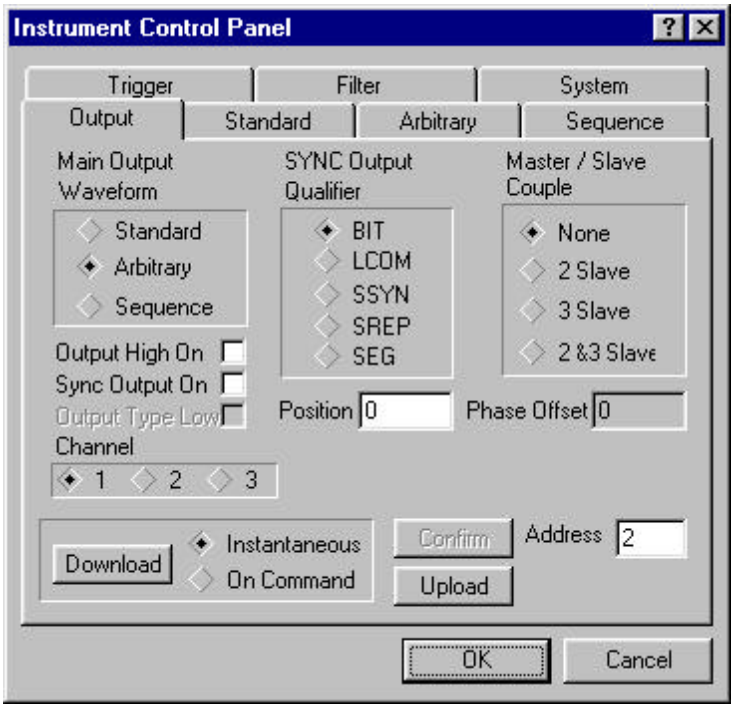


Figure 3-1, Output Control with a WaveCAD Panel

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Selecting an Output Type

There are three main types of waveforms that the model 3153 can produce: Standard (fixed), Arbitrary (user) and Sequenced waveforms. Standard waveforms are computed from formulas that are built into the Model 3153. The instrument can output arbitrary and sequenced waveforms only after waveform, segment, and sequence data has been downloaded into its memory.

Use the following command to select the output function type:

FUNCtion:MODE {FIXed | USER | SEQuence}

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

The query:

FUNCtion:MODE?

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

Selecting a Standard Function Shape

Standard (fixed) waveforms are built into the instrument’s program. Nine standard function shapes are available: Sine, Triangle, Square, Pulse, Ramp, Sinc, Exponential decaying pulse, Gaussian pulse, and dc. Every time a standard function is selected the coordinates for this function are re-computed and placed in the waveform memory. Therefore, there is a minimal delay from when you select the function until the output starts generating the waveform.

Use the following command to select a standard output function:

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

The selected waveform is generated using the previously selected frequency, amplitude, offset, and other relevant settings. The standard waveform is available at the output connector 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, or DC.

The Standard Waveform Instrument Control Panel from WaveCAD is shown in Figure 3-2 as an example of a high-level implementation of Standard Waveform Selection.

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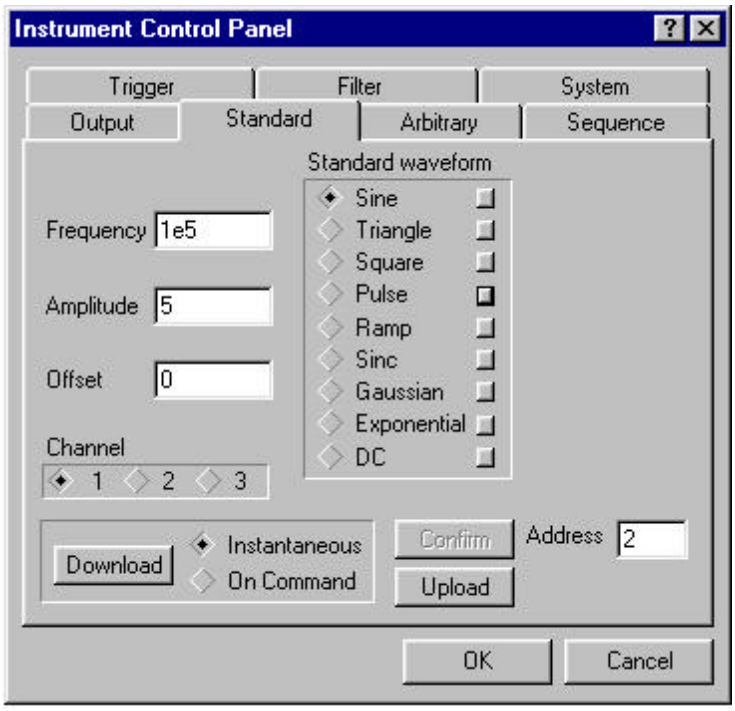


Figure 3-2, Standard Waveform Selection Panel from WaveCAD

Changing the Frequency and Sample Clock

Users should be careful not to confuse waveform frequency with sample clock frequency. The waveform frequency parameter is valid for standard waveforms only and controls waveform frequency at the output connector. On the other hand, the sample clock frequency parameter is valid for arbitrary waveforms only and defines the frequency at which the generator clocks data points.

Standard waveform frequency is measured in units of Hertz (Hz). Arbitrary waveform sample clock frequency is measured in units of Samples per second (Sa/s). The frequency of a given arbitrary waveform at the output connector must be computed using the sample clock frequency and the number of data points. Use the following equation for computing the frequency of (one cycle of) an arbitrary waveform:

Frequency = Sample Clock / Number of data points

For example, using a sample clock of 80MSa/s with a 1000-point waveform will generate an 80kHz waveform at the output connector.

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 parameters.

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The query:

FREQuency?

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

The command:

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

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

Selecting the External SCLK

The Model 3153 has three independent sample clock generators, one for each channel. The three sample clock generators allow each of the output channels to generate its own waveform frequency.

In cases where synchronization to other instruments in the system is needed, one may use the front panel SCLK 1 and SCLK 2/3 inputs for replacing the internal sample clock generators. Although there are three channels, the Model 3153 has only two inputs for external sample clock signals. SCLK 1 can be used for channel 1 only and SCLK 2/3 can be used for one of channels 2 or 3 or both.

When channels 2 or 3 are coupled to channel 1, the SCLK 2/3 input is disabled and SCLK 1 is distributed as the sample clock signal to the slave channels, if selected. Use the following command to select the external SCLK input:

FREQuency:RASTer:SOURce {INTernal | EXTernal}

INT is the default state of the instrument after power up. Select EXT to activate the front panel SCLK 1 or SCLK 2/3 inputs. An LED turns on with the selected input.

The query:

FREQuency:RASTer:SOURce?

queries the sample clock source and returns INT or EXT.

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Selecting the Reference Oscillator

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

ROSCillator:SOURce {CLK10 | EXTernal }

CLK10 is the standard reference for the Model 3153. EXT connects the front panel reference input to the main clock circuit. The frequency of the reference oscillator is always 10MHz however, since CLK10 is accurate to within 100 ppm only, the accuracy and stability of the Model 3153 may be improved by applying an external reference to the front panel input.

The query:

ROSCillator:SOURce?

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

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 5.00V (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.

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Amplitude-Offset Interaction

Offset voltage is injected at the input of the output amplifier. Therefore, reducing the output amplitude has an automatic affect on the offset voltage. The 3153 has three internal amplitude ranges that are transparent to the user. However, it is necessary to understand these ranges in case a specific amplitude-offset combination is needed. The relationship between the internal amplitude ranges, their respective offset ranges and the resultant peak range limits are given in the equation and the table below.

$$\frac{Amplitude}{2} + |Offset| \leq PeakRangeLimit$$

Internal Amplitude Range	Offset Range	Peak Range Limit
10.00mV to 99.99mV	0 to 45.00mV	50mV
100.0mV to 999.9mV	0 to 450.0mV	500mV
1.000V to 10.00V	0 to 4.500mV	5V

Amplitude-offset settings outside these limits generate "settings conflict" errors. Amplitude setting determines the range of the offset. For example, lets compute the maximum allowed offset range for an amplitude of 800mV:

Offset Range = 500mV - 800mV/2 = 0 to 100mV

Programming 200mV in this case generates a settings conflict error.

Selecting the Filter Type

Two filters are available for each channel. These filters have fixed cutoff frequencies, the characteristics of which are specified in Appendix A. The built-in filters are switched in downstream from the DAC circuit and are used for reducing the noise, harmonics and spurious signals above the specified cutoff frequency.

The built-in filters are available to the user in standard, arbitrary and sequenced modes. The only built-in function that does not allow external control of the filter is the sine waveshape, where filters are used to shape the sine from a rectangular waveform.

Filters are selected by their reference number, not be their cutoff frequencies. Use the following command to select the filter type:

OUTPut:FILTer {NONE | 1 | 2 | ALL}

selects the filter for the currently active function.

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Note

The default output function of the generator is the sine waveform. The instrument uses filters to generate this waveform. Therefore, the state of the OUTP:FILT can not be changed until another output function is selected. A settings conflict error will occur if one attempts to change the filter state before changing to another output function.

The default filter setting is NONE, meaning that no filter is selected after power on. A setting of 1 and 2 are different for each channel. Below is a list of filter types that can be switched in using this command. The command ALL is used to switch in both filters.

Channel 1 filters:

Filter Type	Cutoff Frequency
1	50 MHz
2	25 MHz

Channel 2 filters:

Filter Type	Cutoff Frequency
1	25 MHz
2	12.5 MHz

Channel 3 filters:

Filter Type	Cutoff Frequency
1	25 MHz
2	250kHz

The query:

OUTPut:FILTer?

queries the currently selected filter setting and returns either NONE, 1, 2 or ALL.

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

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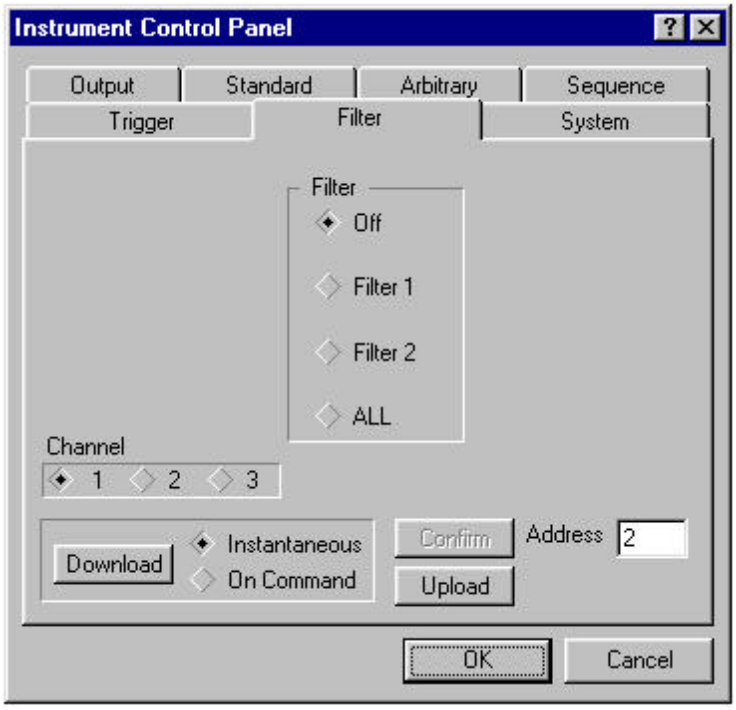


Figure 3-3, WaveCAD Filter Control Panel

Selecting an Operating Mode

The Model 3153 offers four operating modes: Continuous, Triggered, Gated and Burst. The selected waveform is repeated continuously when the instrument is set to operate in Continuous mode. In this mode, the Model 3153 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 or output a burst of waveforms is given in the following paragraphs. The WaveCAD Trigger control panel shows a high-level example of selecting the trigger mode.

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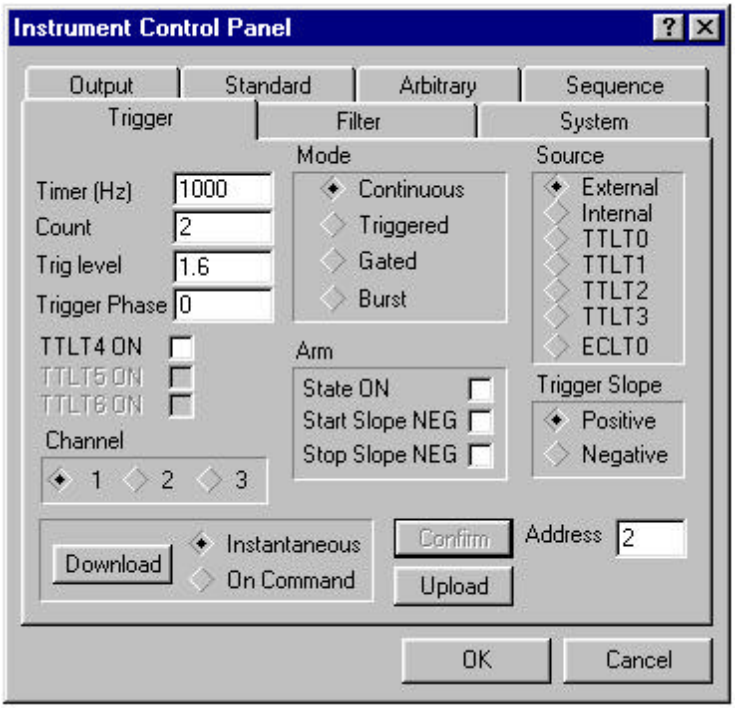


Figure 3-4, WaveCAD Control Panel for Trigger Mode

Triggered Mode

In Triggered mode, the output remains at a certain DC level as long as the TRIG IN signal from the front panel remains inactive. The trigger input is sensitive to either a rising edge or a falling edge. Each time a transition at the trigger input occurs, the Model 3153 generates one complete output waveform. At the end of the output cycle, the output resumes position at a DC level that is equal to the amplitude of the last point of the waveform.

The Triggered mode operates on standard waveforms and arbitrary waveforms. Observe the limitations of the trigger signal as listed in the specification section of this manual. To place the Model 3153 in Triggered mode, use the following command:

INITitiate:CONTinuous {OFF | ON}

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

The query:

INITitiate:CONTinuous?

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

There are a few things to consider when placing one or more channels in triggered mode:

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1. You can mix operating modes between channels.
2. Each channel has its own trigger input.
3. Channels can be coupled for synchronous operation. When coupled, channel 1 becomes master and channels 2, 3 or both become slaves.
4. In master-slave mode, the channel 1 trigger input is available. All other inputs are disabled.
5. Start phase relationship is retained in master-slave mode. All channels will start generating waveforms at the same time regardless of their respective sample clock frequency. There is a possibility of a forced delay after trigger to account for the channel with the slowest waveform in the loop.
6. The Master channel overrides operating modes of the slave channels. Slave channels recover to their previous operating mode (i.e., continuous, trigger modes, etc.) after de-coupling from the master channel.

Gated Mode

The Model 3153 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 front-panel TRIG IN signal remains inactive. The gating signal can be programmed to be either active high or active low. As long as the proper level is present at the trigger input connector, the Model 3153 generates output waveforms. 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. To place the Model 3153 in Gated mode, use the following commands:

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

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

The query:

```
TRIGger:GATE?
```

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

Burst Mode

Burst mode is very similar to Triggered mode with the exception that only one trigger signal is needed to generate a counted number of output waveforms. In Burst mode, the output remains at a DC level as long as the TRIG IN signal from the front panel remains inactive. The trigger input is sensitive to either the rising edge or the falling edge. Each time a transition at the trigger input occurs, the Model 3153 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 1Meg. The default burst value is 1.

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Burst mode operates with standard waveforms and arbitrary waveforms only. Note that the Model 3153 cannot operate in Sequence and Burst modes simultaneously. Observe the limitations of the trigger signal as listed in the specification section of this manual. To place the Model 3153 in Burst mode, use the following commands:

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

INIT:CONT OFF places the Model 3153 in a non-continuous mode. TRIG:BURS ON turns the burst function on. The TRIG:COUN specifies the number of output waveforms 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 "0" (OFF) or "1" (ON).

The query:

```
TRIGger:COUNt?
```

queries the burst count and returns an integer.

Selecting the Trigger Source

When an external source is not available, use either the built-in trigger generator or a backplane trigger to stimulate its output.

Use the following command to select the trigger source for the instrument:

```
TRIGger:SOURce:ADVance {EXTernal | INTernal | TTLTrg<n> | ECLTrg0}
```

EXT is the default trigger source for the Model 3153. Select the TTLT<n> option with <n> ranging from 0 to 3 or ECLT0 to use one of the trigger lines available on the backplane. Select INT to use the internal trigger generator. Remember to program the period of the internal generator (as shown later).

The query:

```
TRIGger:SOURce:ADVance?
```

queries the trigger source and returns EXT, INT, TTLT<n> or ECLT0.

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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 and 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 20µs to 1000s. The default period is 100µs. The internal trigger generator is ignored when either an external, TTLTrig or ECLTrig source is enabled.

The query:

TRIGger:TIMer?

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

Selecting the Trigger Slope

The trigger slope command toggles edge sensitivity for the selected trigger input. The Model 3153 can be made sensitive to either positive or negative transitions. Use the following command to select the slope for the trigger signal:

TRIGger:SLOPe {POSitive | NEGative}

Positive going transitions trigger the Model 3153 when the POS option is selected. Negative transitions trigger the Model 3153 when the NEG option is selected. POS is the default slope. In Gated mode, a high level gates the generator when the POS option is selected; a low level does 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. Note that only channel 1 has this feature; trigger inputs to other channels have fixed TTL level thresholds.

Trigger level is adjustable from -10V to +10V 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>

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

The query:

TRIGger:LEVel?

queries the trigger level and returns a value in Volts.

Programming the Trigger's Start Phase Offset

The model 3153 generates waveforms from its memory. The waveforms are either downloaded by the user, or computed from built-in equations. For example, if you select the sine waveform, the 3153 has to compute this function and place the appropriate values in its memory. The waveform is then generated by applying the digital point values to the DAC.

Having full control over point position is an advantage because now one can specify what will be the first point to be clocked by the generator. This control is referred to as trigger's start phase offset. The parameter is programmed in waveform points. For example, a 4000-point sine waveform is downloaded and the generator is set for triggered mode with the start phase offset set to 1000 points (1000/4000x360=90°). The output will generate positive going haversines. Similarly, if you set the start phase offset to 3000 points(3000/4000x360=270°), the output will generate negative going haversines.

Note:

The phase offset parameter is programmable in integer multiples of 4 points. If you use phase offset values that are not divisible by 4, the generator automatically rounds the number up or down to the nearest valid multiple of 4.

Use the following command to program the start phase offset:

TRIGger:PHASe <trigger_phase_offset>

Trigger phase offset is set in waveform points.

The query:

TRIGger:PHASe?

queries the trigger phase offset and returns an integer number

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Using the Soft Trigger

The soft trigger command allows you to write a program that can trigger the 3153 directly from within your application. To use the soft trigger command, place the instrument in TRIG:SOUR EXT mode. Soft triggers are ignored in INTernal, TTLT<n> and ECLT0 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 command to trigger the Model 3153 in Trigger, Burst or Triggered Sequence Advance modes.

Enabling the SYNC Outputs

The 3153 has three SYNC outputs designated as SYNC1, SYNC2 and SYNC3. The SYNC outputs generate signals that are synchronous to the main output waveform. Output level is fixed however, some other parameters can be programmed to make the 3153 generate these signals at specific locations, width and with certain qualifications. Information on how to set the various SYNC parameters is given below.

For safety reasons, SYNC outputs default to OFF. Enable or disable the SYNC outputs using the following command:

OUTPut:SYNC {OFF | ON}

ON enables the SYNC output and generates TTL level pulses. OFF disables the SYNC output and places a logical “0” at the output connector.

The query:

OUTPut:SYNC?

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

Assigning the Source For The SYNC Output

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

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

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

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

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

SREPetition Generates a sync signal at the start of each wave segment repetition within a sequence.

SEGment Generates a sync at the start of the first repetition of each wave segment within a sequence.

The query:

OUTPut:SYNC:SOURce?

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

Selecting the SYNC Position

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

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.

Setting the SYNC Width

The width of the SYNC output pulse can be programmed to any width from 4 to 800 points by setting the width parameter to 1 to 200. This is because the setting resolution is 4 points. Use the following command to select the SYNC pulse width:

OUTPut:SYNC:WIDTh <value>

For example, if you load a 1000 point waveform and use sample clock of 1Msa/s, the command:

OUTPut:SYNC:WIDTh 50

generates a sync width output of 50 x 4 x 1 µs = 200 µs.

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Computing the sync width in FIXed mode is a bit trickier. In this mode, the 3153 computes the number of points and the sample clock from the programmed waveform frequency. Therefore, setting the required sync width in FIXed mode may take some experimenting until you find the right value. You can compute the exact number of points from the equations given on pages 3-26 and 3-27.

The query:

OUTPut:SYNC:WIDTh?

queries the output SYNC width and returns an integer value that is the value of the SYNC pulse width in points divided by four.

Activating the Backplane ECLTRG and TTLTRG Lines

The Model 3153 can receive signals on VXIbus ECLTRG line zero and TTLTRG lines zero through three. The instrument can also transmit signals on VXIbus TTLTRG 4 through 6. Note that TTLT lines zero through 3 and ECLT0 can be used as inputs only while TTLT 4 through 6 can be used as outputs only.

As was mentioned above, the TTLTRG lines zero through three can only be used as inputs, while TTLTRG lines 4 through 6 can only be used as outputs.

Use the following command to generate triggers on the backplane using one or more of the backplane TTLTRG lines:

OUTPut:TTLTrg<n> { OFF | ON}

where <n> designates the activated trigger line 4 through 6. 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).

Using the Start and Stop inputs

Start and Stop inputs are provided at the front panel. The purpose of these inputs is to allow external intervention with the normal generation of output waveforms. Figure 3-6 below shows an example of how waveforms are affected using the start and stop signals.

There is only one set of start and stop inputs. These inputs can be allocated to channels using the ARM command. In master-slave mode, and if these inputs were allocated to channel 1, transitions at these inputs will affect all channels that are slaved to channel 1 automatically.

The start and stop inputs are active after they have been armed. However, the start signal has no affect on the waveform before applying the stop signal. After the stop signal has stopped the waveform, the only signal that will re-start it is the start signal. Trigger signals during the stop interval are ignored.

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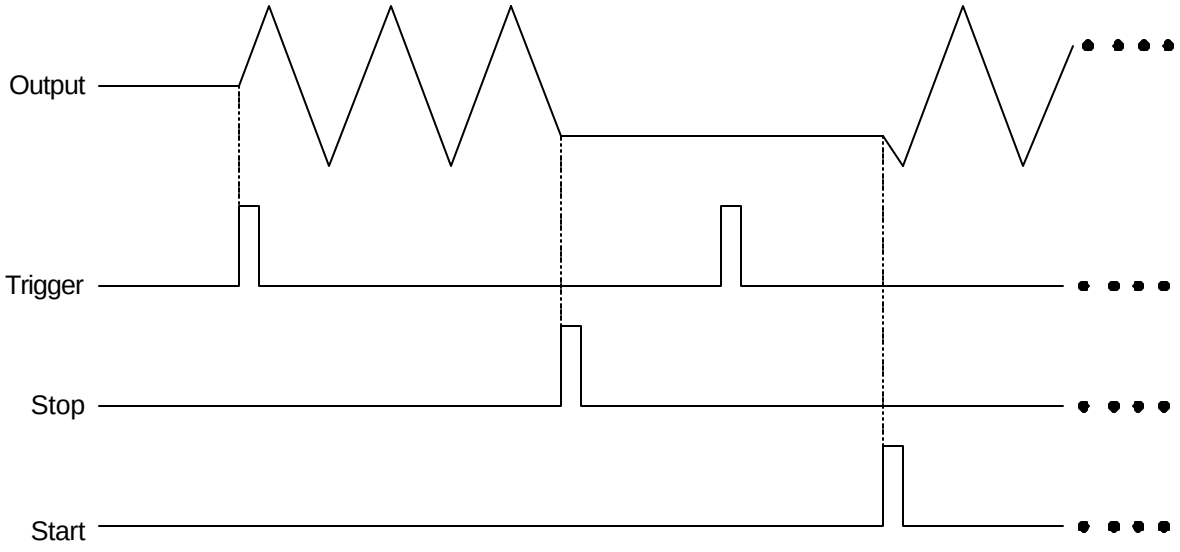


Figure 3-5, Start Stop Operation

The start and stop inputs accept TTL level signals. The Model 3153 reacts to transitions – either positive or negative going.

The start and stop inputs affect the instrument in all of its operating modes, i.e., continuous, triggered, sequence, etc. The sequence of events to start and stop the waveform is as follows:

1. Select the channel you want to arm using the INST:SEL command.
2. Arm the active channel using the following command:

   ARM {OFF | ON}

“ON” arms the generator and connects the start and stop inputs, “OFF” disables the start and stop inputs.

The query:

ARM?

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

3. The next step is to select edge sensitivity. Use the following commands to select the slope for the start input:

   ARM:SLOPe {POSitive | NEGative}

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Select “POS”, the default state, which causes the 3153 to start on positive going transitions. Select “NEG” to start on negative going transitions.

The query:

ARM:SLOP?

queries the state and returns POS or NEG.

4. Use the following commands to select the slope for the stop input:

ARM:SLOPe:STOP {POSitive | NEGative}

Select “POS”, the default state, which causes the 3153 to stop on positive going transitions. Select “NEG” to stop on negative going transitions.

The query:

ARM:SLOP:STOP?

queries the state and returns POS or NEG.

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, 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 for generating standard waveforms at various frequencies is computed as follows:

Channel 1:

Frequency ≤ 97.6562kHz, Points = 1024
Frequency > 97.6562kHz, Points = N

Channel 2:

Frequency ≤ 48.8281kHz, Points = 1024
Frequency > 48.8281kHz, Points = N

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Channel 1:

$$N = 8 \times 2^{INT\left\{\log_2\left[\frac{INT\frac{100}{FREQ}}{8}\right]\right\}}$$

Channels 2/3:

$$N = 8 \times 2^{INT\left\{\log_2\left[\frac{INT\frac{50}{FREQ}}{8}\right]\right\}}$$

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

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

For the positive EXPonential:

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

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

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For the negative EXPonential:

$$F(m) = -\frac{A}{2} + \frac{A}{2}\left[e^{\frac{m}{7.7i}} - 1\right]$$

For the GAUSsian:

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

For the SINC:

$$F(m) = \frac{Sine\left(2\pi\frac{m}{R}\right)A}{2\pi\frac{m}{R}}$$

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

Standard waveforms are available at the output connector after the FUNC:MODE FIX command has been executed.

When using FUNC:SHAP PULS mode, parameters for the PULSe function shape can be modified, immediately changing the output waveform. Note that changes made to pulse parameters are independent of other parameters.

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 transition 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 100ms, 5% rise time equals 5ms. Pulse rise time is

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measured between the two transition points of the first edge.

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 transition 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 transition points of the falling edge.

The query:

PULSe:TRANsition:TRAiling?

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

Generating Arbitrary Waveforms

The Model 3153 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.

The Model 3153 has the following waveform memory capacity:

Channel 1 - 512k standard, 2Meg optional

Channel 2/3 – 2Meg standard, 4 and 8Meg optional

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Each horizontal point has a unique address - the first being 00000 and the last depends on the memory option. In cases where smaller waveform lengths are required, the waveform memory can be divided into smaller segments. Then it is possible to select which segment is sampled, how many times and in what sequence.

When the instrument is programmed to output arbitrary waveforms, the clock samples the data points (one at a time) from address 0 to the last address. The rate at which each sample is replayed is defined by the sample clock rate parameter. The Model 3153 provides programmable sample clock rates from 10Sa/s to 100MSa/s.

The Arbitrary Waveform screen together with the Instrument Control Panel (figure 3-6) in WaveCAD allow arbitrary waveforms to be created graphically.

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 below.

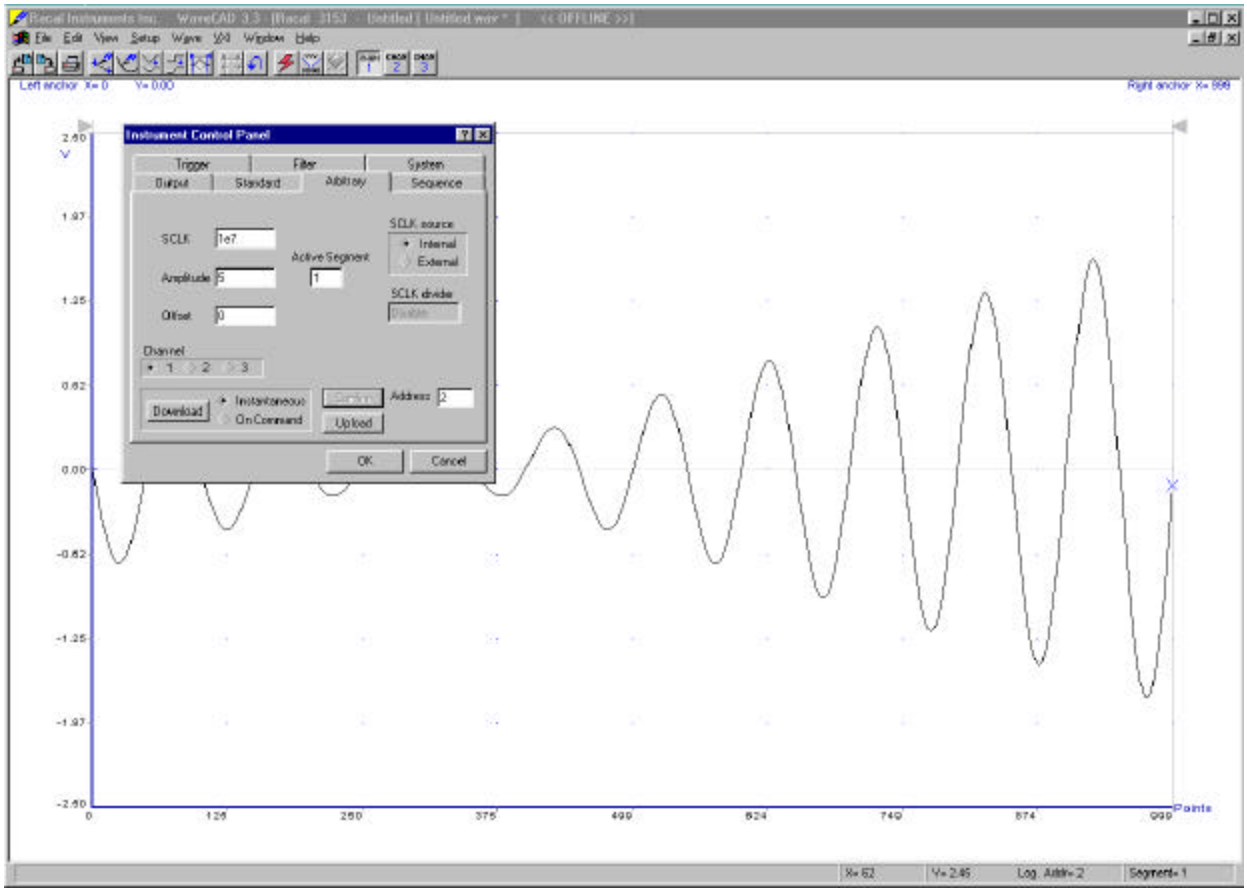


Figure 3-6, WaveCAD's Arbitrary Waveform Control Panel

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Arbitrary Memory Management

The arbitrary memory in comprised of a finite number of words. The maximum size arbitrary waveform that can be loaded into memory depends on the option that is installed in your instrument. The various options are listed in Chapter 1 of this manual. If you purchased the Model 3153 with in its basic configuration, you should expect to have 512k for channel 1 and 2Meg each for channels 2 and 3.

Waveforms are created using small sections of the arbitrary memory. The memory can be partitioned into smaller segments (up to 4096) and different waveforms can be loaded into each segment, each having a unique length. Minimum segment size is 8 points, as long as its playback time is more than 10 µs. Information on how to partition the memory is given in the following paragraphs.

Memory Management Commands

Arbitrary memory can be divided into smaller segments; up to 4096 different arbitrary waveforms can be stored in the Model 3153'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>

Note that numbers, not names, are assigned to segments. Segment numbers can range from 1 through 4096. The order of assignment is not important as long as segment size does not change after they have already been defined.

Note

Minimum segment length is 8 points. Segment size may be set from 8 points to the maximum memory size, in increments of 4 points. A size of 1002 is not a valid segment length since it is not evenly divisible by 4. An error will occur if 1002 points is assigned to a segment.

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 you intend to use.

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

TRACe:DELete: ALL

CAUTION

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

Loading Arbitrary Waveforms

There are three ways to load waveforms into the 3153; 1) Using a graphical user interface, i.e., WaveCAD, 2) LabWindows/ CVI or LabVIEW driver, or 3) Low-level programming. When using WaveCAD, disregard most of this chapter as WaveCAD does the work for you. If you write your own application or instrument driver, use the following commands to load data into a specific memory segment.

First, define the work area. Define the segment number and its associated length. The segment length must be divisible by four or an error will occur. For example, to use segment number 8 with a waveform length of 1048 points use this command:

TRACe:DEFine 8,1048

Next, make segment 8 the active segment. The active segment must be selected because as waveforms are loaded, the Model 3153 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 can be loaded into the Model 3153 using a high-speed binary word serial transfer mode. 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 small quantities of data. Faster data transfer rates are available using shared memory, discussed below.

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The Model 3153 accepts this command to transfer arbitrary waveform data 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.

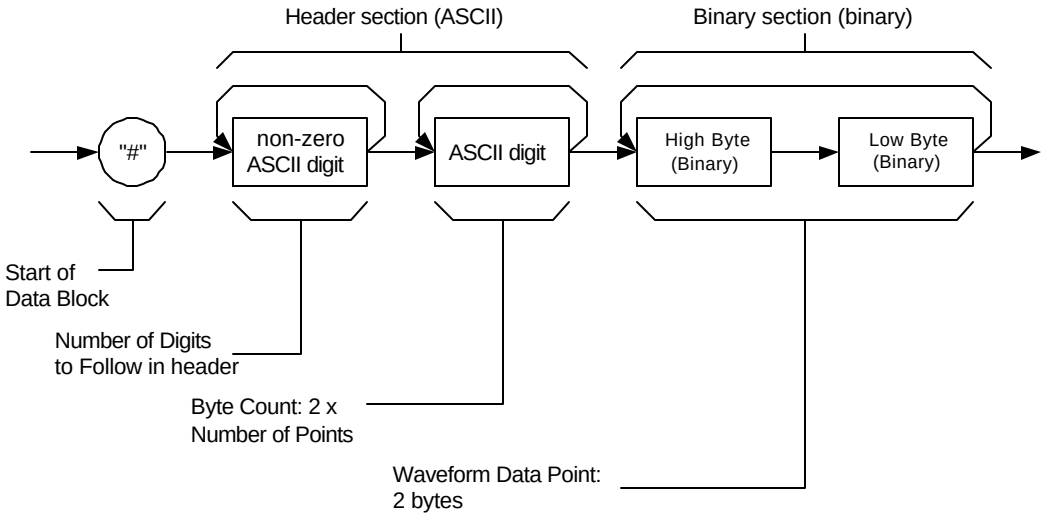


Figure 3-7, Definite Length Arbitrary Block Data Format

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 Model 3153, the final byte must be transmitted with the EOI bit set. Carriage Return and Line Feed will not be detected as terminators. This permits the values ODH and OAH to be used as data points. The IEEE-STD-488.2 definition of Definite Length Arbitrary Block Data Format is demonstrated in Figure 3-7.

16 bits of data are sent to the Model 3153 even though only 12 bits are required to generate the waveform. The order of bytes and bits and their values are shown in Figure 3-8.

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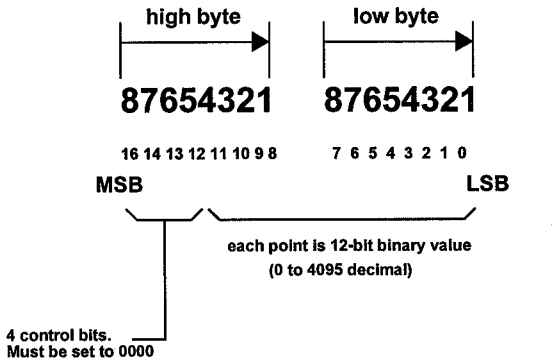


Figure 3-8, 12-Bit Waveform Data Format

Note

The Model 3153 operates in interlaced mode where four memory cells generate one byte of data. Segment size can be programmed in numbers evenly divisible by four only. For example, 2096 bytes is an acceptable length for a binary block. 2002 is not a multiple of 4, therefore the generator will generate an error message if this segment length is used.

Reversing Byte Order

Binary data is sent to the Model 3153 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 to the Model 3153. In shared memory mode, the Model 3153'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 or A32 memory space. Byte and bit order is shown in Figure 3-9. Waveform points must be loaded in groups of 4 words. After the data is loaded into the Model 3153, control is returned to the instrument.

In shared memory mode, the Model 3153's memory acts like Direct

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Memory Access (DMA). The instrument has to be told when to receive data, send data, surrender control or gain control. The Model 3153 has an auto-increment address counter. The Slot 0 Controller need only select the base address for the write cycle. Shared Memory commands are explained below.

To write to a segment, the user must first define the segment using the TRACe:DEFine command or by using the high speed segment table download feature. The trace must then be selected using the TRACe:SELect command. Refer to Loading Arbitrary Waveforms or Fast Binary Segment Table Downloads for more information.

The command:

SMEMory:TYPE { WAVE | SEGment | SEQuence }

sets the DMA port to receive either waveform data, segment table data or sequence table data. Segment and sequence table data will be discussed later in this chapter.

The query:

SMEMory:TYPE?

queries the shared memory type and returns WAVE, SEG or SEQ.

The command:

SMEMory: {OFF | ON}

places the Model 3153 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?

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

The following sequence should be used for shared memory transfers:

```
TRAC:DEF (n),(m)
TRAC:SEL <n>
SMEM:TYPE WAVE
SMEM:STATE ON
```


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

SMEM:STATE OFF

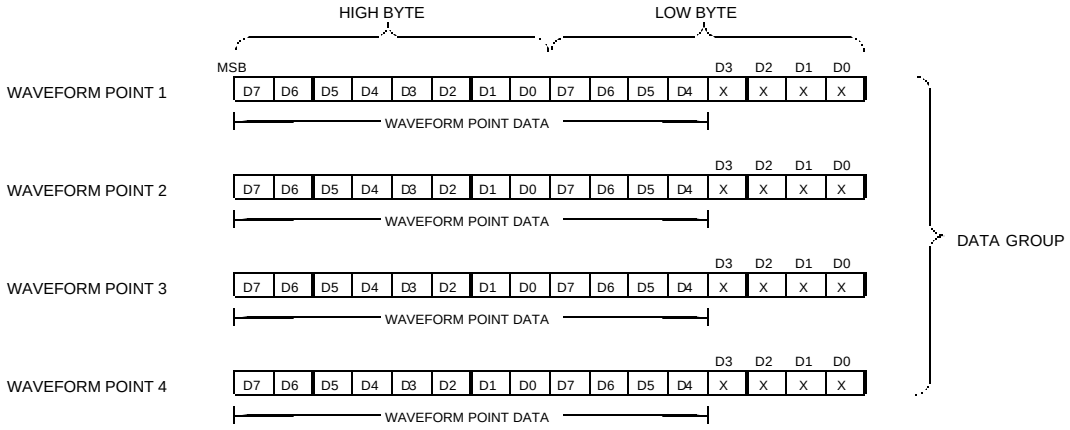


Figure 3-9, Data format for shared memory download

The following program fragment shows an example of programming the 3153

```
#include <visa.h>
#include <ansi_c.h>
#include "ri3153.h"
#include <cvirte.h>    /* Needed if linking in external compiler; harmless otherwise */
/*============================================================================*/
/* Function: Load Arbitrary Data
                        */
/* Location: ri3153.c
                                        */
/* Purpose:  This function loads arbitrary data into the specified segment */
/*============================================================================*/
ViStatus _VI_FUNC ri3153_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 = ri3153_int_range (segment_number, RI3153_MIN_SEG_NUMBER,
```


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```
                    RI3153_MAX_SEG_NUMBER, VI_ERROR_PARAMETER2))
                    return( error );

          max_size = ri3153_get_mem_size(vi);
          if (error = ri3153_int32_range (number_of_points, RI3153_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, RI3153_READ_LEN, &cnt)) < 0)
                    return( error );

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


          if ((error = viRead(vi, (unsigned char *) readbuf, RI3153_READ_LEN, &cnt)) < 0)
                    return( error );

          if (readbuf[0] != '1')
                    return( RI3153_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( RI3153_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( RI3153_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,
```


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```
                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 3153 in slot 7 */
        ri3153_init ("VXI::7::INSTR", 1, 1, &vi);

        /* Select Arbitrary waveform mode */
        ri3153_select_waveform_mode (vi, RI3153_MODE_ARB);

        /* Turn Output on */
        ri3153_output (vi, RI3153_OUTPUT_ON);
        /* Define Segment 1 */
        ri3153_define_arb_segment (vi, 1, 24, 1);
        /* Download 24 points */
        ri3153_load_arb_data (vi, 1, data_pts, 24);
}
```

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

16-Bit Shared Memory Download

When you download waveform data using the standard shared memory routine, the Model 3153 accepts waveform data only and the internal CPU places the various bits that control segment length, SYNC position, etc. Look at Figure 3-9 and observe that you must download 16 bits, of which only 12 determine point value while the other 4 bits are not used.

The process of downloading waveforms, using the standard shared memory mode requires a few steps: 1) Select segment, 2) Define segment length, 3) Define SYNC position, 4) Define breakpoint, 5) Select the active segment etc. These operations are multiplied by the number of segments that you want to program.

The 16-bit shared memory download mode lets you bypass all of these steps and program the entire memory, including SYNC, trigger start point, break point and stop bit in one download process, thus saving many valuable time.

There is a basic difference between the two download modes. The standard shared memory download mode lets you download waveforms alone. After the waveform has downloaded the CPU takes control and performs the basic tasks such as placing the data at the appropriate start address, SYNC, break point and trigger offset bits and setting the stop bits. The information to set these bits is calculated by the CPU and therefore, the internal circuit has full control over the memory function.

In contrast, when the download mode is changed to 16-bit shared memory download, one must expect that control be passed from the instrument to the user. In this case, the CPU does not perform control bit settings so it is entirely up to the user to place all bits at the exact location otherwise the Model 3153 will not generate waveforms as

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expected.

Use the commands below to download waveform data using the 16-bit shared memory download mode:

Change the download mode to 16-bit using the following command:

FORMat:WAVE {NORMal | USER}

NORM is the default setting. USER places the Model 3153 in 16-bit memory download mode.

WARNING

Changing modes from NORM to USER and vice-versa is destructive to the waveform memory. This command has an affect on the segment table and SYNC and break point bits location. Other parameters, such as amplitude, offset and sample clock frequency are not affected by this command.

The query:

FORMat:WAVE?

queries the waveform download mode and returns NORM or USER.

The following command:

SMEMory:TYPE {WAVE | SEGment | SEQuence]

sets the DMA port to receive either waveform data, segment table data or sequence table data. Segment and sequence table data will be discussed later in this chapter.

The query:

SMEMory:TYPE?

queries the shared memory type and returns WAVE, SEG or SEQ.

The command:

SMEMory: {OFF | ON}

toggles the shared memory state. OFF is the default position. After this command, 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.

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The query:

SMEMory?

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

Following the SMEM ON command, you can start downloading waveform data. Figure 3-10 shows an example of waveform data points. Explanation of the various words and control bits are given below.

Things to consider when you lay out your data:

1. Waveform data points are made of 16-bit words.

2. Minimum number of words to download is 8.

3. Words are downloaded in groups of 4. Therefore, the minimum number of groups is 2.

4. In each word, D0 through D2 are ignored. D3 is used for one of the control bits. D4 through D15 are used for point data. D15 is the msb.

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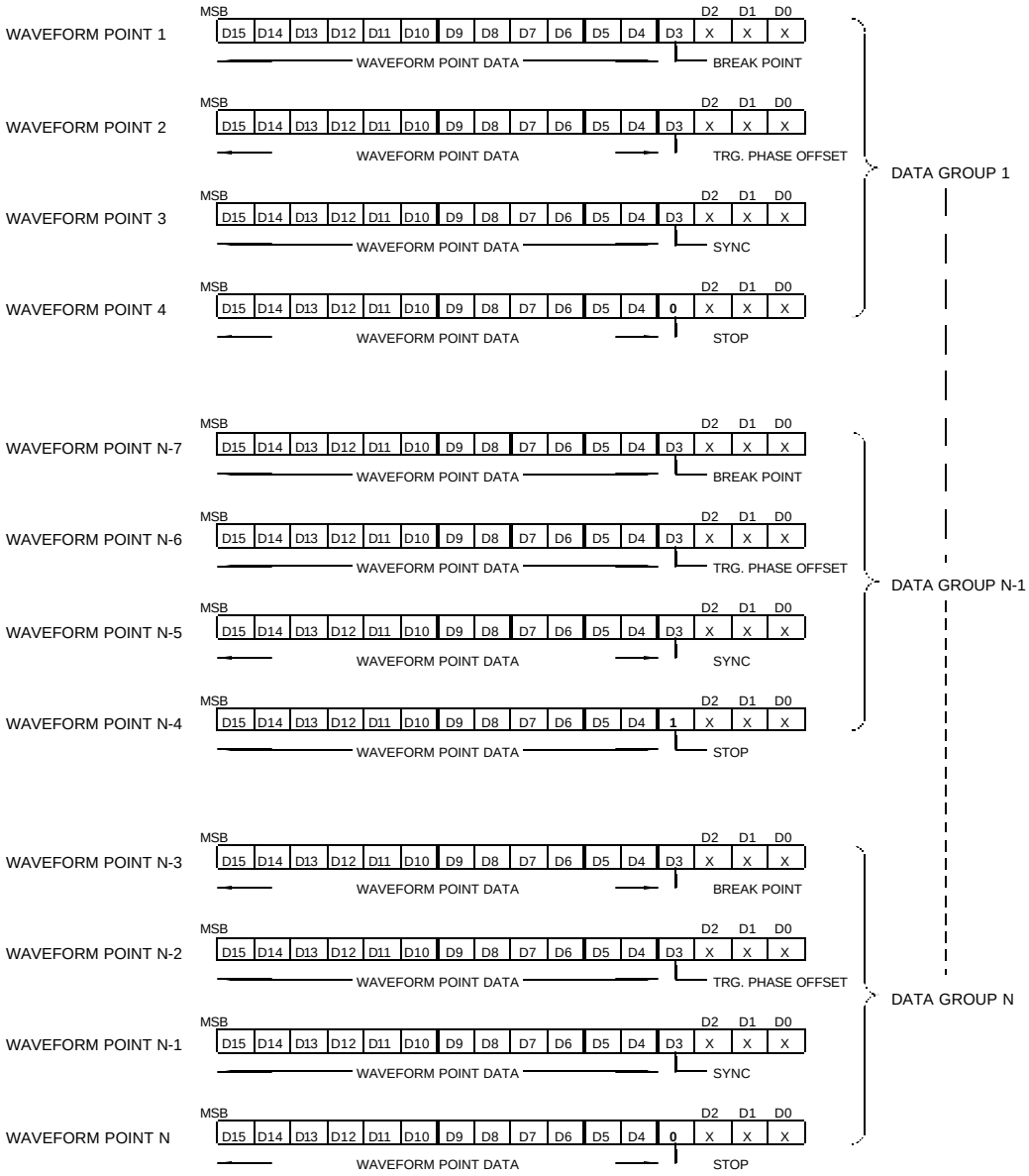


Figure 3-10, Data format for 16-bit shared memory download

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The Control Bits

There are four control bits that must be loaded within a group of four words, they are: break point, trigger phase offset, SYNC and stop bits. The control bits are downloaded one at a time with each word, and always at D3. The order that these bits are placed within a group is critical to the operation of the instrument therefore, use the example in Figure 3-10 to build your data accordingly.

The bits are described below in the same order as they must be placed in each data group..

Break Point Bit - The break point bit determines the point where the waveform will stop immediately after a stop signal has been received. If you placed the break point bit at point n, the actual stop occurs at point n+2.

Break point bits can be placed in more than one location. Place the break point at the first word of a group. When D3 = 1, the break point bit is active. With D3 = 0, the break point bit is disabled.

Trigger Start Offset Bit – The trigger start offset bit determines the offset point in the waveform where the waveform will start after receiving a trigger signal. If you placed the trigger start offset bit at point n, the actual start offset occurs at point n+3.

Trigger start offset bits can be placed in one location only. Place the trigger start offset bit at the second word of a group. When D3 = 1, the trigger start offset bit is active. With D3 = 0, the trigger start offset bit is disabled.

SYNC Bit – The SYNC bit determines the offset point on the waveform where the waveform will output a SYNC signal. The SYNC signal width is always 4 clock cycles. If you placed the SYNC bit at point n, the actual SYNC occurs from point n-2 to point n+1.

Multiple SYNC bits can be placed in any location along the length of the programmed waveform. Place the SYNC bit at the third word of a group. When D3 = 1, the SYNC bit is active. With D3 = 0, the SYNC bit is disabled.

Stop Bit – The Stop bit determines the end point of the waveform. If you placed the stop bit at point n, the actual stop occurs at point n+4.

Stop bit can be placed in one location only. If you place multiple stop bits, the waveform will stop at the first stop bit that is encounters. Place the stop bit at the fourth word of a group. When D3 = 1, the stop bit is active. With D3 = 0, the stop bit is disabled.

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Fast Binary Segment Table Download

As was discussed above, there are two methods of downloading and dividing the waveform memory: 1) ASCII download and 2) Fast binary download.

The traditional ASCII method of downloading one waveform at a time in inefficient in cases where multiple waveforms have to be loaded in the shortest possible time.

There are provisions built into the Model 3153 that allow fast binary downloads of waveform data. Using this method, the memory is first loaded with one long waveform that is made of many smaller waveforms, then, using fast binary access, the segment table is downloaded to the generator through a DMA port. The segment table contains start address and size information for each segment.

The procedure is as follows:

1. Externally, combine your waveforms to one long waveform. Convert your ASCII data to binary format as shown in Figure 3-9 above.

2. Use the commands below to place the 3153 in the right mode to accept waveform data:

   SMEM:TYPE WAVE;:SMEM ON

3. Download your waveform to the generator. Use the program fragment shown before as an example of programming the 3153 to download waveform data.

4. The command: SMEM OFF terminates the waveform download sequence.

5. Prepare the segment table using the format shown in Figure 3-11.

6. Use the commands below to place the 3153 in the right mode to accept segment table data:

   SMEM:TYPE SEG;:SMEM ON

7. Download your segment table to the generator. You can use the program for downloading waveform data as an example of programming the 3153 to download segment table data.

8. The command: SMEM OFF terminates the segment table download sequence.

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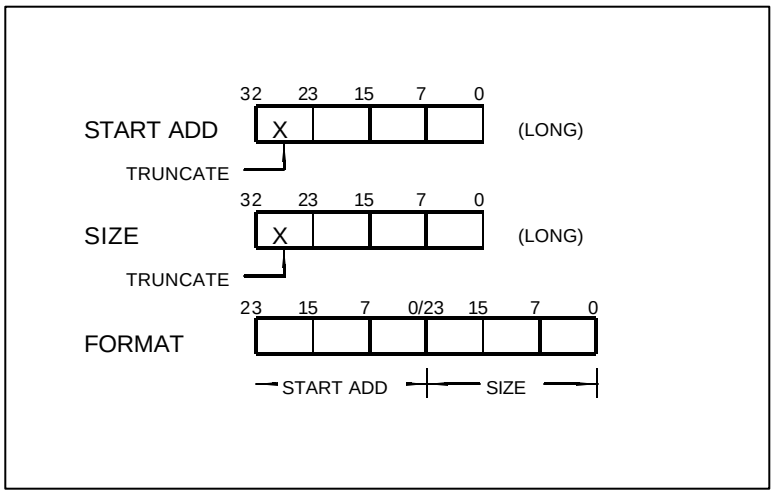


Figure 3-11, Segment Table Download Format

There are a few things to consider when preparing segment tables:

1. Data for each segment must have 6 bytes

2. The total number of bytes in a complete segment table must divide by 6. The Model 3153 has no control over data sent to its DMA port during data transfer. Therefore, wrong data and/or incorrect numbers of bytes will cause erroneous memory partitioning.

3. The start address for segment 1 is **0x100**.

4. Compute the start address for segment “n” using the following equation:

$$ADD_n = ADD_{n-1} + (SIZE_{n-1} / 4)$$

For example, say you have two segments, the first is 10,000 points. The start address for segment number 2 is as follows:

$$ADD_2 = ADD_1 + (SIZE_1 / 4) =$$

$$= 256 + 10{,}000 / 4 = 256 + 2{,}500; \text{ and in hex}$$

$$= 0x100 + 0x9C4 = 0xAC4$$

5. The segment size is entered using the actual size of the segment in points. **Do not** divide the segment size as was done for the address. For example, for a 10,000 point segment, use 0x2710 as the segment size.

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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 (sequence table). Before using a sequence of waveforms, load arbitrary memory with the required waveforms. Use TRAC# or shared memory methods to load waveforms into memory. Information on how to partition the memory and load waveforms is given in the section entitled **Generating Arbitrary Waveforms**.

An example of how sequenced waveforms work is demonstrated in figure 1-4. The sequence generator lets you link and loop segments in user-defined order. Figure 1-4 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. Fast binary download of sequence tables is also available. Description of both methods of downloading sequence tables is given below.

A sequence is made of steps. A step can stand on its own or link to another step. It is possible to have only one step in a sequence but the output will look like a continuous waveform. If only one step is specified and the Model 3153 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 three other parameters: segment number, repeat counter and mixed mode switch. The segment number specifies which segment will be linked, and the repeat counter specifies how many times the segment will loop.

The mixed mode switch is used in conjunction with the Mixed Sequence Advance Mode only and does not have to be specified if you do not intend to use this advance mode.

Use the following command to generate a sequence:

SEQuence:DEFine
{<step_number>,<segment_number>,<repeat>[,<0/1>]}

Use this command up to 4096 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.

Fast Binary Sequence Table Download

As was discussed previously, there are two ways to download a sequence table: 1) ASCII download and 2) Fast binary download.

The traditional ASCII method of downloading a sequence table is inefficient in cases where the table is large and where fast download time is critical to the speed of the system.

There are provisions built into the Model 3153 that allow fast binary downloads of sequence tables. Using fast binary access, the sequence table is downloaded to the generator through a DMA port. The sequence table contains sequence steps, segment numbers and repeat value.

The table also contains one bit which defines whether the selected step is in normal or triggered mode when the Model 3153 is placed in Mixed Sequence Advance.

The following procedure assumes that you have already downloaded data and partitioned your memory into segments:

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1. Prepare the sequence table using the format shown in Figure 3-12.

2. Use the commands below to place the 3153 in the right mode to accept sequence table data:

   SMEM:TYPE SEQ;:SMEM ON

3. Download your sequence table to the generator. You can use the program for downloading waveform data as an example of programming the 3153 to download sequence table data.

4. The command: SMEM OFF terminates the sequence table download procedure.

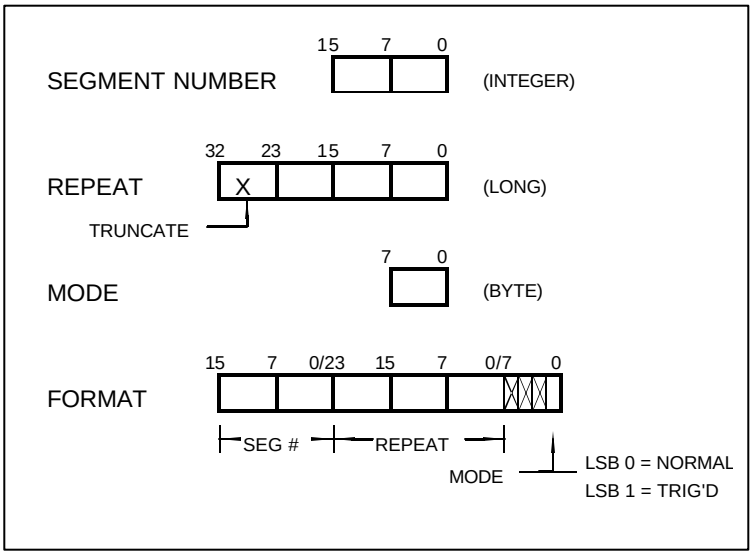


Figure 3-12, Sequence Table Download Format

There are a few things to consider when you prepare sequence tables:

1. The data for each step must be 6 bytes long.

2. The number of bytes in a complete sequence table must be divisible by 6. The Model 3153 has no control over data sent to its DMA port during data transfer. Therefore, wrong data and/or an incorrect number of bytes will cause an erroneous sequence setting.

3. The LSB bit is the only bit used in the mode byte. This bit has an affect on the operation of the sequence only when Mixed Step Advance mode is active. With the LSB bit set to “0”, the sequence generator will advance to the next step automatically. With the LSB bit set to “1”, the sequence generator will advance to the next step only when a valid trigger signal is sensed at the trigger input.

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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 command to control how the sequence advances through the sequence table steps:

SEQuence:ADVance {AUTO | STEP | SINGle |

| SINGle1 | MIXed}

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. Repeats may be specified for each step in an AUTO sequence. AUTO is the default sequence advance mode.

In **STEP** advance mode, the sequence is advanced to the next waveform only when a valid trigger is received. The output of the model 3153 generates the first segment continuously until a trigger signal advances the sequence to the next segment. If repeats were specified in the sequence table, they are ignored in STEP advance mode.

In **SING** advance mode, the Model 3153 idles between steps until a valid trigger signal is sensed. This advance mode is available when the 3153 is in triggered mode only. An attempt to select the SING advance mode when the Model 3153 is in continuous operating mode will generate an error. After a trigger, the generator outputs one (or more) waveform cycle(s). 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 segment is repeated n times automatically before it begins idling. After executing all of the programmed loops the sequencer will step to the next segment in the sequence when it receives its next valid trigger.

In **SING1** advance mode, the Model 3153 idles between steps until a valid trigger signal is sensed. This advance mode is available when the 3153 is in triggered mode only. An attempt to select the SING1 advance mode when the Model 3153 is in continuous operating mode will generate an error. After a 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 sequencer repeats this segment each time a trigger is received, until the number of repeats specified for this step has been reached. After reaching this number, the sequencer advances to the next step in the sequence.

MIX mode is a special mode, which combines continuous advance with triggered step advance in a sequence. There are three conditions that must be met for the sequence generator to operate in this mode:

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1) Generator is set to operate in continuous mode

2) MIX sequence advance mode is selected

3) Mixed mode bits are assigned for each step in the sequence table. “0” programs normal advance, “1” programs triggered advance.

Steps with a “0” bit assigned to it will advance automatically to the next step. If “1” is assigned to a step, the instrument will generate this step and its associated number of repeats, then will idle at the last point of the waveform. Only a valid trigger signal will cause the sequencer to advance to the next step.

The query:

SEQuence:ADVance?

queries sequence advance mode and returns AUTO, STEP, SING, SING1 or MIX.

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 all other modes: STEP, STEP1, SING, SING1 and MIX, the user must specify an advance source. Use the following commands to select the advance source.

SEQuence:ADVance:SOURce {INTernal | EXTernal | 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. Note that TTLT0, TTLT1, TTLT2 and TTLT3 are the only lines that can be selected as inputs.

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The query:

SEQuence:ADVance:SOURce?

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

Synchronizing 2 or More Channels

The Model 3153 has three independent output channels. Each channel has its own sample clock generator, trigger inputs, sequence generator and control logic. There is no synchronization between channels unless the channel synchronization is programmed. The channel coupling command links one master channel with one or two slave channels.

The generator is designed so that only channel 1 can become master. Channels 2, 3 or both, when coupled to channel 1, are designated as slave channels. A slave channel receives its sample clock and trigger input from the master channel. All other parameters can be programmed separately for the slave channel.

On power-up, the internal reset routine sets all channels to operate independently. Use the following command to synchronize two or three channels:

INSTrument:COUPle {NONE | 2 | 3 | ALL}

NONE designates three free-running channels. Besides waveforms, output levels, and operating mode, each channel has control over its own sample clock and trigger input.

Selecting **"2"** or **"3"** automatically modifies channel 1 to become master and the other channel as a slave. In this configuration, channel 2 or 3 as slave can no longer operate independently from the master channel because the sample clock and the trigger input for the slave channels are sourced by the master channel. After executing this command, he output waveforms from channels 1 and 2 or channels 1 and 3 are synchronized.

In master-slave mode, the following parameters are overridden by the master channel: sample clock, trigger mode, and trigger input. Waveform shape, sample clock divider, amplitude, filter, and output state remain unchanged.

The **ALL** parameter modifies both channels 2 and 3 from free-running channels to slave channels. In this configuration, the sample clocks and the trigger inputs for the slave channels are sourced by the master channel. After executing this command, the output waveforms on all 3 channels are synchronized.

The query:

INSTrument:COUPle?

queries channel synchronization setting and returns NONE, 2, 3 or ALL.

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Using the SCLK Dividers

Channels 2 and 3 have Sample Clock dividers. The main usage of these dividers is in synchronized mode, when channel 1 provides the master clock and channel 2 and 3 divide this clock using their sample clock dividers. Note that the sample clock divider can accept integer values only from 1 through 64k.

The dividers are active at all times. Upon power up, the SCLK dividers are set to 1. Changing the dividing ratio from 1 to another number modifies the sample clock from the value of the active sample clock to the sample clock divided by the clock divider value. For example, if channel 2's active sample clock is 10 MSa/s and the clock divider is set to 5, the resultant sample clock frequency will be 2 MSa/s.

Sample clock dividers affect the channel's sample clock regardless of whether the sample clock source is internal, external or coupled from the master channel.

Use the following command to program the sample clock divider:

FREQuency:RASTer:DIVider <integer>

Note that only integer numbers ranging from 1 through 64k can be used as sample clock dividers. If a floating point number is specified as a parameter then an error will occur.

The query:

FREQuency:RASTer:DIVider?

queries the sample clock divider and returns an integer number.

Adjusting Phase Between Channels

Channel synchronization controls the start phase such that all channels start generating waveforms at the same instance, regardless of waveform shape and frequency settings.

In general, the initial start phase offset is around 0°. However, due to variations in propagation delays, there is an unavoidable (but minimal) skew between the channels. The initial skew between channels is specified in Appendix A.

There are no internal provisions to correct skew between channels. However, phase skew can be corrected by adjusting the length of cable connected to the output connectors. One meter of 50Ω coax cable amounts to about 2 ns of delay time. Use this general guideline to adjust the skew for your system. For example, if channel 2 lags channel 3 by 1.2 ns, delay the output of channel 3 by 1.2 ns. The output cable for channel 3 should be made roughly 0.6 meters longer than that of channel 1 to compensate for this skew.

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While the initial skew between channels may be nulled only by using external cables, the Model 3153 provides a command for programming an adjustable phase offset between channels. Phase offset is adjusted in multiples of 4 waveform points so that the more points in the waveform, the better the phase offset resolution. For example, for a 1000-point waveform, resolution is 4 ÷ 1000 x 360° = 1.44°; for a 100,000-point waveform, the resolution is 0.144°.

Phase offsets are always referenced to channel 1. Therefore, phase offsets are programmable for channels 2 and 3 only. An attempt to program channel 1 with this parameter will result in an error message. Note that the phase offset parameter is programmable in integer multiples of 4 points. If you use phase offset values that are not divisible by 4, the generator automatically rounds the number up or down to the nearest valid multiple of 4.

Use the following command to add phase offset to a channel:

INSTrument:PHASe <phase_offset>

Phase offset is set in waveform points.

The query:

INSTrument:PHASe?

queries the phase offset and returns an integer number.

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 *IDN? Query returns a string like "Racal Instruments,3153,0,1.0."

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 3153. The response is “0” for no option, “1" for 4 Meg, and “2” for 8 Meg.

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Chapter 4

SCPI COMMAND REFERENCE

What's In This Chapter

This chapter contains reference information for programming the Model 3153. Standard Commands For Programmable Instruments (SCPI) convention rules and syntax are explained in detail. Table 4-1 lists all SCPI commands used for programming the Model 3153. The command summary for each SCPI model is also included in this chapter.

This chapter teaches you how to use SCPI commands to control functions, modes, waveforms and other aspects of the instrument. Prior understanding of SCPI programming is necessary for low level programming of the Model 3153.

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

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

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system:

```
OUTPut
   :FILTer
      [:LPASs]    {NONE    |    1    |    2    |ALL}
    [:STATe] OFF|ON
```

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

Command Format

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

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

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

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

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

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

Command Separator

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

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

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

```
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
```


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```
TRIG:INT:RATE 5e-3
```

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

```
OUTP:STATE ON;:TRIG:STAT ON
```

The MIN and MAX Parameters

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

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

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

Querying Parameter Setting

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

```
SOUR:FUNC:SHAP SQR
```

Query the output function by executing:

```
SOUR:FUNC:SHAP?
```

Query Response Format

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

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

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

Discrete Parameters

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

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


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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 Model 3153 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.

Table 4-1. Model 3153 SCPI Command Summary

Keyword	Parameter Form (Default in Bold)	SCPI 1993.0	Notes
:FORMat			
:BORDer	NORMal | SWAPped	Confirmed	
:WAVE	NORMal | USER	Not confirmed	
:INSTRument		Confirmed	
:SELect	1 | 2 | 3	Confirmed	
:COUPLe	NONE | 2 | 3 | ALL	Confirmed	
:PHASe		Confirmed	
[:OFFSet]	(0;0;n)	Confirmed	n = waveform length
:OUTPut		Confirmed	
[:STATe]	OFF | ON	Confirmed	
:TYPE	HIGH | LOW	Confirmed	
:FILTer		Confirmed	
[:LPASs]	NONE | 1 | 2 | ALL	Confirmed	
:TTLTrg<n>	(0;0;3)	Confirmed	(default;min;max)
[:STATe]	OFF | ON	Confirmed	
:SYNC		Not confirmed	

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Table 4-1. VXIbus Model 3153 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	SCPI 1993.0	Notes
[:STATe]	OFF | ON	Confirmed	
:SOURce	BIT | LCOMplete | SSYNc	Not confirmed	
:POSition		Not Confirmed	
[:POINt]	(0;0;n)	Not Confirmed	n = waveform length
:WIDTh	(1;1;200)	Not Confirmed	WIDTh x 4 = # samples
[: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	
[:CW]	(1E6;10E-3;12.5E6) | MINimum | MAXimum	Confirmed	Channel 1 only
[:CW]	(1E6;10E-3;6.25E6) | MINimum | MAXimum	Confirmed	Channels 2 and 3
:RASTer	(1E6;10;100E6)| MINimum | MAXimum	Not confirmed	Channel 1 only
:RASTer	(1E6;10;50E6)| MINimum | MAXimum	Not confirmed	Channels 2 and 3
:SOURce	EXTernal | INTernal	Not Confirmed	
:DIVider	(1;1;65536)	Not Confirmed	
:ROSCillator		Confirmed	
:SOURce	**CLK10** | EXTernal	Confirmed	
:VOLTage		Confirmed	
[:LEVel]		Confirmed	
[:AMPLitude]	(5.000;10E-3;10.00)	Confirmed	
:OFFSet	(0;-4.95;+4.95)	Confirmed	
:FUNCtion		Confirmed	
:MODE	**FIXed** | USER | SEQuence	Confirmed	
:SHAPe	**SIN** | TRI | SQU | PULS | RAMP | SINC | GAUS | EXP | DC	Confirmed	

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Table 4-1. VXIbus Model 3153 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	SCPI 1993.0	Notes
:SINusoid		Not Confirmed	
:PHASe	(0;0;360)	Not Confirmed	
:TRIangle		Not Confirmed	
:PHASe	(0;0;360)	Not Confirmed	
:SQUare		Not Confirmed	
:DCYCle	(50;1;99)	Not Confirmed	
:PULSe		Confirmed	
:DELay	(10;0;99.9)	Confirmed	
:WIDTh	(10;0;99.9)	Confirmed	
:TRANsition		Confirmed	
[:LEADing]	(10;0;99.9)	Confirmed	
:TRAiling	(10;0;99.9)	Confirmed	
:RAMP		Not Confirmed	
:DELay	(0;0;99.9)	Not Confirmed	
:TRANsition		Not Confirmed	
[:LEADing]	(60;0;99.9)	Not Confirmed	
:TRAiling	(30;0;99.9)	Not Confirmed	
:SINC		Not Confirmed	
:NCYCle	(10;4;100)	Not Confirmed	
:GAUSsian		Not Confirmed	
:EXPonent	(20;10;200)	Not Confirmed	
:EXPonential		Not Confirmed	
:EXPonent	(-20;-100;100)	Not Confirmed	
:DC		Not Confirmed	
[:VOLTage]		Not Confirmed	
[:AMPLitude]	(100;-100;100)	Not Confirmed	
:SEQuence		Not Confirmed	
:DATA		Not Confirmed	
:ADVance	**AUTOmatic** | STEP | SINGle | SINGle1 | MIXed	Not Confirmed	
:SOURce	**EXTernal** | INTernal | TTLTrg<0-3> | ECLTrg0	Not Confirmed	
:DEFine	(1;1;4096),(1;1;4096),(1;1;1E6)[,(0,0,1)	Not Confirmed	
:DELete		Not Confirmed	
[:NAME]	(1;1;4096)	Not Confirmed	
:ALL		Not Confirmed	
:RESet		Confirmed	
:SYSTem		Confirmed	

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Table 4-1. VXIbus Model 3153 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	SCPI 1993.0	Notes
:ERRor?		Confirmed	
:VERSion?		Confirmed	
:TRACe		Confirmed	
[:DATA]		Confirmed	
:DEFine	(1;1;4096),(16;106;524288)	Confirmed	Even number, 512 K memory, divisible by 4
:DEFine	(1;1;4096),(16;16;2097152)	Confirmed	Even number, 2 Meg memory, divisible by 4
DEFine	(1;1;4096),(16;16;4194304)	Confirmed	Even number, 4 Meg memory, divisible by 4
DEFine	(1;1;4096),(16;16;8388608)	Confirmed	Even number, 8 Meg memory, divisible by 4
:DELete		Confirmed	
[:NAME]	(1;1;4096)	Confirmed	
:ALL		Confirmed	
:SELect	(1;1;4096)	Confirmed	
:INITiate		Confirmed	
[:IMMediately]		Confirmed	
:CONTinuous	OFF | **ON**	Confirmed	
:ARM		Confirmed	
[:STATe]		Confirmed	
:SLOPe		Not Confirmed	
[:STARt]	**POSitive** | NEGative	Not Confirmed	
:STOP	**POSitive** | NEGative	Not Confirmed	
:STARt		Not Confirmed	Immediate start
:STOP		Not Confirmed	Immediate stop
:BREakpoint		Not Confirmed	
:POSition	(0;0;524288)	Not Confirmed	512K memory
:POSition	(0;0;2097152)	Not Confirmed	2 Meg memory
:POSition	(0;0;4194304)	Not Confirmed	4 Meg memory
:POSition	(0;0;8388608)	Not Confirmed	8 Meg memory
:TRIGger		Not Confirmed	
[:IMMediate]			
:BURSt		Not Confirmed	
[:STATe]	**OFF** | ON	Confirmed	

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Table 4-1. VXIbus Model 3153 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	SCPI 1993.0	Notes
:COUNt	(1;1;1E6)	Confirmed	Channel 1 only
:LEVel	(1.6;-10.00;+10.00)	Not Confirmed	
:SOURce		Not Confirmed	
:ADVance	**EXTernal** | INTernal | TTLTrg<0-3> | ECLTrg0	Not Confirmed	
:GATE		Not Confirmed	
[:STATe]	**OFF** | ON	Confirmed	
:SLOPe	**POSitive** | NEGative	Confirmed	
:TIMer	(100e-6;20e-6;1000)	Confirmed	
:PHASe	(0;0;n)	Confirmed	Memory size dependent
:SMEMory	**WAVE** | SEGment | SEQuence	Not Confirmed	HS binary downlaod
:TYPE	**OFF** | ON	Not Confirmed	
[:STATe]			
		Confirmed	
:TEST		Confirmed	
[:ALL]?			
*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	

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Instrument Programming Command Summary

Instrument Programming commands define how SCPI commands will affect the generator. These commands define waveform data format, which of the channels is the active listener and if the channels will operate separately or synchronized to a master channel. Optional nodes may be omitted from these commands. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable.

Commands and Parameters

:FORMat:BORDer {NORMal | SWAPped}
:FORMat:BORDer?
:FORMat:WAVE {**NORMal** | USER}
:FORMAt:WAVE?

:INSTrument: {**1** | 2 | 3}
:INSTrument?
:INSTrument:COUPle {**NONE** | 2 | 3 | ALL}
:INSTRument:COUPle?
:INSTrument:PHASe {phase_offset} (**0**,0,n)
:INSTRument:PHASe?

Output Configuration Command Summary

Output Configuration commands control the output function, shape, frequency, amplitude and filter type. Optional nodes may be omitted from these commands. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable. Use the Standard Waveform parameters as described in **Using The APPLy Command**.

Commands and Parameters **{Default,** Low Limit,High Limit**}**

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

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

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:FREQuency {<frequency> | MINimum | MAXimum}	(**1e6,**10e-3,50e6) Chan 1
:FREQuency {<frequency> | MINimum | MAXimum}	(**1e6,**10e-3,25e6) Chan 2/3
:FREQuency?	
:FREQuency:RASTer {<frequency> | MINimum | MAXimum}	(**1e6,**10,100e6) Chan 1
:FREQuency:RASTer {<frequency> | MINimum | MAXimum}	(**1e6,**10,50e6) Chans 2/3
:FREQuency:RASTer?	
:FREQuency:RASTer:SOURce {**EXTernal** | INTernal}	
:FREQuency:RASTer:SOURce?	
:FREQuency:RASTer:DIVider	(**1**,1,64K)
:FREQuency:RASTer:DIVider?	
:ROSCillator:SOURce {**CLK10** | EXTernal}	
:ROSCillator:SOURce?	
:VOLTage {<amplitude>| MINimum | MAXimum}	(**2**,10e-3,10)
:VOLTage?	
:VOLTage:OFFSet <offset>	(**0**,-4.95,4.95)
:VOLTage:OFFSet?	

:OUTPut: {**OFF** | ON}	
:OUTPut?	
:OUTPut:TYPE {**HIGH** | LOW}	
:OUTPut:FILTer {**NONE** | 1 | 2 | ALL}	
:OUTPut:FILTer?	
:OUTPut:SYNC {**OFF** | ON}	
:OUTPut:SYNC?	
:OUTPut:SYNC:SOURce {**BIT** | LCOMplete | SSYNc | SREPetition | SEGment}	
:OUTPut:SYNC:SOURce?	
:OUTPut:SYNC:POSition <value>	
(**0,**0,512K,1M,2M,4M,8M)	
:OUTPut:SYNC:POSition?	
:OUTPut:SYNC:WIDTh? <value>	(**1**,1,200)
:OUTPut:ECLTrg0 {**OFF** | ON}	
:OUTPut:TTLTrg<0-3> {**OFF** | ON}	

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Standard Waveform Command Summary

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

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

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Arbitrary Waveform, Sequence, and Shared Memory Command Summary

Arbitrary Waveform commands allow the definition of segments and their corresponding lengths, addition and deletion of segments, and the loading of waveform data. Sequence commands control which segments are linked and the number of times each segment is repeated. The shared memory commands place the Model 3153 in a special data transfer mode where the Model 3153'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

:TRACe #<binary_block>
:TRACe:DEFine <segment_number>,<length>
:TRACe:DELete <segment_number>
:TRACe:DELete:ALL
:TRACe:SELect <segment_number>

:SEGment:DATA #<binary_block>
:SEQuence:DATA #<binary_block>

:SEQuence:ADVance {**AUTOmatic** | STEP | SINGle | SINGle1 | MIXed}
:SEQuence:ADVance?
:SEQuence:ADVance:SOURce {**EXTernal** | INTernal | TTLTrg<0-3> | ECLTrg0}
:SEQuence:ADVance:SOURce?
:SEQuence:DEFine <step_number>,<segment_number>,<#_repeat>[,<mix_state>]
:SEQuence:DELete <sequence_number>
:SEQuence:DELete:ALL

:SMEMory:TYPE {**WAVE** | SEGment | SEQuence}
:SMEMory:TYPE?
:SMEMory {**OFF** | ON}

Trigger Command Summary

The Trigger commands control the trigger modes of the Model 3153. The Model 3153 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**}	
:INITiate:CONTinuous?	
:TRIGger:BURSt {**OFF** | ON}	
:TRIGger:BURSt?	
:TRIGger:COUNt <value>	(**1**,1,1e6)
:TRIGger:COUNt?	
:TRIGger:GATE {**OFF** | ON}	
:TRIGger:GATE?	

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:TRIGger:LEVel <value> (**1.6**,-10,10)
:TRIGger:LEVel?
:TRIGger:SLOPe {**POSitive** | NEGative}
:TRIGger:SLOPe?
:TRIGger:SOURce:ADVance {**EXTernal** | INTernal | TTLTrg<0-3> | ECLTrg0}
:TRIGger:SOURce:ADVance?
:TRIGger:TIMer: <value> (**100e-6**,20e-6,1000)
:TRIGger:TIMer?
:TRIGger:PHASe: <value> (**0**,0,n)
:TRIGger:PHASe?
:TRIGger:IMMediate
*TRG

:ARM {**OFF** | ON}
:ARM?
:ARM:SLOPe[:STARt] {**POSitive** | NEGative}
:ARM:SLOPe[:STARt]?
:ARM:SLOPe:STOP {**POSitive** | NEGative}
:ARM:SLOPe:STOP?
:ARM:STARt
:ARM:STOP
:ARM:BREakpoint:POSition <position> (**0**,0,n)

System-Related Command Summary

The system-related commands are not related directly to waveform generation but are an important part of operating the Model 3153. These commands can reset or test the instrument, or query the instrument for system information.

Commands 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, which all compatible devices must use. This avoids situations where devices from various manufacturers use different sets of commands to enable functions and report status. The IEEE-STD-488.2 treats common commands and queries as device dependent commands. For example, *TRG is sent over the bus to trigger the instrument. Some common commands and queries are optional, but most of them are mandatory.

The following is a complete listing of all common commands and queries, which are used in the Model 3153.

***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. A sample Model 3153 response to *IDN? is:

RACAL INSTRUMENTS,3153,0,1.0.

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

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

***OPT?** - Returns the value "0" for a Model 3153 with 512k/2Meg/2Meg of memory. Returns a "1" for a Model 3153 with 2Meg/4Meg/4Meg of memory. Returns a "2" for a Model 3153 with 2Meg/8Meg/8Meg of

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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 effects the generator if it is first placed in the Trigger or Burst mode of operation and the trigger source is set to "BUS".

***TST?** - Implements an internal self-test and returns a value as described below. Approximately 90% of Model 3153 functionality is tested.

0 – Self test passed
1 – CPU RAM fail
2 - Channel 1 RAM fail
4 - Channel 1 Frequency fail
8 - Channel 1 sequence fail
16 - Channel 2 RAM fail
32 - Channel 2 Frequency fail
64 - Channel 2 clock divider fail
128 - Channel 2 sequence fail
256 - Channel 3 RAM fail
512 - Channel 3 Frequency fail
1024 - Channel 3 clock divider fail
2048 - Channel 3 sequence fail

More than one failure can be reported at one time. For example, the returned value “17” indicates that both a CPU RAM problem and a Channel 2 RAM problem exist.

***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 Model 3153 uses the Status Byte register group and the Standard Event register group to record various instrument conditions. Figure 4-1 shows the SCPI status system.

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

An Event Register defines which bits in the corresponding event register are logically ORed together to form a single summary bit. The user can read from and write to an Enable Register. Querying an Enable Register will not clear it. The *CLS command does not clear Enable Registers but it does clear bits in the event registers. To enable bits in an enable register, write a decimal value that corresponds to the binary-weighted sum of the bits required to enable in the register.

The Status Byte Register (STB)

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

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

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

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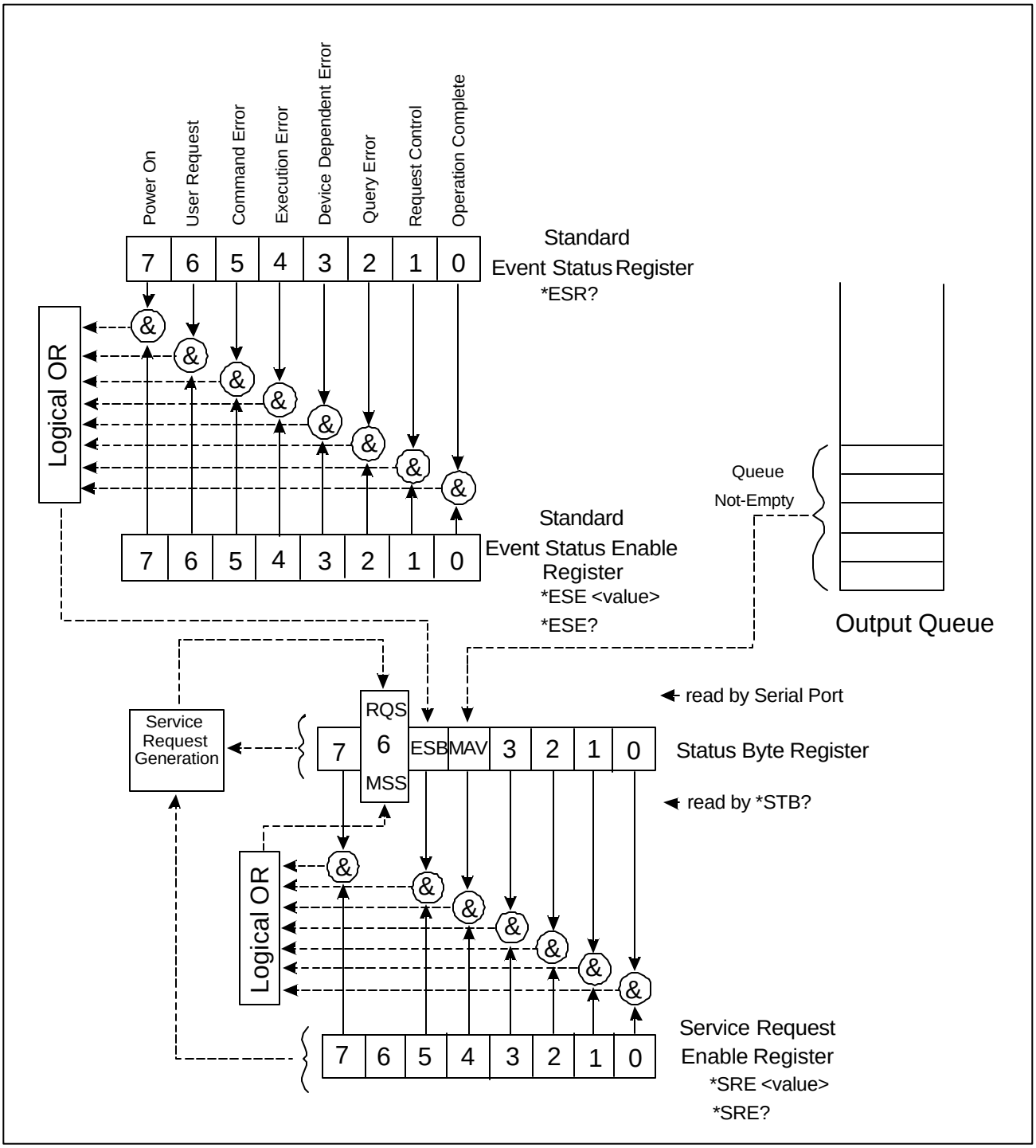


Figure 4-1 SCPI Status Registers

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Reading the Status Byte Register

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

Clearing the Status Byte Register

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

Service Request Enable Register (SRE)

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

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

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

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

***SRE1** - Not used.

***SRE2** - Not used.

***SRE4** - Not used.

***SRE8** - Not used.

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

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

***SRE128** - Not used.

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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 Model 3153.

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 9;:VOLTage:OFFSet 2

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

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

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

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

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

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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. 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 Model 3153 receives an invalid SCPI command, it automatically generates an error. Errors are stored in a special error queue and may be retrieved from this buffer one at a time. Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. When you have read all errors from the queue, the generator responds with a 0,"No error" message.

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

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

SYSTem:ERRor?

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

-102,"Syntax error"

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

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

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

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

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

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

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

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

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

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

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

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

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

Any operating mode

Sum of Pulse parameters more than 100%
Sum of Ramp parameters more than 100%
Amplitude + offset exceed range
INIT:CONT OFF;:TRIG:BURST ON;:FUNC:MODE SEQ

Sequence operating mode

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Any of the following commands:

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

Triggered operating mode

Any of the following commands:

OUTP:ECLT0 ON
OUTP:TTLT0 ON
OUTP:TTLT1 ON
OUTP:TTLT2 ON
OUTP:TTLT3 ON

Channel 1, 2 or 3 are separate

An attempt to couple channel 2 or 3 and one of channels 1, 2 or 3 that was in FIXed function mode.

An attempt to couple channels 2 or 3 to channel 1 while channel 1's sample clock frequency is >50 MSa/s and the Channel 2 or 3 clock divider is set to 1.

Channel 2 or 3 are slaves

An attempt to select FIXed function mode on any channel.

An attempt to change sample clock divider to 1 while the channel 1 sample clock is set to a sample rate >50 MSa/s.

-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 Model 3153 conforms to the 1993.0 version of the SCPI standard. Some of the commands used are not included in the 1993.0 version. However, these commands are designed with the SCPI standard in mind and they follow all of the command syntax rules defined by the standard. Table 4-1 lists all device-specific commands that were designed specifically for the Model 3153 as not confirmed SCPI 1993.0 commands.

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Chapter 5

MAINTENANCE AND PERFORMANCE CHECKS

What's in This Chapter

This chapter provides maintenance and service information, performance tests, and the procedures necessary to adjust and troubleshoot the Model 3153 Waveform Synthesizer.

WARNING

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



CAUTION

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



Disassembly Instructions

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

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

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

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

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Special Handling of Static Sensitive Devices

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

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

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

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

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

5. Use only anti-static type solder suckers.

6. Use only grounded soldering irons.

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

Cleaning

The Model 3153 should be cleaned as often as operating conditions require. To clean the instrument, use the following procedure:

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

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

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

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

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Repair and Replacement

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

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

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

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

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

Performance Checks

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

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

2. As part of the troubleshooting procedure;

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

Environmental Conditions

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

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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 Model 3153 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 Model 3153 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.

Equipment	Model No.	Manufacturer
Oscilloscope	2465B	HP
Distortion Analyzer	6900A	Krohn Hite
Digital Multimeter	2000	Keithley
Freq. Counter	2201	Racal Instruments
Clock Reference	9480	Racal Instruments
Spectrum Analyzer	E4411	HP
Pulse Generator (with manual trigger)	F-46	Racal Instruemtns

Performance Check Procedures

Use the following procedures to check the Model 3153 against the specifications. A complete set of specifications is listed in Appendix A. The following paragraphs show how to set up the instrument for the test, what the specifications for the tested function are, and what acceptable limits for the test are. If the instrument fails to perform within the specified limits, the instrument must be calibrated or tested to find the source of the problem.

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Frequency Accuracy

1. Configure model 3153 to output square waveforms with 1Vp-p amplitude.

2. Perform Frequency Accuracy tests using Table 5-1.

Table 5-1, Frequency Accuracy.

3153 Setting	Error Limits	Counter Reading			Pass	Fail
		CH 1	CH 2	CH 3		
10.00000Hz	±.001Hz					
100.0000Hz	±.01Hz					
1.000000kHz	±.1Hz					
10.00000kHz	±1Hz					
100.0000kHz	±10Hz					
1.000000MHz	±100Hz					
10.00000MHz	±1kHz					
25.00000MHz	±2.5kHz					
50.00000MHz	±5kHz		X	X	X	X

3. Configure model 3153 to accept external 10 MHz reference. Make sure that the external reference accuracy is better than 1ppm.

4. Use the Frequency Counter to perform Frequency Accuracy tests using Table 5-1a.

Table 5-1a, Frequency Accuracy Using External 10 MHz Reference.

3153 Setting	Error Limits	Counter Reading			Pass	Fail
		CH 1	CH 2	CH 3		
10.00000 MHz	±10Hz					
25.00000 MHz	±25Hz					
50.00000 MHz	±50Hz		X	X	X	X

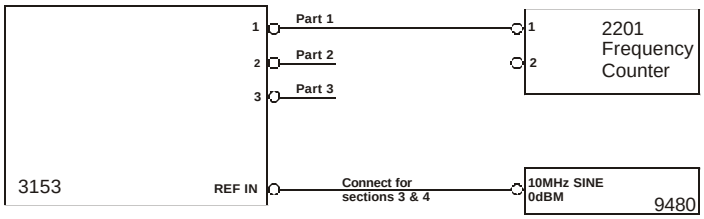


Figure 5-1, Frequency Accuracy Setup Diagram

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Amplitude Accuracy

1. Configure model 3153 to output sine waveforms and a frequency of 1kHz.

   *RST;:FREQ 1e3; OUTP ON

2. Perform Amplitude Accuracy tests using Table 5-2.

Table 5-2, Amplitude Accuracy.

3153 Amplitude Setting Command	Error Limits	DMM Reading			Pass	Fail
		CH 1	CH 2	CH 3		
VOLT 10	3.534V, ±53.0mV					
VOLT 5	1.767V, ±26.5mV					
VOLT 1	353.4mV, ±5.30mV					
VOLT .1	35.34mV, ±2.35mV					
VOLT .01	3.534mV, ±0.235mV					
			2 – Low	3 - Low		
OUTP:TYPE LOW	2Vp-p ±100mV	X				

Offset Characteristics

1. Configure model 3153 to output sine waveforms, amplitude of 10.00 mV, and frequency of 1MHz.

2. Perform Offset Accuracy tests using Table 5-3.

3. Precede command settings with INST:SEL 1|2|3 to select the appropriate channel.

Table 5-3, Offset Accuracy.

3153 Offset Setting Command	Error Limits	DMM Reading			Pass	Fail
		CH 1	CH 2	CH 3		
VOLT:OFFS 4	±60mV					
VOLT:OFFS 0.4	±6mV					
VOLT:OFFS -0.4	±6mV					
VOLT:OFFS -4	±60mV					

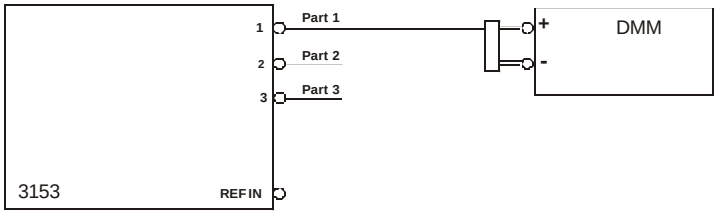


Figure 5-2, Amplitude, Offset, and Square Wave Setup Diagram

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Square Wave Characteristics

1. Configure model 3153 to output a square waveform, amplitude of 8 V, and frequency of 1 MHz. Run *RST and then:

   VOLT 8:;FREQ 1e6;:OUTP ON

2. Use INST:SEL 2 or INST:SEL 3 before the above command string to set channels 2 and 3.

3. Perform Squarewave Characteristics tests using Table 5-4.

Table 5-4, Squarewave Accuracy.

3153 Setting	Error Limits	DMM Reading			Pass	Fail
		CH 1	CH 2 High	CH 3 High		
Rise/Fall Time	≤ 15ns					
Ringing	< 7% + 10mV					
Overshoot	< 7% + 10mV					
			2 Low	3 Low		
Rise/Fall Time	≤ 5ns	X				
Ringing	< 5% + 10mV	X				
Overshoot	< 5% + 10mV	X				

Sine Characteristics

1. Configure model 3153 to output an arbitrary sine waveform, 4096 points at amplitude of 8 V. Run *RST and then:

   VOLT 8;:FUNC:MODE USER;:OUTP ON

   Use WaveCAD, Set Axis 4096 points, Wave Sine, Download.

2. Use INST:SEL 1|2|3 before the above command string and download to select the proper channnel.

3. Perform Sinewave Characteristics tests using Table 5-5.

4. Precede the commands below with INST:SEL 1|2|3 as needed.

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Table 5-5, Sinewave Characteristics.

3153 Setting	Reading Limits	Distortion Analyzer Reading			Pass	Fail
		CH 1	CH 2	CH 3		
FREQ 10	< 0.3%					
FREQ 100	< 0.3%					
FREQ 1E3	< 0.3%					
FREQ 1E4	< 0.3%					
			2 Low	3 Low		
FREQ 1E3	< 0.3%	X				
FREQ 1E4	< 0.3%	X				
FREQ 1E5	< 0.3%	X				

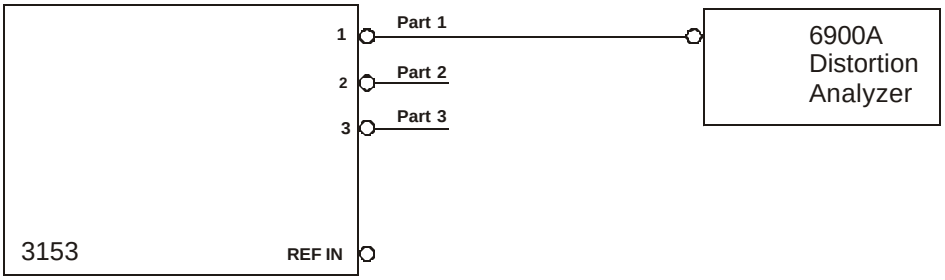


Figure 5-3, Sine Characteristics Test Setup Diagram

3. Perform Spectral Purity test using Table 5-5a.

Table 5-5a, Spectral Purity Characteristics.

3153 Setting Command	Reading Limits	Spectrum Analyzer Reading			Pass	Fail
		CH 1	CH 2	CH 3		
FREQ 1E6	>55dBc					
FREQ 10E6|FREQ 5E6	>45dBc					
			2 Low	3 Low		
FREQ 1E6	>55dBc	X				
FREQ 10E6|FREQ 5E6	>45dBc	X				

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Trigger Gate & Burst Characteristics

1. Configure all three channels to output a 1.56 MHz Sinewave, 5 Vp-p, burst count of 10. Set internal trigger generator rate 1 ms. Run *RST and then:

   FREQ 1.56E6;:TRIG:TIM 1E3:;TRIG:CONN 10

2. Use INST:SEL 1|2|3 before the above commands as needed.

3. Perform trigger, gate, and burst tests using Tables 5-6a, 5-6b and 5-6c.

Table 5-6a, Channel 1 - Trigger, gate, and burst Characteristics.

3153 Setting	External Trigger Signal	Oscilloscope Reading	Pass	Fail
INST:SEL 1;:INIT:CONT OFF	10kHz, TTL, 20ns width	Triggered waveform		
TRIG:GATE ON (TRIG:GATE OFF when done)	10kHz, TTL, 20ns width	Gated Waveform		
TRIG:BURST ON (TRIG:BURST OFF when done)	10kHz, TTL, 20ns width	10 waveforms, triggered		
TRIG:SOUR:AGV INT	None	One cycle every 1 ms		

Table 5-6b, Channel 2 - Trigger, gate, and burst Characteristics.

3153 Setting	External Trigger Signal	Oscilloscope Reading	Pass	Fail
INST:SEL 2;:INIT:CONT OFF	10kHz, TTL, 20ns width	Triggered waveform		
TRIG:GATE ON (TRIG:GATE OFF when done)	10kHz, TTL, 20ns width	Gated Waveform		
TRIG:BURST ON (TRIG:BURST OFF when done)	10kHz, TTL, 20ns width	10 waveforms, triggered		
TRIG:SOUR:AGV INT	None	One cycle every 1 ms		

Table 5-6c, Channel 2 - Trigger, gate, and burst Characteristics.

3153 Setting	External Trigger Signal	Oscilloscope Reading	Pass	Fail
INST:SEL 3;:INIT:CONT OFF	10kHz, TTL, 20ns width	Triggered waveform		
TRIG:GATE ON (TRIG:GATE OFF when done)	10kHz, TTL, 20ns width	Gated Waveform		
TRIG:BURST ON (TRIG:BURST OFF when done)	10kHz, TTL, 20ns width	10 waveforms, triggered		
TRIG:SOUR:AGV INT	None	One cycle every 1 ms		

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Sequence Operation

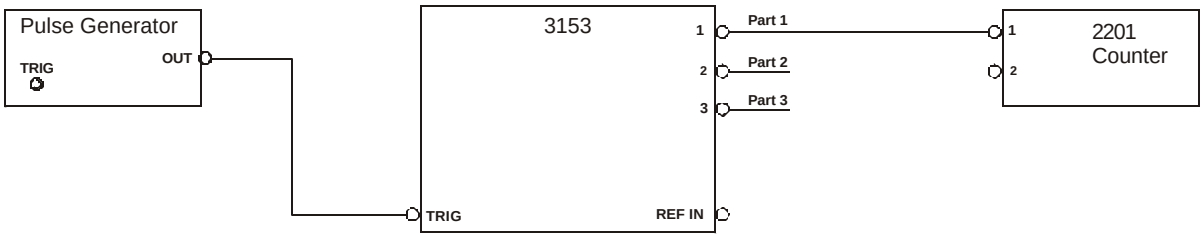


Figure 5-4, Automatic Sequence Advance Test Setup

Automatic Advance

1. Configure all channels to output a 5-step sequence, each step repeated 100,000 times, sampling clock 100 MHz for channel 1 and 50 MHz for channels 2 and 3, and amplitude of 2V. Load 64-point waveforms to the first 5 segments. Place model 3153 in triggered mode. Use WaveCAD, output and sequence tabs on the instrument control panel.

2. Perform the sequence test using Table 5-7.

Table 5-7, Sequence Operation – Automatic Advance.

3153 Setting	External Trigger Signal	Counter Reading (Totalize)	Pass	Fail
Triggered	20ns width, single shot	500,000 counts		

Step Advance

1. Use the same arb setting as for the Automatic Advance Test. Set sequence advance mode to step. Download different waveforms to each segment. Select a repeat of 2 for each step. Each trigger advances the sequence to the next waveform. Use WaveCAD to create and download the sequence table.

2. Perform the sequence test using Table 5-7a.

Table 5-7a, Sequence Operation – Step Advance.

Step	External Trigger Signal	Oscilloscope Reading	Ch 1 Pass	Ch 1 Fail	Ch 2 Pass	Ch 2 Fail	Ch 3 Pass	Ch 3 Fail
1	No trigger	Segment 1						
2	20ns width, single shot	Segment 2						
3	20ns width, single shot	Segment 3						
4	20ns width, single shot	Segment 4						
5	20ns width, single shot	Segment 5						
6	20ns width, single shot	Segment 1						

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Single and Single 1 Advance

1. Configure model 3153 to output as was done in the Step Advance Test. Set sequence advance mode to single 1 and 3153 operating mode to trigger. Each trigger advances the sequence to the next waveform however; the advanced segment is generated once only with each trigger. If repeats are programmed for the step, the waveform will repeat then idle at the last waveform point.

   INIT:CONT OFF;:SEQ:ADV SING1

2. Add INST:SEL 1|2|3 before the above command string as needed.

3. Perform sequence test using Table 5-7b.

Table 5-7b, Sequence Operation – Single 1 Advance.

Step	External Trigger Signal	Oscilloscope Reading	Ch 1		Ch 2		Ch 3	
			Pass	Fail	Pass	Fail	Pass	Fail
1	No trigger	Segment 1						
2	20ns width, single shot	Segment 2						
3	20ns width, single shot	Segment 3						
4	20ns width, single shot	Segment 4						
5	20ns width, single shot	Segment 5						
6	20ns width, single shot	Segment 1						

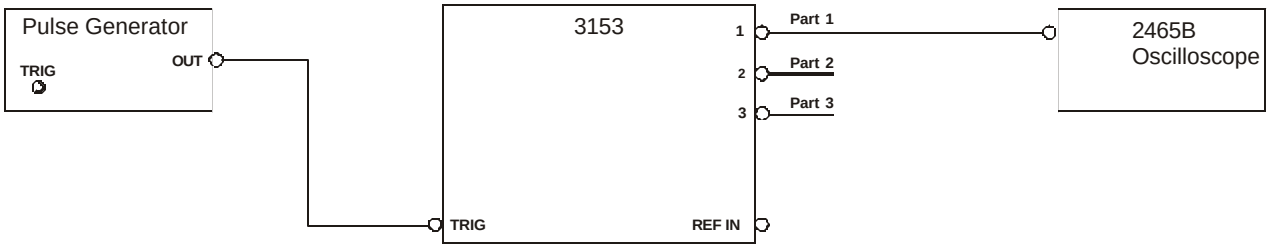


Figure 5-5, Triggered and Triggered Sequence Advance Setup

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4. Set sequence advance mode to single or all three (3) channels. (INST:SEL 1|2|3;:SEQ:ADV SING)

5. Perform sequence test using Table 5-7c. Each trigger advances the sequence to the next step.

Table 5-7c, Sequence Operation – Single Advance.

Step	External Trigger Signal	Oscilloscope Reading	Ch 1		Ch 2		Ch 3	
			Pass	Fail	Pass	Fail	Pass	Fail
1	No trigger	Segment 1						
2	20ns width, 2 shot	Segment 2						
3	20ns width, 2 shot	Segment 3						
4	20ns width, 2 shot	Segment 4						
5	20ns width, 2 shot	Segment 5						
6	20ns width, 2 shot	Segment 1						

Mixed Advance

1. Configure model 3153 to output as was done in the Step Sequence Advance test. Set sequence advance mode to mixed.

2. Program steps 2 and 3 with the mixed mode bit = 1. Use WaveCAD to modify the sequence table and download on all three (3) channels.

3. Perform sequence test using Table 5-7d.

Table 5-7d, Sequence Operation – Single Advance.

Step	External Trigger Signal	Oscilloscope Reading	Ch 1		Ch 2		Ch 3	
			Pass	Fail	Pass	Fail	Pass	Fail
1	No trigger	Segment 1						
2	20ns width, 2 shot	Segment 2						
3	20ns width, 2 shot	Segment 3						
4	20ns width, 1 shot	Segment 4						
5	20ns width, 1 shot	Segment 5						
6	20ns width, 1 shot	Segment 1						

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Sample Clock Source and Dividers

1. Program all three channels as follows:

   Operating mode: User (arbitrary).

   FUNC:MODE USER

   Sample clock frequency: 100 MSa/s for channel 1; 50 MSa/s for channels 2/3.

   FREQ:RAST 100E6;:INST:SEL 2;:FREQ:RAST 50E6;:INST:SEL 3;:FREQ:RAST 50E6

   Waveform: Download 100-point squarewave

   WaveCAD, axis 100 points, wave square, download

   Clock Dividers 2/3: 1

   INST:SEL 2;:FREQ:RAST:DIV 1;:INST:SEL 3;:FREQ:RAST:DIV 1

2. Test the sample clock source and dividers using Table 5-8

Table 5-8, Sample Clock Source Tests.

SCLK Source	Channel 2,3 Divider	Counter Reading CH 1	CH 2	CH 3	Pass	Fail
Ch 1,2,3 – Int	1	500kHz	500kHz	500kHz		
INST:SEL 2|3;:FREQ:RAST:SOUR EXT	1	500kHz	500kHz	500kHz		
INST:SEL 1;:FREQ:RAST:SOUR EXT INST:SEL 2|3;:FREQ:RAST:SOUR INT	1	500kHz	500kHz	500kHz		
INST:SEL 2|3;:FREQ:RAST:SOUR EXT	1	500kHz	500kHz	500kHz		
INST:SEL 1|2|3;:FREQ:RAST:SOUR INT	INST:SEL 2|3;:FREQ:RAST:DIV 100	500kHz	5kHz	5kHz		
Ch 1,2,3 – Int	INST:SEL 2|3;:FREQ:RAST:DIV 1000	500kHz	500Hz	500Hz		
Ch 1,2,3 – Int	INST:SEL 2|3;:FREQ:RAST:DIV 10000	500kHz	50Hz	50Hz		

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Channel Synchronization and Skew

1. Program all three channels as follows:
   Operating mode: User (arbitrary).
   (FUNC:MODE USER)
   Trigger mode: Triggered
   (INIT:CONT OFF)
   Trigger advance source: Internal
   (TRIG:SOUR:ADV INT)
   Internal trigger generator: 10 KHz (10 µs)
   (TRIG:TIM 10E-6)
   SCLK channel 1: 50 MSa/s
   (FREQ:RAST 50E6)
   SCLK channel 2: 10 MSa/s
   (INST:SEL 2;:FREQ:RAST 10E6)
   SCLK channel 3: 5 MSa/s
   (INST:SEL 3;:FREQ:RAST 5E6)
   Channel 2 divider: 10
   (INST:SEL 2;:FREQ:RAST:DIV 10)
   Channel 3 divider: 5
   (INST:SEL 3;:FREQ:RAST:DIV 5)
   Waveform: Download 100-point squarewave
   (Use WaveCAD)
   Channels 2/3 slaves, channel 1 master
   (INST:COUPLE ALL)
2. Verify the following:

Channels 1, 2 and 3 start with the same phase		
Test Results:	€ Pass	€ Fail
Channel 1 to 2/3 skew is £10ns		
Test Results:	€ Pass	€ Fail
Channel 2 to 3 skew is £5ns		
Test Results:	€ Pass	€ Fail

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Adjustments

INTRODUCTION

This document contains the calibration procedure for the 100 MS/s triple–channel Arbitrary Waveform Generator Model 3153. A list of specifications is given in Appendix A of the Operations Manual. The calibration procedures that are described in this document are for use by qualified service personnel only. Do not perform these procedures unless qualified to do so. This procedure is intended to be used once before complete and final performance verification to verify that the 3153 meets or exceeds its published specifications.

Description

The 3153 is a VXI module. The output can generate a standard set of waveforms. These waveforms include Sine, Triangle, Square, Pulse, Ramp, Sinc, Gaussian, Exponential Decaying/Rising Pulse, Noise, and DC. Arbitrary waveforms are generated by downloading data to memory. Large waveform memories are provided so that multiple waveforms can be loaded at once. Powerful sequencing allows the waveform segments to be generated in any order. Communicating with the 3153 is done via the VXI bus.

Environmental Conditions

The 3153 can operate from 0°C to 50°C. Calibration should be performed under laboratory conditions having an ambient temperature of 25°C, ±5°C and at relative humidity of less than 80%. Turn on the power to the 3153 and allow it to warm up for at least 30 minutes before beginning the adjustment procedure. 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.

Initial Instrument Setting

To avoid confusion as to what initial setting is to be used for each calibration, it is required that the instrument be reset to factory default values prior to each adjustment.

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Required Equipment

Recommended equipment for calibration is listed below. Instruments other than those listed may be used only if their specifications equal or exceed the required minimal characteristics. Also listed below are accessories required for calibration.

SMB to BNC cable

Dual banana to BNC adapter

50Ω Feedthrough termination

Equipment	Model No.	Manufacturer
Digital Multimeter	2000	Keithley

Adjustment Procedures

Use the following procedures to calibrate the Model 3153. The following paragraphs show how to set up the instrument for the calibration and what are the acceptable limitations for the calibrated function.

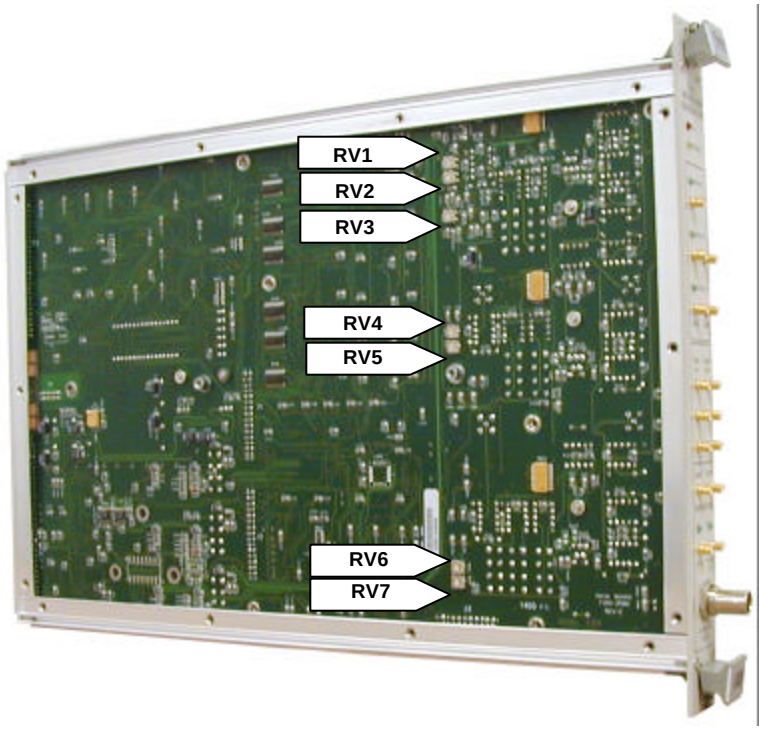


Figure 5-6, Left Side 3153

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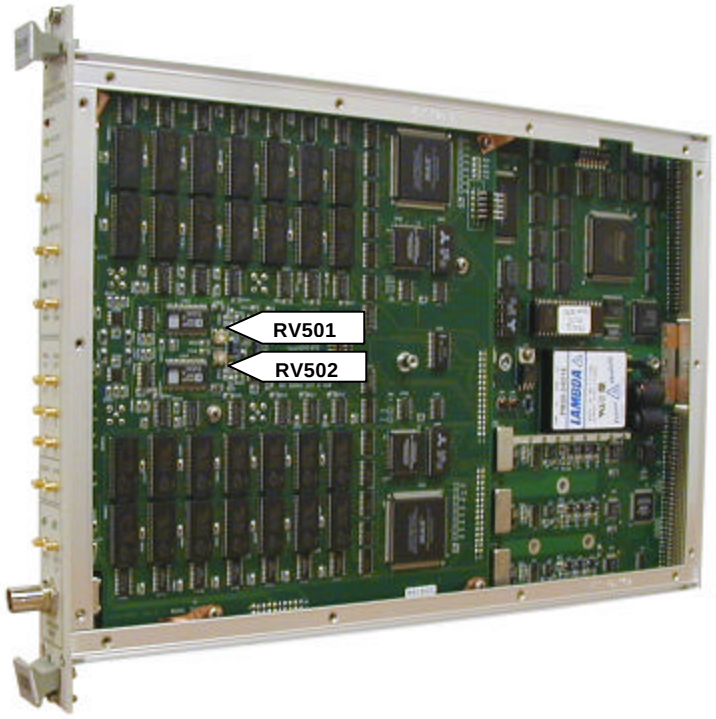


Figure 5-7, Right Side 3153

Amplitude Adjustment, Channels 1, 2 and 3

Equipment:

DMM

50Ω Feedthrough termination

Dual banana to BNC connector

3153 Settings (all channels):

Parameter	Setting	Comand(s)
Output	**ON**	**INST:SEL 1|2|3;:OUTP ON**
Frequency	**1kHz**	**INST:SEL 1|2|3;:FREQ 1e3**
Amplitude	**8V**	**INST:SEL 1|2|3;:VOLT 8**
Waveform	**SINE**	**INST:SEL 1|2|3;:FUNC:SHAP SINE**

Procedure:

1. Modify DMM setting to ACV/20V
2. Connect Channel 1 (then 2 and 3) output to the DMM. Use 50Ω Feedthrough termination at the DMM end of the cable
3. Adjust RV1 (channel 1), RV501 (channel 2) and RV502 (channel 3) for a DMM reading of 2.837V ±20mV reading

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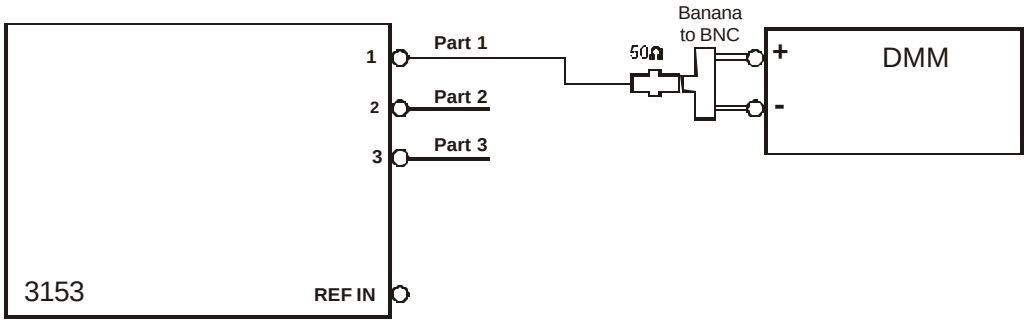


Figure 5-8, Amplitude Adjustment Setup

Offset Adjustment, Channels 1, 2, and 3

Equipment:

DMM

50Ω Feedthrough termination

Dual banana to BNC connector

3153 Settings (all channels):

Parameter	Setting	Command(s)
Output	**ON**	**INST:SEL 1|2|3;:OUTP ON**
Frequency	**1MHz**	**INST:SEL 1|2|3;:FREQ 1e6**
Amplitude	**1V**	**INST:SEL 1|2|3;:VOLT 1**
Waveform	**SINE**	**INST:SEL 1|2|3;:FUNC:SHAP SINE**

Procedure:

1. Modify DMM setting to DCV/200mV
2. Connect Channel 1 (then 2 and 3) output to the DMM. Use 50Ω Feedthrough termination at the DMM end of the cable
3. Adjust RV2 (channel 1), RV4 (channel 2) and RV7 (channel 3) for a DMM reading of 0V ±10mV reading
4. Modify 3153 offset setting for all three channels to 4V
5. Modify DMM setting to DCV/20V
6. Adjust RV3 (channel 1), RV5 (channel 2) and RV6 (channel 3) for a DMM reading of 4V ±20mV reading
7. Modify 3153 offset setting for all three channels to -4V
8. Verify DMM reading for all three channels of –4V ±20mV. If reading is not within range, then compensate with RV3 (channel 1), RV5 (channel 2) and RV6 (channel 3).
9. Repeat steps 6 and 7 until DMM readings are within range

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Chapter 6

PRODUCT SUPPORT

Product Support

Racal Instruments has a complete Service and Parts Department. If you need technical assistance or should it be necessary to return your product for repair or calibration, call 1-800-722-3262. If parts are required to repair the product at your facility, call 1-949-859-8999 and ask for the Parts Department.

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

For worldwide support and the office closes to your facility, refer to the Support Offices section on the following page.

Reshipment Instructions

Use the original packing material when returning the 3153 to Racal Instruments for calibration or servicing. The original shipping box and associated packaging material will provide the necessary protection for safe reshipment.

If the original packing material is unavailable, contact Racal Instruments Customer Service for information.

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Support Offices

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Appendix A
SPECIFICATIONS

VXIbus General Information

Module Form	Single slot VXIbus C-size module
Connectors	P1, P2
Protocol	A24/A32/D16 Slave, Message-Based
VXIbus Revision	2.0
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 (Write only)	A24, A32, D16

Module General Information

Configuration	Three independent waveform generators
Master/Slave Configuration	Master channel (100MS/s channel) provides sample clock for slave channels. Each slave channel can divide the sample clock down by an integer from 1 to 64k. Only the 100MS/s Channel is configurable as master, either or both 50MS/s channels are configurable as slaves. Phase offsets, in reference to channel 1, can be applied to channels 2 and 3
Independent Configuration	Each channel uses its own sample clock and trigger.

Synchronization Modes

Description	Each waveform generator can operate in one of three main modes. Each mode can be synchronized and or triggered as indicated.
Synchronization	Only the 100 MSa/s Channel is configurable as master, either or both 50 MSa/s channels are configurable as slaves. The master clock source may be internal or external. The sample clock may be divided from 1-64K on channels 2 and 3. Master Slave configuration is for User and Sequence Modes.

Output Waveforms

Fixed (standard)	The waveform generator outputs one of nine standard, pre-defined waveform.

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User (arbitrary)	The waveform generator outputs the selected arbitrary waveform.
Sequenced	The waveform generator outputs the arbitrary waveforms specified by the sequence. Each channel has an independent sequencer.

Fixed (Standard) Waveforms

Description	The standard waveforms are created by using the first 1024 points in waveform memory and by varying the Internal Sample Clock Frequency. Standard waveforms cannot be mixed with arbitrary waveforms. There is a minimal delay to reload standard waveforms when the points have been loaded with arbitrary waveforms. The first 1024 points are also available to User waveforms, but this section is the last to be allocated.

Waveforms

Frequency Range	Waveform dependent
Source	Internal synthesizer

Sine

Frequency Range	
Channel 1	10mHz to 50MHz
Channels 2/3	10mHz to 6.25MHz, usable to 25MHz
Programmable Parameters	
Start Phase	0 to 360°

Square

Frequency Range	
Channel 1	10mHz to 50MHz
Channels 2/3	10mHz to 25MHz
Programmable Parameters	
Duty Cycle	1% to 99%

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Triangle

Frequency Range	10mHz to 1MHz, usable above 1 MHz
Programmable Parameters	
Start Phase	0 to 360°

Pulse/Ramp

Frequency Range	10mHz to 1MHz, usable above 1 MHz
Programmable 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	10mHz to 1MHz, usable above 1 MHz
Programmable Parameters	
Cycles	4 to 100 cycles

Gaussian Pulse

Frequency Range	10mHz to 1MHz, usable above 1 MHz
Programmable Parameters	
Time Constant	10 to 200

Exponential Decaying/Rising Pulse

Frequency Range	10mHz to 1MHz, usable above 1 MHz
Programmable Parameters	
Time Constant	-100 to 100

DC

Range	-100% to 100% of amplitude

User (Arbitrary) Waveforms

Waveform Memory	
Channel 1	512k points (2 Meg optional)
Channels 2, 3	2 Meg points (4 or 8 Meg optional)
Waveform Memory Download	
Mode 1:	12-bit (Data only, Arb sets control bits)
Mode 2:	16-bit (User sets data and control bits)
Memory Segmentation	
Number of Segments	1 to 4096

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Memory Interleave	4 to 1
Segment Table Download	
Mode 1	SCPI Commands
Mode 2	High speed binary download
DAC Resolution	12 bits (4096 points)

Sequenced Arbitrary Waveforms

Description	The waveform memory can be divided into smaller segments. The sequencer allows the segments to be linked, and repeated in user-selectable fashion. Extremely long waveform can be generated using the sequencer. Note: The sequencer cannot use “Standard Waveforms." The sequencer can be started and stopped through firmware commands and by external triggers.
Advance Modes	
Automatic Sequence Advance	The wave segment is repeated the specified number of times (1 -1 M). No triggers are required to step from one segment to the next. The sequence is repeated continuously.
Stepped Sequence Advance	The current segment is sampled continuously, trigger advances to the next programmed segment. Control input is the TRIG IN connector, backplane trigger or internal trigger.
Single Sequence Advance	The current segment is sampled the specified number of repetitions and then idles at the end of the segment. The next trigger advances to next segment. Control input is the TRIG IN connector, backplane trigger or internal trigger.
Single1 Sequence Advance	The current segment is sampled one time and then idles at the end of the segment. The next trigger causes the next repeat (if any) to be sampled. Only after all repeats are complete will the sequencer advance to the next segment. Control input is the TRIG IN connector, backplane trigger or internal trigger.
Mixed Sequence Advance	Each step of a sequence can be programmed to advance either a) automatically (Auto Seq. Adv.) or b) with a trigger in the same manner as Single Sequence Advance.
Breakpoints	See Sequence Start and Stop sections

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Sequence Table Download	
Mode 1	SCPI Commands
Mode 2	High speed binary download
Sequencer Steps	From 1 to 4096
Segment Loops	From 1 to 1M
Min Segment Size	8 points
Minimum Segment Duration	1 µs (Points x SCLK period ≥ 1µs)

Synchronization

Description	Only the 100MS/s Channel is configurable as master, either or both 50MS/s channels are configurable as slaves. The master clock source may be internal or external. The sample clock may be divided from 1-64k on channels 2 and 3. Master Slave configuration is for User and Sequence Modes. Phase offsets, in reference to channel 1, can be applied to channels 2 and 3. Synchronization applies also for the following operating modes and conditions:

1) All trigger modes, where unique waveform length can be programmed to each channel
2) Mixed user and sequence modes (i.e., channel 1 is on user and channels 2 and 3 in sequence mode)
3) In continuous mode, synchronization between channels is possible only if all channels have the same waveform length, or if the longest waveform is an integer multiple of the other two shorter waveforms.

Inter-Channel Phase Offset

Description	Phase offset is applied to channels 2 or 3 to create skew between channels. Channel 1 is the reference channel.
Initial Skew	≤5 ns
Phase Offset Units	Waveform points or degrees, programmable
Range	1 to N; 0° to 360°
Resolution	4 waveform points
Accuracy	±(2/N + 10/W) x 360°, where N = number of waveform points, W = wave duration in ns

System Trigger Modes

Description	(Valid for all operating modes, sample clocks are independent)
Separate	Channels are triggered independently
Common	Two or three channels are triggered together. The trigger input is the master channel trigger from which channel 2, channel 3, or channels 2 and 3 may be triggered. Equal waveform length is not required for synchronization in this mode.

Trigger Modes

Normal	Continuous waveform is generated.

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Triggered	Each input cycle generates a single output cycle.
Internal Trigger	An internal timer repeatedly generates a single output cycle.
Gated	External signal enables generator. First output cycle is synchronous with the active slope of the triggering signal. Last cycle of output waveform is always completed.
External Burst	Preset number of up to 1M cycles stimulated by a backplane TTL trigger or external trigger. This mode is available in Fixed and User modes only.
Internal Burst	An internal timer repeatedly generates a burst of up to 1Meg counted output cycles. This mode is available in Fixed and User modes only. One timer is available for all 3 channels.

Breakpoint

Description	Waveform starts after trigger and stops at breakpoint position. Each channel can be programmed with its unique breakpoint
Event to cause stop at breakpoint	SCPI command or valid stop signal at the STOP input.
Breakpoint Error	±2 points

Trigger Start Phase

Description	Waveform starts from point n and completes at point n-1.
Programmable Units	Waveform points, degrees
Range	1 to waveform length; 0° to 360°
Resolution	4 points

Trigger Advance Sources

Internal (On one channel only)	Internal programmable rate generator
Period	From 20µs to 1000s
Accuracy	±(1% + 1µs)
External	
Input	1) Front panel SMB
	2) VXIbus (TTLTRG 0-3)
	3) VXIbus ECLTRG0
Frequency	
Fixed and User Mode	DC to 5MHz
Sequence Mode	DC to 500kHz
Software	IEEE 488.2 -TRG, VXI Word Serial trigger command

System Delay (Trigger to Waveform Output)

Separate	150ns + 1 Sample Clock
Common	150ns + 2 Slowest Sample Clock Periods

Inter-Channel Skew (Common Trigger Mode)

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Channel 1 to Channel 2 or 3	±10ns maximum
Channel 2 to Channel 3	±5ns maximum

Sample Clock Synthesizer

Internal Synthesizer

Channel 1 Range	10Hz to 100MHz
Channel 2, 3 Range	10Hz to 50MHz
Resolution	9 digits
Accuracy	Same as reference
Stability	Same as reference

External Synthesizer

Description	Can be enabled for channels 1-3 using the SCLK 1/2/3 input and for channels 2-3 only using the SCLK 2/3 input.
Level	> 0dBm, sine wave

Synthesizer Reference Source

Standard (internal)	>0.01% (100ppm) initial tolerance over a 19°C to 29°C temperature range; 100ppm/°C below 19°C and above 29°C; 100ppm/year aging rate (VXIbus CLK10)
External	Connector Front Panel BNC, 10MHz Input Impedance 50Ω nominal, AC coupled
Level	> 0dBm, sine wave

Sine Wave Performance

Description	Sine wave performance is measured using the maximum sample clock rate and the maximum amplitude resolution of the DAC. The output level is 10Vpk-pk. The Spectrum Analyzer Setting: Start Frequency=0MHz; Stop Frequency = 1GHz.
Sine wave Total Harmonic Distortion	0.3%, measured with maximum vertical resolution and horizontal sampling rate.

Channel 1 High Level Output

Harmonics and non-related spurious	< -55dBc for carrier frequencies < 1MHz < -40dBc for carrier frequencies < 5 MHz < -35dBc for carrier frequencies <10 MHz

In-band spurious and non-harmonic at 40MHz (measured with sample clock = 100MHz, 400-cycle sine waveforms in 1000 point segment).

	< -22dBc for amplitude ≤5Vp-p < -8dBc for amplitude ≤10Vp-p
Two Tone inter-modulation	< -35dBc for 23.1MHz & 24.1MHz, ≤5Vp-p < -25dBc for 23.1MHz & 24.1MHz, ≤10Vp-p

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Channels 2 and 3 High Level Output

Harmonics and non-related spurious	< -55dBc for carrier frequencies < 1MHz < -40dBc for carrier frequencies < 5 MHz

In-band spurious and non-harmonic at 20MHz. Measured with sample clock = 50 MHz, 400-cycle sine waveforms in a 1000 point segment

	< -25dBc for amplitude ≤5Vp-p < -15dBc for amplitude ≤10Vp-p
Two Tone inter-modulation	< -35dBc for 12.1MHz & 13.1MHz, ≤5Vp-p < -30dBc for 23.1MHz & 24.1MHz, ≤10Vp-p

Channels 2 and 3 Low Level Output

Harmonics and non-related spurious	< -60dBc for carrier frequencies < 1MHz < -45dBc for carrier frequencies < 5 MHz

In-band spurious and non-harmonic at 20MHz. Measured with sample clock = 50 MHz, 400-cycle sine waveforms in a 1000 point segment

	< -35dBc
Two Tone inter-modulation	< -55dBc for 12.1MHz & 13.1MHz

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Outputs (Each Channel)

Main Output

Connector	Front panel SMB
Standby	Output Off or Normal
Impedance	50Ω, ±1%
Protection	Protected against short to case ground
Amplitude	
Range	10mV to 10$V_{pk\text{-}pk}$ into 50Ω in three internal ranges
Resolution	3.5 digits, each range
Accuracy (1kHz)	±1%
Offset	
Range	0 to ±4.5 V in three internal ranges, amplitude dependent
Resolution	3.5 digits, each range
Accuracy	±1%

Amplitude-Offset Interaction

Description

Offset voltage is injected at the input of the output amplifier. Therefore, reducing the output amplitude has an automatic affect on the offset voltage. The 3153 has three internal amplitude ranges that are transparent to the user. However, it is necessary to understand these ranges in case a specific amplitude-offset combination is needed. The relationship between the internal amplitude ranges, their respective offset ranges and the resultant peak range limits are given in the equation and the table below.

$$\frac{Amplitude}{2} + \left|Offset\right| \leq PeakRangeLimit$$

Internal Amplitude Range	Offset Range	Peak Range Limit
10.00mV to 99.99mV	0 to 45.00mV	50mV
100.0mV to 999.9mV	0 to 450.0mV	500mV
1.000V to 10.00V	0 to 4.500mV	5V

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Filters	2 per Channel
Channel 1	none, 25 MHz, 50 MHz 7-pole
25MHz Amplitude Response	
Insertion Loss	<4 dB (DC-22.5MHz)
Stopband Attenuation	>47dB @ 55MHz
50MHz Amplitude Response	
Insertion Loss	<4 dB (DC-45MHz)
Stopband Attenuation	>47dB @ 110MHz
Channel 2	none, 12.5MHz, 25MHz 7-pole
12.5MHz Amplitude Response	
Insertion Loss	<4 dB (DC-11.25MHz)
Stopband Attenuation	>47dB @ 27.5MHz
25MHz Amplitude Response	
Insertion Loss	<4 dB (DC-22.5MHz)
Stopband Attenuation	>47dB @ 55MHz
Channel 3	none, 250 kHz, 25MHz 7-pole
250kHz Amplitude Response	
Insertion Loss	<1.75 dB (DC-250kHz)
Stopband Attenuation	>55dB @ 500kHz
25MHz Amplitude Response	
Insertion Loss	<4 dB (DC-22.5MHz)
Stopband Attenuation	>47dB @ 55MHz
Square Wave, Pulse	
Channels 1-3	
Rise/Fall time	<12ns, 10% to 90% of amplitude
Aberration	<5% + 10mV

Low Level Outputs

Description	Channels 2 and 3 have alternate outputs of fixed amplitude, 2Vpk-pk. Selection of these alternate outputs disables operation of channel 2 and 3 main outputs. Output filter selections are valid for Channel 2 and 3 low level outputs.

SYNC Output

Description	The sync output generates a single TTL pulse for synchronizing other instruments to the output waveform. The sync signal is validated for a number of different reasons. The sync signal can be delayed a fixed number of clock cycles. Each channel has a single sync output. Sync position and width are programmable.

SYNC Sources

Front Panel

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Connector	Front panel SMB, one output per channel
Standby	Output Off or Normal
Impedance	50Ω, ±10%
Level	> 2V into 50Ω, 5V nominal into 10kΩ
Protection	Protected against temporary short to case ground

VXIbus Backplane

Channels 1-3	TTLTrg4-6, respectively

Validations

BIT	Generate a sync signal each time a point within a specific wave segment is accessed.
LCOM	Generate a sync signal only once when the selected segment appears within a Sequence.
SSYN	Useful in triggered and gated modes to generate a sync signal at intervals that are synchronized with the start of the waveform. This mode help removing the ±1 clock jitter when observing the triggered signal on an oscilloscope
SREP	(Segment Repetition) Generate a sync signal at the start of each wave segment repetition.
SEG	(Segment Start) Generate a sync signal at the start of each wave segment within a sequence.
Custom	See Waveform Memory Download Mode 2

SYNC Parameters

Position	0 to N waveform points, 4-point setting resolution
Width Range	1(x4) to 200(x4), 4-point setting resolution. 1 generates 4-point width, 10 generates 40-points width, etc. Maximum sync width is 800 waveform points. Smaller segment than 800 points overrides width setting to segment length.

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Inputs (Each Channel)

TRIG Input

Connector	Front panel SMB
Impedance	10kΩ, ±5%
Threshold Range (Ch. 1)	Programmable Threshold
Threshold (Chs. 2 & 3)	TTL
Max Input Voltage	±12 V dc
Min Pulse Width	20ns
Slope	Positive or negative going edge.

Inputs (Global)

External 10 MHz Reference

Connector	Front Panel BNC
Impedance	50Ω nominal, AC coupled
Level	> 0dBm, sine wave

External Sample Clock Inputs

Description	An external sample clock can be routed to channels 1-3 using the SCLK 1/2/3 input and to channels 2-3 only using the SCLK 2/3 input. The sample clock can be divided by integer values from 1 to 65536 for channels 2 and 3 only. These External Clock inputs can be disabled through firmware.
Connectors	Front Panel SMB
Range	10MHz to 100MHz
Impedance	50Ω nominal, AC coupled
Level	>0dBm, sine wave
Isolation (SCLK to Ch1, 2, or 3 Output)	>60dB

Stop Input

Description	Valid signal at the Stop input stops the waveform at a programmed breakpoint. The Stop input operates simultaneously on all channels. Channel stop occurs separately and independently at a breakpoint uniquely programmed for each channel. If breakpoint has not been programmed, the waveform will stop after the last point.
Connector	Front panel SMB
Impedance	10k?, ±5%
Threshold Range	TTL

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Max Input Voltage	±12VDC
Min Pulse Width	20ns
Slope	Positive or negative going edge.

Start Input

Description	Valid signal at the Start input causes all channels to start generating waveforms from the last breakpoint. The start signal affects the output only after a stop signal has been received. Generating start signals while the 3153 generates waveforms has no affect on the output. The Start input operates simultaneously on all channels
Connector	Front panel SMB
Impedance	10k?, ±5%
Threshold Range	TTL
Max Input Voltage	±12VDC
Min Pulse Width	20ns
Slope	Positive or negative going edge

General

Front Panel Indicator LED's

Fail	Red - Power-up self test failure
Access	Amber - Module addressed on Vxlbus
Output On (Each Channel)	Green - Output on / off
External Clock	Green - Input on / off

Power Requirements

Maximum Total Module Power	<50 W

EMC

Radiated Emissions (Close Field)	VXlbus B.8.6.3 (Rev 1.4, Page 85)
Radiated Susceptibility	VXlbus B.8.6.4 (Rev 1.4, Page 94)
Conducted Emissions	VXlbus B.8.7.3 (Rev 1.4, Page 94)
Conducted Susceptibility	VXlbus 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

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Pressure (for 10°C rise)	0.5 mm H_2O
Environmental	
Operating temperature	0°C - 50°C
Humidity (non-condensing)	11°C - 30°C 80% +5%
	31°C - 40°C 75% +5%
	41°C - 50°C 45% +5%
Altitude	
Operating	10000 ft
Storage	15000 ft
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
Safety	Designed to meet IEC 1010-1, UL 311 1-1, CSA 22.2 #1010

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