User Manual
Models 5325 / 5300
50 / 125 MS/s PCIbus
Arbitrary Waveform Generators
Publication No. 120110

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PUBLICATION DATE: January 10, 2012

REVISION: 2.1

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DECLARATION OF CONFORMITY

We: Tabor Electronics Ltd.
9 Hatasia Street, Tel Hanan
ISRAEL 36888

declare, that the 50/100MS/s Single Channel Arbitrary Waveform Generators

Models 5325 and 5300

meet the intent of Directive 89/336/EEC for Electromagnetic Compatibility and the requirements of the Low Voltage Directive 73/23/EEC amended by 93/68/EEC. Compliance was demonstrated to the following specifications as listed in the official Journal of the European Communities:

Safety:
IEC/EN 61010-1 2nd Edition: 2001+ C1, C2

EMC:
EN 50081-1 Emissions:
EN 55022 - Radiated, Class B
EN 55022 - Conducted, Class B
EN 50082-1 Immunity:
IEC 801-2 (1991) - Electrostatic Discharge
IEC 801-3 / ENV50140 (1993) - RF Radiated
IEC 801-4 (1991) - Fast Transients

Models 5325 and 5300 are built on the same platform and share specifications and features except the 5325 is limited to 50MS/s (25MHz BW), while the 5300 is limited to 125MS/s (50MHz BW). The tests were performed on a typical configuration.

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Getting Started

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What's In This Chapter

This chapter contains general and functional description of the Model TE5325/ TE5300 Arbitrary Waveform Generator. It lists and describes various options available for this model. It also describes the front panel connectors and operational modes.

The Model TE5325 has maximum sample clock rate of 50 MS/s and maximum frequency output of 25 MHz while the Model TE5300 has maximum sample clock rate of 125 MS/s and maximum frequency output 50 MHz.

This manual provides description of all features and options available with the instruments; however, some items, which are described in the following paragraphs and chapters, may not apply to your instrument.

If you purchased the Model TE5325, replace all references to sample clock and frequency references with 50 MS/s and 25 MHz, respectively.

Introduction

Model TE5300 is a single-channel PCI-based Arbitrary Waveform Generator. It is a high performance waveform generator that combines three powerful instruments in one small package: function generator, Waveform generator and modulation generator. Supplied free with the instrument is ArbConnection software, which is used for controlling the TE5300 and for generating, editing and downloading waveforms from a remote computer. The following highlights the TE5300 and ArbConnection features.

Conventions Used in this Manual

The following conventions may appear in this manual:

NOTE
A Note contains information relating to the use of this product

⚠ *CAUTION*
A Caution contains information that should be followed to avoid personal damage to the instrument or the equipment connected to it.

⚠ *WARNING*
A Warning alerts you to a potential hazard. Failure to adhere to the statement in a WARNING message could result in personal injury.

The following symbol may appear on the product:

⚠ *CAUTION:*
Refer to Accompanying Documents

This refers you to additional information contained in this manual. The corresponding information in the manual is similarly denoted.

TE53xx Series Feature Highlights

- 50 MS/s sample clock frequency – TE5325
- 125 MS/s sample clock frequency – TE5300
- PCI Single Slot Module
- Built-in standard waveforms. Up to 50 MHz sinewave output
- 10 digits frequency setting, limited by 1 μS/s
- 14-bit vertical resolution
- 2M memory depth (1M – TE5325)
- Ultra fast waveform downloads
- 1 ppm clock stability
- Extremely low phase noise carrier
- Frequency agility: FSK, ramped FSK, sweep, FM
- Trigger start phase control and breakpoints
- Built-in sequence generator
- Multiple instrument synchronization with tight phase control
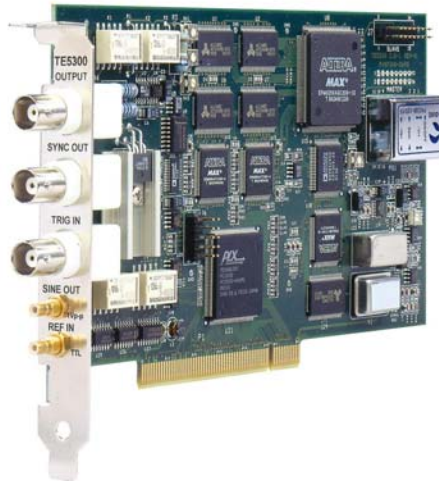
Figure 1-1, TE5300

ArbConnection Feature Highlights

- Three powerful tools in one software package: Instrument control panel, Waveform composer and FM signal composer
- Detailed virtual front panels control all TE5300 functions and modes
- Wave composer generates, edits and downloads complex waveforms
- FM wave composer generates and downloads complex modulating signals
- Automatic detection of active instruments
- Equation editor generates waveforms from equations
- SCPI command and response editor simulates ATE operation
- Translates waveform coordinates from ASCII and other formats
- Simplifies generation of complex sequences
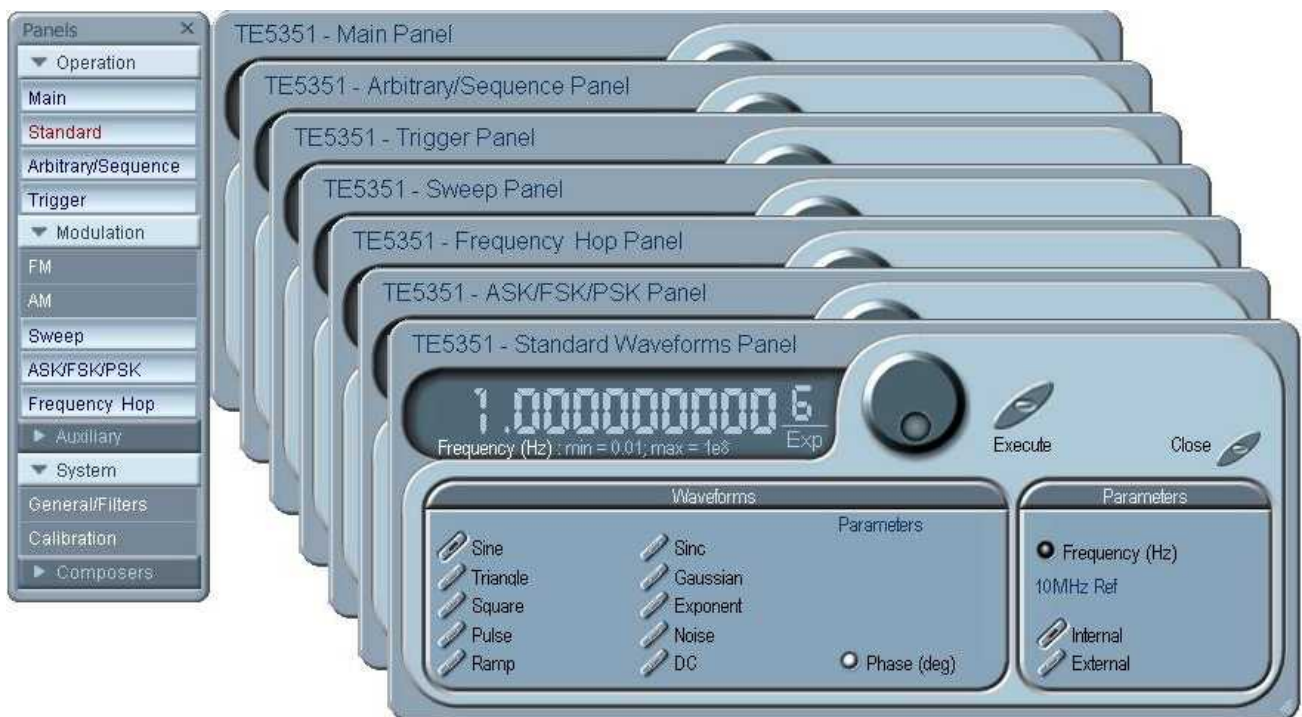
Figure 1-2, ArbConnection - Control Panels
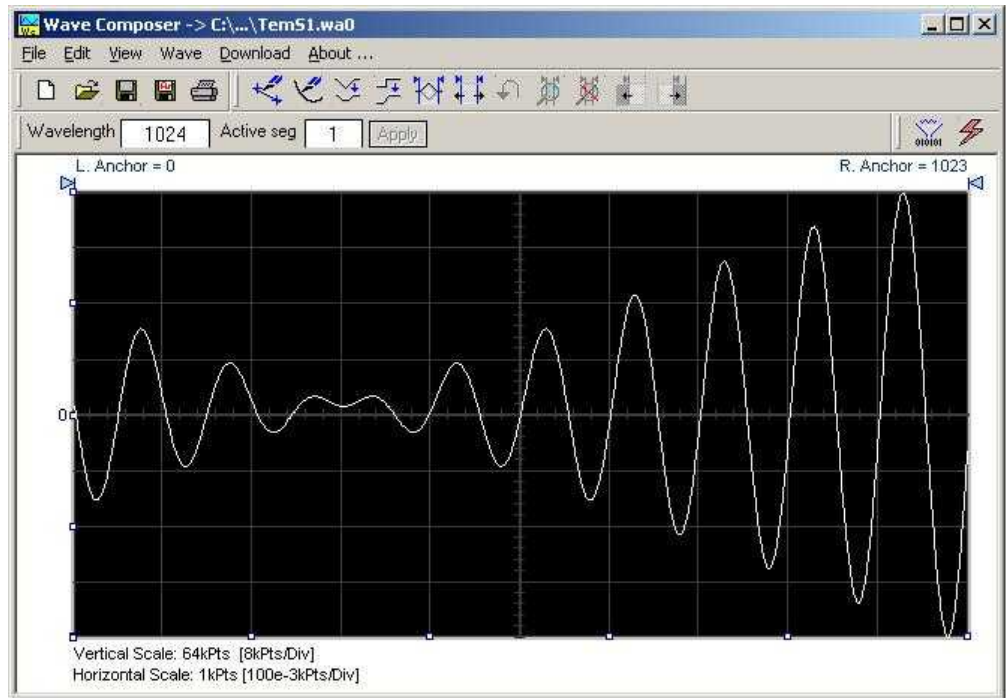
Figure 1-3, ArbConnection - Wave Composer
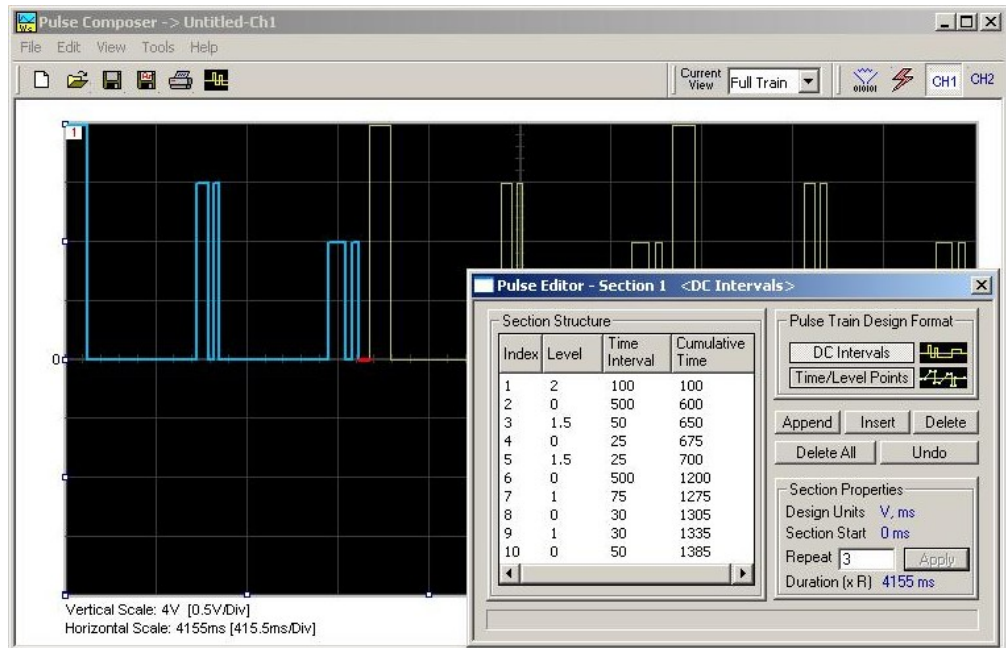
Figure 1-4, ArbConnection - Pulse Composer

Functional Description

Detailed functional description is given following the general description of the features and functions available with the TE5300.

Output Functions Model TE5300 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 a few standard functions such as sine wave, triangular wave and square wave. Each time that a standard function is required, the instrument calculates its coordinates and places them in the waveform memory. Therefore, every time a standard function is selected, minimal time is required for the controller to compute the function and load its data to the waveform memory.

Frequency Waveform frequency and sample clock are programmed with 10 digits, limited only by 1 μS/s. Frequency accuracy of the output waveform is determined by the clock reference, either external, the 1ppm standard TCXO or CLK10, which provides 100ppm accuracy and stability over time and temperature.

Amplitude The output level may be programmed from 200 mV to 20 Vp-p into open circuit, or 100 mV to 10 V into 50Ω. Offset may be applied to the output to shift the signal either positive or negative. Offset and amplitude are inter-related, so make sure you understand the offset-amplitude ranges before you apply offset to your signal.

Trigger Modes Besides its normal continuous mode, the TE5300 responds to a variety of trigger sources. The output waveform may be gated, triggered, or generate a counted burst of waveforms. A built-in trigger generator, having a programmable period can be used as a replacement of an external trigger source. The internal trigger generator can be programmed with resolution of 7 digits. The TE5300 can be programmed to output triggers on one or more of 8 trigger lines that are connected to P2, as well as, be programmed to respond to these same trigger lines.

Arbitrary Waveforms The Model TE5300 generates arbitrary waveforms with 14 bits of vertical resolution. Any waveform it generates must first be loaded to its waveform memory. The arbitrary waveform memory is a bank of 14-bit words. Each word represents a point on the horizontal waveform scale. Each word has a horizontal address that can range from 0 to 2,097,152 and a vertical address that can range from -8192 to +8191 (14 bits). Using a high speed clocking circuit, the digital contents of the arbitrary waveform memory is 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.

Memory Segmentation There is no need to use the entire memory every time an arbitrary waveform is generated. The waveform memory can be divided into

smaller segments and different waveforms can be loaded into individual 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 128 K times.

Remote Control   The instrument must be used in conjunction with a host computer. All of its functions, modes and parameters are fully programmable using SCPI commands and syntax. There are three ways to program the Model TE5300, the first being low-level programming of each individual parameter, using SCPI commands. The second alternative is to use ArbConnection for high-level programming. ArbConnection is a software package supplied with the TE5300 that simulates a mechanical front panel. It has all the necessary push buttons, displays and dials to operate the instrument as if you were using it on the bench. The third alternative is using application specific drivers, such LabVIEW.

The TE5300 must be programmed to generate waveforms. Therefore, it is recommended that the user becomes familiar with its basic features, functions and programming concepts as described in this and subsequent chapters.

Frequency Agility The instrument generates its sample clock from a DDS circuit (direct digital synthesis). The DDS circuit enables frequency agility through the complete frequency range of the TE5300. Having such an enormous range opens the door for a wide range of applications such as wide band sweep, FSK and frequency modulation. The TE5300 can generate FSK, Ramped FSK and Linear or Logarithmic sweep. The instrument can also frequency modulate its carrier using one of its built-in waveforms, or with can also generate any user-defined modulating signal, which can be downloaded using the FM wave composer.

Supplied Accessories

The instrument is supplied with a CD that includes an Instruction Manual, ArbConnection for Windows 95/98/ME/2000/XP/NT and plug & play drivers.

Specifications

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

Functional Description

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

Front Panel Connectors

The TE5300 has 3 BNC connectors on its front panel: main and SYNC outputs and trigger input. There are also 2 SMB connectors: sine output and 10 MHz reference input. These connectors are described below.

Output

The output connector outputs fixed (pre-defined) waveforms to 50 MHz, user (arbitrary) and sequenced waveforms with sampling clock to 125 MS/s. Output impedance is 50Ω, that is, the cable connected to this output should be terminated with 50Ω load. Amplitude accuracy is calibrated when connected to a 50Ω load. The amplitude is doubled when the output impedance is above 1 MΩ.

SYNC Output

The SYNC output generates a single TTL pulse for synchronizing other instruments (i.e., an oscilloscope) to the output waveform. The SYNC signal always appears at a fixed point relative to the waveform. The location of the SYNC signal along the waveform is programmable. The SYNC output is also used as marker output when the sweep, or FM functions are turned on.

TRIG/FSK IN   In general, this input accepts signals that stimulate generation of output waveforms. The trigger input is inactive when the generator operates in continuous mode. When placed in trigger, gated or burst modes, 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 TE5300. The direction of the transition is programmable. In gated mode, the trigger input is level sensitive, i.e., the generator is gated when the logic level is high and idle when the level is logic low. Trigger level for this input is TTL.

The same input is used in FSK mode, where the output hops between two frequencies – carrier and shifted frequencies. The output generates carrier frequency when the FSK input is false and shifted frequency when the FSK input is true.

The trigger input is also used as stop and start input when the TE5300 is placed in Arm mode.

SINE OUT   This SMB connector outputs dc coupled, fixed level (1 V_{pk-pk} into 50Ω) sine waveforms. This output is derived directly from the sample clock generator and is active at all times, regardless of present operating mode of the TE5300. The frequency of the sine output is programmed using the sample clock parameter. Frequency agility and modulation affect this output directly. The sine waveform output is programmed to 125 MHz, so it may serve as an additional output to those available on the front panel.

REF IN   This SMB connector accepts 10 MHz, TTL level reference signal. The external reference input is available for those applications requiring better accuracy and stability reference than the one provided inside the TE5300. The reference input is active only after selecting the external reference source mode.

Operating Modes

The TE5300 can be programmed to operate in one of four operating modes: continuous, triggered, gated and (counted) burst. These modes are described below.

Continuous Mode

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

Triggered Mode

In triggered mode, the TE5300 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. When triggered, the generator outputs one waveform cycle and remains idle at the first point of the waveform. The instrument can be armed to receive a trigger signal from either the front panel connector, soft command, an internal trigger generator, from one of 8 backplane trigger lines or from a backplane STAR line. As an alternative to an external source, the TE5300 has a built-in trigger generator that can be programmed through a wide range of frequencies and with 7 digits of resolution.

The trigger signal, whether it comes from the front panel, backplane or from a soft command, has to pass through some electrical circuits. These circuits cause small delay known as system delay. System delay cannot be eliminated completely and 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.

Gated Mode

In gated mode, the TE5300 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 reverts to an idle state. The idle amplitude level, after the gating signal goes low, is the last point on the waveform.

Burst Mode

The burst mode is an extension of the triggered mode where the generator can be programmed to output a pre-determined number of waveforms. The sources to trigger a burst are the same as for the trigger mode.

Frequency Agility

Using the latest DDS (direct digital synthesis) technology, the TE5300 is extremely agile. Operations like sweep, FSK and FM are directly derived from the DDS circuit by controlling its input bits. Frequency agility is described below.

Sweep

The TE5300 can sweep from minimum to maximum sample clock frequency settings. You may select to sweep up or down using linear or logarithmic increments. Sweep time is programmable from 1 ms to 1000 seconds with 7 digits. The sweep start and stop frequencies program the front-panel sine output connector. You may also use the sweep from the main output but must first calculate start stop frequencies, depending on the present sample clock frequency and waveform length. You may use the sweep in continuous, triggered, or gated modes.

FSK

FSK (frequency shift keying) function controls the sine output connector. The trigger input is used to flag the TE5300 when to output carrier frequency (trigger false) or when it should switch to the shift frequency (trigger true). You may also use the FSK function from the front panel as long as you do your own calculation of carrier and shifted frequencies, depending on the present sample clock frequency and waveform length.

Ramped FSK

Ramped FSK is the same as the FSK function except the output frequency is ramped instead of switched to the shift frequency. Ramp time is programmable with 3 digits from 100 μs to 1 second.

FM

The FM function modulates the TE5300 sample clock frequency. You can frequency modulate the output either with built-in waveforms, or download complex waveforms to the modulation memory. Using the latest DDS technology, the modulation is wide band and extremely linear. FM can be used in continuous, triggered and gated modes. The TE5300 can generate two types of frequency modulation: 1) Standard and 2) Arbitrary. In standard mode, the modulating waveform is selected from a built-in library of 4 standard waveforms: sine, triangle, square and ramped. In arbitrary mode, the modulating signal is downloaded to the modulation waveform memory. There are 20,000 points allocated specifically for the arbitrary memory that is used for arbitrary frequency modulation.

Output Type

The TE5300 can output three types of waveforms: standard (Fixed), arbitrary (User) and sequenced waveforms. Description of the various waveform types that the instrument can generate is given below.

Standard (FIXED) Waveforms

The TE5300 must pre-load its memory before it can generate waveforms. 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 TE5300 can be programmed to output one of nine standard waveform shapes: sine, triangle, square, pulse/ramp, sine(x)/x pulse, gaussian pulse, rising/decaying exponential pulse, noise and dc. There are some parameters associated with each waveform, which modify the shape of the waveform to better suit your needs. For example, different start phase for the sine waveform can be programmed for each channel to create phase offsets between the two instruments.

Arbitrary (User) Waveforms

The arbitrary waveform memory is capable of storing one or more user-defined waveforms. As was discussed before, the TE5300 is supplied with 2 Meg memory bank. There are up to 2 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 and loaded with different waveforms and 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 2 Meg points are loaded in one shot. The TE5300 utilizes a DMA (direct memory access) concept that speeds data transfer from host computer to the instrument.

Sequenced Waveforms

The sequence generator is a 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 1-5a through 1-5c. 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 1-5d.

The sequence circuit is useful for generating long waveforms with repeated sections. The repeated waveform has to be programmed once and the repeater loops on this segment as many times as selected. When in sequenced mode, there is no loss of time between linked or looped segments.
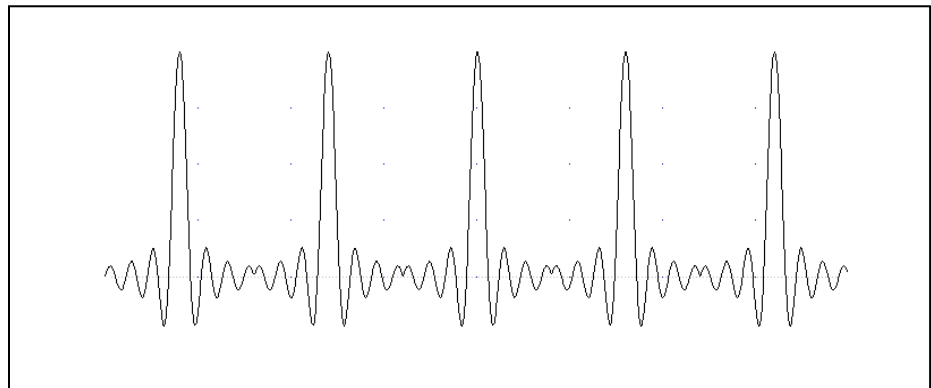
Figure 1-5a, Segment 1 – Sin (x)/x Waveform
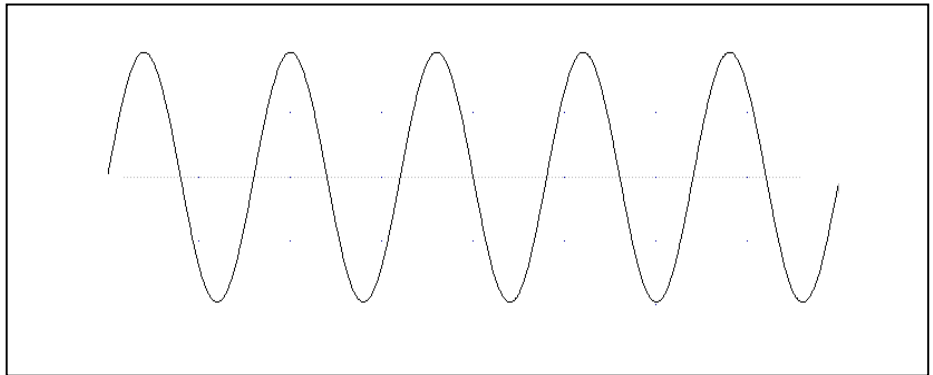
Figure 1-5b. Segment 2 – Sine Waveform
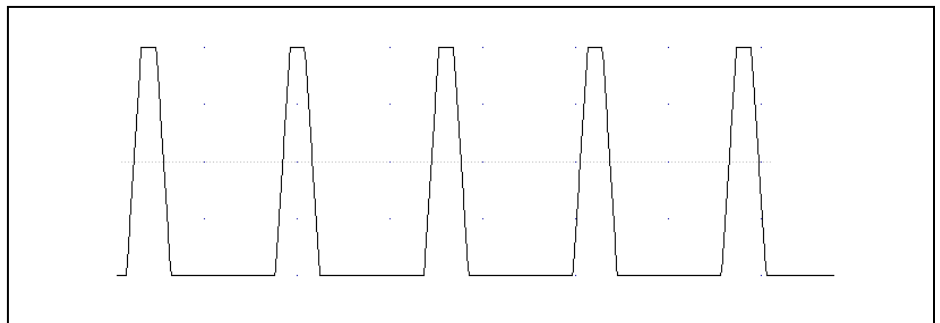
Figure 1-5c Segment 3 – Pulse Waveform

The following sequence was made of segment 2 repeated twice, segment 1 repeated four times, and segment 3 repeated two times.
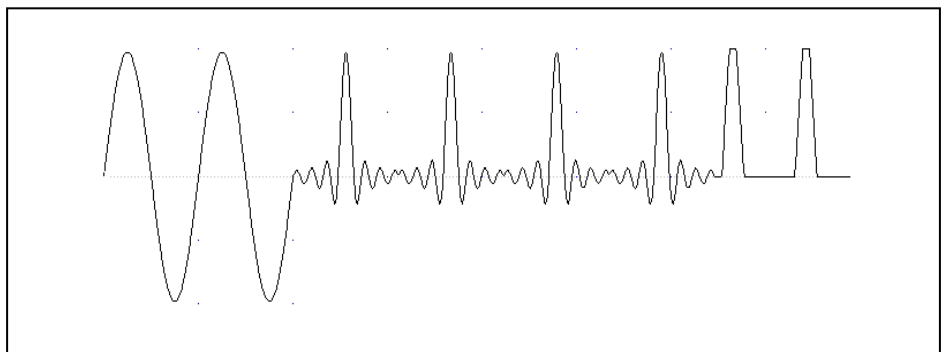
Figure 1- 5d. Sequenced Waveforms

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.

Filters

Two filters are built into the TE5300. 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. The filters are also used for reconstructing the standard sine waveform.

Programming the TE5300

The TE5300 does not have front panel control capability. Also, waveform data and sequence tables must be loaded to the TE5300 from a host computer before it can be output arbitrary or sequenced waveforms. There are a number of ways to "talk" to the instrument. They all require that an appropriate software driver be installed in the host computer. The rest is a matter of practice and knowledge of the language in use. These topics are discussed in later chapters.

Low level programming of the TE5300 is accomplished using SCPI (Standard Commands for Programmable Instruments) language. Programming aspects are covered in Chapter 4.

Supplied with the TE5300 is a PC software package called ArbConnection. This software provides a user interface that allows interacting with and controlling the TE5300 directly. Details on how to use ArbConnection are given in Chapter 3.

Chapter 2
Configuring the Instrument

Installation Overview

This chapter contains information and instructions necessary to prepare the Model 5300 for operation. Details are provided for initial inspection, grounding requirements, repackaging instructions for storage or shipment 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. The following sections contain information and cautions that must be observed to keep the 5300 operating in a correct and safe condition.

⚠ **CAUTION**

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 chassis. 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.

Operating Environment

The 5300 is intended for operation within a computer chassis as a plug-in module. Ensure the computer chassis being used to host the 5300 fully conforms to the latest PCI specifications, including 3.3V supply rail.

The 5300 is intended for indoor use and should be operated in a clean, dry environment with an ambient temperature within the range of 0 °C to 40 °C.

⚠️ *WARNING*

The 5300 must not be operated in explosive, dusty, or wet atmospheres. Avoid installation of the module close to strong magnetic fields.

The design of the 5300 has been verified to conform to EN 61010-1 safety standard per the following limits:

Installation (Overvoltage) Category I (Measuring terminals)
Pollution Degree 2

Installation (Overvoltage) Category I refers to signal level, which is applicable for equipment measuring terminals that are connected to source circuits in which measures are taken to limit transient voltages to an appropriately low level.
Pollution Degree 2 refers to an operating environment where normally only dry non-conductive pollution occurs. Occasionally a temporary conductivity caused by condensation must be expected

Power Requirements

The 5300 operates from a computer chassis. DC Voltages are supplied to the instrument from the PCI connector. The instrument requires a variety of DC voltages as outlined in the Specifications section (Appendix A). Ensure the PCI bus is capable of delivering required voltages and has sufficient current to drive the generator.

⚠️ *CAUTION*

Disconnect power to the computer Chassis before installing or removing the 5300.

Grounding Requirements

To conform to the applicable safety and EMC requirements, ensure that the 5300 instrument panel and the computer chassis are "earth" grounded.

⚠️ *CAUTION*

The outer shells of the front panel terminals (OUTPUT, SYNC OUT, TRIG IN, SCLK IN, 10M REF IN) are connected to the instrument's chassis and therefore to the safety ground.

⚠️ *CAUTION*

Do not attempt to float the OUTPUT from ground as it may damage the 5300 and other equipment connected to the 5300 I/O connectors.

Calibration

The recommended calibration interval is two years. Calibration should be performed by qualified personnel only.

Abnormal Conditions

Operate the 5300 only as intended by the manufacturer. If you suspect the 5300 has been impaired, remove it from the computer chassis and secure against any unintended operation. The 5300 protection is likely to be impaired if, for example, the instrument fails to perform the intended measurements or shows visible damage.

⚠️ *WARNING*

Any use of the 5300 in a manner not specified by the manufacturer may impair the protection provided by the instrument

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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 Tabor Electronics representative or the Tabor Electronics 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 Tabor Electronics 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 returned authorization order number (RMA) as well as the date and method of shipment. ALWAYS OBTAIN A RETURN AUTHORIZATION NUMBER FROM THE FACTORY BEFORE SHIPPING THE INSTRUMENT TO Tabor Electronics.

Preparation For Use

Preparation for use include removing the instrument from the bag, installing the 5300 inside the computer chassis, copying instrument drivers to the computer and installing the graphical interface (ArbConnection).

Removing the Instrument from the Bag

The 5300 is supplied in an antistatic bag. Check the seal on the bag to make sure the bag was not opened in a static-unsafe environment. Place the enveloped card on static free surface and hook yourself up with a grounding strap. Only then break the seal and remove the card from the envelope. Hold the card at the metal panel end. Refrain from touching the instrument with your finger at all times.

Installation

Plug the 5300 into your computer's PCI bus. Push the card firmly until the PCI connector until the metal panel makes contact with the metal edge of the computer chassis. Using a suitable screwdriver, tighten the retaining screw.

⚠️ *CAUTION*

Disconnect power to the computer Chassis before installing or removing the 5300. An attempt to insert or remove the instrument while the power is connected to the chassis will result in severe damage to the instrument and will automatically revoke your warranty.

⚠️ *CAUTION*

Once the 5300 is installed in the chassis cover all remaining open slots to ensure proper airflow. Using the 5300 without proper airflow will result in damage to the instrument.

Installing Instrument Drivers

The 5300 is a Plug & Play instrument, meaning that after you install it in your computer chassis, Windows will automatically detect its presence and will ask you to supply the appropriate drivers to operate this instrument. After you copy the drivers, Windows will add the drivers to the device manager and will assigns resources for the instrument.

The 5300 is supplied with a CD that contains the *inf file for installing the necessary drivers for operating the instrument on your computer. Follow the instructions below to install the driver to your computer.

Minimum System Requirements

Minimum host system requirements for the instrument are as follows:

1. Windows XP
2. 128 MB of RAM, 250MB or more recommended
3. 20 MB hard drive space

Windows Software Installation

📝 *Note*

The install program will automatically detect older software version and you will be provided with a choice of either removing it and installing newer versions, or keeping your old installation intact. The install program will not remove instrument drivers. In case you want to remove the instrument driver from your computer, go to the Windows Device Manager and remove the Arbitrary Waveform Generator Model 5300 under the Tabor Electronics heading.

In general, installation is very similar for different Windows variants however, you should follow the exact procedure as applicable for you're your computer. The following paragraphs will guide you through device driver installation for Windows XP.

Windows XP Device Driver Installation

A device driver is necessary for the 5300 software to communicate with PCI boards. The 5300's installation CD includes instrument drivers for supporting the required Windows platform. In Windows XP, the installation package cannot automatically assign device drivers for PCI devices and therefore leaving for the Plug & Play Manager the responsibility for detecting devices and prompting the user for the correct driver. To assign a driver to a device, Windows refers to an *.INF file. The *.INF file provides instructions for Windows as to which driver files to install and which registry entries to insert. To install a driver for your 5300, complete the following steps:

1. Power down your computer and computer chassis.
2. Insert the 5300 board into a free PCI slot.
3. Power on your computer chassis
4. Power on the computer. Windows should first detect the new hardware device with a "Found New Hardware Wizard" message box.
5. Windows then displays the "Found New Hardware Wizard" as shown in Figure 2-1, which will search for new drivers
6. Follow the procedure as shown below.

Figure 2-1 – The Welcome to the Found New Hardware Wizard

Press Next and select one of the options in the dialog box below. We recommend that you check the "Search for a suitable driver for my device" option as shown in Figure 2-2.

Figure 2-2 – Install Hardware Device Drivers

Press Next and you'll now be prompted to select the location of your driver files on your computer as shown in Figure 2-3. Check the "Specify a Location" option only.

Figure 2-3 – Locate Driver Files

The 5300 is supplied with an installation At this time, CD. Insert this CD into your CD-ROM drive. If you already have the instrument drivers installed somewhere on your computer, you can specify your custom location. Either type in the complete path or click on the Browse button to identify your driver location.

🗒️ *NOTE*

After you insert the installation CD, Windows XP will automatically load the autorun program and the CD interface will show on your screen. The CD menu is not required for the driver installation so you can either leave the menu on screen and ignore it for now or click on Exit to remove the application from your desktop. The installation CD must be left in the CD-Rom drive for the continuation of the installation process.

Press Browse… and specify the subfolder W2kdrv located in the Drivers folder on your installation CD, as shown in Figure 2-4. Press OK to acknowledge the selected path.

Figure 2-4 – Copying Device Drivers

Windows displays the Driver Files Search Results as shown in Figure 2-5. Click Next and then Finish completing the installation process.
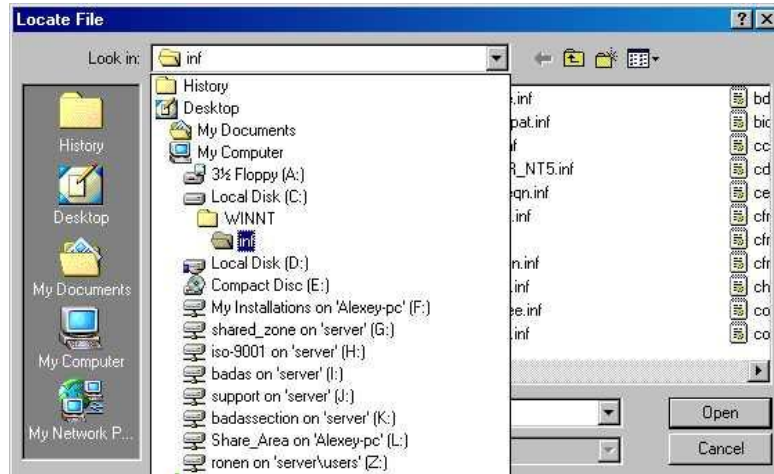
Figure 2-5 – Driver Files Search Results

Figure 2-6 – Completing the Found New Hardware Wizard

The next step is necessary to verify that the device driver was installed properly and is displayed correctly in the System Device Manger. Do the following:

1. Click on the Start button, then Settings and then Control Panel.
2. In the Control Panel dialog box, find the icon labeled System.
3. Double click on the System icon and then on the Hardware
4. On the Hardware tab click on the Device Manager button.
5. Click on Tabor Electronics. If you installed the driver properly, your device manager should show the Arbitrary Waveform Generator Model 5300 as shown in figure 2-7.
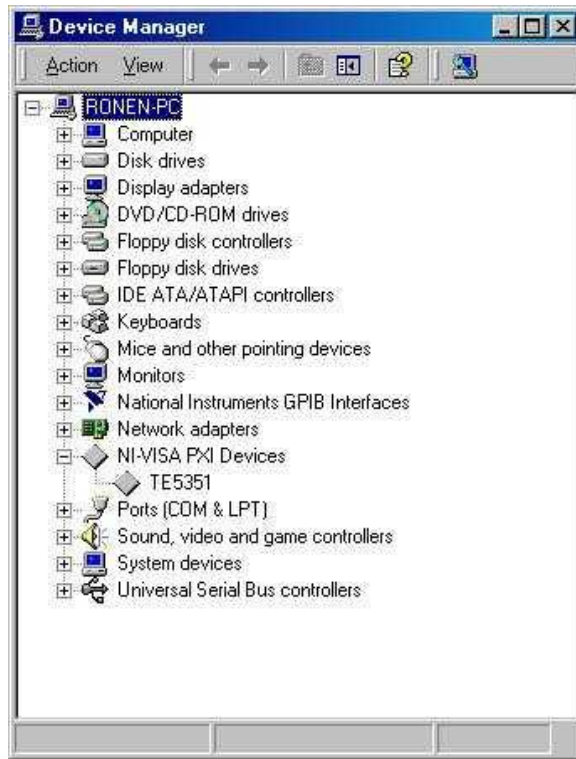
Figure 2-7 – Device Manager

Click on "X" to remove the System Properties dialog box from the screen.

Installing Software Utilities

The 5300 is supplied with a CD that contains the following programs: IVI Driver, ArbConnection, device driver and some other utilities to aid you with the operation of the instrument, including a manual in pdf format. It is recommended that you stow away the CD in a safe place after you load the drivers and the necessary utilities to control the 5300.

The *IVI driver* is a useful utility that provides standard communication and commands structure to control the 5300 from remote. Programming examples are also available to expedite your software development. The IVI driver comes free with the 5300 however, you'll need the IVI engine and visa32.dll run time utilities to be able to use the IVI driver. The additional utilities can be downloaded for free from NI's (National instrument) web site – www.ni.com.

ArbConnection is a user friendly program that lets you control instruments functions and features from a remote computer. It also lets you generate and edit arbitrary waveforms on the screen, build sequence tables, modulating signals and much more and then

download the signals to your 5300 without the hustle of writing complex programs and utilities. This is also a great tool for you to experiment simple, or complex command string to gain experience before you write your own code. ArbConnection has a command editor feature that allows direct low-level programming of the 5300 using SCPI commands, just as you will be using them in your program. Installation of ArbConnection is simple and intuitive and only requires that visa32.dll runtime file be added to your Windows system folder. Download the file from NI's (National instrument) web site – www.ni.com. Installation and operating instruction for ArbConnection are given in Chapter 4.

The *Device* driver is mandatory to operate the 5300. If you do not intend to use any of the IVI or ArbConnection software utilities, you must copy the dll to your development folder. If you install the IVI driver and ArbConnection, the dll is automatically installed in your Windows->System32 sub-folder.

Installing IVI Drivers and ArbConnection

ArbConnection or the IVI drier are two software utilities that one of them must be installed on your computer for you to be able to operate and control the 5300. ArbConnection has three basic function: 1) Control instrument setups, 2) Create, edit and download complex arbitrary waveforms to your instrument and 3) Create, edit and download complex (frequency) modulating waveforms.

Advanced users may want to write their own applications to control the 5300 functions and features. For this purpose, C++ libraries and DLL's are available on the CD and can be copied to your application folder. This is done automatically when installing the IVI driver. However, if you are first time user and can't wait to get your hands on some controls and waveforms, it is recommended that you install ArbConnection now. ArbConnection and waveform generation aspects are covered in other sections of this manual.

To proceed with the installation process, insert the supplied CD into your CD-ROM drive and wait for a GUI (Graphical User Interface) to pop up on your screen. If you wait for a long time and the GUI fails to load it is possible that your computer is not set up to load CD programs automatically. In this case, Invoke Run and type:

```
N:\Autorun.exe  (where N is your CD drive letter)
```

To install the software click on "Install Software Utilities" and follow the install program as shown in Figure 2-8. The preparing phase will check few things such as if your computer has any previous installations installed on.

If you are an advanced user and in preparation to write your own code and application, you'll have to copy support libraries and some DLL's from the installation CD. In this case, select the "Copy Developer Libraries" option and specify the folder location for your application. The function of the libraries and other programming aspects are cover in the programming section of this manual.
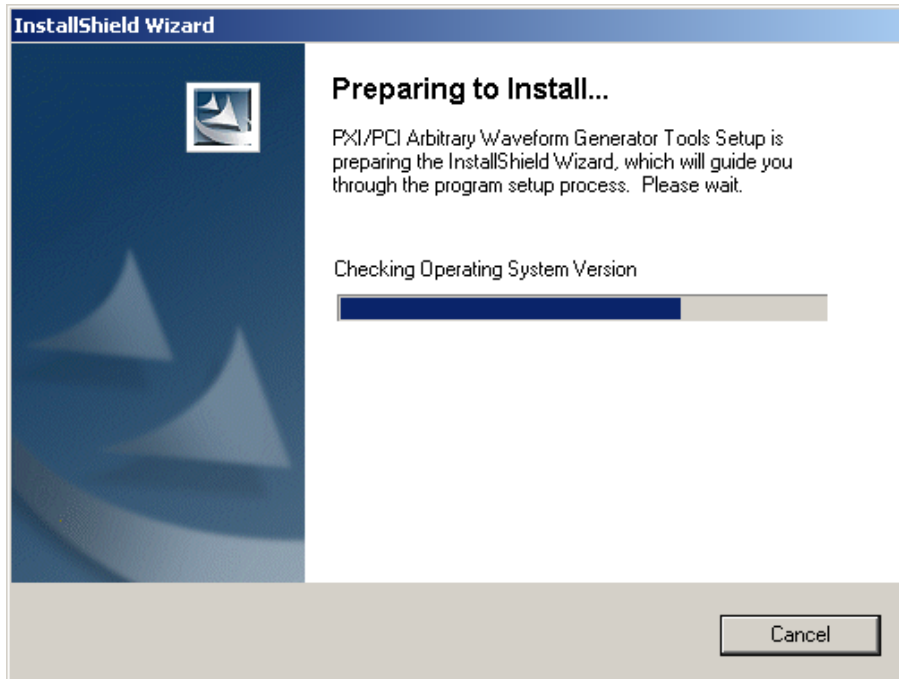
Figure 2-8 – Install preparation

After finishing the "Preparing to Install" phase, the install wizard shown in Figure 2-9 will take you to the first installation step assuming that no problems were detected.
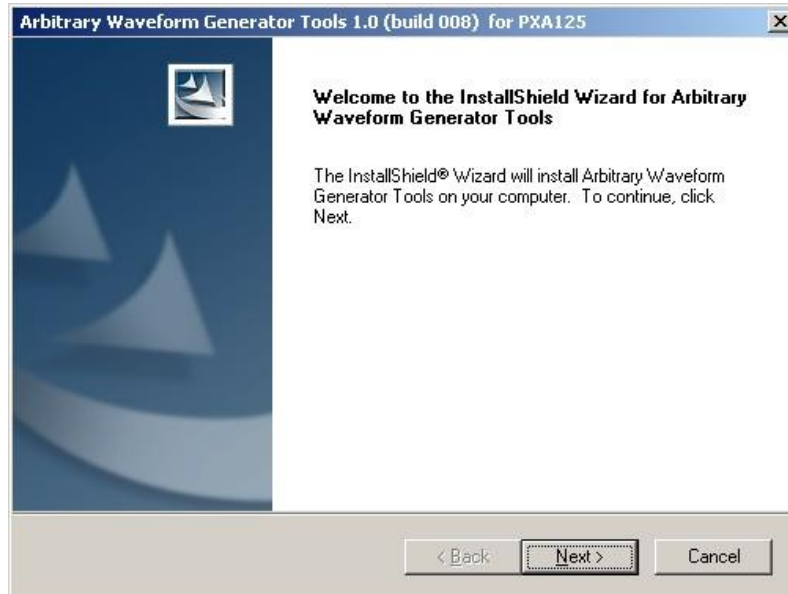
Figure 2-9 – First Installation Step

Press Next and type the customer details at the "Customer Information" Window, as shown in Figure 2-10.
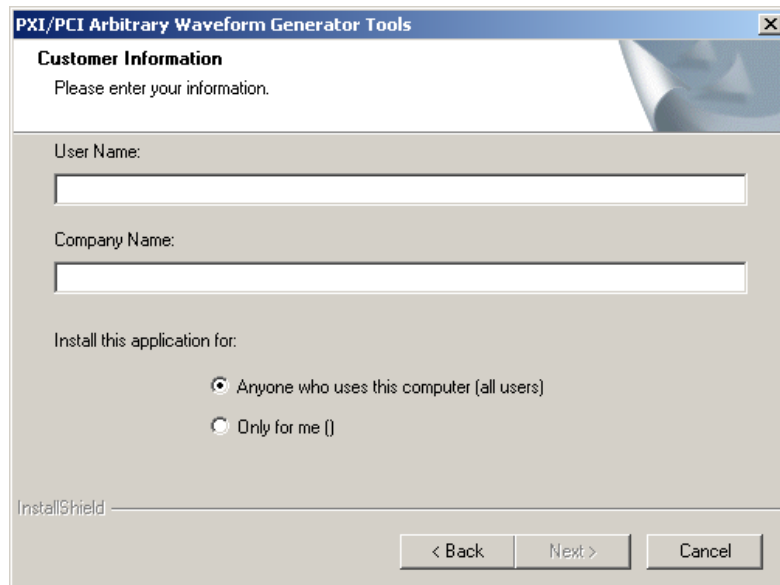
Figure 2-10 – Customer Information Step

After typing the customer details press Next and select the Setup Type. You can select from three options: 1) Select 5300 if you purchased and are installing the 5300, or 2) Select Custom if you are an advanced user and want to refine your installation process.

We recommend that you install using option above and complete the installation process by clicking on the Next button and then Finish. If you select the Custom option, then you'll have to type in some other parameters such as new path for your destination folder and choosing which feature to install, as shown in Figures 2-11.
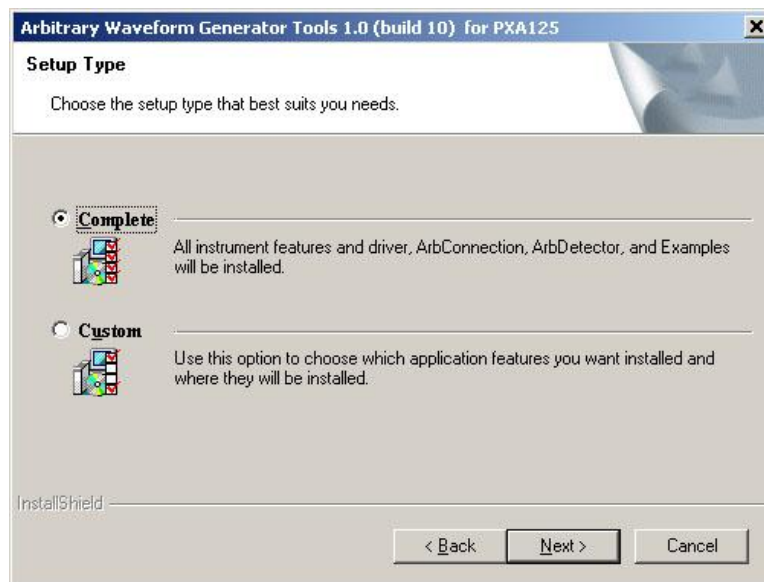
Figure 2-11 – Selecting Setup Type

If you select the Custom option, proceed to change your Destination Folder, as shown in Figure 2-12, by pressing the Browse button, select the appropriate path, press OK and then press Next.
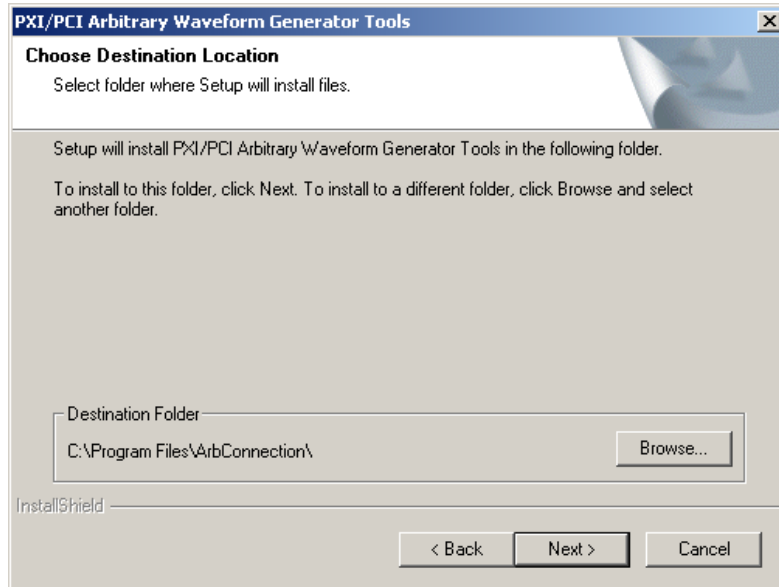
Figure 2-12 – Selecting Destination

The final step to complete the installation process, you'll be prompted to restart your computer. You can select to either restart your computer immediately or do it later, but remember that the software will not function properly if you do not restart your computer.
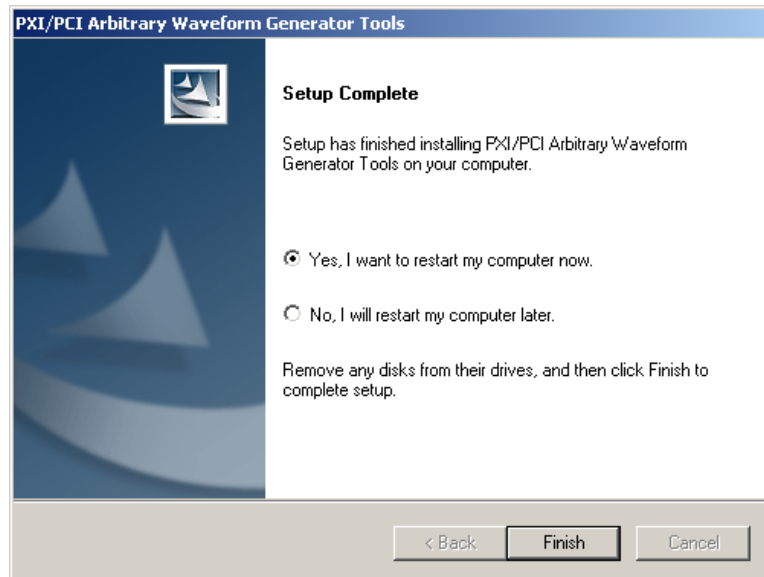
Figure 2-13 – Setup Complete

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Chapter 3
ArbConnection

What's in This Chapter?

This Chapter contains information how to install, invoke and use ArbConnection. Introduction to ArbConnection and examples how to program instrument controls and parameters and how to generate waveforms and download them to the 5300 are also given in the following sections.

Introduction to ArbConnection

In general, ArbConnection is a utility program that serves as an aid for programming the Model 5300. ArbConnection has many functions and features of which all of them share a common purpose – controlling 5300 functions from remote. As minimum, to use ArbConnection, you'll need the following tools:

1. Computer, Pentium III or better

2. Windows 2000/XP, or higher

3. High resolution screen, at least, 1024 x 768 pixels

4. Pointing device, mouse or ball

5. Visa 2.6, or higher installation

6. Last, but not least, some basic knowledge how to operate computers and Windows-based programs.

ArbConnection operation is divided into three main functions: 1) Front panel control, 2) Waveform generation and editing and 3) Low level SCPI editing. These operating options are described in this chapter however, you must install ArbConnection before you can use it. The next paragraphs describe installation and first steps before going into in-depth operation.

Installing ArbConnection

The installation program installs ArbConnection on a logical drive of your choice. The default is drive C. It automatically creates a new directory and copies the files that are required to run the program. Before you install ArbConnection, make sure that there is at least 10 megabytes of available memory on your hard disk drive.

To install ArbConnection, insert the distribution CD in the CD drive and follow the on-screen instructions to install ArbConnection. If your computer fails to detect the CD, access the CD from My Computer and invoke the Setup command.

The install program does the complete job far you and creates a workgroup and icons to start ArbConnection.

Quitting ArbConnection

Before you start roaming through menus and editing commands, we strongly recommend that you make yourself familiar with ArbConnection basics and concept. For now quit the program and spend some more time with this section of the manual. Point the mouse cursor to the File menu and press the left mouse button. Move the mouse cursor to the Exit command and press the left mouse button.

For the New and Advanced Users

For the New User
Learning to use ArbConnection is easy, intuitive and quick, even if you have never used such programs before. After you have installed ArbConnection on your computer read the following paragraphs to learn how to find your way around ArbConnection's menus.

Once you are familiar with the basics, you'll continue to learn about features, programming, and editing commands. If you can't find the answer to a question in this guide, call your distributor or the LeCroy customer support service near you and we'll gladly assist you with your problems.

For the Advanced User
If you are already familiar with computer conventions and have basic knowledge of Windows programming, you may want to skip some of the following paragraphs.

Conventions Used in This Manual

This manual uses certain typographical conventions to make it easier for you to follow instructions. These conventions are de-scribed in the following:

[Enter, or ↵] Press the Enter or Return key.

[Esc] Press the Escape key.

[Alt-F] Press the Alt key and the key that follows, simultaneously. In this example the key that follows is F.

[Ctrl-S] Press the Control key and the letter that follows, simulta-neously. In this example, the letter is S. The control key also appears in the menus as a target sign.

[↑] [↓] [→] [←] Press the Arrow key with the symbol pointing in the direction specified (i.e., up, down, left, or right).

<+> Press the key for the character or word enclosed in angle brackets. In this case, the Plus sign key.

The Opening Screen

Invoke ArbConnection by double clicking on the icon. If you cannot find the icon on your desktop, click on Start, Programs and ArbConnection. The opening screen will show. If you installed the program correctly, your screen should look as shown in Figure 3-1.
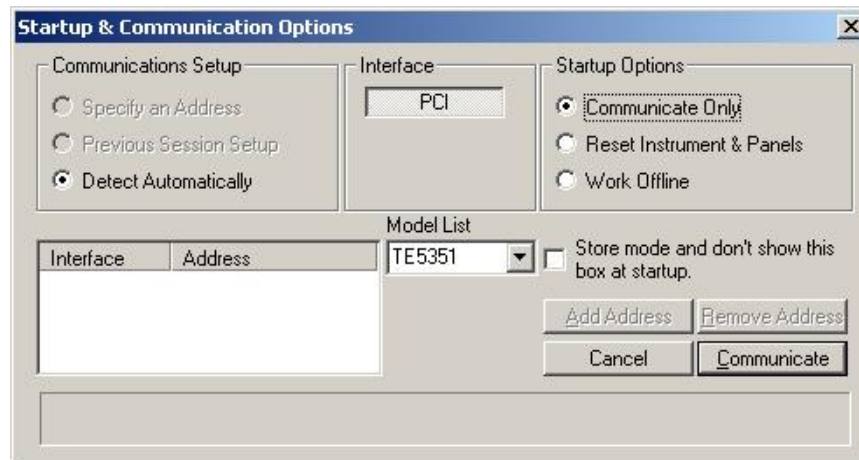
Figure 3-1, Startup & Communication Options

The Startup & Communication Options dialog box is displayed. You can check the "Store mode and don't show…" so next time you invoke ArbConnection, this dialog box will not be displayed. The purpose of this dialog box is to update the program in the way you intend to use it. For example, if you are using two cards in your computer but intend to use a specific device, you can click on the Specify an Address option and type in the required address so the next time you use ArbConnection, the program will automatically resume communication with the same card address as was originally detected.

If you chose to hide this dialog box, you can still access and change the options from the System command, at the top of the screen.

Make your selection and click OK. The Startup & Communication Updater dialog box will be removed from the screen. And the Main panel will now be accessible. But before we go into panel operation, let's look at the toolbars at the left top of the screen as shown in Figures 3-2 and 3-3.

Figure 3-2, ArbConnection's Toolbars

The standard Windows **Menu Bar** is the top bar. It provides access to main system controls like saving files, and viewing or removal of screen images.

The second bar is called **Link** bar. It provides direct access to different instruments that are active on the active interface bus. ArbConnection can control a number of 5300 units simultaneously. If the instruments were connected to the interface while invoking ArbConnection, they will automatically be detected by the program and will be placed in the Link pull-down window. The active instrument is displayed with its associated address. If you run ArbConnection in offline mode, the Link bar will show 5300, Offline.

The **Panels** toolbar, as shown in Figure 3-3, provides direct access to instrument control panels. The individual control panels are explained later in this chapter. The Main, Standard, Arbitrary, Trigger and the other buttons will bring up to the screen panels that are associated with these names. The Composers button provides access to the Waveform and Pulse composers. The first time you launch ArbConnection, the opening screen will have the Main panel open. Click on other buttons and interactively get the feel how ArbConnection opens and closes control panels.
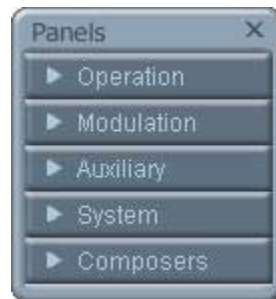
Figure 3-3, the Panels Toolbar

ArbConnection Features

ArbConnection's main purpose is controlling 5300 functions and parameters. The 5300 can generate standard waveforms from a built-in library, arbitrary waveforms from user-downloaded coordinates, modulated waveforms, digital patterns and much more. The only way to access all of these features is through software utilities such as Plug & Play drivers, and soft front panels. ArbConnection is built to provide complete control over the 5300.

ArbConnection has three main screens: control panels, waveform composers and various utility control panels. The various screen images along with instructions how to access and use them are described below in detail.

The Control Panels

The control panels look and feel just as if you would operate an instrument from its front panel. They even look like instrument front panels, so operating function and changing parameters is easy and intuitive. Let's look at the first panel that shows at the opening screen. This panel, as shown in Figure 3-5, is called the Main Panel.

To begin with, let's explore the panel controls to see how they feel, react and what they do. All other panels share almost the same feel, so the description of how to operate the Main Panel can serve as general guide for controlling the rest of the panels.

Looking at the panel you can identify the following controls: Push buttons, LED's, radio buttons, Dial and Digital display. The function of each control is described below.

Push Buttons – These are used for toggling a function on and off. For example, the Output Enable button in the Output group toggles the output on and off. The first mouse click will push the button inwards and will turn on a red bar at the center of the button, indicating that the function is on. The second mouse click will turn the function off.

Radio Buttons – Are used for changing operating modes, or selecting between mode options. One of the radio buttons is always on with a red dot in its center, indicating its state condition.

LED's – The LED's indicate which of the parameters are displayed on the Digital Display. Red LED indicates that the parameter name next to this LED is selected. Only one LED can be ON at a time.

💡 *HINT*

LED's are turned on by clicking on the LED or the text next to it. The selected parameter is flagged by a darker LED shade.

Dial – Use the dial to modify displayed reading. To use the dial, press and hold the mouse cursor on the dial and move the mouse in a clockwise circle to increase the number, or counterclockwise circle to decrease the displayed number. The dial modifies digits at the cursor position and will allow modification within the legal range of the displayed parameter. If you reach the end of the range, the dial will have no further effect on the display. If you do not want to use the dial, you can still change the display reading by using the [↑], or [↓] keys, or simply type the required number using the standard keyboard features.

NOTE

After you change the displayed readout, the 5300 will be updated with the new parameter only after you press the Execute button.

Digital Display – The display is used for displaying and reading various 5300 parameters, just as you would use it on your instrument.

Note

Normal color of the digital reading is dark blue. If you modify the reading, the color changes to a lighter shade of blue, indicating that the 5300 has not been updated yet with the new parameter. Pressing Execute will update the instrument and will restore the color of the digital readout to dark blue, indicating that the displayed value is the same as the generator setting.

Also note that the digital readout has an autodetect mechanism for the high and low limits. You cannot exceed the limits if you are using the dial but only if you use the keypad. In case you do, the program will not let you download an illegal parameter and you'll be requested to correct your setting.

The Operation Panels

The Operation tab provides access to a group of panels that control the basic operation of the generator. From this group you can set the output function, run mode, turn the outputs on and off and adjust the parameters for the various functions. There are four panels in this group: Main, Standard, Arbitrary/Sequence and Trigger. The Main panel is always visible because this is the panel that controls operating functions, run modes and sets the outputs on and off. The other panels can be made visible by clicking on the appropriate tab in the Operation group. The Operations Panels bar is shown in Figure 3-4 and the operation panels are described below.

Figure 3-4, the Operations Panels

Main

The Main Panel, as shown in Figure 3-5, is the first panel you see after invoking ArbConnection. Notice how buttons and LED's are grouped; this is done specifically so that common parameters are placed in functional groups. The Main Panel groups allow (from left to right) adjustment of amplitude and offset, selection of waveform mode, selection of run mode and control over SYNC and Main output parameters. Controls, where applicable, are provided for each channel separately.

Figure 3-5, the Main Panel

If you are connected properly to a PC and ArbConnection has detected your instrument, then every time you press a button, you are getting an immediate action on the 5300. It is different if you are changing parameters on the display; Doing this, you'll have to press the Execute button for the command to update the instrument. The functional groups in the Main Panel are explained below.

Parameters

The Parameters group has two parameters for each channel: Amplitude and Offset. To access the required parameter, click on the LED or the text next to it to display the required parameter. The value that is associated with the lit LED is displayed on the digital display. You can use the dial, keyboard, or the [↑] [↓} keys to adjust the readout to the required setting. After you modify the reading, press Execute to update the 5300 with the new reading.

Function

The Function group is used for selecting between function types. The 5300 provides four types of waveforms: Standard, Arbitrary, Sequenced and Modulated. By pressing one of these buttons output waveform will change to the selected option. The default function type is Standard. If you want to change standard waveform parameters, you can select Standard from the Panels bar.

Run Mode

The Run Mode group is used for selecting the active run mode for the instrument. You can select between continuous, triggered, gated and burst modes. There is no additional panel associated with the continuous mode, but if you press one of the other run mode options, you'll be able to adjust the trigger parameters from the Trigger Panel.

Output Control

The Output Control group controls the state of the main outputs and the sate of the SYNC output. Click on the State buttons to toggle the outputs on and off.

From this group you also control the position of the SYNC pulse.

The load impedance buttons allow you to adjust the display amplitude reading to your actual load impedance value. The default value is 50 Ω and the output range is calculated in reference to this value. If your actual load impedance is higher than 50 Ω and you increase the load impedance value in this group, the output of the 5300 will display the correct value as is measured on your load impedance.

Standard

The Standard Panel, as shown in Figure 3-6, is accessible after you click on the Standard button in the Panels bar. The Standard Waveform Panel groups allow (from left to right) adjustment of waveforms and their associated parameters. The functional groups in the Standard panel are described below.

Figure 3-6, the Standard Waveforms Panel

Waveforms

The Waveforms group provides access to a library of built-in standard waveforms. The library includes: Sine, Triangle, Square, Pulse Ramp, Sinc, Exponential, Gaussian and DC waveforms. Each waveform has one or more parameters that can be adjusted for the required characteristics of the output. For example, phase start can be adjusted for the sine and triangle waveforms and duty-cycle can be adjusted for the square waveform. The pulse waveform can be adjusted for rise and fall time as well as width and delay. Parameters that are associated with each waveform are automatically displayed when the waveform is selected.

Note that by clicking a button in this group, you are immediately updating the 5300 output with this waveform shape.

Parameters

The parameters group contains buttons that control the source of the 10 MHz reference and the setting of the output frequency for the standard waveforms function.

The 10 MHz Ref controls toggle between an internal and external references. The default setting is internal, which provides frequency accuracy of 1 ppm. If such accuracy is not sufficient for your application, click on the external option but make sure that a reference source is applied to the rear panel connector; otherwise, the accuracy of the output will deteriorate completely.

The Frequency control lets you program the output frequency of the selected waveform shape. The frequency parameter may be modified when the LED illuminates. You can use the dial, keyboard, or the [↑] [↓} keys to adjust the readout to the required setting. After you modify the reading, press Execute to update the 5300 with the new reading.

Arbitrary/Sequence

The Arbitrary & Sequence panel, as shown in Figure 3-7, is invoked by pressing the Arb/Seq button on the Panels bar. Note that if you invoke the Arbitrary & Sequence Panel from the Panels menu, the 5300 will not change its output type. On the other hand, if you select the arbitrary, or the sequenced options from the Main Panel, the 5300 will immediately change its output to the selected waveform type. The functional groups in the Arbitrary Waveforms Panel are described below.

Parameters

The Parameters group contains three parameters: Amplitude, Offset and Segment. Actually, the amplitude and offset values exhibited in this group are exactly the same as in the Main Panel, so every time you change amplitude and offset in the Parameters group, the other panels are updated automatically. The segment parameter provides access to the active segment for each channel. By selecting a segment as active, the sync pulse is attached to this specific segment number.

To access the required parameter, click on the parameter name. The LED next to the required parameter turns on. The value that is associated with the lit LED is displayed on the digital display. You can use the dial, keyboard, or the [↑] [↓} keys to adjust the readout to the required setting. After you modify the reading, press Execute to update the 5300 with the new reading.

Figure 3-7, the Arbitrary & Sequence Panel

SCLK

The SCLK (Sample Clock) group is comprised of parameters that control the sample clock frequency. The sample clock setting affects the 5300 in arbitrary mode only.

The sample clock rate is programmed in units of S/s (samples per second) and will affect the instrument only when it is programmed to output arbitrary or sequenced waveforms. The SCLK parameter has no effect on the frequency of the standard waveforms.

The two switches in the SCLK group select between internal and external sample clock inputs. The internal is the default setting. When you select the external sample clock option, make sure an appropriate signal is connected to the external sample clock connector on the rear panel.

To access the required parameter, click on the button until the LED next to the required parameter turns on. The value that is associated with the lit LED is displayed on the digital display. You can use the dial, keyboard, or the [↑] [↓} keys to adjust the readout to the required setting. After you modify the reading, press Execute to update the 5300 with the new reading.

10 MHz Ref

The 10 MHz Ref controls toggle between an internal and external references. The default setting is internal, which provides frequency accuracy of 1 ppm. If such accuracy is not sufficient for your application, click on the external option but make sure that a reference source is applied to the rear panel connector; otherwise, the accuracy of the output will deteriorate completely.

Sequence

The Sequence Advance Mode group provides control over advance modes for the sequence generator. Advance options are: Auto, Stepped, Single and Mixed. Refer to the 5300 manual to find out more when and how to use these advance modes. You should be careful while selecting modes because it is possible to cause settings conflict, for example, if you select the Single option before you modified the run mode to Triggered.

Memory Management

The memory management group provides access to the memory partition and waveform studio screens. The Waveform Partition button opens a screen as shown in Figure 3-8 and the Waveform Studio button opens a screen as shown in Figure 3-9. Information how to use these screens is given in the following paragraphs.

Using the Memory Partition Table

If you want to learn more about waveform memory and segment control, you should refer to section 2 of this manual. In general, the 5300 can generate arbitrary waveforms but, before it can generate waveforms, they must be downloaded to the instrument from a host computer. Waveforms are downloaded to the instrument as coordinates and are stored in the 5300 in a place designated as "waveform memory". The waveform memory has a finite size of 2M.

Having such long memory does not necessarily mean that you have to use the entire memory every time you download a waveform. On the contrary, the 5300 allows segmentation of the memory so that up to 10,000 smaller waveforms could be stored in this memory. There are two ways to divide the waveform memory to segments: 1) Define a segment and load it with waveform data, define the next and load with data, then the third etc. or 2) Use what ArbConnection has to offer and that is to make up one long waveform that contains many smaller segments, download it to the instrument in one shot and then download a memory partition table that splits the entire waveform memory into the required segment sizes. Want to use it? Here is how it is done. Point and click on the Memory Partition. A dialog box as shown in Figure 3-8 will pop up.
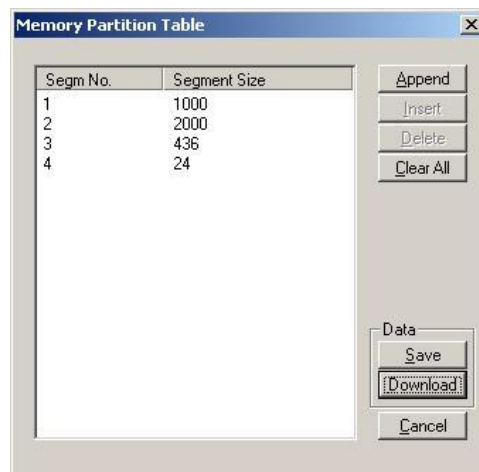
Figure 3-8, the Memory Partition Table

The two main fields in the segment table are Segment number and segment size. The **Seg No** (segment number) is an index field that can has values only, from 1 to 4,096. The **Segment Size** is always associated with the segment number. You can program any segment size from 16 to 2 M.

Use the **Append** key to add a segment at the end of the segment list. If you highlighted a segment, the Append key turns automatically to insert Use the **Insert** key to insert a segment at the cursor location. The **Delete** key is used for deleting a segment at the cursor position.

The **Clear All** key will remove all segments from the table and will let you start designing your segment table from fresh.

Click on the **Close** to discard of the contents of the dialog box without saving your last actions and to remove the Segment Table from the screen.

The **Save** key saves the current session so you can start the Memory Partition table from the same point after you close this session. The **Download** key updates the 5300 with the present segment table settings.

TIP

The Memory Partition table does not download waveforms. Use the memory partition table only if you merged a few waveforms to one. The partition table then divides the memory to the individual and original size of each waveform. If you download waveforms using the waveform studio, they already contain segment size and there is no need for further use of the memory partition table.

Using the Waveform Studio

The Waveform Studio, as shown in Figure 3-9 has two parts: 1) Segment Table and 2) Sequence Table. The purpose of the waveform studio is to provide access to waveform files that are already resident in the system. These files can be delegated to various segments and later be used as individual waveforms or combined into complex sequences.

The Segment Table

Using the Segment Table you may list and download waveform files that were previously stored on the computer. The table shows the segment number and its associated file name, length and its download status. There are other means to download waveforms to memory segments such as the Wave Composer and individual function calls; The waveform studio makes it easier by combining multiple and complex commands into one simple dialog box.

To access the Segment table, click anywhere on the Segment Table area. If it was not yet, it will turn white as opposed to the Sequence Table area that turns gray. The Segment Table area is divided into three parts: the table area, the waveform shape area and control buttons. When you point and click on one of the waveforms, its shape is shown in the Waveform Shape window.

The Segment Table has four fields:

The **Seg** field contains numbers from 1 through 4,096, designating the programmed memory segment. Note that memory segments are numbered from 1 to 4,096.

The **State** field shows the current status of the memory segment. It can be *Free*, if no file has yet been assigned to this segment number, or *Mapped*, if file name has been assigned to the segment but the Download button has not been used yet to move the file to the 5300 memory, or *Loaded*, if the process has been completed by pressing either the Download button or the All (download all) button.

The **File** field is an edit field that lets you browse and select file names to be applied to a specific memory segment. To change or add file name, point and click on the File name field and either type your path or browse to the file location and let Windows find the right path.

The **Length** field displays the length of the selected memory segment. Memory segments size may be programmed from 16 to 2 M. Note that the length field is not accessible and shown for reference purpose only.
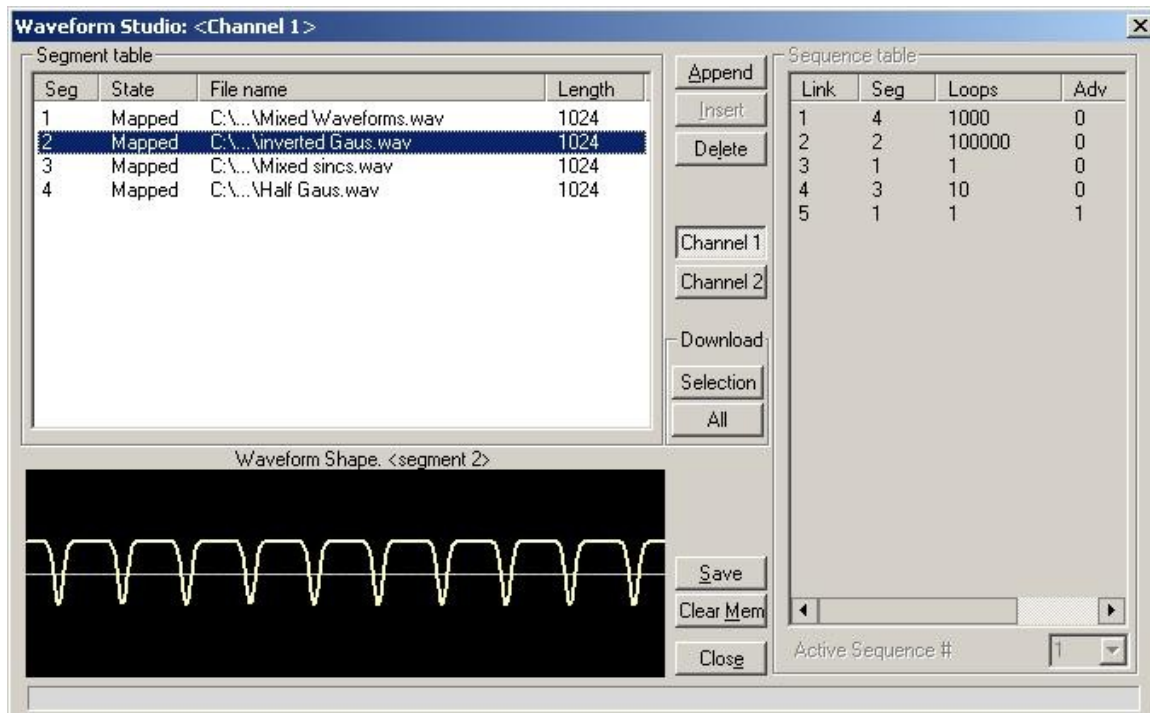
Figure 3-9, the Waveform Studio

💡 *TIP*

Point and click on one of the segments to show its shape in the Waveform Shape window.

Description of the various buttons in the Segment Table is given below.

Append – adds segment number at the end of the table

Insert – adds a segment above a highlighted segment line

Delete – removes a highlighted segment

Save – saves current table settings

(Download) Selection – downloads a highlighted segment only to the 5300 memory

(Download) All – downloads the complete table to the 5300 memory

Clear Mem – wipes out the entire memory and clears the table for fresh settings

Close – removes the Waveform Studio from the screen. If you have not saved your work, the table setting will be lost.

The Sequence Table

As was explained in the above, the waveform memory can be divided into smaller segments and up to 2048 segments can be defined and used as individual arbitrary waveforms. Having a limited size of waveform memory can, for some applications, pose a limitation however, if sections of the waveform are repetitive, one may use the sequence generator to take these segments and replay them as part of the complete waveform without loosing valuable memory space and without scarifying waveform coherences, or integrity. The tool for using repetitive and multiple segments in one long waveform is called Sequence Generator. The 5300 has two separate sequence generators, one for each channel and ArbConnection has a special dialog box where sequences are designed. This tool is called – Sequence Table.

Using the Sequence table you can use waveforms that you already downloaded to the 5300 from the Segment table, link and loop in random order to create one long and complex waveform that combines the individual memory segments.
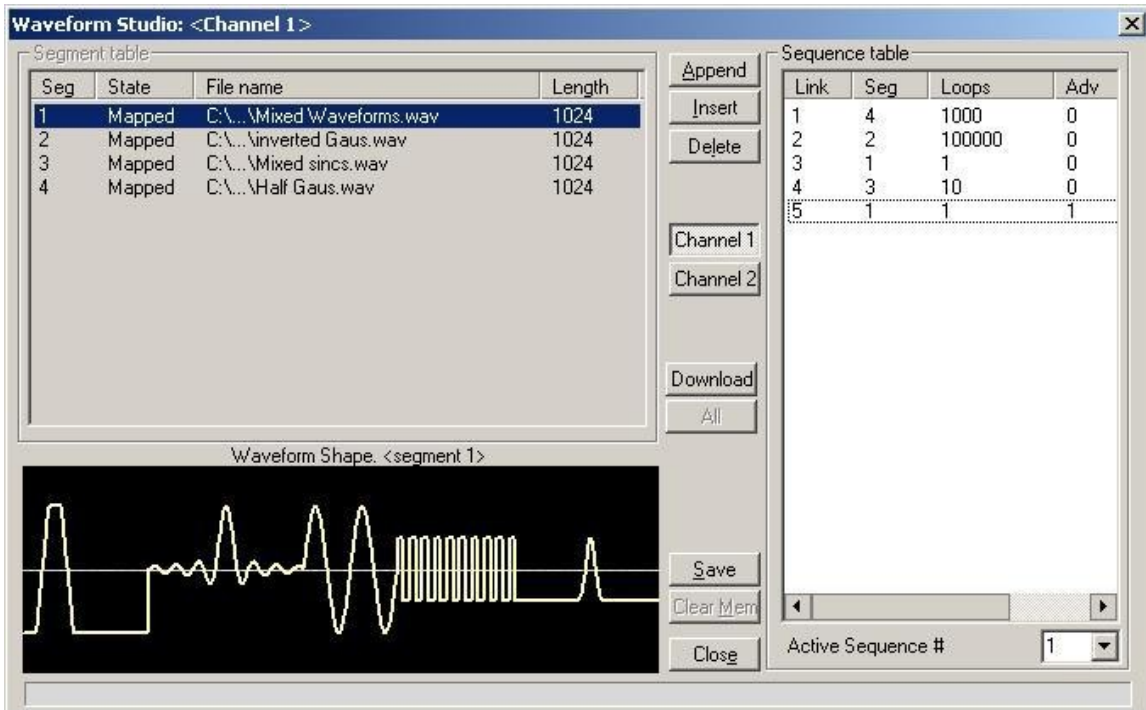
Figure 3-10, the Sequence Table

The Sequence Table is demonstrated in Figure 3-10. To access the Sequence table, click anywhere on the Sequence Table area. If it was not yet, it will turn white as opposed to the Segment Table area that turns gray.

There are four major elements that you should consider while programming a sequence table. They are: Link, Seg, Loops and Adv. These terms are explained below.

Link - This parameter defines an index array for the sequence generator. When generating sequences, the instrument steps though the links in descending order therefore, make sure that you enter your waveform segments in exactly the order you would like them at the output.

Seg - This parameter associates waveform segments with links. You can use different segments for different links or you can use the same segment for a number of links. There are no limitations how you associate links to segments, except you cannot program in the sequence table segments that were not defined earlier.

Loops – This parameter define how many times the segment will loop for the selected link. For example, if you program 2, the waveform will cycle twice through the same segment before transitioning to the next link.

Adv – This parameter flags the advance mode for the specific segment. This flag is active when the advance mode is Stepped. When set to 0, the sequence will advance through the list automatically until a segment that is flagged 1 is encountered. When 1 is encountered, the generator will idle on this segment until an external trigger is applied. Learn more about the sequence advance modes in Chapter 3.

Figure 3-9 shows an example of a 5-step sequence of which the first waveform is made of segment 2, which will loop 15 times; segment 4, looping 2 times; segment 1, looping 7 times; segment 2, once and segment 3, looping 4 times. The Adv bits on links 2 and 5 are set to 1 and therefore, external triggers are required for the sequencer to step through these links.

The control buttons on the left of the Sequence Table have the same functionality as for the Segment Table.

Use the **Append** key to add a step at the end of the sequence list. Use the **Insert** key to insert a step at the cursor location. The **Delete** key is used for deleting a step at the cursor position.

Click on the **Close** to discard of the contents of the dialog box without saving your last actions and to remove the sequence Table from the screen but click on the **Save** key if you want just to save your work before you close the dialog box.

The **Download** key has double action, it will download the sequence table to the instrument and will save the contents of your table so the next time you open this table, it will have the same contents as you saved in your previous session.

Trigger

The Trigger panel, as shown in Figure 3-11, is invoked by pressing the Trigger button on the Panels bar. Note that if you invoke the Trigger Panel from the Panels menu, the 5300 will not change its trigger mode. To modify the instrument run mode, use the Main Panel. The trigger parameters and setting in the Trigger Panel will have an effect on the 5300 only if an appropriate run mode setting has been selected. The Trigger Panel groups allow (from left to right) adjustment of Trigger Modifier and their associated Trigger Parameters. The functional groups in the Standard panel are described below.

Trigger Modifier
The Trigger modifier group provides access to delayed trigger state and its delay parameter, to the Re-trigger state and its parameter and to the burst counter.

To change trigger parameters, point and click on one of these LED's. The value that is associated with the lit LED is displayed on the digital display. You can use the dial, keyboard, or the [↑] [↓} keys to adjust the readout to the required setting. After you modify the reading, press Execute to update the 5300 with the new reading.

Trigger Parameters

Slope - The Slope group lets you select edge sensitivity for the trigger input of the 5300. If you click on Pos, the instrument will trigger on the rising edge of the trigger signal. Likewise, if you click on Neg, the instrument will trigger on the falling edge of the trigger signal.

Source - The 5300 can accept triggers from a number of sources: BUS, External or Mixed. When the Bus option is selected, only bus commands trigger the instrument. The External position is the default trigger option which enables the rear panel trigger input and the front panel manual trigger button. The Mixed position disables the rear-panel trigger input until a software command is executed, the trigger source then reverts to the rear-panel trigger input.

Manual - Use this button when an external generator is not available. Pressing the Manual button is stimulating the instrument as if an external trigger has been applied.

Trigger Level - Programs the trigger level parameter. Depending on the slope setting, the 5300 will be stimulated to output waveforms when the trigger level threshold has been crossed.

Figure 3-11, the Trigger Panel

The Modulation Panels

The Modulation panel, as shown in Figure 3-12, is invoked either by pressing the MOD button or "To Modulation Panel" button on the Main Panel. The modulation panel provides access and control for a number of functions: FM (frequency modulation), FSK (frequency shift keying) and Sweep. The TE5300 can perform only one of these functions at a time and ArbConnection will generate an error if you try to change the state to on for more than one modulation option.

The functional groups in the Modulation Panel are divided to three parts: Frequency Modulation, FSK and Sweep. These groups are described below.
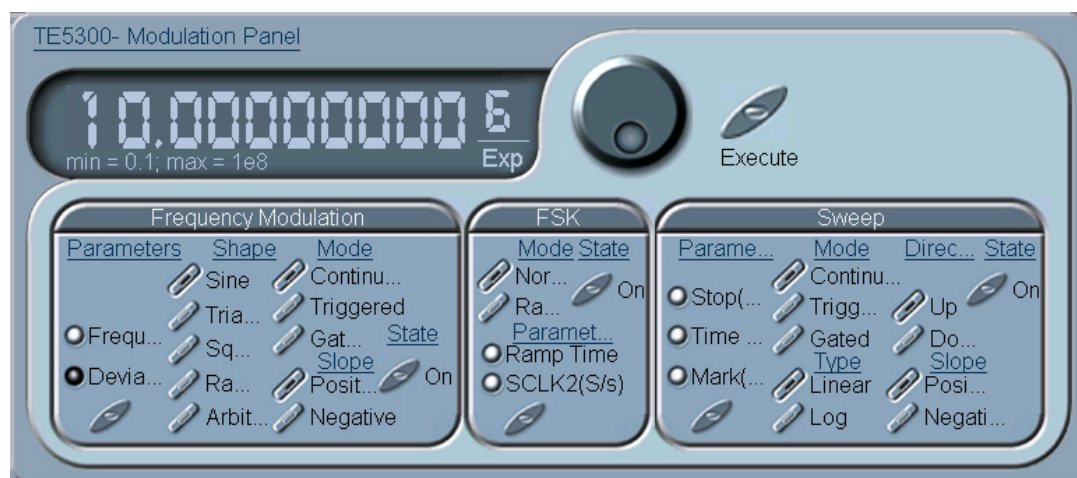
Figure 3-12. The Modulation Panel

FM

The Frequency Modulation group contains parameters for controlling the sample clock. To turn the FM function on and off, click on the State button in this group. There are sub-groups in the FM block: Parameters, Shape, Mode and Slope.

Shape – Determines how the frequency will change. There are four standard patterns that are built into the instrument: sine, triangle, square and ramp, which could be selected from a built-in lookup table. The arbitrary waveform shape must be loaded to the instrument from an external application, or from the FM Composer. Click on the button next to the required modulating waveform shape to select it.

Parameters – Allow adjustment of waveform parameters that are selected from the Shape sub-group. Notice that the parameters are changing as you select different shapes. To access the required parameter, click on the button below parameters sub-group until the LED next to the required parameter turns on. The value that is associated with the lit LED is displayed on the digital display. You can use the dial, keyboard, or the [↑] [↓] keys to adjust the readout to the required setting. After you modify the reading, press Execute to update the TE5300 with the new reading.

Note

Normal color of the digital reading is dark blue. If you modify the reading, the color changes to a lighter shade of blue, indicating that the TE5300 has not been updated yet with the new parameter. Pressing Execute will update the instrument and will restore the color of the digital readout to dark blue, indicating that the displayed value is the same as the generator setting.

Also note that the digital readout has an autodetect mechanism for the high and low limits. You cannot exceed the limits if you are using the dial but only if you use the keypad. In case you do, the program will not let you download an illegal parameter and you'll be requested to correct your setting.

Mode- The Mode sub-group let you select one of the FM operating modes. You have a choice of continuous, triggered and gated FM. Unlike the main trigger function, the trigger modes for the FM function operate in continuous mode. For example, if you place the instrument in triggered FM, the instrument will idle at the carrier frequency and execute one FM cycle when triggered. Refer to the appropriate section in this manual to learn more about triggered FM.

Slope – The Slope sub-group let you select edge sensitivity for the trigger input of the TE5300. If you click on Positive, the instrument will trigger on the rising edge of the trigger signal. Likewise, if you click on Negative, the instrument will trigger on the falling edge of the trigger signal.

FSK

The FSK group contains parameters for controlling the FSK function. To turn the FSK function on and off, click on the State button in this group. There are two other sub-groups in the FSK block: Parameters, and Mode.

Mode – The Mode group lets you select between two shift options: hop and ramped. In hop mode, the sample clock hops to the shift frequency without delays. In ramped mode, the sample clock ramps to the shift frequency at a rate determined by the Ramp Time parameter. Click on the option you prefer to select between hop and ramped modes.

Parameters – Allow adjustment of Ramp Time and Shifted Sample Clock frequency parameters. To access the required parameter, click on the button below parameters sub-group until the LED next to the required parameter turns on. The value that is associated with the lit LED is displayed on the digital display. You can use the dial, keyboard, or the [↑] [↓] keys to adjust the readout to the required setting. After you modify the reading, press Execute to update the TE5300 with the new reading.

AM

The AM group contains parameters for controlling the frequency modulation function. To turn the AM function on and off, click on the FM button in the Modulation group. The various controls in the AM group are described below.

Mod Wave

There is a list of 4 waveforms that can be selected to modulate the carrier waveform (CW). These are sine, triangle, square and ramp. The frequency and amplitude of the modulating waveforms are programmable

Freq - Programs the frequency of the modulating waveform. Note that the frequency setting must be smaller than the CW frequency for the AM function to operate correctly.

Depth - The Depth parameter programs the modulation depth, or index in percent of the un-modulated CW amplitude. The depth is symmetrical about the center of the CW amplitude.

The Pulse Auxiliary Panels

The Pulse Generator panel contains controls that select the pulse function and adjusts the pulse parameters. The pulses are generated digitally suing the arbitrary waveform memory and digital computation and therefore, there are some limitations to the minimum to maximum range that must be observed. The pulse design limitations are given in Appendix A. The various parameters that control the digital pulse generator features are described below.

Figure 3-13, the Digital Pulse Generator Panel

Pulse Mode
The Pulse Mode group has controls to turn on pulse generator functions, select of the output generates single or double pulse shape and selects the pulse polarity from one of the Normal, Complemented and Inverted options.

Polarity
The Polarity group has controls to select between Normal, Complemented and Inverted pulse shapes.

Pulse Parameters
In the pulse parameters group you adjust the complete set of parameters that builds up the pulse shape. Included are: period, rise and fall times, high time delay and high and low amplitude levels.

To display and modify parameters, click on the and next to the required parameter change and modify time per your requirements. The range of each parameter is specified in Appendix A.

The System Panels

The System tab provides access to a group of panels that control some general system parameters and provides access to the calibration. There are two panels in this group: General/System, which provides access to some system commands, utilities and filters; and Calibration, which provides access to the calibration remote calibration utility. Note however, that access to the calibration panel is permitted to qualified service persons and requires special user name and password. Information how to access the calibration panel is given in Adjustments and Software Updates chapter.

The System set of panels are shown in Figure 3-14. Each of the panels is described below.

Figure 3-14, the System Panels

General/Filters

The General/Filters panel provides access to some general system common commands, allows read back of information that is stored in the flash and provides means of adding filters to the output path. The General/Filters panel is shown in Figure 3-23 and the various parameters that control these functions are described below.

System
The System group has three buttons that are normally associated with system control. These are:

Reset – generates soft reset to the instrument controls and dialog boxes and modifies all parameters to factory default. A list of factory defaults is given in the programming chapter of this manual.

Query Error – queries the 5300 for programming errors. This command is normally no necessary because ArbConnection makes sure that programming errors cannot be made from the panels however, while executing commands from the Command Editor, errors can be generated and the only way to monitor the errors is by using this command.

Figure 3-15, the General/Filters Panel

Clear Queue – clears the error queue. The error queue can buffer up to 35 errors and then generates an error queue overflow message while ignoring new errors. This command clears the error queue and allows fresh errors to be captured.

General Information

This General Information group is used for displaying or monitoring of certain parameters that are stored in the flash memory. These are: Instrument serial number and last calibration date. You can also read the installed firmware revision, in case you want to verify that you have the latest firmware revision.

Filters

The filters can be turned on and off freely as long as you are not generating the standard sine waveform. The following filter options are available:

Off – no filter is applied to the output path
25MHz – an Elliptic type filter that has 25 MHz cutoff frequency.
50MHz – an Elliptic type filter that has 50 MHz cutoff frequency.

Calibration

The Calibration panel, as shown in Figure 3-16, provides access to remote calibration procedures. To access the remote calibration panel, you will need to have a valid User Name and Password and to quality to perform such calibration, you'll need to be trained and certified by Tabor Electronics. Information how to access the calibration panel and how to perform the calibration is given in the adjustment and firmware updates chapter. The picture below is just for reference how the calibration panel will look after you gain access to this panel.

Figure 3-16, the Calibration Panel

The Composers Panels

The Composers tab provides access to a group of composers that allow generation and editing of arbitrary waveforms, pulse shapes, arbitrary frequency modulation and 3D profiling. Without utilities such as the above, the operation of an arbitrary waveform generator is extremely limiting.

There are four waveform composers built into ArbConnection:

Wave – for generating arbitrary waveforms. Arbitrary waveforms can be generated from standard libraries, from an equation editor, or imported to the composer from external utilities such as MatLAB. The waveforms can be edited and stored on hard or soft disks.

Pulse – for generating complex pulse trains. Unlike a standard pulse generator, you can design and edit multiple pulse trains with linear transitions and variable amplitudes.

FM – for generating frequency modulation schemes. Unlike a standard frequency modulator, you can design and edit your own frequency modulation profiles.

The Composers set of panels are shown in Figure 3-17. Each of the composers is described below.

Figure 3-17, the Composers Panels

The Wave Composer   Being an arbitrary waveform generator, the 5300 has to be loaded with waveform data before it can start generating waveforms. The waveform generation and editing utility is part of ArbConnection and is called – The Waveform Composer.
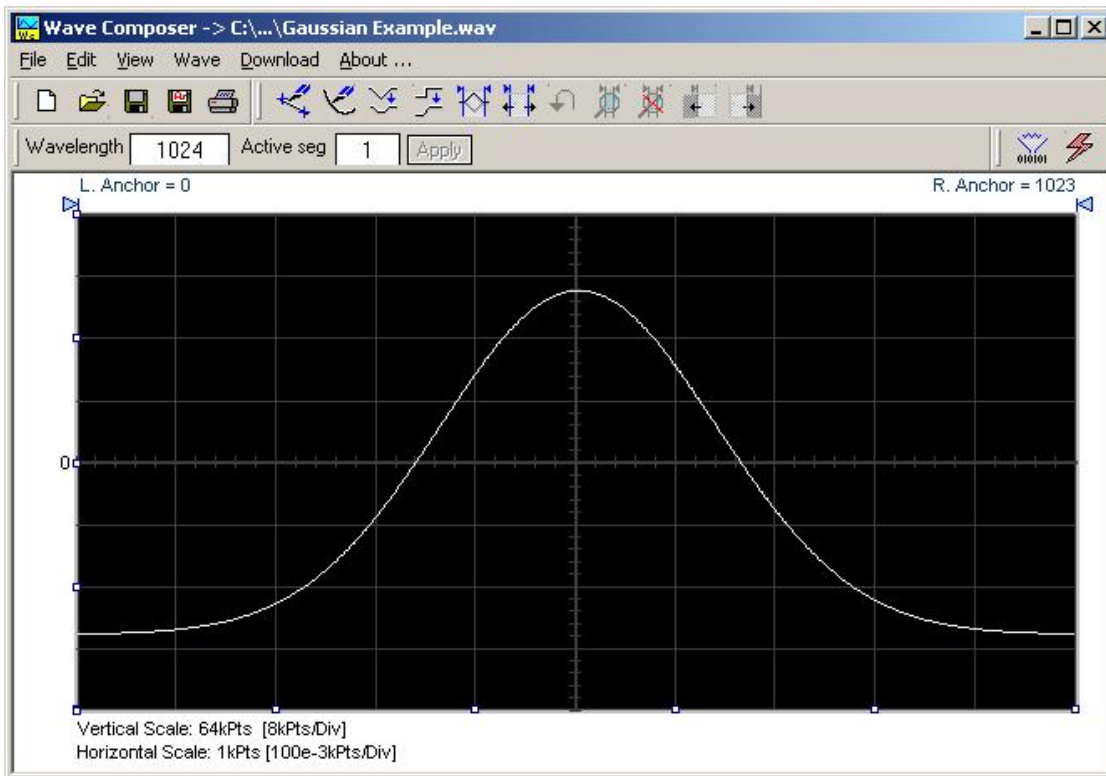
Figure 33-18, the Wave Composer Opening Screen

This program gives you tools to create definitions for arbitrary waveforms. It can also convert coordinates from other products, such as, oscilloscopes and use them directly as waveform data. The program is loaded with many features and options so use the following paragraphs to learn how to create edit and download waveforms to the 5300 using the Waveform Composer.

To launch the wave composer point and click on the Wave tab in the Panels bar. Figure 3-18 shows an example of the wave composer. The Wave Composer has main sections: Commands bar, Toolbar and Waveform screen. Refer to Figure 3-18 throughout the description of these sections.

The Commands bar

The commands bar provides access to standard Windows commands such as File and View. In addition, there are ArbConnection-specific commands such as Edit, Wave and System.

In general, clicking on one of the commands opens a dialog box with an additional list of commands. Then, clicking on an additional command, may open a dialog box, or generate an immediate action. For example, Clicking on File and then Exit will cause an immediate termination of the Wave Composer. On the other hand, clicking on Wave and then on Sine, will open a Sine Wave dialog box that lets you program and edit sine wave parameters. The various commands in the Commands bar are listed and described below.

File Commands

The File command has 4 command lines that control waveform files. Also use this command to print the active waveform, or exit the wave composer program. Description of the various commands under File is given below.

New Waveform
The New Waveform (Ctrl+N) command will remove the waveform from the screen. If you made changes to the waveform area and use the New Waveform command, you should save your work before clearing the screen. The New Waveform command is destructive to the displayed waveform.

Open Waveform…
The Open Waveform… (Ctrl+O) command will let you browse your disk for previously saved waveform files and load these waveforms to the waveform area. This command is also very useful for converting waveform files to format that is acceptable by the Wave Composer. The Open Waveform command can convert ASCII. *CSV (comma delimited text), *PRN (space delimited text) and *.0* (LeCroy binary format). The Open dialog box in Figure 3-31 shows the various file extensions that can be opened into the Wave Composer environment. The file that is opened is automatically converted to *.wav format and can later be saved as a file.

Save Waveform

The Save Waveform (Ctrl+S) command will store your active waveform in your 5300 directory, as a binary file with an *.wav extension. If this is the first time you save your waveform, the Save Waveform As… command will be invoked automatically, letting you select name, location and format for your waveform file.

Save Waveform As…

Use the Save Waveform As… command the first time you save your waveform. It will let you select name, location and format for your waveform file.

Print

With this command you may print the active Waveform Window. The standard printer dialog box will appear and will let you select printer setup, or print the waveform page.
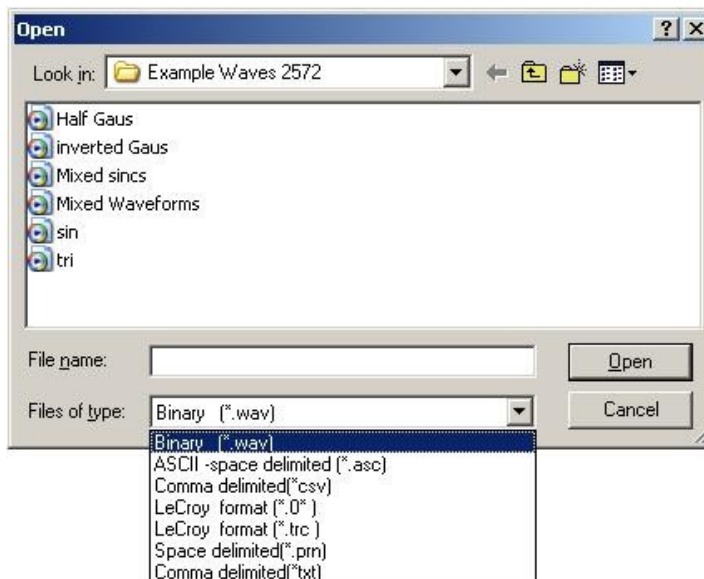
Figure 3-19, the Open Waveform Dialog Box

Exit

The Exit command ends the current Wave Composer session and takes you back to the Panels screen. If you made changes to your waveform since it was last saved, the Wave Composer will prompt you to Save or Abandon changes these changes.

Edit Commands The Edit commands are used for manipulating the waveform that is drawn on the screen. The editing commands are explained in the following paragraphs.

Autoline

The Autoline command lets you draw straight-line segments. To draw a line the left mouse button at the start point. Click again at the next point and then click on the right mouse button to terminate this operation.

Sketch

The Sketch command lets you draw free-hand segments. To draw a line using this command click and hold the left mouse button at the start point. Release the mouse button when you want to stop and then click on the right mouse button to terminate this operation.

Smooth

The Smooth command lets you smooth out rough transitions on your waveform. This is done mathematically by multiplying waveform coordinates by the non-linear portion of a cubic parabola.

The Smooth operation is done on segments of the waveform that are bound by anchors. Anchor operation is described later in this chapter. Place the anchors on the left and right of your waveform segment and select the Smooth command. The waveform will change its shape immediately to follow the mathematical pattern of a parabolic curve.

Note that small segments with fast transitions, when combined with parabolic expressions have tendencies to generate even larger transitions. Therefore, make sure you omit such sections of the waveform when you use this operation.

Filter

The Filter used with this command is moving average. This is done by recalculating each point as an average of symmetrical number of adjacent points. When you select the Filter command, a dialog box pops up, letting you program the filter spacing in number of adjacent points. You can filter the entire waveform, or you may chose to filter a segment of the waveform by placing the anchors as boundaries on the left and right of the segment.

Invert

The Invert command lets you invert the entire waveforms, or marked segments of waveforms. The waveform is inverted about the 0-point axis.

Trim Left

The trim left command lets you trim waveforms to the left of the anchor point. This command is grayed out if the left anchor was not moved from its original left position. The waveform is trimmed and the point at the left anchor point becomes the first point of the waveform.

Trim Right

The trim right command lets you trim waveforms to the right of the anchor point. This command is grayed out if the right anchor was not moved from its original right position. The waveform is trimmed and the point at the right anchor point becomes the last point of the waveform.

Unmark

The unmark command removes the anchors from the waveform screen and resets anchor positions to point 0 and the last point.

Undo
The Undo command undoes the last editing operation.

View Commands

The View commands have commands that let you view various sections of the waveform area. The View commands include: Zoom In, Zoom Out, Hide/Show Toolbars and Channel 1 to 4 waveforms. Description of the view commands is given in the following.

Zoom In
The zoom in command operates between anchors. Anchors are marked as left and right hand triangles. The default position of the anchors is the start and the end of the waveform. To move an anchor to a new location, click and hold on the triangle and drag the anchor to left or right as required. If you move the left anchor to the right and the right anchor to the left, the area between the anchors will zoom in as you select this command.

Looking at the Waveform Map, as shown in Figure 3-28, you'll see that the white portion is the zoomed area. Click and hold on the white area and move your cursor around and the waveform screen will be updated accordingly.

While zoomed in you can perform Autoline and sketch editing, or zoom-in further by clicking and holding the mouse at one corner and releasing the mouse button at the other corner.

Zoom Out
The zoom out restores the screen to display the complete waveform.
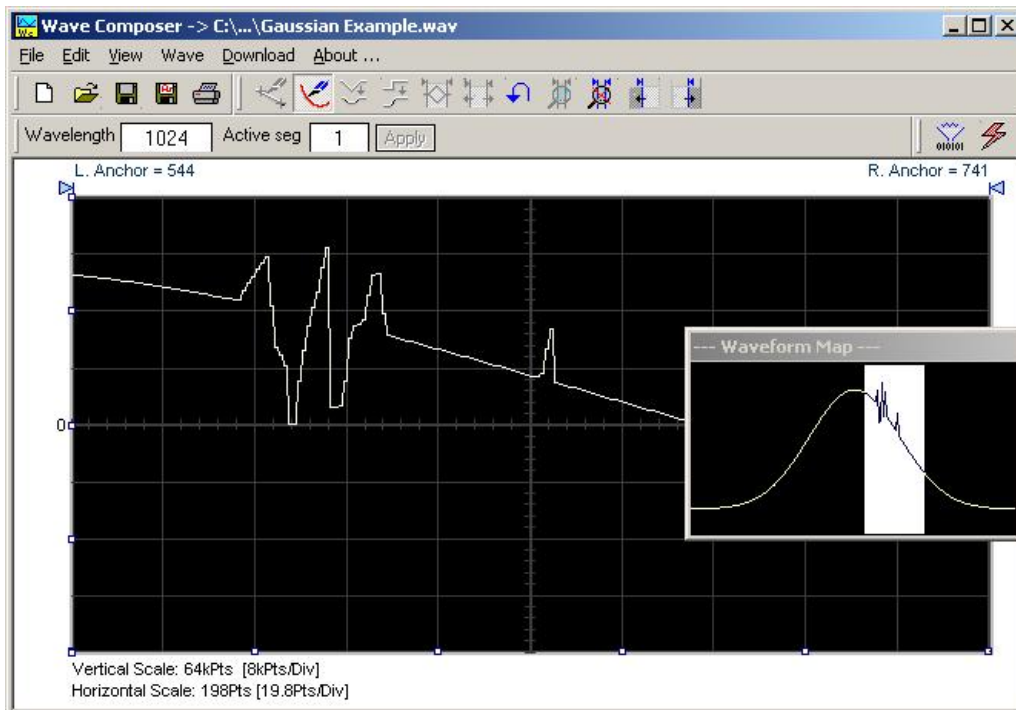
Figure 3-20, Zooming In on Waveform Segments

Wave Commands

The Wave commands let you create waveforms on the screen. The Wave command has a library of 8 waveforms: Sine, Triangle, Square, Sinc, Gaussian, Exponent, Pulse, Noise and dc. Also, from the Wave command, you can create Cardiac waveforms and pulse width modulation. Finaly, custom waveforms are created using the Equation Editor. Information how to create waveforms using the Wave commands is given below.

Creating Waveforms From the Built-in Library
You can create any waveform from the built-in library using the Wave command. Clicking on one of the Wave options will open a dialog box. An example of the Sine waveform dialog box is shown in Figure 3-21. This dialog box is representative of the rest of the waveforms, so other waveforms will not be described.

Creating Sine Waveforms
Use the following procedure to create sine waveforms from the built-in library. Click on Wave, then sine… the dialog box as shown in Figure 3-21 will appear. You can now start programming parameters that are available in this box.

Start Point – Defines the first point where the created wave will start. Note that if you change the start point the left anchor will automatically adjust itself to the selected start point. The example shows start point set at point 0.

End Point – Defines where the created waveform will end. Note that as you change the end point the right anchor will automatically adjust itself to the selected end point, 499 shown in the example.

Cycles – The Cycles parameter defines how many sine cycles will be created within the specified start and end points. The example below shows five sine cycles.

Amplitude – 16-bit of vertical define 32,768 incremental steps. The Amplitude parameter defines how many of these steps are used for generating the sine. The example is showing sine waveform with maximum peak-to-peak amplitude. Any number below the maximum will generate an attenuated sine.

Start Phase – The start phase parameter defines the angle of which the sine will start. The example shows start phase of 90°.

Power – The example shows sine cubed. Sine to the power of 1 will generate a perfect sine. Power range is from 1 through 9.
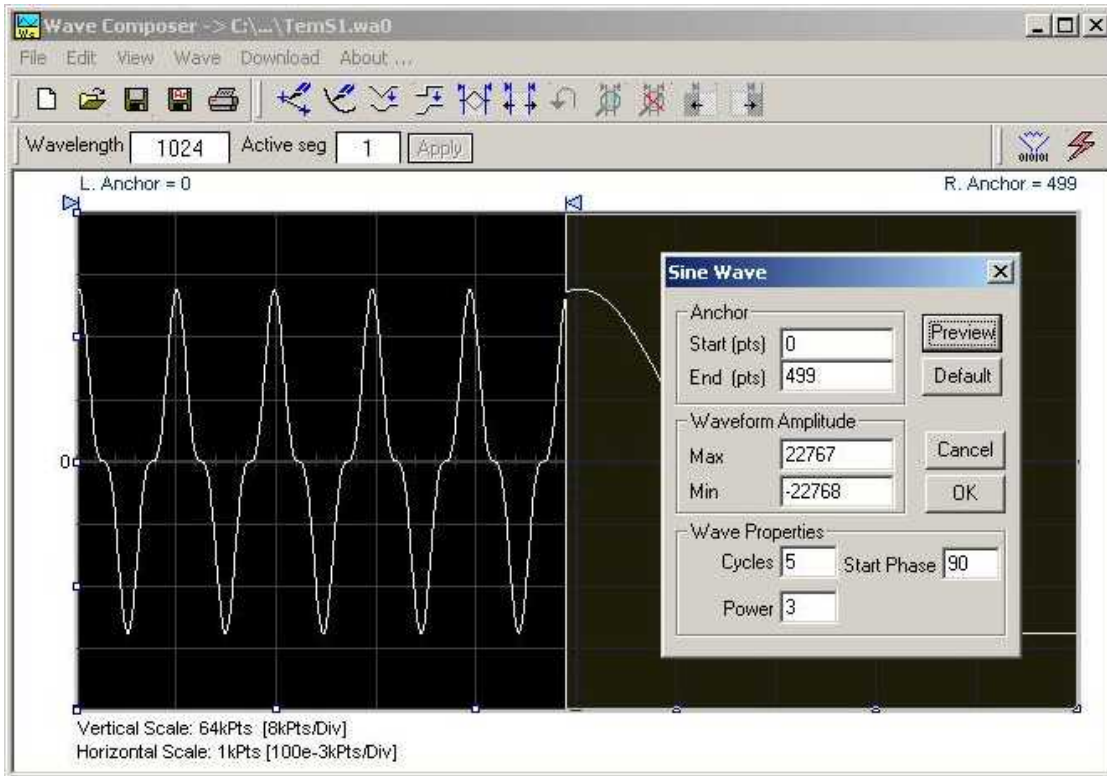
Figure 3-21, Generating Distorted Sine waves from the built-in Library

The Toolbar

The toolbar contains icons for editing the waveform screen, icons for saving and loading waveforms, fields for selecting an active channel and for adjusting segment length and more. The Toolbar is shown in Figure 3-30. For the individual icons, refer to the descriptions above of the Wave Composer Menus.

Figure 3-22, the Toolbar Icons

The Waveform Screen

Waveforms are created and edited on the waveform screen. Figure 3-35 shows an example of a waveform created using the equation editor and the anchors to limit generation of the waveform between points 100 and 900. The various elements of the waveform screen are described below.

The waveform screen has two axes – vertical and horizontal. Both axes are divided into points.

The vertical axis is labeled from -32,767 through 32,768 for a total of 65,536 point (includes point "0"). This number represents 16 bits of vertical resolution and cannot be changed because it is critical to the range of which the 5300 operates.

The horizontal axis, by default has 1000 points (from point 0 to 999). This number can be changed using the Wave Length field in the Toolbar. The maximum length depends on the option installed in your instrument. The wave composer will let you define the horizontal axis to a maximum of 2M words).
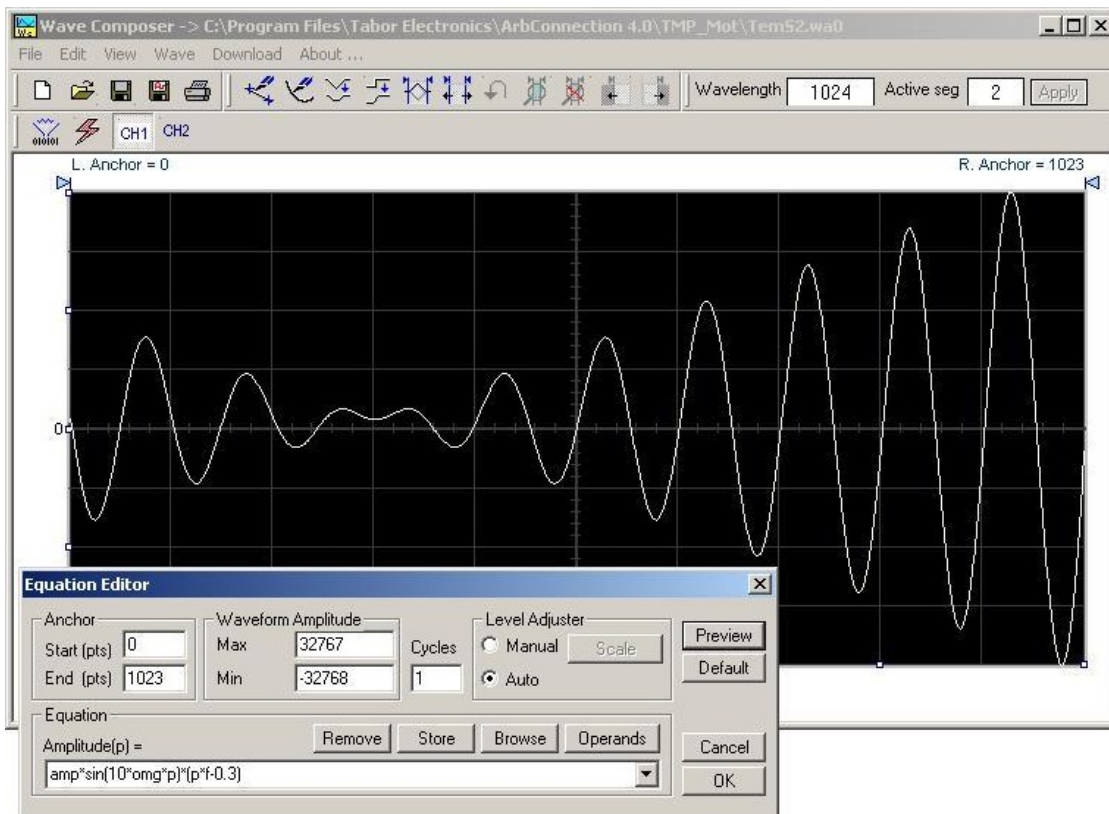
Figure 3-23, the Waveform Screen

Notice on the left top and on the right top there are two triangles pointing to the center of the screen. These are the anchors. The anchors are used as the start and end pointers where your waveform will be created. For example, if you want to create a sine waveform between point 100 and point 500, you place the left anchor at point 100 and the right at point 500 and then generate the sine from the built-in library.

There are two ways to control anchor placements.

1) Click and hold your mouse cursor on the left anchor triangle and then drag the curtain to the left position. Do the same for the

right anchor. Notice the X and Y coordinates at the top of the waveform screen and how they change to correspond to your anchor placement.

2) You can also place your anchors in a more precise manner from the waveform library by programming the start and end points for the waveform. An example of anchor placement using the sine dialog box is shown in Figure 3-21.

Finally, when you are done creating and editing your waveform, you can save your work to a directory of your choice. The name at the title will show you the name you selected for storing your waveform and its path.

Generating Waveforms Using the Equation Editor

One of the most powerful feature within ArbConnection and probably the feature that will be used most is the Equation Editor. The Equation Editor let you write equations the same way as you would do on a blank piece of paper. The equations are then translated to sequential points that form waveforms and are displayed on the waveform screen. The Equation Editor will detect and inform you on syntax errors and, with its self adjusting feature, will automatically adjust your parameters so that none of the points on your waveform will exceed the maximum scale limits.

When you invoke the Equation Editor, the dialog box, as shown in Figure 3-24 will display. Use the following paragraphs to learn how to use this dialog box and how to write your equations.
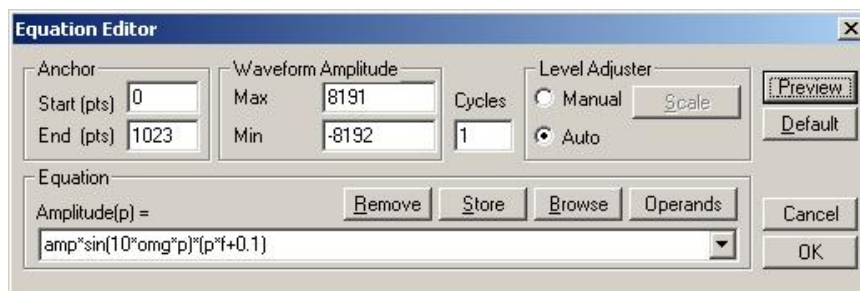
Figure 3-24, the Equation Editor Dialog Box

There are four sub-group parameters in the equation editor plus control buttons and equation field. These parts are described below.

Anchor
The anchors define start and end point of which the equation will be generated. By default the anchors are placed at the start and the end of the horizontal (time) scale however, the equation can be limited to a specific time scale by moving the anchor points from their default locations.

Start – defines the first point where the created wave will start. Note that if you change the start point the left anchor will automatically adjust itself to the selected start point.

End – defines where the created waveform will end. Note that as you change the end point the right anchor will automatically adjust itself to the selected end point.

Waveform Amplitude

The vertical axis of the Wave Composer represents 14-bits of vertical resolution. That means that the equation is computed, resolved and generated with 1/32,768 increments and accuracy. The Waveform Amplitude fields in the Equation Editor are used in two cases: 1) when the "amp" parameter is used in the equation or 2 if the Level Adjuster is set to Auto. Information on these two operations is given later.

Max – defines the positive peak of the vertical axis

Min – defines the negative peak of the vertical axis

Cycles

The Cycles parameter defines how many waveform cycles will be created within the specified start and end anchor points.

Level Adjuster

The Level Adjuster is a convenient tool that helps you adjust the amplitude and offset without modifying your equation. The Level Adjuster mode does not interfere with your calculations and displays the waveform as computed from your equation. The only difference is that your final calculations are stretched or shrunk or offset on the vertical scale to fit the new amplitude and offset boundaries.

If you change the Max and Min setting in the Waveform Amplitude fields and press the Adjust key, your waveform will offset immediately without changing the equation. The same way, you can also change amplitude only or both amplitude and offset. If you check the Manual option, you'll have to click on the Adjust button for the Waveform Amplitude parameters to take effect. The Adjust button name will change to Restore and back to Adjust if you click on it again. If you check the Auto option, your waveform will be created automatically with the new Amplitude setting.

Equation

The Equation group has four buttons and the equation field. You will be using the Equation field for writing your equations. Equation syntax and conventions are discussed in the following paragraphs. The *Remove* button clears the equation field so you can start typing a new equation. Click on the *Store* button to store your equation if you intend to use it again. The Browse button provides access to waveform pre-stored files in your computer for combining them in new equations. The *Operands* button expands the bottom of the dialog box to show the operands you can use with your equation.

While you type and store equations, they are collected in a history file and can be used again by expanding the history log from the equation field.

Control Buttons

There are four control buttons at the right corner of the dialog box. Use the *Preview* button to preview an image of your equation, or use the *OK* button to place your waveform on the waveform screen and to leave the dialog box on the screen. The *Default* button restores the parameters in the equation editor to their original factory default values. The *Cancel* button will remove the dialog box from the screen and will discard of any waveforms that you previewed with your Equation Editor.

Writing Equations

The Equation Editor lets you process mathematical expressions and convert them into waveform coordinates. As you probably already know, waveforms are made of vertical samples. The number of samples on your waveform is determined by the wavelength parameter. For example, if you have 1024 horizontal points, your equation will be computed along 1024 points as a function of the vertical scale. Each vertical sample is computed separately and placed along the horizontal axis. The points are graphically connected to form a uniform and continuous waveform shape however, if you zoom in on a waveform line, you'll see that the points are connected like a staircase. In reality, the 5300 generates its waveforms exactly as shown on the screen but, if the waveform has many horizontal points, the steps get smaller and harder to see without magnification.

Equations are always computed as a function of the vertical (Amplitude) axis therefore the left side of your equation will always look as Amplitude(p)=, where "p" is the equation variables in units of waveform points. You can write equations with up to 256 characters. If the equation is too long to fit in the visible field, parts to the left or right will scroll off the ends.

Equation Convention

The following paragraphs describe the conventions that are used for writing an equation. To avoid errors, it is extremely important that you make yourself familiar with these conventions before you plan your waveforms.

Equations are written in conventional mathematical notation. You may only enter the right part of the equation. The only limitation is that the equation must be of a single variable that is directly related to the current horizontal axis setting. Case is not important and spaces are ignored. Numbers are entered in scientific notation. All calculations are done with double-digit precision. For the trigonometric functions, all angles are expressed in radians.

A number of constants are provided: e, which is the base of the natural logarithm; pi, which is the circumference of a unit-diameter circle; per, which equals the programmed horizontal range; f, which equals 1 /per; omg, which equals 2 * pi / per, and numerals in the range of -1E^20 to 1E^20.

There are three classes of precedence: ^ (raise to power) has the highest precedence; (multiply) and / (divide) come second; + and - have the lowest precedence. Parentheses may be used to change the order of precedence. The following table summarize the mathematical expressions and their respective abbreviated commands that can be used with the Equation Editor.

Equation Editor Operands

^	Raise to the power
*	Multiply
/	Divide
+	Add
Ä	Subtract
( )	Parentheses
e	Base of natural Logarithm
pi (π)	Circumference of unit-diameter circle
per	Horizontal wavelength in points
f	I/per
omg (Ω)	2*π / per
amp	Amplitude in units of points or seconds
sin(x)	The sine of x(*)
cos(x)	The cosine of x
tan(x)	The tangent of x
ctn(x)	The cotangent of x
log(x)	The base IO logarithm of x
ln(x)	The natural (base e) logarithm of x
abs(x)	The absolute value of x
-1E^20<>1E^20	Numerals, equation constants

(*)x = argument mathematical expression

After you get familiar with the operands and conventions, you can commence with a few simple equations and see what they do to your waveform screen. Once you'll get the feel, you'll be able to explore your own creativity to generate much more complicated and complex waveforms.

Typing Equations

If you remember from your old high school studies, the simplest curve of Y as a function of X is defined by the equation Y=aX+b. You can use the same "technique" to generate straight lines with the Equation Editor. Assuming first that p=0, try this:

Amplitude(p)=1000

Press [Preview] and see what you get. Of course, you get an uninteresting line that runs parallel to the X-axis. Now, lets give the line some angle by typing:

Amplitude(p)=-2*p+2000

Press [Preview] and see that the line slopes down. It may still be not very interesting however, pay close attention to the convention that is used in this equation. You cannot type: Amplitude(p)=-2p+1000, like you would normally do in your notebook; You must use the * (multiply) sign, otherwise you'll get a syntax error. Now we'll try to generate a simple sine waveform. Try this:

Amplitude(p)=sin(10)

Press [Preview] and… sorry, you still get nothing on the screen. The Wave Composer did not make a mistake! The sine of 10 in radians is exactly what it shows. You are unable to see the result because the line on your screen running across the 0 vertical point.

💡 *REMEMBER*

The equation must be a function of a single variable and that variable must be directly related to the Horizontal axis Scale setting.

Now try this:

Amplitude(p)=sin(omg*p)

Still no good, but now press the [Adjust] button and here is your sinewave. So what's wrong? Well, if you'll give it a little amplitude it might help so, do it now exactly as follows:

Amplitude(p)=8000*sin(omg*p)

There you go. You should now see a perfect sine waveform with a period of 1000 points. This is because you have asked the Equation Editor to compute the sine along p points ("p" is the equation variable, remember?). If you want to create 10 sine waveforms, you should multiply p by 10. Try this:

Amplitude(p)=8000*sin(omg*p*10)

Equation Samples

So far, you have learned how to create two simple waveforms: straight lines and trigonometric functions. Let's see if we can combine these waveforms to something more interesting. Take the straight line equation and add it to the sinewave equation:

Amplitude(p)=12000*sin(omg*p*l0)-8*p+4000

Press [Preview]. Your screen should look like Figure 3-25.
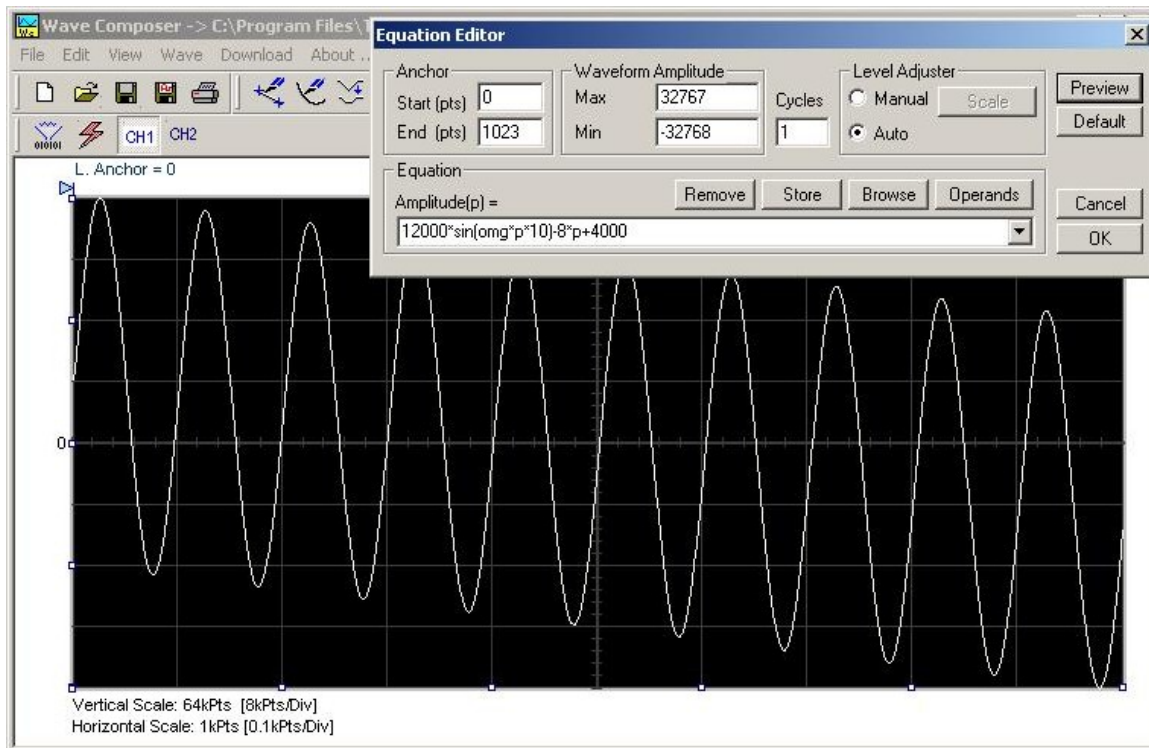
Figure 3-25, an Equation Editor Example

Now let's try to modulate two sine waves with different periods and different start phase. Type this:

Amplitude(p)= 12000*sin(omg*p)*cos(omg*p*30)

Press [Preview]. Your screen should look like Figure 3-26.
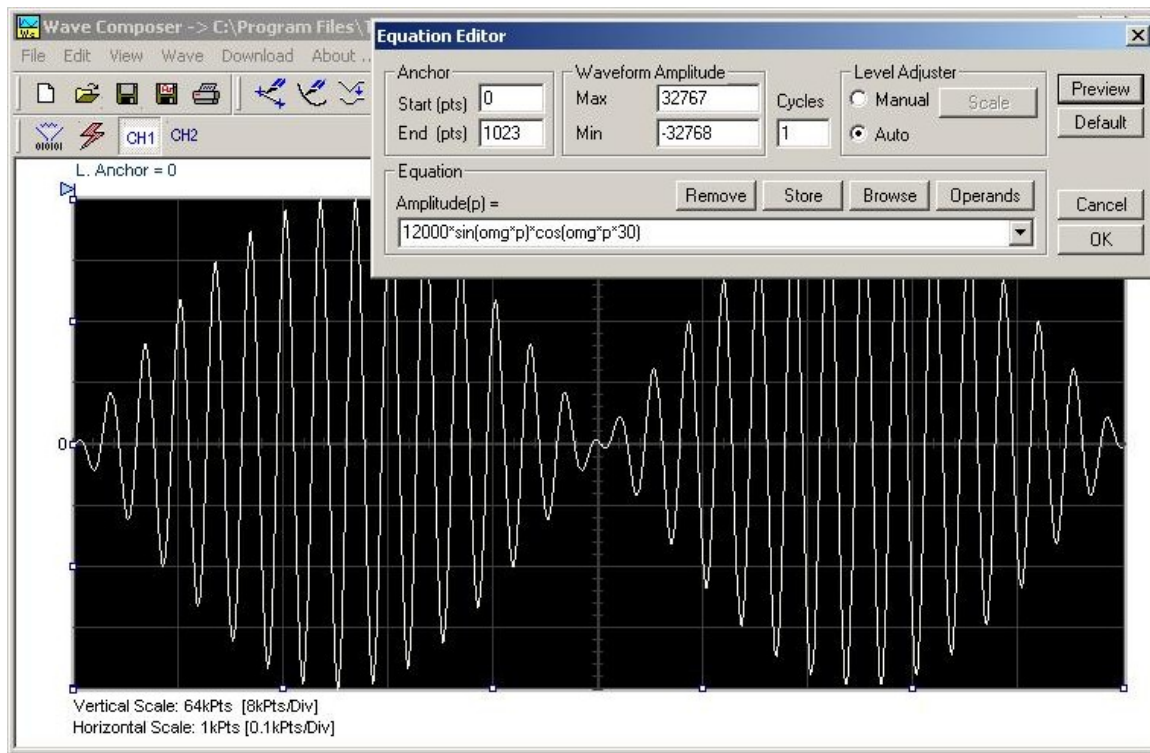
Figure 3-26, Using the Equation Editor to Modulate Sine Waveforms.

In the following example, as shown in Figure 3-40, 20% second harmonic distortion has been added to a standard sinewave. The original waveform had a peak-to-peak value of 24000 points so 19% second harmonic is equivalent to 4500 points. The frequency of the second harmonic is obviously double that of the fundamental, so term +4500*sin(2*omg*p) is added to the original sine wave equation. Use the following equation:

Amplitude(p)=24000*sin(omg*p)+4500*sine(2*omg*p)

Press [Preview]. Your screen should look like Figure 3-27.
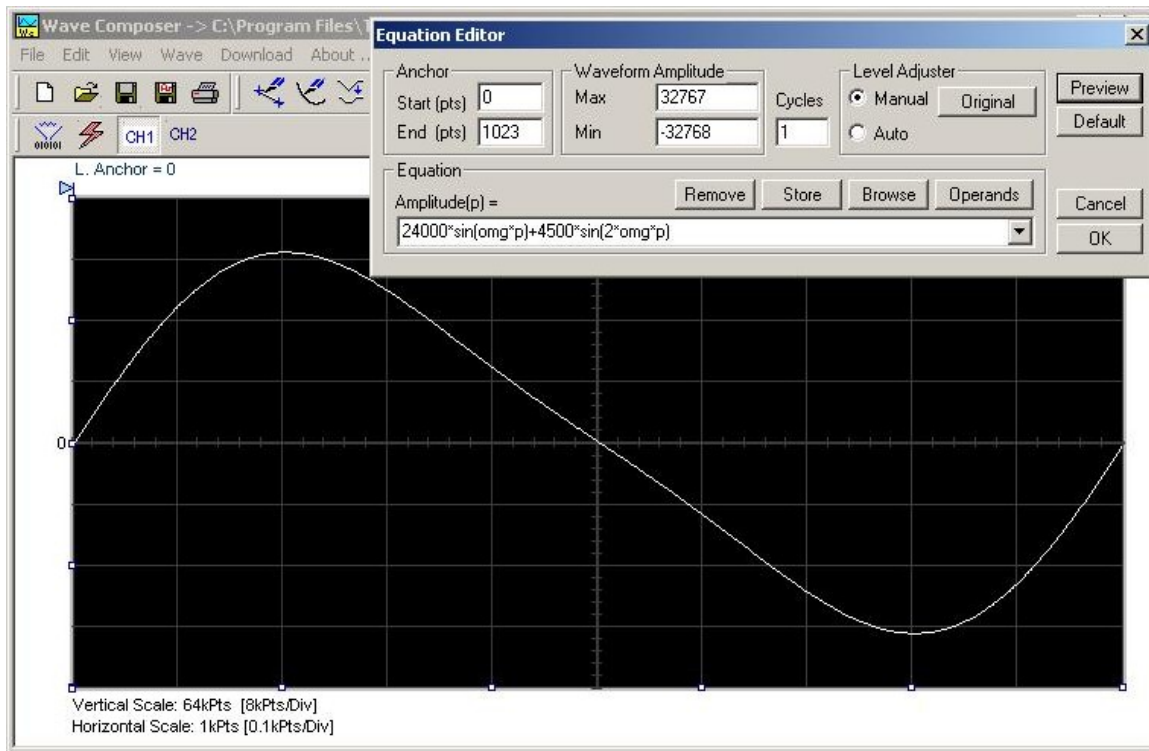
Figure 3-27, Using the Equation Editor to Add Second Harmonic Distortion.

In Figure 3-28 we created 10 cycles of sinewave made to decay exponentially. The original expression for a standard sinewave is multiplied by the term e^(p/-250). Increasing the value of the divisor (200 in this case) will slow down the rate of decay.

Use the following equation:

Amplitude(p)=12000*sin(omg*p*10)*e^(p/-250)

Press [Preview]. Your screen should look like Figure 3-28.
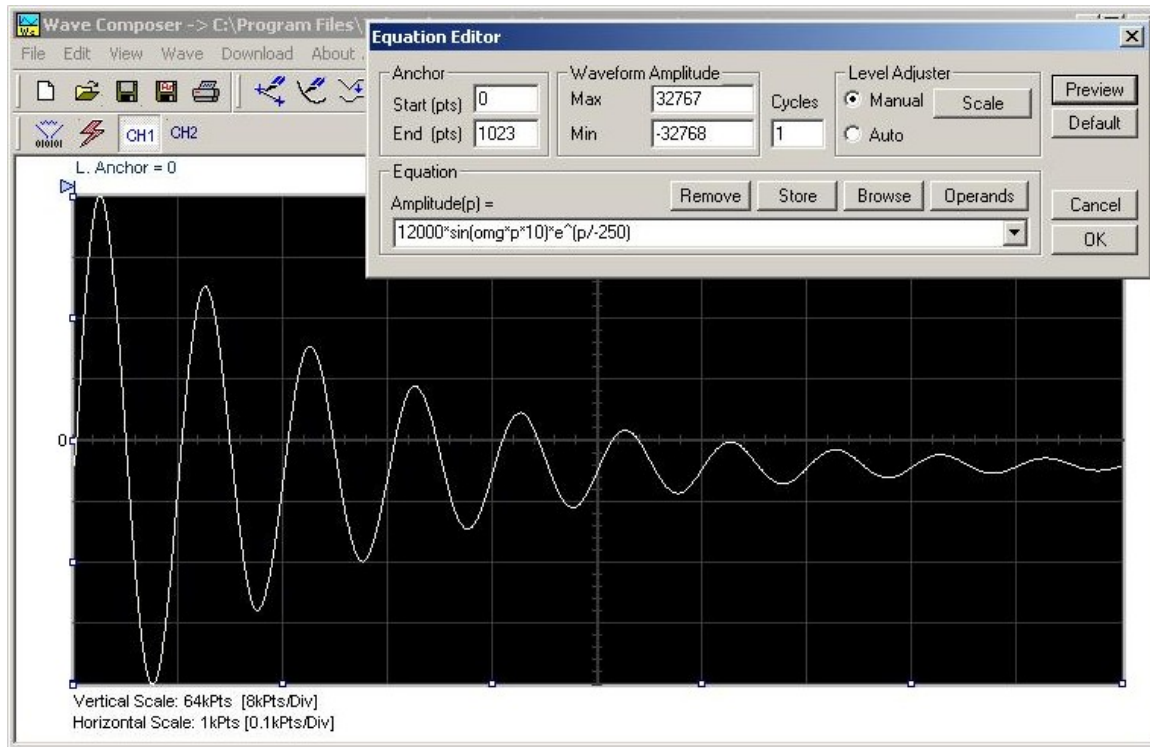
Figure 3-28, Using the Equation Editor to Generate Exponentially Decaying Sinewave

The last example as shown in Figure 3-29 is the most complex to be discussed here. Here, 100 cycles of sinewave are amplitude modulated with 10 cycles of sine wave with a modulation depth of 20%. To achieve this, the upper and lower sidebands are defined separately and added to the fundamental or carrier. The upper sideband is produced by the expression 100*cos(110*omg*p) and the lower sideband by the term 100*cos(90*omg*p).

Use the following equation:

Ampl(p)=6000*sin(100*omg*p)+1200*cos(110*omg*p)-1200*cos(90*omg*p)

Press [Preview]. Your screen should look like Figure 3-29.
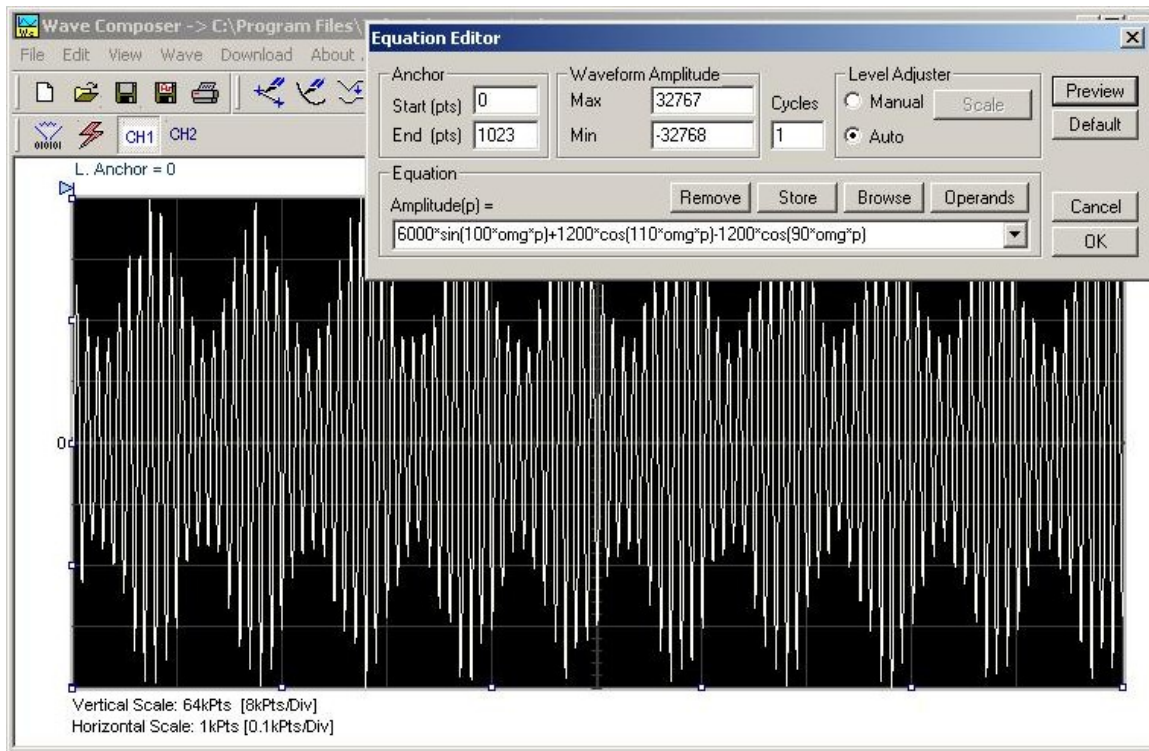
Figure 3-29, Using the Editor to Build Amplitude Modulated Signal with Upper and Lower Sidebands

Combining Waveforms

The last but not least powerful feature allows you to combine waveforms which you previously stored on your hard disc. You can write mathematical expressions that contain waveforms, simple operands and trigonometric functions similar to the example given below. If you want to use waveforms in your equations, you must first generate these waves and store them on your hard disk. You identify waveforms by adding the *.wav extension as shown in the example below.

Amplitude(p)= Sine.wav*sin(omg*p*10)*Noise.wav/1000

The above equation will generate amplitude-modulated waveform with added noise. The following steps demonstrate how to create, store and combine waveforms using this equation.

Step 1 – Create and store sine.wav. Invoke the Wave command and generate a sine waveform. Press OK and then select the Save Waveform As… from the File command. Save this file using the name Sine.wav. Note where you store this waveform as you would have to know the path for the next step.

Step 2 – Create and store Noise.wav. From the Wave command select Noise. Click OK and watch your waveform screen draw noisy signal. From the File menu select Save Waveform As… and save this waveform using the name Noise.wav.

Step 3 – Write and compute the original equation:

Amplitude(p)= c:/Sine.wav*sin(omg*p*5)*c:/Noise.wav/10

If you did not make any mistakes, your waveform screen should look as shown in Figure 3-30
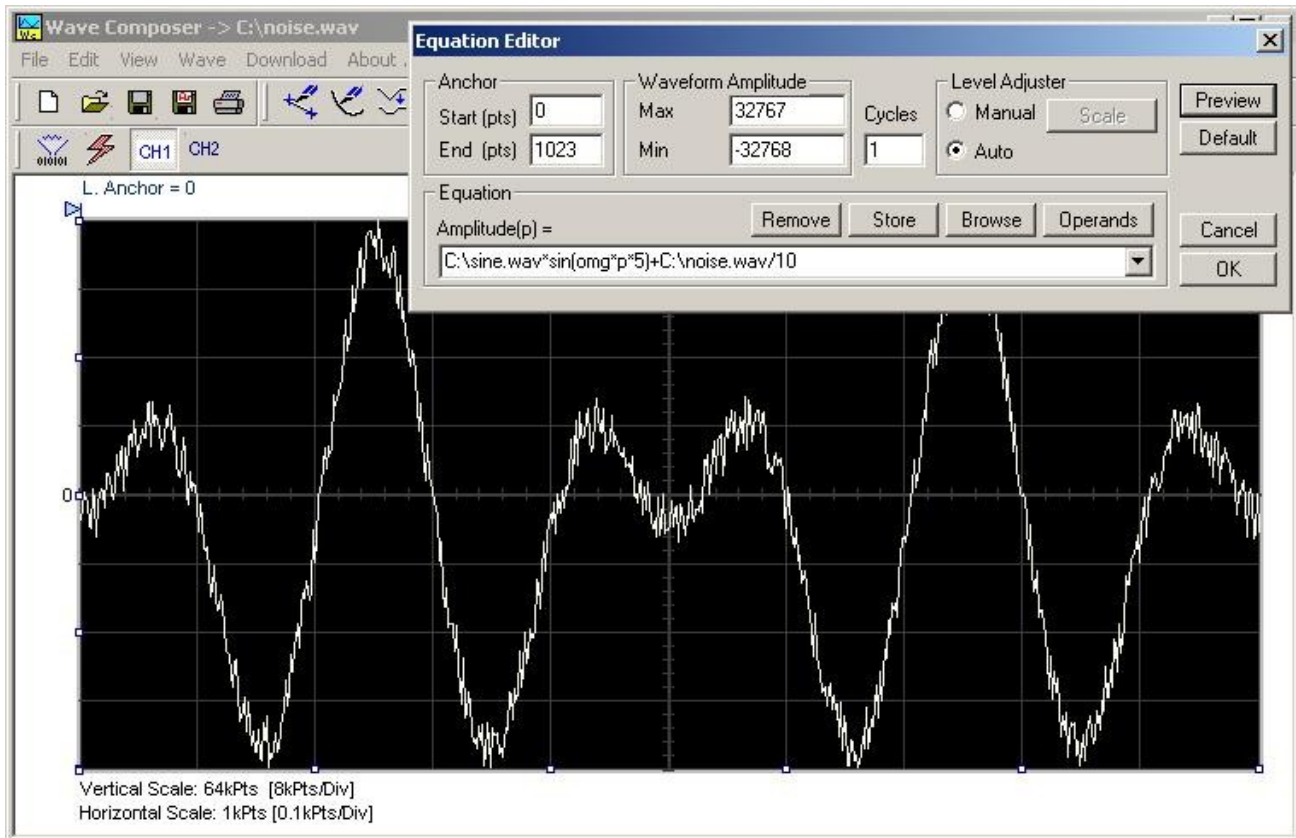
Figure 3-30, Combining Waveforms into Equations

The Pulse Composer

The Pulse Composer is a great tool for creating and editing pulses without the need to think about sample clock, number of points and complex equations. Pulses are created on the screen, simply and efficiently in a special dialog box by typing in the width and level, or by using the "rubber band" method to place straight line segments with the exact amplitude and time duration. The pulse composer can also multiply pulse sections to create pulse duplication along lengthy time intervals.

When you finally have your pulse design on the screen the program determines if the pulse design will fit in one memory segment or use multiple segments and employ the sequence generator for repeatable segments. In either case, bear in mind that if you already have some waveforms stored in memory segments, these will be erased to make room for the new pulse design. If you insist on keeping arbitrary waveforms and still download complex pulses,

you can check the "Force pulse to one segment" option and the 5300 will do some extra "muscle flexing" to fit the pulse as required.

To launch the pulse composer point and click on the Pulse tab in the Panels bar. Figure 3-31 shows an example of the pulse composer. The Pulse Composer has three main sections: Commands bar, Toolbar and Waveform screen. Refer to Figure 3-31 throughout the description of these sections.

The Pulse Composer Commands bar

The commands bar provides access to standard Windows commands such as File and View. In addition, there are ArbExplorer-specific commands such as Edit, Wave and System.

In general, clicking on one of the commands opens a dialog box with an additional list of commands. Then, clicking on an additional command, may open a dialog box, or generate an immediate action. For example, Clicking on File and then Exit will cause an immediate termination of the Pulse Composer. The various commands in the Commands bar are listed and described below.
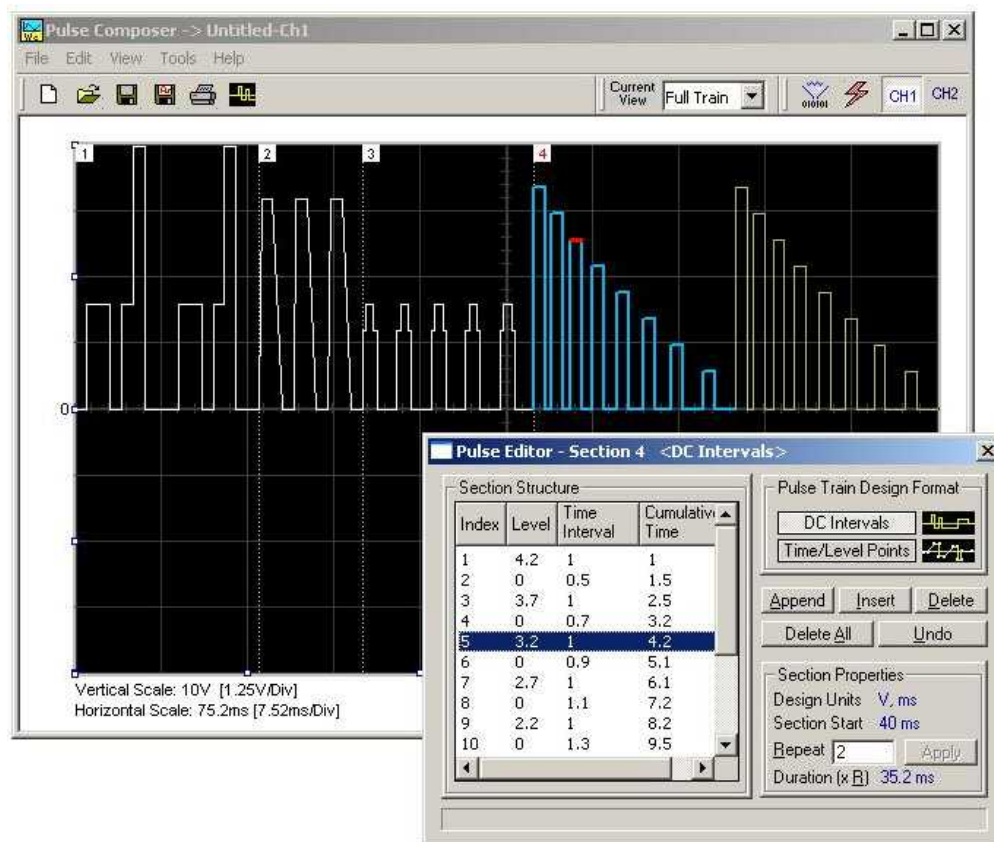
Figure 3-31, the Pulse Composer Screen

File Commands

The File command has 4 command lines that control pulse waveform files. Also use this command to print the active waveform, or exit the pulse composer program. Description of the various commands under File is given below.

New

The New (Ctrl+N) command will remove the waveform from the screen. If you made changes to the waveform area and use the New command, you should save your work before clearing the screen. The New command is destructive to the displayed waveform.

Open…

The Open… (Ctrl+O) command will let you browse through your disk space for previously saved pulse waveform files and load them to the pulse screen area. File extension that can be read to the pulse composer is *.pls.

Save

The Save (Ctrl+S) command will store the active waveform in your 5300 directory with a *.pls extension. If this is the first time you save your waveform, the Save As… command will be invoked automatically, letting you select name, location and format for your waveform file.

Save As…

Use the Save As… command the first time you save your waveform. It will let you select name, location and format for your waveform file.

Print

With this command you may print the active Pulse Window. The standard printer dialog box will appear and will let you select printer setup, or print the waveform page.

Exit

The Exit command ends the current Pulse Composer session and takes you back to the Panels screen. If you made changes to your waveform since it was last saved, the Wave Composer will prompt you to Save or Abandon changes these changes.

Edit Commands

The Edit commands are used for adding or removing pulse train sections. Use these commands to Append, Delete, Insert, or Undo last operation. The editing commands are explained in the following paragraphs.

Append Section

The Append Section command lets you append a new section at the end of the pulse train. Only one new section can be appended at the end of the train. If an empty section already exists, the append command will alert for an error. New sections are always appended at the end of the pulse train.

Insert Section

The insert Section command lets you insert a new section in between sections that were already designed. Only one new section can be inserted at the middle of the train. If an empty section already exists, the insert command will alert for an error.

Delete Section

The Delete Section command lets you remove sections from the pulse train without affecting the rest of the train. If you use this command from the Edit menu, make sure that the section you want to remove is currently the active section.

Remove all Sections

The Remove all Sections command lets you remove the entire pulse design from the pulse screen and start from a fresh page.

Undo

The Undo command undoes the last editing operation. This command is extremely useful in cases where you unintentionally delete a section from the pulse train and want to restore it to the screen.

View Commands

The View commands have commands that let you view various sections of the pulse area. The View commands include: Pulse Editor, Full Train or individual Sections and Options. Description of the view commands is given in the following.

Pulse Editor

The view Pulse Editor command invokes a dialog box as shown in Figure 3-32. In general, the pulse editor is used for placing straight line segments on the screen in intervals that define pulse width, rise/fall times and amplitude. Information how to use the pulse editor to create pulse trains is given later in this chapter.
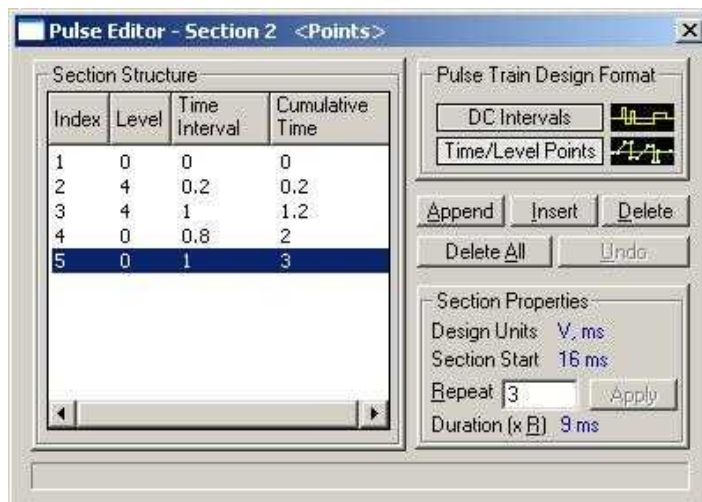
Figure 3-32, the Pulse Editor

Full Train

The view Full Train shows on the pulse screen all sections of the pulse train. Eventually, when all pulse sections have been designed, the entire pulse train as shown when the Full Train option has been selected will be downloaded to the instrument as a single waveform.

Single Section

The view Single Section shows on the pulse screen one section at a time. Eventually, when all pulse sections have been designed, the entire pulse train as shown when the Full Train option has been selected will be downloaded to the instrument as a single waveform.

Options

The view options command opens the dialog box as shown in Figure 3-33. Use this dialog box to fine-tune the pulse composer to the way it should deal with operational modes and the waveform memory. Information on options is given later in this chapter.
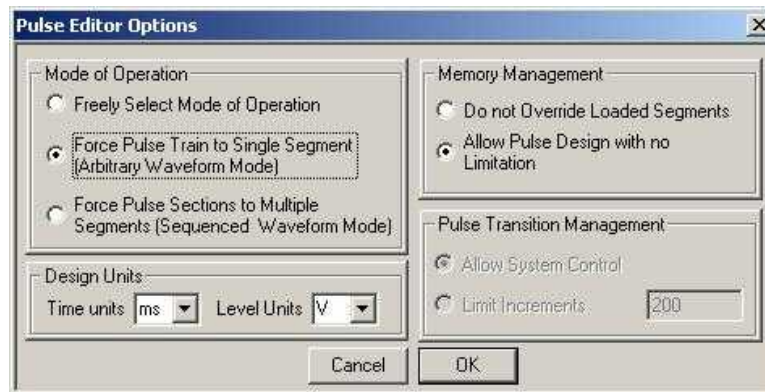
Figure 3-33, the Pulse Editor Options

Tools Commands

The Tools commands let you download pulse trains to the instrument. You can also clear the entire waveform memory using the Clear memory command.

> 📝 *Note*
>
> **The Clear Memory command affects the entire waveform memory of the 5300 and therefore, be careful not to erase memory segments that you'll need to use with the arbitrary function.**

The Pulse Composer Toolbar

The toolbar contains icons for editing the waveform screen, icons for saving and loading waveforms, fields for selecting an active channel and more. The Toolbar is shown in Figure 3-34. The icons, from left to right operate the following functions: New waveform, Open an existing waveform file, Save pulse train, Save pulse train As, Print the screen and open the pulse editor dialog box. Other icons select the current view on the screen, clear the memory and download the displayed pulse train to the active channel.
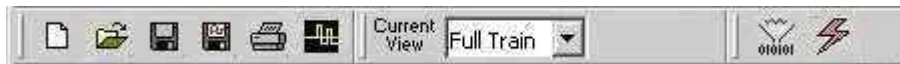
Figure 3-34, the Pulse Composer Toolbar Icons

Creating Pulses

As was mentioned above, creating pulses with the pulse editor is simple and intuitive, just as you would draw the pulse on a piece of paper. The pulse editor then processes the information, determines the appropriate mode and converts to waveform coordinates for downloading to the instrument for it to generate the required pulse shape.

There are a number of terms that will be used throughout the following description; Make yourself familiar with these terms before you proceed with actual design of your pulse.

Pulse Editor
The Pulse Editor is the prime tool for creating pulses. To invoke the pulse editor, point and click on the pulse editor icon on the pulse composer toolbar. You can also invoke the editor by clicking on the Section Number icon as will be shown later in this description. The pulse editor dialog box is shown in Figure 3-40.

Pulse Train
The Pulse Train identifies the entire pulse design. When downloading the waveform to the instrument, the entire pulse train will be downloaded, regardless if part of the pulse train is displayed on the pulse composer screen.

Pulse Section
Pulse train is constructed from 1 or more sections. If the pulse is simple, it can be created using one section only. For more complex pulse train, the train can be divided to smaller sections and each section designed separately for simplicity. Figure 3-35 shows a complex pulse train which was made from five simpler sections and Figure 3-36 shows the design of the fifth section only of the pulse train.
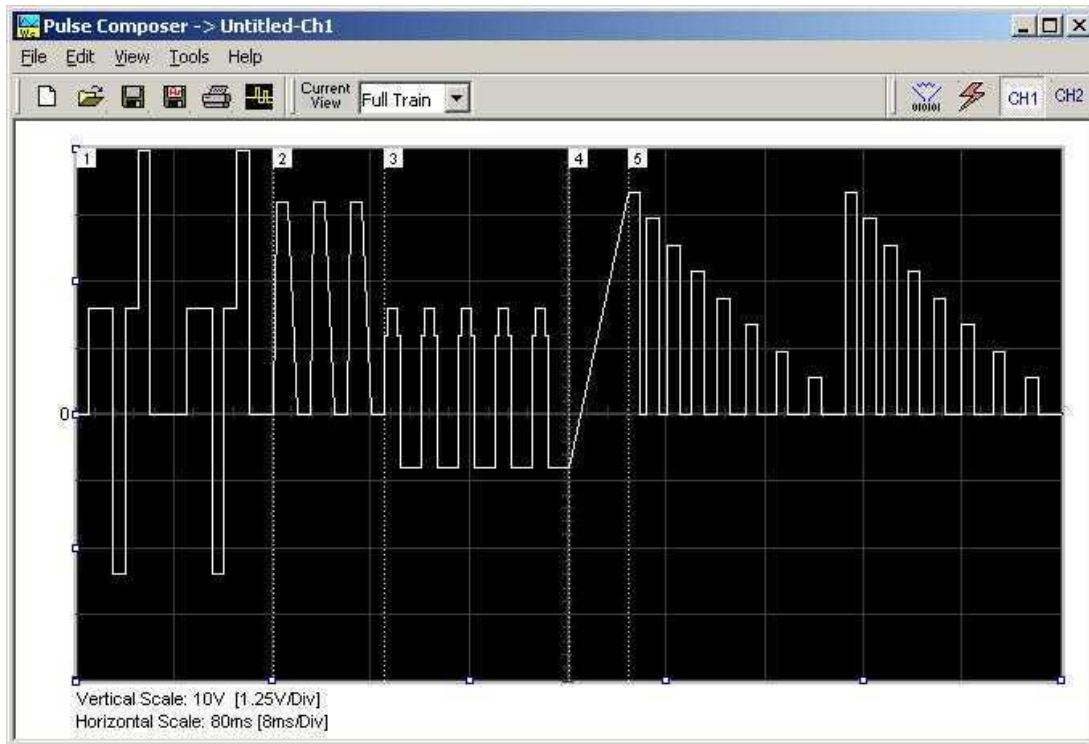
Figure 3-35, Complete Pulse Train Design
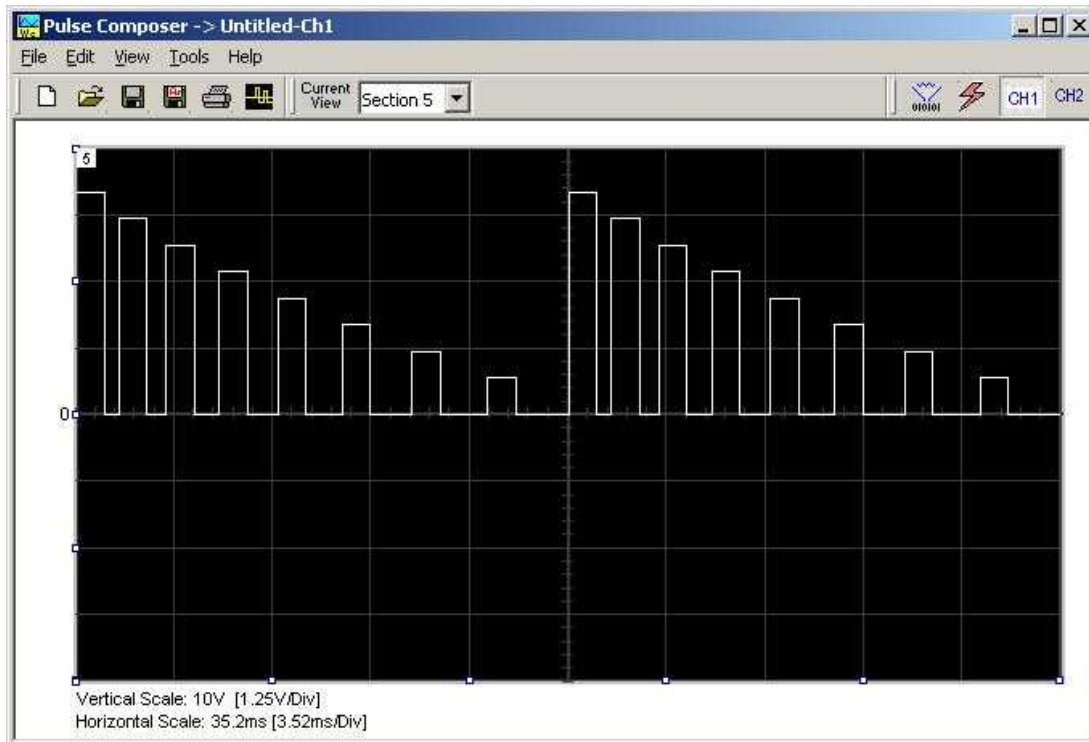
Figure 3-36, Section 5 of the Pulse Train Design

Now that we somewhat understand the terms we use for the pulse design, we start with an example how to design the pulse train as shown in Figure 3-35. If you already have some pulses shown on your pulse composer screen, click on New to start from a fresh page. Another step before you design your pulse train is to set the design parameters in the options menu that will determine the way that the pulse will be distributed in your waveform memory. Click on View→Options and refer to Figure 3-37 throughout the following description.

Figure 3-37, Selecting Pulse Editor Options

Setting the Pulse Editor Options

As shown in Figure 3-37, the pulse editor option dialog box is divided to functional groups: Mode of operation, Design Units, Memory Management and Pulse Transition Management. These groups are described below.

Mode of Operation
There are three options in the mode of operation group.

The force pulse train to single segment option is recommended if you are using one pulse section only. In this case, the pulse waveform will occupy one segment only and the generator will automatically be set to operate in arbitrary mode.

The force pulse sections to multiple segments option will place each section of the pulse train into a different memory segment and the generator will automatically be set to operate in sequenced mode. Select this option for the example we are going to build later.

If you are not sure what to do, select the freely select mode of operation and the generator will do the work for you.

Design Units
As you design your pulse pattern, it will be easier if you design it using the exact units as you would want to output to your load. Select between μs, ms and s for the pulse intervals and mV or V for the amplitude level. Select ms and V for the example we are going to build later.

Memory management
There are two options in the memory management group.

The do not override loaded segments option will make sure that whatever waveforms you already stored for the arbitrary function will stay intact after you save your pulse waveform.

The allow pulse design with no limitations option may overwrite memory segments that you already used previously for the arbitrary function however, this is the recommended option for the program and for the example we are going to build later.

Pulse Transition management
The pulse transition management parameter defines for the program how many waveform points will be used to step from one amplitude level to another amplitude level. The longer the transition time, the program will need more steps to smooth the transition. If you select the limit increments and set a pre-defined number of increments, you manually control how many waveform points will be dedicated for transitions however, if you are not sure what is the optimum number of increments, select the allow system control option for the program to make the transitions efficient in terms of memory usage and slope smoothness.

After you complete setting the pulse editor options, point and click on OK.

Using the Pulse Editor The prime tool for building pulse patterns on the pulse composer screen is the pulse editor. To invoke the pulse editor, point and click on the pulse editor icon on the tools bar. The editor as shown in Figure 3-38 will show. Refer to this figure for the following descriptions.
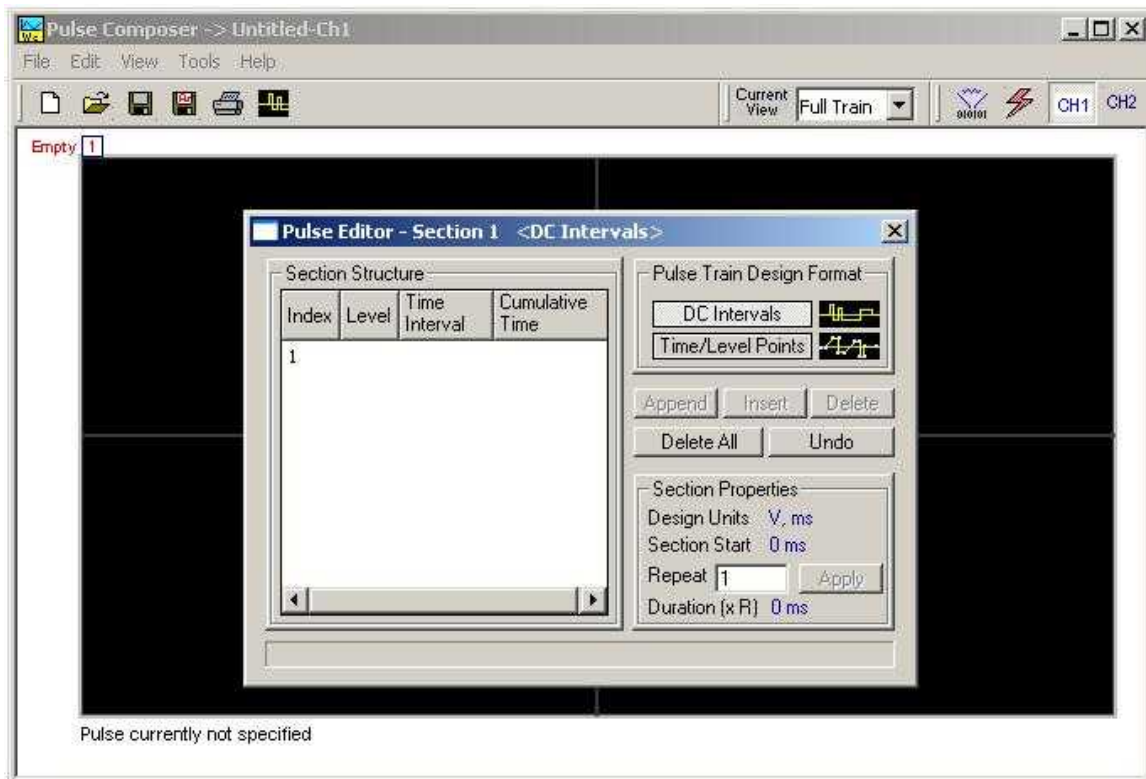
Figure 3-38, Using the Pulse Editor

The Pulse Editor as shown in Figure 3-46 has four groups: Section Structure, Pulse Train Design Format, Section Properties and control buttons. These groups are described below.

Pulse Train Design Format

There are two methods (or formats) that can be use for designing the pulse shape: DC Intervals and Time/Level Points. The design format is unique for the current section and cannot be switched during the section design.

DC Intervals – programs pulse duration using DC levels only. Transition times for this format are at the maximum rate that the generator can produce. For example, if you want to draw a simple square waveform that has 0V to 3.3V amplitude, 50% duty cycle and 1ms period, you enter the following parameters:

Index = 1, Level = 3.3, Time interval = 0.5 (Cumulative Time = 0.5)
Index = 2, Level = 0, Time Interval = 0.5 (Cumulative Time = 1.0)

Note as you build the segments that the pulse is being drawn on the screen as you type in the parameters. Also note that the Cumulative Time column is updated automatically with the cumulative time lapse from the start of the pulse.

Time/Level Points – programs pulse turning points using level and time markers. This format is a bit more complex to use however, it allows pulse design that require linear transition times. For example, if you want to draw a simple square waveform that has 0V to 3.3V amplitude, 50% duty cycle, 1ms period and 100ns transition times, you enter the following parameters:

Index = 1, Level = 0, Time interval = 0, (Cumulative Time = 0)
Index = 2, Level = 3.3, Time Interval = 0.1, (Cumulative Time = 0.1)
Index = 3, Level = 3.3, Time interval = 0.4, (Cumulative Time = 0.5)
Index = 4, Level = 0, Time interval = 0.1, (Cumulative Time = 0.6)
Index = 5, Level = 0, Time interval = 0.4, (Cumulative Time = 1.0)

Note as you build the segments that the pulse is being drawn on the screen as you type in the parameters and the specified point is marked with a red dot. Also note that the Cumulative Time column is updated automatically with the cumulative time lapse from the start of the pulse.

Section Structure
The term Section Structure is used to define part of the pulse train that share common properties. There are four parameters that can be programmed in this group: Index, Level, Time Interval and Cumulative Time.

Index – Is added automatically as you program pulse segments. The index line is highlighted as you point and click on pulse segments on the pulse editor screen.

Level – Specifies that peak level of the programmed segment. As you build the pulse, the level window is expended automatically to fit the required amplitude range. Note however, there is a limit to the level, which is being determined by the generator's peak to peak specification.

Time Interval – Specifies the time that will lapse for the current index level. You can program the time interval and the cumulative time will be adjusted accordingly.

Cumulative Time – Specifies the time that will lapse from the start of the current pulse section. You can program the cumulative time and the time interval will be adjusted accordingly.

Section Properties
The Section Properties contains a summary of properties that are unique for the current section.

Design Units – Provide information on the units that are used when you draw the pulse segments. These units can be changed in the pulse editor options.

Section Start – Provides timing information for the start of the current section. If this is the first pulse section the value will always be 0. Subsequent sections will show the start mark equal to the end mark of the previous section.

Repeat – Allows multiplication of pulse segments without the need to re-design repetitive parts. After you enter a repeat value, press the Apply button to lock in the repeat multiplier.

Duration – Displays the time that will lapse from the start of the pulse section to the end. The duration shows the total time lapse, including the repeated sections.

Control Buttons
The control buttons allow appending, inserting, and deleting one or all index lines. The Undo button is useful in cases where an error was made and restoration of the last operation is critical.

Pulse Example, Section 1   Now that we are better familiar with the pulse editor and its options, we are ready to start building the first section of the pulse as shown in Figure 3-39. Point and click on the New icon and open the pulse editor. Type in the level and time intervals as shown in Figure 3-39. Note that the pulse segments are being created on the screen as you type the values.
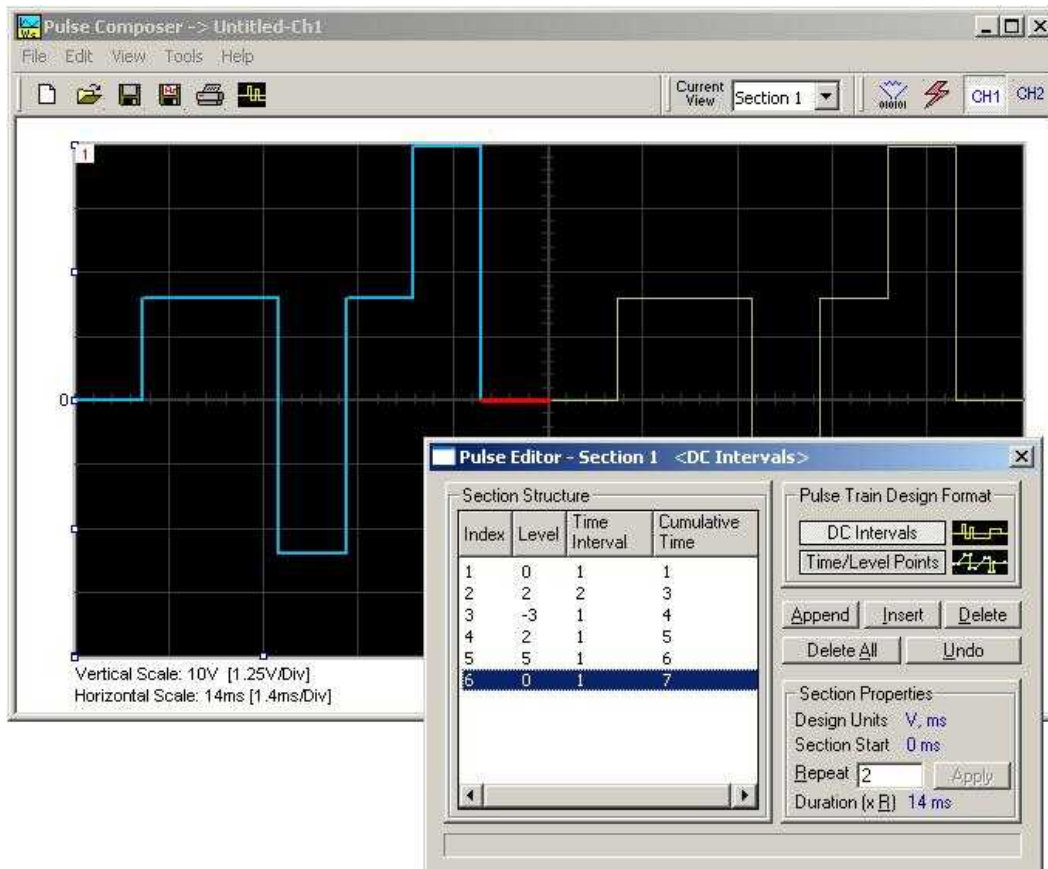
Figure 3-39, Building Section 1 of the Pulse Example

Tips

1. Use the tab button to edit the Section Structure fields.
2. Use Append to add an index line at the end of the list.
3. Use insert to add a segment above a focused line.

Before we proceed with the design of the next section, pay attention to some values that are now available on the composer screen. On the left bottom corner of the composer, Vertical Scale is showing 10 V (1.25 V/Div) and Horizontal Scale is showing 14 ms (1.4 ms/Div). These two values are critical for the integrity of the design because they are later being interpreted by the program and converted to waveform coordinates that the generator can process and output as a pulse shape. These values, may change as you add more sections to the pulse train.
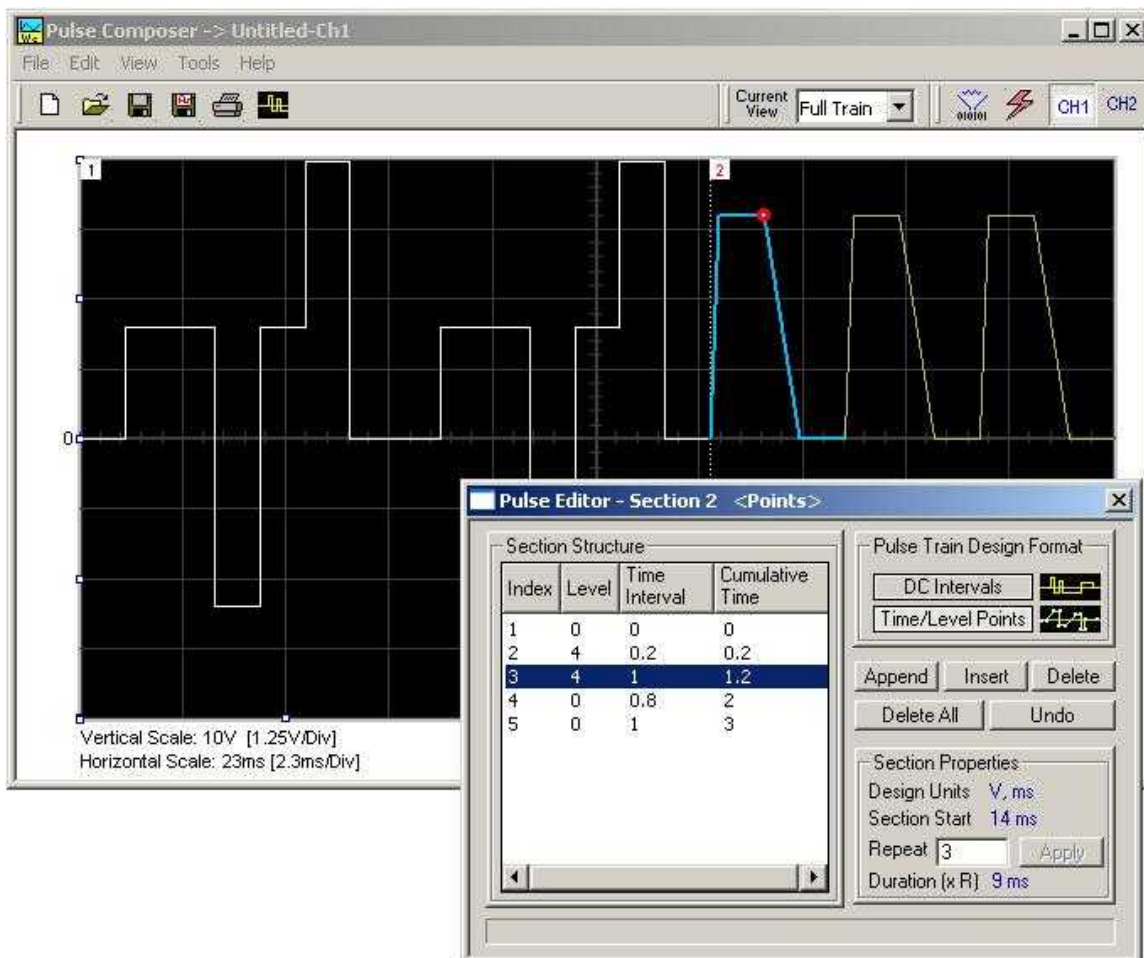
Figure 3-40, Building Section 2 of the Pulse Example

Pulse Example, Section 2   The first pulse section is complete. We are ready now to start building the second section of the pulse as shown in Figure 3-48. Point and click on the Edit command and select the Append Section option. A new section number will appear but it will show empty next to the section identifier.

Before you start entering values to this section, note that there are linear transitions required for this section. Therefore, select the Time/Level Points option in the Pulse Train Design Format. You are now ready to start programming values. In case you made a mistake and want to switch design formats after you have already typed in some values, the Pulse Editor will show an error alerting you that design format can only be changed for empty section. In this case, the only way to recover is to delete all entries and start from an empty index list. Type the section entries as shown in Figure 3-44.

Pulse Example, Section 3   The second pulse section is complete. We are ready now to start building the third section of the pulse as shown in Figure 3-36. Point and click on the Edit command and select the Append Section option. A new section number will appear but it will show empty next to the section identifier.

Before you start entering values to this section, note that there are fast transitions required for this section. Therefore, select the DC Intervals option in the Pulse Train Design Format. You are now ready to start programming values. In case you made a mistake and want to switch design formats after you have already typed in some values, the Pulse Editor will show an error alerting you that design format can only be changed for empty section. In this case, the only way to recover is to delete all entries and start from an empty index list. Type the section entries as shown in Figure 3-41.
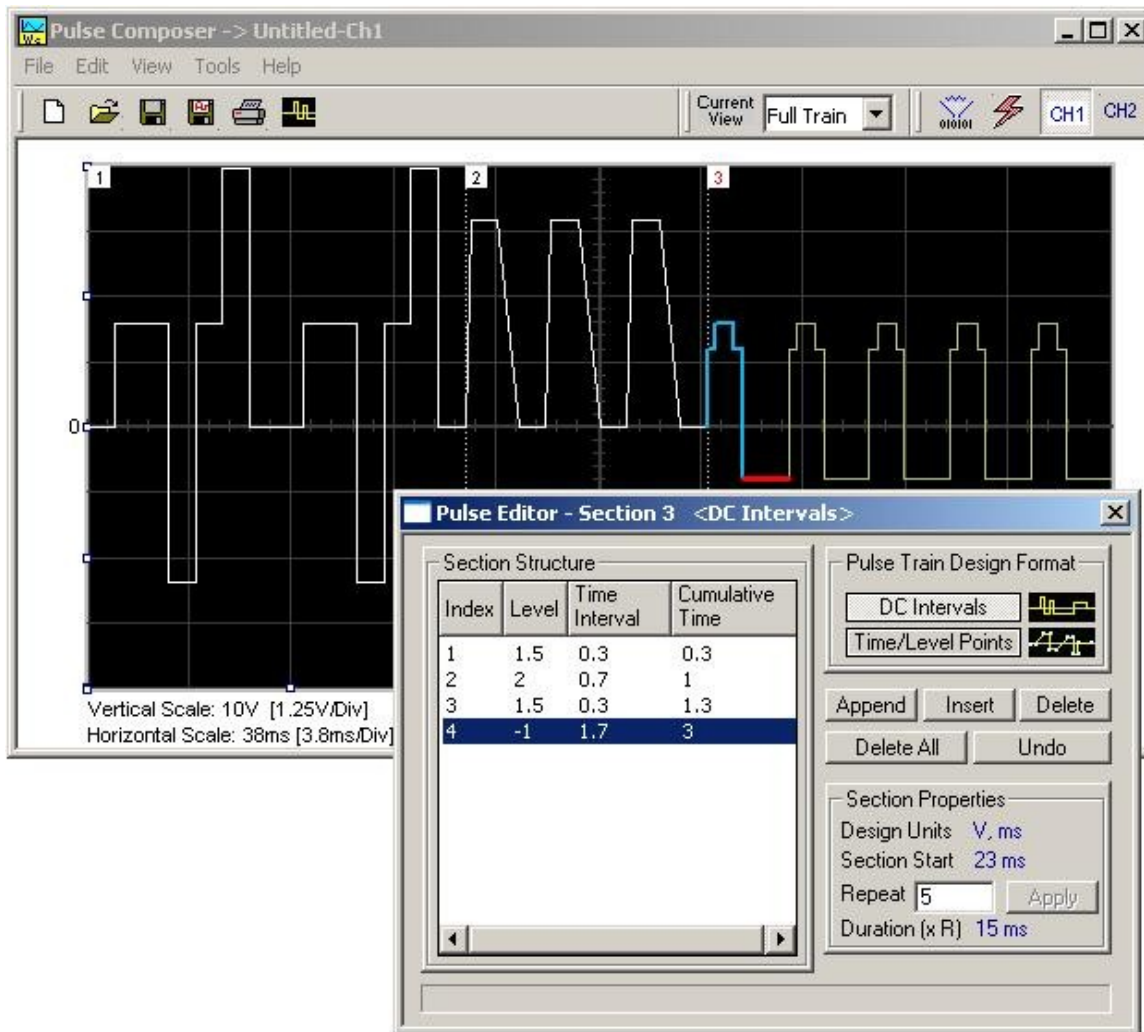
Figure 3-41, Building Section 3 of the Pulse Example

Pulse Example, Section 4
The third pulse section is complete. We are ready now to start building the forth section of the pulse as shown in Figure 3-36. Point and click on the Edit command and select the Append Section option. A new section number will appear and will show empty next to the section identifier.

Before you start entering values to this section, note that there is only one linear transition required for this section that will start from the last point of the previous section and will connect to the start point of the next section. Therefore, select the Time/Level Points option in the Pulse Train Design Format. You are now ready to start programming values. Type the section entries as shown in Figure 3-42.
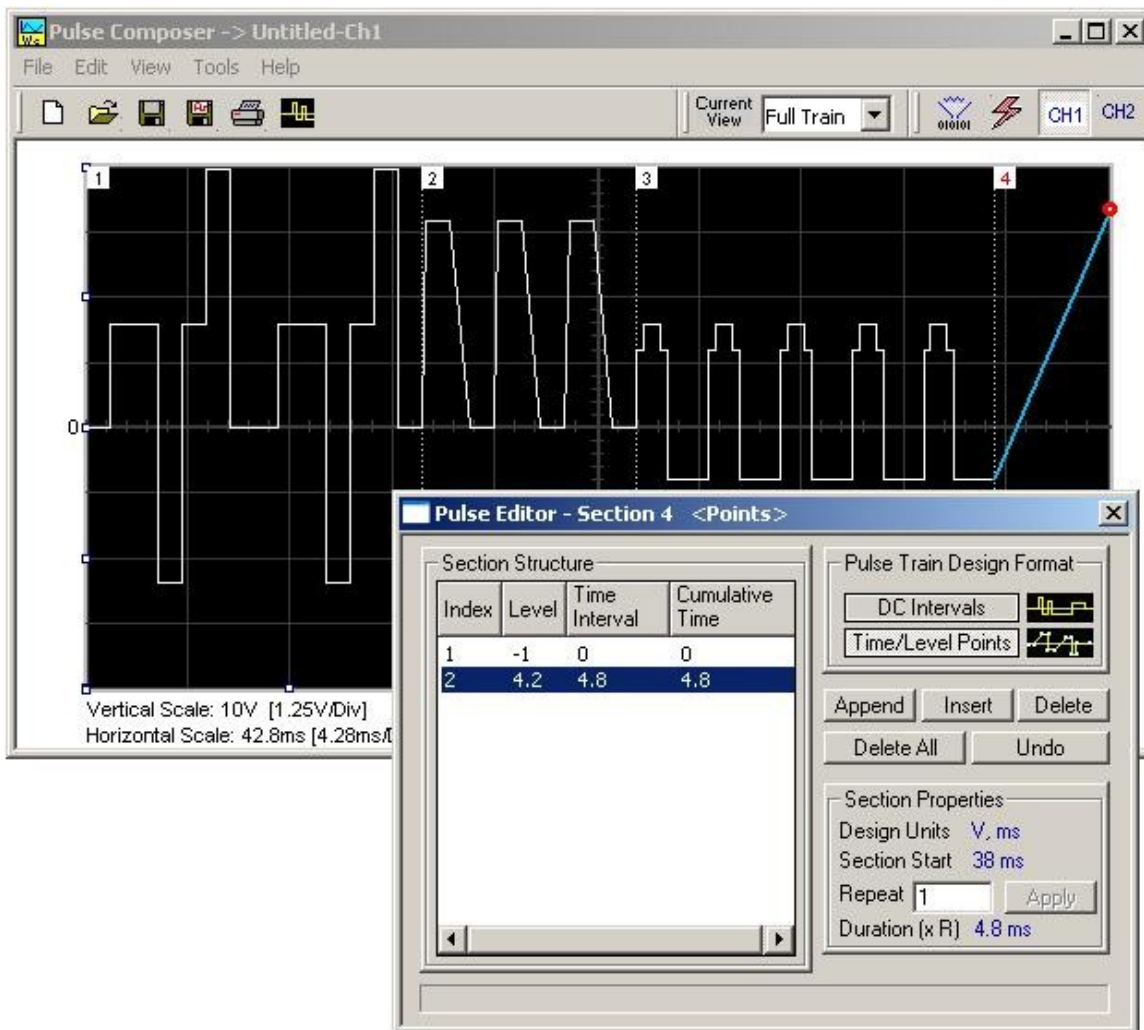
Figure 3-42, Building Section 4 of the Pulse Example

Pulse Example, Section 5 The fourth pulse section is complete. We are ready now to start building the fifth and final section of the pulse as shown in Figure 3-36. Point and click on the Edit command and select the Append Section option. A new section number will appear and will show empty next to the section identifier.

Note that there are fast transitions required for this section that will start from the last point of the previous section and will connect to the start point of the next section. Therefore, select the Time/Level Points option in the Pulse Train Design Format. You are now ready to start programming values. Type the section entries as shown in Figure 3-43.
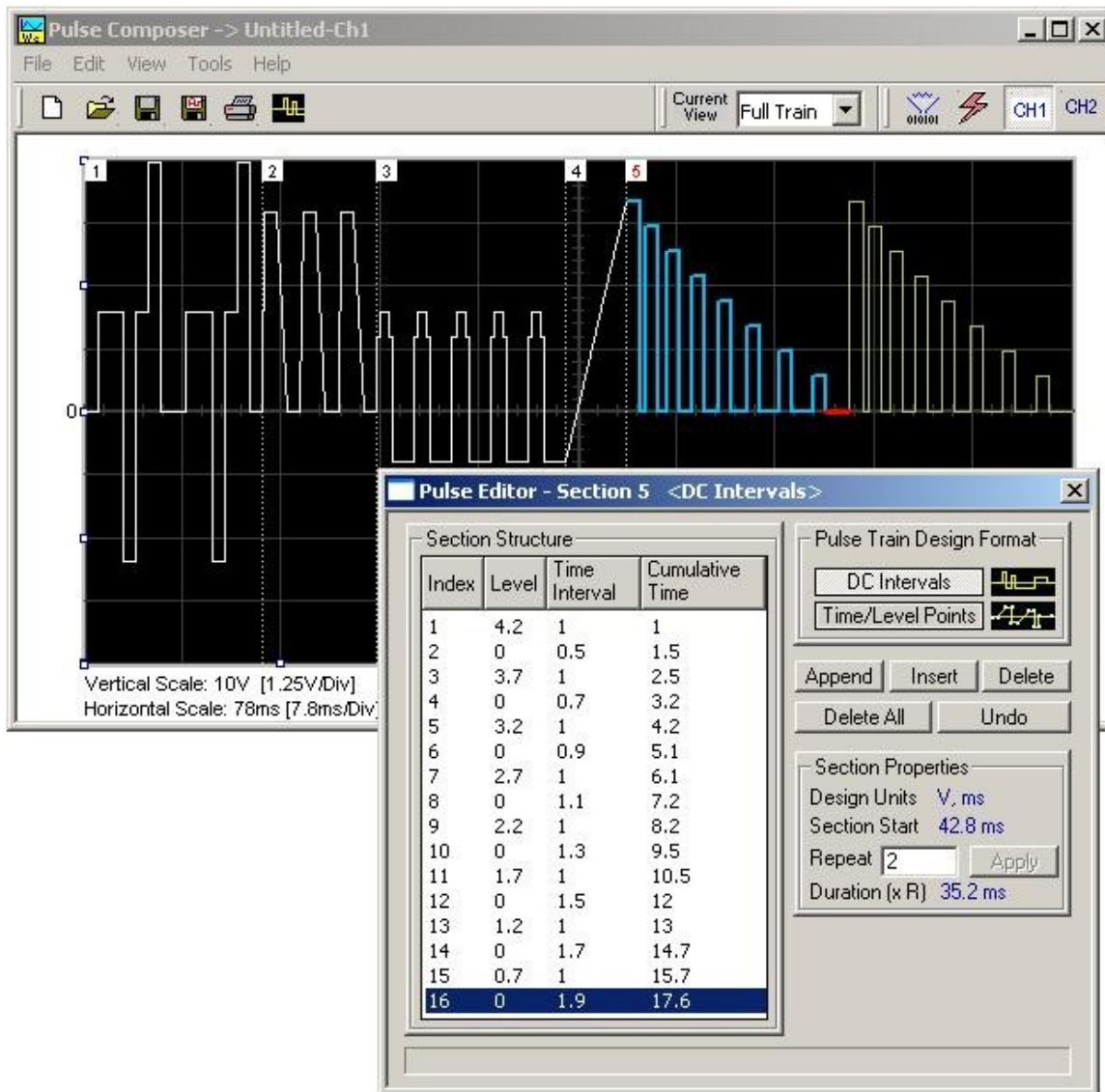
Figure 3-43, Building Section 5 of the Pulse Example

Downloading the Pulse Train

Congratulations for coming that far. If you followed the above description how to build this pulse example, the screen should look exactly as shown in Figures 4-35 and 4-43. If you are happy with the results, the next step is to download what you see on the pulse composer screen to the generator.

One more step before you download the waveform to the instrument is to check the Pulse Train Download Summary as appears after you press the Download icon. You can also view the same information if you select it from the View menu. Refer to Figure 3-52 for information how to interpret your download summary.
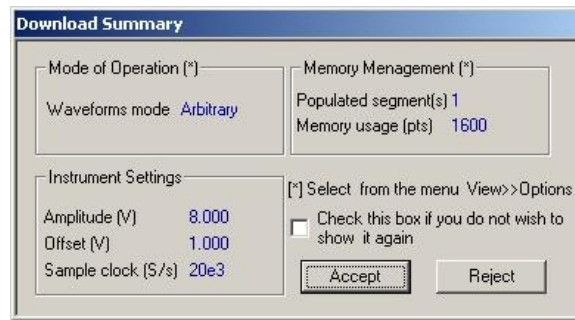
Figure 3-44, the Pulse Editor Download Summary

Interpreting the Download Summary

It is very important for you to understand that when you download a pulse waveform from the pulse composer, parameters and mode of operation may change settings on your generator. The download summary shows what will change and will let you reject the new settings if you do not agree to the changes. Once you press the Accept button, the waveform will be downloaded to the generator and the modes and parameters updated as shown in the dialog box. If you are already familiar with the changes and do not care to see the download summary every time you download a pulse waveform, you can check the box and it will not be shown on your next download. You can restore this summary from the View>>Download Summary command.

Mode of Operation – This describes the new setting of the operating mode. This field could display one of two options: Arbitrary or sequenced. Pay attention to the note (*) that says "Select from the menu View>>Options" Since we checked the Force Pulse Train to Single Segment (see Figure 3-46), the generator determines that the waveform mode be arbitrary and only one segment can be loaded with the pulse train.

Memory management – By selecting the arbitrary mode of operation, the pulse train is forced to a single segment. This summary shows which segment has been populated and how much memory was used to build the required pulse train.

Instrument Settings – Show the amplitude, offset and sample clock settings that will be changed on the generator. The settings in this summary cannot be affected from the pulse editor options settings. These are being computed and modified specifically for the current pulse train pattern and will change from pattern to pattern.

Accept/Reject – These buttons are the final step before you download the pulse train to the instrument. If you are unhappy with the instrument setting and want to change some of the options, there is still time Point and click on the Reject button and go do your changes. Point and click on the Accept button to complete the download process.

The FM Composer

The FM Composer looks and feels almost like the waveform composer except there is a major difference in what it does. If you look at the opening screen as shown in Figure 4-53, you'll see that the vertical axis is marked with frequencies. You'll see later that as you draw waveforms on the FM composer screen, these waveforms represent frequency changes and not amplitude changes as are generated by the waveform composer.

The FM composer is a great tool for controlling frequency agility by generating the agility curve as an arbitrary waveform. For example, if you create a sine waveform, the 5300 will generate frequency-modulated signal that will follow the sine pattern. The resolution and accuracy of the modulated waveform is unsurpassed and can only be duplicated by mathematical simulation. The FM composer is loaded with many features and options so use the following paragraphs to learn how to create and download modulating waveforms to the 5300 using the FM Composer.

Invoke the FM Composer from Panels bar. The Wave Composer has three sections: Commands bar, Toolbar and Waveform screen. Refer to Figure 3-45 throughout the description of these parts.

The Commands bar

The commands bar is exact duplication of the commands bar in the Wave composer. It provides access to standard Windows commands such as File and View.

In general, clicking on one of the commands opens a dialog box with an additional list of commands. Then, clicking on an additional command, may open a dialog box, or generate an immediate action. For example, Clicking on File and then Exit will cause an immediate termination of the FM Composer. On the other hand, clicking on Wave and then on Square, will open a Square Wave dialog box that lets you program and edit square wave parameters. The various commands in the Commands bar are listed and described below.
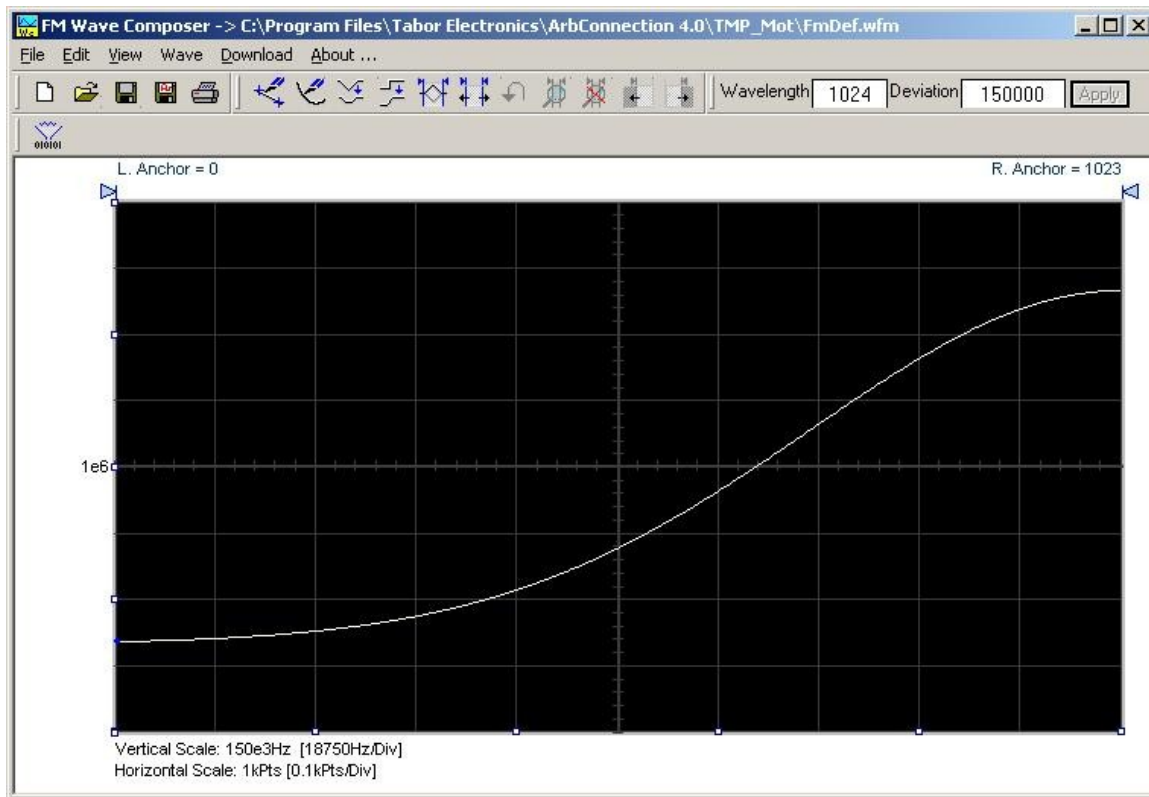
Figure 3-45, The FM Composer opening Screen

File Commands

The File command has 4 command lines that control waveform files. Also use this command to exit the FM composer program. Description of the various commands under File is given below.

New Waveform
The New Waveform command will remove the waveform from the screen. If you made changes to the waveform area and use this command, you should save your work before clearing the screen. The New Waveform command is destructive to the displayed waveform.

Open Waveform…
The Open Waveform… command will let you browse your disk for previously saved waveform files and load these waveforms to the waveform area. This command is also very useful for converting waveform files to format that is acceptable by the Wave Composer.

Save Waveform
The Save Waveform command will store your active waveform in your 5300 directory, as a binary file with a *.wvf extension. If this is the first time you save your waveform, the Save Waveform As… command will be invoked automatically, letting you select name, location and format for your waveform file.

Save Waveform As…

Use the Save Waveform As… command the first time you save your waveform. It will let you select name, location and format for your waveform file.

Print

With this command you may print the active Waveform Window. The standard printer dialog box will appear and will let you select printer setup, or print the waveform page.

Exit

The Exit command ends the current FM Composer session and takes you back to the Panels screen. If you made changes to your waveform since it was last saved, make sure to Save your work before you use this command.

Wave Commands

The Wave commands let you create waveforms on the screen. The Wave command has a library of 6 waveforms: Sine, Triangle, Square, Exponent, Pulse, and Noise. It also lets you create waveforms using an Equation editor. Information how to create waveforms using the Wave commands is given below.

Creating Waveforms From the Built-in Library

You can create any waveform from the built-in library using the Wave command. Clicking on one of the Wave options will open a dialog box. An example of the Sine waveform dialog box is shown in Figure 3-46. This dialog box is representative of the rest of the waveforms, so other waveforms will not be described.

Creating Sine Waveforms

Use the following procedure to create sine waveforms from the built-in library. Click on Wave, then sine… the dialog box as shown in Figure 3-46 will appear. You can now start programming parameters that are available in this box.

Start Point Anchor – Defines the first point where the created wave will start. Note that if you change the start point the left anchor will automatically adjust itself to the selected start point. The example shows start point set at point 200.

End Point Anchor – Defines where the created waveform will end. Note that as you change the end point the right anchor will automatically adjust itself to the selected end point. The example shows end point set at point 499.

Max. Peak Deviation – This parameter defines the forward peak deviation. Note that the forward peak deviation cannot exceed the pre-defined Deviation parameter as shown on the Toolbar. In case you need to exceed the pre-defined peak value you must quit this box and modify the Deviation parameter to provide sufficient range for the forward peak deviation range.
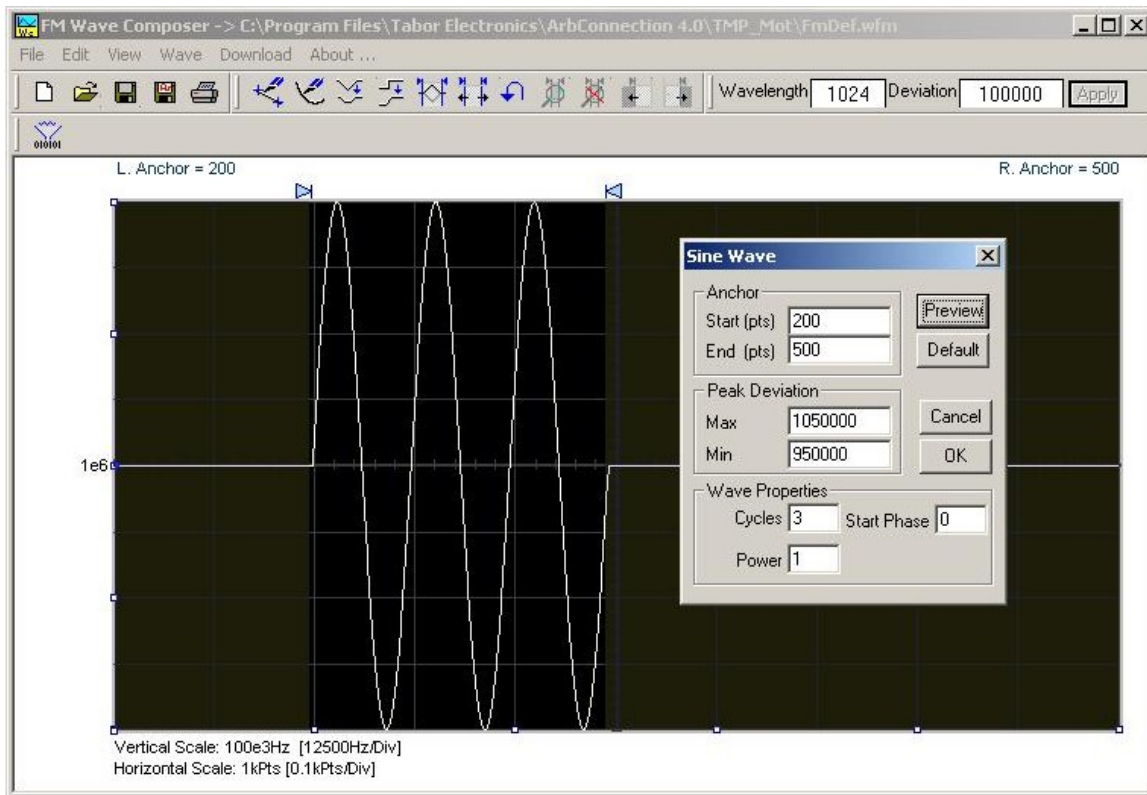
Figure 3-46, Generating Sine Modulation Using the FM Composer

Min. Peak Deviation – This parameter defines the backwards peak deviation. Note that the backwards peak deviation cannot exceed the pre-defined Deviation parameter as shown on the Toolbar. In case you need to exceed the pre-defined peak value you must quit this box and modify the Deviation parameter to provide sufficient range for the backwards peak deviation range.

Cycles – The Cycles parameter defines how many sine cycles will be created within the specified start and end anchor points. The example below shows three sine cycles.

Start Phase – The start phase parameter defines the angle of which the sine will start. The example shows 0° start phase.

Power – Sine to the power of 1 will generate a perfect sine. Power range is from 1 through 9.

Tip

The functionality of the FM composer is similar to the Wave composer. If you need more information on the FM composer functions, features and it equation editor, refer to the Wave composer section in this manual information.

The Command Editor

The Command Editor is an excellent tool for learning low level programming of the 5300. Invoke the Command Editor from the System menu at the top of the screen. Dialog box, as shown in Figure 3-47 will pop up. If you press the Download button, the function call in the Command field will be sent to the instrument.
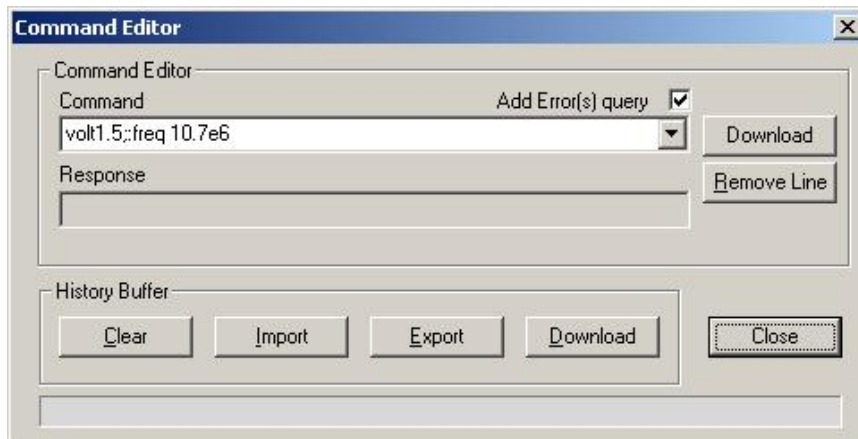
Figure 3-47, the Command Editor

Low-level SCPI commands and queries can be directly sent to the 5300 from the **Command** field and the instrument will respond to queries in the **Response** field. The command editor is very useful while developing your own application. Build your confidence or test various commands using the command editor. This way you can assure that commands or syntax that you use in your application will behave exactly the same way as it responds to the editor commands. A complete list of SCPI commands is available in the programming chapter of this manual.

Logging SCPI Commands

The Log File is very useful for programmers that do not wish to spend a lot of time on manuals. When you use ArbConnection, every time you click on a button or change parameter, the command is logged in the same format as should be used in external applications. Figure 3-48 shows an example of a log file and a set of SCPI commands as resulted from some changes made on ArbConnection panels. You can set up the 5300 from ArbConnection to the desired configuration, log the commands in the log file and then copy and paste to your application without any modifications. Of course, this is true for simple commands that do not involve file download but, on the other hand, this is a great tool to get you started with SCPI programming.
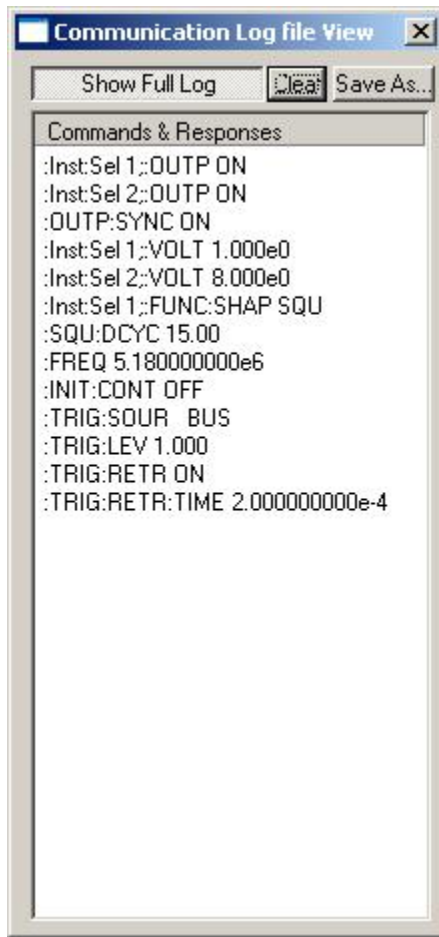
Figure 3-48, Log File Example

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Chapter 4
Remote Programming Reference

What's in This Chapter

This Chapter lists and describes the set of SCPI-compatible (Standard Commands for Programmable Instruments) remote commands used to operate the 5300. To provide familiar formatting for users who have previously used the SCPI reference documentation, the command descriptions are dealt with in a similar manner. In particular, each sub-system's documentation starts with a short description, followed by a table showing the complete set of commands in the sub-system; finally the effects of individual keywords and parameters are described. Complete listing of all commands used for programming the 5300 is given in Table 4-1.

What is Required

To successfully use this instrument, the following conditions must be met:

1. The instrument is installed (and detected) in the PCI mainframe.

2. Visa 4.0 or later is installed.

3. IVI driver is installed.

4. ArbConnection 4.3 or later is installed.

Installation of one of the IVI driver or ArbConnection is mandatory and critical to the operation of the instrument as it places the control dll in the appropriate directory. Installation procedure of the 5300 and its controlling software can be found in the installation chapter of this manual. Even if you do not intend to use the IVI driver, nor will you use ArbConnection, it is suggested that you install both anyway and first operate the instrument through one of these utilities to make sure the 5300 responds correctly to commands and queries.

Both the IVI driver and ArbConnection are using built-in functions that convert standard SCPI commands to machine code. Knowledge of basic SCPI programming and concepts is required to operate the instrument and hence the short introduction to SCPI programming that is given below. If you are not sure what SCPI programming is use the log file in ArbConnection and select the show commands only; This will give you an overview on how commands control various operations of the instrument.

Introduction to SCPI

Commands to program the instrument over the GPIB 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 node or root, thus forming subsystems.

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

```
:OUTPut
 :FILTer
    [:LPASs] {NONE|25M|50M|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.

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:SLOP NEG;COUN 10;LEV -1
```

is the same as sending the following three commands:

```
:TRIG:SLOP NEG
:TRIG:COUN 10
:TRIG:LEV -1
```

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:BURS ON
```

The MIN and MAX Parameters

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

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

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

Querying Parameter Setting

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

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

Query the output function by executing:

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

Query Response Format

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

SCPI Command Terminator

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

IEEE-STD-488.2

The IEEE-STD-488.2 standard defines a set of common commands

Common Commands

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

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

SCPI Parameter Type

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

Numeric Parameters

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

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

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

Discrete Parameters

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

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

Boolean Parameters

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

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

The same command can also be written as follows:

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

Arbitrary Block

Arbitrary block parameters are used for loading waveforms into the

Parameters generator's memory. Depending on which option is installed, the Model 5300 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>
```

Binary Block Parameters Binary block parameters are used for loading segment and sequence tables into the generator's memory. Information on the binary block parameters is given later in this manual.

SCPI Syntax and Styles

Where possible the syntax and styles used in this section follow those defined by the SCPI consortium. The commands on the following pages are broken into three columns; the KEYWORD, the PARAMETER FORM, and any NOTES.

The KEYWORD column provides the name of the command. The actual command consists of one or more keywords since SCPI commands are based on a hierarchical structure, also known as the tree system. Square brackets ([ ]) are used to enclose a **keyword** that is optional when programming the command; that is, the 5300 will process the command to have the same effect whether the optional node is omitted by the programmer or not. Letter case in tables is used to differentiate between the accepted short form (upper case) and the long form (upper and lower case).

The PARAMETER FORM column indicates the number and order of parameter in a command and their legal value. Parameter types are distinguished by enclosing the type in angle brackets (< >). If **parameter** form is enclosed by square brackets ([ ]) these are then optional (care must be taken to ensure that optional parameters are consistent with the intention of the associated keywords). The vertical bar (|) can be read as "or" and is used to separate alternative parameter options.

Table 4-1, Model 5300 SCPI Commands List Summary

Keyword	Parameter Form (Default in Bold)	Notes
:INSTRument		
:COUPle		
[:STATe]	**OFF**	ON	
:MODE	**MASTer**	SLAVe	
:PHASe		
[:OFFSet]	(**0**,0,n) where "n" is the size of the active segment	4 point increments
:SET	0	1	2	
:OUTPut		
[:STATe]	**OFF**	ON	
:FILTer		
[:LPASs]	**NONE**	25M	50M	ALL	
:SYNC		
[:STATe]	**OFF**	ON	
:SOURce	**BIT**	LCOMplete	
:POSition		
[:POINt]	(**0**;0;n) where "n" is the size of the active segment	4 point increments
:WIDTh	(4;4;100000)	4 point increments
[:SOURce]		
:APPLy		
:SINusoid	FREQ,AMPL,OFFS,PHAS	
:TRIangle	FREQ,AMPL,OFFS,PHAS	
:SQUare	FREQ,AMPL,OFFS,DCYC	
:PULSe	FREQ,AMPL,OFFS,DEL,WIDT,LEAD,TRA	
:RAMP	FREQ,AMPL,OFFS,DEL,LEAD,TRA	
:SINC	FREQ,AMPL,OFFS, NCYC	
: GAUSsian	FREQ,AMPL,OFFS,EXP	
: EXPonential	FREQ,AMPL,OFFS,EXP	
: DC	DC_AMPL	
: USER	SEGM,SCLK,AMPL,OFFS	
:FREQuency		
[:CW]	(**1e6**;100e-6;50e6)	MINimum	MAXimum	
:RASTer	(**1e7**;100e-3;100e6)	MINimum	MAXimum	
:SOURce	INTernal	EXTernal	

Table 4-2, Model 5300 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	Notes
:ROSCillator		
:SOURce	**INTernal** | EXTernal | TCXO	
:VOLTage		
[:LEVel]		
[:AMPLitude]	(5.**000**;80E-3;8.00) | MINimum | MAXimum	
:OFFSet	(**0**;-3.6;+3.6)	
:FUNCtion		
:MODE	**FIXed** | USER | SEQuence	
:SHAPe	**SINusoid** | TRIangle | SQUare | PULSe | RAMP |	
	SINC | GAUSsian | EXPonential | NOISe | DC	
:SINusoid		
:PHASe	(**0**;0;360)	
:TRIangle		
:PHASe	(**0**;0;360)	
:SQUare		
:DCYCle	(**50**;1;99)	
:PULSe		
:DELay	(**10**;0;99.9)	
:WIDth	(**10**;0;99.9)	
:TRANsition		
[:LEADing]	(**10**;0;99.9)	
:TRAiling	(**10**;0;99.9)	
:RAMP		
:DELay	(**0**;0;99.9)	
:TRANsition		
[:LEADing]	(**60**;0;99.9)	
:TRAiling	(**30**;0;99.9)	
:GAUSsian		
:EXPonent	(**20**;10;200)	
:SINC		
:NCYCle	(**10**;4;100)	
:EXPonential		
:EXPonent	(**1**;-20.00;20.00)	
:DC		
[:AMPLitude]	(**100**;-100;100)	

Table 4-3, Model 5300 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	Notes
:FM		
:DEViation	(**10e6**;100e-3;100e6)	
:FUNCtion		
:MODE	**FIXed** | USER	
:SHAPe	**SINusoid** | TRIangle | SQUare | RAMP	
:FREQuency	(**1e3**;1e-3;100e3)	
:RASTer	(**1e6**;1e-3;10e6)	
[:STATe]	**OFF** | ON	
:TRIGger		
:MODE	**CONTinuous** | TRIGgered | GATed	
:SLOPe	**POSitive** | NEGative	
:FSK		
:FREQuency		
:RASTer	(**80e6**;100e-3;100e6)	
[:STATe]	**OFF** | ON	
:MODE	**HOP** | RAMP	
:RAMP		
:TIME	(1e-3;10e-6;1)	
:SWEep		
[:FREQuency]		
:STOP	(**20e6**;100e-3;100e6)	
[:STATe]	**OFF** | ON	
:TIME	(**1e-3**;1e-3;1000)	
:DIRection	**UP** | DOWN	
:SPACing	**LINear** | LOGarithmic	
:TRIGger	**CONTinuous** | TRIGgered | GATed	
:MODE	**CONTinuous** | TRIGgered | GATed	
:SLOPe	**POSitive** | NEGative	
:MARKer	(20e6;100e-3;100e6)	
:TRACe		
DEFine	(1;1;4096),(16;16;2097152)	Even number, divisible by 4
:DELete		
[:NAME]	(1;1;4096)	
:ALL		
:SELect	(**1**;1;4096)	

Table 4-4, Model 5300 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	Notes
:SEQuence		
[:DATA]	<binary_block>	
:ADVance	**AUTOmatic** | STEP | SINGle | MIXed	
:SOURce	**EXTernal** | INTernal	
:DEFine	(1;1;4096),(1;1;4096),(1;1;2E17),(0,0,1)	Step, segment, repeat, advance mode
:DELete		
:ALL		
:INITiate		
[:IMMediately]		
:CONTinuous	**ON** | OFF	
:TRIGger		
:BURSt		
[:STATe]	**OFF** | ON	
:COUNt	(**1**;1;1E6)	
:SOURce		
:ADVance	**EXTernal** | INTernal	
:GATE		
[:STATe]	**OFF** | ON	
:SLOPe	**POSitive** | NEGative	
:TIMer	(**1e3**;100e-3;5e6)	In Hz units
:PHASe	(**0**;0;n) where "n" is the size of the active segment	4 points increments
:ARM		
[:STATe]	**OFF** | ON	
:SLOPe		
[:STARt]	**POSitive** | NEGative	
:BREakpoint		
:POSition	(**0**;0;999999)	4 points increments
:RESet		
:SYSTem		
:ERRor?		Query only
:VERSion?		Query only, 1999.0
:IDENtification		Query only

Table 4-5, Model 5300 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	Notes
*CLS		
*ESE	(**0**;0;255)	
*OPC		
*RST		
*SRE	(**0**;0;255)	
*TRG		
*ESE?		Query only
*ESR?		Query only
*IDN?		Query only
*OPC?		Query only
*OPT?		Query only
*SRE?		Query only
*STB?		Query only

SOURce Subsystem

This subsystem is used to control output functions, shape and parameters, frequency, amplitude and amplitude modulation, and filter type. Optional nodes were omitted from these commands. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable.

Keyword Limit	Parameter Form	Default,Low Limit,High
[:SOURce]		
:APPLy (?)		
:SINusoid (?)	{<freq>,<ampl>,<offs>,<phase>}	
:TRIangle (?)	{<freq>,<ampl>,<offs>,<phase>}	
:SQUare (?)	{<freq>,<ampl>,<offs>,<duty_cycle>}	
:PULSe (?)	{<freq>,<ampl>,<offs>,<delay>,<rise>,<high>,<fall>}	
:RAMP (?)	{<freq>,<ampl>,<offs>,<delay>,<rise>,<fall>}	
:SINC (?)	{<freq>,<ampl>,<offs>,<N_cycles>}	
:EXPonential (?)	{<freq>,<ampl>,<offs>,<exp>}	
:GAUSsian (?)	{<freq>,<ampl>,<offs>,<exp>}	
:DC (?)	<%_ampl>	
:USER (?)	{<seg#>,<sclk>,<ampl>,<offs>}	
:FM (?)	{OFF|ON|0|1}	**OFF**
:DEViation (?)	<deviation>	**1e6**,100e-3,100e6
:FUNCtion		
:MODE (?)	{FIXed|USER}	**FIXed**
:SHAPe (?)	{SINusoid|TRIangle|SQUare|RAMP)	**SINusoid**
:FREQuency	<FM_freq>	1e3,1e-3,100e3
:RASTer (?)	<FM_sclk>	**1e6**,1e-3,10e6
:TRIGger		
:MODE (?)	{CONTinuous|TRIGgered|GATed}	**CONTinuous**
:SLOPe (?)	{POSitive|NEGative	**POSitive**
:FREQuency (?)	{<freq>|MINimum|MAXimum}	**1e6**,100e-6,50e6
:RASTer (?)	{<sclk>|MINimum|MAXimum}	**10e6**,100e-3,100e6
:SOURce (?)	{EXTernal|INTernal}	**INTernal**
:FSK (?)	OFF|ON|0|1}	**OFF**
:FREQuency		
:RASTer (?)	<FSK_sclk>	**80e6**,100e-3,100e6
:MODE (?)	{HOP|RAMP}	**HOP**
:RAMP		
:TIME (?)	<time>	**1e-3**,10e-6,1
:FUNCtion		
:MODE (?)	{FIXed|USER|SEQuence}	**FIXed**
:SHAPe (?)	{SINusoid|TRIangle|SQUare|PULSe|RAMP |SINC|EXPonential|GAUSsian|NOISe|DC}	**SINusoid**
:ROCSillator		
:SOURce (?)	(INTernal|EXTernal | TCXO)	**INTernal**
:SWEep (?)	OFF|ON|0|1}	**OFF**
:STOP (?)	<stop_sclk>	**20e6**,100e-3,100e6
:TIME (?)	<time>	**1e-3**,1e-3,1000
:DIRection (?)	(UP|DONW)	**UP**
:SPACing (?)	(LINear|LOGarithmic)	**LINear**
:TRIGger		
:MODE (?)	{CONTinuous|TRIGgered|GATed}	**CONTinuous**
:SLOPe (?)	{POSitive|NEGative	**POSitive**
:MARKer (?)	<mark_sclk>	**64e6**,100e-3,100e6
:VOLTage (?)	{<ampl>|MINimum|MAXimum}	**5**,10e-3,10

```
  :OFFSet (?)          <offs>                    0,-3.6,3.6
:SINusoid
  :PHASe (?)           <phase>                   0,0,360
:TRIangle
  :PHASe (?)           <phase>                   0,0,360
:SQUare
  :DCYCle (?)          <duty_cycle>              50,1,99
:PULSe
  :DELay (?)           <delay>                   10,0,99.9
  :WIDTh (?)           <pulse_width>             10,0,99.9
  :TRANsition (?)      <rise>                    10,0,99.9
    :TRAiling (?)      <fall>                    10,0,99.9
:RAMP
  :DELay (?)           <delay>                   0,0,99.9
  :TRANsition (?)      <rise>                    60,0,99.9
    :TRAiling (?)      <fall>                    30,0,99.9
:SINC
  :NCYCle (?)          N_cycles>                 10,4,100
:GAUSsian
  :EXPonent (?)        <exp>                     20,10,200
:EXPonential
  :EXPonent (?)        <exp>                     -20,-100,+100
:DC (?)                <%_amplitude>             100,-100,+100
```

APPLy:SINusoid{<freq>,<ampl>,<offs>,<phase>}
Purpose
This command is a high-level command that programs the TE5300 to output sine waveform along with its associated parameters

- <freq> sets the output frequency in units of hertz

- <ampl> sets the output amplitude in units of volts

- <offs> sets the output offset in units of volts

- <phase> sets the output start phase in units of degrees

Parameter type
Numeric

Parameter range
<freq>   10e3 to 50e6
<ampl>   80e-3 to 8
<offs>   -3.6 to +3.6
<phase>   0 to 360

APPLy:SINusoid?
Response
The TE5300 will return <freq>, <ampl>,<offs>,<phase>. Default values are 1e6,5,0,0

APPLy:TRIangle{<freq>,<ampl>,<offs>,<phase>}
Purpose
This command is a high-level command that programs the TE5300 to output triangular waveform along with its associated parameters

- <freq> sets the output frequency in units of hertz

- <ampl> sets the output amplitude in units of volts

- <offs> sets the output offset in units of volts

- <phase> sets the output start phase in units of degrees

Parameter type
Numeric

Parameter range
<freq>   10e3 to 50e6
<ampl>   80e-3 to 80
<offs>   -3.6 to +3.6
<phase>   0 to 360

APPLy:TRIangle?
Response
The TE5300 will return <freq>, <ampl>,<offs>,<phase>. Default values are 1e6,5,0,0

APPLy:SQUare{<freq>,<ampl>,<offs>,<duty_cycle>}

Purpose
This command is a high-level command that programs the TE5300 to output square waveform along with its associated parameters

- <freq> sets the output frequency in units of hertz

- <ampl> sets the output amplitude in units of volts

- <offs> sets the output offset in units of volts

- <duty_cycle> sets the squarewave duty cycle in units of %

Parameter type
Numeric

Parameter range
<freq>   10e3 to 50e6
<ampl>   80e-3 to 8
<offs>   -3.6 to +3.6
<duty_cycle> 0 to 360

APPLy:SQUare?
Response
The TE5300 will return <freq>,<ampl>,<offs>,<duty_cycle>. Default values are 1e6,5,0,50

APPLy:PULSe{<freq>,<ampl>,<offs>,<delay>,<rise>,<high>,<fall>}

Purpose
This command is a high-level command that programs the TE5300 to output pulse waveform along with its associated parameters

- <freq> sets the output frequency in units of hertz

- <ampl> sets the output amplitude in units of volts

- <offs> sets the output offset in units of volts

- <delay> sets the delay to the pulse rise transition in units of %

- <rise> sets the pulse rise time in units of %

- <high> sets the pulse high time in units of %

- <fall> sets the pulse fall time in units of %

Parameter type
Numeric

Parameter range
<freq>   10e3 to 50e6
<ampl>   80e-3 to 8
<offs>   -3.6 to +3.6
<delay>   0 to 99.9
<rise>   0 to 99.9
<high>   0 to 99.9
<fall>   0 to 99.9

APPLy:PULSe?
Response
The TE5300 will return <freq>, <ampl>,<offs>,<delay>,<rise>,<high>,<fall>.
Default values are 1e6,5,0,10,10,10,10

APPLy:RAMP{<freq>,<ampl>,<offs>,<delay>,<rise>,<fall>}
Purpose
This command is a high-level command that programs the TE5300 to output ramp waveform along with
its associated parameters

- <freq> sets the output frequency in units of hertz

- <ampl> sets the output amplitude in units of volts

- <offs> sets the output offset in units of volts

- <delay> sets the delay to the pulse rise transition in units of %

- <rise> sets the pulse rise time in units of %

- <fall> sets the pulse fall time in units of %

Parameter type
Numeric

Parameter range
<freq>   10e3 to 50e6
<ampl>   80e-3 to 80
<offs>   -3.6 to +3.6
<delay>   0 to 99.9
<rise>   0 to 99.9
<fall>   0 to 99.9

APPLy:RAMP?

Response
The TE5300 will return <freq>, <ampl>,<offs>,<delay>,<high>,<fall>. Default values are
1e6,5,0,10,10,10

APPLy:SINC{<freq>,<ampl>,<offs>,<N_cycles>}
Purpose
This command is a high-level command that programs the TE5300 to output sinc waveform along with its
associated parameters

- <freq> sets the output frequency in units of hertz

- <ampl> sets the output amplitude in units of volts

- <offs> sets the output offset in units of volts

- <N_cycles> sets the number of zero crossing

Parameter type
Numeric

Parameter range
<freq>   10e3 to 50e6
<ampl>   80e-3 to 80
<offs>   -3.6 to +3.6
<N_cycle> 4 to 100

APPLy:SINC?
Response
The TE5300 will return <freq>, <ampl>,<offs>,<N_cycle>. Default values are 1e6,5,0,10

APPLy:EXPonential{<freq>,<ampl>,<offs>,<exp>}
Purpose
This command is a high-level command that programs the TE5300 to output exponential waveform along
with its associated parameters

- <freq> sets the output frequency in units of hertz

- <ampl> sets the output amplitude in units of volts

- <offs> sets the output offset in units of volts

- <exp> sets the exponent value

Parameter type
Numeric

Parameter range
<freq>   10e3 to 50e6
<ampl>   80e-3 to 80
<offs>   -3.6 to +3.6
<exp>   -20 to +20

APPLy:EXPonential?

Response
The TE5300 will return <freq>, <ampl>,<offs>,<exp>. Default values are 1e6,5,0,1

APPLy:GAUSsian{<freq>,<ampl>,<offs>,<exp>}
Purpose
This command is a high-level command that programs the TE5300 to output gaussian waveform along with its associated parameters

- <freq> sets the output frequency in units of hertz

- <ampl> sets the output amplitude in units of volts

- <offs> sets the output offset in units of volts

- <exp> sets the exponent value

Parameter type
Numeric

Parameter range
<freq>   10e3 to 50e6
<ampl>   80e-3 to 80
<offs>   -3.6 to +3.6
<exp>   10 to 200

APPLy:GAUSsian?
Response
The TE5300 will return <freq>, <ampl>,<offs>,<exp>. Default values are 1e6,5,0,20

APPLy:DC{<%_ampl>}
Purpose
This command is a high-level command that programs the TE5300 to output DC level along with its associated parameter

- <%_ampl> sets the output level as percentage of the amplitude setting

Parameter type
Numeric

Parameter range
<%_ampl>   -100 to +100 in units of %

APPLy:DC?
Response to query version
The TE5300 will return <%_ampl>. Default values are 100

APPLy:USER{<seg# >,<sclk>,<ampl>,<offs>}
Purpose
This command is a high-level command that programs the TE5300 to output user-defined waveform along with its associated parameters

- <seg# > selects the active segment number

- <sclk> sets the sample clock frequency in units of samples per second

- <ampl> sets the output amplitude in units of volts

- <offs> sets the output offset in units of volts

Parameter type
Numeric

Parameter range
<seg#>   1 to 4096
<sclk>   10e-6 to 100e6
<ampl>   80e-3 to 80
<offs>   -3.6 to +3.6

APPLy:USER?
Response
The TE5300 will return <seg#>,<sclk>, <ampl>,<offs>. Default values are 1,10e6,5,0

FM{OFF|ON|0|1}
Purpose
This command will turn the FM function on and off.

- ON or 1 will set the FM on

- OFF or 0 will set the FM off

Parameter type
Boolean

FM?
Response and default
The TE5300 will return 1 if the FM is on, or 0 if the FM is off. Default is 0.

FM:DEViation<deviation>
Purpose
This command will set the deviation frequency in units of samples per second.

- <deviation> sets the phase offset between the channels. Phase offset is in waveform points

Parameter type
Numeric

Parameter range
<deviation>   1e-3 to 100e6 in units of samples per second

FM:DEViation?
Response and default
The TE5300 will return the present frequency deviation value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100E-3 – positive numbers are unsigned). Default value is 1e3. Default value is 1e6.

FM:FUNCtion:MODE{FIXed|USER}
Purpose

This command will set the frequency modulating waveform mode to FIXed (standard) and USER (arbitrary) waveforms.

- FIXed will enable a library of built in standard waveforms

- USER will set the generator to accept arbitrary waveform from an external application

Parameter type
Discrete

FM:FUNCtion:MODE?
Response and default
The TE5300 will return FIX, or USER depending on its present setting. Default is FIX.

FM:FUNCtion:SHAPe{SINusoid|TRIangle|SQUare|RAMP}
Purpose
This command will select one of the waveform shapes as the active modulating waveform.

- SINusoid will select sine shape as modulating waveform

- TRIangle will select triangular shape as modulating waveform

- SQUare will select square shape as modulating waveform

- RAMP will select ramp shape as modulating waveform

Parameter type
Discrete

FM:FUNCtion:SHAPe?
Response and default
The TE5300 will return SIN, TRI, SQU, or RAMP depending on its present setting. Default is SIN.

FM:FREQuency<FM_freq>
Purpose
This command will set the modulating wave frequency. This parameter affects the TE5300 when set to operate in FM:FUNC:MODE FIX

- <FM_freq>   will set the frequency of the modulating waveform

Parameter type
Numeric

Parameter range
<FM_freq>   1e-3 to 100e6 in units of hertz

FM:FREQuency?
Response and default
The TE5300 will return the present modulating waveform frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100E-3 – positive numbers are unsigned). Default value is 1e3.

FM:FREQuency:RASTer<FM_sclk>
Purpose

This command will set the modulating wave sample clock frequency. This parameter affects the TE5300 when set to operate in FM:FUNC:MODE USER

- <FM_sclk> will set the sample clock frequency of the modulating waveform

Parameter type
Numeric

Parameter range
<FM_sclk>   1e-3 to 10e6 in units of samples per second

FM:FREQuency:RASTer?
Response and default
The TE5300 will return the present modulating waveform sample clock frequency value. The returned value will be in standard scientific format (for example: 1KHz would be returned as 1E3 – positive numbers are unsigned). Default value is 1e6.

FM:TRIGger:MODE{CONTinuous|TRIGered|GATEd}
Purpose
This command will select one of the FM modes.

- CONTinuous will select continuous modulation

- TRIGered will select triggered modulation

- GATEd will select gated modulation

Parameter type
Discrete

FM:TRIGger:MODE?
Response and default
The TE5300 will return CONT, TRIG, or GATE depending on its present setting. Default is CONT.

FM:TRIGger:SLOPe{POSitive|NEGative}
Purpose
This command will select slope sensitivity for the FM trigger input.

- POSitive will select rising edge

- NEGative will select falling edge

Parameter type
Discrete

FM:TRIGger:SLOPe?
Response and default
The TE5300 will return POS, or NEG depending on its present setting. Default is POS.

FREQuency{<freq>|MINimum|MAXimum}

Purpose
This command modifies the frequency of the standard waveform in units of hertz (Hz). It has no affect on arbitrary waveforms.

- <freq> sets the waveform frequency
- <MINimum> sets the waveform frequency to its lowest value
- <MAXimum> sets the waveform frequency to its highest value

Parameter type
Numeric

Parameter range
<freq>   100e-6 to 50e6

FREQuency?
Response and default
The TE5300 will return the present frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100E-3 – positive numbers are unsigned). Default value is 1e6.

FREQuency:RASTer{<sclk>|MINimum|MAXimum}
Purpose
This command modifies the sample clock frequency of the arbitrary waveform in units of samples per second (S/s). It has no affect on standard waveforms.

- <sclk> sets the sample clock frequency
- <MINimum> sets the sample clock frequency to its lowest value
- <MAXimum> sets the sample clock frequency to its highest value

Parameter type
Numeric

Parameter range
<sclk>   100e-3 to 100e6

FREQuency:RASTer?
Response and default
The TE5300 will return the present sample clock frequency value. The returned value will be in standard scientific format (for example: 100MHz would be returned as 100E6 – positive numbers are unsigned). Default value is 10e6.

FREQuency:RASTer:SOURce{EXTernal|INTernal}
Purpose
This command selects the source of the sample clock generator. This command affects both the standard and the arbitrary waveforms.

- <EXTernal> selects an external source
- <INTernal> selects the internal source

Parameter type

Discrete

FREQuency:RASTer:SOURce?
Response and default
The TE5300 will return EXT if an external source is selected, or INT if the internal source is selected. Default value is INT.

FSK:FREQuency:RASTer<FM_sclk>
Purpose
This command will set the shift sample clock frequency. When set to operate in FSK mode, the TE5300 will hop from carrier sample clock frequency to shifted sample clock frequency.

- <FSK_sclk>   will set the shifted sample clock frequency for the FSK mode

Parameter type
Numeric

Parameter range
<FSK_sclk>   100e-3 to 100e6 in units of samples per second

FSK:FREQuency:RASTer?
Response and default
The TE5300 will return the present shifted sample clock frequency value. The returned value will be in standard scientific format (for example: 1KHz would be returned as 1E3 – positive numbers are unsigned). Default value is 80e3.

FSK:MODE{HOP|RAMPed}

Purpose
This command will select one of the FSK modes.

- HOP will select non-delayed hops from carrier sclk to shifted sclk
- RAMPed will select ramped shifts from carrier sclk to shifted sclk

Parameter type
Discrete

FSK:MODE?
Response and default
The TE5300 will return HOP, or RAMP depending on its present setting. Default is HOP.

FSK:RAMP:TIME<time>
Purpose
This command will set the time it takes for the sample clock frequency to ramp up and down from carrier to shifted frequencies and back. This parameter will affect the TE5300 only when the instrument is set to operate in ramped FSK mode.

- <time>   will set the ramp up and down time

Parameter type
Numeric

Parameter range
<time>   10e-6 to 1 in units of seconds

FSK:RAMP:TIME?
Response and default
The TE5300 will return the present ramp time value. The returned value will be in standard scientific format (for example: 10ms would be returned as 10E-3 – positive numbers are unsigned). Default value is 1e-3.

FUNCTion:MODE{FIXed|USER|SEQuence}
Purpose
This command defines the type of waveform that will be available at the output connector.

●   <FIXed> selects standard waveforms

●   <USER> selects arbitrary waveforms

●   <SEQuence> selects sequenced waveforms

Parameter type
Discrete

FUNCTion:MODE?
Response and default
The TE5300 will return FIX, USER, or SEQ depending on the present TE5300 setting. Default value is FIX.

FUNCtion:SHAPe{SINusoid|TRIangle|SQUare|PULSe|RAMP|SINC|EXPonential|GAUSsian|NOISe|DC}
Purpose
This command defines the shape of waveform that will be available at the output connector. This command has no affect if present TE5300 setting is USER or SEQ.

●   <SINusoid> selects sine waveform

●   <TRIangle> selects triangular waveform

●   <SQUare> selects square waveform

●   <PULSe> selects pulse waveform

●   <RAMP> selects ramp waveform

●   <SINC> selects sinc waveform

●   <EXPonential> selects exponential waveform

●   <GAUSsian selects gaussian waveform

●   <NOISe> selects random noise waveform

●   <DC> selects dc waveform

Parameter type
Discrete

FUNCtion:SHAPe?
Response and default
The TE5300 will return SIN, TRI, SQU, PULS, RAMP, SINC, EXP, GAUS, NOIS, or DC depending on the present TE5300 setting. Default value is SIN.

ROSCillator:SOURce{INTernal|EXTernal|TCXO}
Purpose
This command will select the reference source for the sample clock generator.

- <INTernal> selects CLK10 off the backplane of the PCI bus

- <EXTernal> activates the external reference input. An external reference must be connected to the TE5300 for it to continue normal operation

- <TCXO> selects an on-board 1ppm TCXO source. Note that the TCXO is an option, so if you did not purchase the instrument with the TCXO option, this command will not be available for you to use.

Parameter type
Discrete

ROSCillator:SOURce?
Response and default
The TE5300 will return INT, EXT, or TCXO depending on the present TE5300 setting. Default value is INT.

SWEep:STOP<stop_sclk>
Purpose
This command will set the stop sample clock frequency. When set to operate in sweep mode, the TE5300 will sweep from carrier sample clock frequency to sweep stop sample clock frequency.

- <stop_sclk>   will set the sweep stop sample clock frequency for the sweep mode

Parameter type
Numeric

Parameter range
<stop_sclk>   100e-3 to 100e6 in units of samples per second

SWEep:STOP?
Response and default
The TE5300 will return the present sweep stop sample clock frequency value. The returned value will be in standard scientific format (for example: 1KHz would be returned as 1E3 – positive numbers are unsigned). Default value is 20e6.

SWEep:TIME<time>
Purpose

This command will set the time it takes for the sample clock frequency to sweep from carrier to stop frequencies. This parameter will affect the TE5300 only when the instrument is set to operate in sweep mode.

- <time>   will set the sweep time

Parameter type
Numeric

Parameter range
<time>   1e-3 to 1000 in units of seconds

SWEep:TIME?
Response and default
The TE5300 will return the present sweep time value. The returned value will be in standard scientific format (for example: 10ms would be returned as 10E-3 – positive numbers are unsigned). Default value is 1e-3.

SWEep:DIRection{UP|DOWN}
Purpose
This command will select the sweep direction up and down.

- <UP> selects an up direction. The sample clock will sweep from start frequency set by the sclk parameter to stop frequency set by the stop sclk parameter
- <DOWN> selects the down direction. The sample clock will sweep from stop frequency set by the stop sclk parameter to start frequency set by the sclk parameter

Parameter type
Discrete

SWEep:DIRection?
Response and default
The TE5300 will return UP, or DOWN depending on the present TE5300 setting. Default value is UP.

SWEep:SPACing{LINear|LOGarithmic}
Purpose
This command will select the sweep spacing from linear spacing and logarithmic spacing.

- <LINear> will select linear steps
- <LOGarithmic> will select logarithmic steps

Parameter type
Discrete

SWEep:SPACing?
Response and default
The TE5300 will return LIN, or LOG depending on the present TE5300 setting. Default value is LIN.

SWEep:TRIGger:MODE{CONTinuous|TRIGered|GATed}
Purpose

This command will select one of the sweep modes.

- CONTinuous will select continuous sweep modulation

- TRIGered will select triggered sweep modulation

- GATed will select gated sweep modulation

Parameter type
Discrete

SWEep:TRIGger:MODE?
Response and default
The TE5300 will return CONT, TRIG, or GATE depending on its present setting. Default is CONT.

SWEep:TRIGger:SLOPe{POSitive|NEGative}
Purpose
This command will select slope sensitivity for the sweep trigger input.

- POSitive will select rising edge

- NEGative will select falling edge

Parameter type
Discrete

SWEep:TRIGger:SLOPe?
Response and default
The TE5300 will return POS, or NEG depending on its present setting. Default is POS.

SWEep:MARKer<mark_sclk>
Purpose
This command will set the marker sample clock frequency for the sweep mode.

- <mark_sclk>   will set the marker sample clock frequency

Parameter type
Numeric

Parameter range
<mark_sclk>   100e-3 to 100e6 in units of samples per second

SWEep:MARKer?
Response and default
The TE5300 will return the present sweep sample clock frequency value. The returned value will be in standard scientific format (for example: 1KHz would be returned as 1E3 – positive numbers are unsigned). Default value is 64e6.

VOLTage{<ampl>|MINimum|MAXimum}
Purpose

This command programs the peak-to-peak amplitude of the output waveform. The amplitude is calibrated when the source impedance is 50Ω.

● <ampl> sets the amplitude

● <MINimum> sets the amplitude to its lowest value

● <MAXimum> sets the amplitude to its highest value

Parameter type
Numeric

Parameter range
<ampl>   10e-3 to 10 in units of volts
<MINimum>   10e-3 in units of volts
<MAXimum>   10 in units of volts

VOLTage?
Response to query version
The TE5300 will return the present amplitude value. The returned value will be in standard scientific format (for example: 100mV would be returned as 100E-3 – positive numbers are unsigned). Default value is 5.

VOLTage:OFFSet<offs>
Purpose
This command programs the amplitude offset of the output waveform. The offset is calibrated when the source impedance is 50Ω.

● <offs> sets the amplitude offset

Parameter type
Numeric

Parameter range
<offs>   -3.6 to +3.6 in units of volts

VOLTage:OFFSet?
Response and default
The TE5300 will return the present offset value. The returned value will be in standard scientific format (for example: 100mV would be returned as 100E-3 – positive numbers are unsigned). Default value is 0.

SINusoid:PHASe<phase>
Purpose
This command programs start phase of the standard sine waveform. This command has no affect on arbitrary waveforms.

● <phase> sets the start phase

Parameter type
Numeric

Parameter range
<phase>   0 to 360 in units of degrees
SINusoid:PHASe?

Response and default
The TE5300 will return the present start phase value. Default is 0.

TRIangle:PHASe<phase>
Purpose
This command programs start phase of the standard triangular waveform. This command has no affect on arbitrary waveforms.

* <phase> sets the start phase

Parameter type
Numeric

Parameter range
<phase>   0 to 360 in units of degrees

TRIangle:PHASe?
Response and default
The TE5300 will return the present start phase value. Default value is 0.

SQUare:DCYCle<duty_cycle>
Purpose
This command programs duty cycle of the standard square waveform. This command has no affect on arbitrary waveforms.

* <duty_cycle> sets the duty cycle value

Parameter type
Numeric

Parameter range
<duty_cycle>   0 to 99 in units of percent

SQUare:DCYCle?
Response and default
The TE5300 will return the present duty cycle value. Default value is 50.

PULSe:DELay<delay>
Purpose
This command programs delay of the standard pulse waveform. This command has no affect on arbitrary waveforms.

* <delay> sets the delay parameter

Parameter type
Numeric

Parameter range
<delay>   0 to 99.9 in units of percent
PULSe:DELay?
Response and default

The TE5300 will return the present delay value. Default value is 10.

PULSe:WIDTh<pulse_width>
Purpose
This command programs pulse high portion of the standard pulse waveform. This command has no affect on arbitrary waveforms.

● <pulse_width> sets the high time parameter

Parameter type
Numeric

Parameter range
<pulse_width>   0 to 99.9 in units of percent

PULSe:WIDTh?
Response and default
The TE5300 will return the present width value. Default value is 10.

PULSe:TRANsition<rise>
Purpose
This command programs pulse transition from low to high of the standard pulse waveform. This command has no affect on arbitrary waveforms.

● <rise> sets the rise time parameter

Parameter type
Numeric

Parameter range
<rise>   0 to 99.9 in units of percent

PULSe:TRANsition?
Response and default
The TE5300 will return the present rise time value. Default value is 10.

PULSe:TRANsition:TRAiling<fall>
Purpose
This command programs pulse transition from high to low of the standard pulse waveform. This command has no affect on arbitrary waveforms.

● <fall> sets the fall time parameter

Parameter type
Numeric

Parameter range
<fall>   0 to 99.9 in units of percent

PULSe:TRANsition:TRAiling?

Response and default
The TE5300 will return the present fall time value. Default value is 10.

RAMP:DELay<delay>

Purpose
This command programs delay of the standard ramp waveform. This command has no affect on arbitrary waveforms.

●   <delay> sets the delay parameter

Parameter type
Numeric
Parameter range
<delay>   0 to 99.9 in units of percent

RAMP:DELay?

Response and default
The TE5300 will return the present delay value. Default value is 0.

RAMP:TRANsition<rise>

Purpose
This command programs ramp transition from low to high of the standard ramp waveform. This command has no affect on arbitrary waveforms.

●   <rise> sets the rise time parameter

Parameter type
Numeric

Parameter range
<rise>   0 to 99.9 in units of percent

RAMP:TRANsition?

Response and default
The TE5300 will return the present rise time value. Default value is 60.

RAMP:TRANsition:TRAiling<fall>

Purpose
This command programs ramp transition from high to low of the standard ramp waveform. This command has no affect on arbitrary waveforms.

●   <fall> sets the fall time parameter

Parameter type
Numeric

Parameter range
<fall>   0 to 99.9 in units of percent

RAMP:TRANsition:TRAiling?

Response and default

The TE5300 will return the present fall time value. Default value is 30.

SINC:NCYCleN_cycles>
Purpose
This command programs the number of "0-crossings" of the standard SINC pulse waveform. This command has no affect on arbitrary waveforms.

- <N_cycle> sets the number of zero-crossings parameter

Parameter type
Numeric (integer only)

Parameter range
<N_cycle>   4 to 100 zero crossings

SINC:NCYCle?
Response and default
The TE5300 will return the present number of zero-crossing value. Default value is 10.

GAUSsian:EXPonent<exp>
Purpose
This command programs the exponent for the standard gaussian pulse waveform. This command has no affect on arbitrary waveforms.

- <exp > sets the exponent parameter

Parameter type
Numeric

Parameter range
<exp>   10 to 200

GAUSsian:EXPonent?
Response and default
The TE5300 will return the present exponent value. Default value is 20.

EXPonential:EXPonent<exp>
Purpose
This command programs the exponent for the standard exponential waveform. This command has no affect on arbitrary waveforms.

- <exp > sets the exponent parameter

Parameter type
Numeric

Parameter range
<exp>   -100 to 100

EXPonential:EXPonent?
Response and default
The TE5300 will return the present exponent value. Default value is –20.

DC<%_amplitude>

Purpose

This command programs the amplitude of the standard DC waveform. This command has no affect on arbitrary waveforms.

- <%_amplitude > sets the dc level as percentage of the programmed amplitude setting

Parameter type

Numeric

Parameter range

<%_amplitude> -100 to 100 in units of percent

DC?

Response and default

The TE5300 will return the present dc value. Default value is 100.

OUTPut Subsystem

This subsystem controls the characteristics of the output. It controls filter type and filter cutoff frequency. It is also used to control the sync output, source and position. Optional nodes were omitted from these commands. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable.

Keyword Limit	Parameter Form	Default,Low Limit,High
:OUTPut (?)	{OFF|ON|0|1}	**OFF**
:FILTer (?)	{NONE|25M|50M|ALL}	**NONE**
:SYNC (?)	{OFF|ON|0|1}	**OFF**
:SOURce (?)	{BIT|LCOMplete}	**BIT**
:POSition (?)	<position>	**0,**0,n
:WIDTh (?)	<width>	**4,**4,100000

OUTPut{OFF|ON|0|1}
Purpose
This command will turn the TE5300 output on and off.

- ON or 1 will set the output on
- OFF or 0 will set the output off

Parameter type
Discrete

OUTPut?
Response and default
The TE5300 will return 1 if the output is on, or 0 if the output is off. Default value is 0.

OUTPut:FILTer{NONE|25M|50M|ALL}
Purpose
This command will select which filter is connected to the TE5300 output. Observe the following restrictions when you try to use this command:

1) Filter selection is not available when the instrument is set to output the standard sine waveform. In fact, the default waveform shape is sine. Therefore, filter selection will be available for use only after you select a different waveform, or change the output mode to use.
2) Filters are placed before the output amplifier. Therefore, do not expect the filters to remove in-band amplifier harmonics and spurious.

- NONE will disconnect all filters from the output path
- 25M will connect 25 MHz low pass elliptic filter
- 50M will connect 50 MHz low pass elliptic filter
- ALL will connect both the 25 MHz and the 50 MHz filters in series

Parameter type
Discrete

OUTPut:FILTer?
Response and default
The TE5300 will return NONE, 25M, 50M, or ALL depending on the type of filter presently connected to the output. Default value is NONE.

OUTPut:SYNC{OFF|ON|0|1}
Purpose
This command will turn the TE5300 SYNC output on and off.

- ON or 1 will set the SYNC output on

- OFF or 0 will set the SYNC output off

Parameter type
Discrete

OUTPut:SYNC?
Response and default
The TE5300 will return 1 if the SYNC output is on, or 0 if the SYNC output is off. Default value is 0.

OUTPut:SYNC:SOURce{BIT|LCOMplete}
Purpose
This command will select the TE5300 SYNC option.

- BIT will set the SYNC to output a narrow pulse

- LCOMplete will set the SYNC to transition high at the beginning of the sequence and low a the end of the sequence

Parameter type
Discrete

OUTPut:SYNC:SOURce?
Response and default
The TE5300 will return BIT, or LCOM depending on the present setting of the SYNC source. Default value is BIT.

OUTPut:SYNC:POSition<position>
Purpose
This command will program the TE5300 SYNC position. This command is active in arbitrary (USER) mode only.

- <position> will set the SYNC position in waveform points

Parameter type
Numeric (integer only)

Parameter range

<position>   0 to "n" in units of waveform points, where "n" is the size of the active segment. The sync position can be programmed in increments of 4 points minimum.

OUTPut:SYNC:POSition?

Response and default
The TE5300 will return the present duty cycle value. Default value is 50.

Response to query version
The TE5300 will return the present SYNC position value. Default value is 0.

OUTPut:SYNC:WIDTh<width>

Purpose
This command will program the width of the SYNC pulse. The sync width can be varied through a limited range to allow widening of the sync pulse.

● <width> will set the SYNC width

Parameter type
Numeric (integer only)

Parameter range

<width>   4 to n in units of waveform points. n = defined segment length

OUTPut:SYNC:WIDTh?

Response and default
The TE5300 will return the present SYNC width value. Default value is 4.

INSTrument Subsystem

A dual channel arbitrary waveform generator is considered as two logical instruments. The INSTrument subsystem provides a mechanism to identify and select instrument channels. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable.

Keyword Limit	Parameter Form	Default,Low Limit,High
:INSTrument (?)	{1|2}	**1**
:COUPle (?)	{OFF|ON|0|1}	**OFF**
:MODE (?)	(MASTer|SLAVe)	**MASTer**
:PHASe (?)	\<phase\>	**0**,0,n
:SET	{0|1|2}	**0**,0,2

INSTrument:COUPle{OFF|ON|0|1}
Purpose
This command will enable daisy-chained instruments to operate in multi-instrument synchronization mode.

- ON or 1 will set the couple mode on
- OFF or 0 will set the couple mode off

Parameter type
Discrete

INSTrument:COUPle?
Response and default
The TE5300 will return 0, or 1 depending on the present instrument couple setting. Default value is 0.

INSTrument:COUPle:MODE{MASTer|SLAVe}
Purpose
This command will select master and slave instruments in multi-instrument synchronization mode. Note that only one instrument in a chain may be set as master. All other instruments must be set as slaves.

- MASTer will set the master instrument
- SLAVe will set the slave instrument

Parameter type
Discrete

INSTrument:COUPle:MODE?
Response and default
The TE5300 will return MAST, or SLAV depending on the present instrument couple setting. Default value is MAST.

INSTrument:COUPle:PHASe<phase>

Purpose

This command will program the phase offset between master and slave units. This command has no effect on the instrument in modes other than instrument couple.

● <phase> will set the leading edge offset between master and slave units

Parameter type

Numeric (integer only)

Parameter range

<phase>   0 to "n" in units of waveform points, where "n" is the size of the active segment. The phase offset can be programmed in increments of 4 points.

INSTrument:COUPle:PHASe?

Response to query version

The TE5300 will return the present phase offset value. Default value is 0.

INSTrument:SET {0|1|2}

Purpose

This command will prepare the master and slave units for multi-instrument synchronization. The procedure how to synchronize multiple instruments is given below.

Parameter type

Numeric (integer only)

Appendices

Appendix	Title	Page

Appendix A
Specifications

Output Channels   1

Multiple Instrument synchronization

Description   Multiple instruments can be connected together and
                                           synchronized to provide multi-channel synchronization.

Sample Clock
    Source   From Master card to slave boards through the local bus
    Range and Resolution   Same as Sample Clock but limited to 80 Ms/s
    Initial Skew   <20 ns to the first master; 20 ns cumulative to additional
                                           slaves

Phase Offset Between Instruments   Programmable from 0 to n points

SAMPLE CLOCK

Range (TE5325)   100 mS/s to 50 MS/s
Range (TE5300)   100 mS/s to 125 MS/s
Resolution   10 digits limited by 1 μHz
Accuracy   Same as reference
Stability   Same as reference
Reference
    Internal $\geq$0.0001% (1 ppm) initial tolerance over a 19°C to 29°C
                                           temperature range; 1ppm/°C below 19°C and above 29°C;
                                           1ppm/year aging rate
    External   10 MHz TTL, 50% $\pm$2% duty cycle

SAMPLE CLOCK MODULATION

FM – Built-in Standard Waveforms

Description   Sample clock can be frequency modulated by internal
                                           waveforms that are resident in internal memory (fixed
                                           waveforms).

Modulation Source   Internal sine square, triangle and ramp
Modulation Frequency Range   2 mHz to 100 KHz
    Resolution   10 digits
    Accuracy   0.1%
Peak Frequency Deviation   DC to 25 MHz (TE5325)
Peak Frequency Deviation   DC to 62.5 MHz (TE5300)
Advance   Automatic, triggered, gated or software command
Marker
    Output and Level   Same as SYNC output.
    Position   Fixed at carrier frequency

FM – Downloaded Arbitrary Waveforms

Description	Sample clock can be frequency modulate arbitrary waveforms that are downloaded by the user
Modulation Source	User waveform, any shape, 10 to 20000 waveform points
Modulation Sample Clock Range	1 mS/s to 2 MS/s
Resolution	7 digits
Accuracy	0.1%
Peak Sample Clock Deviation	DC to 50 MHz (TE5325)
Peak Sample Clock Deviation	DC to 125 MHz (TE5300)
Advance	Automatic, triggered, gated or software command
Marker	
Output and Level	Same as SYNC output.
Position	Programmable for selected sample clock frequency
Waveform Download Rate	5 Meg points per second

FSK

Description	Current segment is sampled continuously. TTL low-level programs carrier sample clock, TTL high level programs shifted sample clock frequency. Sample clock changes coherently between frequencies. FSK operates on arbitrary waveforms only.
Carrier Sample Clock Range	100 mS/s to 50 MS/s (TE5325)
Carrier Sample Clock Range	100 mS/s to 125 MS/s (TE5300)
FSK Stimuli	
External	Front-panel Trigger input BNC. Low level = carrier sample clock; High level = hop frequency
Frequency Range	From 10 MHz to DC
Internal	Same as internal trigger range
FSK Delay	Minimum 1 waveform cycle + 50 ns

Ramped FSK

Description	Same as FSK except carrier sample clock ramps to shifted frequency at a rate defined by the ramp time parameter. TTL low-level programs carrier sample clock, TTL high level programs shifted frequency.
Ramp Time Range	10 μs to 1 s, 3 digits, $\pm$0.1%

Sweep

Description	Sample Clock sweeps continuously from start to stop, at a rate defined by the sweep time. More complex sweep modes and types can be generated using the FM mode in conjunction with the FM composer program.
Type	Linear or logarithmic
Direction	Up or down, depending on the start and stop setting
Range	100 mS/s to 50 MS/s (TE5325)
Range	100 mS/s to 125 MS/s (TE5300)
Time	1 ms to 1000 s, 7 digits, $\pm$0.1%
Advance	Automatic, triggered, gated or software command
Marker	
Output and Level	Same as SYNC output.
Position	Programmable for selected frequency

OPERATING MODES

Normal	Continuous waveform is generated
Triggered	Each input cycle generates a single output cycle.
Gated	External signal enables generator. First output cycle synchronous with the active slope of the triggering signal. Last cycle of output waveform always completed
External Burst	Preset number of up to 128K cycles stimulated by an internal, or external trigger. This mode is not available in Sequence mode.

Trigger Sources

External	
Input	Front panel BNC
Level	TTL
Slope Sensitivity	Positive or negative, programmable
Frequency	5 MHz to DC
Internal	
Range	100 mHz to 2 MHz
Resolution	7 digits
Accuracy	0.01%
Software	SCPI command

System Delay

Trigger to waveform output	1 Sample Clock+120 ns

STANDARD WAVEFORMS LIBRARY

Waveforms	Sine, Triangle, Square, Pulse, Ramp, Sinc, Gaussian Pulse, Exponential decay/Rise Pulse, Noise, DC
Frequency Range	Waveform dependent

ARBITRARY WAVEFORMS

Waveform Memory	1M points (TE5325)
Waveform Memory	2M points (TE5300)
Memory Segmentation	
Number of Segments	1 to 4096
Min Segment Size	16 points
Memory Interleave	4 (All trace lengths must be multiples of 4)
Vertical Resolution	14 bits (16,384 points)
Waveform Download Rate	5 Meg points per second

Sine Wave Performance

Description	Sine wave performance is measured using the maximum sample clock rate, at 5 Vp-p, the maximum amplitude resolution of the DAC (14-bit) and without filters. Spectrum analyzer settings: Start frequency = 0 MHz; stop frequency = 50 MHz (Nyquist frequency)
Sinewave Total Harmonic Distortion	0.05% to 100 KHz
Harmonics and non-related spurious	< -55dBc for carrier frequencies ≤1MHz
	< -40dBc for carrier frequencies ≤5MHz
	< -35dBc for carrier frequencies ≤10MHz

SEQUENCED ARBITRARY WAVEFORMS

Operation	Permits division of the memory bank into smaller segments. Segments may be linked, and repeated in user-selectable fashion to generate extremely long waveforms.
Advance Modes	
Automatic Sequence Advance	No triggers required to step from one segment to the next. Sequence is repeated continuously through a pre-programmed sequence list (table)
Stepped Sequence Advance	Current segment is sampled continuously, external trigger advances to next programmed segment. Control input is TRIG IN connector.
Single Sequence Advance	Current segment is sampled to the end of the segment including repeats and idles there. Next trigger advances to next segment. Control input is TRIG IN connector.
Mixed Sequence Advance	Each step of a sequence can be programmed to advance either a) automatically (Automatic Sequence Advance), or b) with a trigger (Stepped Sequence Advance)
Advance Source	External, Internal, or soft trigger
Sequencer steps	From 1 to 4096
Segment loops	From 1 to 128 K

OUTPUTS

Waveform Output

Connector	Front panel BNC
Stand-by	Output Off or Normal
Impedance	50Ω, ±1%
Protection	Protected against temporary short to case ground
Amplitude	
Range	100 mV to 10 Vp-p, into 50Ω; Double into open circuit
Resolution	3.5 digits
Accuracy (1 KHz)	
800 mV to 8 Vp-p	±(1% + 10 mV)
80 mV to 799.9 mVp-p	±(1% + 1 mV)

Offset

Offset	Offset is attenuated with amplitude
Range	0 to ±4.5 V, amplitude dependent
Resolution	2.2 mV within 5V window; 220 mV within 500 mV window
Accuracy	
	±(1% of reading + 1% of amplitude + 2 mV)
Filters	25MHz and 50 MHz, 7-pole elliptic

Square Wave, Pulse

Rise/Fall time	<10 ns, 10% to 90% of amplitude
Aberration	<5%, ±10 mV

SYNC/Marker Output

Description	Provides dual functionality. All functions and modes, this output generates sync pulse, which is synchronous with the output waveform. In FM and sweep modes only, this output generates a marker having properties similar to the sync pulse output.
Outputs	
Front panel	SYNC Output BNC connector
Validation	
BIT	Generates a sync signal each time a point within a specific wave segment is accessed.
LCOM (Loop Complete)	Generates a single SYNC signal. Starts at a beginning of a sequence and ends at the end of the sequence.
Impedance	50Ω, ±1%
Level	>2 V into 50Ω, 4V nominal into 10KΩ
Protection	Protected against temporary short to case ground
Position	Point 0 to n, Programmable with 4-point resolution
Width	Programmable with 4 points resolution

Sine Output

Description	An output that is directly derived from the sample clock generator and has an output frequency equal to the programmed sample clock frequency. This output generates sine waveform that corresponds to sample clock setting, including modulated waveform, such as FM, sweep and FSK
Connector	Front panel SMB
Impedance	50Ω, ±1%
Level	1 V into 50Ω
Protection	Protected against temporary short to case ground
Source	Sample clock frequency
Frequency Range and Resolution	Same as Sample clock
Flatness	-3dB at 100 MHz
Total Harmonic Distortion	0.3% to 100 KHz
	-55dBc to 1 MHz
Harmonics and non-related spurious	-45dBc to 10 MHz
	-35dBc to 100 MHz

INPUTS
TRIG Input

Connector	Front panel BNC
Impedance	10 KΩ, ±5%
Threshold Level	TTL
Damage Level	±10 V
Min Pulse Width	20 ns
Slope	Positive or negative going edge.

10 MHz Reference Input

Connector	Front panel SMB
Impedance	10 KΩ, ±5%
Threshold Level	TTL
Damage Level	±10 V
Duty Cycle	50%, ±5%

GENERAL

Power Requirements	10W maximum
Current Consumption	+5 V - 30 mA
	+12 V - 500 mA
	+3.3 V - 1.4 A
Dimensions	Single width, 3U high
Environmental	
Temperature (Operating)	0 to 50°C
Temperature (Non-Operating)	-40 to 71°C
Humidity (non-condensing)	5 to 95% RH at or below 30°C
	Upper limit derates to:
	75% RH above 30°C and
	45% RH above 40°C
Certifications	CE Marked
EMC	Conforms to EN 61326-1:1998
Safety	Conforms to EN 61010-1:2001
Workmanship Standards	Conforms to IPC-A-610D