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***User Manual***

# **Model 8251**

**250MHz Single Channel  
Function / Arbitrary Generators**

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***Tabor Electronics Ltd.***

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# FOR YOUR SAFETY

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

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

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

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

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

Before operation this instrument:

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

If the instrument:

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

Do not operate until performance is checked by qualified personnel.

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# Chapter 1

## Getting Started

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## **What's in This Chapter**

This chapter contains a general description of the Model 8251 Arbitrary / Function Generator and an overall functional description of the instrument. It also describes the front and rear panel connectors and indicators.

## **Introduction**

Model 8251 is a single-channel, high frequency and wide bandwidth Arbitrary / Function generator. It provides high performance arbitrary waveform generation combined with exciting modulation schemes. The instrument can be used on the bench as well as in automated test systems. Color LCD display and keyboard buttons are used for front panel control of all functions and features. Remote programming is done from any of the three interfaces that are available as standard: USB, GPIB or high speed LAN. The instrument is packaged in a 2U high and 8.5" wide metal case that assures excellent immunity to RFI noise and ESD discharge. Supplied free with the instrument is ArbConnection software utility, which is used for controlling the 8251 and for generating, editing and downloading waveforms from a remote computer. The following highlights the 8251 and ArbConnection features.

## **8251 Feature Highlights**

- Single-channel Function Generator
- 250MHz sine and 150MHz square waves
- Triangle, ramp, sinc, Gaussian, exponential, noise, pulse generation with variable edge, and DC waveforms
- 4 Vp-p into 50 $\Omega$ , 8Vp-p into open circuit
- 12 Bit, 625 MS/s, 512 Kpoint arbitrary waveforms
- Linear & logarithmic sweeps, triggered, gate and burst
- FM, FSK, and PSK modulation
- 1ppm clock stability
- Remote calibration without removing case covers
- Built-in digital pulse generator
- High resolution 3.8" LCD, color display
- GPIB, USB and Ethernet interfaces

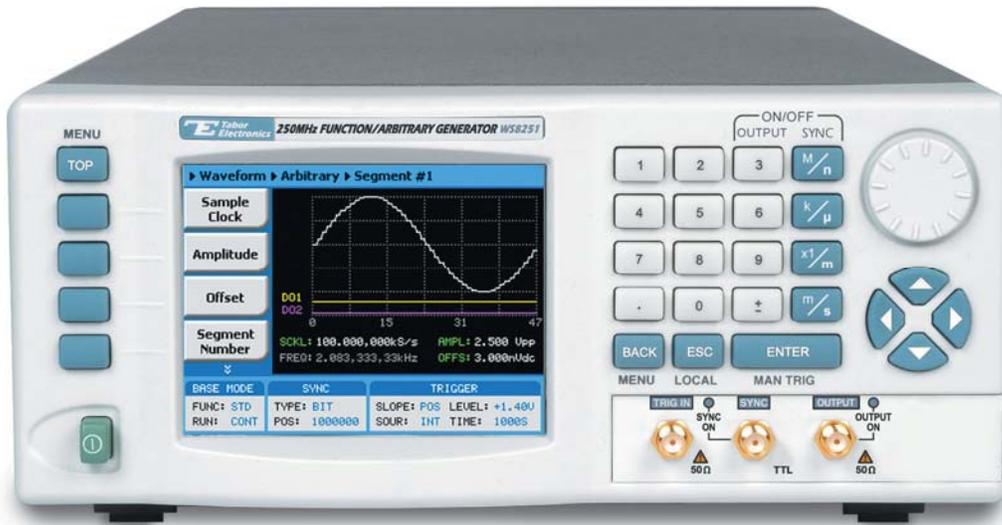


Figure 1-1, Model 8251

## ArbConnection Feature Highlights

- Three powerful tools in one software package: Complete instrument control, Waveform and pulse composers
- Detailed virtual front panels control all 8251 functions and modes
- Wave composer generates, edits and downloads complex waveforms
- Easy, on-screen generation of complex pulses using the pulse composer
- Equation editor generates waveforms from equations
- SCPI command and response editor simulates ATE operation
- Translates waveform coordinates from ASCII and other formats
- Special utility panel for complete remote calibration

Various screens of the ArbConnection program are shown in Figures 1-2 through 1-4.

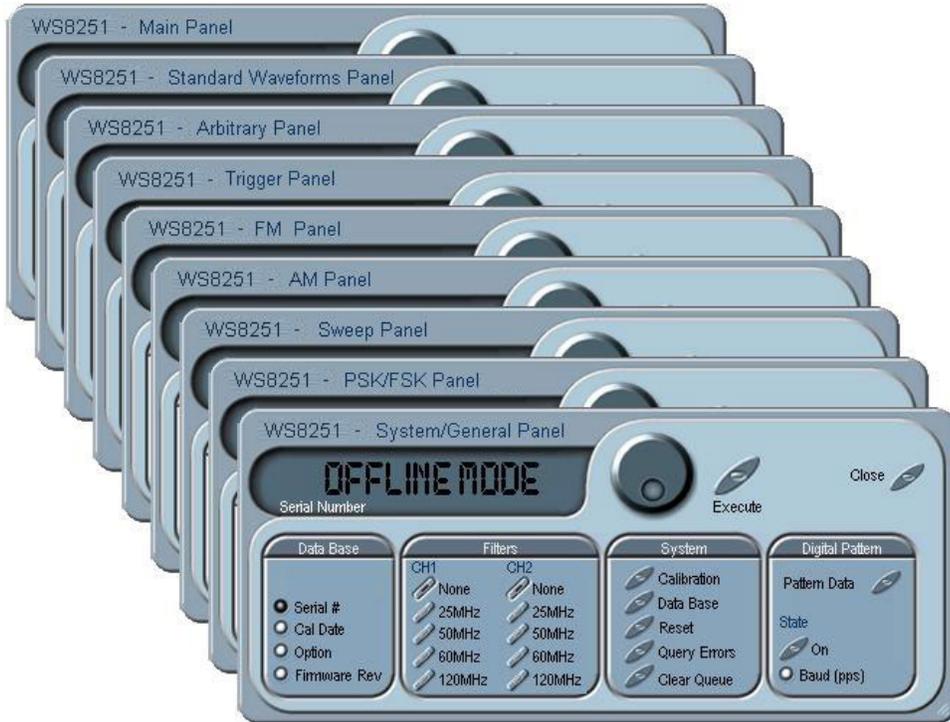


Figure 1-2, ArbConnection – The Control Panels

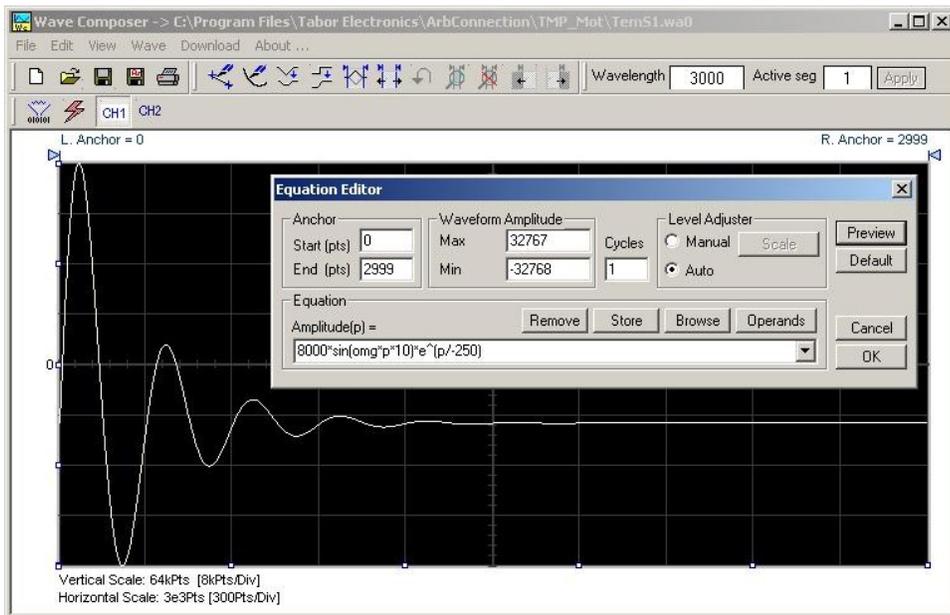


Figure 1-3, ArbConnection – The Wave Composer

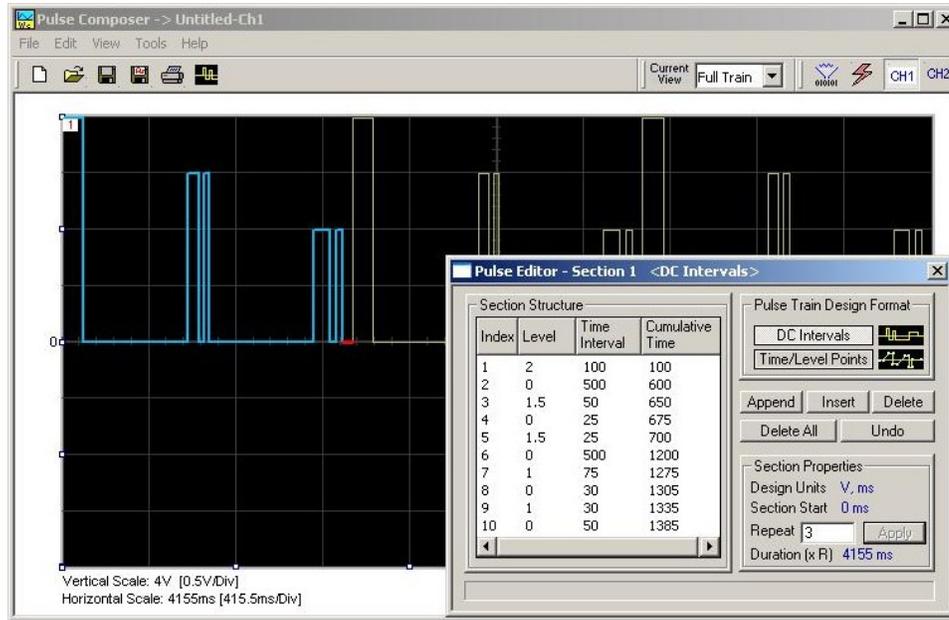


Figure 1-4, ArbConnection – The Pulse Composer

## Introduction

A detailed functional description is given following the general description of the features, functions, and options available with the Model 8251.

The Model 8251 is a bench-top, 2U high, half rack wide, single-channel Arbitrary / Function Generator, a high performance instrument that provides multiple and powerful functions in one small package. The 8251 generates an array of standard waveforms from a built-in waveform library as well as arbitrary and modulated waveforms. The generator outputs 12-bit waveforms at sample clock rates up to 625 MS/s with different waveform properties. The unique design provides increased dynamic range and lower “noise floor” making it ideal for the generation high fidelity and complex signals.

Direct Digital Synthesis (DDS) technology, utilized in the design of the 8251, allows flexibility in usage of features like FM, FSK, PSK and sweep. For example, the FM feature can be stimulated by an internal source, or arbitrary FM waveform allowing the production of customized chirp signals. The included ArbConnection software can be used to breadboard custom frequency modulation profiles graphically.

Based entirely on digital design, the 8251 has no analog functions resident in its hardware circuits and therefore, data has to be downloaded to the instrument for it to start generating waveforms. The instrument can compute and generate a number of standard functions such as sine, square, triangle and others, however, complex waveforms must be converted to an appropriate format and downloaded to the 8251 as waveform coordinates. Dedicated waveform memory stores waveforms in memory segments and allows playback of a selected waveform, when required. The waveforms are backed up by batteries or can be stored in a flash memory for use at a later time. Sample rates up to 625 MS/s are available with memory size of 512k standard.

Frequency accuracy of the output waveform is determined by the clock reference. Using the internal TCXO the reference oscillator provides 1ppm accuracy and stability over time and temperature. If higher accuracy and/or stability are required, one may connect an external reference oscillator to the rear panel input and use this input as the reference for the 8251. Frequency may be programmed with up to 14 digits, so using an external reference is recommended, if you intend to utilize the full resolution provided by the instrument.

Output amplitude is programmable from 50 mV to 4 V<sub>p-p</sub> into 50Ω. Amplitude and offsets are programmed independently with 4 digits of resolution as long as the +3 V and the -3 V rail limitations (double into open circuit) are not exceeded.

Besides its normal continuous mode, the Model 8251 responds to a variety of trigger sources. The output waveform may be gated, triggered, or may generate a counted burst of waveforms. A built-in trigger generator with a programmable period can be used as a replacement of an external trigger source. Triggers can be delayed to a specific interval by a built-in trigger delay generator that has a range of 0 to 512k waveform points.

The arbitrary waveform memory is comprised of a bank of 16-bit words. Each word represents a point on the horizontal waveform scale. Each word has a horizontal address that can range from 0 to 512k and a vertical address that can range from -2047 to +2048 (12 bits). Using a high speed clocking circuit, the digital contents of the arbitrary waveform memory 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.

There is no need to use the complete memory bank every time an arbitrary waveform is generated. Waveform memory can be divided into up to many smaller segments and different waveforms can be loaded into each segment.

The 8251, being a digital instrument with a lot of memory space, can be converted to operate as a stand-alone digital pulse generator. Simply switch to the auxiliary pulse generator panel and start using the box as if it was designed only to output pulses. One can program period, high and low amplitude levels, rise and fall times, as well as other parameters that are available on a dedicated pulse generator. The only limitation to the pulse generation is the ratio of the smallest pulse increment to the available memory size.

The Tabor Model 8251 can be operated from either: GPIB, USB, or LAN interfaces. The product is supplied with IVI.COM driver and ArbConnection software. ArbConnection simulates an array of mechanical front panels with the necessary push buttons, displays and dials to operate the Model 8251 from a remote interface as if it is a bench-top instrument. ArbConnection also allows on-screen creation and editing of complex waveforms and patterns to drive the 8251 various outputs.

It is highly recommended that the user become familiar with the 8251 front panel, its basic features, functions and programming concepts as described in this and the following chapters.

## **Manual Changes**

Technical corrections to this manual (if any) are listed in the back of this manual on an enclosed MANUAL CHANGES sheet.

## Safety Considerations

The Model 8251 has been manufactured according to international safety standards. The instrument meets EN61010-1 and UL1244 standards for safety of commercial electronic measuring and test equipment for instruments with an exposed metal chassis that is directly connected to earth via the chassis power supply cable.



### **WARNING**

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

---

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

## Supplied Accessories

The instrument is supplied with a CD that includes the User Manual, ArbConnection and IVI engine and driver.

The instrument is supplied with a power cord and a CD which contains ArbConnection, manual, IVI driver and supporting files. USB, LAN and synchronization cables and a service manual are available upon request.

## Specifications

Instrument specifications are listed in Appendix A. These specifications are the performance standards or limits against which the instrument is tested. Specifications apply under the following conditions: output terminated into 50  $\Omega$  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 input and output connectors, rear panel input and output connectors, operating modes, output type, output state, synchronization, and front panel indicators.

---

## Front Panel Connectors

The Model 8251 has 3 SMA connectors on its front panel: two main outputs one SYNC output and one trigger input. The function of each of the front panel connectors is described in the following paragraphs. The 8251 front panel layout is shown in Figure 1-5.

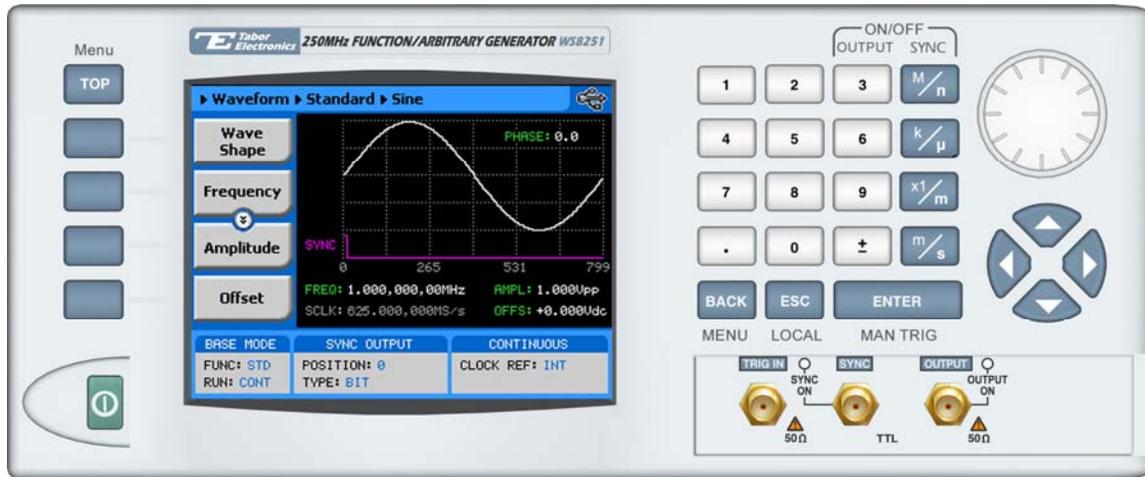


Figure 1-5, 8251 Front Panel Connectors and Indicators

## Main Output

The main output connectors generate fixed (standard) waveforms to 250 MHz, user (arbitrary) and modulated waveforms. The arbitrary waveforms are sampled with sampling clock rate to 625 MS/s. CW from the modulated function is programmable to 250 MHz. Output source impedance is 50Ω, hence the cable connected from the outputs to the load should be terminated with 50Ω load resistance. If the output is connected to a different load resistance, determine the actual amplitude from the following equation:

$$V_{\text{out}} = 4V_{\text{prog}} \left( \frac{50\Omega}{50\Omega + R_L} \right)$$

The output amplitude is doubled when the output impedance is above roughly 10 kΩ.

Note that regardless if the outputs are on or off, the electrical circuit maintains low impedance path to the output connector. It is recommended that the connecting cables are removed from the outputs, if uncontrolled transitions can damage the equipment that is connected to the sync output, which might occur when you power the 8251 on.

## SYNC Output

The SYNC output generates single or multiple TTL pulses 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 pulse sync along the waveform is programmable. The SYNC output is also used as marker output when the 8251 is programmed to one of the modulation functions.

Note that regardless if the output is on or off, the electrical circuit maintains low impedance path to the output connector. It is recommended that the connecting cables are removed from the output, if uncontrolled transitions can damage the equipment that is connected to the sync output, which might occur when you power the 8251 on.

## TRIG IN

In general, the trigger input is used for stimulating output waveforms at the main output connector(s). The trigger input is inactive when the generator is in continuous operating mode. When placed in trigger, gated or burst mode, the trigger input is made active and waits for the right condition to trigger the instrument. The trigger input is edge sensitive, i.e., it senses transitions from high to low or from low to high.

Trigger level and edge sensitivity are programmable for the trigger input. For example, if your trigger signal rides on a dc level, you can offset the trigger level to the same level as your trigger signal, thus assuring correct threshold for the trigger signal. The trigger level is adjustable from -5V to +5V.

The same input is also used in FSK mode, where the output shifts between two frequencies – carrier and shifted frequencies. The output generates carrier frequency when the input signal is false (below trigger level) and shifted frequency when the input is true (above trigger level).

Information how to use the TRIG IN signal in the various modes is given in Chapter 3.

---

## Front Panel Indicators

The Model 8251 has 2 LED indicators on its front panel. The purpose of these indicators is to flag when an output is active. The function of each of the front panel indicators is described in the following paragraphs. The 8251 front panel layout is shown in Figure 1-5.

## Output On

The Output On LED illuminates when the generator is programmed to output signals from its connector. The output can be turned on using either a front panel hot key, menu command or from a remote interface. The default condition for this LED is off.

Note that regardless if the output is on or off, the electrical circuit maintains low impedance path to the output connector. It is therefore recommended that the connecting cables are removed from the output, if uncontrolled transitions can damage the equipment that is connected to the output, which might occur when you power the 8251 on.

## SYNC On

The SYNC On LED illuminates when the generator is programmed to output signals from its sync connector. The sync output can be turned on using either a front panel hot key, menu command or from a remote interface. The default condition for this LED is off.

Note that regardless if the sync output is on or off, the electrical circuit maintains low impedance path to the output connector. It is therefore recommended that the connecting cables are removed from the output, if uncontrolled transitions can damage the equipment that is connected to the sync output, which might occur when you power the 8251 on.

## Front Panel Controls

Front panel controls and keys are grouped in logical order to provide efficient and quick access to instrument functions and parameters. Refer to Figure 1-6 throughout the following description to learn the purpose and effect of each front panel control.

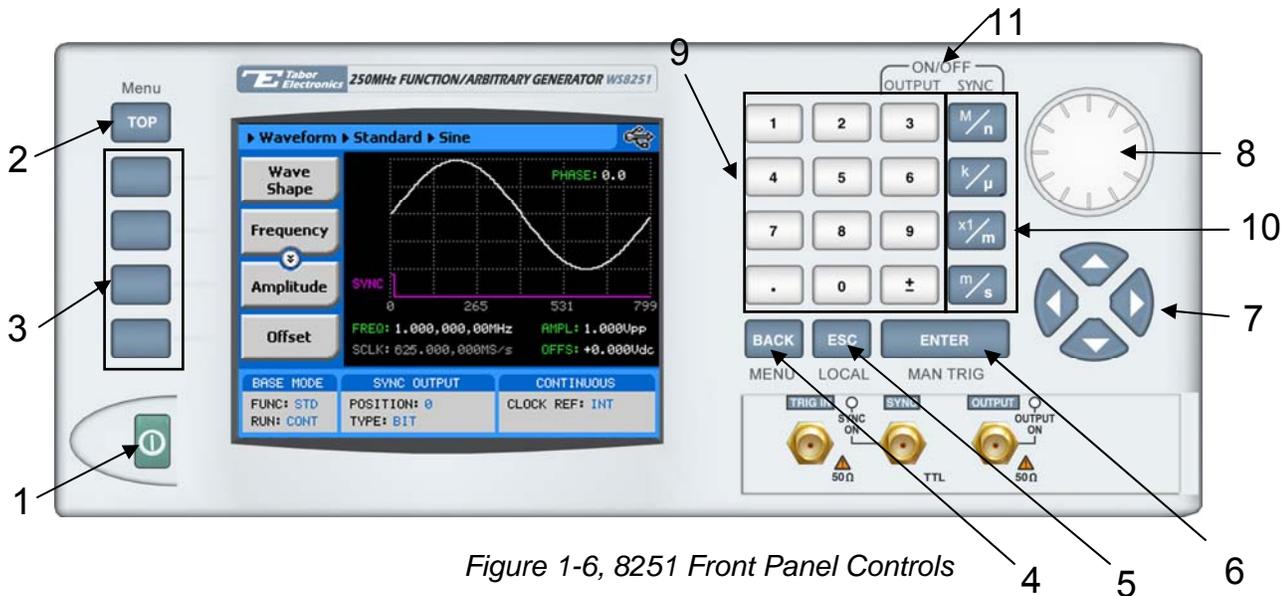


Figure 1-6, 8251 Front Panel Controls



**Note**

**The index in the following paragraphs point to the numbered arrows in Figure 1-6.**

1. *Power Switch* – Toggles 8251 power ON and OFF
2. *Menu Top* – Selects the root menu. This button is disabled during parameter editing
3. *Menu Soft Keys* – Soft keys have two functions:
  - 1) Selects output function shape or operating mode,
  - 2) Selects parameter to be auditedThese buttons are disabled during parameter editing
4. *Menu Back* – Backs up one menu position. This button is disabled during parameter editing
5. *Cancel (Local)* – Has two functions:
  - 1) When in edit mode, cancels edit operation and restore last value
  - 2) When operating the 8251 from a remote interface, none of the front panel buttons are active. The Local button moves control back from remote to front panel buttons
6. *Enter (Man Trig)* – Has two functions:
  - 1) When multiple parameters are displayed on the screen, the cursor and the dial scroll through the parameters. Pressing Enter selects the parameter for edit. After the parameter has been modified, the Enter button locks in the new variable and releases the buttons for other operations
  - 2) When the 8251 is placed in “Triggered” run mode, the Man Trig button can be used to manually trigger the 8251
7. *Cursor UP, Down, Left and Right* – Has two functions:
  - 1) When multiple parameters are displayed on the screen, the cursor and the dial scroll through the parameters
  - 2) When parameter is selected for editing, cursor buttons right or left move the cursor accordingly. Cursor buttons up or down modify parameter value accordingly
8. *Dial* – Has similar functionality as the cursor UP and Down keys
9. *Numerical keypad* – These keys are used for modifying an edited parameter value

10. *Parameter Suffixes (M/n, k/ $\mu$ , x1/m and m/s)* – These keys are used to place suffix at the end of the parameter. They are also used for terminating an edit operation
11. *ON/OFF Output, Sync* – These keys can be used only when the 8251 is not in edit mode. The Output ON/OFF toggles output waveform, at the output connector, ON and OFF. The Sync ON/OFF toggles the sync waveform, at the SYNC output connector, ON and OFF

## Rear Panel Input & Output Connectors

The 8251 has a number of connectors on its rear panel. These connectors are described below. Figure 1-7 shows rear panel receptacles, indicators, connectors and other parts. The connectors are described from left to right.



Figure 1-7, 8251 Rear Panel

### LAN

This RG45 connector accepts standard Ethernet cable. Correct setting of the IP address is required to avoid conflicts with other instruments or equipment on the network. Information how to change IP address and load instrument drivers to the computer is provided in the Installation chapter of this manual.

### USB

This connector accepts standard USB-1 cable. The connection to the host computer is automatic and does not require any address setting from within the 8251. The first time the 8251 is connected to the computer, it will request the driver file. This file is located on the CD which is supplied with the instrument. Information how to install the driver is provided in the Installation chapter of this manual.

## **GPIB**

This 24-pin connector accepts standard GPIB cable. The GPIB address is configured using the front panel utility menu. The 8251 conforms to the IEEE-488.2 standard. Programming protocol is SCPI version 1993.0. GPIB cables are available separately from your Tabor dealer.

## **REF IN**

This BNC connector accepts 10MHz, TTL level reference signal. The external reference input is available for those applications requiring better accuracy and stability than what is provided by the 8251. The reference input is active only after selecting the external reference source mode. In cases where TTL signals are inappropriate for system connection, one can change the input configuration to accept 0 dBm sine waveforms. This modification however, requires removal of the top cover and placement of two jumpers in a position that modifies the input to accept sine waveforms. Such an operation can be required by qualified service person but can also be ordered from the factory with the correct input setting.

## **AC LINE**

This 3-prong AC LINE connector accepts ac line voltage. The 8251 senses the line voltage and sets the appropriate range automatically. Therefore, the traditional line voltage selector is not available on the rear panel. To avoid potentially hazardous situations, always connect the center pin to mains ground using the line cord that is supplied with the instrument.

## **AC FUSE**

The AC fuse protects the 8251 from excessive current. Always replace the fuse with the exact type and rating as printed on the rear panel. If the fuse blows again after replacement, we recommend that you refer your instrument immediately to the nearest Tabor service center.

## **Run Modes**

The 8251 can be programmed to operate in one of four run modes: Continuous, Triggered, Gated and counted burst. There are two other modes that can operate in conjunction with the basic four run modes, these are: Delayed Trigger and internal Trigger, The various run mode options are described below. Summary of run modes and optional trigger sources are listed in Table 1-1, identifying legal run modes and listing possible setting conflicts.

---

## Continuous

In normal continuous mode, the selected waveform is generated continuously at the selected frequency, amplitude and offset. Only when operated from a remote interface, the output can be toggled on and off using a trigger command.

---

## Triggered

In triggered mode, the Model 8251 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 stimulate output waveforms. You may also program the trigger level to the desired threshold level. When triggered, the generator outputs one waveform cycle and remains idle at the last point of the waveform. The Model 8251 can be triggered from a number of sources: 1) Rear panel connector, designated as TRIG IN, 2) Front panel button marked as MAN TRIG (second function to the Enter button) and 3) bus commands that are applied to the instrument from any interface, LAN, USB or GPIB.

The trigger signal, whether it comes from an external source or from an interface command, is routed through some electrical circuits. These circuits cause some small delay, normally referred to as system delay. System delay cannot be eliminated completely. The system delay is a factor that must be considered when applying a trigger signal. It defines the time that will lapse from a valid trigger edge or software command to the instant that the output reacts.

---

## Burst

The burst mode is an extension of the triggered mode where the Model 8251 can be programmed to output a pre-determined number of waveforms.

---

## Gated

In gated mode, the 8251 generates output waveforms between two gating signal. Only hardware triggers can be used to open and close the gate. The gate opens on the first transition and closes on the second transition. Trigger level and trigger slope are programmable. Trigger delay and internal trigger do not affect the gated run mode.

## Delayed Trigger

The delayed trigger function is exactly the same as the trigger mode except a programmable delay inhibits signal output for a pre-determined number of sample clock cycles after a valid trigger. The delay time defines the time that will lapse from a valid trigger (hardware or software) to output. The delay is programmable in steps of sample clock intervals from 0 to 512k sample clock periods. The trigger delay affects the 8251 in trigger and burst run modes only.

## Internal Trigger

The internal trigger run mode is useful where an external stimulation device is not available. When turned on, an internal, free-running oscillator supplies the required triggering sequence. The period of the internal trigger generator is programmable from 100ns to 100s. Note that the internal trigger oscillator is free-running and cannot be synchronized to the waveform or external devices except through the SYNC output where a sync pulse is available at intervals that are synchronized to the internal trigger generator.

Table 1-1, Run Modes and Trigger Source Options Summary

<b>Run Mode</b>	<b>Trigger Option</b>	<b>Status</b>
<i>Continuous</i>	<i>External Bus Delayed Trigger Internal Trigger</i>	<i>Disabled Disabled Disabled Disabled</i>
<i>Triggered</i>	<i>External Bus Delayed Trigger Internal Trigger</i>	<i>Active Active Active Active</i>
<i>Counted Burst</i>	<i>External Bus Delayed Trigger Internal Trigger</i>	<i>Active Active Active Active</i>
<i>Gated</i>	<i>External Bus Delayed Trigger Internal Trigger</i>	<i>Active Disabled Disabled Disabled</i>

## Trigger Source

The Model 8251 can be triggered from a number of sources: 1) Rear panel connector, designated as TRIG IN; 2) Front panel button marked as MAN TRIG (second function to the Enter button); and 3) bus commands that are applied to the instrument from any interface, LAN, USB or GPIB. Description of the various trigger source options is given in the following paragraphs. Summary of trigger options and optional trigger sources are listed in Table 1-2, identifying legal operating modes and listing possible setting conflicts.

---

## External

When selecting the External trigger source, the rear panel TRIG IN connector becomes active and every legal signal that is applied to this input is causing the 8251 to trigger. Alternately, if an external signal is not available, the front panel MAN TRIG button may also be used to trigger the instrument. When EXT is selected, triggers commands from a remote interface are ignored. EXT is the default trigger source.

---

## Bus

When selecting the Bus as a trigger source, the rear panel TRIG IN connector and the front panel MAN TRIG button are disabled and only trigger commands from a remote interface are accepted by the instrument. Make sure that the appropriate trigger source is selected if you mix remote and local operation.

Table 1-2, Trigger Source Options Summary

<b>Trigger Option</b>	<b>Source/ Description</b>	<b>Status</b>
<i>External</i>	<i>Interface trigger commands Rear panel TRIG IN connector Front panel MAN TRIG button</i>	<i>Disabled Active Active</i>
<i>internal</i>	<i>Interface trigger commands Rear panel TRIG IN connector Front panel MAN TRIG button</i>	<i>Disabled Disabled Disabled</i>
<i>Bus</i>	<i>Interface trigger commands Rear panel TRIG IN connector Front panel MAN TRIG button</i>	<i>Active Disabled Disabled</i>

## Output Type

The Model 8251 can output three types of waveforms: Standard, Arbitrary and Modulated waveforms. The various output types are described in the following paragraphs.

---

## Standard Waveforms

The 8251 can generate an array of standard waveforms. The waveforms are generated mathematically from standard equations and converted to waveform coordinates that are downloaded internally to the working memory. Unlike analog function generators that use electrical circuits to produce the wave shapes, the 8251 must compute the waveform coordinates every time a new function is selected or every time the parameters of the function change.

The 8251 can produce 11 standard waveforms: sine, triangle, square, ramp and pulse, sinc, gaussian and exponential pulses, dc and Pseudo-random noise. Some of the waveforms parameters can be modified such as start phase for sine and triangle, duty cycle for square, rise and fall times for pulses etc. The standard waveforms are the most commonly used wave shapes and therefore were collected to a library of standard waveforms that can be used without the need to compute and download waveform coordinates.

The repetition rate of the standard waveforms is given in units of Hz. Figure 1-8 shows typical front panel for the standard waveform display and Figure 1-9 shows typical standard waveform panel as displayed when ArbConnection is used for remote programming.

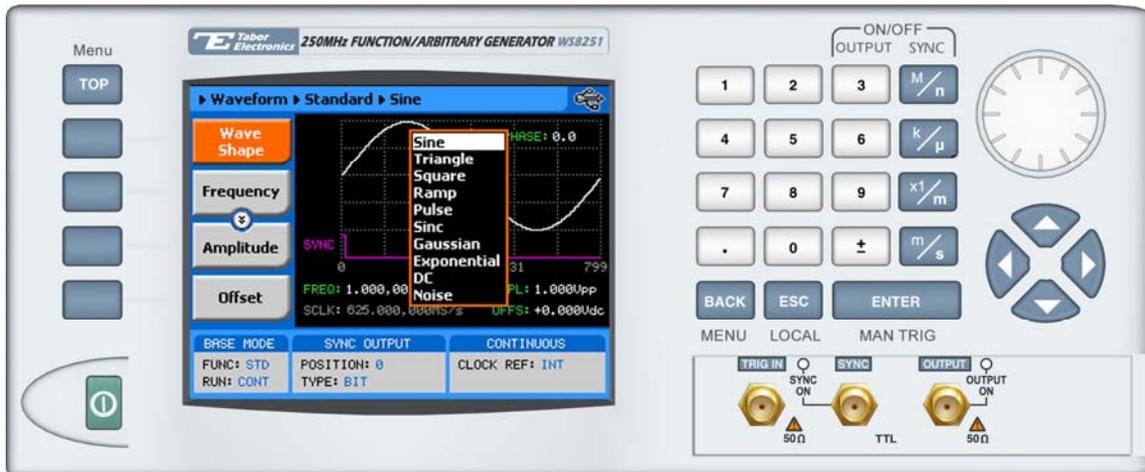


Figure 1-8, Typical 8251 Standard Waveforms Display

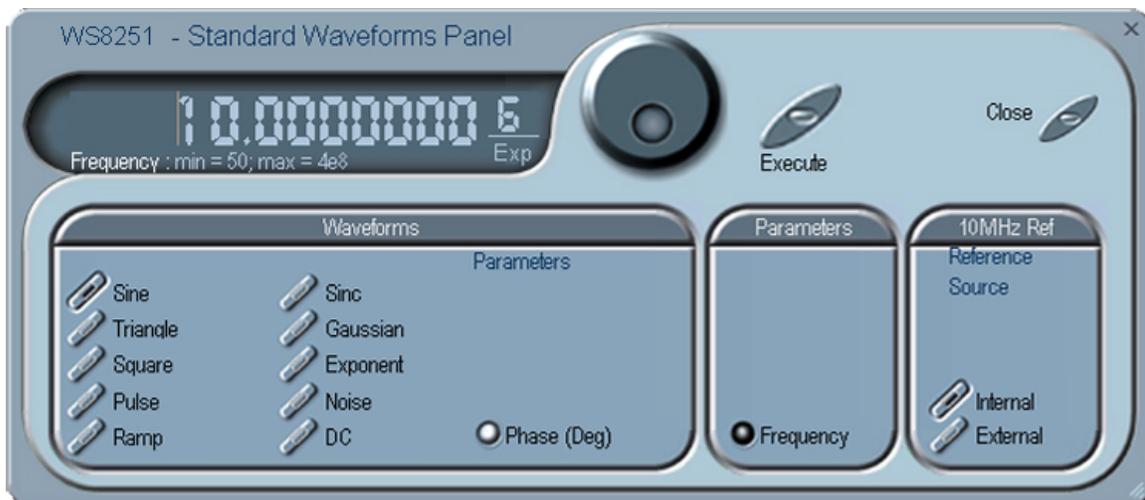


Figure 1-9, ArbConnection Example - Typical Standard Waveforms Panel

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## Arbitrary Waveforms

One of the main functions of the Tabor model 8251 is generating real-life waveforms. These are normally not sine waves and squares but user specific waveforms. Generating such waveforms require external utilities such as MatLAB or even spreadsheets but having the program alone is not enough for the 8251; Once the waveform is computed and defined, it must be converted to a format which the instrument can accept and the coordinates downloaded to the generator memory for re-play.

Arbitrary waveforms are stored as digital XY coordinates in a special memory, normally referred to as working memory. Each coordinate is referred to as waveform point, or waveform sample. The waveform is better defined if it has many waveform points. For example, with only 16 point, sine waveform will hardly resemble the shape of a sine wave and will look more like an up-down staircase, but with 128 points, the same sine waveform will look almost perfect.

The final shape of the waveform is produced by a DAC (Digital to Analog Converter) The waveform samples are clocked to the DAC at a rate defined by the sample clock frequency. The output of the DAC converts the digital data to analog levels and passes on the signal to the output amplifier. The shape of the function is more or less the same as it comes out of the DAC except it could be amplified or attenuated, depending on the require amplitude level.

The size of the working memory is limited to the way the hardware was designed. The 8251 has 512k points to build one or more waveforms. There is no need to use the entire memory for only one waveform; The memory can be divided into smaller segments loaded with different waveforms while the instrument can be programmed to output one segment at a time.

Figure 1-10 shows typical front panel for the arbitrary waveform display and Figure 1-11 shows typical ArbConnection panel as displayed when ArbConnection is used for remote programming.

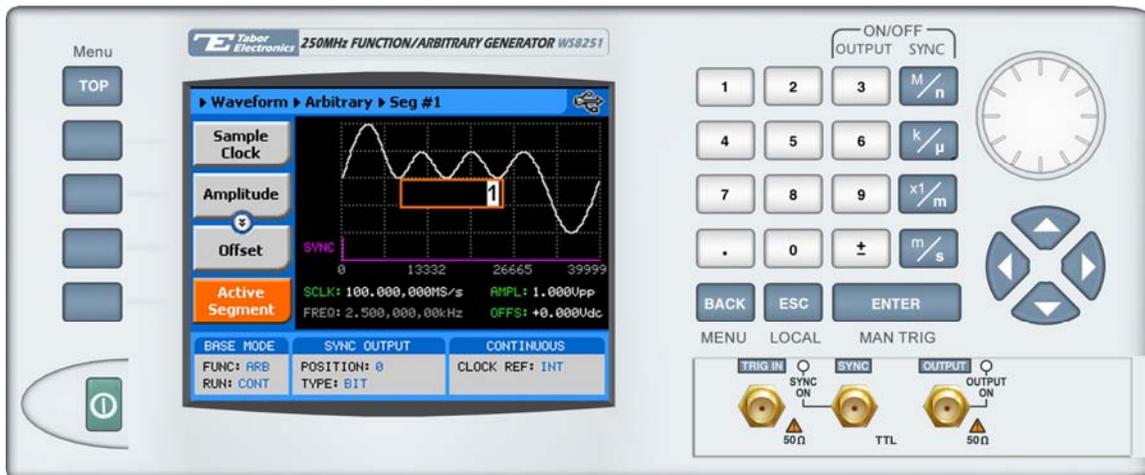


Figure 1-10, Typical 8251 Arbitrary Waveforms Display



Figure 1-11, ArbConnection Example – Typical Arbitrary Waveforms Panel

## Modulated Waveforms

Using the latest DDS technology, the 8251 is capable of producing an array of modulation which places this generator in-line with stand-alone, high performance modulation generators. The 8251 can produce: FM, FSK, PSK and Sweep.

Figure 1-12 shows typical front panel entry for modulated waveform and Figure 1-13 shows an ArbConnection example of a modulation panel.

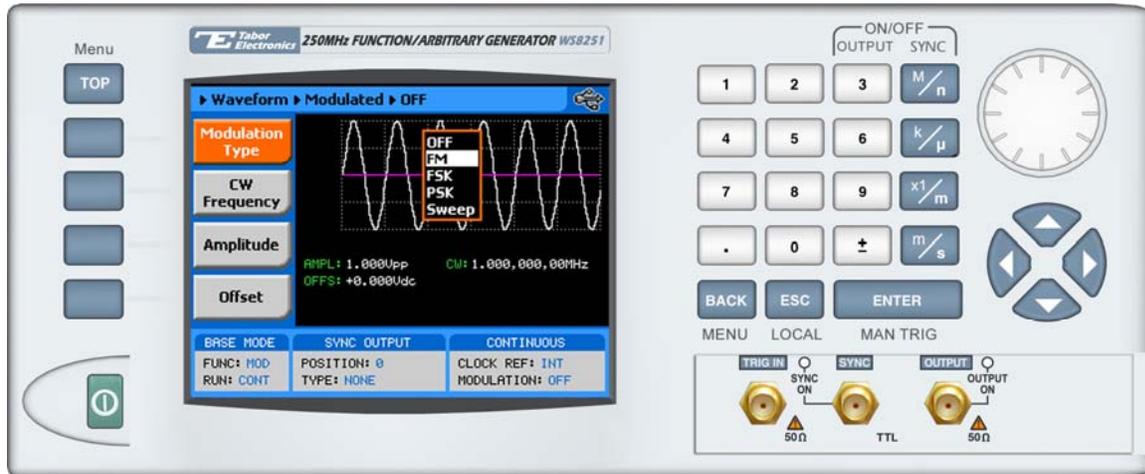


Figure 1-12, Typical Modulated waveform Display



Figure 1-13, ArbConnection Example – FM Panel

## Modulation Off

The Modulation Off is a special case of the modulation function where the output is not modulated but generates carrier waveform (CW) frequency only. CW is the sine waveform that is being modulated. When placed in Modulation Off, the sine waveform is generated from the main outputs continuously. The advantage of this mode is that sine waveforms can be generated from 1Hz to 250MHz. The disadvantage of this mode is that the modulation off operates in continuous mode only. The CW parameter does not change when you switch from one modulation function to another.

**FM**

The FM function allows frequency modulation of a carrier waveform (CW). The carrier waveform is sinewave and it is being modulated by an internal waveform, normally referred to as modulating waveform. The modulating waveform can be selected from sine, triangle or square waveforms. Carrier waveforms are programmed with 9 digits resolution from 10MHz to 250MHz. There are other parameters that control how the frequencies are hopped, these are:

**Modulation Frequency** – defines the frequency of the modulating waveform. The modulating waveform is programmed from 1mHz to 100kHz.

**Peak Deviation** – defines the range of frequencies of which the modulation will go through. The peak value is symmetrical around the value of the carrier waveform frequency. Peak deviation is programmable from 100mHz to 248MHz.

**Marker Position** – programs a unique frequency where the SYNC output generates a pulse to mark this frequency.

**FSK**

FSK (Frequency Shift keying) modulation allows frequency hops between two pre-programmed frequencies: Carrier Waveform Frequency and Shifted Frequency. The Modulation source is external and is connected to the Trigger In connector. Note that CW is sinewave only. The CW and shifted frequencies can be programmed with 10 digits throughout the entire frequency range of the instrument, from 1Hz to 250MHz.

**PSK**

PSK (Phase Shift keying) modulation allows phase hops between two pre-programmed phases: The initial phase is 0°. The shifted phase can be programmed from 0 to 360°. The Modulation source is external and is connected to the Trigger In connector

**Sweep**

Sweep modulation allows carrier waveform (CW) to sweep from one frequency, defined by the sweep start parameter to another frequency, defined by the sweep stop parameter. Note that CW is sinewave only. The start and stop frequencies can be programmed with 9 digits throughout the entire frequency range of the instrument, from 1Hz to 250MHz. There are other parameters that control how the waveforms are swept, these are:

**Sweep Time** – defines the time that will lapse from sweep start to sweep stop frequencies. Sweep time is programmable from 100µs to 1000s.

**Sweep Step** – selects between linear or logarithmic steps.

**Sweep Direction** – defines if the carrier will sweep from start to stop or from stop to start frequencies.

**Marker Position** – programs a unique frequency where the SYNC output generates a pulse to mark this frequency.

## Modulation Run Modes

Run modes are shared by all waveforms that are generated by the 8251, including modulation. However, when in modulation function, where run mode options take different meaning. When in triggered, burst or gated run modes, the 8251 outputs sine carrier waveform (CW) until a valid trigger is received and then reacts to the trigger. If triggers cease to stimulate the input, the output resumes generating CW frequency only. Carrier frequency is common to all modulation functions and can be programmed from the modulation menus.

## Auxiliary Functions

The 8251, besides its standard waveform generation functions, has an additional auxiliary function that can transform the box instrument one to a stand-alone, full-featured, Digital Pulse Generator. Operating instructions for the auxiliary function is given in Chapter 3. The following describes the auxiliary function in general.

---

## Digital Pulse Generator

The digital pulse generator auxiliary function transforms the 8251 into a pulse generator with the capability to generate pulses exactly as they would be generated by a stand-alone pulse generator instrument. When using this function one could program all pulse parameters in timing units. All pulse parameters are programmable including period, pulse width, rise and fall times, delay, polarity and more. Operating instructions for the digital pulse generator are given in Chapter 3. 8251 front panel and ArbConnection control panel examples for the digital pulse generator function are shown in figures 1-14 and 1-15, respectively.

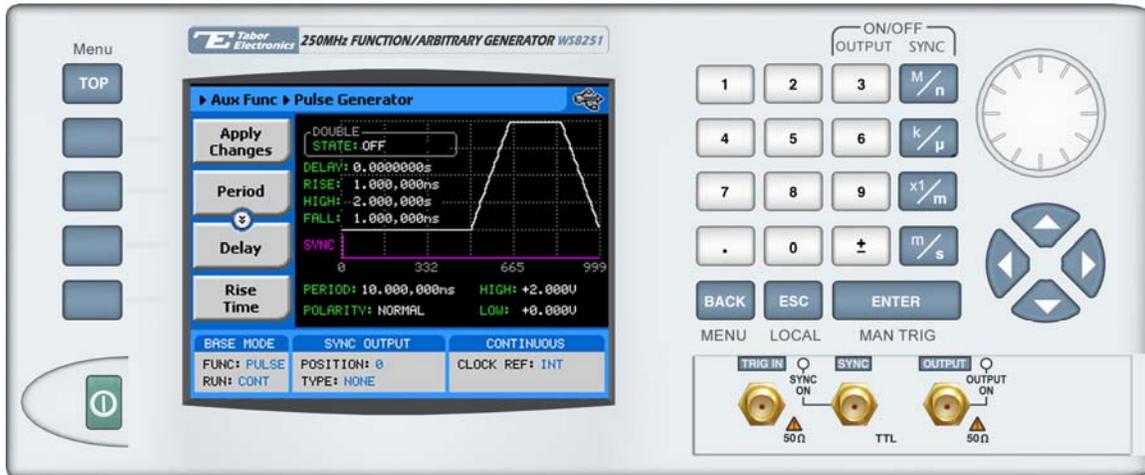


Figure 1-14, 8251 Digital Pulse Generator Menu Example

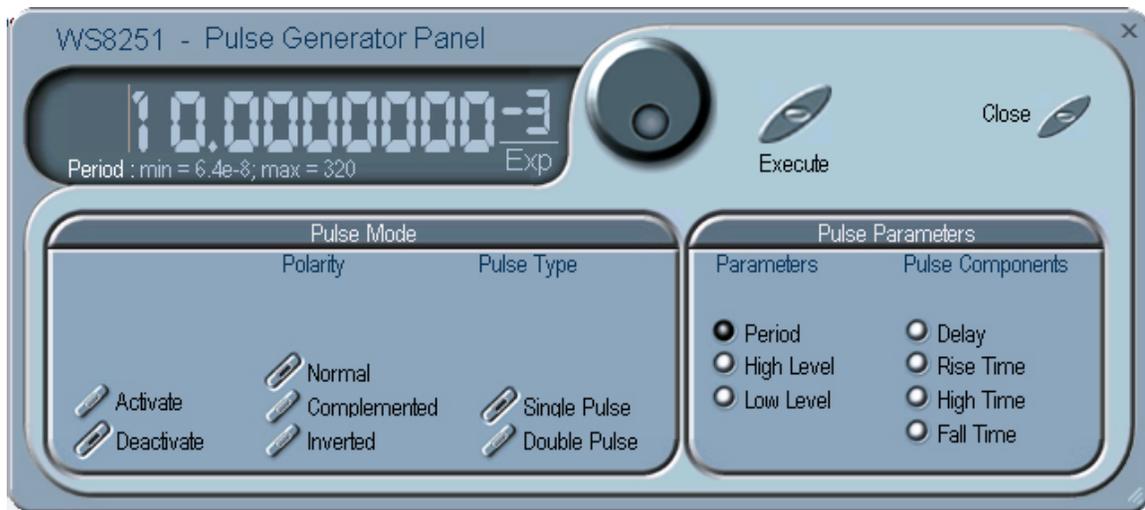


Figure 1-15, ArbConnection Digital Pulse Generator Panel Example

## Programming the Model 8251

All instrument functions, parameters, and modes can be accessed through remote commands. 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. There are other system considerations like address selection that have to be settled before programming the instrument. These topics are discussed in later chapters.

Low level programming of the Model 8251 is done using SCPI commands. Programming aspects are covered in Chapters 4.

High level drivers like IVI drivers are beyond the scope of this manual. Contact your Taber representative for more information about high level drivers for the Model 8251.

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## **Chapter 2**

# **Configuring the Instrument**

<b>Title</b>	<b>Page</b>
Installation Overview.....	2-3
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## Installation Overview

This chapter contains information and instructions necessary to prepare the Model 8251 for operation. Details are provided for initial inspection, grounding safety requirements, repackaging instructions for storage or shipment, installation information and Ethernet address configuration.

## 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. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.



### CAUTION

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

---

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



### WARNING

**For maximum safety, do not touch the product, test cables, or any other instrument parts while power is applied to the circuit under test. ALWAYS remove power from the entire test system before connecting cables or jumpers, installing or removing cards from the computer, or making internal changes such as changing the module address.**

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

---

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

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

## Performance Checks

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

## Grounding Requirements

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



### **WARNING**

**Do not attempt to float the output from ground as it may damage the Model 8251 and your equipment.**

---

## Long Term Storage or Repackaging for Shipment

If the instrument is to be stored for a long period of time or shipped to a service center, proceed as directed below. If repacking procedures are not clear to you or, if you have questions, contact your nearest 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.



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 RMA (Returned Materials Authorization) order as well as the date and method of shipment. **ALWAYS OBTAIN AN RMA NUMBER FROM THE FACTORY BEFORE SHIPPING THE 8251 TO TABOR ELECTRONICS.**

---

## Preparation for Use

Preparation for use includes removing the instrument from the container box, installing the software and connecting the cables to its input and output connectors.

## Installation

If this instrument is intended to be installed in a rack, it must be installed in a way that clears air passage to its cooling fans. For inspection and normal bench operation, place the instrument on the bench in such a way that will clear any obstructions to its rear fan to ensure proper airflow.



### **CAUTION**

**Using the 8251 without proper airflow will result in damage to the instrument.**

---

## Installing Software Utilities

The 8251 is supplied with a CD that contains the following programs: IVI Driver, ArbConnection, USB driver and some other utilities to aid you with the operation of the instrument. For bench operation, all that you need from the CD is this manual however, it is recommended that you stow away the CD in a safe place in case you'll want to use the 8251 from a host computer or in a system.

The *IVI driver* is a useful utility that provides standard communication and commands structure to control the 8251 from remote. Programming examples are also available to expedite your software development. The IVI driver comes free with the 8251 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](http://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, modulating signals and much more and then download the signals to your 8251 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 8251 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](http://www.ni.com). Installation and operating instruction for *ArbConnection* are given in Chapter 4.

The *USB* driver is required if you intend to connect the 8251 to a host computer on a *USB* bus. Information how to connect the *USB* cable and how to load the software is given in this chapter.

## Controlling the Instrument from Remote

In general, the 8251 can be controlled from remote using one of the following interfaces: *USB*, *Ethernet* and *GPIB*. Remote interface cables are not supplied with the instrument so if you plan on using one of the remote programming option, make sure you have a suitable cable to connect to your host computer. The following paragraphs describe how to connect and configure the 8251 to operate from remote. The description is given for computers fitted with *Windows XP* but little changes will show while installing software on different *Windows* versions.

## Connecting to a Remote interface

You can connect your Tabor 8251 to GPIB, USB, or LAN adapters, depending on your application and requirements from your system. Installing interface adapters in your computer will not be described in this manual since the installation procedures for these adapters change frequently. You must follow the instructions supplied with your particular adapter. Before proceed with the remote interface installation, install an adapter card and follow the instructions in the following paragraphs.

### ***GPIB Connection***

Direct connection between a host computer and a single device with GPIB is not recommended since GPIB adapter is usually expensive and is not really required for direct connection. Use GPIB connection in cases where download speed is critical to the system or when you already have GPIB system in place and you are adding the 8251 as a GPIB device. The GPIB port is connected with a special 24-wire cable. Refer interconnection issues to your GPIB supplier. After you connect the 8251 to the GPIB port, proceed to the GPIB Configuration section in this chapter for instructions how to select a GPIB address.

### ***USB Connection***

Direct connection between a single host computer and a single device with USB is most recommended as this does not require any specific considerations and device configuration. Just connect your Tabor 8251 to your PC using a standard USB cable and the interface will self configure. After you connect the 8251 to the USB port, proceed to the USB Configuration section in this chapter for instructions how to install the USB driver.

### ***LAN Connection***

Direct connection between a single host computer and a single device with 10/100 BaseT is possible, but you must use a special cable that has its transmit and receive lines crossed. If your site is already wired connect the 8251 via twisted pair Ethernet cable. Take care that you use twisted pair wires designed for 10/100 Base T network use (phone cables will not work). Refer interconnection issues to your network administrator. After you connect the 8251 to the LAN port, proceed to the LAN Configuration section in this chapter for instructions how to set up LAN parameters.

## Selecting a Remote interface

The 8251 is supplied by the factory with the active remote interface set to USB. If you intend to use USB connection, then all you need to do is connect your USB cable and proceed with the USB Configuration instructions as given in this chapter to install the USB driver and to configure the USB port (first connection only). If you already used your instrument in various platforms and want to re-select your interface

To select an active Interface, you need to access the Select

Interface screen as shown in Figure 2-1. To access this screen press the TOP menu button, then select the Utility soft key and scroll down with the dial to the Remote Setup option and press the Enter key. The Select Interface soft key will update the display with the interface parameters.

Use the cursor keys left and right to point to the required interface option then press Enter. The new interface will Initialize and the icon at the top will be updated and will flag the active interface option.

The interface icon is always displayed at the top of the screen so if you are not sure which of the interfaces is selected, compare the following icons to what you have on the screen:



Designates GPIB interface is selected and active. GPIB configuration is required to communicate with your PC.



Designates USB interface is selected and active. First connection requires USB configuration and software driver installation to communicate with your PC.



Designates LAN interface is selected and active. LAN configuration is required to communicate with your PC.



Figure 2-1, Selecting a Remote interface

## GPIB Configuration

GPIB configuration requires an address setting only. If you intend to use more than one instrument on the bus, you have to make sure each device has a unique address setting. GPIB address is programmed from the front panel Utility menu as shown in Figure 2-2. To access this screen press the TOP menu button, then select the Utility soft key and scroll down with the dial to the Remote Setup

option and press the Enter key. The GPIB soft key will update the display with the GPIB address parameter. The default address is 4. To modify the address, press the Enter key and use the dial or keypad to select the new address. Press Enter for the 8251 to accept the new address setting.



**Note**

**Configuring your GPIB address setting does not automatically select the GPIB as your active remote interface. Setting a remote interface is done from the Select interface menu. Information how to select and Interface is given hereinbefore.**



Figure 2-2, GPIB Configuration Screen

## USB Configuration

The USB requires no front panel configuration parameters. Following simple installation steps as shown later, just connect your Taber 8251 to your PC using a standard USB cable and the interface will self configure. The first time you connect the generator to your PC, the new hardware will be detected and the message as shown in Figure 2-3 will appear:



Figure 2-3, USB Device Detected



Figure 2-4, Found New Hardware Wizard

Immediately thereafter, the Found New Hardware Wizard will open, as shown in Figures 2-4 and 2-5. Select the Install from a list or specific Location option and click on next. At this time insert the installation CD into your CD driver. If you know the logical letter for your CD drive, type in the information in the path field, as shown in Figure 2-6. If you are not sure where this driver is, click on the Browse button and look for the path. Check the appropriate controls as shown in Figure 2-5 and then click on Next. With Service Pack 2 only, you'll be prompted with a Windows Logo Warning message advising you that the software has not been verified for its compatibility with Windows XP. Click on Continue Anyway. To complete the process press on Finish, as shown in Figure 2-8.



Figure 2-5, Found New Hardware Wizard

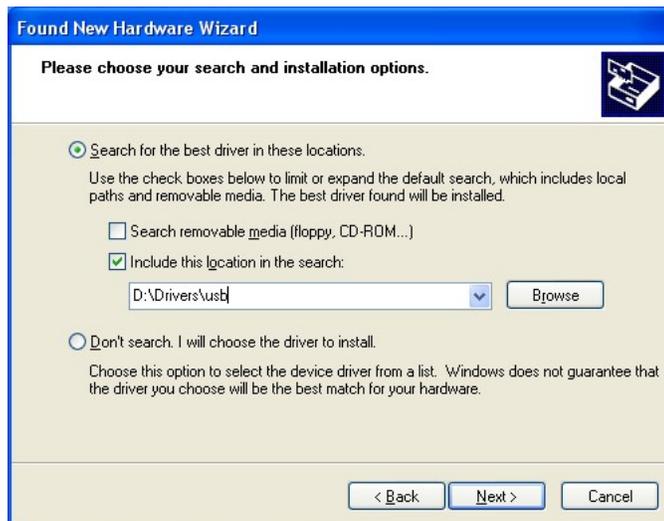


Figure 2-6, Choose Your Search and installation Options



Figure 2-7, Windows XP Logo Testing Warning



Figure 2-8, New Hardware Found and Software installed

Figure 2-9 shows that the Tabor 8251 USB Waveform Generator has been found and software driver installed. However, the process does not end at this point but continues to assign a logical port address to the USB driver. After you click on Finish, the Found New Hardware message appears however, this time it has found a USB serial port, as shown in Figure 2-9.



Figure 2-9, Found New Hardware - USB Serial Port

Proceed with the installation till a logical drive is assigned to the USB port. The process is very similar to what you have done before, just select the path and options in the next dialog box and click on Next as shown in Figures 2-10 and 2-11. To complete the process click on Finish.



Figure 2-10, Found New Hardware



Figure 2-11, Found New USB Serial Port

Proceed with the installation till a logical drive is assigned to the USB port. The process is very similar to what you have done before, just select the path and options in the next dialog box and click on Next as shown in Figures 2-12 and 2-13. To complete the process click on Finish.

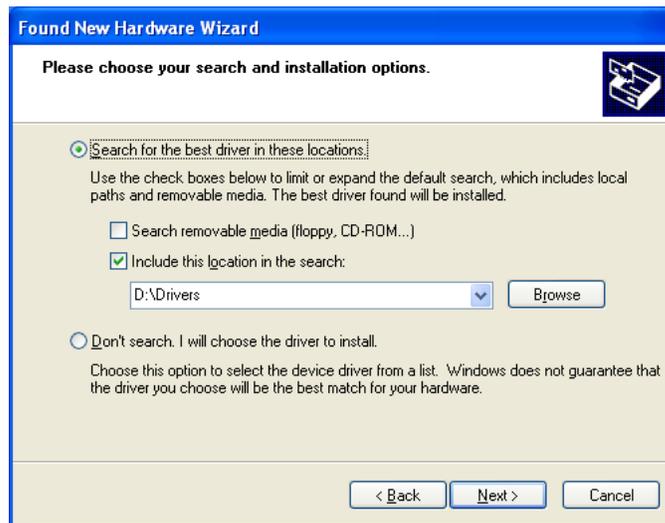


Figure 2-12, Choose Your Search and installation Options



Figure 2-13, Windows XP Logo Testing Warning



Figure 2-14, New Hardware Found and Software installed

The process above detected a USB device and installed the software for it, then it has assigned a Serial Port address to the USB post. In fact, this ends the process unless you want to verify that the drivers and the port are correctly assigned on your PC.

To make sure your USB port and the Tabor 8251 configured correctly, compare your Device Manager to the example in Figure 2-15.



**Note**

**Configuring your USB setting does not automatically select the USB as your active remote interface. Setting a remote interface is done from the Select interface menu. Information how to select and Interface is given hereinbefore.**

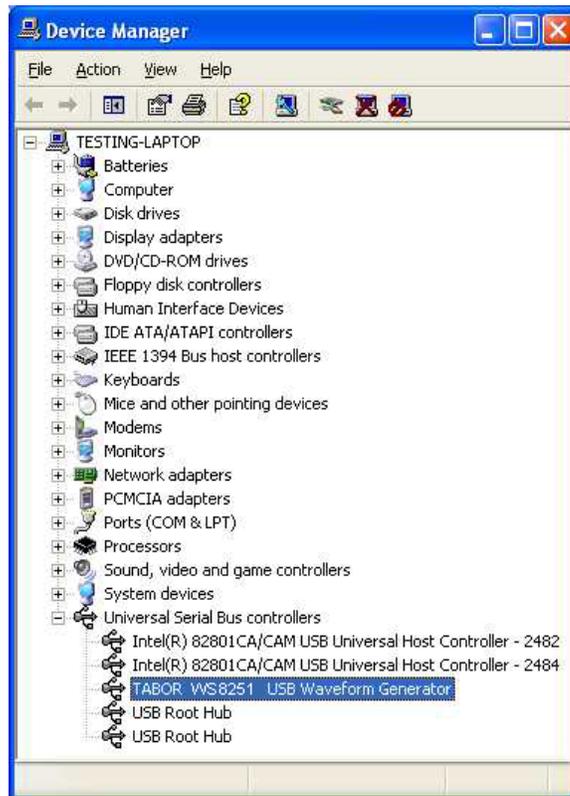


Figure 2-15, Model 8251 Configured for USB Operation

## LAN Configuration

There are several parameters that you may have to set to establish network communications using the LAN interface. Primarily you'll need to establish an IP address. You may need to contact your network administrator for help in establishing communications with the LAN interface. To change LAN configuration, you need to access the LAN 10/100 screen as shown in Figure 2-16. To access this screen press the TOP menu button, then select the Utility soft key and scroll down with the dial to the Remote Setup option and press the Enter key. The LAN 10/100 soft key will update the display with the LAN parameters.

Note there are some parameters that are shown on the display that cannot be accessed or modified; These are: Physical Address and Host Name. These parameters are set in the factory and are unique for product. The only parameters that can be modified are the IP Address, the Subnet mask and the Default gateway. Correct setting of these parameters is essential for correct interfacing with the LAN network. Description of the LAN settings and information how to change them is given in the following.



**Note**

**Configuring your LAN setting does not automatically select the LAN as your active remote interface. Setting a remote interface is done from the Select interface menu. Information how to select and Interface is given hereinbefore.**



Figure 2-16, LAN Configuration Screen

There are three LAN parameters in this screen that can be modified and adjusted specifically to match your network setting; These are described below. Consult your network administrator for the setting that will best suit your application.

- **IP address** - The unique, computer-readable address of a device on your network. An IP address typically is represented as four decimal numbers separated by periods (for example, 192.160.0.233). Refer to the next section - Choosing a Static IP Address.

- **Subnet mask** - A code that helps the network device determine whether another device is on the same network or a different network.
- **Gateway IP** - The IP address of a device that acts as a gateway, which is a connection between two networks. If your network does not have a gateway, set this parameter to 0.0.0.0.

### Choosing a Static IP Address

#### **For a Network Administered by a Network Administrator**

If you are adding the Ethernet device to an existing Ethernet network, you must choose IP addresses carefully. Contact your network administrator to obtain an appropriate static IP address for your Ethernet device. Also have the network administrator assign the proper subnet mask and gateway IP.

#### **For a Network without a Network Administrator**

If you are assembling your own small Ethernet network, you can choose your own IP addresses. The format of the IP addresses is determined by the subnet mask. You should use the same subnet mask as the computer you are using with your Ethernet device. If your subnet mask is 255.255.255.0, the first three numbers in every IP address on the network must be the same. If your subnet mask is 255.255.0.0, only the first two numbers in the IP addresses on the network must match.

For either subnet mask, numbers between 1 and 254 are valid choices for the last number of the IP address. Numbers between 0 and 255 are valid for the third number of the IP address, but this number must be the same as other devices on your network if your subnet mask is 255.255.255.0.

Table 2-1 shows examples of valid and invalid IP addresses for a network using subnet mask 255.255.255.0. All valid IP addresses contain the same first three numbers. The IP addresses in this table are for example purposes only. If you are setting up your own network, you probably do not have a gateway, so you should set these values to 0.0.0.0.

Table 2-1, Valid and Invalid IP Addresses for Subnet Mask 255.255.255.0

IP Address	Comment
123.234.45.211	Valid.
123.234.45.213	Valid. The first three numbers match the previous IP address. The fourth number must be a unique number in the range of 1 to 254.
123.202.45.214	Invalid. Second number does not match the previous IP addresses. The first three numbers must match on all IP addresses with subnet mask 255.255.255.0.
123.234.45.0	Invalid. The first three numbers are valid but the fourth number cannot be 0.
123.234.45.255	Invalid. The first three numbers are valid but the fourth number cannot be 255.



**TIP**

To find out the network settings for your computer, perform the following steps:

- For Windows 98/Me/2000/XP
  1. Open a DOS prompt.
  2. Type IPCONFIG.
  3. Press <Enter>.

If you need more information, you can run ipconfig with the /all option by typing IPCONFIG /all at the DOS prompt. This shows you all of the settings for the computer. Make sure you use the settings for the LAN adapter you are using to communicate with the LAN device.

- For Windows 95
  1. Open a DOS prompt.
  2. Type WINIPCFG.
  3. Press <Enter>.

Select the Ethernet adapters you are using to communicate with the *Ethernet device* from the drop-down list.

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# Chapter 3

## Using the Instrument

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## Overview

This chapter contains information about how to operate the Tabor 8251. Operation is divided into two general categories: basic bench operation, and remote operation (GPIB, USB and ENET). Basic bench operation, which is covered in this section, describes how to use the arbitrary waveform generator from its front panel.

The 8251 is supplied with ArbConnection, a PC based software package with a graphical user interface to allow users to program all of the functions directly. IVI.com drivers and a set of SCPI commands are available for more experienced programmers.

The following paragraphs describe the various modes of operation and give examples of how to program the Model 8251. The manual is organized by instrument function and instructions are given in each paragraph on how to use the function from its panel. Operation from ArbConnection is described in Chapter 4.

---

## Output Termination

During use, output connectors must be properly terminated to minimize signal reflection or power loss due to impedance mismatch. Proper termination is also required for accurate amplitude levels at the output connectors. Use 50  $\Omega$  cables and terminate the output(s) cables as required. Always place the termination at the far end of the cables.

---

## Input / Output Protection

The Model 8251 provides protection for internal circuitry connected to input and output connectors. Refer to the specifications in Appendix A to determine the level of protection associated with each input or output connector.

## Power On/Reset Defaults

The 8251 utilizes non-volatile memory backup that automatically stores the last setup before the generator has been turned off. Every time you turn on the instrument, the non-volatile memory updates the front panel setting with modes, parameters and waveforms from its last setting with only one exception, for safety reasons, the outputs remain off even if they were turned on before powering down the 8251.

After power on, the instrument displays information messages and updates the display with the last setup information. The 8251 can always be reset to its default values; Information on how to restore default parameters is given below.

If you are not yet fully familiar with front panel operation of the 8251, you may find yourself locked into a "dead-end" situation where nothing operates the way it should. The fastest way to restore the generator to a known state is by resetting the instrument to factory defaults.

Observe Figure 3-1 and reset parameters to factory defaults as follows:

1. Press the Utilities soft key
2. Scroll down to the, or
3. Press button 3 to restore factory defaults

Table 3-1 summarizes factory defaults for the most common parameters. A complete list of all parameters, their defaults, as well as their maximum and minimum values is given in Chapter 5.

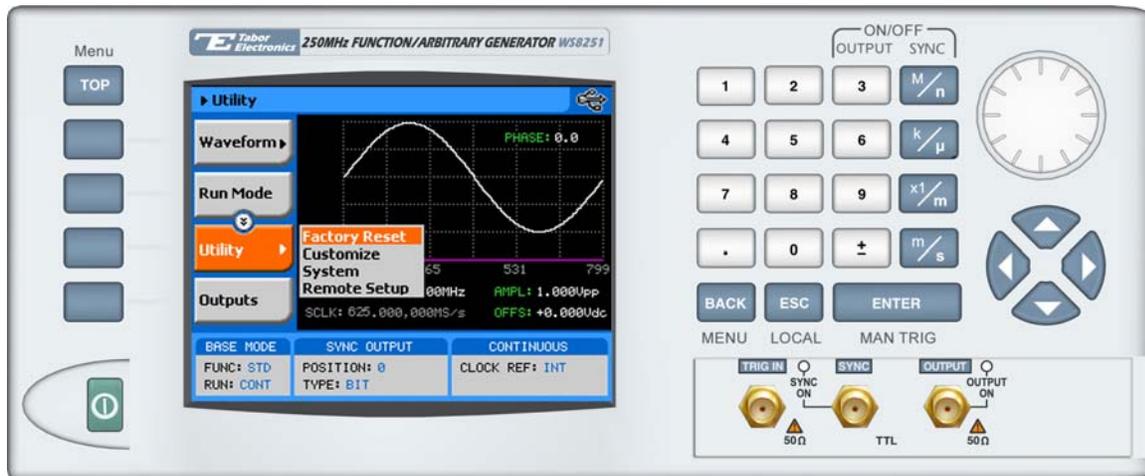


Figure 3-1, Reset 8251 to Factory Defaults

Table 3-1, Default Conditions After Reset

Function / Parameter	Default
Outputs State	Off
SYNC State	Off
Operating Mode	Continuous
Output Function	Standard
Output Function Shape	Sine
Standard Wave Frequency	10MHz
User Wave Sample Clock	100MS/s
Sample Clock Source & Reference	Internal

Amplitude	1V
Offset	0V
Filter State	Off
Filter Type	Auto
Trigger Slope	Positive
Trigger Level	1.6V
Trigger Source	External
Trigger Delay	Off
Internal Trigger Timer	1e-3s
Modulation State	Off

## Controlling the 8251

Controlling 8251 function, modes and parameters is simply a matter of pressing once or twice the appropriate button as described in the following paragraphs. Refer to Figure 3-2 throughout this description.

1. **Power Switch** – Toggles 8251 power ON and OFF
2. **Menu Top** – Selects the root menu. This button is disabled during parameter editing
3. **Menu Soft Keys** – Soft keys have two functions:
  - 1) Selects output function shape or operating mode,
  - 2) Selects parameter to be audited
 These buttons are disabled during parameter editing
4. **Menu Back** – Backs up one menu position. This button is disabled during parameter editing
5. **Cancel (Local)** – Has two functions:
  - 1) When in edit mode, cancels edit operation and restore last value
  - 2) When operating the 8251 from a remote interface, none of the front panel buttons are active. The Local button moves control back from remote to front panel buttons

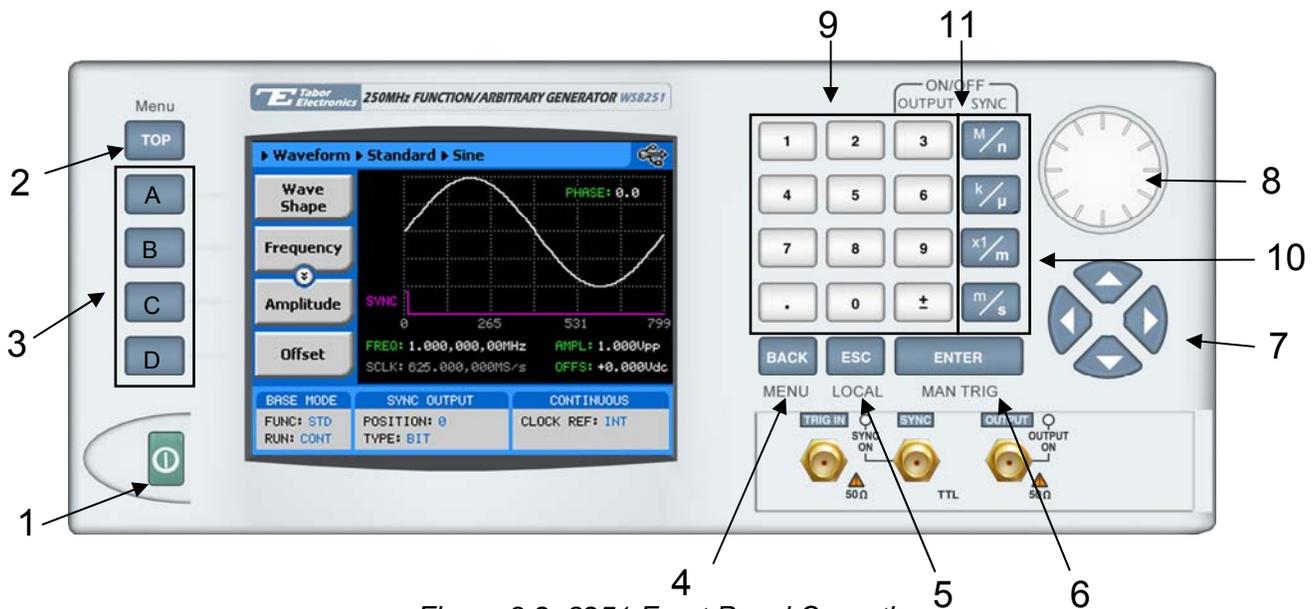


Figure 3-2, 8251 Front Panel Operation

6. **Enter (MAN TRIG)** – Has two functions:
  - 1) When multiple parameters are displayed on the screen, the cursor and the dial scroll through the parameters. Pressing Enter selects the parameter for edit. After the parameter has been modified, the Enter button locks in the new variable and releases the buttons for other operations
  - 2) When the 8251 is placed in “Triggered” run mode, the Man Trig button can be used to manually trigger the 8251
7. **Cursor UP, Down, Left and Right** – Has two functions:
  - 1) When multiple parameters are displayed on the screen, the cursor and the dial scroll through the parameters
  - 2) When parameter is selected for editing, cursor buttons right or left move the cursor accordingly. Cursor buttons up or down modify parameter value accordingly
8. **Dial** – Has similar functionality as the cursor UP and Down keys
9. **Numeral keypad** – These keys are used for modifying an edited parameter value
10. **Parameter Suffixes (M, k, x1 and m)** – These keys are used to place suffix at the end of the parameter. They are also used for terminating an edit operation
11. **ON/OFF Output, Sync** – These keys can be used only when the 8251 is not in edit mode. The Output ON/OFF toggles output waveform, at the output connector, ON and OFF. The Sync ON/OFF toggles the sync waveform, at the SYNC output connector, ON and OFF

Table 3-2, Front Panel Menus

Soft Key	TOP Menu	2 <sup>nd</sup> Level Menu	3 <sup>rd</sup> Level Menu	Notes
A	Waveform			
A		Standard		
A			Wave Shape	Select from a wave shapes list
B			Frequency	Programs standard waveform frequency
C			Amplitude	Programs output amplitude
D			Offset	Programs output offset
↓D (*)			Phase	Parameters depend on selected shape
↓D			Reset Parameters	Resets parameters for this waveform only
B		Arbitrary		
A			Sample Clock	Programs sample clock frequency
B			Amplitude	Programs output amplitude
C			Offset	Programs output offset
D			Active Segment	Programs the active waveform segment
↓D			Wave Composer	Opens the wave composer dialog box
↓D			Delete Segments	Deletes a selected segment

Table 3-2, Front Panel Menus (continued)

Soft Key	TOP Menu	2 <sup>nd</sup> Level Menu	3 <sup>rd</sup> Level Menu	Mod. Opt.	Notes
D		Modulated			
A			Modulation Type		Selects from Off, FM, FSK, PSK, or Sweep
B			CW Frequency	Off	Programs the CW frequency
C			Amplitude	Off	Programs the CW Amplitude
D			Offset	Off	Programs the CW Offset
B			Modulation Shape	FM	Programs the modulating waveform shape
C			CW Frequency	FM	Programs the CW frequency
D			Frequency Deviation	FM	Programs FM deviation frequency
↓D			Modulation Freq	FM	Parameter modulation frequency
↓D			Marker	FM	Programs the marker frequency
↓D			Amplitude	FM	Programs the CW Amplitude
↓D			Offset	FM	Programs the CW Offset
B			CW Frequency	FSK	Programs the CW frequency
C			Shifted Frequency	FSK	Programs the shifted frequency
D			Amplitude	FSK	Programs the CW Amplitude
↓D			Offset	FSK	Programs the CW Offset
B			CW Frequency	FSK	Programs the CW frequency
C			Shifted Phase	PSK	Programs the shifted phase
D			Amplitude	PSK	Programs the CW Amplitude

↓D			Offset	PSK	Programs the CW Offset
B			Sweep Type	Sweep	Selects from linear or logarithmic
C			Direction	Sweep	Selects from up or down
D			Start Frequency	Sweep	Programs the start frequency
↓D			Stop Frequency	Sweep	Programs the stop frequency
↓D			Sweep Time	Sweep	Programs the sweep time
↓D			Marker	Sweep	Programs the marker frequency
↓D			Amplitude	Sweep	Programs the CW Amplitude
↓D			Offset	Sweep	Programs the CW Offset
C	Utility				Provides access to 8251 factory reset, display customization, system parameters and remote setup
D	Outputs				Provides access to output control, filter type, sync output control and position and bypass output level and control
↓D	Auxiliary Functions				Provides access to the digital pulse generator

(\*) ↓D denotes you have to scroll down to access the menu. Scroll using the arrows up or down or the dial.

## Enabling the Outputs

For safety reasons, main outputs default setting is OFF. The outputs can be turned on and off using either the hot keys, or the Output Menu. Observe Figure 3-3 and disable or enable the main outputs using the procedure below. The same procedure can be used for enabling and disabling the SYNC output. The numbers on Figure 3-3 correspond to the procedure steps in the following description. While *not* editing any parameter, Press ON/OFF OUTPUT or SYNC to toggle main and sync output on and off.



### WARNING

**The electrical circuits maintain low impedance path to the output connector, regardless if the outputs are on or off. It is recommended that the connecting cables are removed from the outputs, if uncontrolled transitions can damage the equipment that is connected to the sync output, which might occur when you power the 8251 on.**

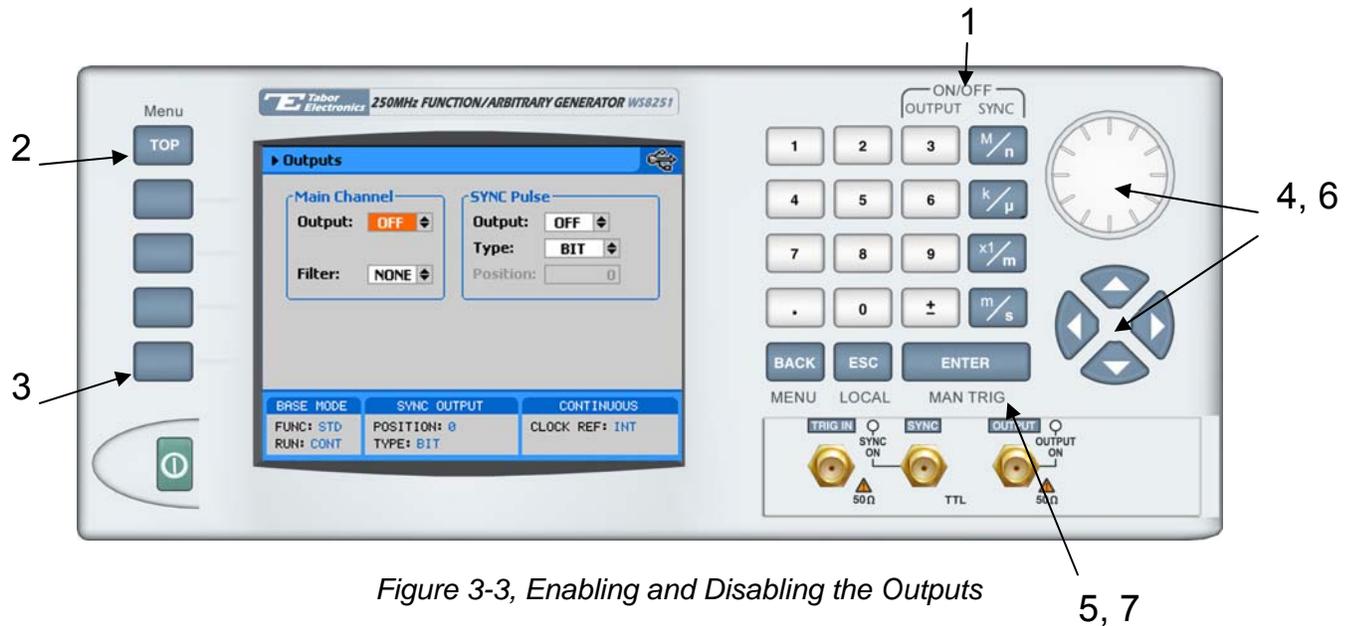


Figure 3-3, Enabling and Disabling the Outputs

Alternately, the outputs can be turned on and off from the Outputs sub menu. Use the following procedure to open the Outputs dialog box press to toggle output state:

2. Press TOP to display the root menu
3. Press Outputs to open the Outputs dialog box as shown in Figure 3-3
4. Use the dial or arrow keys to access the required field. Focus is on a field that is painted orange.
5. To edit the field press Enter. The edited field will turn white with orange borders
6. Use the dial or arrow keys to change the field
7. Press Enter again to lock in the setting

## Selecting a Waveform Type

There are three main types of waveforms that the 8251 can produce: Standard, Arbitrary and Modulated waveforms. Standard and modulated waveforms are computed from equations and tables that are built into the program. The instrument can output arbitrary waveforms however, only after waveform data has been downloaded into its memory.

Refer to Figure 3-4 and use the following procedure to select an output type.

Note that there are sub-menus associated with each output type menu. Accessing and using these sub-menus is described later in this chapter. The numbers on Figure 3-4 correspond to the procedure steps in the following description.

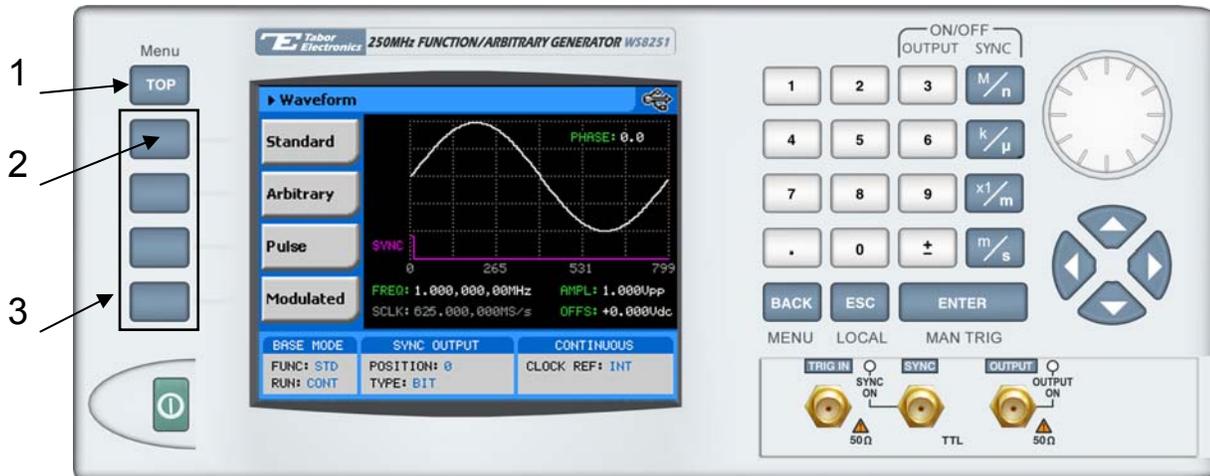


Figure 3-4, Selecting an Output Waveform Type

Alternately, the outputs can be turned on and off from the Outputs sub menu. Use the following procedure to open the Outputs dialog box press to toggle output state:

1. Press TOP to display the root menu
2. Press Waveforms, the display as shown in Figure 3-4 will open.
3. Press one of the soft keys to select the required waveform.

Note the waveform screen shows a sine waveform. The sine is the default waveform. After you select a different waveform type, the screen will be updated with a new symbol, which is associated with the new type.



**Note**

**The picture in the 8251 LCD display is an icon only. The actual output waveform may look entirely different.**

## Changing the Output Frequency

You should be careful not to confuse waveform frequency with sample clock frequency. The waveform frequency parameter is valid for standard waveforms only and controls waveform frequency at the output connector; The sample clock frequency parameter is valid for arbitrary and sequenced waveforms only and defines the frequency of which the generator clocks data points.

Standard waveform frequency is measured in units of Hz. Arbitrary waveform sample clock frequency is measured in units of S/s (samples per second). The frequency of a given arbitrary waveform

at the output connector is dependant on sample clock frequency, the number of data points, and other specific waveform definitions.

The frequency of the output waveform will change only if a standard waveform is generated. First select a standard waveform as described earlier and then proceed with frequency modification.

Observe Figure 3-5 and modify frequency using the following procedure. The index numbers in Figure 3-5 correspond to the procedure steps in the following description.

1. Press the Frequency soft key to select the frequency parameter
2. Use the numeric keypad to program the new frequency value
3. Press M, k, x1 or m to terminate the modification process

Alternately, you can modify the frequency value with the dial and arrow keys but then the termination of the process is by pressing Enter only.

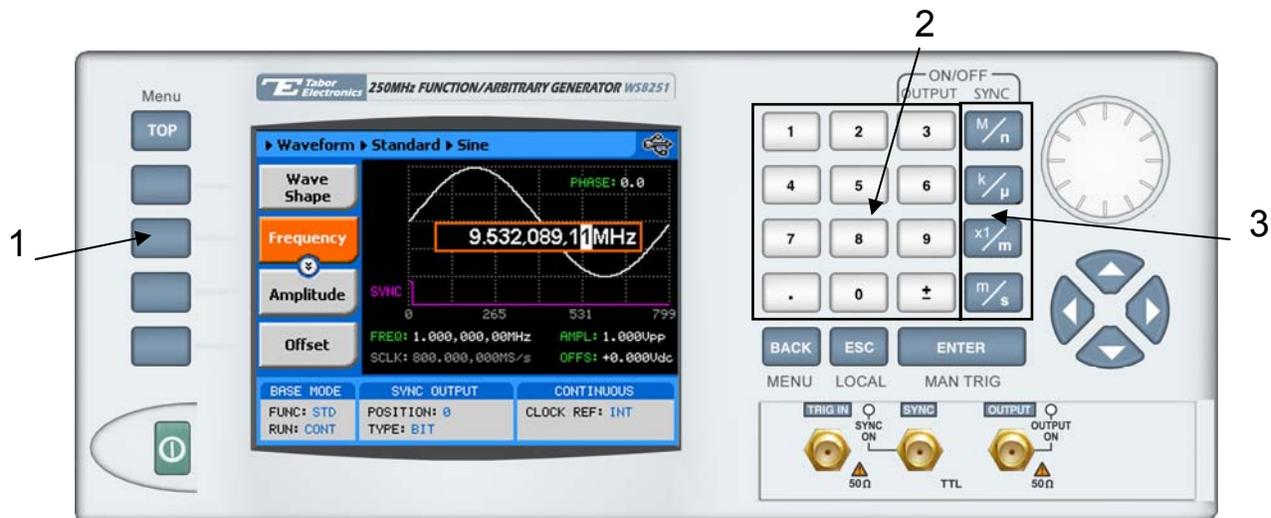


Figure 3-5, Modifying Output Frequency

**Note**

If you use the dial or arrow keys to modify the frequency parameter, the output is updated immediately as soon as you modify the parameter. The final value will be locked in as soon as you press Enter. If you choose to leave the old value, press Cancel to terminate the process and to discard of any change made to this parameter

## Changing the Sample Clock Frequency

The frequency of the sample clock will affect the output waveform only if arbitrary or sequenced waveforms are generated. First select an arbitrary waveform as described earlier and then proceed with sample clock frequency modification.

Observe Figure 3-6 and modify the sample clock using the following procedure. The index numbers in Figure 3-6 correspond to the procedure steps in the following description.

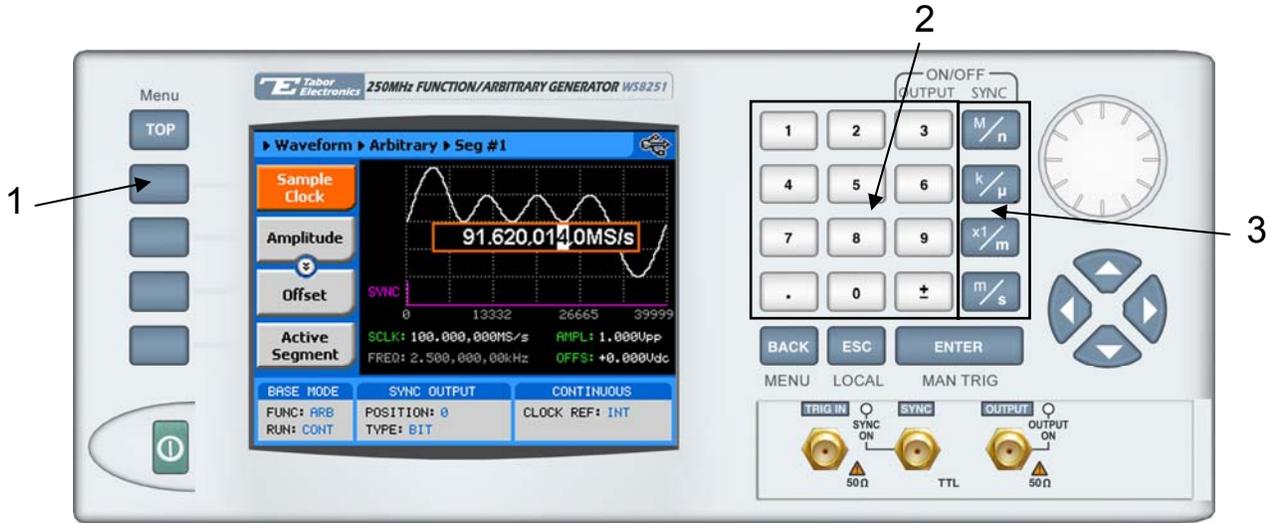


Figure 3-6, Modifying Sample Clock Frequency

1. Press the Frequency soft key to select the Sample Clock parameter
2. Use the numeric keypad to dial the new sample clock frequency value
3. Press “M” for MHz, “k” for kHz, “x1” for Hz, or “m” for mHz to terminate the modification process

Alternately, you can modify the sample clock frequency value with the dial and arrow keys but then the termination of the process is by pressing Enter only.



### Note

If you use the dial or arrow keys to modify the sample clock frequency parameter, the output is updated immediately as soon as you modify the parameter. The final value will be locked in as soon as you press Enter. If you choose to leave the old value, press Cancel to terminate the process and to discard of any change made to this parameter

## Programming the Amplitude and Offset

Amplitude and offset are set within windows, so before you select values for these parameters, make sure you do not exceed the limits. Amplitude and offset can be programmed independently as long as the following relationship between the two values is not exceeded:

$$Window \geq \frac{Amplitude}{2} + |Offset|$$

The amplitude and offset parameters are duplicated in multiple screens however, when changed for a specific function shape, the new value is updated on all screens for all other function shapes. Refer to Figure 3-7 and modify amplitude and offset using the procedure as described below. The index numbers in Figure 3-7 correspond to the procedure steps in the following description.

1. Press the Amplitude soft key button
2. Press Enter to edit the Amplitude value
3. Use the numeric keypad to program the new value
4. Press “m” for mV, or “x1” for volts to select the suffix letter.
5. Press Enter to lock in the value

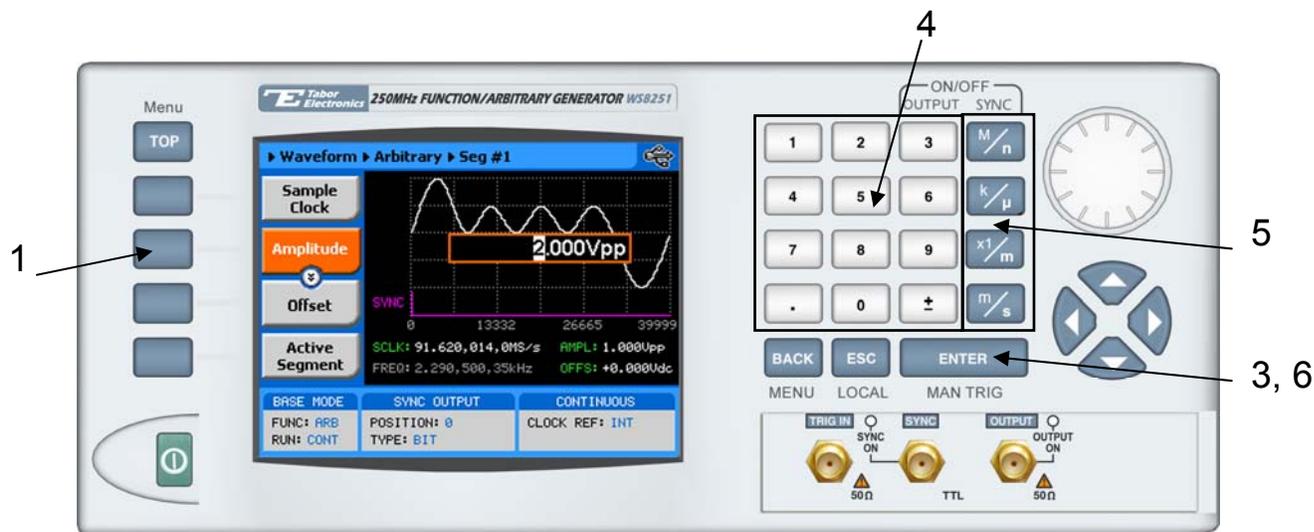


Figure 3-7, Programming Amplitude and Offset

Alternately, you can modify the amplitude value with the dial and arrow keys but then the termination of the process is by pressing Enter.

Offset is programmed the same way as amplitude except select Offset from the soft key menus to access the offset parameter.



**Note**

If you use the dial or arrow keys to modify the amplitude or offset parameters, the output is updated immediately as soon as you modify the parameter. The final value will be locked in as soon as you press Enter. If you choose to leave the old value, press Cancel to terminate the process and to discard of any change made to this parameter

## Selecting a Run Mode

The Model 8251 offers four run modes: Continuous, Triggered, Gated and Burst.

The selected waveform is repeated continuously when the instrument is set to operate in Continuous mode. The continuous output can be turned on and off from a remote interface, and thus controlling the start and stop of the waveform from an external source. The operating mode defaults to continuous after reset.

Triggered, Gated, and Burst modes require an external signal to initiate output cycles. In some case, an internal trigger generator is available to generate the required trigger stimuli without the need to connect to external devices. Figure 3-8 show the run mode options. Press one of the soft keys in the left to select the required run mode.

Description of the various run modes and the parameters that are associated with each run mode is given in the following paragraphs.



Figure 3-8, Run Mode Options

3, 5



**Burst run mode is shown in Figure 3-8 as an example however, the following description applies to all Run Mode menus.**

---

In general, a specific run mode is selected from the Run Mode soft key menu. The screen as shown in Figure 3-8 is displayed. Proceed to select the run mode and to program parameters as follows:

1. Press one of the soft keys to select from: Continuous, Triggered, Gated or burst. The output will immediately be updated with the selected run mode
2. Use the arrow keys or the dial to scroll down to the parameter field you want to modify
3. Press Enter to edit the selected value
4. Use the arrow keys or the dial to modify the edited parameter
5. Press Enter to lock in the value

---

## Triggered Mode

In Triggered mode, the output remains at a DC level as long as a valid trigger signal has not occurred. Each time a trigger occurs, the 8251 generates one complete output waveform. At the end of the output cycle, the output resumes position at a DC level that is equal to the amplitude of the last point of the waveform.

Note that the generator behaves differently when the output waveform is modulated. In this case, the 8251 generates carrier waveform frequency as long as the trigger input is inactive. Each time a trigger occurs, the 8251 generates one modulation cycle. At the end of the cycle, the output resumes CW frequency. The Trigger run mode parameters are shown in Figure 3-9.

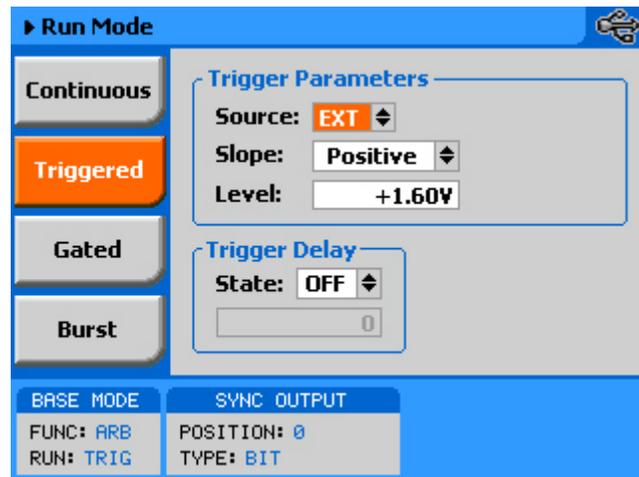


Figure 3-9, Trigger Run Mode Parameters

The instrument may be triggered from one of the following sources: A rear panel input, designated as TRIG IN, front panel button, marked MAN TRIG, an internal trigger generator that has a programmable trigger period and a remote command such as \*TRG. When placed in EXT (external) trigger source, remote commands are ignored and the instrument monitors the TRIG IN connector or the MAN TRIG control. When in BUS, the hardware inputs are ignored and only remote commands can trigger the instrument. The INT is a special trigger advance mode that is driven from an internal, free-running, asynchronous, trigger generator whose period is programmable throughout the trigger period range.

There are four parameters you can adjust for this mode:

**Source** – defines the trigger source. EXT enables the rear panel trigger input, INT enables the built in trigger generator and BUS enables remote commands.

**Slope** – defines edge sensitivity for the trigger input. POS will trigger on rising transitions and NEG will trigger on the falling edge.

**Level/Timer** – Level sets the trigger level crossing point for the rear panel TRIG IN connector. Signal transition to above the trigger level will trigger the instrument. When the slope is set to negative, transitions to below the trigger level will trigger the instrument. Trigger level sensitivity and maximum level should be observed to avoid damaging the input. When the internal trigger option is selected, the field changes to Timer, allowing programming of the period of the internal trigger generator.

**Trigger Delay** – defines the state of the delayed trigger function.

**Delay Time Field** – when the delayed trigger feature is turned on, this field becomes accessible and allows programming of the delay time

You may use the triggered mode to trigger standard, arbitrary sequenced and modulated waveforms. However, note that in modulation mode, the output generate CW frequency before and after the trigger event.

## Delayed Trigger

The delayed trigger function operates in conjunction with the triggered and counted burst modes. When enabled, it inhibits the output signal for a pre-determined period from a valid trigger signal. The delay time defines the time that will lapse from a valid trigger (hardware or software) to output. To enable the delayed trigger feature, scroll down to the Trigger Delay State field and press Enter. Use the down key to change the state to ON and press enter again to lock in the state position. The delay field then becomes active. Scroll down to the delay field and press enter. Modify the delay to match your delay requirement and press Enter again.

Note that the delay is specified in sample clock intervals, or waveform points. It can be programmed from 0 to 16M waveform points.

## Internal Trigger

The internal trigger function operates in conjunction with the triggered and counted burst modes. When enabled, it starts an automatic sequence of internal triggers that generate repeated output cycles or waveforms or bursts. The time in the re-trigger group defines the time that will lapse from the start of the signal to the start of the next signal.

To enable the internal trigger feature, scroll to the Source field and press Enter. Use the down key to change the selection to INT and press Enter again to lock in the state position. The internal trigger time field then becomes active. Scroll down to the internal trigger time field and press enter. Modify the time to match your requirement and press Enter again.

## Gated Mode

When set to gated mode, the 8251 output remains at a DC level as long as the rear-panel TRIG IN signal remains inactive. The output gates on and off on level change, either positive or negative, depending on the slope setting. Only the rear panel TRIG IN connector can be used for operating the gated mode.

When placed in gated mode, the generator idles on a DC level until the first gate on transition. The signal will complete after the gate off transition and the generator will once again resume DC level equal to the last point of the waveform.

Note that the generator behaves differently when the output waveform is modulated. In this case, the 8251 generates carrier waveform frequency as long as the gating input is inactive. Each time a gate is applied, the 8251 generates modulation cycles for the

duration of the gate. At the end of the gate cycle, the output resumes CW frequency.

There are two parameters you can adjust for the gated mode:

**Source** – defines the gating signal source. Since the gated run mode relies on hardware transitions, only EXT is a valid source for the gated mode.

**Slope** – defines if the generator is gating on and off on positive or negative transitions. When POS is selected, the generator will generate signals when the gating signal is high and visa versa, when the NEG option is selected, the generator will generate signals when the gating signal is low.

**Level** – sets the trigger level crossing point for the rear panel TRIG IN connector. Signal level to above the trigger level will gate the instrument. When the slope is set to negative, levels below the trigger level will gate the instrument. Trigger level sensitivity and maximum level should be observed to avoid damaging the input.

You may use the gated mode to gate standard, arbitrary, and modulated waveforms. The gated run mode parameters are shown in Figure 3-10.

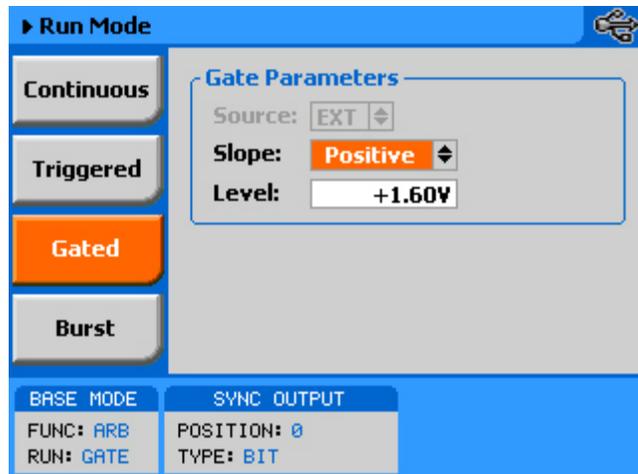


Figure 3-10, Gated Mode Parameters

## Burst Mode

Burst mode is similar to Triggered mode with the exception that only one trigger signal is needed to generate a counted number of output waveforms. In Burst mode, the output remains at a DC level as long as a valid trigger signal has not occurred. Each time a trigger occurs, the 8251 generates a counted number of burst of waveforms. At the end of the output burst, the output resumes position at a DC level that is equal to the amplitude of the last point of the waveform. Note that the counted burst mode does not operate in conjunction with the modulated waveforms function

The instrument may be triggered from one of the following sources: A rear panel input, designated as TRIG IN, front panel button, marked MAN TRIG, an internal trigger generator that has a programmable trigger period and a remote command such as \*TRG. When placed in EXT (external) trigger source, remote commands are ignored and the instrument monitors the TRIG IN connector or the MAN TRIG control. When in BUS, the hardware inputs are ignored and only remote commands can trigger the instrument. The INT is a special trigger advance mode that is driven from an internal, free-running, asynchronous, trigger generator whose period is programmable throughout the trigger period range.

There are four parameters you can adjust for this mode:

**Source** – defines the trigger source. EXT enables the rear panel trigger input, INT enables the built in trigger generator and BUS enables remote commands.

**Slope** – defines edge sensitivity for the trigger input. POS will trigger on rising transitions and NEG will trigger on the falling edge.

**Level/Timer** – Level sets the trigger level crossing point for the rear panel TRIG IN connector. Signal transition to above the trigger level will trigger the instrument. When the slope is set to negative, transitions to below the trigger level will trigger the instrument. Trigger level sensitivity and maximum level should be observed to avoid damaging the input. When the internal trigger option is selected, the field changes to Timer, allowing programming of the period of the internal trigger generator.

**Trigger Delay** – defines the state of the delayed trigger function.

**Delay Time Field** – when the delayed trigger feature is turned on, this field becomes accessible and allows programming of the delay time

**Burst Count**– defines the number of cycles the generator will output after a trigger signal. Each channel can be programmed to have a unique burst counter.

You may use the counted burst mode in conjunction with standard and arbitrary waveforms only. Sequenced and modulated waveforms can not be used in burst mode. The Burst run mode parameters are shown in Figure 3-11.

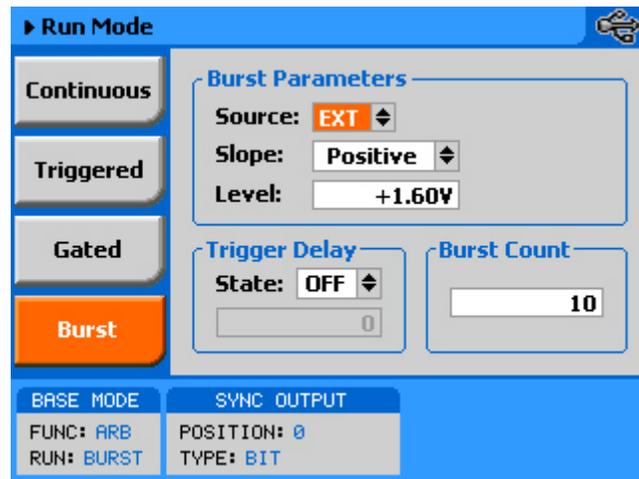


Figure 3-11, Burst Run Mode Parameters

## Using the Manual Trigger

The manual trigger allows you to trigger or gate the 8251 directly from the front panel. This button is active only when the generator is placed in external trigger only. The MAN TRIG button is a second function to the Enter button and can be used only when the display is not in editing mode.

## Using the SYNC Output

For safety reasons, every time you turn the 8251 OFF and ON, the SYNC output defaults to OFF. If you want to use the SYNC output you must turn it on immediately after you power up the generator. You can turn the SYNC on using the ON/OFF SYNC hot key as was explained earlier in this chapter or you can do it from the Outputs menus shown in Figure 3-12.

There are three parameters you can adjust for the SYNC output:

**Output** – turns the SYNC output on and off. Note that the termination of the output state shifts the dc level to 0V but leaves a low impedance path to the connector and therefore, if your UUT (unit under test) is sensitive to level transitions, make sure you remove the cable from this connector before turning the output state off.

**Type** – selects between BIT, if you require the output to be 16 points wide or SCOM (segment completed), if you require the output to be segment length wide -16 points. The selection is available for standard and arbitrary waveforms only. The type changes to LCOM (loop completed) when the waveform function is sequenced and to MARKER, for all modulation functions.

**Position** – lets you place the sync start at any point along the length of the waveform. Placement resolution is 16 points. As default, the sync signal is positioned at the beginning of the waveform.

The SYNC parameters are shown in Figure 3-12. The Menu is accessible by selecting the Outputs soft key as shown in Figure 3-3.

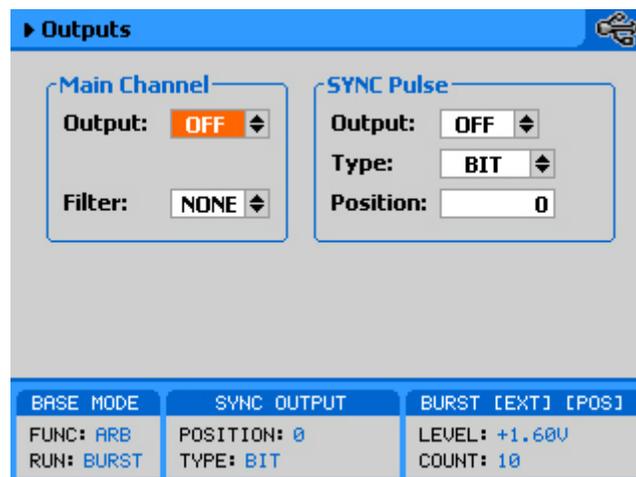


Figure 3-12, SYNC and Filter Parameters

## Applying Filters

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

The built-in filters are available for the user in standard, arbitrary, and modulated modes. The only function where the Model 8251 does not allow external control is when standard sinusoidal waveform is selected.



**The default output function of the generator is the sine waveform. The instrument is using filters to reconstruct this waveform and therefore, the state of the filters can not be changed until another output function is selected. A setting conflict error will occur if one attempts to change the filter state before changing to another output function.**

---

If you do not plan on using the filters, make sure that you leave the selection OFF. This will eliminate confusing setting conflicts.

Modification of the filter state and range is done from the Outputs menu. To access this menu select the Outputs screen as shown in Figure 3-3 and modify the parameters as shown in Figure 3-12.

## Generating Standard Waveforms

The majority of applications require the use of common waveforms such as sinusoidal, triangular and square. In fact, these are the only waveforms that function generators can produce and therefore, one should expect that these waveforms be available even in a complex generator such as this. The 8251, being a completely digital instrument, has a library of built-in waveforms that allow generation of these basic waveforms plus many more.

By default, the 8251 is programmed to generate one of the common waveforms in the market – sine waveform. Figure 3-13 shows a list of all other waveforms that the instrument can generate however, one must not forget that the waveforms are generated digitally from either lookup tables or formulated from standard equations and therefore, each time a new waveform is selected, one should expect to have a slight delay between the time the waveform was selected to when it is being generated at the output connector.

The waveforms that reside in the built- in library are referred to as

Standard Waveforms. The meaning of this term is that these waveforms have standard characteristics that is commonly known and or associated with these waveforms. For example, sine waveform has known spectral and power distribution that could be compared to published mathematical equations. The quality of the generator determines how closeness of the waveform generation to its pure mathematical properties.

The 8251 has a library of 9 standard waveforms: Sine, Triangle, Square, Ramp, pulse, sinc, Gaussian, Exponential, DC and Noise. Some of the parameters for these waveforms can be modified to fine tune the waveforms for specific applications. For example, changing the sine start phase. The standard waveforms and their parameters that can be modified are summarized in the following paragraphs.

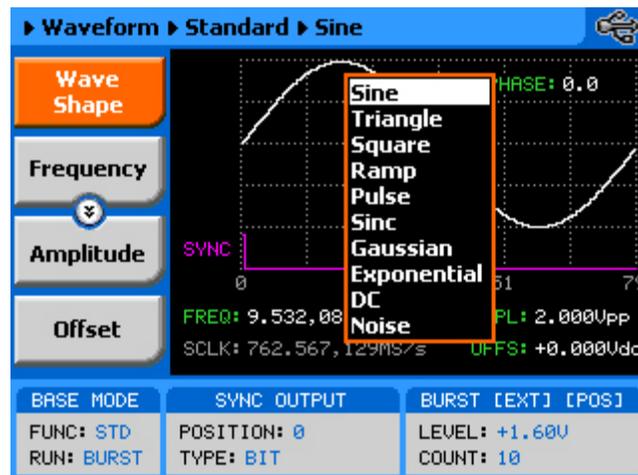


Figure 3-13, Built-in Standard Waveforms Menu

### **Sine Wave**

The sine waveform is the most commonly used waveform. The waveform is generated from a lookup table that has 1000 points and therefore, the sine waveform is generated with 1000-points accuracy up to about frequency setting of 1MHz (output frequency = sample clock frequency / number of points). As frequency is increased above 1MHz the number of points is being reduced automatically up to a point where filters are being switched in to reconstruct the waveform. The technique of generating sine waves above certain frequency is not within the scope of this manual however, one should remember that above certain frequency the waveform is losing purity and quality because the number of points that are available to construct the waveform are inversely proportional to the output frequency. This statement is true for all standard waveforms and this is the reason for limiting the upper frequency of certain waveforms.

There are certain menus that provide access to sine waveform parameters; These are:

**Frequency** – programs the frequency of the sine waveform. Note that at low frequencies (up to about 1MHz), when you modify the frequency parameter, the output responds with coherent change however, at higher frequencies, the waveform has to be re-computed every time and therefore, when you modify the frequency, the output wanders until the waveform is being re-computed and then restored to full accuracy.

**Amplitude** – programs the amplitude of the output waveform. Note that amplitude and offsets can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the amplitude parameter in this menu overrides amplitude setting in all other menus.

**Offset** – programs the offset of the output waveform. Note that offset and amplitude can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the offset parameter in this menu overrides offset setting in all other menus.

**Phase** – sets the start phase of the output waveform. You will not be able to see any change in the waveform if you generate a continuous sine waveform however, if you place the generator in triggered run mode, the output will start the sine wave generation from a point defined by the Phase parameter. The start phase is programmed in units of degree.

**Reset Parameters** – Resets the sine wave parameters to their original factory defaults.

### **Square Wave**

The square waveform is a commonly used waveform. The waveform is generated from a lookup table that has 1000 points and therefore, the square waveform is generated with 1000-points accuracy up to about frequency setting of 1MHz (output frequency = sample clock frequency / number of points). As frequency is increased above 1MHz the number of points is being reduced automatically. The square waveform is reasonable up to about 150MHz where the rise time of the amplifier rounds the square shape to a sine-like waveform.

There are certain menus that provide access to square waveform parameters; These are:

**Frequency** – programs the frequency of the square waveform. Note that at low frequencies (up to about 1MHz), when you modify the frequency parameter, the output responds with coherent change however, at higher frequencies, the waveform has to be re-computed every time and therefore, when you modify the

frequency, the output wanders until the waveform is being re-computed and then restored to full accuracy.

**Amplitude** – programs the amplitude of the output waveform. Note that amplitude and offsets can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the amplitude parameter in this menu overrides amplitude setting in all other menus.

**Offset** – programs the offset of the output waveform. Note that offset and amplitude can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the offset parameter in this menu overrides offset setting in all other menus.

**Duty Cycle** – programs the square wave duty cycle (pulse width to period ratio). The duty cycle is programmed as percent of the period. The default value is 50%.

**Reset Parameters** – Resets the square wave parameters to their original factory defaults.

### **Triangle Wave**

The triangle waveform is a commonly used waveform. The waveform is generated from a lookup table that has 1000 points and therefore, the triangle waveform is generated with 1000-points accuracy up to about frequency setting of 1MHz (output frequency = sample clock frequency / number of points). As frequency is increased above 1MHz the number of points is being reduced automatically. The triangular waveform is reasonable up to about 50MHz where 20 points are available to generate its shape. As the number of points decrease further, the shape becomes distorted to a point where it is not usable anymore.

There are certain menus that provide access to triangle waveform parameters; These are:

**Frequency** – programs the frequency of the triangle waveform. Note that at low frequencies (up to about 1MHz), when you modify the frequency parameter, the output responds with coherent change however, at higher frequencies, the waveform has to be re-computed every time and therefore, when you modify the frequency, the output wanders until the waveform is being re-computed and then restored to full accuracy.

**Amplitude** – programs the amplitude of the output waveform. Note that amplitude and offsets can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the amplitude parameter in this menu overrides amplitude setting in all other menus.

**Offset** – programs the offset of the output waveform. Note that offset and amplitude can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the offset parameter in this menu overrides offset setting in all other menus.

**Phase** – sets the start phase of the output waveform. You will not be able to see any change in the waveform if you generate a continuous triangular waveform however, if you place the generator in triggered run mode, the output will start the triangle wave generation from a point defined by the Phase parameter. The start phase is programmed in units of degree.

**Reset Parameters** – Resets the triangular wave parameters to their original factory defaults.

### **Ramp Wave**

The ramp waveform is a special case of the triangular waveform with a slight difference, the ramp can be adjusted for its rise and fall times. The ramp waveform is a very common waveform and is required for numerous applications however, not being a true ramp generator, the ramp parameters are computed and programmed as percent of the ramp period. The waveform is computed every time a parameter is modified. 1000 points are allocated for the ramp shape up to about frequency setting of 1MHz (output frequency = sample clock frequency / number of points). As frequency is increased above 1MHz the number of points is being reduced automatically. The ramp waveform is reasonable up to about 50 MHz where 20 points are available to generate its shape. As the number of points decrease further, the resolution of the parameters is lost to a point where it is not usable anymore.

There are certain menus that provide access to ramp waveform parameters; These are:

**Frequency** – programs the frequency of the ramp waveform. Note that at low frequencies (up to about 1MHz), when you modify the frequency parameter, the output responds with coherent change however, at higher frequencies, the waveform has to be re-computed every time and therefore, when you modify the frequency, the output wanders until the waveform is being re-computed and then restored to full accuracy.

**Amplitude** – programs the amplitude of the output waveform. Note that amplitude and offsets can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the amplitude parameter in this menu overrides amplitude setting in all other menus.

**Offset** – programs the offset of the output waveform. Note that offset and amplitude can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the offset parameter in this menu overrides offset setting in all other menus.

**Delay** – sets the delay time for the ramp start. The delay is programmed as percent of the ramp period.

**Rise** – programs the ramp rise time. The rise time is programmed as percent of the ramp period.

**Fall** – programs the ramp fall time. The fall time is programmed as percent of the ramp period.

Note that the sum of the delay, rise and fall times cannot exceed 100%. If the sum is less than 100%, the end of the ramp will remain at a dc level to the completion of the period.

**Reset Parameters** – Resets the ramp wave parameters to their original factory defaults.

### **Pulse Wave**

The pulse waveform is a very common waveform and is need for the majority of the applications however, not being a true pulse generator, the pulse parameters are computed and programmed as percent of the pulse period. The waveform is computed every time a parameter is modified. 1000 points are allocated for the pulse shape up to about frequency setting of 1MHz (output frequency = sample clock frequency / number of points). As frequency is increased above 1MHz the number of points is being reduced automatically. The pulse waveform is reasonable up to about 125MHz where 8 points are available to generate its shape. As the number of points decrease further, the resolution of the parameters is lost to a point where it is not usable anymore.

There are certain menus that provide access to pulse waveform parameters; These are:

**Frequency** – programs the frequency of the pulse waveform. Note that at low frequencies (up to about 1MHz), when you modify the frequency parameter, the output responds with coherent change however, at higher frequencies, the waveform has to be re-computed every time and therefore, when you modify the frequency, the output wanders until the waveform is being re-computed and then restored to full accuracy.

**Amplitude** – programs the amplitude of the output waveform. Note that amplitude and offsets can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the amplitude parameter in this menu overrides amplitude setting in all other menus.

**Offset** – programs the offset of the output waveform. Note that offset and amplitude can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the offset parameter in this menu overrides offset setting in all other menus.

**Delay** – sets the delay time for the ramp start. The delay is programmed as percent of the ramp period.

**Rise** – programs the ramp rise time. The rise time is programmed as percent of the ramp period.

**Fall** – programs the ramp fall time. The fall time is programmed as percent of the ramp period.

Note that the sum of the delay, rise, high and fall times cannot exceed 100%. If the sum is less than 100%, the end of the pulse will remain at a dc level to the completion of the period.

**Reset Parameters** – Resets the pulse wave parameters to their original factory defaults.

### **Sinc Wave**

The sinc pulse (sine x/x) waveform is a very common waveform and is required in many applications however, not being a true pulse generator, the sinc pulse parameters are re-computed every time a parameter is changed. 1000 points are allocated for the sinc pulse shape up to about frequency setting of 1MHz (output frequency = sample clock frequency / number of points). As frequency is increased above 1MHz the number of points is being reduced automatically. The sinc pulse waveform is reasonable up to about 50 MHz where 20 points are available to generate its shape. As the number of points decrease further, the shape of the pulse is deteriorated to a point where it is not usable anymore.

There are certain menus that provide access to sinc pulse waveform parameters; These are:

**Frequency** – programs the frequency of the sinc waveform. Note that at low frequencies (up to about 1MHz), when you modify the frequency parameter, the output responds with coherent change however, at higher frequencies, the waveform has to be re-computed every time and therefore, when you modify the frequency, the output wanders until the waveform is being re-computed and then restored to full accuracy.

**Amplitude** – programs the amplitude of the output waveform. Note that amplitude and offsets can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the amplitude parameter in this menu overrides amplitude setting in all other menus.

**Offset** – programs the offset of the output waveform. Note that offset and amplitude can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the offset parameter in this menu overrides offset setting in all other menus.

**#Cycles** – sets the number of “0” crossing cycles for the sinc function. Note that the default value is 4. Changing the value to a different number requires re-calculation of the waveform and may take a few seconds until the waveform is computed and generated at the output connector.

**Reset Parameters** – Resets the sinc pulse wave parameters to their original factory defaults.

### **Gaussian Wave**

The gaussian pulse waveform is useful in many applications. The gaussian pulse parameters are re-computed every time a parameter is changed. 1000 points are allocated for the gaussian pulse shape up to about frequency setting of 1MHz (output frequency = sample clock frequency / number of points). As frequency is increased above 1MHz the number of points is being reduced automatically. The gaussian pulse waveform is reasonable up to about 50MHz where 20 points are available to generate its shape. As the number of points decrease further, the shape of the pulse is deteriorated to a point where it is not usable anymore.

There are certain menus that provide access to gaussian pulse waveform parameters; These are:

**Frequency** – programs the frequency of the sinc waveform. Note that at low frequencies (up to about 1MHz), when you modify the frequency parameter, the output responds with coherent change however, at higher frequencies, the waveform has to be re-computed every time and therefore, when you modify the frequency, the output wanders until the waveform is being re-computed and then restored to full accuracy.

**Amplitude** – programs the amplitude of the output waveform. Note that amplitude and offsets can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the amplitude parameter in this menu overrides amplitude setting in all other menus.

**Offset** – programs the offset of the output waveform. Note that offset and amplitude can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the offset parameter in this menu overrides offset setting in all other menus.

**Exponent** – sets the exponent factor for the gaussian function. Changing the default exponent value to a different number requires re-calculation of the waveform and may take a few seconds until the waveform is computed and generated at the output connector.

**Reset Parameters** – Resets the gaussian pulse wave parameters to their original factory defaults.

### **Exponential Wave**

The exponential pulse waveform is useful in applications simulating capacitor charge or discharge. Not being a true pulse generator, the exponential pulse parameters are re-computed every time a parameter is changed. 1000 points are allocated for the exponential pulse shape up to about frequency setting of 1MHz (output frequency = sample clock frequency / number of points). As frequency is increased above 1MHz the number of points is being reduced automatically. The exponential pulse waveform is reasonable up to about 50MHz where 20 points are available to generate its shape. As the number of points decrease further, the shape of the pulse is deteriorated to a point where it is not usable anymore.

There are certain menus that provide access to sinc pulse waveform parameters; These are:

**Frequency** – programs the frequency of the sinc waveform. Note that at low frequencies (up to about 1MHz), when you modify the frequency parameter, the output responds with coherent change however, at higher frequencies, the waveform has to be re-computed every time and therefore, when you modify the frequency, the output wanders until the waveform is being re-computed and then restored to full accuracy.

**Amplitude** – programs the amplitude of the output waveform. Note that amplitude and offsets can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the amplitude parameter in this menu overrides amplitude setting in all other menus.

**Offset** – programs the offset of the output waveform. Note that offset and amplitude can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the offset parameter in this menu overrides offset setting in all other menus.

**Exponent** – sets the exponent factor for the exponential function. Setting the exponent to a negative value inverts the exponential function. Changing the default exponent value to a different number requires re-calculation of the waveform and may take a few seconds until the waveform is computed and generated at the output connector.

**Reset Parameters** – Resets the exponential pulse wave parameters to their original factory defaults.

### **DC Wave**

The DC waveform is useful applications requiring simply an accurate DC level.

There are certain menus that provide access to the DC waveform parameters; These are:

**DC Level** – programs the level of the DC output function. The amplitude is programmed in units of volts and generated continuously at the output connector in a similar way as a power supply generates its output. Note however, that the amplitude is calibrated when the output is terminated into 50Ω load impedance.

**Reset Parameters** – Resets the DC amplitude parameter to its original factory default.

### **Noise Wave**

The noise waveform is useful in applications requiring generation of simple noise. The spectral spread of the noise is pseudo-random and is limited in its bandwidth by the bandwidth parameter. The noise parameters are re-computed every time a parameter is changed. 1000 points are allocated for the noise shape up to about frequency setting of 1MHz (output frequency = sample clock frequency / number of points). As frequency is increased above 1MHz the number of points is being reduced automatically. The noise waveform is reasonable up to about 150MHz where 20 points are available to generate its shape. As the number of points decrease further, the shape of the noise is deteriorated to a point where it is not usable anymore.

There are certain menus that provide access to noise waveform parameters; These are:

**Amplitude** – programs the amplitude of the output waveform. Note that amplitude and offsets can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the amplitude parameter in this menu overrides amplitude setting in all other menus.

**Offset** – programs the offset of the output waveform. Note that offset and amplitude can be programmed freely within the specified amplitude window, as explained in the Programming Amplitude and Offset section in this chapter. Note that setting the offset parameter in this menu overrides offset setting in all other menus.

**Bandwidth** – sets the sample clock rate which generates the noise. It also serves as a simple tool to limit the bandwidth of the noise to a known value.

Note that while generating noise, bear in mind that the noise is generated in a certain memory size and it is being repeated over and over until the function is disabled. Therefore, the noise is not really random as is the pure translation of the word.

**Reset Parameters** – Resets the gaussian pulse wave parameters to their original factory defaults.

## Generating Arbitrary Waveforms

In general, the Model 8251 cannot by itself create arbitrary waveforms. If you want to use arbitrary waveforms, you must first load them into the instrument. The 8251 is supplied with waveform creation and editing, called – ArbConnection. Besides waveform generation, ArbConnection has instrument control features, sequence table generator, FM and pulse composers and many other features that will be described separately. Figure 3-14 shows an example of a waveform that was created with ArbConnection. Once the waveform is created on the screen, downloading it to the 8251 is just a click of a mouse away.

Detailed information on the structure of the arbitrary waveform and the commands that are needed to download arbitrary waveforms to the 8251 is given in Chapter 5. Information in this Chapter will give you some general idea what arbitrary waveforms are all about.

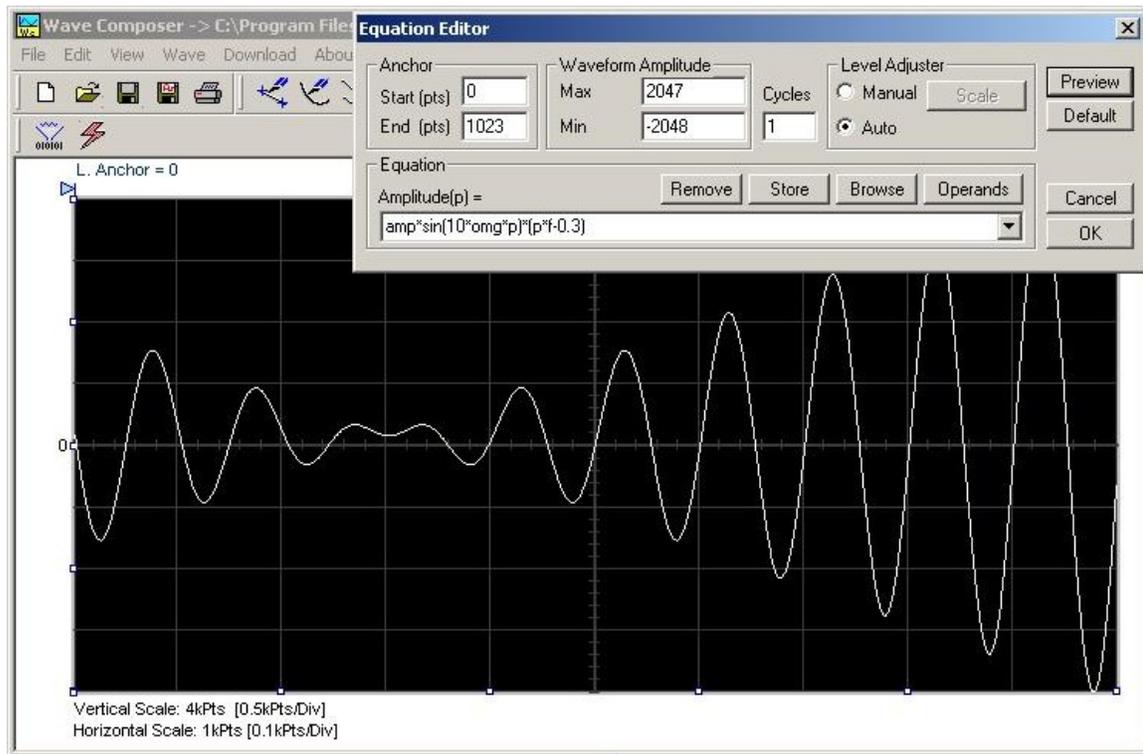


Figure 3-14, The Wave Composer Tool for Generating Arbitrary Waveforms

## What Are Arbitrary Waveforms?

Arbitrary waveforms are generated from digital data points, which are stored in a working memory. The working memory is connected to a digital to analog converter (DAC) and a sample clock generator is clocking the data points, one at a time, to the output circuit. In slow motion, the output generates a waveform that resembles the look of a staircase. In reality, the DAC is generating amplitude hops that depend on bit arrangement and sample clock speed.

The working memory has two major properties: vertical resolution and memory depth.

**Vertical Resolution** – This term defines the precision along the vertical axis of which data points can be placed and generated by the DAC. The 8251 is using 12-bit DAC's to generate arbitrary waveforms. Converting 16 bits to precision shows that each data point can be placed along the vertical axis with a precision of  $\frac{1}{4,096}$ .

**Memory Depth** – Defines how many data points can be stored for a single waveform cycle. The 8251 has 512K waveform memory capacity.

Having such large memory capacity is an advantage. Modern applications in the telecommunications industry require simulation of long waveforms without repeatable segments. The only way to create such waveforms is having sufficient memory depth. On the

other hand, if you do not need to use very long waveforms but must have many other waveforms stored in your working memory, the 8251 lets you divide the memory bank to smaller segments and load different waveforms into each segment.

---

## Generating Arbitrary Waveforms

Downloading waveforms to the 8251 and managing arbitrary memory are explained in the programming section of this manual. This section assumes that you have already downloaded waveforms and want the instrument to output these waveforms.

Refer to Figure 3-15 and use the following description to learn how to output arbitrary waveforms and how to program arbitrary waveform parameters. To select Arbitrary waveforms as the output waveform type press Waveforms, then Arbitrary. The screen as shown in Figure 3-15 will display and the output will already generate arbitrary waveforms. Note the channel you are currently programming and make sure the icon at the upper right corner agrees with your required programming sequence. Use the following procedure to modify the parameters that are associated with the arbitrary waveform function:

1. Press the soft key next to the required parameter to display the edit field
2. Punch in the value using the numeric keypad. Be careful not to exceed parameter limits while you key the numbers
3. Select and press a suffix
4. Press Enter to lock in the new value

Alternately, after you display the edit field, you may use the dial and/or the arrow keys to modify the field then, press Enter to lock in the new value. If you did not make programming errors and did not make any mistake while downloading your waveform segment(s), then the output should generate your desired waveform.

There are four parameters that are available for programming in this window:

**Sample Clock** – defines the sample clock frequency for the arbitrary waveform. Information how to modify the sample clock is given in this chapter.

**Amplitude** – defines the amplitude of the arbitrary waveform. Note that regardless of the amplitude setting, the vertical resolution of which the waveform is generated is always 12 bits.

**Offset** – defines the offset value of the arbitrary waveform. The offset and the amplitude can be freely programmed within a 2V window (+1V to -1V rails).

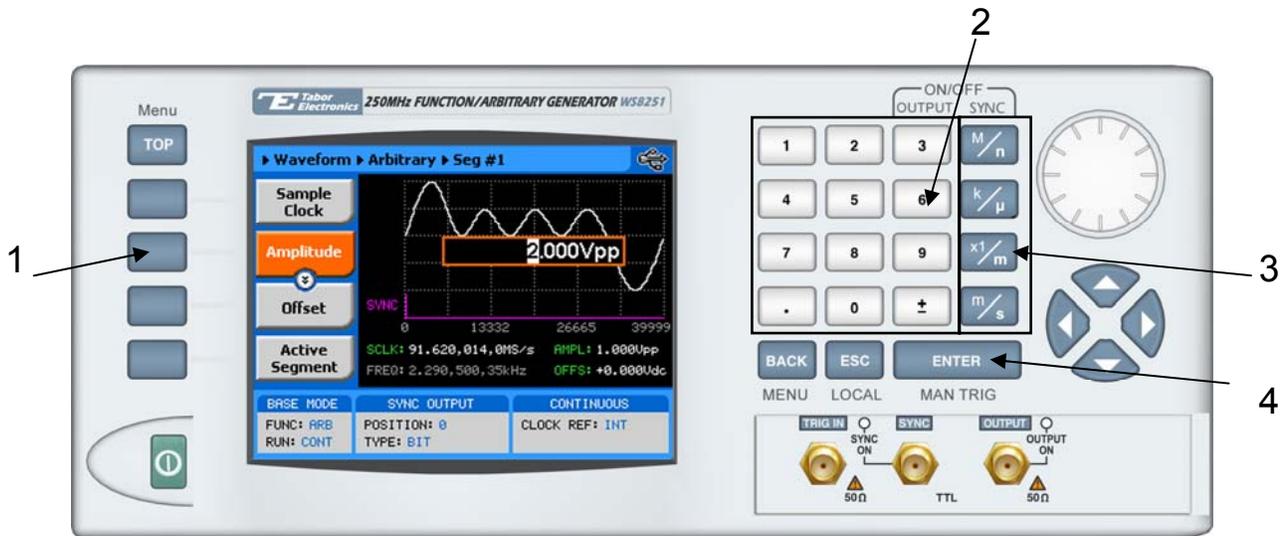


Figure 3-15, Programming Arbitrary Waveform Parameters

**Segment Number** – defines which of the segments in the working memory is currently active at the output connector. As was discussed earlier, the working memory can be divided to 1k segments and different waveforms loaded in each segment. Any segment is available at the output connector only if it has been selected to be the active segment. The segment selection field lets you select any segment from 1 to n regardless if it contains waveform data or not so be careful when you select a segment number as it may be empty and no output will be generated.

**Delete Segments** – allows none-distractive removal of all segments from the memory. This command does not erase the memory but only removes the table that defines start and stop for each segment location. If you have recorded your segment sizes you can always re-define the segment table, which will restore the original waveforms in each segment. There is however, no way back if you perform a download action after you delete the segment table.

## Generating Modulated Waveforms

Utilizing DDS (direct digital synthesis) technology, the Model 8251 is extremely frequency-agile. Changing the sample clock frequency is as easy as changing bits at the DDS control. The DDS has an extremely wide dynamic range with excellent linearity throughout the complete range. The properties of the DDS are passed on directly to the output therefore, the frequency is modulated within an extremely wide band, without losing linearity. For example, the 8251 can sweep linearly from minimum to its maximum frequency whereas similar instruments that use the standard VCO design can sweep through 3 decades only.

The 8251 has the following modulation options: OFF, FM, FSK, PSK and Sweep. These functions are described below.

Modulated waveforms are selected from the waveforms menu. Figure 3-16 shows how to select the FM. To access this menu, press TOP, then waveforms and select the Modulated waveforms option.

Modulation type is selected from the Modulation Type menu. Refer to Figure 3-16 and use the following procedure to select the modulation type.

1. Press on the Modulation Type soft key. The following options will display: Off, FM, FSK, PSK and Sweep
2. Using the dial or the up and down arrow keypad, scroll down to the desired option
3. Press Enter to lock in the selected modulation type. The output will be updated immediately after you press the Enter button.

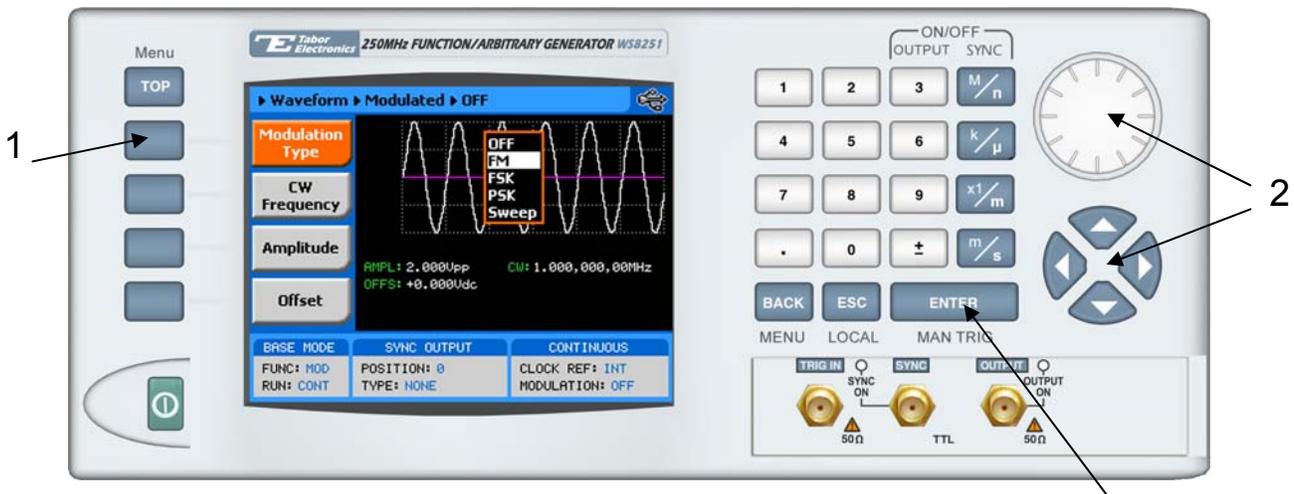


Figure 3-16, Selecting a modulated Waveform

## Off

In modulation OFF, the output generates continuous Carrier Waveform frequency. The carrier waveform is sinewave and its frequency can be programmed using the CW Frequency menu. The value programmed for the CW Frequency parameter, is used for all other modulation functions.

Amplitude and offset can also be programmed from the modulation off menus, as shown in Figure 3-17.

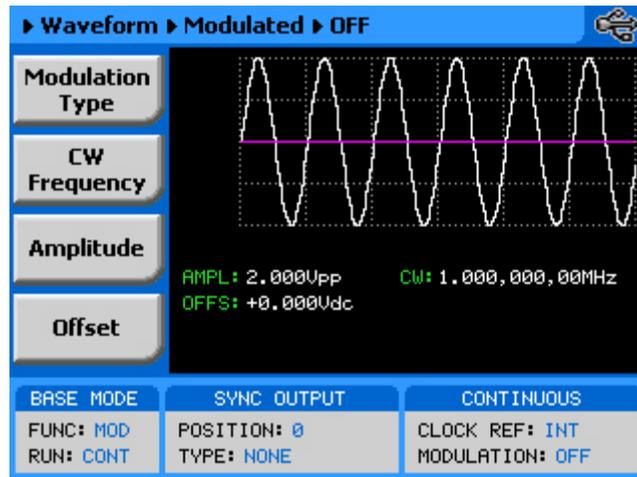


Figure 3-17, Modulation OFF Parameters

## FM – Standard Waveforms

Frequency modulation is the most common modulation scheme used in telecommunications. In this mode, the carrier waveform (CW) is modulated by an internal modulating waveform. The FM function has a number of menus that control the modulation parameters. These are shown in Figure 3-18 and described in the following paragraphs:

**Modulation Shape** – Defines the shape and type of the modulating waveform. Although there are 5 options shown in the menu, there is a significant difference between the first four: Sine Triangle, Square and Ramp, and the last option – Arbitrary. The two types are described below. The Modulation Shape menu that provides access to the selection of the envelop waveform is shown in Figure 3-19.

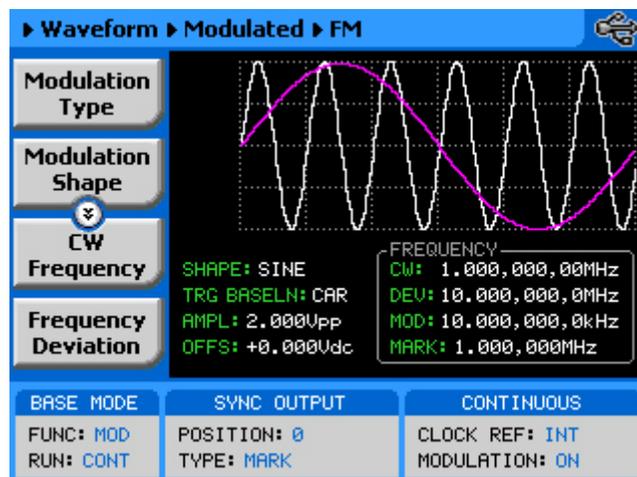


Figure 3-18, FM Modulation Parameters

**CW Frequency** – programs the carrier waveform frequency. The shape of the carrier waveform is always sine wave.

**Frequency Deviation** – programs the frequency deviation of the modulating waveform. The deviation is normally programmed as peak to peak deviation from the center (CW) frequency.

**Modulation Frequency** – programs the frequency of the modulating waveform.

**Marker** – programs the frequency position of the marker. The marker is output through the front panel SYNC OUT connector as a single pulse when the CW frequency is equal to the marker frequency setting.

**Amplitude** – programs the amplitude of the carrier waveform.

**Offset** – programs the offset of the carrier waveform.

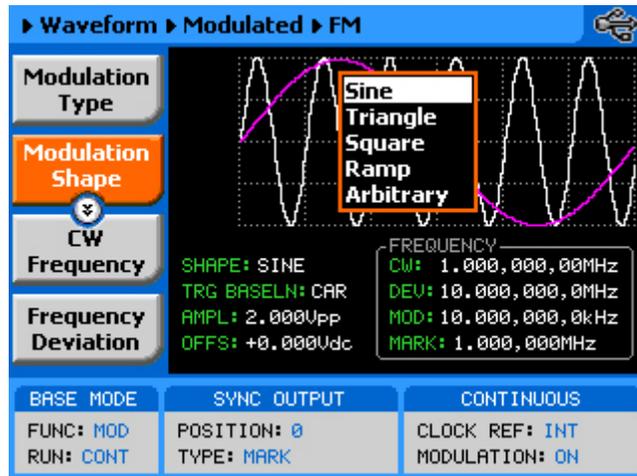


Figure 3-19, Modulating Waveform Shapes

## FSK

In Frequency Shift Keying (FSK), the output of the 8251 hops between two frequency settings: carrier and shifted frequency. The FSK sequence is controlled from the trigger input connector. Level below the trigger level setting generates CW and high generates shifted frequency.

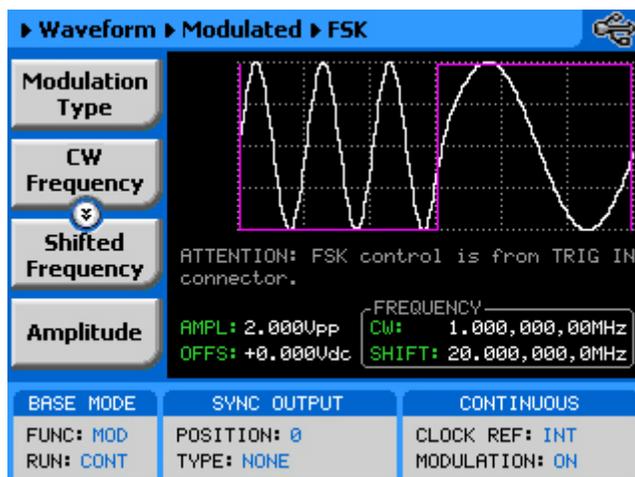


Figure 3-20, FSK Menus

When you select FSK modulation, the parameters, as shown in Figure 3-20 and described in the following paragraphs, will be available for modification:

**CW Frequency** – programs the carrier waveform frequency. The shape of the carrier waveform is always sine wave.

**Shifted Frequency** – programs the shifted frequency parameter.

**Amplitude** – programs the amplitude of the carrier waveform.

**Offset** – programs the offset of the carrier waveform.

## PSK

In Phase Shift Keying (PSK), the output of the 8251 hops between two phase settings: start and shifted phase while the frequency of the carrier waveform remain the same. The PSK sequence is controlled from the trigger input connector. Level below the trigger level setting generates 0° phase and high shifts the phase.

When you select PSK modulation, the parameters, as shown in Figure 3-21 and described in the following paragraphs, will be available for modification:

**CW Frequency** – programs the carrier waveform frequency. The shape of the carrier waveform is always sine wave.

**Shifted Phase** – programs the shifted phase parameter.

**Amplitude** – programs the amplitude of the carrier waveform.

**Offset** – programs the offset of the carrier waveform.

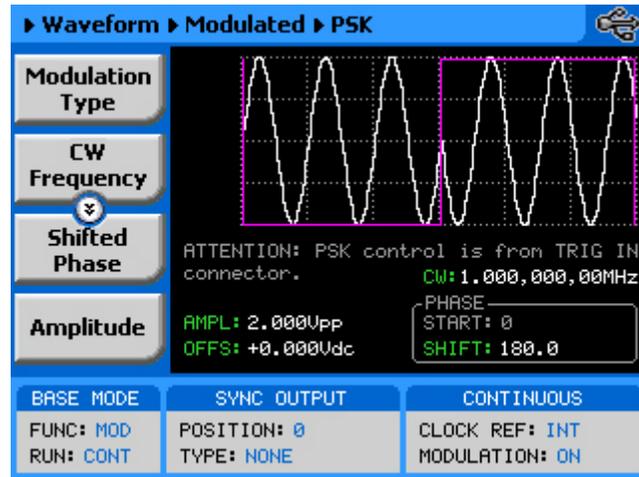


Figure 3-21, PSK Menus

## Sweep

In sweep modulation, the 8251 sweeps from start to stop frequencies at a rate set by the sweep time.

When you select sweep modulation, the menus, as shown in Figure 3-22 and described in the following paragraphs, will be available for modification:

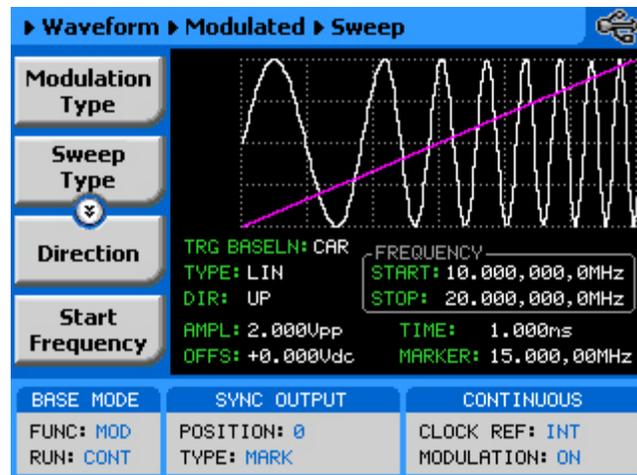


Figure 3-22, Sweep Menus

**Sweep Type** – defines the steps of which the frequency increments or decrements from start to stop frequencies. A choice is provided between linear and logarithmic steps. If you select linear sweep the carrier waveform frequency steps through the frequencies within a time interval which is set by the sweep time parameter. Likewise, using the logarithmic sweep type, the frequency span between the start and stop frequencies is stepped through using logarithmic steps. The menu that selects the sweep type is shown in Figure 3-23.

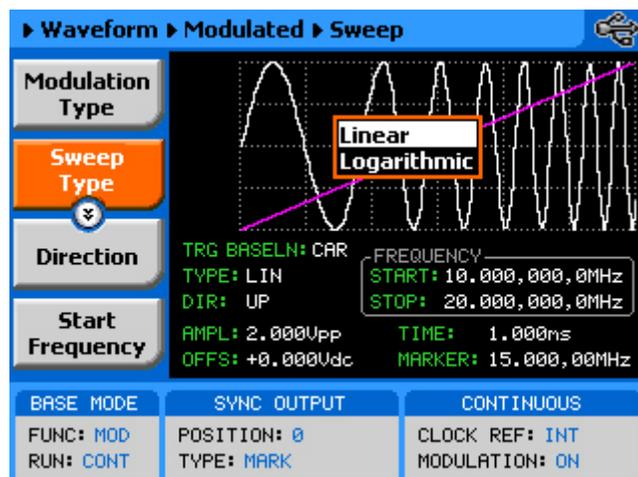


Figure 3-23, Selecting the Sweep Type

**Direction** – defines the sweep direction. UP sets sweep direction from start frequency to stop frequency; DOWN reverses the sweep direction so the output sweeps from stop frequency to start frequency.

**Start Frequency** – programs the start frequency value for the carrier waveform.

**Stop Frequency** – programs the stop frequency value for the carrier waveform.

**Sample Clk** – This parameter specifies where the sweep will stop. Note that sweep stop does not necessarily have to have lower value than the sweep stop frequency. If you define sweep stop frequency higher than the sweep start frequency, then the generator will sweep up. You can also reverse the direction of the sweep by using the sweep direction parameter.

**Sweep Time** – sets the time that will lapse for the 8251 output to execute one complete sweep cycle.

**Marker** – defines a frequency of which, when transitioned through, will output a marker pulse at the SYNC output connector. The default position of the marker is the sweep start frequency.

**Amplitude** – programs the amplitude of the carrier waveform.

**Offset** – programs the offset of the carrier waveform.

## Digital Pulse Generator

The Digital Pulse Generator feature adds capability to the 8251 in a form that allows programming pulse parameters in units of time, exactly as they are being programmed in a dedicated pulse generator product except, the waveforms are being generated from a digital circuit and make use of the large bank of arbitrary waveform memory that is available in the instrument.

Because the waveform is being generated digitally, the smallest increment of the pulse definition is a function of the size of the memory. The basic 8251 has 512K points of memory and therefore the smallest increment can be designed as  $1/512e3$  of the programmed period. For example, 10 ns of pulse width can be designed within a maximum period of 5.12 ms. As another example; Repetition rate of 1600 seconds can be designed with resolution of 3.125 ms.

The down side of the above feature is that the arbitrary waveform and the digital pulse design share one memory and therefore, the pulse design might overwrite memory segments that were downloaded to the arbitrary memory. Hence, in case you intend to sequentially use both the arbitrary waveforms and digital pulses, make sure your computer is ready with the arbitrary waveforms, every time you select the digital pulse function and then want to use the arbitrary function generator.

## Hardware compatibility

Since this added feature is basically construed of firmware routines, there are no hardware limitations to implement this feature in past or current hardware revision. The only limitation is memory size; For 512 K of memory, the programmable resolution is 1 increment over 512 K units.

## Firmware Version & Upgrade

The digital pulse generator feature is construed of firmware design only and no hardware updates are necessary for this function. In case you face difficulties or encounter operational bugs, contact the factory and request the latest firmware version be sent to you. You may then upgrade your instrument using the software update instructions that are given in Chapter 2.

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## Generating Pulses

The digital pulse generator function provides means of designing pulses and their associated parameters in units of time, exactly as would be done on a stand-alone, bench-type, analog pulse generator. Note however, that the pulse is built in the same memory as the arbitrary waveforms are being stored and therefore, changing from arbitrary to digital pulse modes and reverse, may overwrite waveforms that were downloaded to the memory. Use the instructions below to access and program the pulse menus.

1. Press TOP to display the root menu.
2. Press Waveform soft key and notice the Pulse function.
3. Press Pulse soft key Press to select the digital pulse generator function. Figure 3-25 shows the Digital Pulse Generator panel and menus.

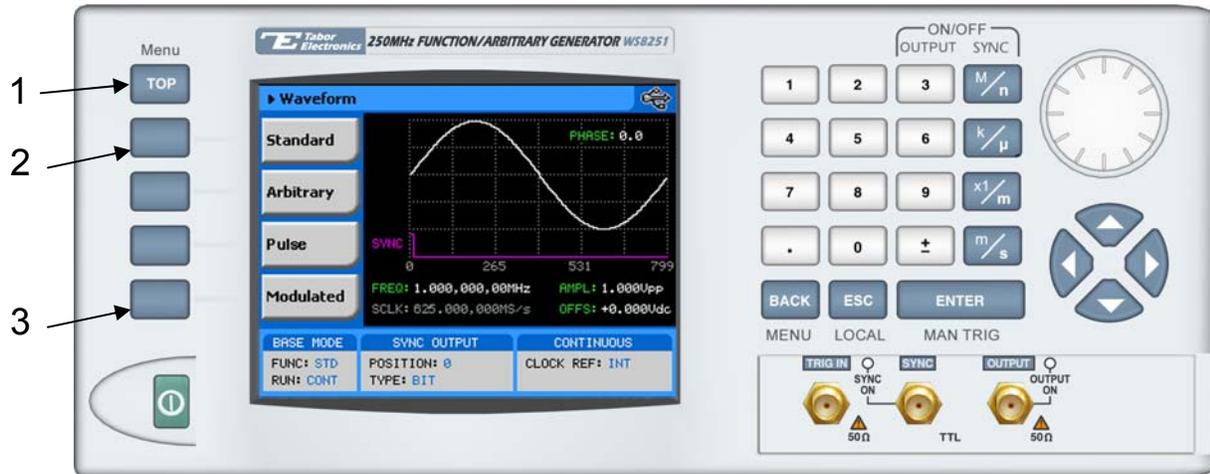


Figure 3-24, Accessing the Digital Pulse Generator Menus



**Note**

The picture in the 8251 LCD display is an icon only. The actual output waveform may look entirely different.



Figure 3-25, the Digital Pulse Generator Menus

The digital pulse generator menus provide access to all pulse parameters just as they would be programmed on an analog pulse generator.

To access the pulse parameters, use one of the soft keys. If you do not see a required parameter on the screen, press the key up or down to scroll through the menus.

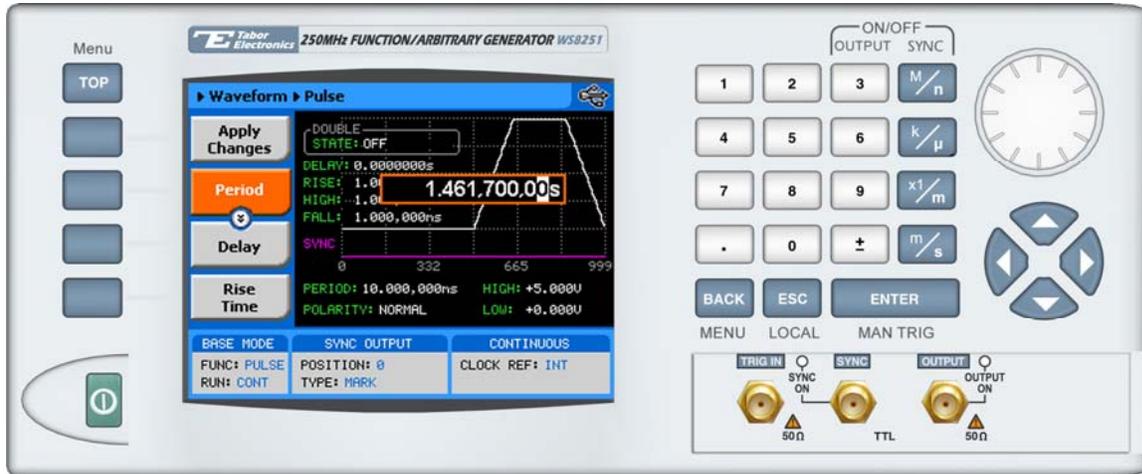


Figure 3-26, Programming the Pulse Period Parameter

The technique of changing parameter values is exactly the same as you are using to modify standard waveform parameters. Simply press the soft key that is associated with the parameter, then punch in the numbers using the numeric keyboard and complete the modification by assigning a suffix and pressing the Enter button. Figure 3-25 shows the screen after the Period soft key has been depressed.

The final step before the modified pulse shape will be available at the output connector is pressing the Apply Changes soft key. No change will be made on the pulse shape and at the output connector before the Apply Changes button has been pressed, except when the High and Low Level buttons are exercised. This was done to let the internal computing circuit do the calculation of the pulse parameters only once every time one or more parameters have been modified.

Adjusting the pulse shape with the required characteristics can only be done if all of its parameters can be adjusted both in the time and amplitude domain. The Model 8251 provides all the necessary controls to do just that. However, always bear in mind that the pulse is being generated digitally and therefore there are some limitations that would have to be observed. These limitations will be discussed later in this chapter. Below you will find a list of all pulse parameters that you'll be able to access through the soft key menus.

## Pulse Generator Menus

### **Apply Changes**

This, by far, is the most important key to understanding the pulse generation process. The 8251 is actually an arbitrary waveform generator, not a pulse generator however, with some firmware changes, the same memory that is being used by the arbitrary waveform function can be converted to design pulse shapes. In this case, every change of pulse period, parameter or transition, requires re-computation of the pulse shape and download sequence to the arbitrary waveform memory. The process is critical to assure that the pulse design was done within the legal boundaries and generation capabilities of the model 8251. To avoid multiple design conflicts and tedious exploration of why a pulse cannot be designed with this or that parameter, the Apply Changes button makes the choice only once at the end of the pulse design. Therefore, always make sure that after you complete the design of your pulse, press the Apply Changes soft key button to end the design process and to route the new pulse design to the output terminal.

### **Period**

The period defines the repetition rate of the pulse. The period is programmable from 4 ns to 16 s.

### **Delay**

The delay defines the time the pulse is delayed from its start to the first transition. The delay time is computed as part of the pulse period and therefore, if you do not plan to have a delayed pulse, change its value to 0 s.

### **Rise Time**

The rise time defines the time it takes for the pulse to transition from its low level to its high level settings. Do not confuse this parameter with the industry-standard interpretations of rise time such 10% to 90% of amplitude. The rise time is computed as part of the pulse period and therefore, if you do not plan to have linear transitions, change its value to 0 s.

### **High Time**

The high time defines the time idles on its high level setting. Do not confuse this parameter with the industry-standard interpretations of pulse width that is normally measured at 50% of amplitude level.

### **Fall Time**

The fall time defines the time it takes for the pulse to transition from its high level to its low level settings. Do not confuse this parameter with the industry-standard interpretations of fall time such 90% to 10% of amplitude. The fall time is computed as part of the pulse period and therefore, if you do not plan to have linear transitions, change its value to 0 s.

### **High Level**

The high level parameter defines the top amplitude level of the pulse. Any value is acceptable as long as it is larger than the low

level setting and does not exceed +3 V and does not fall short of the 100 mV minimum high to low level setting.

**Low Level**

The low level parameter defines the lower amplitude level of the pulse. Any value is acceptable as long as it is smaller than the high level setting and does not exceed -3 V and does not fall short of the 100 mV minimum high to low level setting.

**Polarity**

The polarity parameter provides access to selecting the polarity of the pulse. Three options are available: Normal, Inverted and Complemented. These options are defined below.

Normal – The pulse is generated with the parameters as programmed for the pulse

Inverted – The pulse is inverted about the 0V base line setting

Complemented – The pulse is inverted about the mid-amplitude base line setting

Note that except for Normal output, inverted and complemented replace high and low levels and rise and fall times.

**Double State**

The Double State toggles between single and double pulse modes. When double pulse state is turned on, the screen is replaced by an icon that shows that the double pulse mode is on, as shown in Figure 3-27. In this case, the Double Delay button is made available enabling access to the double pulse delay parameter.

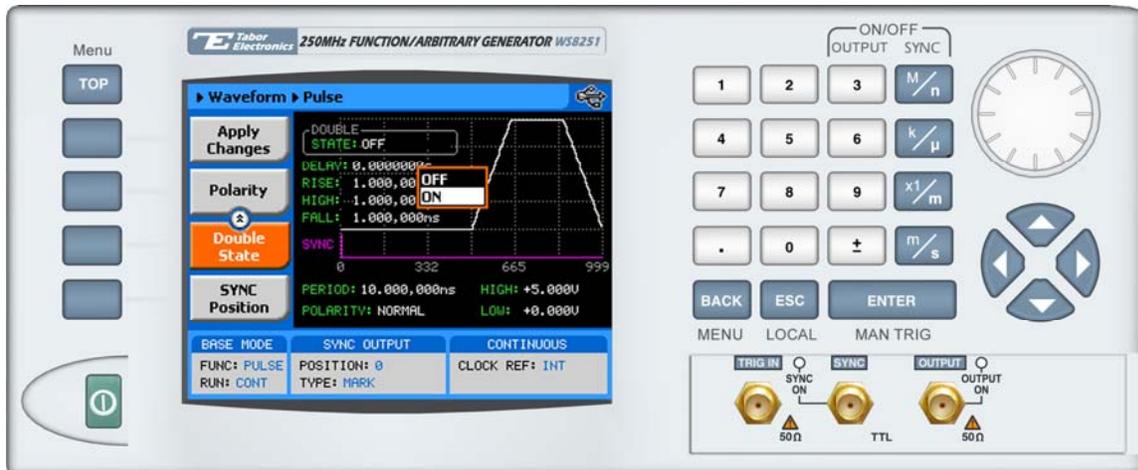


Figure 3-27, Double Pulse Mode

## Pulse Design Limitations

### **Double Delay**

The Double Delay parameter programs the delay between the two adjacent pulses. This parameter is active only when the double pulse mode is turned on.

### **Sync Position**

The Sync Position parameter programs the position of the sync output along the pulse cycle. The position is the only parameter that is programmed in units of waveform points. The location of the sync is visible on the screen below the pulse icon and the number of points that are used for building the pulse shape is shown below the horizontal axis.

Keeping in mind that the pulse is created digitally, using memory points, one should understand there are limitations of creating such pulses that evolve from this system. These limitations are summarized below.

#### *1. Step increment defines resolution and period*

The pulse is being created digitally using a sample clock generator that clocks memory points. The rate of the sample clock defines the incremental resolution. Consider that you want to generate 100 ms pulse rates with 1 ms high time pulse and the rest of the period low. In this case, the generator can select the 1 kS/s to 10 kS/s clock rate because this is enough for generating a high signal of 1 ms using just 100 to 1000 memory points. However, when you want to define much smaller pulse widths at larger rep rates, the number of points that are used for the generation increases as a function of the period. The limitation is set by the number of memory points; with the basic model 8251, the incremental resolution is 1 in 512 K.

#### *2. Sum of pulse parameters cannot exceed the period*

While designing a pulse shape, bear in mind that the generator will detect automatically if you are trying to mess with the mathematics. Therefore, remember, the sum of all parameters cannot exceed the period. Always start your pulse design by assigning the correct pulse period and only then work your way down the parameters list.

#### *3. Only single and double pulse can be designed*

Just as a stand-alone pulse generator, the capability that is built into the digital pulse generator allows generation of these two waveforms. This allows generation of single or double pulse patterns having a fixed high and low amplitude values. In case you need to design complex trains of pulse waveforms, you can always do it using the Pulse Composer in ArbConnection. The pulse composer allows creation of complex pulse trains without limiting amplitude, shape and number of pulses in one pulse train.

## Firmware Version & Upgrade

The digital pulse generator feature is construed of firmware design only and no hardware updates are necessary for this function. In case you face difficulties or encounter operational bugs, contact the factory and request the latest firmware version be sent to you. You may then upgrade your instrument using the software update instructions that are given in Chapter 2.

## Monitoring Internal Temperature

The 8251 has an internal temperature sensor that allows monitoring of the internal temperature. In cases where you suspect that the instrument is getting too warm, or malfunction occurs, you can monitor the internal temperature to see if the cause is excessive heat inside the unit. The temperature information is also available to read from a remote interface, so constant control over system temperature can be maintained.

Temperature reading is automatically read and displayed every time you select the System display from the Utility menus. Figure 3-28 is an example of the System menu, showing the temperature inside the unit as 35°C. The reading will not be update while in this menu so if you want to read it again at a later time, exit the System menu and re-enter it when you are ready for your next reading.



Figure 3-28, Reading the 8251 Internal Temperature

## Customizing the Menus

The 8251 allows some freedom in how you intend to set up the repetition rate of the output waveform. Normal set up is available in units of Hertz however, some users prefer to set up the repetition rate using units of time – seconds. If you prefer to set up your repetition rate in units of time, go to the Utility menu as shown in Figure 3-29 and select the Customize option, as shown in Figure 3-

30. Highlight the Horizontal Unit field and press Enter. Using the dial, change the units from Frequency to Period or back to Frequency and press Enter again to lock the selection.

Notice how your dial operates and, if you want to change its rotation action, change its direction using the same way as you changed the horizontal unit filed.



Figure 3-29, Selecting the Customize Menu



Figure 3-30, Customizing the 8251

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# Chapter 4

## ArbConnection

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## **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 8251 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 8251. ArbConnection has many functions and features of which all of them share a common purpose – controlling 8251 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) FM waveform generation and 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 disk in the A: drive.

Invoke Run and type:

```
A:\Setup
```

The install program does the complete job for 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 Tabor 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 described 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, simultaneously. 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 4-1.

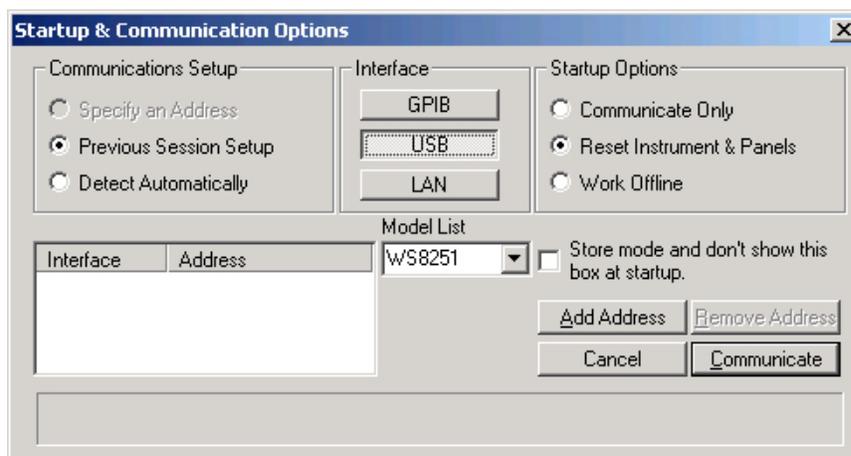


Figure 4-1, Startup & Communication Options

The Startup & Communication Options dialog box is displayed. You can check the “Store 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 a GPIB device that has address 4, 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 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 Figure 4-2.



Figure 4-2, 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 8251 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 8251, Offline.

The **Panels** toolbar, as shown in Figure 4-2, 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

## ArbConnection Features

ArbConnection's main purpose is controlling 8251 functions and parameters. The 8251 can generate standard waveforms from a built-in library, arbitrary waveforms from user-downloaded coordinates, modulated waveforms 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 8251.

ArbConnection has three main screens: Control panels, Waveform composer, 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 4-3, 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 8251 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 8251 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 8251 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



Figure 4-3 -, 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 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 operation set of panels are described below.

---

## The Main Panel

The Main Panel, as shown in Figure 4-3a, 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.



Figure 4-3a, 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 8251. 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: 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 8251 with the new reading.

#### **Wave Mode**

The Wave Mode group is used for selecting between waveform types. The 8251 provides three types of waveforms: Standard, Arbitrary, 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 this STD panel 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.

### SYNC Output

The SYNC control group controls the state and the source of the sync output. Click on the State buttons to toggle the SYNC output on and off. Note that regardless if the output is on or off, the electrical circuit maintains low impedance path to the output connector. It is recommended that the connecting cables are removed from the output, if uncontrolled transitions can damage the equipment that is connected to the sync output, which might occur when you power the 8251 on.

From this group you also control the position of the SYNC pulse and the source of the sync. If you select the SYNC source to be BIT, the sync pulse will have the shape of a single pulse at having a width of 16 sample clock periods and position as set by the position parameter. Selecting the SCOM will cause the sync output to transition at the beginning of the segment. The sync output will transition back to low level 16 points before the end of the segment. If the position parameter has been changed from point 0 to another location, the high transition will occur at the new position point and back to low 16 point before the end of the segment.

### Output

The output control group controls the state of the main output. Click on the State buttons to toggle the output on and off.

## The Standard Waveforms Panel

The Standard Waveforms panel, as shown in Figure 4-4, is accessible after you click on the Standard button in the Panels bar. The functional groups in the Standard Waveforms Panel are described below.

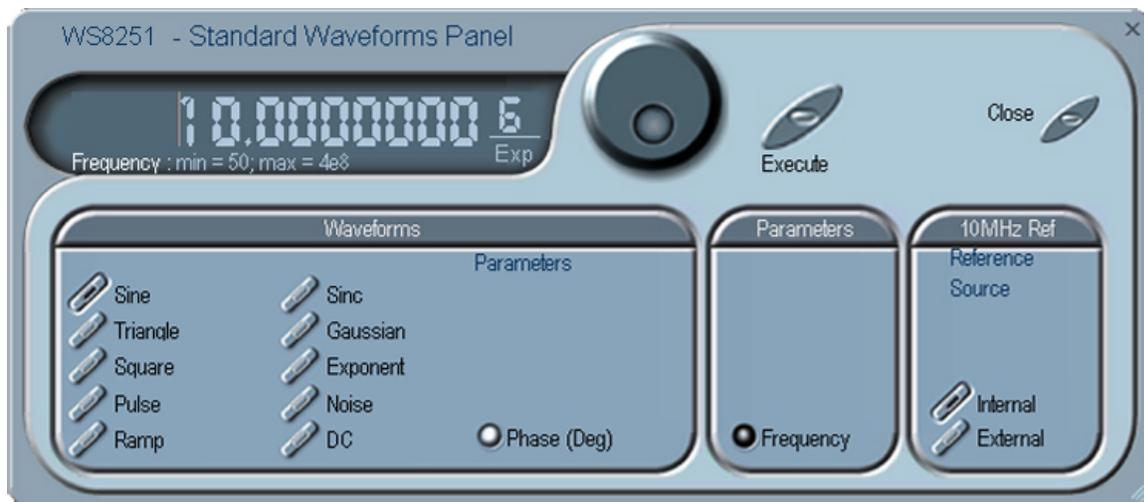


Figure 4-4, the Standard Waveforms Panel

### **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 8251 output with this waveform shape.

### **Parameters**

The parameters group provides access to setting of the output frequency for the standard waveforms function.

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 8251 with the new reading.

### **10MHz Ref**

The 10MHz Reference group contains buttons that control the source of the 10MHz.

The 10MHz Ref controls toggle between an internal and external references. The default setting is internal, which provides frequency accuracy of 1ppm. 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 Arbitrary Panel

The Arbitrary panel, as shown in Figure 4-5, is invoked by pressing the Arbitrary button on the Panels bar. Note that if you invoke the Arbitrary Panel from the Panels menu, the 8251 will not change its output type. On the other hand, if you select the arbitrary wave mode from the Main Panel, the 8251 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 Select Segment. The values of the first two parameters as 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 main panel is updated automatically. The Select Segment provides access to the active segment that is generated.

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 8251 with the new reading.



Figure 4-5, 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 8251 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 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 8251 with the new reading.

### **Memory Management**

The memory management group provides access to the memory partition screen. The Waveform Partition button opens a screen as shown in Figure 4-6. Information how to use this screen 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 3 of this manual. In general, the 8251 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 8251 in a place designated as “waveform memory”. The waveform memory has a finite size of 512k.

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 8251 allows segmentation of the memory so that up to 1000 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 4-6 will pop up.

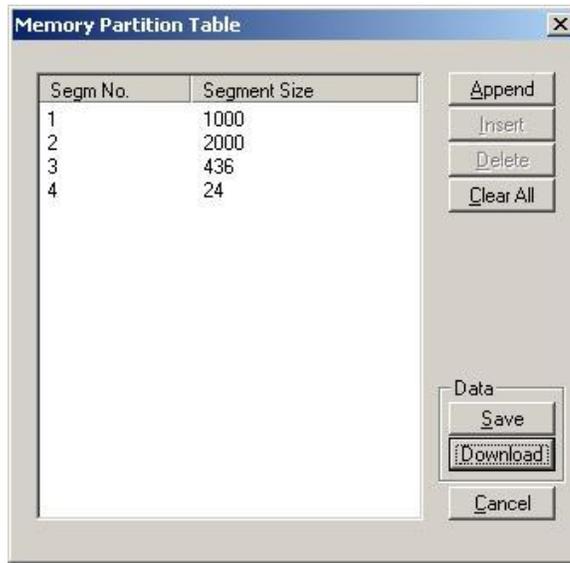


Figure 4-6, the Memory Partition Table

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 1000. The **Segment Size** is always associated with the segment number. You can program any segment size from 16 to 512k.

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 8251 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.

## The Trigger Panel

The Trigger panel, as shown in Figure 4-7, is invoked by pressing the Trigger button on the Panels bar. Note that if you invoke the Trigger Panel from the Panels menu, the 8251 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 8251 only if an appropriate run mode setting has been selected. The functional groups in the Trigger Panel are described below.



Figure 4-7, the Trigger Panel

### Trigger Modifier

The Trigger modifier group provides access to delayed trigger state and its delay parameter. To change trigger delay parameter, point and click on the Trigger Delay parameter. The value 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 8251 with the new reading.

### Trigger Parameters

**Slope** - The Slope group lets you select edge sensitivity for the trigger input of the 8251. 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 8251 can accept triggers from a number of sources: External, Internal or BUS. When the BUS option is selected, only bus commands triggers the instrument. The EXT option is the default trigger option which enables the rear panel trigger input and the front panel manual trigger button. The Internal option disables the rear-panel trigger input and ignores remote command and enables an internal built-in trigger oscillator that can be adjusted for its period. The internal trigger generator is free running and is asynchronous to the sample clock or the 10MHz reference oscillator.

**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.

**Int Trigger** – Programs the period of the internal trigger generator. The programmed parameter will affect the 8251 only when it will be set to use the internal trigger generator.

**Trigger Level** – Programs the trigger level parameter. Depending on the slope setting, the 8251 will be stimulated to output waveforms when the trigger level threshold has been crossed.

**Trigger Level** – Programs the trigger level parameter. Depending on the slope setting, the 8251 will be stimulated to output waveforms when the trigger level threshold has been crossed.

**Burst** – Programs the burst count parameter. The programmed parameter will affect the 8251 only when it will be set to burst run mode. Minimum burst count is 2.

To modify one of the trigger parameters, point and click on one of these parameters. 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 8251 with the new reading.

---

## The Modulation Panels

The Modulation functions were designed over two separate panels, as shown in Figures 4-8 and 4-9. The panels are invoked by pressing the Modulation header and then one of the modulation panels that appear below it. These panels provide access to all modulation functions and their respective run modes and parameters. The modulation functions that are available on these panels are: FM (frequency modulation), FSK (frequency shift keying), PSK (phase shift keying) and Sweep. When modulation run is other than continuous, the instrument generates non-modulated carrier frequency (CW) until a valid stimuli signal is applied.

Each of the modulation panels has a different set of functions and parameters. The Modulation Panel 1 has control for selecting the modulation function and for programming the FM function. These

groups are described below. The panel is invoked by pressing the FM button on the panels bar.

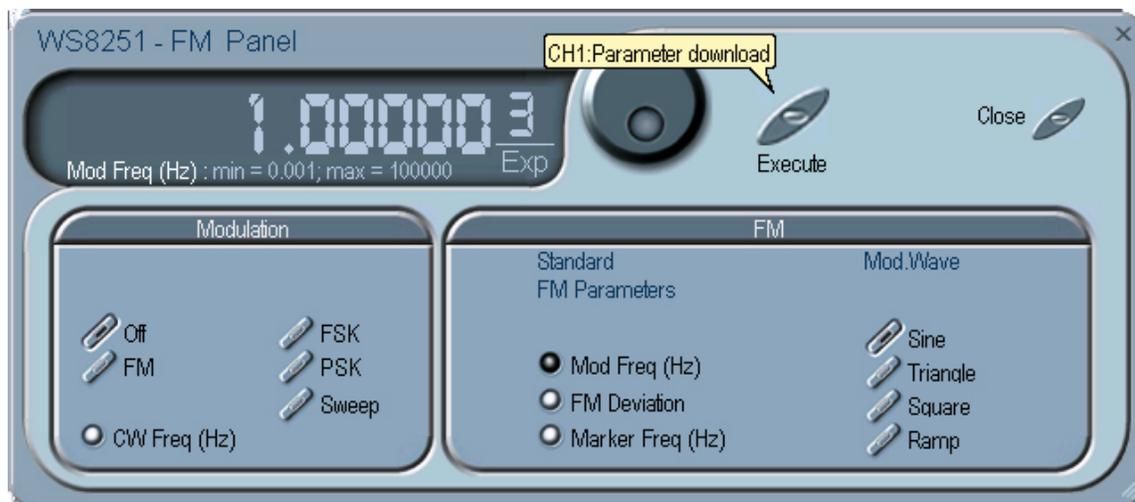


Figure 4-8, the FM Modulation Panel

## FM

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

### **Mod. Wave**

Defines the shape of the modulating waveform. There are two basic options: Standard waveforms and Arbitrary waveforms. If you do not need exotic waveforms, you can use one of the built-in standard wave shapes: Sine, Triangle, Square, or Ramp. These waveforms can be adjusted for their frequency and deviation range. On the other hand, you can select the arbitrary modulating wave option where you can use any shape however, you must load the modulating waveform from an external application, such as the FM composer in ArbConnection. Information on the standard and arbitrary FM functions is given in Chapter 3. Click on the button next to the required modulating waveform shape to select it.

### **Standard FM Parameters**

Allow adjustment of the parameters that are associated with the standard modulating waveform. The controllable parameters are Modulation, Deviation and the Marker Frequencies.

### **Arbitrary FM Parameters**

Allow adjustment of the sample clock of the modulating waveform. The shape of the modulating waveform must be downloaded from an external utility such as ArbConnection and the sample clock is programmed from this location.

To change the FM parameters, point and click on 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 8251 with the new reading.



Figure 4-9, the Sweep & FSK/PSK Modulation Panel

## Sweep

The Sweep group contains parameters for controlling sweep options. To turn the Sweep function on and off, click on the Sweep button in Modulation group. The various parameters that control sweep features are described below.

### Parameters

Allow adjustment of Sweep Start, Stop and Sweep Time. You can also place a marker at a position programmed by the Mark parameter. 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 8251 with the new setting.

### Step

Use these keys to select sweep step from two increment options: linear, or logarithmic.

### Direction

Use these keys to program sweep direction. Up select sweep from Start to Stop sample clock setting and Down selects sweep from the Stop to Start sample clock setting. Refer to Chapter 3 of this manual to learn more about sweep operation.

## FSK/PSK

The FSK/PSK group contains parameters for controlling the FSK and the PSK functions. To select the required function, click on the FSK or PSK button.

### **“1” Frequency**

In FSK, the carrier waveform (CW) has two frequencies: an initial frequency which is set by the CW parameter and shifted frequency which is set by the “1” frequency. The control is external from the rear panel trigger input. When the trigger level is low, the 8251 outputs CW. When the trigger level is high, the 8251 outputs shifted frequency. In FSK, phase of the waveforms is always 0°.

### **“1” Phase**

In PSK, the carrier waveform (CW) frequency is constant while the phase shifts between two phases: an initial phase 0° and shifted phase which is set by the “1” phase parameter. The control is external from the rear panel trigger input. When the trigger level is low, the 8251 outputs CW with 0°. When the trigger level is high, the 8251 outputs shifted phase.

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 8251 with the new reading.

---

## The Utilities Panel

The Utilities 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: System/General, which provides access to some system commands, utilities, filters and calibration; and Pulse Generator which contains controls that select the pulse function and adjusts the pulse parameters.

## System/General

The System/General panel has three groups: Data base, for monitoring instrument-specific identifications, Filter, for assigning a specific filter to the output path and System Commands for accessing certain calibration and data base structures and for sending specific system commands to the instrument. The System/General panel and the various parameters that control these functions are described below.

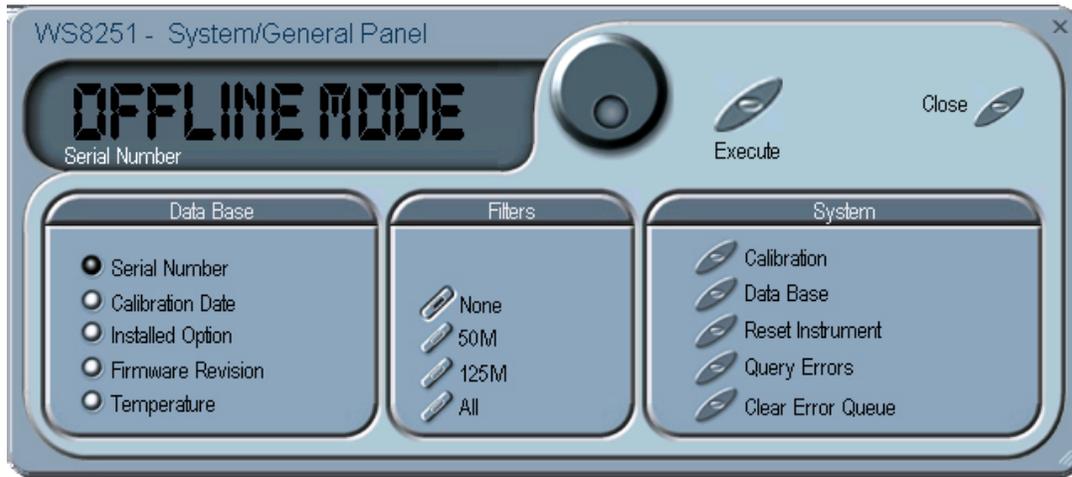


Figure 4-10, the Utility Panel

### **Data Base**

The data Base group provides access to specific instrument identifications such as: Serial Number, Calibration Date, Options and Firmware Revision. These parameters should be current or there is danger that the instrument is not updated to the latest firmware revision. Compare the listing with that published on the web to check if your instrument is current. Also note that the recommended calibration period is 1 year and therefore, if your calibration date is not current, your instrument may not meet the published or updated specifications. Information how to calibrate the instrument is given in Chapter 7.

### **Filter**

The Filter group provides access to filters for both the Normal and Inverted outputs. The filters can only be used when the instrument is NOT generating standard sinewave because the filters are automatically used for sine wave reconstruction and cannot be switch in and out while in this function. There are two filters available. When in Off, the filters are disabled. Whn in both, both filters are switched in.

### **System**

The System Commands group provides access to system parameters such as Instrument Reset and Query Errors. The Reset Instrument button is needed in places where you get stuck with instrument programming and want to start from a fresh and know state. The default parameters are described in the programming section of this manual.

You can also access the calibration panel from this panel however, entering the calibration panel requires password that is available to service centers only. Information how to access the calibration and data base functions is given in Chapter 7.

## Pulse Generator

The Pulse Generator panel contains controls that select the pulse function and adjusts the pulse parameters. The pulses are generated digitally using 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.

### **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.

### **Pulse Parameters**

There are two types of pulse parameters: the Shared parameters are common to both channels so modification of one of these parameters affects both channels simultaneously. The shared parameters are Period, Rise Time, High Time and Fall time.

There are also other parameters that can be programmed individually for each channel. These are: Delay, High Level and Low level.

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 Command Editor

The Command Editor is an excellent tool for learning low level programming of the 8251. Invoke the Command Editor from the System menu at the top of the screen. Dialog box, as shown in Figure 4-11 will pop up. If you press the Download button, the function call in the Command field will be sent to the instrument.

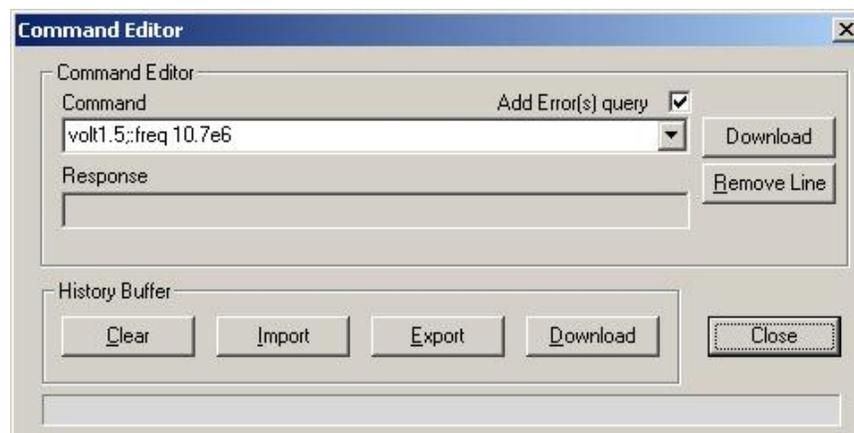


Figure 4-11, the Command Editor

Low-level SCPI commands and queries can be directly sent to the 8251 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 Chapter 5.

## The Wave Composer

Being an arbitrary waveform generator, the 8251 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. 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 8251 using the Waveform Composer.

To launch the wave composer point and click on the WAVE button in the Panels bar. Figure 4-12 shows an example of the wave composer. The Wave Composer has main sections: Commands bar, Toolbar and Waveform screen. Refer to Figure 4-12 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.

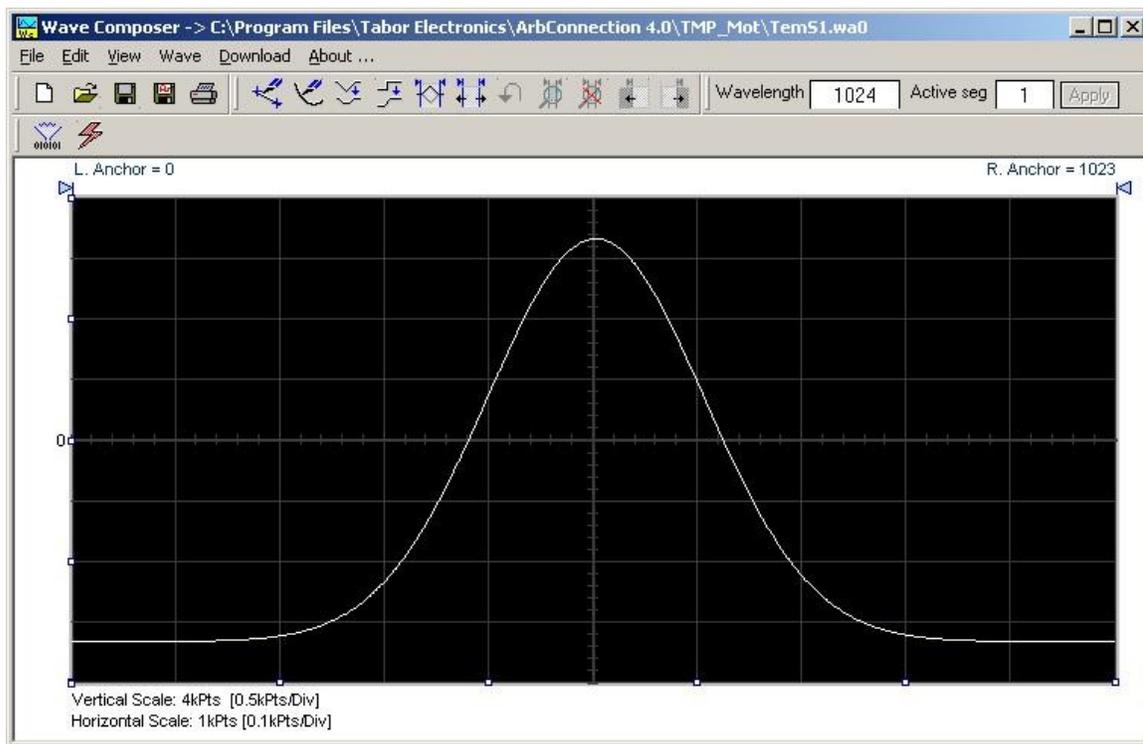


Figure 4-12, the Wave Composer Opening Screen

## 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 4-13 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 standard ArbConnection file.

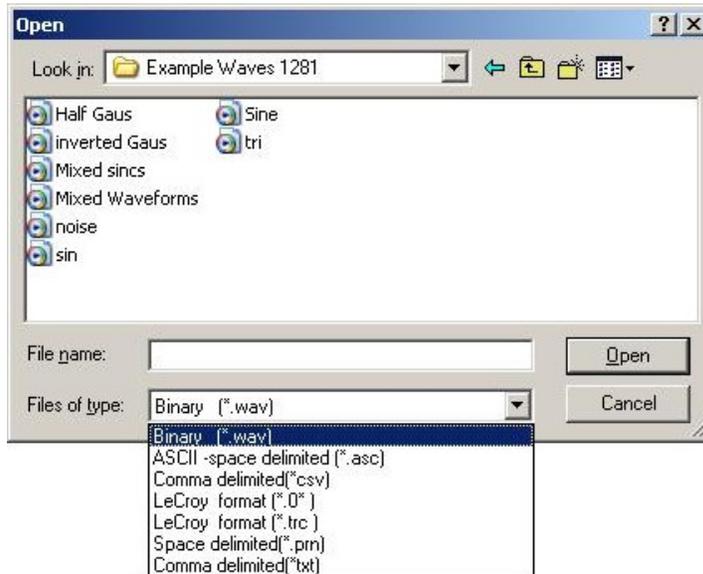


Figure 4-413, the Open Waveform Dialog Box

### **Save Waveform**

The Save Waveform (Ctrl+S) command will store your active waveform in your 8251 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.

### **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 waveform 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  $\frac{1}{2}$  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 4-14, 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.

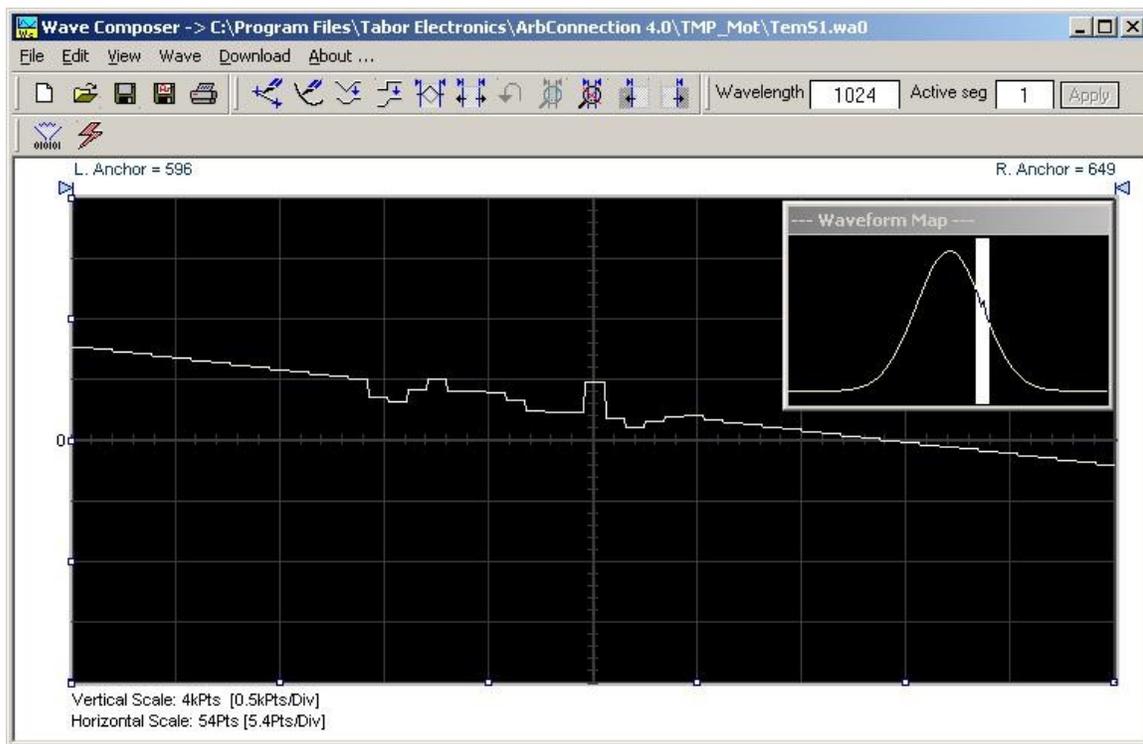


Figure 4-14, Zooming In on Waveform Segments

## Wave Commands

The Wave commands let you create waveforms on the screen. The Wave command has a library of 8 waveforms: Sine, Sawtooth, Square, Sinc, Gaussian, Exponent, Pulse, and Noise. It also lets you create waveforms 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 4-15. 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 4-15 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. The example shows end point

set at point 499.

**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** – 12-bit of vertical define 4,096 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.

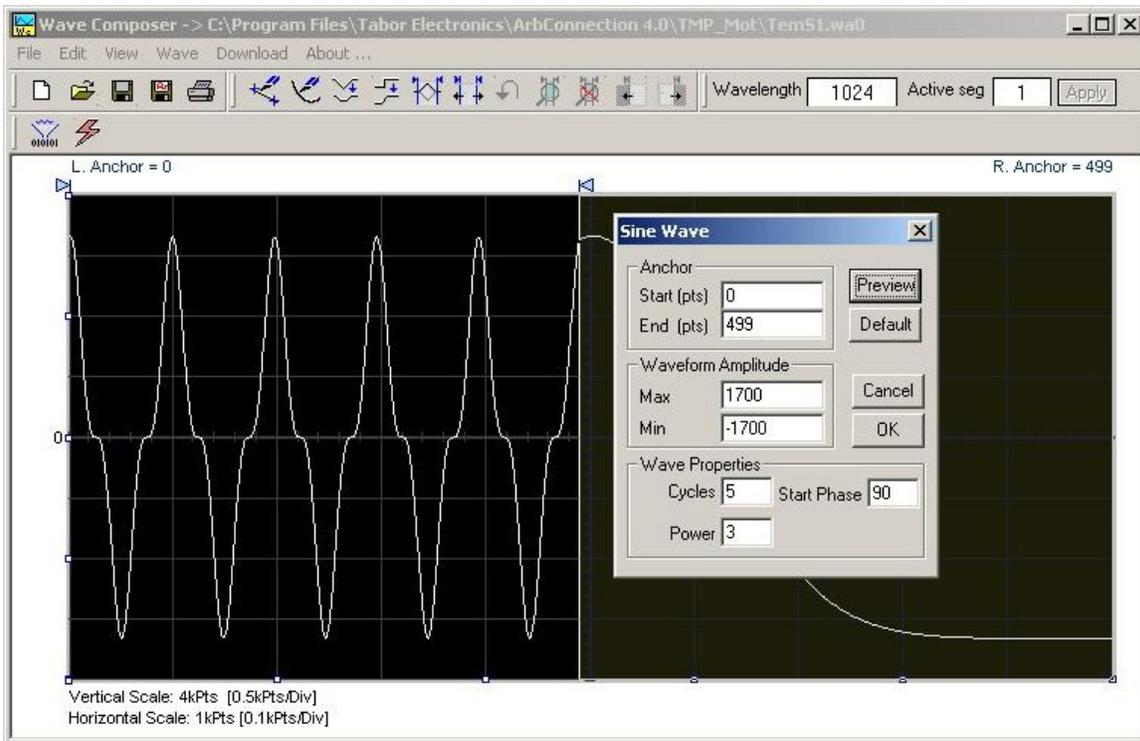


Figure 4-15, Generating Distorted Sine waves from the built-in Library

## 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 4-16. For the individual icons, refer to the descriptions above of the Wave Composer Menus.



Figure 4-16, the Toolbar Icons

## The Waveform Screen

Waveforms are created and edited on the waveform screen. Figure 4-17 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 –2047 through 2048 for a total of 4096 point. This number represents 12 bits of vertical resolution and cannot be changed because it is critical to the range of which the 8251 operates.

The horizontal axis, by default has 1024 points (from point 0 to 1023). 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 512k words.

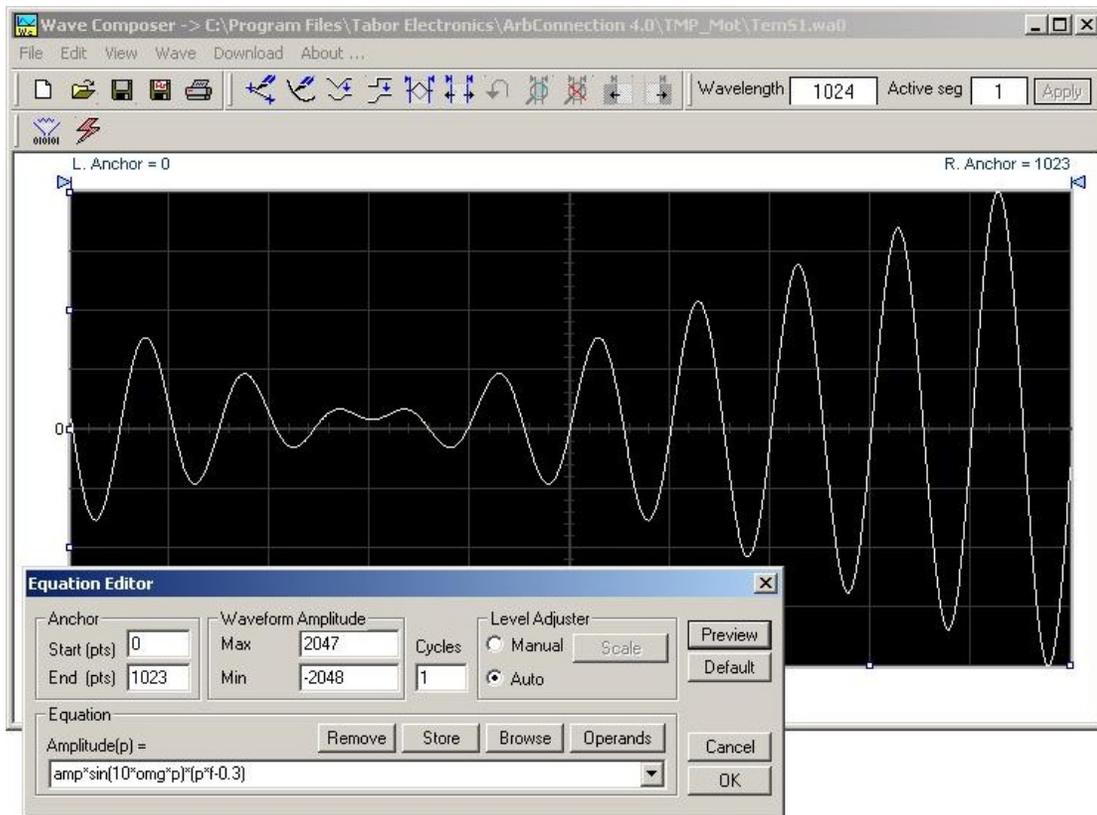


Figure 4-17, the Waveform Screen

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 4-15.

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 4-18 will display. Use the following paragraphs to learn how to use this dialog box and how to write your equations.

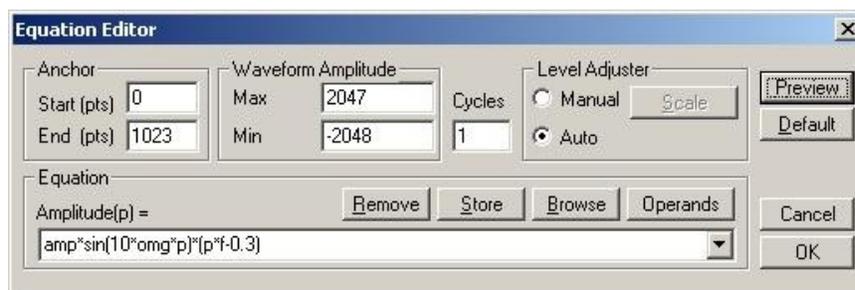


Figure 4-18, the Equation Editor Dialog Box

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.

For example, look at the equation that is shown in Figure 4-19. This equation will generate the waveform as shown in Figure 4-20.

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 8251 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  $\text{Amplitude}(p)=$ , 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 Conventions

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  $1 / \text{per}$ ; omg, which equals  $2 * \text{pi} / \text{per}$ , and numerals in the range of  $-1\text{E}^{20}$  to  $1\text{E}^{20}$ .

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
-	Subtract
()	Parentheses
e	Base of natural Logarithm
pi ( $\pi$ )	Circumference of unit-diameter circle
per	Horizontal wavelength in points
f	$1 / \text{per}$
omg ( $\Omega$ )	$2 * \text{pi} / \text{per}$
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 10 logarithm of x

$\ln(x)$	The natural (base e) logarithm of x
$\text{abs}(x)$	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:

$$\text{Amplitude}(p)=1000$$

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

$$\text{Amplitude}(p)=-2*p+2000$$

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:  $\text{Amplitude}(p)=-2p+1000$ , 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:

$$\text{Amplitude}(p)=\sin(10)$$

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:

$$\text{Amplitude}(p)=\sin(\text{omg}*p)$$

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:

$$\text{Amplitude}(p)=4000*\sin(\text{omg}*p)$$

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:

$$\text{Amplitude}(p)=4000*\sin(\text{omg}*p*10)$$

## 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:

$$\text{Amplitude}(p)=4000*\sin(\text{omg}*p*10)-8*p+4000$$

Press [Preview]. Your screen should look like Figure 4-19.

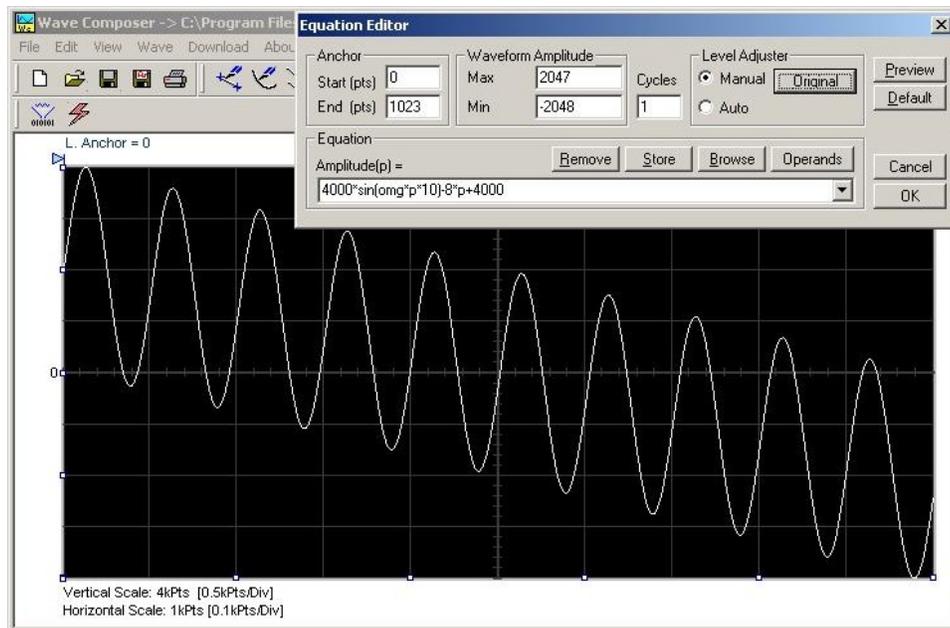


Figure 4-19, an Equation Editor Example

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

$$\text{Amplitude}(p)= 2000*\sin(\text{omg}*p)*\cos(\text{omg}*p*30)$$

Press [Preview]. Your screen should look like Figure 4-20.

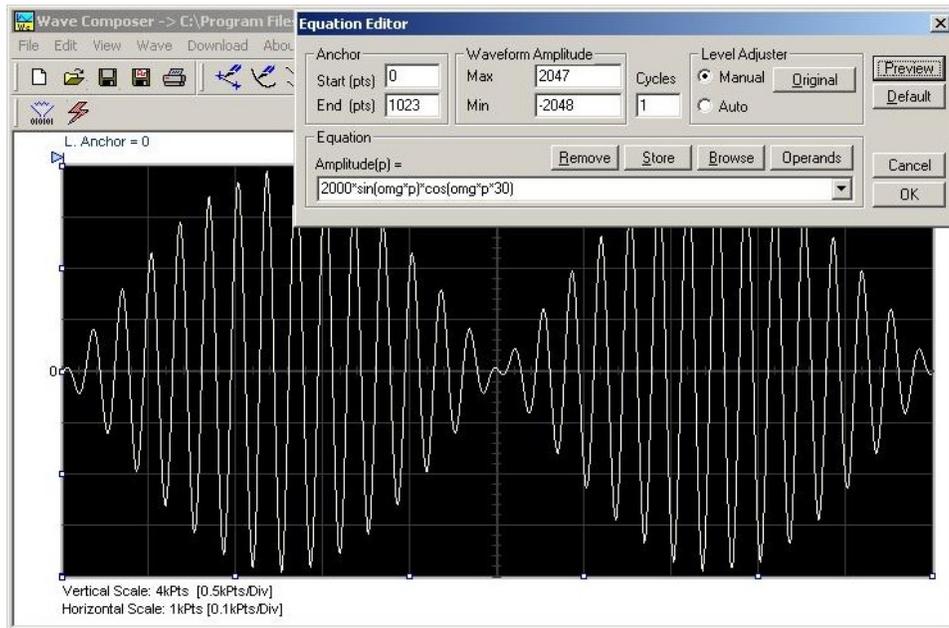


Figure 4-20, Using the Equation Editor to Modulate Sine Waveforms.

In the following example, as shown in Figure 4-22, 16.6% second harmonic distortion has been added to a standard sinewave. The original waveform had a peak-to-peak value of 1800 points so 16.6% second harmonic is equivalent to 300 points. The frequency of the second harmonic is obviously double that of the fundamental, so term  $+300 \cdot \sin(2 \cdot \omega m g \cdot p)$  is added to the original sine wave equation. Use the following equation:

$$\text{Amplitude}(p) = 1800 \cdot \sin(\omega m g \cdot p) + 300 \cdot \sin(2 \cdot \omega m g \cdot p)$$

Press [Preview]. Your screen should look like Figure 4-21.

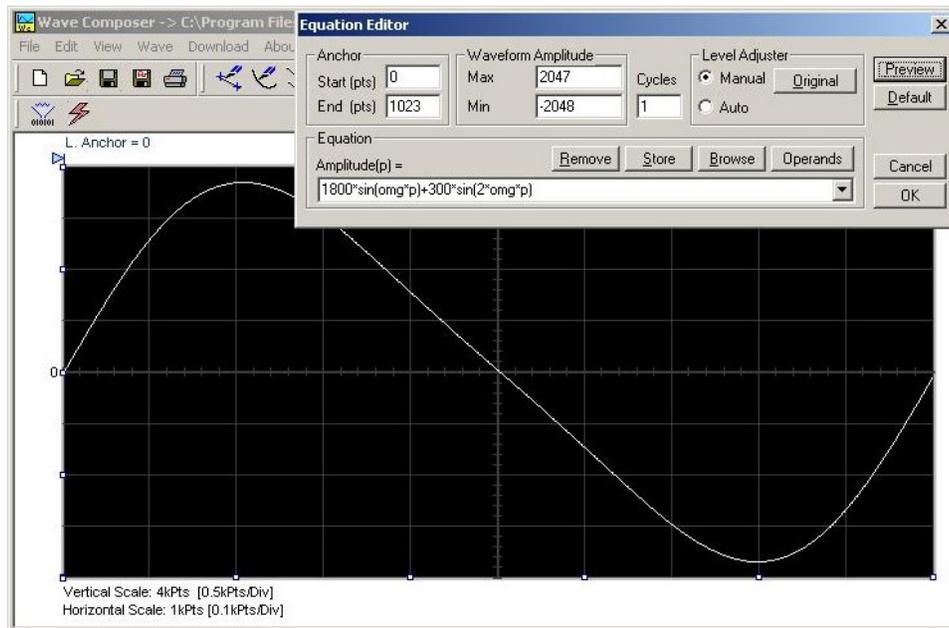


Figure 4-21, Using the Equation Editor to Add Second Harmonic Distortion.

In Figure 4-22 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 divider (250 in this case) will slow down the rate of decay.

Use the following equation:

$$\text{Amplitude}(p)=2000*\sin(\text{omg}*p*10)*e^{(p/-250)}$$

Press [Preview]. Your screen should look like Figure 4-22.

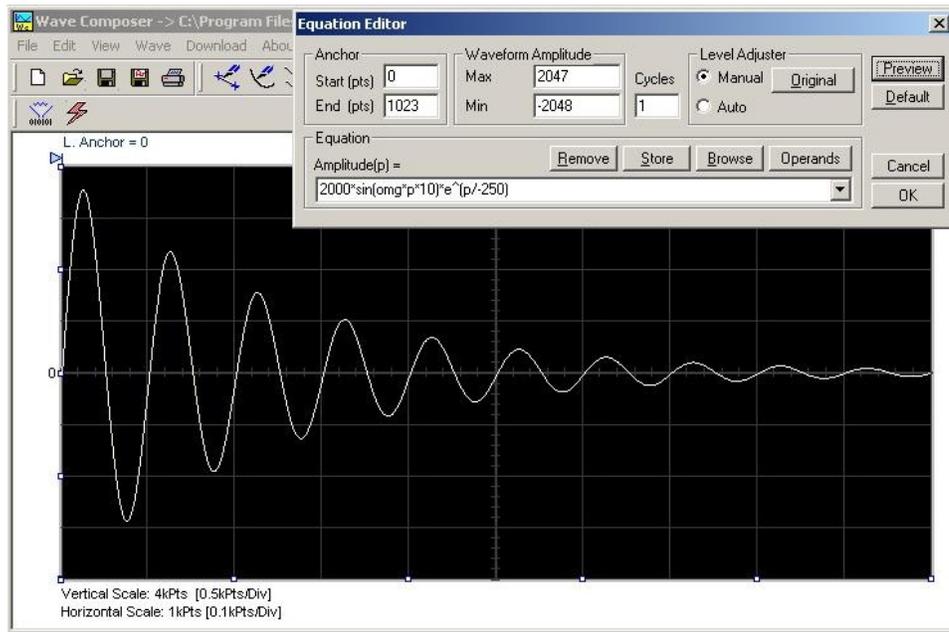


Figure 4-22, Using the Equation Editor to Generate Exponentially Decaying Sinewave

The last example as shown in Figure 4-23 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  $100 \cdot \cos(110 \cdot \text{omg} \cdot p)$  and the lower sideband by the term  $100 \cdot \cos(90 \cdot \text{omg} \cdot p)$ .

Use the following equation:

$$\text{Ampl}(p) = 6000 \cdot \sin(100 \cdot \text{omg} \cdot p) + 1200 \cdot \cos(110 \cdot \text{omg} \cdot p) - 1200 \cdot \cos(90 \cdot \text{omg} \cdot p)$$

Press [Preview]. Your screen should look like Figure 4-23.

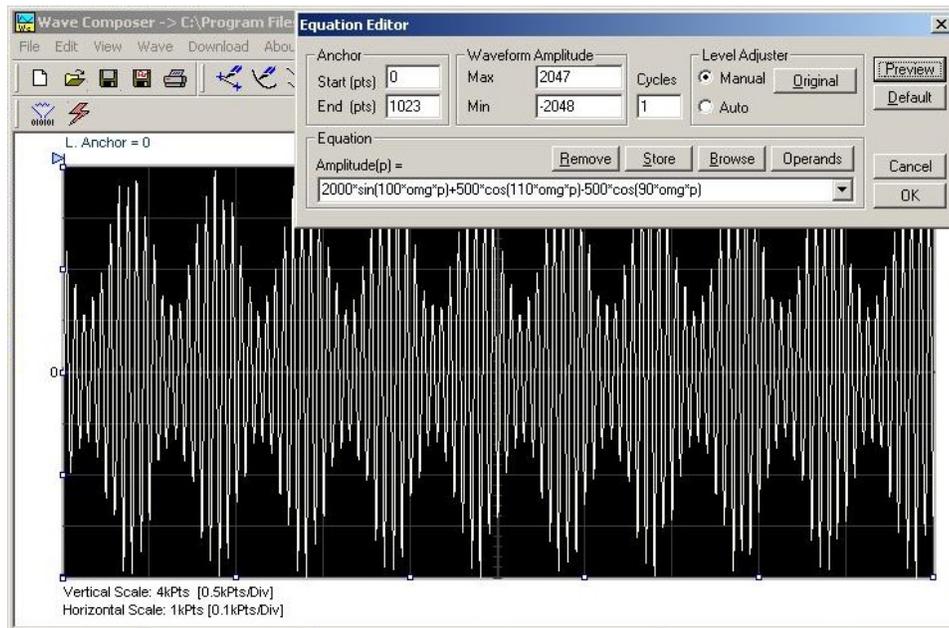


Figure 4-23, Using the Editor to Build Amplitude Modulated Signal with Upper and Lower Sidebands

## 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.

$$\text{Amplitude}(p) = \text{Sine.wav} * \sin(\text{omg} * p * 10) * \text{Noise.wav} / 1000$$

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:

$$\text{Amplitude}(p) = c / \text{Sine.wav} * \sin(\text{omg} * p * 5) * c / \text{Noise.wav} / 10$$

If you did not make any mistakes, your waveform screen should look as shown in Figure 4-24

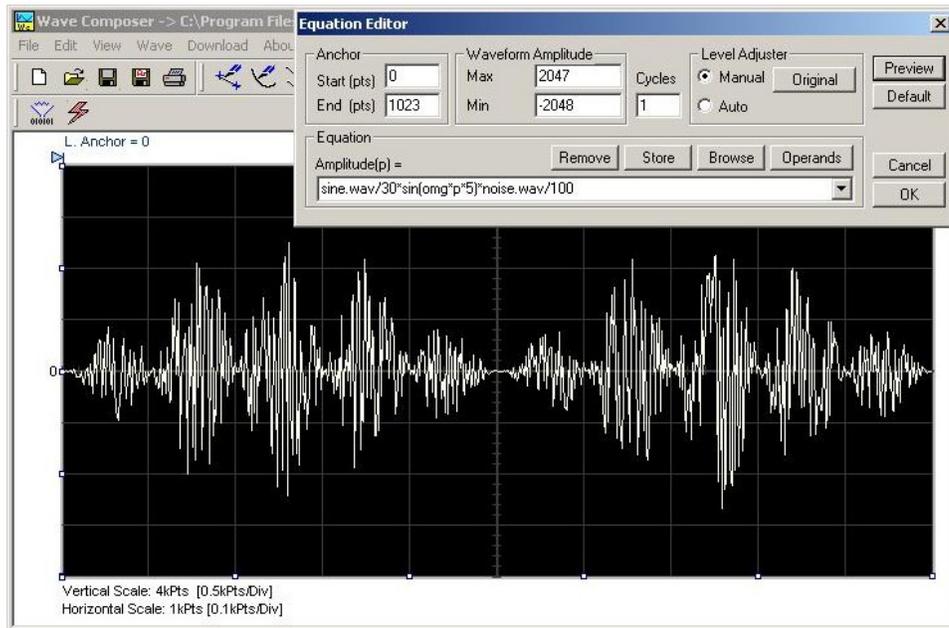


Figure 4-24, Combining Waveforms into Equations

## 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.

To launch the pulse composer point and click on the PULSE button in the Panels bar. Figure 4-25 shows an example of the pulse composer. The Pulse Composer has three main sections: Commands bar, Toolbar and Waveform screen. Refer to Figure 4-26 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 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 Pulse Composer. The various commands in the Commands bar are listed and described below.

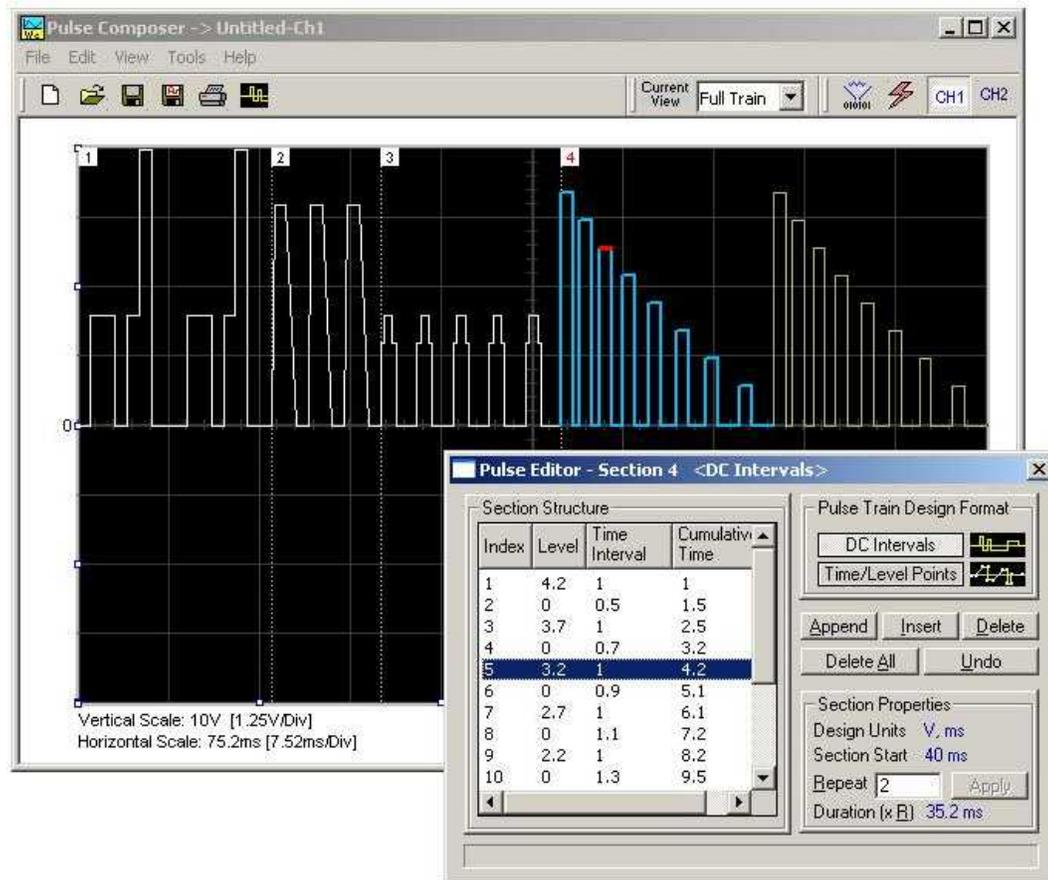


Figure 4-25, the Pulse Composer Screen

## 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 8251 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, Channel 1 and 2 screens 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 4-26. 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.

**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.

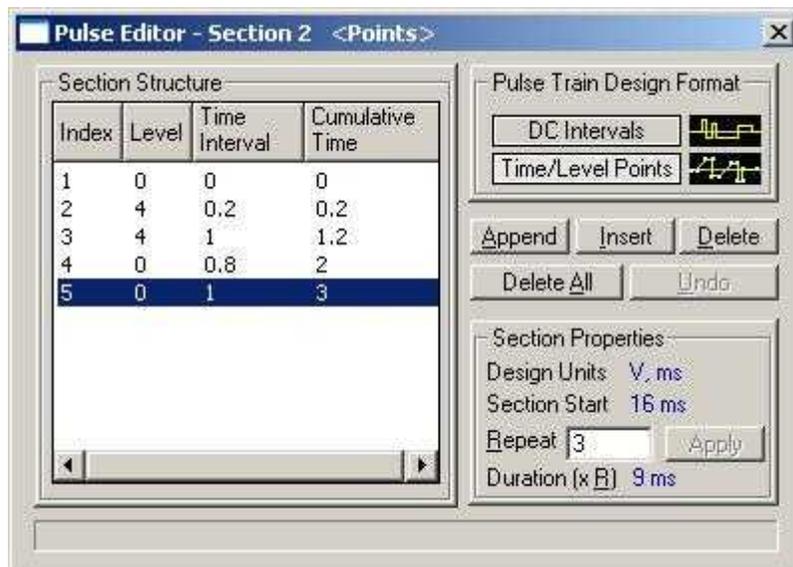


Figure 4-26, the Pulse Editor

### 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 3-27. Use this dialog box to fine-tune the pulse composer to the way it should deal with operational modes and the waveform memory. Options information options is given later in this chapter.

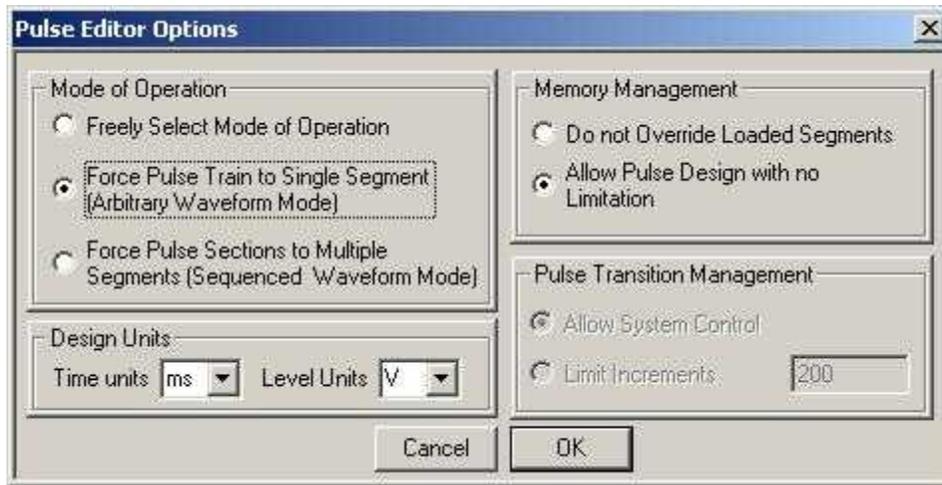


Figure 4-27, the Pulse Editor Options

## Tools Commands

The Tools commands let you download pulse trains. 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 8251 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 4-28. 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 clear the memory and download the displayed pulse train to the active channel.

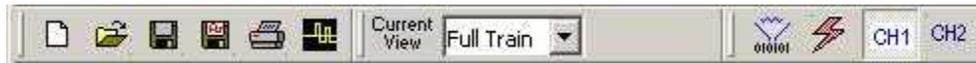


Figure 4-28, the Pulse Composer Toolbar Icons

## 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 4-26.

### **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 4-29 shows a complex pulse train which was made from five simpler sections and Figure 4-30 shows the design of the fifth section only of the pulse train.

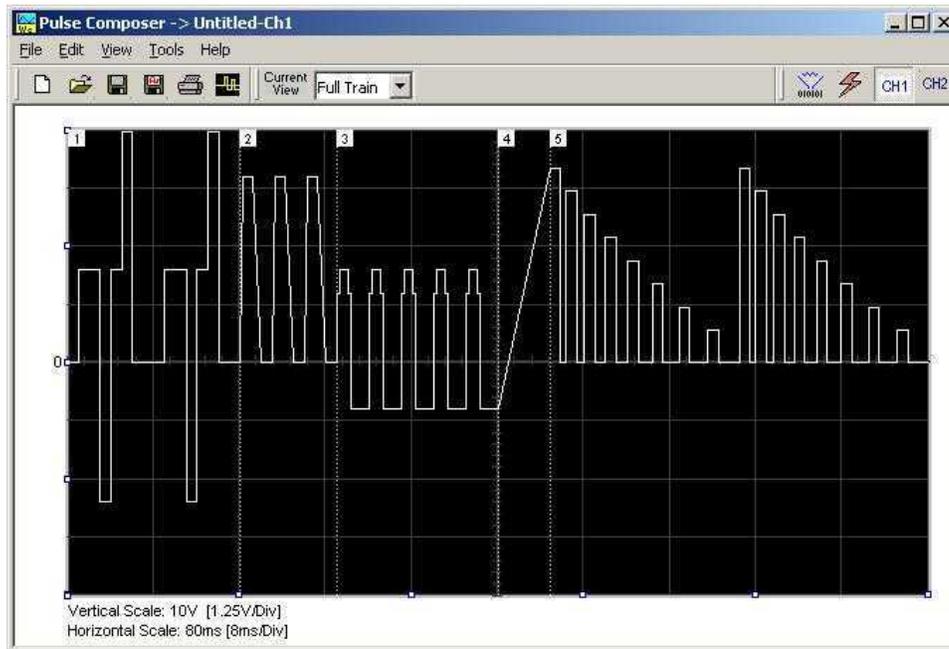


Figure 4-29, Complete Pulse Train Design

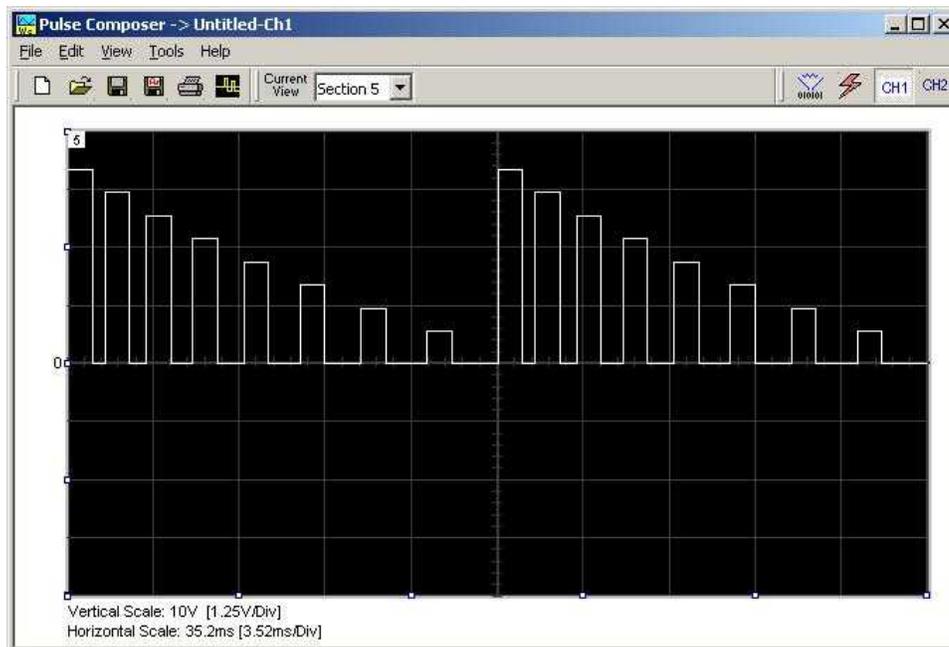


Figure 4-30, Section 5 of the Pulse Train Design

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 4-30. 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 4-31 throughout the following description.

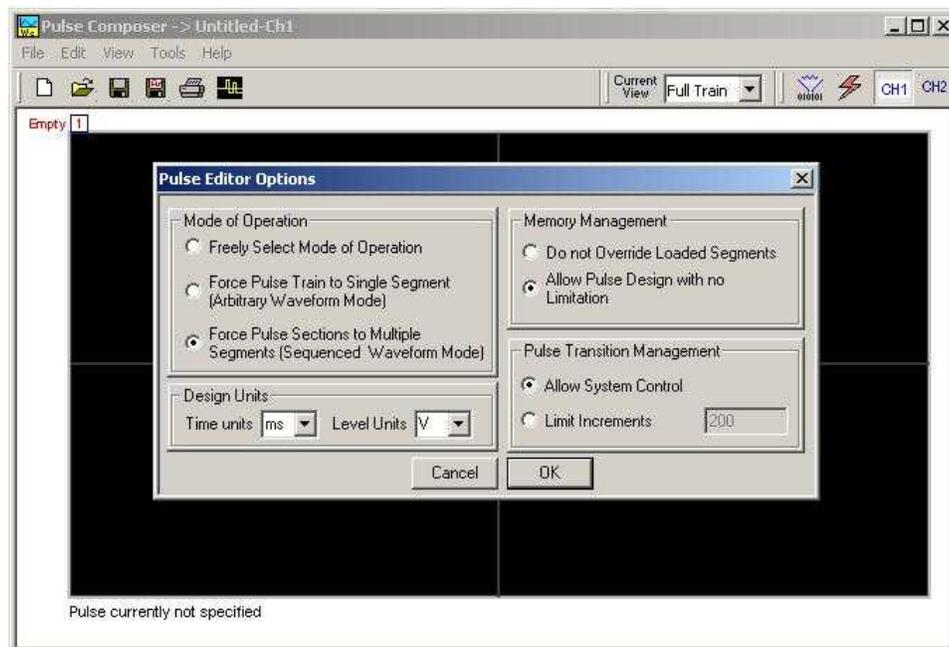


Figure 4-31, Selecting Pulse Editor Options

## Setting the Pulse Editor Options

As shown in Figure 4-31, 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.

### **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  $\mu\text{s}$ , 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 4-32 will show. Refer to this figure for the following descriptions.

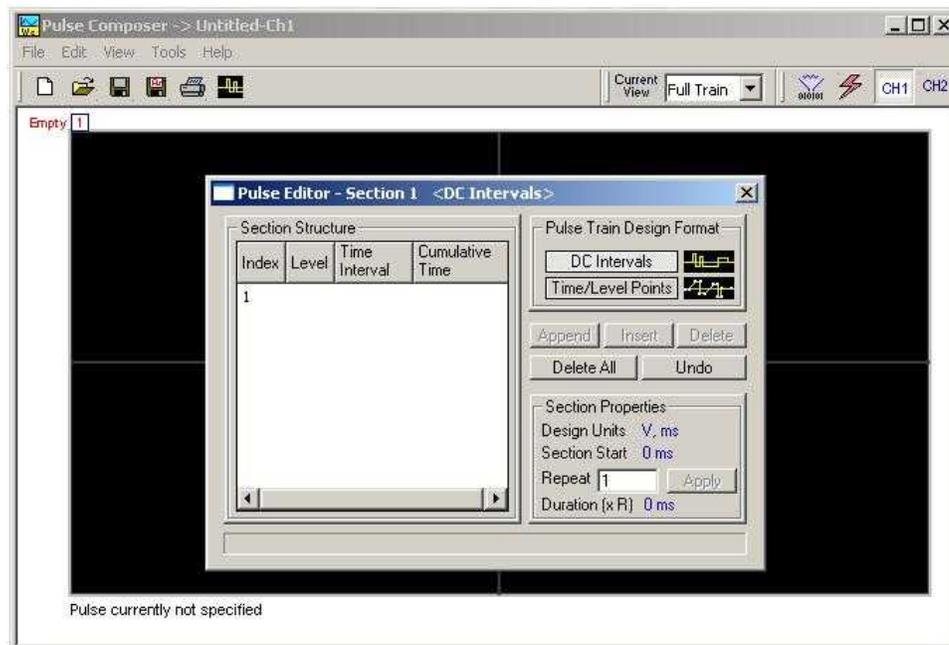


Figure 4-32, Using the Pulse Editor

The Pulse Editor as shown in Figure 4-32 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 = 1, 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 =1, Time Interval = 0.1, (Cumulative Time = 0.1)

Index = 3, Level =1, 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 4-29. Point and click on the New icon and open the pulse editor. Type in the level and time intervals as shown in Figure 4-33. Note that the pulse segments are being created on the screen as you type the values.



**Tips**

**Use the tab button to edit the Section Structure fields.**  
**Use Append to add an index line at the end of the list.**  
**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 4V (.5V/Div) and Horizontal Scale is showing 1ms (0.1ms/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.

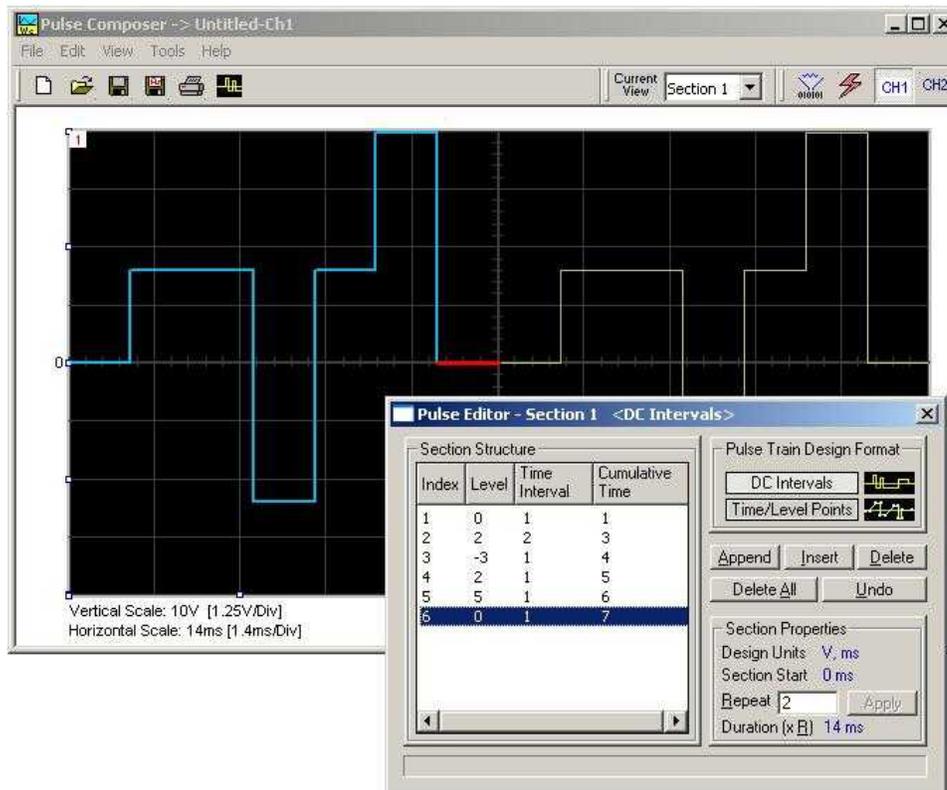


Figure 4-33, Building Section 1 of the Pulse Example

**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 4-33. 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 4-34.

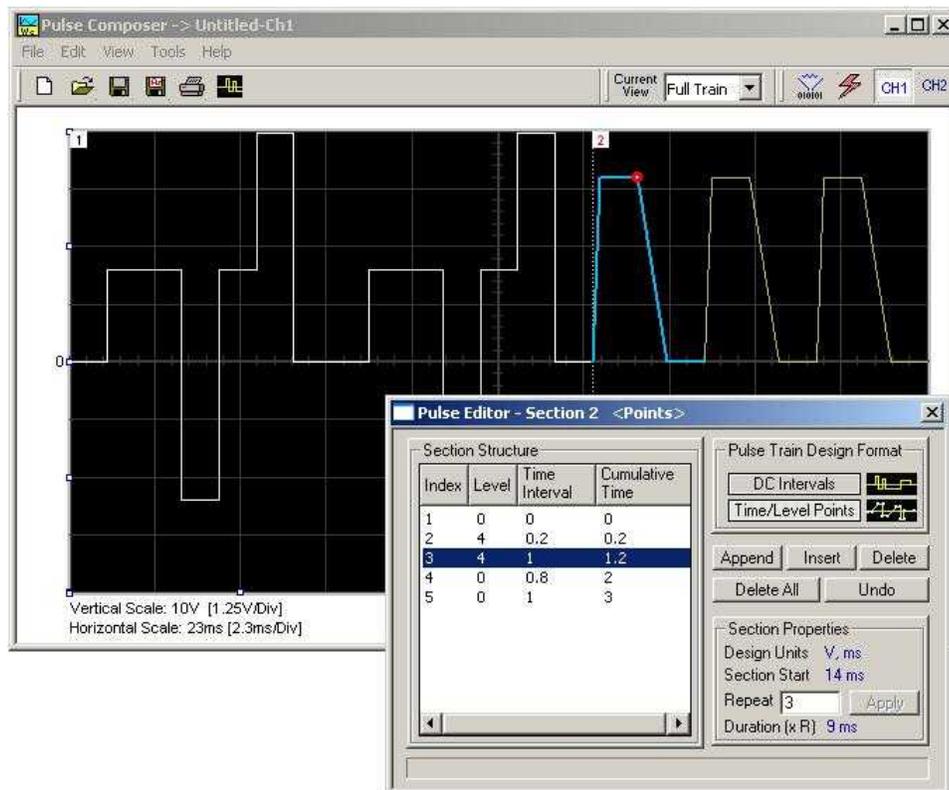


Figure 4-34, Building Section 2 of the Pulse Example

**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 4-35. 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 4-35.

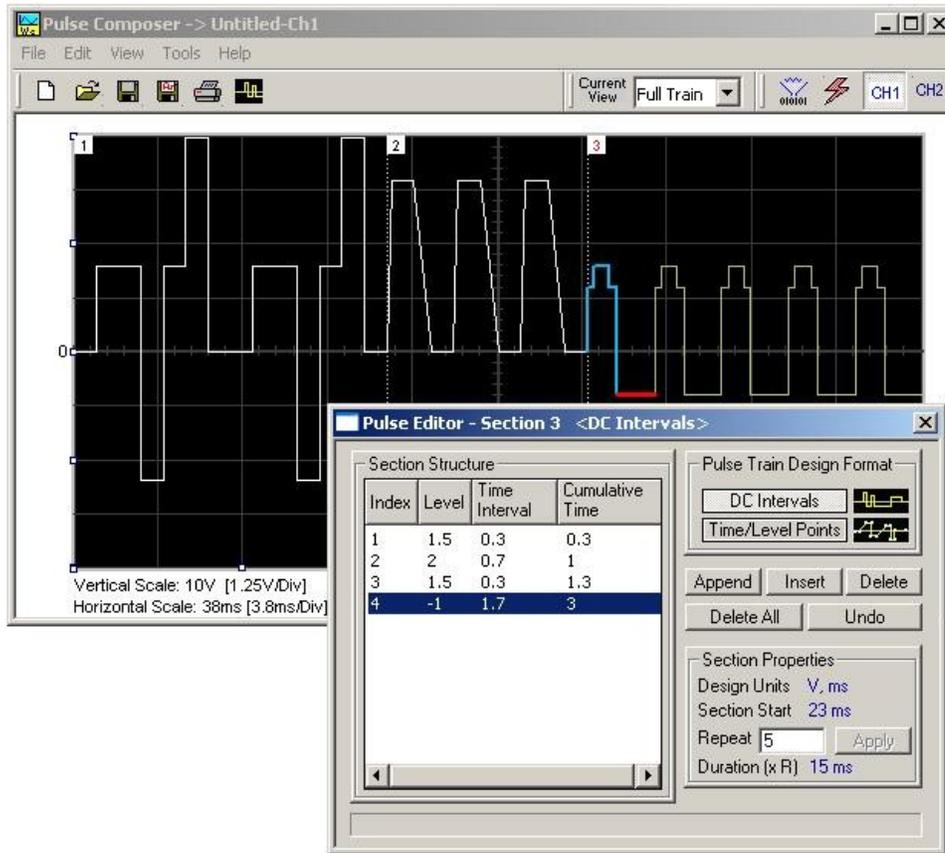


Figure 4-35, Building Section 3 of the Pulse Example

**Pulse Example, Section 4** The third pulse section is complete. We are ready now to start building the fourth section of the pulse as shown in Figure 4-36. 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 4-36.

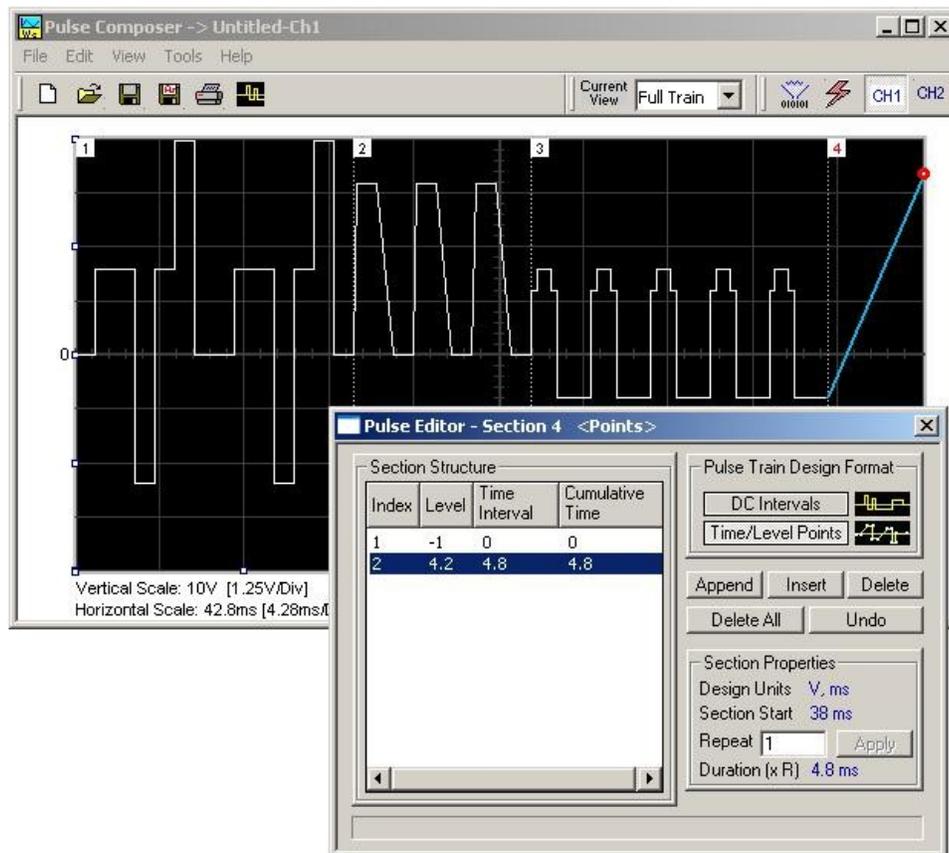


Figure 4-36, Building Section 4 of the Pulse Example

**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 4-36. 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 4-37.

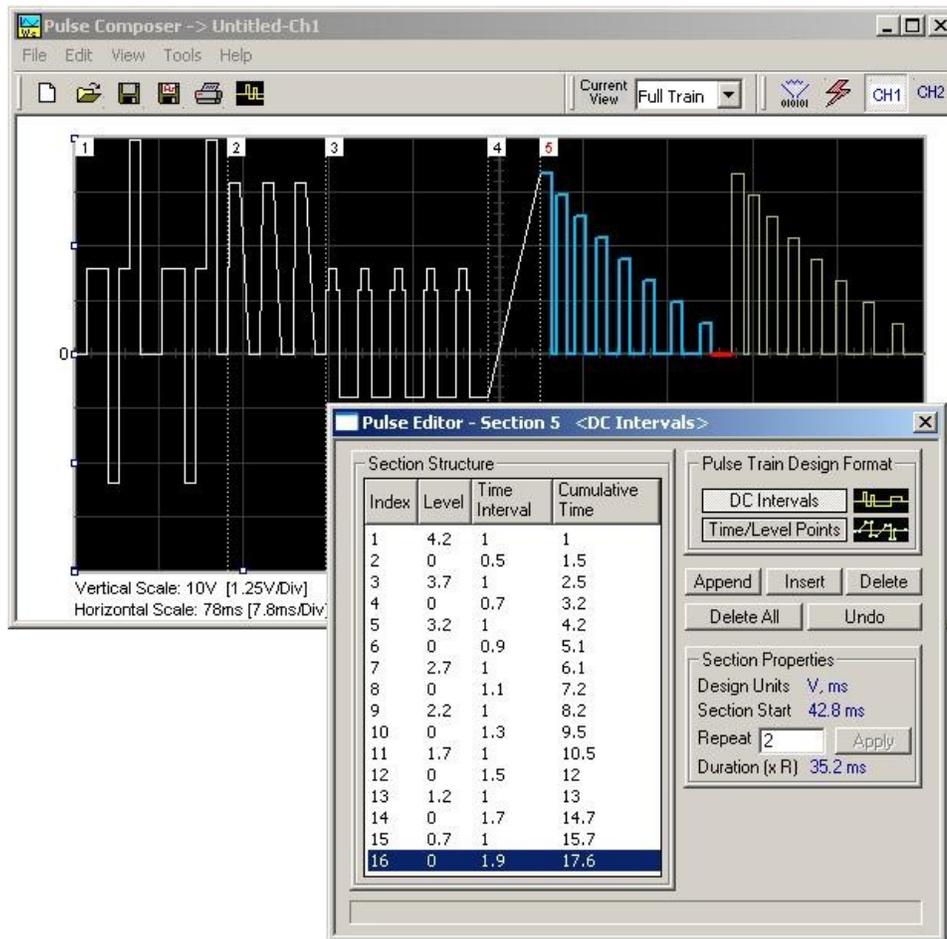


Figure 4-37, Building Section 5 of the Pulse Example

## Downloading the Pulse Train

Congratulations for coming this far. If you followed the above description how to build this pulse example, the screen should look exactly as shown in Figures 4-33 and 4-37. 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 4-38 for information how to interpret your download summary.

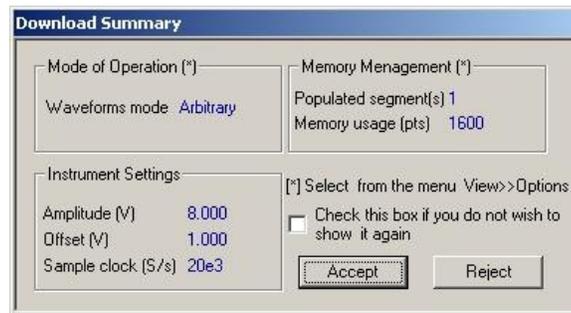


Figure 4-38, the Pulse Editor Download Summary

## 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.

*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.

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# Chapter 5

## *Remote Programming Reference*

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## 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 8251. 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 8251 is given in Table 5-1.

## 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;TIM 5e-3
```

is the same as sending the following three commands:

```
:TRIG:SLOP NEG  
:TRIG:COUN 10  
:TRIG:TIM 5e-3
```

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

```
OUTP:STATE ON;:TRIG: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 Common Commands

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

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

## SCPI Parameter Type

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

### Numeric Parameters

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

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

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

### Discrete Parameters

Discrete parameters are used to program settings that have a limited number of values (i.e., FIXed, USER and MODulated 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|MODulated}
```

### Boolean Parameters

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

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

The same command can also be written as follows:

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

### Arbitrary Block Parameters

Arbitrary block parameters are used for loading waveforms into the generator's memory. Depending on which option is installed, the Model 8251 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 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 8251 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 5-1, Model 8251 SCPI Commands List Summary

Keyword	Parameter Form	Default
<i>Instrument Control Commands</i>		
:OUTPut		
[:STATe]	OFF   ON   0   1	0
:SYNC		
[:STATe]	OFF   ON   0   1	0
:POSition	0 to n (n=segment size)	0
:TYPE	BIT   SCOM	BIT
:FILTer		
[:LPASs]	NONE   50M   125M   ALL	NONE
[:SOURce]		
:ROSCillator		
:SOURce	INTernal   EXTernal	INT
:FREQuency		
[:CW]	50e0 to 250e6   MINIMUM   MAXIMUM	10e6
:RASTer	50e3 to 625e6   MINIMUM   MAXIMUM	100e6
:VOLTage		
[:LEVe]		
[:AMPLitude]	100e-3 to 4.00   MINIMUM   MAXIMUM	1
:OFFSet	-1.0 to +1.0	0
:FUNCTion		
:MODE	FIXed   USER   MODulated	FIX
<i>Standard Waveforms Commands</i>		
:SHAPe	SINusoid   TRIangle   SQUare   PULSe   RAMP   SINC   GAUSSian   EXPonential   NOISe   DC	SIN
:SINusoid		
:PHASe	0.0 to 360.0	0
:TRIangle		
:PHASe	0.0 to 360.0	0
:SQUare		
:DCYCLE	0.0 to 99.99	50
:PULSe		
:DELay	0.0 to 99.99	10
:WIDTh	0.0 to 99.99	10
:TRANsition		
[:LEADing]	0.0 to 99.99	10
:TRAILing	0.0 to 99.99	10

Table 5-1, Model 8251 SCPI Commands List Summary (continued)

Keyword	Parameter Form	Default
:RAMP		
:DELay	0.0 to 99.99	0
:TRANsition		
[:LEADing]	0.0 to 99.99	60
:TRAIling	0.0 to 99.99	30
:SINC		
:NCYCLE	4 to 100	10
:GAUSSian		
:EXPonent	10 to 200	20
:EXPonential		
:EXPonent	-100 to 100	1
:DC		
[:AMPLitude]	-2.0 to 2.0	1
<i>Arbitrary Waveforms Commands</i>		
:TRACe		
[:DATA]	Waveform data binary string	
:DEFine	(1 to 1k),(16 to 512k)	
:DELete		
[:NAME]	1 to 1k	
:ALL		
:SELect	1 to 1k	1
:SEGMENT		
[:DATA]	Segment data binary string	
:TRANsition	NORMal   FAST	NORM
<i>Modulated Waveforms Commands</i>		
:MODulation		
:CARRier		
[:FREQuency]	1 to 250e6	10e6
:TYPE	OFF   FM   FSK   PSK   SWEep	OFF
:FM		
:DEViation	100e-3 to 248e6	1e6
:FUNCTion		
:SHAPE	SINusoid   TRIangle   SQUare   RAMP	SIN
:FREQuency	1e-3 to 100e3	1e3
:MARKer		
[:FREQuency]	100.0e-3 to 250.0e6	10e6

Table 5-1, Model 8251 SCPI Commands List Summary (continued)

Keyword	Parameter Form	Default
:FSK		
:FREQuency		
:SHIFted	1 to 250e6	20e6
:PSK		
:PHASe		
:SHIFted	0.0 to 360.0	180
:SWEep		
[:FREQuency]		
:STARt	1 to 250e6	10e6
:STOP	1 to 250e6	20e6
:TIME	100e-6 to 1000	1e-3
:DIRection	UP   DOWN	UP
:SPACing	LINear   LOGarithmic	LIN
:MARKer		
[:FREQuency]	1 to 250e6	15e6
<i>Run Mode Commands</i>		
:INITiate		
[:IMMediately]		
:CONTinuous	OFF   ON   0   1	ON
:TRIGger		
[:IMMediate]		
:BURSt		
[:STATe]	OFF   ON   0   1	0
:COUNt	2 to 1M	
:GATE		
[:STATe]	OFF   ON   0   1	0
:SOURce		
[:ADVance]	EXTernal   INTernal   BUS	EXT
:SLOPe	POSitive   NEGative	POS
:LEVel	-5.0 to 5.0	1.6
:TIMer	100e-9 to 100	1e-3
:DELay		
[:STATe]	OFF   ON   0   1	0
:TIME	0 to 512e3	0

Table 5-1, Model 8251 SCPI Commands List Summary (continued)

Keyword	Parameter Form	Default
<i>Auxiliary Commands</i>		
:AUXiliary		
:PULSe		
:DELay	0 to n	0
:DOUBle		
[:STATe]	OFF   ON   0   1	0
:DELay	0 to n	2e-3
:HIGH	1e-9 to n	1e-3
:LEVel		
:HIGH	-2.90 to 3	0.5
:LOW	-3 to 2.90	-0.5
:PERiod	4e-9 to 10 s	10e-3
:POLarity	NORMal   INVert   COMPlmented	NORM
:TRANsition		
[:LEADing]	0 to n	1e-3
:TRAILing	0 to n	1e-3
<i>System Commands</i>		
:RESet		
:SYSTem		
:ERRor?		
:VERSion?		
:TEMPerature?		
:INFORMation		
:MODEl?		
:SERial?		
:CALibration?		
:FIRMware		
[:VERSion]?		

Table 5-1, Model 8251 SCPI Commands List Summary (continued)

Keyword	Parameter Form	Default
<i>Common Commands</i>		
*CLS		
*ESE	1 to 255	1
*OPC		
*RST		
*SRE	1 to 255	1
*TRG		
*ESR?		
*IDN?		
*OPT?		0
*STB?		

## Instrument Control Commands

This group is used to control output channels and their respective state, amplitude and offset settings, as well as the waveform mode. You can also select filters to re-structure the shape of your waveform. The output frequency and the reference source are also selected using commands from this group. Table 5-2 summarizes the instrument control commands. Factory defaults after \*RST are shown in the Default column. Parameter range and low and high limits are listed, where applicable.

Table 5-2, Instrument Control Commands Summary

Keyword	Parameter Range	Default
:OUTPut		
[:STATe]	OFF   ON   0   1	0
:SYNC		
[:STATe]	OFF   ON   0   1	0
:POSition	0 to n (n=segment size)	0
:TYPE	BIT   SCOM	BIT
:FILTer		
[:LPASs]	NONE   50M   125M   ALL	NONE
[:SOURce]		
:ROSCillator		
:SOURce	INTernal   EXTernal	INT
:FREQuency		
[:CW]	50e0 to 250e6   MINIMUM   MAXIMUM	10e6
:RASTer	50e3 to 625e6   MINIMUM   MAXIMUM	100e6
:SOURce	INTernal   EXTernal	INT
:VOLTage		
[:LEVe]		
[:AMPLitude]	100e-3 to 4.0   MINIMUM   MAXIMUM	1
:OFFSet	-1.0 to 1.0	0
:FUNCTion		
:MODE	FIXed   USER   MODulated	FIX

## OUTPut{OFF|ON|0|1}(?)

### **Description**

This command will turn the 8251 output on and off. Note that for safety, the outputs always default to off, even if the last instrument setting before power down was on

### **Parameters**

Range	Type	Default	Description
0-1	Discrete	0	Sets the output on and off

### **Response**

The 8251 will return 1 if the output is on, or 0 if the output is off.

## OUTPut:SYNC{OFF|ON|0|1}(?)

### **Description**

This command will turn the 8251 SYNC output on and off. Note that for safety, the SYNC output always defaults to off, even if the last instrument setting before power down was on

### **Parameters**

Range	Type	Default	Description
0-1	Discrete	0	Will set the SYNC output on and off

### **Response**

The 8251 will return 1 if the SYNC output is on, or 0 if the SYNC output is off.

## OUTPut:SYNC:POSition<position>(?)

### **Description**

This command will program the 8251 SYNC position. This command is active in arbitrary (USER) mode only.

### **Parameters**

Name	Range	Type	Default	Description
<position>	0 to n	Numeric (Integer only)	0	Will set the SYNC position in waveform points. The sync position can be programmed in increments of 16 points minimum. The n limit depends on the memory option and the segment size.

### **Response**

The 8251 will return the present SYNC position value

## OUTPut:SYNC:TYPE{BIT|SCOMplete}(?)

### Description

This command will program the 8251 SYNC mode.

### Parameters

Name	Type	Default	Description
BIT	Discrete	None	Programs the BIT as the qualifying condition of the SYNC output. The sync output will generate a pulse at the beginning of the segment having a width of 16 waveform points. The position of the pulse is programmable using the outp:sync:pos command.
SCOMplete	Discrete		Programs the SCOM as the qualifying condition of the SYNC output. The sync output will transition high at the beginning of the segment and will transition low at the end of the segment less 16 waveform points. The start of the transition is programmable using the outp:sync:pos command.

### Response

The 8251 will return BIT or SCOM depending on the present SYNC mode

## OUTPut:FILTEr{NONE|50M|125M|ALL}(?)

### Description

This command will select which filter is connected to the 8251 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.

### Parameters

Name	Type	Default	Description
None	Discrete	None	Disables all filters at the output path. This option cannot be selected when standard waveform is generated
50M	Discrete		Connects a 50MHz Bessel type filter to the output path
125M	Discrete		Connects a 125MHz Bessel type filter to the output path
ALL	Discrete		Connects both the 50MHz and 125MHz filters to the output path

### Response

The 8251 will return NONE, 50M, 125M or ALL, depending on the type of filter presently connected to the output.

## ROSCillator:SOURce{INTernal|EXTernal}(?)

### **Description**

This command will select the reference source for the sample clock generator.

### **Parameters**

Name	Type	Default	Description
INTernal	Discrete	INT	Selects an internal source. The internal source could be either the standard 100ppm oscillator, or the optional 1ppm TCXO
EXTernal	Discrete		Activates the external reference input. An external reference must be connected to the 8251 for it to continue normal operation

### **Response**

The 8251 will return INT, or EXT depending on the present 8251 setting.

## FREQuency{<freq>|MINimum|MAXimum}(?)

### **Description**

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

### **Parameters**

Name	Range	Type	Default	Description
<freq>	50e0 to 250e6	Numeric	10e6	Will set the frequency of the standard waveform in units of Hz. Although the display resolution for the frequency setting is 9 digits only, the frequency command can be used with resolutions up to 14 digits. The accuracy of the instrument however, can only be tested to this accuracy using an external reference that provides the necessary accuracy and stability
<MINimum>		Discrete		Will set the frequency of the standard waveform to the lowest possible frequency (50e0).
<MAXimum>		Discrete		Will set the frequency of the standard waveform to the highest possible frequency (250e6).

### **Response**

The 8251 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).

## FREQuency:RASTer{<sclk>|MINimum|MAXimum}{?}

### Description

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.

### Parameters

Name	Range	Type	Default	Description
<sclk>	50e3 to 625e6	Numeric	100e6	Will set the sample clock frequency of the arbitrary waveform in units of S/s. Although the display resolution for the frequency setting is 9 digits only, the frequency command can be used with resolutions up to 14 digits. The accuracy of the instrument however, can only be tested to this accuracy using an external reference that provides the necessary accuracy and stability
<MINimum>		Discrete		Will set the sample clock frequency to the lowest possible frequency (50e3).
<MAXimum>		Discrete		Will set the frequency of the standard waveform to the highest possible frequency (625e6).

### Response

The 8251 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).

## VOLTage{<ampl>|MINimum|MAXimum}{?}

### Description

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

### Parameters

Name	Range	Type	Default	Description
<ampl>	50e-3 to 4	Numeric	1	Will set the amplitude of the output waveform in units of volts. Amplitude setting is always peak to peak. Offset and amplitude settings are independent providing that the offset + amplitude do not exceed the specified window.
<MINimum>		Discrete		Will set the amplitude to the lowest possible level (50 mV).
MAXimum>		Discrete		Will set the amplitude to the highest possible level (4.0 V).

### Response

The 8251 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).

## VOLTage:OFFSet<offs>(?)

### Description

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

### Parameters

Name	Range	Type	Default	Description
<offs>	-1.0 to 1.0	Numeric	0	Will set the offset of the output waveform in units of volts. Offset and amplitude settings are independent providing that the offset + amplitude do not exceed the specified window.

### Response

The 8251 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).

## FUNCTION:MODE{FIXed|USER|MODulated}(?)

### Description

This command defines the type of waveform that will be available at the output connector.

### Parameters

Name	Type	Default	Description
FIXed	Discrete	FIX	Selects the standard waveform shapes. There is an array of waveforms that is built into the program. You can find these waveform shapes in the standard waveforms section.
USER	Discrete		Selects the arbitrary waveform shapes. Arbitrary waveforms must be loaded to the 8251 memory before they can be replayed. You can find information on arbitrary waveforms in the appropriate sections in this manual.
MODulated	Discrete		Selects the modulated waveforms. There is an array of built-in modulation schemes. However, you can also build custom modulation using the arbitrary function.

### Response

The 8251 will return FIX, USER, or MOD depending on the present 8251 setting

## Standard Waveforms Control Commands

This group is used to control the standard waveforms and their respective parameters. There is an array of standard waveforms that could be used without the need to download waveform coordinates to the instrument. You can also modify the parameters for each waveform to a shape suitable for your application.

Factory defaults after \*RST are shown in the Default column. Parameter range and low and high limits are listed, where applicable.

Table 5-3, Instrument Control Commands Summary

Keyword	Parameter Range	Default
:FUNction		
:SHAPE	<b>SINusoid</b>   TRlangle   SQUare   PULSe   RAMP   SINC   GAUSSian   EXPonential   NOISe   DC	<b>SINusoid</b>
:SINusoid		
:PHASe	0.0 to 360.0	0
:TRlangle		
:PHASe	0.0 to 360.0	0
:SQUare		
:DCYClE	0.0 to 99.99	50
:PULSe		
:DELay	0.0 to 99.99	10
:WIDTh	0.0 to 99.99	10
:TRANsition		
[:LEADing]	0.0 to 99.99	10
:TRAIling	0.0 to 99.99	10
:RAMP		
:DELay	0.0 to 99.99	0
:TRANsition		
[:LEADing]	0.0 to 99.99	60
:TRAIling	0.0 to 99.99	30
:SINC		
:NCYClE	4 to 100	10
:GAUSSian		
:EXPonent	10 to 200	20
:EXPonential		
:EXPonent	-100 to 100	1
:DC		
[:AMPLitude]	-2.0 to 2.0	1

## **FUNCTION:SHAPE{SINusoid|TRiangle|SQUare|PULSe|RAMP|SINC|EXPo nential| GAUSSian|NOISe|DC}(?)**

### **Description**

This command defines the type of waveform that will be available at the output connector.

### **Parameters**

<b>Name</b>	<b>Type</b>	<b>Default</b>	<b>Description</b>
SINusoid	Discrete	SIN	Selects the sine waveform from the built in library.
TRiangle	Discrete		Selects the triangular waveform from the built in library.
SQUare	Discrete		Selects the square waveform from the built in library.
PULSe	Discrete		Selects the pulse waveform from the built in library.
RAMP	Discrete		Selects the ramp waveform from the built in library.
SINC	Discrete		Selects the sinc waveform from the built in library.
EXPonential	Discrete		Selects the exponential waveform from the built in library.
GAUSSian	Discrete		Selects the gaussian waveform from the built in library.
DC	Discrete		Selects the DC waveform from the built in library.
NOISe	Discrete		Selects the noise waveform from the built in library.

### **Response**

The 8251 will return SIN, TRI, SQU, PULS, RAMP, SINC, EXP, GAUS, NOIS, or DC depending on the present 8251 setting

## **SINusoid:PHASe<phase>(?)**

### **Description**

This command programs start phase of the standard sine waveform. This command has no affect on arbitrary waveforms.

### **Parameters**

<b>Name</b>	<b>Range</b>	<b>Type</b>	<b>Default</b>	<b>Description</b>
<phase>	0 to 360	Numeric	0	Programs the start phase parameter in units of degrees

### **Response**

The 8251 will return the present start phase value.

## TRiangle:PHASe<phase>(?)

### Description

This command programs start phase of the standard triangular waveform. This command has no affect on arbitrary waveforms.

### Parameters

Name	Range	Type	Default	Description
<phase>	0 to 360	Numeric	0	Programs the start phase parameter in units of degrees

### Response

The 8251 will return the present start phase value.

## SQUare:DCYClE<duty\_cycle>(?)

### Description

This command programs duty cycle of the standard square waveform. This command has no affect on arbitrary waveforms.

### Parameters

Name	Range	Type	Default	Description
<duty_cycle>	0 to 99.9	Numeric	50	Programs the square wave duty cycle parameter in units of percent

### Response

The 8251 will return the present duty cycle value.

## PULSe:DELay<delay>(?)

### Description

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

### Parameters

Name	Range	Type	Default	Description
<delay>	0 to 99.9	Numeric	10	Programs the pulse delay parameter in units of percent

### Response

The 8251 will return the present pulse delay value.

## PULSe:WIDTh<pulse\_width>(?)

### **Description**

This command programs pulse high portion of the standard pulse waveform. This command has no affect on arbitrary waveforms.

### **Parameters**

Name	Range	Type	Default	Description
<pulse_width>	0 to 99.9	Numeric	10	Programs the pulse width parameter in units of percent

### **Response**

The 8251 will return the present width value.

## PULSe:TRANSition<rise>(?)

### **Description**

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

### **Parameters**

Name	Range	Type	Default	Description
<rise>	0 to 99.9	Numeric	10	Programs the pulse rise time parameter in units of percent

### **Response**

The 8251 will return the present rise time value

## PULSe:TRANSition:TRAIling<fall>(?)

### **Description**

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

### **Parameters**

Name	Range	Type	Default	Description
<fall>	0 to 99.9	Numeric	10	Programs the pulse fall time parameter in units of percent

### **Response**

The 8251 will return the present fall time value.

## RAMP:DElay<delay>(?)

### Description

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

### Parameters

Name	Range	Type	Default	Description
<delay>	0 to 99.9	Numeric	10	Programs the ramp delay parameter in units of percent

### Response

The 8251 will return the present ramp delay value.

## RAMP:TRANSition<rise>(?)

### Description

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

### Parameters

Name	Range	Type	Default	Description
<rise>	0 to 99.9	Numeric	60	Programs the pulse rise time parameter in units of percent

### Response

The 8251 will return the present rise time value

## RAMP:TRANSition:TRAIling<fall>(?)

### Description

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

### Parameters

Name	Range	Type	Default	Description
<fall>	0 to 99.9	Numeric	30	Programs the ramp fall time parameter in units of percent

### Response

The 8251 will return the present fall time value.

## SINC:NCYCLE<N\_cycles>(?)

### **Description**

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

### **Parameters**

Name	Range	Type	Default	Description
<N_cycle>	4 to 100	Numeric (Integer only)	10	Programs the number of zero-crossings parameter

### **Response**

The 8251 will return the present number of zero-crossing value.

## GAUSSian:EXPONENT<exp>(?)

### **Description**

This command programs the exponent for the standard gaussian pulse waveform. This command has no affect on arbitrary waveforms.

### **Parameters**

Name	Range	Type	Default	Description
<exp>	4 to 100	Numeric (Integer only)	20	Programs the exponent parameter

### **Response**

The 8251 will return the present exponent value.

## EXPONENTIAL:EXPONENT<exp>(?)

### **Description**

This command programs the exponent for the standard exponential waveform. This command has no affect on arbitrary waveforms.

### **Parameters**

Name	Range	Type	Default	Description
<exp>	-100 to 100	Numeric (Integer only)	1	Programs the exponent parameter

### **Response**

The 8251 will return the present exponent value.

## DC<amplitude>(?)

### **Description**

This command programs the exponent for the standard exponential waveform. This command has no affect on arbitrary waveforms.

### **Parameters**

<b>Name</b>	<b>Range</b>	<b>Type</b>	<b>Default</b>	<b>Description</b>
<amplitude>	-3 to 3	Numeric	1	Programs the DC amplitude parameter

### **Response**

The 8251 will return the present DC amplitude value.

## Arbitrary Waveforms Control Commands

This group is used to control the arbitrary waveforms and their respective parameters. This will allow you to create segments and download waveforms. Using these commands you can also define segment size and delete some or all unwanted waveforms from your memory. Use the commands in this group to turn the digital output on and off and to download data to the digital pattern buffer.

Factory defaults after \*RST are shown in the Default column. Parameter range and low and high limits are listed, where applicable.

### Generating Arbitrary Waveforms

Arbitrary waveforms are generated from digital data points, which are stored in a dedicated waveform memory. Each data point has a vertical resolution of 12 bits (4096 points), i.e., each sample is placed on the vertical axis with a precision of 1/4096. The Model 8251 has a 512k waveform memory capacity.

Each horizontal point has a unique address - the first being 0000 and the last is 0x7FFF. In cases where smaller waveform lengths are required, the waveform memory can be divided into smaller segments.

When the instrument is programmed to output arbitrary waveforms, the clock samples the data points (one at a time) from address 0 to the last address. The rate at which each sample is replayed is defined by the sample clock rate parameter.

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

### Arbitrary memory Management

The arbitrary memory is comprised of a finite length of words. The maximum size arbitrary waveform that can be loaded into memory is 512k.

Waveforms are created using small sections of the arbitrary memory. The memory can be partitioned into smaller segments (up to 1k) and different waveforms can be loaded into each segment, each having a unique length. Minimum segment size is 16 points. Information on how to partition the memory, define segment length and download waveform data to the 8251 is given in the following paragraphs.

Table 5-4, Arbitrary Waveforms Commands Summary

Keyword	Parameter Range	Default
:TRACe		
[:DATA]	Segment binary data	
:DEFine	(1 to 1k), (16 to 512k)	
:DELete		
[:NAME]	1 to 1k	
:ALL		
:SELect	1 to 1k	1
:SEGMENT		
[:DATA]		
:TRANSition	NORMal   FAST	NORM

## TRACe#<header><binary\_block>

### Description

This command will download waveform data to the 8251 memory. Waveform data is loaded to the 8251 using high-speed binary transfer. A special command is defined by IEEE-STD-488.2 for this purpose. High-speed binary transfer allows any 8-bit bytes (including extended ASCII code) to be transmitted in a message. This command is particularly useful for sending large quantities of data. As an example, the next command will download to the generator an arbitrary block of data of 1024 points

```
TRACe#42048<binary_block>
```

This command causes the transfer of 2048 bytes of data (1024 waveform points) into the active memory segment. The <header> is interpreted this way:

- The ASCII "#" (\$23) designates the start of the binary data block.
- "4" designates the number of digits that follow.
- "2048" is the even number of bytes to follow.

---

### NOTE

**It is mandatory to pause for at least 200ms after the transmission of the header and before and after the transmission of the binary data to allow the CPU to prepare the memory for direct binary download of data. The binary data is downloaded to the 8251 using a high-speed DMA sequence and therefore, if you send commands before the instrument is ready to accept, there is a risk of losing data and possible a complete lockup of the controlling bus, with recovery only through re-cycling of the mains power .**

---

The generator accepts binary data as 16-bit integers, which are sent in two-byte words. Therefore, the total number of bytes is always twice the number of data points in the waveform. For example, 20000 bytes are required to download a waveform with 10000 points. The IEEE-STD-488.2 definition of Definite Length

Arbitrary Block Data format is demonstrated in Figure 5-1.

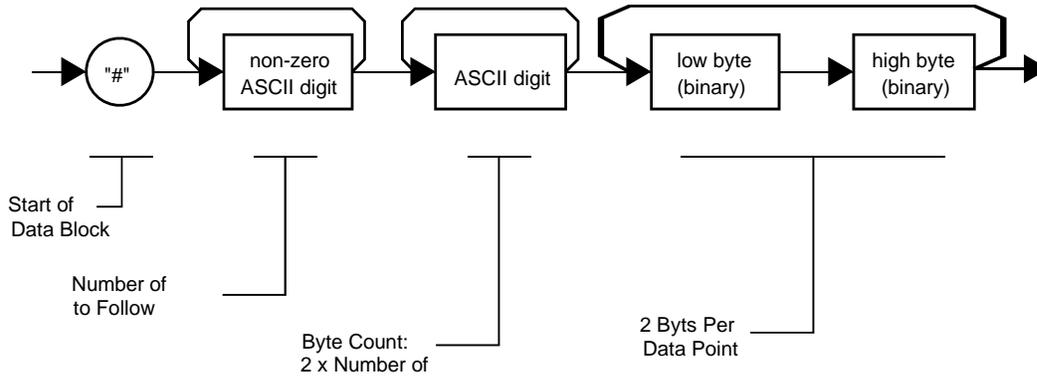


Figure 5-1, Definite Length Arbitrary Block Data Format

Transfer of definite length arbitrary block data must terminate with the EOI bit set. This way, carriage-return (CR – 0dH) and line feed (LF – 0aH) characters can be used as waveform data points and will not cause unexpected termination of the arbitrary block data.

The binary data that is downloaded to the waveform memory contains coordinates for the arbitrary waveform. The waveform data is arranged in the first 12. Bits 13, 14, 15 and 16 are not used.

The waveform data is made of 12-bit words. Therefore, the data has to be prepared as 16-bit words and only then downloaded to through the remote controller. There are a number of points you should be aware of before you start preparing the data:

1. Each waveform data point has 16-bit values
2. Data point range is 0 to 4,096 decimal
3. Data point 0 to data point 4,096 corresponds to full-scale amplitude setting.

Figure 5-2 shows how to initially prepare the 16-bit word for a waveform data point.

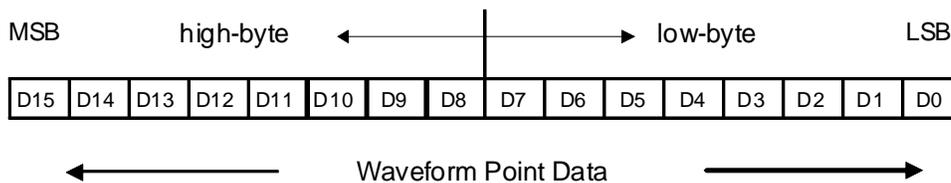


Figure 5-2, 16-bit Waveform Representation

**Parameters**

Name	Type	Description
<header>	Discrete	Contains information on the size of the binary block that contains waveform coordinates.
<binary_block>	Binary	Block of binary data that contains information on the waveform coordinates. As well as for the B13 and B14 outputs

**TRACe:DEFine<segment\_number>,<length>**

**Description**

Use this command to attach size to a specific memory segment. The final size of the arbitrary memory is 512k points. The memory can be partitioned to smaller segments, up to 1k segments. This function allows definition of segment size. Total length of memory segments cannot exceed the size of the waveform memory.

**NOTE**

The 8251 operates in interlaced mode where four memory cells generate one byte of data. Therefore, segment size can be programmed in numbers evenly divisible by sixteen only. For example, 2096 bytes is an acceptable length for a binary block. 2002 is not a multiple of 16, therefore the generator will generate an error message if this segment length is used.

**Parameters**

Name	Range	Type	Default	Description
<segment_number>	1 to 1k	Numeric (integer only)	1	Selects the segment number of which will be programmed using this command
<length>	16 to 512k	Numeric (integer only)		Programs the size of the selected segment. Minimum segment length is 16 points, the maximum is limited to 512k

**TRACe:DELeTe<segment\_number>**

**Description**

This command will delete a segment. The memory space that is being freed will be available for new waveforms as long as the new waveform will be equal or smaller in size to the deleted segment. If the deleted segment is the last segment, then the size of another waveform written to the same segment is not limited. For example, let consider two segments, the first being a 1000-point waveform and the second with 100 points. If you delete segment 1, you can reprogram another waveform to segment 1 with size to 1000 points. If you reprogram segment 1 with 1004 points, the instrument will generate an error and will not accept this waveform. On the other hand, if you delete segment 2, which was the last segment you programmed, then you can reprogram this segment with waveforms having length limited only by the size of the entire memory space.

### Parameters

Name	Range	Type	Default	Description
<segment_ number>	1 to 1k	Numeric (integer only)	1	Selects the segment number of which will be deleted

## TRACe:DELeTe:ALL

### Description

This command will delete all segments and will clear the entire waveform memory. This command is particularly important in case you want to de-fragment the entire waveform memory and start building your waveform segments from scratch.



### TIP

The TRAC:DEL:ALL command does not re-write the memory so, whatever waveforms were downloaded to the memory are still there for recovery. The TRAC:DEL:ALL command removes all stop bits and clears the segment table. You can recover memory segments by using the TRAC:DEF command. You can also use this technique to resize, or combine waveform segments.

## TRACe:SELEct<segment\_number>

### Description

This command will select the active waveform segment for the output. By selecting the active segment you are performing two function:

1. Successive :TRAC commands will affect the selected segment
2. The SYNC output will be assigned to the selected segment.

### Parameters

Name	Range	Type	Default	Description
<segment_ number>	1 to 1k	Numeric (integer only)	1	Selects the active segment number

### Response

The 8251 will return the active segment number.

## SEGment#<header><binary\_block>

**Description**

This command will partition the waveform memory to smaller segments and will speed up memory segmentation. The idea is that waveform segments can be built as one long waveform and then just use this command to split the waveform to the appropriate memory segments. In this way, there is no need to define and download waveforms to individual segments.

Using this command, segment table data is loaded to the 8251 using high-speed binary transfer in a similar way to downloading waveform data with the trace command. High-speed binary transfer allows any 8-bit bytes (including extended ASCII code) to be transmitted in a message. This command is particularly useful for large number of segment. As an example, the next command will generate three segments with 12 bytes of data that contains segment size information.

```
SEGment#212<binary_block>
```

This command causes the transfer of 12 bytes of data (3 segments) into the segment table buffer. The <header> is interpreted this way:

- The ASCII "#" (\$23) designates the start of the binary data block.
- "2" designates the number of digits that follow.
- "12" is the number of bytes to follow. This number must divide by 16.

The generator accepts binary data as 32-bit integers, which are sent in two-byte words. Therefore, the total number of bytes is always 4 times the number of segments. For example, 36 bytes are required to download 9 segments to the segment table. The IEEE-STD-488.2 definition of Definite Length Arbitrary Block Data format is demonstrated in Figure 5-1. The transfer of definite length arbitrary block data must terminate with the EOI bit set. This way, carriage-return (CR – 0dH) and line feed (LF – 0aH) characters can be used as segment table data points and will not cause unexpected termination of the arbitrary block data.

The segment table size data is made of 32-bit words however, the GPIB link has 8 data bus lines and accepts 8-bit words only. Therefore, the segment size data has to be prepared as 32-bit words and rearranged as six 8-bit words before it can be used by the 8251 as segment size table data. Figure 5-4 shows how to prepare the 32-bit work for the segment size. There are a number of points you should be aware of before you start preparing the data:

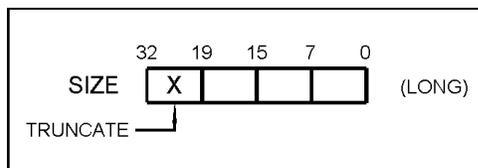


Figure 5-3, Segment Size Example

1. Each channel has its own segment table buffer. Therefore, make sure you selected the correct active channel (with the INST:SEL command) before you download segment table data to the generator
2. Minimum number of segments is 1; maximum number of segments is 16k
3. Maximum segment size is 512k.
4. Segment table data has 32-bit values of which are used for segment size. Therefore, Data for each segment must have 4 bytes
5. The number of bytes in a complete segment table must divide by 4. The Model 8251 has no control over data sent to its segment table during data transfer. Therefore, wrong data and/or incorrect number of bytes will cause erroneous memory partition

**Parameters**

Name	Type	Description
------	------	-------------

<binary_block >	Binary	Block of binary data that contains information on the segment table.
--------------------	--------	--

## SEGment:TRANSition{NORMal|FAST}(?)

### **Description**

This command will modify the way the 8251 transitions from one segment to another. This command affects segment transitions when the instrument is set to operate either in Arbitrary or Arbitrary FM. The effect will prevail regardless if the segments are controlled from the front panel or from remote. Transitions occur coherently, when the normal mode is selected and will occur immediately, without completing the waveform cycle, when the fast mode is selected.

### **Parameters**

Range	Type	Default	Description
NORMal	Discrete	NORM	This programs the instrument to transition coherently from segment to segment. The transition to the next segment will occur only after the waveform completed its cycle.
FAST	Discrete		This programs the instrument to transition immediately from segment to segment. The transition to the next segment will occur immediately, without waiting for the waveform to complete its cycle.

### **Response**

The 8251 will return NORM or FAST, depending on the segment transition control setting.

## Modulated Waveforms Control Commands

This group is used to control the modulated waveforms and their respective parameters. Note that the modulation can be turned off to create continuous carrier waveform (CW). The following modulation schemes can be selected and controlled: OFF, Standard FM, Arbitrary FM, FSK, PSK, and Sweep. The modulation commands are summarized in Table 5-6. Factory defaults after \*RST are shown in the Default column. Parameter range and low and high limits are listed, where applicable.

Table 5-5, modulated Waveforms Commands

Keyword	Parameter Form	Default
[:SOURce]		
:MODulation		
:CARRier		
[:FREQuency]	1 to 250e6	10e6
:BASeline	CARRier   DC	CARR
:TYPE	OFF   FM   FSK   PSK   SWEep	OFF
:FM		
:FUNCTion		
:SHAPe	SINusoid   TRlangle   SQUare   RAMP	SIN
:FREQuency	1e-3 to 100e3	1e3
:RASTer	1 to 2.5e6	1e6
:DEViation	100e-3 to 248e6	1e6
:MARKer		
[:FREQuency]	100.0e-3 to 250.0e6	10e6
:DATA	Arbitrary FM data binary string	
:SEGment		
:DEFine	1 to 31, 4 to 65,536	1,4
:DELete	1 to 31	
:ALL		
:SELect	1 to 31	1
:FSK		
:FREQuency		
:SHIFted	1 to 250e6	20e6
:PSK		
:PHASe		
:SHIFted	0.0 to 360.0	180
:SWEep		
[:FREQuency]		
:START	1 to 250e6	10e6
:STOP	1 to 250e6	20e6
:TIME	100e-6 to 1000	1e-3
:DIRection	UP   DOWN	UP
:SPACing	LINear   LOGarithmic	LIN
:MARKer		
[:FREQuency]	1 to 250e6	15e6

## MODulation:CARRier<frequency>(?)

### Description

This command programs the CW frequency. Note that the CW waveform is sine only and its frequency setting is separate to the standard sine waveform. The CW frequency setting is valid for all modulation types.

### Parameters

Name	Range	Type	Default	Description
<frequency>	1 to 250e6	Numeric	10e6	Programs the frequency of the carrier waveform in units of Hz. Note that the CW waveform is sine only and its frequency setting is separate to the standard sine waveform.

### Response

The 8251 will return the current carrier frequency value.

## MODulation:CARRier:BASeline{CARRier|DC}(?)

### Description

This command affects the 8251 in triggered, burst and gated run modes only. It defines if the output idles on DC level or on the carrier waveform. The default selection is carrier, which means that when placed in one of the interrupted run modes, the output generates continuous carrier waveform shape until triggered, when the trigger sequence ends, the output resumes generation of continuous carrier waveforms.

### Parameters

Name	Type	Default	Description
CARRier	Discrete	CARR	This selects the continuous carrier waveform output before valid trigger is accepted. Following the completion of the modulation cycle, the output resumes generation of continuous carrier waveforms.
DC	Discrete		This selects the DC output before valid trigger is accepted. Following the completion of the modulation cycle, the output resumes generation of DC level.

### Response

The 8251 will return CARR, or DC depending on the present baseline type setting.

## MODulation:TYPE{OFF|FM|FSK|PSK|SWEep}(?)

### Description

This command will select the modulation type. All modulation types are internal, thus external signals are not required for producing modulation.

### Parameters

Name	Type	Default	Description
------	------	---------	-------------

---

OFF	Discrete	OFF	Modulation off is a special mode where the output generates continuous, non-modulated sinusoidal carrier waveform (CW).
FM	Discrete		This turns on the FM function. Program the FM parameters to fine tune the function for your application. FM source is internal.
FSK	Discrete		This turns on the FSK function. Program the FSK parameters to fine tune the function for your application. FSK source is external.
PSK	Discrete		This turns on the PSK function. Program the PSK parameters to fine tune the function for your application. PSK source is external.
SWEep	Discrete		This turns on the sweep function. Program the sweep parameters to fine tune the function for your application.

***Response***

The 8251 will return OFF, FM, FSK, PSK, or SWE depending on the present modulation type setting.

## FM Modulation Programming

Use the following command for programming the FM parameters. FM control is internal. The standard waveforms are built in a library of waveforms and could be used anytime without external control.

### FM:FUNCTION:SHAPE(SINusoid|TRIangle|SQUare|RAMP)(?)

#### Description

This command will select one of the waveform shapes as the active modulating waveform.

#### Parameters

Name	Type	Default	Description
SINusoid	Discrete	SIN	Selects the sine shape as the modulating waveform
TRIangle	Discrete		Select the triangular shape as the modulating waveform
SQUare	Discrete		Select the square shape as the modulating waveform
RAMP	Discrete		Selects the ramp shape as the modulating waveform

#### Response

The 8251 will return SIN, TRI, SQU, RAMP, or depending on the selected function shape setting.

### FM:FREQUENCY<fm\_freq>(?)

#### Description

This command will set the modulating wave frequency for the built-in standard modulating waveform library.

#### Parameters

Name	Range	Type	Default	Description
<fm_freq>	1e-3 to 100e3	Numeric	1e3	Programs the frequency of the modulating waveform in units of Hz. The frequency of the built-in standard modulating waveforms only is affected.

#### Response

The 8251 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).

## FM:DEVIation<deviation>(?)

### Description

This programs the deviation range around the carrier frequency. The deviation range is always symmetrical about the carrier frequency. If you need non-symmetrical deviation range, you can use the arbitrary FM composer screen or an external utility to design such waveforms.

### Parameters

Name	Range	Type	Default	Description
<deviation>	100e-3 to 248e6	Numeric	1e6	Programs the deviation range around the carrier frequency in units of Hz.

### Response

The 8251 will return the present deviation frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

## FM:MARKer<frequency>(?)

### Description

This function programs marker frequency position. FM marker can be placed inside the following range: (carrier frequency  $\pm$  deviation frequency / 2). The marker pulse is output from the SYNC output connector.

### Parameters

Name	Range	Type	Default	Description
<frequency>	100e-3 to 250e6	Numeric	10e6	Programs the marker frequency position in units of Hz.

### Response

The 8251 will return the present marker frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

## FSK Modulation Programming

Use the following command for programming the FSK parameters. FSK control is external. The frequency will shift from carrier to shifted frequency setting at a rate determined by a signal which is applied to the TRIG IN connector. Trigger input level below the threshold level generates frequency that is programmed using the carrier waveform frequency parameter; Trigger input level above the threshold level generates frequency that is programmed using the shifted frequency parameter.

The commands for programming the frequency shift keying function are described below. Note that the carrier waveform frequency (CW) setting is common to all modulation schemes.

## FSK:FREQUency:SHIFted<shift\_freq>(?)

### Description

This programs the shifted frequency. The frequency shifts when the trigger input level is TTL logic logical "1".

### Parameters

Name	Range	Type	Default	Description
<shift_freq>	1 to 250e6	Numeric	20e6	Programs the shifted frequency value in units of Hz.

### Response

The 8251 will return the present shifted frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

## PSK Modulation Programming

Use the following command for programming the PSK parameters. PSK control is external. The phase will shift from start to shifted phase setting at a rate determined by a signal which is applied to the TRIG IN connector. Trigger input level below the threshold level generates 0° phase; Trigger input level above the threshold level generates a phase that is programmed using the shifted frequency parameter.

The commands for programming the phase shift keying function are described below. Note that the carrier waveform frequency (CW) setting is common to all modulation schemes.

## PSK:PHASe:SHIFted<shift\_phase>(?)

### Description

This programs the shifted phase. The phase shifts when the pointer in the data array points to "1".

### Parameters

Name	Range	Type	Default	Description
<shift_phase>	0 to 360	Numeric	180	Programs the shift phase for the carrier waveform in units of degrees.

### Response

The 8251 will return the present shift phase value.

## Sweep Modulation Programming

Use the following command for programming the sweep parameters. Sweep control is internal. The frequency will sweep from start to stop frequencies at an interval determined by the sweep time value and controlled by a step type determined by the

sweep step parameter.

There are two sweep modes: Linear, where the step of which the generator increments from start to stop frequency is linear and Logarithmic, where the step of which the generator increments from start to stop frequency is logarithmic

The commands for programming the frequency sweep function are described below.

## **SWEep:START<start\_freq>(?)**

### **Description**

This specifies the sweep start frequency. The 8251 will normally sweep from start to stop frequencies however, if the sweep direction is reversed, the output will sweep from stop to start frequencies. The start and stop frequencies may be programmed freely throughout the frequency of the standard waveform frequency range.

### **Parameters**

Name	Range	Type	Default	Description
<start_freq>	1 to 250e6	Numeric	10e6	Programs the sweep start frequency. Sweep start is programmed in units of Hz.

### **Response**

The 8251 will return the present sweep start frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

## **SWEep:STOP<stop\_freq>(?)**

### **Description**

This specifies the sweep stop frequency. The 8251 will normally sweep from start to stop frequencies however, if the sweep direction is reversed, the output will sweep from stop to start frequencies. The start and stop frequencies may be programmed freely throughout the frequency of the standard waveform frequency range.

### **Parameters**

Name	Range	Type	Default	Description
<stop_freq>	1 to 250e6	Numeric	2e6	Programs the sweep stop frequency. Sweep stop is programmed in units of Hz.

### **Response**

The 8251 will return the present sweep stop frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

## **SWEep:TIME<time>(?)**

### **Description**

This specifies the time that will take the 8251 to sweep from start to stop frequencies. The time does not depend on the sweep boundaries as it is automatically adjusted by the software to the required interval. At the end of the sweep cycle the output waveform maintains the sweep stop frequency setting except if the 8251 is in continuous run mode where the sweep repeats itself continuously.

**Parameters**

Name	Range	Type	Default	Description
<time>	100e-6 to 1000	Numeric	1e-3	Programs the sweep time. Sweep time is programmed in units of s.

**Response**

The 8251 will return the present sweep time. The returned value will be in standard scientific format (for example: 100ms would be returned as 100e-3 – positive numbers are unsigned).

## **SWEep:DIRection(UP|DOWN){?}**

**Description**

This specifies if the 8251 output will sweep from start-to-stop (UP) or from stop-to-start (DOWN) frequencies. Sweep time does not affect the sweep direction and frequency limits. At the end of the sweep cycle the output waveform normally maintains the sweep stop frequency setting but will maintain the start frequency, if the DOWN option is selected except if the 8251 is in continuous run mode where the sweep repeats itself continuously.

**Parameters**

Name	Type	Default	Description
UP	Discrete	UP	Selects the sweep up direction
DOWN	Discrete		Select the sweep down direction

**Response**

The 8251 will return UP, or DOWN depending on the selected direction setting.

## **SWEep:SPACing(LINear|LOGarithmic){?}**

**Description**

This specifies the sweep step type. Two options are available: logarithmic or linear. In linear, the incremental steps between the frequencies are uniform throughout the sweep range. Logarithmic type defines logarithmic spacing throughout the sweep start and stop settings.

**Parameters**

Name	Type	Default	Description
LINear	Discrete	LIN	Selects the linear sweep spacing
LOGarithmic	Discrete		Select the logarithmic sweep spacing

**Response**

The 8251 will return LIN, or LOG depending on the selected spacing setting.

## **SWEep:MARKer<frequency>(?)**

### **Description**

This function programs marker frequency position. Sweep marker can be placed in between the start and the stop frequencies. The marker pulse is output from the SYNC output connector.

### **Parameters**

<b>Name</b>	<b>Range</b>	<b>Type</b>	<b>Default</b>	<b>Description</b>
<frequency>	1 to 250e6	Numeric	15e6	Programs the marker frequency position in units of Hz.

### **Response**

The 8251 will return the present marker frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

## Run Mode Commands

The Run Mode Commands group is used to synchronize device actions with external events. These commands control the trigger modes of the Model 8251. The generator can be placed in Triggered, Gated or Burst mode. Trigger source is selectable from an external source, an internal re-trigger generator or a software trigger. Optional nodes were omitted from these commands. The Run Mode settings affect all waveform shapes equally except when using the modulated waveforms. In the case of modulated waveform, the output idles on the carrier waveform until stimulated to output a modulation cycle or burst of cycles. Additional information on the run mode options and how the 8251 behaves in the various run mode options is given in Chapter 3. Factory defaults after \*RST are shown in bold typeface. Parameter low and high limits are given where applicable.

Table 5-6, Run Mode Commands

Keyword	Parameter Form	Default
<i>Run Mode Commands</i>		
:INITiate		
[:IMMediately]		
:CONTinuous	OFF   ON   0   1	ON
:TRIGger		
[:IMMediate]		
:BURSt		
[:STATe]	OFF   ON   0   1	0
:COUNt	2 to 1M	
:GATE		
[:STATe]	OFF   ON   0   1	0
:SOURce		
[:ADVance]	EXTernal   INTernal   BUS	EXT
:SLOPe	POSitive   NEGative	POS
:LEVel	-5.0 to 5.0	1.6
:TIMer	100e-9 to 100	1e-3
:DELay		
[:STATe]	OFF   ON   0   1	0
:TIME	0 to 16e6	0

## INITiate:CONTInuous{OFF|ON|0|1}(?)

### Description

This command will set the output in continuous operation and interrupted operation. The run mode commands will affect the 8251 only after it will be set to interrupted operation.

### Parameters

Name	Type	Default	Description
ON	Discrete	ON	Disables all interrupted modes and forces the continuous run mode
OFF	Discrete		Select the interrupted run mode. While in this switch option, you can program the 8251 to operate in triggered, gated, or counted burst run modes.

### Response

The 8251 will return OFF, or ON depending on the selected option.

## TRIGger:BURSt{OFF|ON|0|1}(?)

### Description

This command will toggle the counted burst run mode on and off. This command will affect the 8251 only after it will be set to INIT:CONT OFF.

### Parameters

Name	Type	Default	Description
OFF	Discrete	OFF	Turns the burst run mode off.
ON	Discrete		Enables the counted burst run mode. Burst count is programmable using the TRIG:BURS:COUN command.

### Response

The 8251 will return OFF, or ON depending on the selected option.

## TRIGger:BURSt:COUNT<burst>(?)

### Description

This function sets the number of cycles when the Burst Mode is on. Use the init:cont off;;trig:burs on commands to select the Burst Mode.

### Parameters

Name	Range	Type	Default	Description
<burst>	2 to 1M	Numeric (integer only)	2	Programs the burst count.

**Response**

The 8251 will return the present burst count value.

**TRIGger:GATE{OFF|ON|0|1}(?)**

**Description**

This command will toggle the gate run mode on and off. This command will affect the 8251 only after it will be set to INIT:CONT OFF.

**Parameters**

Name	Type	Default	Description
OFF	Discrete	OFF	Turns the gate run mode off.
ON	Discrete		Enables the gated run mode.

**Response**

The 8251 will return OFF, or ON depending on the selected option.

**TRIGger:SOURce:ADVance{EXTernal|INTernal|BUS}(?)**

**Description**

This selects the source from where the 8251 will be stimulated to generate waveforms. The source advance command will affect the generator only after it has been programmed to operate in interrupted run mode. Modify the 8251 to interrupted run mode using the init:cont off command.

**Parameters**

Name	Type	Default	Description
EXTernal	Discrete	EXT	Activates the rear panel TRIG IN input and the front panel MAN TRIG button. Either a front panel button push or a legal signal which will be applied to the rear panel input will stimulate the 8251 to generate waveforms. BUS commands are ignored.
INTernal	Discrete		Selects the internal, free-running trigger generator. The period of the internal trigger generator can be programmed using the trig:tim command. External and remote commands are ignored.
BUS	Discrete		Selects the remote controller as the trigger source. Only software commands are accepted while rear and front panel signals are ignored

**Response**

The 8251 will return EXT, INT, or BUS depending on the selected trigger source advance setting.

## TRIGger:SLOPe{POSitive|NEGative}(?)

### Description

The trigger slope command selects the sensitive edge of the trigger signal that is applied to the TRIG IN connector. The Model 8251 can be made sensitive to either the positive or negative transitions. Positive going transitions will trigger the generator when the POS option is selected. Negative transitions will trigger the generator when the NEG option is selected. In Gated mode, two transitions in the same direction are required to gate on and off the output. The trigger slope command will affect the generator only after it has been programmed to operate in interrupted run mode. Modify the 8251 to interrupted run mode using the init:cont off command.

### Parameters

Name	Type	Default	Description
POSitive	Discrete	POS	Selects the positive going edge.
NEGative	Discrete		Selects the negative going edge.

### Response

The 8251 will return POS, or NEG depending on the selected trigger slope setting.

## TRIGger:LEVel<level>(?)

### Description

The trigger level command sets the threshold level at the trigger input connector. The trigger level command will affect the generator only after it has been programmed to operate in interrupted run mode. Modify the 8251 to interrupted run mode using the init:cont off command.

### Parameters

Name	Range	Type	Default	Description
<level>	-5 to +5	Numeric	1.6	Programs the trigger level. The value affects the rear panel input only.

### Response

The 8251 will return the present burst count value.

## TRIGgger:TIME<time>(?)

### Description

This parameter specifies the period of the internal trigger generator. The period is programmed in units of seconds. This command will affect the generator only after it has been programmed to operate in internal trigger run mode. Modify the 8251 to interrupted run mode using the init:cont off command.

### Parameters

Name	Range	Type	Default	Description
<time>	200e-9 to 100	Numeric	1e-3	Programs the re-trigger period.

### Response

The 8251 will return the present internal trigger period value.

## TRIGger:DElay{OFF|ON|0|1}(?)

### **Description**

This command will toggle the delayed trigger mode on and off. This command will affect the 8251 only after it will be set to INIT:CONT OFF.

Note: System delay must always be considered when using an external trigger. System delay is measured from a valid trigger input to the transition of the first waveform point. It has a fixed period that adds to the programmed trigger delay value. Consult Appendix A for the system delay specification.

### **Parameters**

Name	Type	Default	Description
OFF	Discrete	OFF	Turns the delayed trigger mode off.
ON	Discrete		Enables the delayed trigger mode.

### **Response**

The 8251 will return OFF, or ON depending on the selected option.

## TRIGger:DElayTime<time>(?)

### **Description**

The trigger delay time parameter defines the time that will elapse from a valid trigger signal to the initiation of the first output waveform. It can be turned ON and OFF using the trig:del command. The trigger delay time command will affect the generator only after it has been programmed to operate in interrupted run mode but is not available when the internal trigger generator is active. Modify the 8251 to interrupted run mode using the init:cont off command.

### **Parameters**

Name	Range	Type	Default	Description
<time>	0 to 16e6	Numeric	200e-9	Programs the trigger delay time. The delay units are waveform point of which their period is determined by the sample clock frequency setting.

### **Response**

The 8251 will return the present trigger delay time value.

## Auxiliary Commands

The auxiliary commands control auxiliary functions that are not directly related to the main function of the arbitrary waveform generator however, constitute an important part of operating the 8251. These commands can transform the 8251 into a stand-alone pulse generator.

Table 5-7, Auxiliary Commands

Keyword	Parameter Form	Default
<i>Auxiliary Commands</i>		
:AUXiliary		
:PULSe		
:DELay	0 to n	0
:DOUBle		
[:STATe]	OFF   ON   0   1	0
:DELay		2e-3
:HIGH	1e-9 to n	1e-3
:LEVel		
:HIGH	-2.90 to 3	0.5
:LOW	-3 to 2.90	-0.5
:PERiod	4e-9 to 10	10e-3
:POLARity	NORMal   INVert   COMPlmented	NORM
:TRANsition		
[:LEADing	0 to n	1e-3
:TRAILing]	0 to n	1e-3

## Digital Pulse Programming

Use the following command for programming the pulse parameters. The pulse is created digitally however, it closely simulates an analog pulse generator so pulse parameters are programmed just as they would be programmed on a dedicated pulse generator instrument. Just bear in mind that since this is a digital instrument, there are some limitations to the pulse design that evolve from the fact that the best resolution is one sample clock interval and also, keep in mind that the pulse is created digitally in the arbitrary memory and therefore, its smallest incremental step has a maximum value limitation as specified in Appendix A.

### AUXiliary:PULse:DELay<delay>(?)

#### **Description**

This command will program the delayed interval of which the output idles on the low level amplitude until the first transition to high level amplitude.

#### **Parameters**

Name	Range	Type	Default	Description
<delay>	0 to n	Numeric	0	Will set the delay time interval in units of seconds. Note that the sum of all parameters, including the pulse delay time must not exceed the programmed pulse period and therefore, it is recommended that the pulse period be programmed first and then all other pulse parameters.

#### **Response**

The 8251 will return the pulse delay value in units of seconds.

### AUXiliary:PULse:DOUBle{OFF|ON|0|1}(?)

#### **Description**

This command will turn the double pulse mode on and off. The double pulse mode duplicates the first pulse parameters at a delayed interval set by the double pulse delay value.

#### **Parameters**

Range	Type	Default	Description
0-1	Discrete	0	Sets the double pulse mode on and off

#### **Response**

The 8251 will return 0, or 1 depending on the present double mode setting.

## AUXiliary:PULse:DOUble:DELAy<d\_delay>(?)

### Description

This command will program the delay between two adjacent pulses when the double mode is selected. Otherwise, the double pulse delay has no effect on the pulse structure.

### Parameters

Name	Range	Type	Default	Description
<d_delay>	0 to n	Numeric	2e-3	Will set the delay between two adjacent pulses for the double pulse mode in units of seconds. Note that the sum of all parameters, including the pulse delay time must not exceed the programmed pulse period and therefore, it is recommended that the pulse period be programmed before all other pulse parameters.

### Response

The 8251 will return the present double pulse delay value in units of seconds.

## AUXiliary:PULse:HIGH<high>(?)

### Description

This command will program the interval the pulse will dwell on the high level value. Although they have similar interpretation, the high time and pulse width are significantly different. The standard terminology of pulse width defines the width of the pulse at the mid-point of its peak-to-peak amplitude level. Therefore, if you change the rise and fall time, the pulse width is changing accordingly. The digital pulse high time parameter defines how long the pulse will dwell on the high level so even if you change the rise and fall times, the high time remains constant. The pulse high time is programmed in units of seconds.

### Parameters

Name	Range	Type	Default	Description
<high>	0 to n	Numeric	1e-3	Will set the width of the high time for the pulse shape in units of seconds. Note that the sum of all parameters, including the high time must not exceed the programmed pulse period and therefore, it is recommended that the pulse period be programmed before all other pulse parameters.

### Response

The 8251 will return the present high time value in units of seconds

## AUXiliary:PULse:LEVel:HIGH<high>(?)

### Description

This command will program the high level for the pulse shape. Note that the same level is retained for the second pulse in the double pulse mode.

### Parameters

Name	Range	Type	Default	Description
<high>	-2.90 to 3	Numeric	0.5	Will set the pulse high level in units of volts. Note that the high level setting must be higher than the low level setting. Also note that high to low level value must be equal or larger than 100 mV.

### Response

The 8251 will return the present low level value in unit of volts.

## AUXiliary:PULse:LEVel:LOW<low>(?)

### Description

This command will program the phase offset between two adjacent instruments. Normally this command should be used on the slave unit. The phase offset control provides means of generating multiple signals with phase offset between them.

### Parameters

Name	Range	Type	Default	Description
<low>	-3 to 2.90	Numeric	-0.5	Will set the pulse low level in units of volts. Note that the low level setting must be smaller than the high level setting. Also note that low to high level value must be equal or larger than 100 mV.

### Response

The 8251 will return the present high level value in unit of volts.

## AUXiliary:PULse:PERiod<period>(?)

### Description

This command will program the pulse repetition rate (period). Note that the sum of all parameters, including the pulse delay, rise, high and fall times must not exceed the programmed pulse period and therefore, it is recommended that the pulse period be programmed first before all other pulse parameters. Note that by selecting the double pulse mode, the pulse period remains unchanged.

### Parameters

Name	Range	Type	Default	Description
<period>	4e-9 to 10	Numeric	10e-3	Will program the period of the pulse waveform in units of seconds.

### Response

The 8251 will return the present pulse period value in units of seconds.

## AUXiliary:PULse:POLarity{NORMal|INVerted|COMPlmented(?)

### Description

This command will program the polarity of the pulse in reference to the base line level. The polarity options are: Normal, where the pulse is generated exactly as programmed; Inverted, where the pulse is inverted about the 0 level base line; and Complemented, where the pulse is inverted about its mid amplitude level.

### Parameters

Name	Type	Default	Description
NORMal	Discrete	NORM	Programs normal pulse output
INVerted	Discrete		Programs an inverted pulse output
COMPlmented	Discrete		Programs complemented pulse output

### Response

The 8251 will return NORM, INV or COMP depending on the present polarity setting

## AUXiliary:PULse:TRANSition<rise>(?)

### Description

This command will program the interval it will take the pulse to transition from its low to high level settings. The parameter is programmed in units of seconds.

### Parameters

Name	Range	Type	Default	Description
<rise>	0 to n	Numeric	1e-3	Will set the rise time parameter. Note that the sum of all parameters, including the rise time must not exceed the programmed pulse period and therefore, it is recommended that the pulse period be programmed before all other pulse parameters.

### Response

The 8251 will return the present rise time value in units of seconds.

## AUXiliary:PULse:TRANSition:TRAILing<fall>(?)

### Description

This command will program the interval it will take the pulse to transition from its high to low level settings. The parameter is programmed in units of seconds.

### Parameters

Name	Range	Type	Default	Description
<fall>	0 to n	Numeric	1e-3	Will set the fall time parameter. Note that the sum of all parameters, including the fall time must not exceed the programmed pulse period and therefore, it is recommended that the pulse period be programmed before all other pulse parameters.

### Response

The 8251 will return the present fall time value in units of seconds.

**System Commands** The system-related commands are not related directly to waveform generation but are an important part of operating the 8251. These commands can reset or test the instrument, or query the instrument for system information.

Table 5-8, System Commands Summary

Keyword	Parameter Form	Default
:RESet		
:SYSTem		
:ERRor?		
:VERSion?		
:TEMPerature?		
:INFOrmation		
:MODel?		
:SERial?		
:CALibration?		
:FIRMware		
[:VERSion]?		

## RESet, or \*RST

### *Description*

This query will reset the 8251 to its factory defaults.

## SYSTem:ERRor?

### *Description*

This query will interrogate the 8251 for programming errors.

### *Response*

The 8251 will return error code. Error messages are listed later in this manual.

## SYSTem:VERSion?

### *Description*

This query will interrogate the 8251 for its current SCPI version.

### *Response*

The 8251 will return the current SCPI version code.

## SYSTem:TEMPerature?

### *Description*

This query will interrogate the temperature inside the 8251. Temperatures around 40°C are normal and should be preserved for long term operation. Use this command to periodically monitor the temperature when you surround the instrument with hot devices or when stacking inside a 19" rack.

**Response**

The generator will return its model internal temperature reading.

## **SYSTem:INFormation:MODeL?**

**Description**

This query will interrogate the instrument for its model number.

**Response**

The generator will return its model number.

## **SYSTem:INFormation:SERial?**

**Description**

This query will interrogate the instrument for its serial number.

**Response**

The generator will return its serial number.

## **SYSTem:INFormation:CALibration?**

**Description**

This query will interrogate the instrument for its last calibration date. Note that normal calibration cycles is 2 years; Refer your 8251 to a service center for calibration if your last calibration date is older than 2 year

**Response**

The generator will return its last calibration date..

## **SYSTem:INFormation:FIRMware?**

**Description**

This query will interrogate the instrument for its firmware version. Firmware can be updated using a software utility as described in Chapter 2. Firmware updates are not recommended unless you feel the instrument does not function as expected. Contact the factory if you are not sure that you have the latest firmware revision.

**Response**

The generator will return its last calibration date.

## **IEEE-STD-488.2 Common**

Since most instruments and devices in an ATE system use similar commands that perform similar functions, the IEEE-STD-488.2 document has specified a common set of commands and queries

## Commands and Queries

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

The following is a complete listing of all common-commands and queries, which are used by the 8251

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

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

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

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

**\*IDN?** - Query the generator's identity. The returned data is organized into four fields, separated by commas. The generator responds with its manufacturer and model number in the first two fields, and may also report its serial number and options in fields three and four. If the latter information is not available, the device must return an ASCII 0 for each. For example, Model 8251 response to \*IDN? is:

**Tabor,8251,0,1.0**

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

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

**\*OPT?** - Returns the value "0" for a 8251 with no options. "1, 2, 3 and 4" flag options are installed. Options are listed in Appendix A.

**\*RST** - Resets the generator to its default state. Default values are listed in Table 5-1.

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

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

**\*STB?** - Query the Status Byte summary register. The \*STB?

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

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

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

---

## The SCPI Status Registers

The Model 8251 uses the Status Byte register group and the Standard Event register group to record various instrument conditions. Figure 5-1 shows the SCPI status system.

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

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

## The Status Byte Register (STB)

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

**Bit 0** - Decimal value 1. Not used, always set to 0.

**Bit 1** - Decimal value 2. Not used, always set to 0.

**Bit 2** - Decimal value 4. Not used, always set to 0.

**Bit 3** - Decimal value 8. Not used, always set to 0.

**Bit 4** - Decimal value 16. Message Available Queue Summary Message (MAV). The state of this bit indicates whether or not the output queue is empty. The MAV summary message is true when the output queue is not empty. This message is used to synchronize information exchange with the controller. The controller can, for example, send a query command to the device and then wait for MAV to become true. If an application program begins a read operation of the output queue without first checking for MAV, all system bus activity is held up until the device responds.

**Bit 5** - Decimal value 32. Standard Event Status Bit (ESB) Summary Message. This bit indicates whether or not one or more of the enabled ESB events have occurred since the last reading or clearing of the Standard Event Status Register.

**Bit 6** - Decimal value 64. Master Summary Status (MSS)/Request Service (RQS) Bit. This bit indicates if the device has at least one condition to request service. The MSS bit is not part of the IEEE-STD-488.1 status byte and will not be sent in response to a serial poll. However, the RQS bit, if set, will be sent in response to a serial poll.

**Bit 7** - Decimal value 128. Not used, always set to 0.

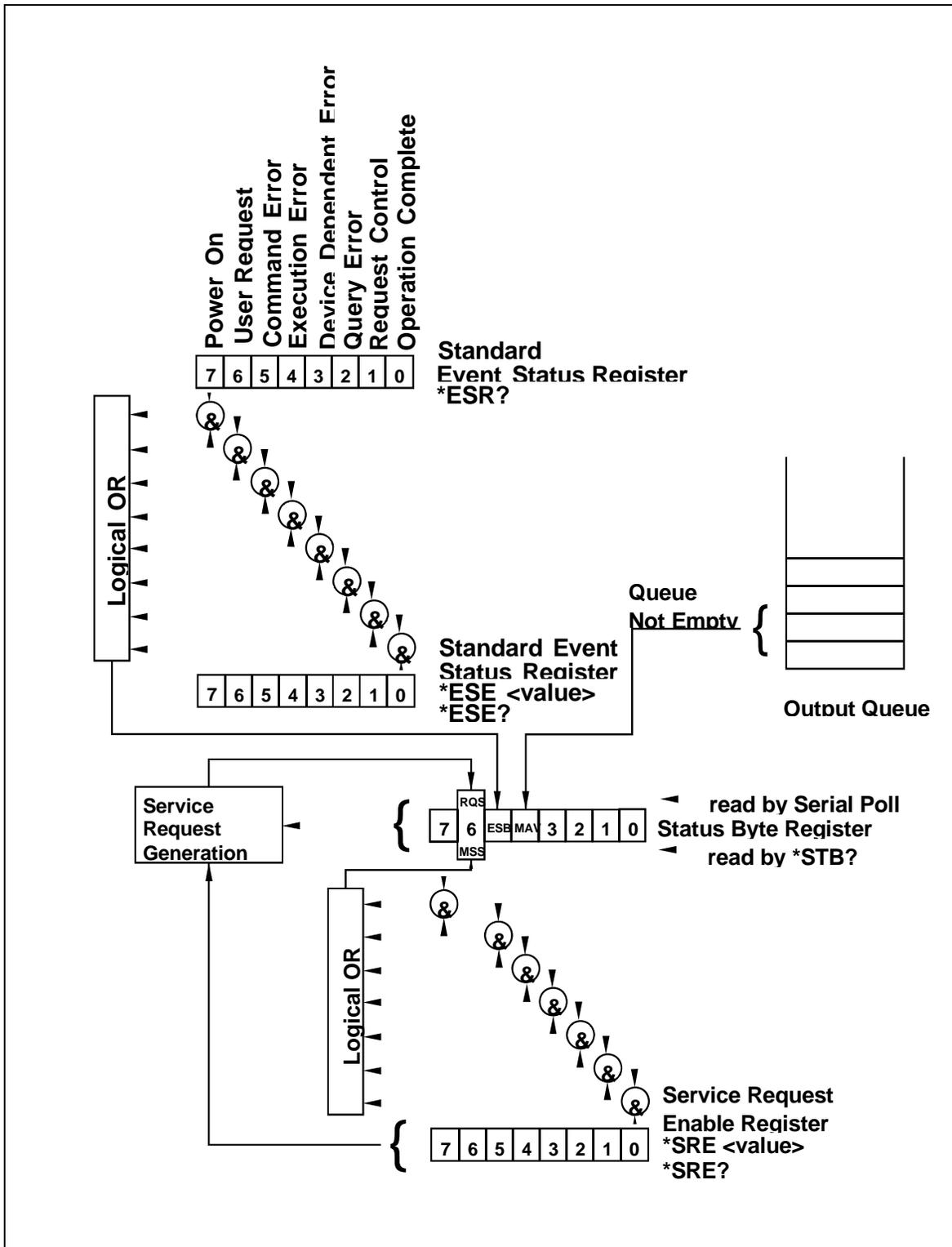


Figure 5-4, SCPI Status Registers

## Reading the Status Byte Register

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

## Clearing the Status Byte Register

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

## Service Request Enable Register (SRE)

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

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

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

- \*SRE0 - Clears all bits in the register.
- \*SRE1 - Not used.
- \*SRE2 - Not used.
- \*SRE4 - Not used.
- \*SRE8 - Not used.
- \*SRE16 - Service request on MAV.
- \*SRE32 - Service request on ESB summary bit.
- \*SRE128 - Not used.

## Standard Event Status Register (ESR)

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

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

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

**Bit 1** - Request Control. This bit operation is disabled on the Model 8251.

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

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

```
VOLTage 5;:VOLTage:OFFSet 2
```

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

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

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

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

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

## Standard Event Status Enable Register (ESE)

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

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

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

- \*ESE0 – No mask. Clears all bits in the register.
- \*ESE1 – ESB on Operation Complete.
- \*ESE2 – ESB on Request Control.
- \*ESE4 – ESB on Query Error.
- \*ESE8 – ESB on Device Dependent Error.
- \*ESE16 – ESB on Execution Error.
- \*ESE32 – ESB on Command Error.
- \*ESE64 – ESB on User Request.
- \*ESE128 – ESB Power on.

## Error Messages

In general, whenever the 8251 receives an invalid SCPI command, it automatically generates an error. Errors are stored in a special error queue and may be retrieved from this buffer one at a time. Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. When you have read all errors from the queue, the generator responds with a 0, "No error" message.

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

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

SYSTem:ERRor?

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

-102,"Syntax error"

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

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

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

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

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

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

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

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

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

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

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

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

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

1. Sum of pulse or ramp parameters is more than 100. Corrective action: Change parameters to correct the problem.
2.  $\text{ampl}/2 + |\text{offset}|$  is more than 2. Corrective action: Reduce offset to 0, then change amplitude-offset values to correct the problem.
3. Activating filters when the 8251 is set to output the built-in sine waveform, or activating the built-in sine waveform when one of the 8251 filters is turned on. Corrective action: If in sine, select

another function and activate the filter(s).

-222,"Data out of range". Parameter data, which followed a specific header, could not be used because its value is outside the valid range defined by the generator.

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

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

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

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

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

# Chapter 6

## Performance Checks

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## What's in This Chapter

This chapter provides performance tests necessary to troubleshoot the Model 8251 Universal Waveform Generator.



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

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**ALWAYS PERFORM PERFORMANCE TESTS IN A STATIC SAFE WORKSTATION.**

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## Performance Checks

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

1. As a part of the incoming inspection of the instrument specifications;
2. As part of the troubleshooting procedure;
3. After any repair or adjustment before returning the instrument to regular service.

## Environmental Conditions

Tests should be performed under laboratory conditions having an ambient temperature of 25°C,  $\pm 5^\circ\text{C}$  and at relative humidity of less than 80%. If the instrument has been subjected to conditions outside these ranges, allow at least one additional hour for the instrument to stabilize before beginning the adjustment procedure.

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## Warm-up Period

Most equipment is subject to a small amount of drift when it is first turned on. To ensure accuracy, turn on the power to the Model 8251 and allow it to warm-up for at least 30 minutes before beginning the performance test procedure.

## Initial Instrument Setting

To avoid confusion as to which initial setting is to be used for each test, it is required that the instrument be reset to factory default values prior to each test. To reset the Model 8251 to factory defaults, use the Factory Rest option in the Utility menu.

## Recommended Test Equipment

Recommended test equipment for troubleshooting, calibration and performance checking is listed in Table 6-1 below. Test instruments other than those listed may be used only if their specifications equal or exceed the required characteristics.

*Table -1, Recommended Test Equipment*

Equipment	Model No.	Manufacturer
Oscilloscope (with jitter package)	LT342	LeCroy
Distortion Analyzer	6900B	Krohn Hite
Digital Multimeter	2000	Keithley
Frequency Counter	6020R	Tabor Electronics
Spectrum Analyzer	E4411	HP
Pulse Generator (with manual trigger)	8500	Tabor Electronics

## Test Procedures

Use the following procedures to check the Model 8251 against the specifications. A complete set of specifications is listed in Appendix A. The following paragraphs show how to set up the instrument for the test, what the specifications for the tested function are, and what acceptable limits for the test are. If the instrument fails to perform within the specified limits, the instrument must be calibrated or tested to find the source of the problem.

## Frequency Accuracy

Frequency accuracy checks tests the accuracy of the internal oscillators. It also tests the accuracy of the 8251 with an external, 10MHz, reference oscillator and external sample clock generator. Both the external signals are applied to the rear panel connectors.

**Frequency Accuracy, Internal Reference**

Equipment: Counter

Preparation:

1. Configure the counter as follows:  
Termination: 50 Ω, DC coupled
2. Connect the 8251 Normal output to the counter input – channel A
3. Configure the 8251, as follows:  
Waveform: Squarewave  
Amplitude: 2 V  
Output: On  
Frequency: As specified in Table 6-2

Test Procedure:

1. Perform frequency Accuracy tests using Table 6-2

*Table -2, Frequency Accuracy*

8251 Setting	Error Limits	Counter Reading	Pass	Fail
50.0000000 Hz	±50 µHz			
100.000000 Hz	±100 µHz			
1.00000000k Hz	±1 mHz			
10.0000000 kHz	±10 mHz			
100.000000 kHz	±100 mHz			
1.00000000 MHz	±1 Hz			
10.0000000 MHz	±10 Hz			
100.0000000 MHz	±100 Hz			
200.0000000 MHz	±200 Hz			

**Frequency Accuracy, External 10MHz Reference**

Equipment: 10 MHz reference (at least 0.1 ppm), Counter

Preparation:

1. Leave counter setting and 8251 connections as in last test
2. Connect the 10MHz reference oscillator to the 8251 rear panel input
3. Configure the 8251 as follows:  
10 MHz: External  
Waveform: Squarewave  
Amplitude: 2 V  
Output: On  
Frequency: As specified in Table 6-3

Test Procedure

1. Perform frequency Accuracy tests using Table 6-3

*Table 6-3, Frequency Accuracy Using External 10MHz Reference*

8251 Setting	Error Limits	Counter Reading	Pass	Fail
10.0000000 MHz	±1 Hz			
250.0000000 MHz	±25 Hz			

## Amplitude Accuracy

Amplitude accuracy checks tests the accuracy of the output amplifier and attenuators. Amplitude path is checked for both the DAC route (arbitrary and standard waveforms) and the DDS route (CW and modulated waveforms).

### Amplitude Accuracy, Arbitrary Waveforms

Equipment: DMM

Preparation:

1. Configure the DMM as follows:
  - Termination: 50  $\Omega$  feedthrough at the DMM input
  - Function: ACV
2. Connect 8251 outputs to the DMM input
3. Configure the 8251 as follows:
  - Frequency: 1 kHz
  - Output: On
  - Amplitude: As specified in Table 6-5

Test Procedure

1. Perform amplitude Accuracy tests using Table 6-5

Table 6-4, Amplitude Accuracy, Arbitrary Waveforms

8251 Amplitude Setting	Error Limits	DMM Reading	Pass	Fail
4.000 V	1.414 V, $\pm 47$ mV			
2.000 V	0.707 V, $\pm 26$ mV			
1.000 V	353.4 mV, $\pm 16$ mV			
500.0 mV	176.7 mV, $\pm 10$ mV			
100.0 mV	35.35 mV, $\pm 6$ mV			

### Amplitude Accuracy, Modulated Waveforms

Equipment: DMM

Preparation:

1. Configure the DMM as follows:
  - Termination: 50  $\Omega$  feedthrough at the DMM input
  - Function: ACV
2. Connect 8251 Channel outputs to the DMM input
3. Configure the 8251 as follows:
  - Waveform: Modulated
  - Modulation: OFF
  - CW Frequency: 1 kHz
  - Output: On
  - Amplitude: As specified in Table 6-6

Test Procedure

1. Perform amplitude Accuracy tests using Table 6-6.

Table 6-5, Amplitude Accuracy, Modulated Waveforms

8251 Amplitude Setting	Error Limits	DMM Reading	Pass	Fail
4.000 V	1.414 V, $\pm 47$ mV			
2.000 V	0.707 V, $\pm 26$ mV			
1.000 V	353.4 mV, $\pm 16$ mV			
500.0 mV	176.7 mV, $\pm 10$ mV			
100.0 mV	35.35 mV, $\pm 6$ mV			
50.00 mV	17.67 mV, $\pm 5$ mV			

## Offset Accuracy

The offset accuracy checks tests the accuracy of the offset generators.

## Offset Accuracy, Arbitrary Waveforms

Equipment: DMM

Preparation:

- Configure the DMM as follows:
  - Termination: 50  $\Omega$  feedthrough at the DMM input
  - Function: DCV
- Connect 8251 Channel outputs to the DMM input
- Configure the 8251 as follows:
  - Frequency: 1 MHz
  - Amplitude: 50 mV (100 mV with option 2)
  - Output: On
  - Offset: As specified in Table 6-8

Test Procedure

- Perform Offset Accuracy tests using Table 6-8

Table 6-6, Offset Accuracy, Arbitrary Waveforms

8251 Offset Setting	Error Limits	DMM Reading	Pass	Fail
+1.000 V	1.000 V $\pm 80$ mV			
+500m V	500 mV $\pm 65$ mV			
0.000 V	$\pm 50$ mV			
-500.0m V	-500 mV $\pm 65$ mV			
-1.000 V	-1.000 V $\pm 80$ mV			

## Squarewave Characteristics

This tests the characteristics of the square waveform. It includes transition times and aberrations. Each output characteristics is being tested separately.

## Squarewave Checks

Equipment: Oscilloscope, 50  $\Omega$ , 20 dB attenuator feed through

Preparation:

1. Configure the Oscilloscope follows:
  - Termination: 50  $\Omega$ , 20 dB attenuator feed through at the oscilloscope input
  - Setup: As required for the test
2. Connect 8251 outputs to the oscilloscope input  
Configure the 8251 as follows:
  - Frequency: 1 MHz
  - Waveform: Squarewave
  - Amplitude: As specified in Table 6-9
  - Output: On

Test Procedure

1. Perform Squarewave Characteristics tests using Table 6-9.

Table 6-7, Square wave Characteristics

8251 Amplitude	Parameter Tested	Error Limits		Oscilloscope Reading	Pass	Fail
		Std.	Opt 2			
1 V	Rise/Fall Time	<0.75 ns	<1 ns			
1 V	Ringing	<10 %	<10 %			
1 V	Over/undershoot	<10 %	<10 %			
2 V	Rise/Fall Time	<0.75 ns	<1 ns			
2 V	Ringing	<10 %	<10 %			
2 V	Over/undershoot	<10 %	<10 %			
4 V	Rise/Fall Time	-	<1 ns			
4 V	Ringing	-	<10 %			
4 V	Over/undershoot	-	<10 %			

## Sinewave Characteristics

This tests the characteristics of the sine waveform. It includes distortions, spectral purity and flatness. Tests are done for both the DAC route (arbitrary and standard waveforms) and the DDS route (CW and modulated waveforms).

**Sinewave Distortions, Arbitrary Waveforms**

Equipment: Distortion Analyzer, Spectrum Analyzer, and ArbConnection

Preparation:

1. Connect the 8251 outputs to the distortion analyzer input. Use 50Ω feed through termination at the distortion analyzer input
2. Configure the 8251 as follows:
  - SCLK: As required by the test
  - Waveform: Arbitrary
  - Amplitude: 2 V
  - Output: On
3. Using ArbConnection prepare and download the following waveform:
  - Wavelength: As required by the test
  - Waveform: Sinewave

Test Procedure

1. Perform Sinewave distortion tests on both outputs using Table 6-10

Table 6-8, Sinewave Distortion, Arbitrary Waveforms Tests

8251 SCLK Settings	Sinewave Points	8251 Frequency	Reading Limits	Distortion	Pass	Fail
1M S/s	10000	100.0 Hz	<0.7 %			
10 Ms/s	10000	1.000 kHz	<0.7 %			
100 Ms/s	10000	10.00 kHz	<0.7 %			

**Sinewave Spectral Purity, Arbitrary Waveforms**

Equipment: Spectrum Analyzer

Preparation:

1. Connect the 8251 outputs to the spectrum analyzer input.
2. Configure the 8251 as follows:
  - Frequency: As required by the test
  - Amplitude: 4 V
  - Output: On

Test Procedure

1. Perform sinewave spectral purity, Arbitrary waveforms tests using Table 6-11

Table 6-9, Sinewave Spectral Purity, Arbitrary Waveforms Test

8251 Freq Settings	Reading Limits	Spectrum Analyzer, Settings & Results			Pass	Fail
		Start	Stop	Result		
1MHz	>37 dBc	100 kHz	10 MHz			
11 MHz	>30 dBc	1 MHz	100 MHz			
57 MHz	>25 dBc	10 MHz	300 MHz			
123 MHz	>25 dBc	10 MHz	400 MHz			

## Sinewave Flatness, Modulated Waveforms

Equipment: Oscilloscope

Preparation:

1. Configure the Oscilloscope follows:
  - Termination: 50  $\Omega$
  - Setup: As required for the test
2. Connect the 8251 outputs to the oscilloscope input
3. Configure the 8251 as follows:
  - Waveform: Modulated
  - Modulation: Off
  - CW Frequency: As required by the test
  - Amplitude: 4 V
  - Output: On

Test Procedure

1. Adjust the vertical controls of the Oscilloscope to get 6 division of display exactly the marker frequency position.
2. Perform Sine flatness, Modulated waveforms tests on both outputs using Table 6-10

Table 6-10, Sinewave Flatness, Modulated Waveforms Output, Option 2 Test

8251 CW Frequency	Error Limits	Oscilloscope Reading		Pass	Fail
		Normal	Inverted		
1 MHz	6 Divisions	Reference	Reference	X	X
10 MHz	6 $\pm$ 0.6 Divisions				
50 MHz	6 $\pm$ 0.6 Divisions				
100 MHz	6 $\pm$ 0.6 Divisions				
150 MHz	6 $\pm$ 0.6 Divisions				
180 MHz	6 $\pm$ 0.6 Divisions				

## Trigger operation Characteristics

This tests the operation of the trigger circuit. It includes tests for the triggered, gated and counted bursts run modes. It also tests the operation of the trigger advance options and the delayed trigger functions, as well as the trigger input level and slope sensitivity. The run modes are common to both outputs and therefore the tests are performed on the Normal channel.

## Trigger, Gate, and Burst Characteristics

Equipment: Oscilloscope, function generator, counter

Preparation:

1. Configure the Oscilloscope follows:
  - Termination: 50  $\Omega$
  - Setup: As required for the test

2. Connect 8251 Normal output to the oscilloscope input
3. Configure the function generator as follows:
  - Frequency: As required by the test
  - Run Mode: As required by the test
  - Wave: Square
  - Amplitude: 2 V
  - Offset: 1 V
4. Connect the function generator output to the 8251 TRIG IN connector
5. Configure the 8251 as follows:
  - Frequency: 125 MHz
  - Waveform: Sinewave
  - Run Mode: As required by the test
  - Burst Count: 1e6 counts, each channel
  - Trigger Source: External
  - Output: On

Test Procedure

1. Perform trigger and gate tests using Tables 6-15
2. Set counter trigger level to 100mV.
3. Configure the counter to TOTB Measurements and perform burst tests using Tables 6-18.

Table 6-11, Trigger, gate, and burst Characteristics.

8251 Run Mode	External Trigger Pulse	Oscilloscope Reading	Pass	Fail
		Normal		
Triggered	1 MHz, Continuous	Triggered waveform		
Gated	1 MHz, Continuous	Gated Waveform		
Burst	Single shot	Burst, 1e6 waveforms		

**Delayed Trigger Characteristics**

Equipment: Function generator, 50 Ω “T” connector, Counter, ArbConnection

Preparation:

1. Configure the Function generator as follows:
  - Amplitude: 4 V
  - Frequency: As required by the test
  - Trigger Mode: Triggered.
  - Wave: Squarewave
2. Place the “T” connector on the output terminal of the function generator. Connect one side of the “T” to the 8251 TRIG IN connector and the other side of the “T” to the channel A input of the counter
3. Connect the 8251 output to channel B input of the counter
4. Configure the counter as follows:
  - Function: T1 A to B measurements
  - Impedance: 50 Ω, both channels
5. Using ArbConnection prepare and download the following

waveform:

Wavelength: 128 points  
Waveform: Pulse, Delay = 0.1, Rise/Fall = 0, High Time = 90

6. Configure the 8251 as follows:

SCLK: 625 MS/s  
Waveform: Arbitrary  
Run Mode: Triggered  
Trigger Level: 0 V  
Delayed Trigger: On  
Delay: As required for the test  
Trigger Source: External  
Output: On

Test Procedure

1. Perform trigger delay tests using Tables 6-19

Table 6-12, Trigger Delay Tests

Ext Freq Setting	8251 Delay Setting	Error Limits	Counter Reading	Pass	Fail
10 kHz	(Delay 0 = Ref) 0	100 ns	Note reading	X	X
10 kHz	1	1.6 ns ±1.6 ns + Delay 0			
10 kHz	3	4.8 ns ±1.6 ns + Delay 0			
10 kHz	5	8 ns ±1.6 ns + Delay 0			
10 kHz	250	400 ns ±1.6 ns + Delay 0			
1 kHz	5000	8 μs ±1.6 ns + Delay 0			
10 Hz	512000	819.2 μs ±1.6 ns + Delay 0			

## Internal Trigger Characteristics

Equipment: Counter

Preparation:

1. Configure the counter to period averaged measurements
2. Connect the counter channel A to the 8251 Normal output
3. Configure the 8251 as follows:
  - Frequency: 10 MHz
  - Waveform: Standard square wave
  - Run Mode: Triggered
  - Trigger Source: Internal
  - Trigger Period: As required by the test
  - Output: On

Test Procedure

1. Manually trigger the instrument
2. Perform trigger delay tests using Tables 6-20

Table 6-13, Internal Trigger Tests

8251 Internal Trigger Period	Error Limits	Counter Reading	Pass	Fail
1 $\mu$ s	1 $\mu$ s, $\pm$ 1 ns			
1 ms	1 ms, $\pm$ 1 $\mu$ s			
1 s	1 s, $\pm$ 1 ms			
10 s	10 s, $\pm$ 10 ms			

### Trigger Slope

Equipment: Oscilloscope, function generator

Preparation:

- Configure the Oscilloscope follows:  
Termination: 50  $\Omega$   
Setup: As required for the test
- Connect 8251 normal output to the oscilloscope input
- Configure the function generator as follows:  
Frequency 10 kHz  
Run Mode: Continue  
Waveform: TTL Output
- Connect the function generator TTL output to the 8251 TRIG IN connector
- Connect the function generator main output to the 2<sup>nd</sup> channel of the oscilloscope
- Configure the 8251 as follows:  
Frequency: 1 MHz  
Waveform: Sine wave  
Run Mode: Triggered  
Output: On

Test Procedure

- Toggle 8251 trigger slope from positive to negative visa versa
- Verify on the oscilloscope that the 8251 transitions are synchronized with the slope of the trigger

Test Results	Pass		Fail	

### Trigger Level

Equipment: Oscilloscope, function generator

Preparation:

- Configure the Oscilloscope as follows:  
Termination: 50 $\Omega$   
Setup: As required for the test
- Connect 8251 Normal output to the oscilloscope input
- Configure the function generator as follows:  
Frequency 10kHz

Run Mode: Continuous  
Waveform: Squarewave.  
Amplitude: 1V

4. Connect the function generator output to the 8251 TRIG IN connector
5. Configure the 8251 as follows:  
Frequency: 1MHz  
Waveform: Sine wave  
Run Mode: Triggered  
Trigger level: 0V  
Output: On

Test Procedure

1. Verify that the 8251 outputs triggered waveforms spaced at 0.1ms
2. Modify the function generator offset to +4V and change the 8251 trigger level to +4V. Verify that the 8251 outputs triggered waveforms spaced at 0.1ms
3. Modify the function generator offset to -4V and change the 8251 trigger level to -4V. Verify that the 8251 outputs triggered waveforms spaced at 0.1ms

<b>Test Results</b>	Pass		Fail	
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## Modulated Waveforms Characteristics

This tests the operation of the modulation circuits. It includes tests for the various modulation functions: FM, FSK, PSK, and Sweep. Since the run modes are common to all modulation functions, they are being tested on the FM function only.

### FM - Standard Waveforms

Equipment: Oscilloscope

Preparation:

1. Configure the oscilloscope as follows:
  - Time Base: 50  $\mu$ s
  - Sampling Rate: 50 MS/s at least.
  - Trace A View: Jitter, Type: FREQ, CLK.
  - Trigger source: Channel 2, positive slope
  - Amplitude: 0.2 V/div
2. Connect 8251 Normal output to the oscilloscope input, CH1
3. Connect the 8251 SYNC output to the oscilloscope input, CH2
4. Configure model 8251 controls as follows:
  - Waveform: Modulated
  - Modulation: FM
  - Carrier Freq: 1 MHz
  - Mod Frequency: 10 kHz
  - Deviation: 1 MHz
  - Sync: On
  - Output: On

Test Procedure:

1. Verify FM operation on the oscilloscope as follows:
  - Waveform: Sine
  - Frequency: 10 kHz
  - Max A: 1.5 MHz
  - Min A: 500 kHz

<b>Test Results</b>	Pass		Fail
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2. Modify 8251 modulating waveform to triangle, then square and ramp and verify FM waveforms as selected

<b>Test Results</b>	Pass		Fail
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## Triggered FM - Standard Waveforms

Equipment: Oscilloscope, function generator

Preparation:

1. Configure the oscilloscope as follows:
  - Time Base: 0.2 ms
  - Sampling Rate: 50 MS/s at least.
  - Trace A View: Jitter, Type: FREQ, CLK.
  - Trigger source: Channel 2, positive slope
  - Amplitude: 0.2 V/div
2. Connect 8251 normal output to the oscilloscope input, CH1
3. Connect the 8251 SYNC output to the oscilloscope input, CH2
4. Configure the function generator as follows:
  - Frequency 1 kHz
  - Run Mode: Continuous
  - Waveform: Squarewave.
  - Amplitude: 2 V
  - Offset: 1 V
5. Connect the function generator output connector to the 8251 TRIG IN connector
6. Configure model 8251 controls as follows:
  - Waveform: Modulated
  - Modulation: FM
  - Mod Run Mode: Triggered
  - Carrier Freq: 1 MHz
  - Mod Frequency: 10 kHz
  - Deviation: 1 MHz
  - Sync: On
  - Output: On

Test Procedure:

1. Verify triggered FM – standard waveforms operation on the oscilloscope as follows:
  - Waveform: Triggered sine waves
  - Sine Frequency: 10 kHz
  - Trigger Period: 1 ms
  - Max A: 1.5 MHz
  - Min A: 500 kHz

Test Results	Pass		Fail	
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## Gated FM - Standard Waveforms

Equipment: Oscilloscope, function generator

Preparation:

1. Configure the oscilloscope as follows:
  - Time Base: 0.2 ms
  - Sampling Rate: 50 MS/s at least.
  - Trace A View: Jitter, Type: FREQ, CLK.
  - Trigger source: Channel 2, positive slope

- Amplitude: 0.2 V/div
- 2. Connect 8251 Normal output to the oscilloscope input, CH1
- 3. Connect the 8251 SYNC output to the oscilloscope input, CH2
- 4. Configure the function generator as follows:
  - Frequency 1 kHz
  - Run Mode: Continuous
  - Waveform: Squarewave.
  - Amplitude: 2 V
  - Offset: 1 V
- 5. Connect the function generator output connector to the 8251 TRIG IN connector
- 6. Configure model 8251 controls as follows:
  - Waveform: Modulated
  - Modulation: FM
  - Mod Run Mode: Gated
  - Carrier Freq: 1 MHz
  - Mod Frequency: 10 kHz
  - Deviation: 1 MHz
  - Sync: On
  - Output: On

Test Procedure:

1. Verify triggered FM – standard waveforms operation on the oscilloscope as follows:
  - Waveform: Gated sine waveforms (5 cycles)
  - Sine Frequency: 10 kHz
  - Gated Period: 0.5 ms
  - Max A: 1.5 MHz
  - Min A: 500 kHz

<b>Test Results</b>	Pass		Fail	
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**FSK**

Equipment: Oscilloscope, Function generator

Preparation:

1. Configure the oscilloscope as follows:
  - Time Base: 50  $\mu$ s
  - Sampling Rate: 50 MS/s at least.
  - Trace A View: Jitter, Type: FREQ, CLK.
  - Trigger source: Channel 2, positive slope
  - Amplitude: 0.2 V/div.
2. Connect 8251 Normal output to the oscilloscope input, Ch1
3. Connect the 8251 SYNC output to the oscilloscope input, Ch2
4. Configure the function generator as follows:
  - Frequency: 10 kHz
  - Run Mode: Continuous
  - Waveform: Square Wave

- Amplitude: 2 V
- Offset: 1 V
- 5. Connect the function generator output to the 8251 TRIG IN connector
- 6. Configure model 8251 controls as follows:
  - Waveform: Modulated
  - Modulation: FSK
  - Carrier Freq: 2 MHz
  - Shift Frequency: 4 MHz
  - Output: On

Test Procedure:

1. Verify FSK operation on the oscilloscope as follows:
  - Waveform: Squarewave
  - Period: 0.1 ms
  - Max A: 4 MHz
  - Min A: 2 MHz

<b>Test Results</b>	Pass		Fail
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## PSK

Equipment: Oscilloscope, Function generator

Preparation:

1. Configure the oscilloscope as follows:
  - Time Base: 2  $\mu$ s
  - Trigger source: Channel 2, positive slope
  - Amplitude: 0.2 V/div.
2. Connect 8251 Normal output to the oscilloscope input, Ch1
3. Connect the 8251 SYNC output to the oscilloscope input, CH2
4. Configure the function generator as follows:
  - Frequency: 100 kHz
  - Run Mode: Continuous
  - Waveform: Square Wave
  - Amplitude: 2 V
  - Offset: 1 V
5. Connect the function generator output to the 8251 TRIG IN connector
6. Configure model 8251 controls as follows:
  - Waveform: Modulated
  - Modulation: PSK
  - Carrier Freq: 2 MHz
  - Shift Phase: 180 degrees
  - Output: On

Test Procedure:

1. Verify PSK operation on the oscilloscope as follows:
  - Waveform: Sinewave
  - Phase: Every 5  $\mu$ s change 180 degrees

Test Results	Pass		Fail	
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**Sweep**

Equipment: Oscilloscope

Preparation:

1. Configure the oscilloscope as follows:
  - Time Base: 0.5 ms
  - Sampling Rate: 50 MS/s at least.
  - Trace A View: Jitter, Type: FREQ, CLK.
  - Trigger source: Channel 2, positive slope
  - Amplitude: 0.2 V/div
2. Connect 8251 Normal output to the oscilloscope input, CH1
3. Connect the 8251 SYNC output to the oscilloscope input, CH2
4. Configure model 8251 controls as follows:
  - Waveform: Modulated
  - Modulation: Sweep
  - Start Frequency: 1 MHz
  - Stop Frequency: 2 MHz
  - Sweep Time: 1 ms
  - Sweep Type: Linear
  - Sync: On
  - Output: On

Test Procedure:

1. Verify Sweep operation on the oscilloscope as follows:
  - Waveform: Ramp up
  - Frequency: 1 kHz
  - Max A: 2 MHz
  - Min A: 1 MHz

Test Results	Pass		Fail	
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2. Move 8251 sweep marker position to 1.5 MHz and verify marker position at the middle of the ramp

Test Results	Pass		Fail	
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3. Reverse between Start and Stop frequencies and verify oscilloscope reading as before except the ramp is down

Test Results	Pass		Fail	
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- Change sweep step to logarithmic and verify oscilloscope exponential down waveform with properties as in 3 above

Test Results	Pass		Fail	
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## SYNC Output operation

This tests the operation of the SYNC output. There are two parameters being tested, the qualifier and the sync source. The sync output has a fixed TTL level amplitude into an open circuit.

## SYNC Qualifier - Bit

Equipment: Oscilloscope

Preparation:

- Configure the oscilloscope as follows:
  - Time Base: As required by the test
  - Amplitude: 1 V/div
- Connect 8251 SYNC output to the oscilloscope input
- Configure model 8251 as follows:
  - Waveform: Sine
  - Output: On
  - SYNC: On

Test Procedure:

- Verify trace on the oscilloscope shows synchronization pulses at 100 ns intervals

Test Results	Pass		Fail	
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## SYNC Qualifier - SCOM

Equipment: Oscilloscope

Preparation:

- Configure the oscilloscope as follows:
  - Time Base: As required by the test
  - Amplitude: 1 V/div
- Connect 8251 SYNC output to the oscilloscope input
- Configure model 8251 as follows:
  - Waveform: Sine
  - Output: On
  - SYNC: On

SYNC Type: SCOM

Test Procedure:

1. Verify trace on the oscilloscope shows synchronization pulses at 1 $\mu$ s intervals except the pulse is negative going

Test Results	Pass		Fail	
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## Waveform Memory Operation

This tests the integrity of the waveform memory. The waveform memory stores the waveforms that are being generated at the output connector and therefore, flaws in the memory can cause distortions and impurity of the output waveforms.

### Waveform memory

Equipment: Distortion Analyzer, ArbConnection

Preparation:

1. Connect 8251 Normal output to the distortion analyzer input.
2. Configure the 8251 as follows:
  - SCLK: 625 MS/s
  - Waveform: Arbitrary
  - Output: On
3. Using ArbConnection prepare and download the following waveform:
  - Wavelength: 512k points
  - Waveform: Sine wave

Test Procedure

1. Perform Sine wave distortion. It should be less than 0.5 %

Test Results	Pass		Fail	
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## Remote Interfaces

This tests the communication with the 8251 using the various interface options. Connecting and setting up the 8251 for operation with the various interface options is described in Chapter 2. Before you proceed with any of the following tests, make sure first that the 8251 is configured to operate with the selected test. GPIB operation requires setting of the GPIB address, LAN operation requires correct setting of the LAN parameters and USB operation requires that the USB port is configured correctly and USB driver installed on the host computer.

## GPIB Control

Equipment: Distortion Analyzer, ArbConnection

### Preparation:

1. Set up the 8251 for GPIB operation and connect the instrument to a host controller
2. Connect 8251 Normal output to the distortion analyzer input.
3. Configure the 8251 as follows:  
SCLK: 625 MS/s  
Waveform: Arbitrary  
Output: On
4. Using ArbConnection prepare and download the following waveform:  
Wavelength: 512k points  
Waveform: Sine wave

### Test Procedure

1. Check the resulting trace on the oscilloscope
2. Perform Sine wave distortion. It should be less than 0.5 %

Test Results	Pass		Fail	
--------------	------	--	------	--

## USB Control

Equipment: Distortion Analyzer, ArbConnection

### Preparation:

1. Set up the 8251 for USB operation and connect the instrument to a host controller
2. Connect 8251 Normal output to the distortion analyzer input.
3. Configure the 8251 as follows:  
SCLK: 625 MS/s  
Waveform: Arbitrary  
Output: On
4. Using ArbConnection prepare and download the following waveform:  
Wavelength: 512k points  
Waveform: Sine wave

### Test Procedure

1. Check the resulting trace on the oscilloscope
2. Perform Sine wave distortion. It should be less than 0.5 %

Test Results	Pass		Fail	
--------------	------	--	------	--

## LAN Control

Equipment: Distortion Analyzer, ArbConnection

### Preparation:

1. Set up the 8251 for USB operation and connect the instrument to a host controller
2. Connect 8251 Normal output to the distortion analyzer input.
3. Configure the 8251 as follows:
  - SCLK: 625 MS/s
  - Waveform: Arbitrary
  - Output: On
4. Using ArbConnection prepare and download the following waveform:
  - Wavelength: 512k points
  - Waveform: Sine wave

Test Procedure

1. Check the resulting trace on the oscilloscope
2. Perform Sine wave distortion. It should be less than 0.5 %

<b>Test Results</b>	Pass		Fail	
---------------------	------	--	------	--

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# **Chapter 7**

## **Adjustments and Firmware Update**

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## What's in This Chapter

This chapter provides adjustment information for the 8251 – 625MS/s Function / Arbitrary waveform generator.



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



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

## Performance Checks

Do not attempt to calibrate the instrument before you verify that there is no problem with the functionality of the product. A complete set of specification is listed in Appendix A. If the instrument fails to perform within the specified limits, the instrument must be tested to find the source of the problem.

In case there is a reasonable suspicion that an electrical problem exist within the 8251, perform a complete performance checks as given in Chapter 6 to verify proper operation of the instrument.

## Environmental Conditions

The 8251 can operate from 0°C to 50°C. Adjustments should be performed under laboratory conditions having an ambient temperature of 25°C,  $\pm 5^\circ\text{C}$  and at relative humidity of less than 80%. Turn on the power to the 8251 and allow it to warm up for at least 30 minutes before beginning the adjustment procedure. If the instrument has been subjected to conditions outside these ranges, allow at least one additional hour for the instrument to stabilize before beginning the adjustment procedure.

## Warm-up Period

Most equipment is subject to a small amount of drift when it is first turned on. To ensure accuracy, turn on the power to the Model 8251 and allow it to warm-up for at least 30 minutes before beginning the performance test procedure.

## Recommended Test Equipment

Recommended equipment for adjustments is listed in Table 6-1. Instruments other than those listed may be used only if their specifications equal or exceed the required minimal characteristics. Also listed below are accessories required for calibration.

Table -1, Recommended calibration for Adjustments

Equipment	Model No.	Manufacturer
Oscilloscope (with jitter package)	LC684	LeCroy
Digital Multimeter	2000	Keithley
Frequency Counter (Rubidium reference)	6020R	Tabor Electronics
Function Generator (with manual trigger)	8020	Tabor Electronics
Accessories	SMA to BNC cables	
	50Ω Feedthrough termination	
	50Ω End termination	
	Dual banana to BNC adapter	

## Adjustment Procedures

Use the following procedures to calibrate the Model 8251. The following paragraphs show how to set up the instrument for calibration and what the acceptable calibration limits are.

Calibration is done with the covers closed and the 8251 connected through an interface to a host computer. Any interface can be used from the following: USB, LAN, or GPIB. Calibration requires that ArbConnection utility be installed and interfaced to the instrument.

Calibration is performed from the Calibration Panel in ArbConnection. To invoke this panel, one requires a password that is available to service centers only. Contact your nearest Tabor service center for information and permit to obtain your calibration password. Use the following procedure to calibrate the generator:

1. Invoke ArbConnection
2. Click on the UTIL icon on the Panels bar
3. On the Utility Panel click on Calibration and expect to be prompted with the following dialog box



Figure 7-1, Calibration Password

4. Type your User Name Password and click on OK. The Calibration Panel as shown in Figure 7-2 will appear.

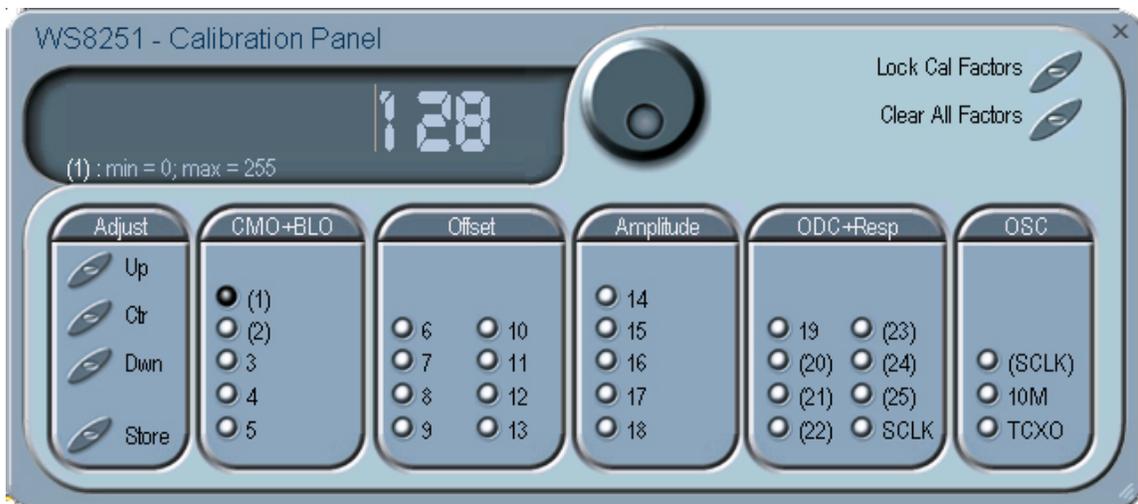


Figure 7-2, Calibration Panel



## NOTES

- 1. Initial factory adjustments require that the covers be removed from the instrument.**
- 2. Field calibration does not require re-adjustments of these factory settings unless the unit was repaired in an authorized service center.**
- 3. Factory adjustments are enclosed in parentheses to differentiate from normal field calibration setups; bypass these adjustments when performing field calibration.**
- 4. Most of the adjustments are performed with the Normal output connected to the measuring device. ALWAYS terminate the Inverted output with a 50Ω end-termination, otherwise the adjustments will not be valid.**

Calibrations are marked with numbers from 1 through 25 and, except the TCXO and SCLK adjustments in the OSC group. They should be carried out exactly in the order as numbered on the panel. The numbers that are associated with each adjustment are identified as Setup Number at the title of each of the adjustments in the following procedure.

Remote adjustments have the range of 1 through 256 with the center alignment set to 128. Therefore, if you are not sure of the direction, set the adjustment to 128 and add or subtract from this value. If you have reached 1 or 256 and were not able to calibrate the range, there is either a problem with the way you measure the parameter or possibly there is a problem with the instrument. In either case, do not leave any adjustment in its extreme setting but center the adjustment and contact your nearest service center for clarifications and support.

Note in the following procedures that although configuration of the 8251 is done automatically, some of the configuration is shown for reference. There is no requirement to change configuration of the 8251 during the remote adjustment procedure except in places where specifically noted.

---

## Common Mode Offset Adjustments

The common mode offset adjustments assure that the AC signal is balanced between the normal and inverted output. Use this procedure if you suspect that there is a base line accuracy issue.

### (Setup 1)

#### Common Mode Offset - Arbitrary

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feedthrough termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:  
Function: DCV  
Range: 100 mV
2. Connect the DMM to U150 (1).
3. Configure the 8251 as follows:  
Output: On  
Freq: 1 MHz  
Amplitude: 4 V  
CAL:SETUP: 1  
CAL:SERV 1

Adjustment:

1. Adjust RV3 for DMM reading of 0 V,  $\pm 20$  mV

### (Setup 2)

#### Common Mode Offset - DDS

Equipment: DMM, SMA to BNC cable, 50 $\Omega$  Feedthrough termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:  
Function: DCV  
Range: 100 mV
2. Connect the DMM to U150 (1).
3. Configure the 8251 as follows:  
Output: On  
CW Freq: 1 MHz  
Amplitude: 4 V  
Waveform: Modulated  
CAL:SERV 2  
CAL:SETUP: 2

Adjustment:

1. Adjust RV1 for DMM reading of 0 V,  $\pm 20$  mV

## Base Line Offset Adjustments

The base line offset adjustments assure that the AC signal is symmetrical around the 0 V line. Use this procedure if you suspect that there is a base line accuracy issue.

### Setup 3

#### Power Amplifier Baseline Offset

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feedthrough termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:  
Function: DCV  
Range: 100 mV
2. Connect the WW8251 output to the DMM input. Terminate the 8251 output at the DMM input with the, 50  $\Omega$  Feedthrough termination
3. Configure the 8251 as follows:  
CAL:SERV: 0  
Output: On  
Freq: 1 MHz  
Amplitude: 100 mV

Adjustment:

1. Adjust CAL:SETUP 3 for DMM reading of 0V,  $\pm 20$  mV. Note the reading.

### Setup 4

#### Pre-Amplifier Baseline Offset - Arbitrary

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feed through termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:  
Function: DCV  
Range: 100 mV
2. Connect the 8251 output to the DMM input. Terminate the 8251output at the DMM input with the, 50 $\Omega$  Feed through termination
3. Configure the 8251 as follows:  
Output: On  
Freq: 1 MHz  
Amplitude: 4 V  
CAL:SERV 0

Adjustment:

1. Adjust CAL:SETUP 4 for DMM reading of 0 V,  $\pm 20$  mV. Note the reading.

## Setup 5

### Pre-Amplifier Offset - DDS

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feed through termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:

Function: DCV  
Range: 100 mV

2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the, 50  $\Omega$  Feed through termination

3. Configure the 8251 as follows:

Output: On  
CW Freq: 1 MHz  
Amplitude: 4 V  
Waveform: Modulated  
CAL:SERV 0

Adjustment:

1. Adjust CAL:SETUP 5 for DMM reading of 0 V,  $\pm 20$  mV. Note the reading.

---

## Offset Adjustments

The offset adjustments assure that the DC offsets are within the specified range. Use this procedure if you suspect that the offset accuracy is an issue.

## Setup 6

### +500 mV Offset

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feedthrough termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:

Function: DCV  
Range: 2 V

2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the 50  $\Omega$  Feed through termination

3. Configure the 8251 as follows:

Amplitude: 100 mV  
Offset +500 mV  
Output: On  
CAL:SERV 0

Adjustment:

1. CAL:SETUP 6 for DMM reading of +500 mV,  $\pm 10$  mV

## Setup 7

### +600 mV Offset

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feedthrough termination,

BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:  
Function: DCV  
Range: 2 V
2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the 50  $\Omega$  Feed through termination
3. Configure the 8251 as follows:  
Amplitude: 100 mV  
Offset: +600 mV  
Output: On  
CAL:SERV 0

Adjustment:

1. CAL:SETUP 7 for DMM reading of +600 mV,  $\pm 10$  mV

## Setup 8

### +700 mV Offset

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feedthrough termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:  
Function: DCV  
Range: 2 V
2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the 50  $\Omega$  Feed through termination
3. Configure the 8251 as follows:  
Amplitude: 100 mV  
Offset: +700 mV  
Output: On  
CAL:SERV 0

Adjustment:

1. CAL:SETUP 8 for DMM reading of +700 mV,  $\pm 10$  mV

## Setup 9

### +800 mV Offset

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feedthrough termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:  
Function: DCV  
Range: 2 V
2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the 50  $\Omega$  Feed through termination
3. Configure the 8251 as follows:  
Amplitude: 100 mV  
Offset: +800 mV  
Output: On  
CAL:SERV 0

Adjustment:

1. CAL:SETUP 9 for DMM reading of +800 mV,  $\pm 10$  mV

## Setup 10

### +850 mV Offset

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feedthrough termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:  
Function: DCV  
Range: 2 V
2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the 50  $\Omega$  Feed through termination
3. Configure the 8251 as follows:  
Amplitude: 100 mV  
Offset +850 mV  
Output: On  
CAL:SERV 0

Adjustment:

1. CAL:SETUP 10 for DMM reading of +850 mV,  $\pm 10$  mV

## Setup 11

### +900 mV Offset

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feedthrough termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:  
Function: DCV  
Range: 2 V
2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the 50  $\Omega$  Feed through termination
3. Configure the 8251 as follows:  
Amplitude: 100 mV  
Offset +900 mV  
Output: On  
CAL:SERV 0

Adjustment:

1. CAL:SETUP 11 for DMM reading of +900 mV,  $\pm 10$  mV

## Setup 12

### +950 mV Offset

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feedthrough termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:  
Function: DCV  
Range: 2 V
2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the 50  $\Omega$  Feed through termination
3. Configure the 8251 as follows:  
Amplitude: 100 mV  
Offset +950 mV

Output: On  
CAL:SERV 0

Adjustment:

1. CAL:SETUP 12 for DMM reading of +950 mV,  $\pm 10$  mV

## Setup 13

### -500 mV Offset

Equipment: DMM, SMA to BNC cable, 50 $\Omega$  Feedthrough termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:

Function: DCV  
Range: 2 V

2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the 50  $\Omega$  Feed through termination
3. Configure the 8251 as follows:

Amplitude: 100 mV  
Offset -500 mV  
Output: On  
CAL:SERV 0

Adjustment:

1. CAL:SETUP 13 for DMM reading of -500 mV,  $\pm 10$  mV;

---

## Amplitude Adjustments

The amplitude adjustments assure that the AC levels are within the specified range. Use this procedure if you suspect that the amplitude accuracy is an issue.

## Setup 14

### Minimum Scale Amplitude - Arbitrary

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feed through termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:

Function: ACV  
Range: 2 V

2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the, 50  $\Omega$  Feed through termination
3. Configure the 8251 as follows:

Frequency: 1 kHz  
Output: On  
Amplitude: 3.565 V  
CAL:SERV 3

Adjustment:

1. Adjust CAL:SETUP14 for DMM reading of 630 mV  $\pm 10$  mV (1.260 V  $\pm 20$  mV with option 2)

## Setup 15

### Full Scale Amplitude - Arbitrary

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feed through termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:  
Function: ACV  
Range: 2 V
2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the, 50  $\Omega$  Feed through termination
3. Configure the 8251 as follows:  
Frequency: 1 kHz  
Output: On  
Amplitude: 4 V  
CAL:SERV 3

Adjustment:

1. Adjust CAL:SETUP15 for DMM reading of 1.414 V  $\pm$ 20 mV

## Setup 16

### Full Scale Amplitude - DDS

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feed through termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:  
Function: ACV  
Range: 2 V
2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the, 50  $\Omega$  Feed through termination
3. Configure the 8251 as follows:  
CW Frequency: 1 kHz  
Output: On  
Amplitude: 4 V  
Waveform: Modulated  
CAL:SERV 0

Adjustment:

1. Adjust CAL: SETUP16 for DMM reading of 1.414 V  $\pm$ 20 mV

## Setup 17

### Positive Amplitude Correction

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feed through termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:  
Function: ACV  
Range: 2 V
2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the, 50  $\Omega$  Feed through termination
3. Configure the 8251 as follows:  
Frequency: 1 kHz  
Output: On

Amplitude: 1 V  
Offset: 1 V  
CAL:SERV 0

Adjustment:

1. Adjust CAL: SETUP17 for DMM reading of 353.5 V  $\pm$ 10 mV

## Setup 18

### Negative Amplitude Correction

Equipment: DMM, SMA to BNC cable, 50  $\Omega$  Feed through termination, BNC to dual banana adapter

Preparation:

1. Configure the DMM as follows:

Function: ACV  
Range: 2 V

2. Connect the 8251 output to the DMM input. Terminate the 8251 output at the DMM input with the, 50  $\Omega$  Feed through termination
3. Configure the 8251 as follows:

Frequency: 1 kHz  
Output: On  
Amplitude: 1 V  
Offset: -1 V  
CAL:SERV 0

Adjustment:

1. Adjust CAL: SETUP18 for DMM reading of 353.5 mV  $\pm$ 10 mV

---

## Pulse Response & Flatness Adjustments

The pulse response adjustments assure that the rise and fall times, as well as, the aberrations are within the specified range. It also calibrates the output flatness. Use this procedure if you suspect that the pulse response, or flatness are not within specification.

### (Setup 20)

### Pulse Response Adjustment

Equipment: Oscilloscope, SMA to BNC cable, 20 dB (50  $\Omega$ ) attenuator

Preparation:

1. Configure the Oscilloscope as follows:

Time Base 1 ns/div  
Range: 200 mV/div

2. Configure the 8251 as follows:

Output: On  
Amplitude: 2 V  
Sync: On  
Wave: Square  
CAL:SERV 0  
CAL:SETUP: 20

3. Connect the 8251 output to the Oscilloscope input

Adjustment:

1. Adjust C55 for the best pulse response.

**(Setup 21)**

**CW Flatness 10 MHz**

Equipment: Oscilloscope, SMA to BNC cable

Preparation:

1. Configure the Oscilloscope as follows:  
Time Base            1 ms/div  
Range:                200 mV/div
2. Configure the 8251 as follows:  
Waveform:            Modulated  
Amplitude:           4 V  
Output:                On  
CAL:SERV            0  
CAL:SETUP:          21
3. Connect the 8251 Normal output to the Oscilloscope input
4. Adjust the trace on the oscilloscope to 6 vertical division

**(Setup 22)**

**CW Flatness 50 MHz**

Equipment: Oscilloscope, SMA to BNC cable

Preparation:

1. Leave oscilloscope configuration as in Setup 21
2. Modify the 8251 frequency as follows:  
CW Frequency:      50 MHz  
CAL:SERV            0  
CAL:SETUP:          22

Adjustment:

1. Adjust C12 for the best flatness and note reading

**(Setup 23)**

**CW Flatness 100MHz**

Equipment: Oscilloscope, SMA to BNC cable

Preparation:

1. Leave oscilloscope configuration as in Setup 21
2. Modify the 8251 frequency as follows:  
CW Frequency:      100 MHz  
CAL:SERV            0  
CAL:SETUP:          23

Adjustment:

1. Adjust C12 for the best flatness between steps 20 through 23

**(Setup 24)**

**CW Flatness 150 MHz**

Equipment: Oscilloscope, SMA to BNC cable

Preparation:

1. Leave oscilloscope configuration as in Setup 21
2. Modify the 8251 frequency as follows:  
CW Frequency:      150 MHz  
CAL:SERV            0

CAL:SETUP: 24

Adjustment:

1. Adjust C12 for the best flatness between steps 20 through 24

## (Setup 25)

### CW Flatness 200 MHz

Equipment: Oscilloscope, SMA to BNC cable

Preparation:

1. Leave oscilloscope configuration as in Setup 21
2. Modify the 8251 frequency as follows:

CW Frequency: 180MHz

CAL:SERV 0

CAL:SETUP: 25

Adjustment:

1. Adjust C12 for the best flatness between steps 20 through 25



#### NOTE

**Repeat steps 20 through 25 until best flatness is achieved.  
Maximum error should not exceed  $\pm 0.2$  vertical divisions.**

---

## SCLK Duty Cycle Adjustments

The oscillator duty cycle assure that the sample clock generator operates correctly with the correct duty cycle setting for the subsequent circuits. Use this procedure if you suspect that the duty cycle setting is an issue.

### SCLK

#### 625 MS/s Duty Cycle

Equipment: Oscilloscope, SMA to BNC cable

Preparation:

1. Configure the Oscilloscope as follows:

Time Base 0.1  $\mu$ s/div

SCLK 4 GS/s minimum

Range: 20 mV/div

Persistence On

2. Configure the 8251 as follows:

Output: On

Sync: On

Waveform: Arbitrary

SCLK: 625 MS/s

CAL:SERV 0

3. Download a 1024-points sine waveform to the 8251.

4. Connect the Normal output to the oscilloscope input

Adjustment:

1. Adjust CAL:SETUP26 for best and stable output waveform

## Reference Oscillators Adjustments

Use this procedure to adjust the reference oscillators. The reference oscillators determine the accuracy of the output frequency so if you suspect that there is an accuracy issue, proceed with the calibration of the reference oscillators

### 10M TCXO

#### 10 MHz TCXO Frequency

Equipment: Counter, SMA to BNC cables

Preparation:

1. Configure the counter as follows:  
Function: Freq A  
Termination: 50  $\Omega$
2. Connect the 8251 Normal output to the counter input.
3. Configure the 8251 as follows:  
Frequency: 10 MHz  
Output: On  
Amplitude 2 V  
Wave: Square

Adjustment:

1. Adjust CAL:SETUP27 for counter reading of 10 MHz,  $\pm 2$  Hz.

## Updating the 8251 Firmware



### WARNING

**Only qualified persons may perform Firmware updates. DO NOT even attempt to perform this operation unless you were trained and certified by Tabor as you may inflict damage on the instrument. Always verify with the factory that you have the latest firmware file before you start with your update.**

---

Before you update the firmware of your 8251, check the revision level which is installed in your instrument. Each firmware update was done for a reason and therefore, if you want to update the firmware for a problem in your system, check the readme file that is associated with the update to see if an update will solve your problem. The revision level of your firmware can be displayed as shown in Figure 7-3. To access this screen, select the TOP menu, then select the Utility soft key and scroll down to the System option. Press Enter and the screen will show with the system information. Check both the Software Version and the Version Date as both should match with the latest release.



Figure 7-3, Software Version Screen

---

 **NOTE**

**Firmware updates are performed with the LAN set as the active interface and with the 8251 communicating with the PC through the network.**

---

To update the 8251 firmware, you will have to run the **NETConfig** utility. If you do not have this utility installed on your computer, run the installation procedure from the enclosed CD. You will not be able to update firmware without the NETConfig utility. To invoke this utility, complete the following steps:

1. Turn the 8251 power **OFF**
2. Click on NETConfig shortcut on the desktop or select Start »Programs» Tabor Electronics» NETConfig» NETConfig 1.0

The NETConfig window lists Tabor devices found on your subnet. Figure 7-4 shows an example of this display.

3. Click on the “Use wait message” to select this option as shown in Figure 7-4.



Figure 7-4, The NETConfig Utility

4. Turn the 8251 power **ON** and observe that the progress bar, as shown in Figure 7-5, is advancing from left to right. Do not do anything on the 8251 until the progress bar completes its travel to the right end.



**Tips**

If the progress bar is not moving check the following for possible problems:

1. If you are connecting to a LAN network, make sure your device is connected with standard LAN wire to your wall plug
2. If you use direct connection from your PC to the 8251, your cable should be cross wired. You can get such cable from any computer store near your area
3. If your network is using a managed switch, it is possible that it is configure to break the package with broadcast address and therefore, the only way to use NetConfig is to connect the instrument directly to the PC with a cross wired cable

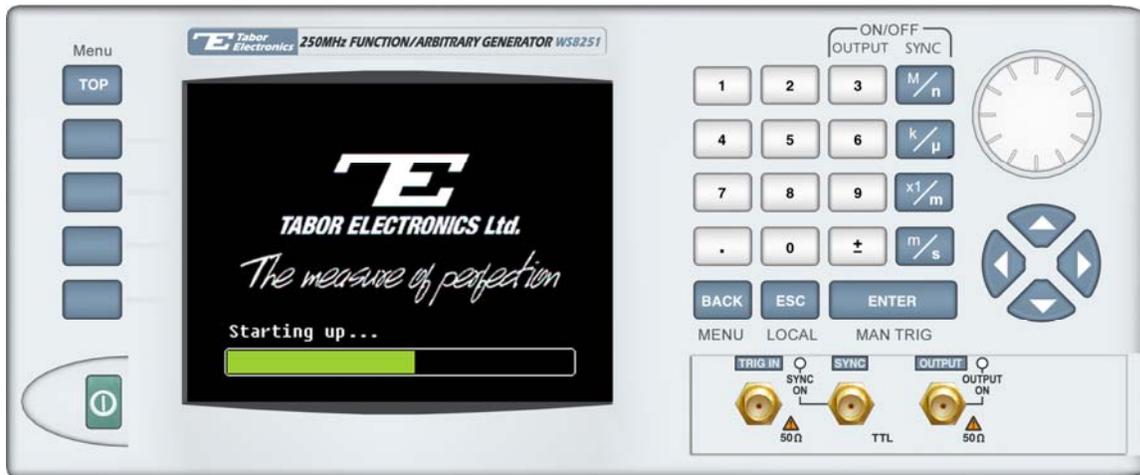


Figure 7-5, Check for Progress Bar Movement

5. As soon as the progress bar reached the far right hand of the bar, click on the Refresh button. If your device was connected and booted correctly, the device address will appear in the device list, as shown in Figure 7-6.

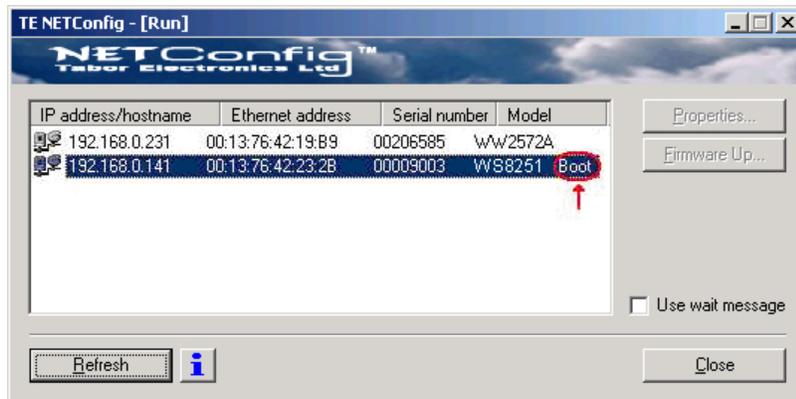


Figure 7-6, WW8251 has been Detected on the LAN Network

---

 **NOTES**

Click Refresh again if you do not see your device in the list of Ethernet devices. If you cannot detect your device after a few attempts check that you have not lost the connection as described in previous paragraphs.

You can only update instrument(s) that appear in the NETConfig window.

---

Point and click on the device you want to update. The selected device will now have blue background. Click on the Firmware Up... button. The firmware Update dialog box as shown in Figure 6-7 appears.



Figure 7-7, The Firmware Update Dialog Box

In the TE NETConfig [Firmware Update] dialog box click on the  button to browse and locate the upgrade file. After you select the file its complete path will be displayed in the Flash binary image filename field as shown in Figure 7-8. Make sure the file in the path agrees with that specified by your supervisor. To complete the update process, click on Update and observe the File Transfer Progress bar. The update will complete with a Firmware Update d Successfully message, as shown in Figure 7-9.

Click on Back to close NETConfig Firmware Update dialog box and turn off the power to the 8251. The next time you power up the instrument, the device automatically reboots with the new firmware in effect.



Figure 7-8, Firmware Update Path



Figure 7-9, Firmware Update Completed

# ***Appendices***

<b>Appendix</b>	<b>Title</b>	<b>Page</b>
<b>A</b>	Specifications.....	A-1

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**Internal**

Range Free-running trigger generator, adjustable from 0.1  $\mu$ s to 100 s  
 Resolution 4 digits, limited by 0.1  $\mu$ s  
 Accuracy 0.1%

**Software**

Remote interface trigger commands (TRIG, \*trg)

**Trigger Delay**

Description Waveform start is delayed from trigger to point n  
 Programmable Units Waveform points  
 Range 0 to 512K sample clocks  
 Resolution 1 sample clock  
 Jitter  $\pm 1$  sample clock

**System Delay**

Trigger to waveform output 1 Sample Clock+100 ns

**STANDARD WAVEFORMS**

Frequency Range Waveform dependent  
 Source Internal synthesizer

**Sine**

Frequency Range 50 Hz to 125 MHz, triggerable;  
 50 Hz to 250 MHz, continuous

**Flatness**

1MHz to 25 MHz <0.3 dBc  
 25 MHz to 100 MHz <0.5 dBc  
 100 MHz to 250 MHz <1 dBc

**Start Phase**

0 to 360°, programmable

**Total Harmonic Distortion**

Harmonics and Spurious (1 Vpp) 0.3% to 100 kHz

	1 V	2 V	4 V
Below 10 MHz	<-50 dBc	<-43 dBc	<-37 dBc
10 MHz to 50 MHz	<-40 dBc	<-38 dBc	<-30 dBc
50 MHz to 125 MHz	<-35 dBc	<-32 dBc	<-25 dBc
125 MHz to 250 MHz	<-30 dBc	<-30 dBc	<-25 dBc

**Phase Noise**

100 Hz Offset <-83 dBc/Hz  
 1 kHz Offset <-85 dBc/Hz  
 10 kHz Offset <-85 dBc/Hz  
 100 kHz Offset <-112 dBc/Hz  
 1 MHz Offset <-132 dBc/Hz

**Triangle**

Frequency Range: 50 Hz to 50 MHz  
 Start Phase 0 to 360°

**Square**

Frequency Range 50 Hz to 150 MHz  
 Duty Cycle 1.0% to 99.9%  
 Rise/Fall time 1 ns typical  
 Overshoot, typical <5%

Jitter(rms) 10ps

### Pulse/Ramp

Frequency Range 50 Hz to 125 MHz  
 Programmable Parameters Delay, rise time, high time and fall time. Parameters are adjustable with the resolution of 0.01% of the period interval

### Sinc (Sine(x)/x)

Frequency Range 50 Hz to 50 MHz  
 "0" Crossing Cycles 4 to 100

### Gaussian Pulse

Frequency Range 50 Hz to 50 MHz  
 Time Constant 10 to 200

### Exponential Decaying/Rising Pulse

Frequency Range 50 Hz to 50 MHz  
 Time Constant -100 to 100

### Noise

Bandwidth Same as sample clock setting

### DC

Range -3 V to 3 V

## Pulse Generator Waveforms

Operation

The 8251 has a special mode where the instrument is transformed to operate as a digital pulse generator. When this mode is selected, the operation of the arbitrary waveform is disabled and possibly, arbitrary waveforms are overwritten

1. All pulse parameters, except rise and fall times, may be freely programmed within the selected pulse period provided that the ratio between the period and the smallest incremental unit does not exceed the ratio of 512,000 to 1, hence the specifications below do not show maximum limit as each must be computed from the above relationship.
2. Rise and fall times, may be freely programmed provided that the ratio between the rise/fall time and the smallest incremental unit does not exceed the ratio of 100,000 to 1.
3. The sum of all intervals of the pulse parameters must not exceed the pulse period setting.

Programmability

Pulse Mode

Single or double, programmable

Polarity

Normal, inverted or complemented

Period

4 ns minimum, programmed with 2 ns increments

Delay

0 ns minimum

Pulse Width

5 ns minimum

Double Pulse Delay

0 ns minimum

Rise/Fall Times

0 ns minimum (actual minimum = <600 ps)

High Time

0 ns minimum

Amplitude Window

100 mVp-p to 4 Vp-p

Low Level

-3 V to +2.90 V

High Level

-2.90 V to +3 V



## ARBITRARY WAVEFORMS

Description	Provides waveform segment programming and selection through front panel controls or remote controller. Output hops coherently between segments 512K points standard
Waveform Memory	
Memory Segmentation	
Number of Segments	1 to 1k
Min Segment Size	64 points
Memory Interleave	16 (All trace lengths must be multiples of 16)
Vertical Resolution	12 bits (8,192 amplitude increments)
Waveform Download	Through USB, GPIB, or Ethernet

## MODULATED WAVEFORMS

Description	Modulating waveforms are stored in lookup tables and used for modulating sine carrier. Modulation functions include: FM, sweep, FSK and PSK
Carrier Waveform	Sine wave only
Connector	Main output
Output characteristics	Same as for Main output

## FM – Built-in Standard Modulating Waveforms

Description	Sine waveform is frequency modulated by internal waveforms that are resident in internal memory
Modulation Source	Internal waveform: sine square, triangle and ramp
Modulation Frequency Range	1 mHz to 100 kHz
Deviation Range	100 mHz to 248 MHz
Advance	Automatic, triggered, burst, gated or software command
Marker	
Output and Level	Same as SYNC output.
Position	Programmable for selected frequency

## FSK

Description	Carrier sine waveform is generated continuously. External signal, at the TRIG IN connector, programs shifted frequency (frequency hop). Output hops between frequencies immediately after the sine waveform completes 360° cycle.
Carrier and Shifted Frequency Range	1 Hz to 250 MHz
FSK Source	
External	Front panel Trigger input SMA. Low level = carrier frequency; High level = shifted frequency
Baud Range	From 10 MHz to DC

## PSK

Description	Carrier sine waveform is generated continuously. External signal, at the TRIG IN connector, programs shifted phase (phase hop).
Carrier Range	1 Hz to 250 MHz
Shifted Phase Range	0° to 360°
Resolution	Frequency dependent, not usable above 125 MHz
PSK Source	
External	Front panel Trigger input SMA. Low level = carrier phase; High level = shifted phase
Baud Range	From 10 MHz to DC

## Sweep

Description	Sine waveform 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	1 Hz to 250 MHz
Time	1 ms to 1000 s, 7 digits, $\pm 0.1\%$
Flatness	$\pm 3$ dB, throughout the frequency range
Advance	Automatic, triggered, gated or software command
Marker	
Output and Level	Same as SYNC output.
Position	Programmable for selected frequency

## OUTPUTS

### Main Output

Coupling	DC coupled
Connectors	Front panel SMA's
Impedance	50 $\Omega$ nominal, each output
Protection	Protected against temporary short to case ground
Amplitude Range	100 mV to 4 Vp-p, into 50 $\Omega$ ; 200 mV to 8 Vp-p into high Z
Resolution	4 digits
Accuracy (1 KHz)	$\pm(3\% +5 \text{ mV})$

### Offset

Range	0 to $\pm 1$ V,
Resolution	4 digits
Accuracy	$\pm(3\% +50\text{mV})$

### Filters

50 MHz, 125 MHz, 3-pole Bessel low-pass

### 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 at designated frequencies
Connector	Front panel SMA
Level	>2 V into 50 $\Omega$ , 3 V nominal into high impedance
Protection	Protected against temporary short to case ground
Type	
BIT	Available in standard and arbitrary waveforms only. Pulse width is 16 points wide.
SCOM	Available in standard and arbitrary waveforms only. Pulse is segment width less 16 points.
Position	Point 0 to maximum segment size, programmable with 16-point resolution

## GENERAL

### GPIB

Connector	Rear panel standard D type GPIB connector
GPIB Revision	IEEE-488.2
Protocol	SCPI commands over GPIB
SCPI Revision	1993.0

### Ethernet

Connector	Rear panel RJ-45, female
Physical Layer	twisted pair 10/100Base-T
Baud Rate	10/100 Mbit/sec with auto negotiation
Protocol	SCPI commands over TCP/IP.

### USB

Connector	Type A receptacle
Specifications	Version 1.1
Protocol	SCPI commands over USB.

### Front Panel Display

Color LCD, 3.5" reflective, 320 x 240 pixels, back-lit

### Power Requirements

Mains Input Range	85 to 265 Vac, 47-63 Hz
Maximum Total Power	60 W max

### EMC Certification & Safety

CE marked, EN61010-1, 2<sup>nd</sup> addition

### Mechanical

Dimensions	212 x 88 x 415 mm (W x H x D)
Weight	Approximately 3.5kg

### Environmental

Operating temperature	0 °C - 40 °C
Humidity (non-condensing)	11 °C - 30 °C 85%
	31 °C - 40 °C 75%