User Manual

Models 1071/1072

100 MS/s Single / Dual
Arbitrary Waveform Generators
Publication No. 050526

Tabor Electronics Ltd.

PUBLICATION DATE: May 26, 2005

WARRANTY STATEMENT

Products sold by Tabor Electronics Ltd. are warranted to be free from defects in workmanship or materials. Tabor Electronics Ltd. will, at its option, either repair or replace any hardware products which prove to be defective during the warranty period. You are a valued customer. Our mission is to make any necessary repairs in a reliable and timely manner.

Duration of Warranty

The warranty period for this Tabor Electronics Ltd. hardware is three years, except software and firmware products designed for use with Tabor Electronics Ltd. Hardware is warranted not to fail to execute its programming instructions due to defect in materials or workmanship for a period of ninety (90) days from the date of delivery to the initial end user.

Return of Product

Authorization is required from Tabor Electronics before you send us your product for service or calibration. Call your nearest Tabor Electronics support facility. A list is located on the last page of this manual. If you are unsure where to call, contact Tabor Electronics Ltd. Tel Hanan, Israel at 972-4-821-3393 or via fax at 972-4-821-3388. We can be reached at: support@tabor.co.il

Limitation of Warranty

Tabor Electronics Ltd. shall be released from all obligations under this warranty in the event repairs or modifications are made by persons other than authorized Tabor Electronics service personnel or without the written consent of Tabor Electronics.

Tabor Electronics Ltd. expressly disclaims any liability to its customers, dealers and representatives and to users of its product, and to any other person or persons, for special or consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, handling, repair, maintenance, replacement or use of said products.

Representations and warranties made by any person including dealers and representatives of Tabor Electronics Ltd., which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitations of the liability of Tabor Electronics Ltd. as set forth above), shall not be binding upon Tabor Electronics Ltd. unless reduced to writing and approved by an officer of Tabor Electronics Ltd.

Except as stated above, Tabor Electronics Ltd. makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and except to the extent stated above, Tabor Electronics Ltd. shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

PROPRIETARY NOTICE

FOR YOUR SAFETY

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

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

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

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

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

DECLARATION OF CONFORMITY

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

declare, that the 100MS/s Arbitrary Waveform Generators

Models 1071 and 1072

complies with the requirements of the Electro Magnetic Compatibility 89/336/EEC as amended by 92/31/EEC, 93/68/EEC, 92/263/EEC and 93/97/EEC and the Low Voltage Directive 73/23/EEC amended by 93/68/EEC, according to testing performed at ORDOS/E.M.I TEST LABs (#2TBR172SX, Feb. 2005). Compliance was demonstrated to the following specifications as listed in the official Journal of the European Communities:

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

EMC:
EN55022:2001 Class A Radiated and Conducted Emission
IEC61000-3-2:2001(Am1) Harmonics
IEC61000-3-3:2002(Am1) Flickers
IEC61000-4-2:2001(Am1+Am2)   ESD : Contact Discharge ±4Kv
                                                         Air Discharge ±8Kv
IEC61000-4-3:2002(Am1) Radiated immunity - 3V/m (80MHz-1000MHz)
IEC61000-4-4:2001 (Am2) Electrical Fast Transient and Burst ±1.0kV, 5KHz
IEC61000-4-5:2001 (Am1) Surges DM ±1.0kV CM ±2.0Kv
IEC61000-4-6:2003 Current injection immunity - 3Vrms
IEC61000-4-8:2001 Magnetic field 1Amper
IEC61000-4-11:2001 Voltage dips and variation

Models 1071 and 1072 are built on the same platform and share specifications and features except the 1071 is a single channel version and while the 1072 has two channels. The tests were performed on a typical configuration.

Table of Contents

Appendices

List of Tables

List of Figures

Chapter 1
Getting Started

Title	Page

What's in This Chapter?

This chapter contains a general description of the Model 1072 Universal Waveform Generator and an overall functional description of the instrument. It lists and describes various options available for this model. It also describes the front panel connectors and indicators.

This manual provides description of all features and options available with the instruments; however, some items described in the following paragraphs and chapters may not be installed in your instrument. If you purchased Model 1071, ignore all references in this manual to Channel 2.

Introduction

Model 1071 is a single-channel Arbitrary Waveform Generator. Model 1072 is a dual-channel, Arbitrary Waveform Generator. It is a high performance waveform generator that combines two separate and powerful channels in one small package. Supplied free with the instrument is ArbConnection software, which is used for controlling the 1072 and for generating, editing and downloading waveforms from a remote computer. The following highlights the 1072 and ArbConnection features.

1072 Feature Highlights

- Dual output configuration with Independent waveform control
- Tight phase offset control between channels (1 point resolution)
- 14-bit vertical resolution
- Nearly 19-bit offset resolution
- 1 Meg memory depth for each channel
- Ultra fast waveform downloads using DMA
- 100MS/s sample clock frequency
- 100MHz, rear-panel, sinewave output
- 1 ppm clock stability
- Extremely low phase noise carrier
- External amplitude modulation
- Sample clock modulation: FSK, ramped FSK, sweep, FM
- Trigger start phase control and breakpoints
- Built-in standard waveforms
- Separate sequence generators for each channel
- Multiple instrument synchronization with tight phase control
- GPIB, USB and Ethernet interfaces
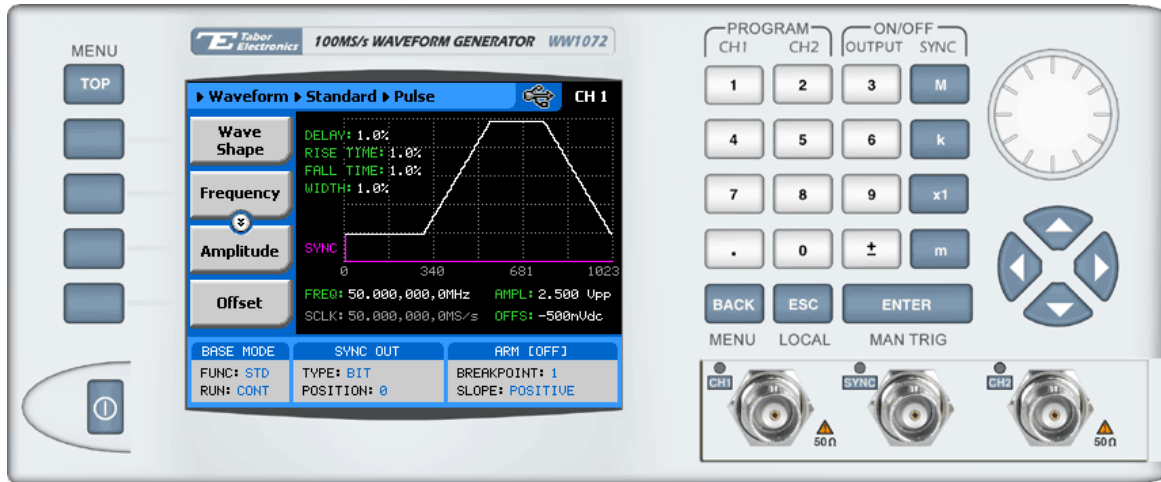
Figure 1-1, The Model 1072

ArbConnection Feature Highlights

- Four powerful tools in one software package: Complete instrument control, Waveform, pulse and FM composers

- Detailed virtual front panels control all 1072 functions and modes

- Wave composer generates, edits and downloads complex waveforms

- FM wave composer generates and downloads complex modulating signals

- 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

- Simplifies generation of complex sequences

Various screens of the ArbConnection program are shown in Figures 1-2 through 1-5.
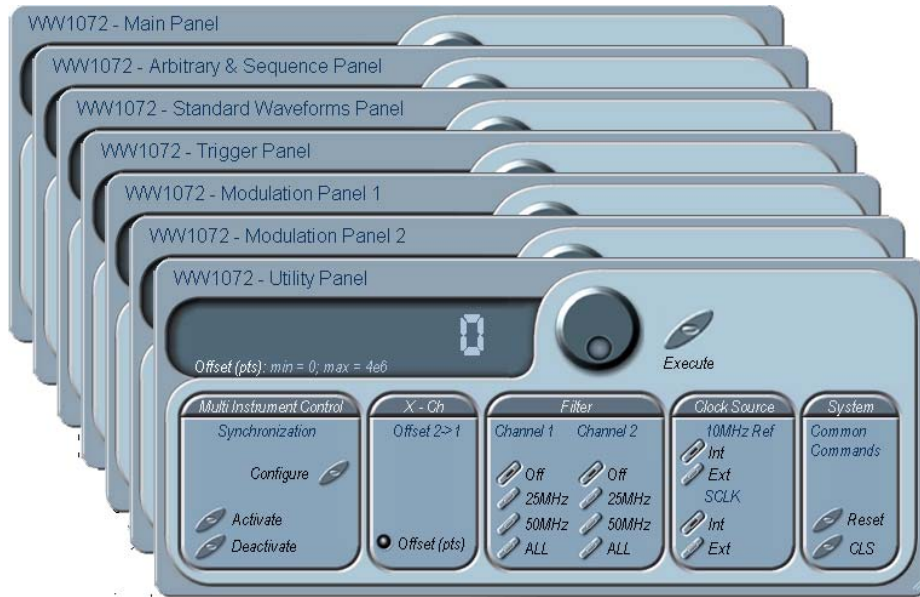
Figure 1-2, ArbConnection – The Control Panels
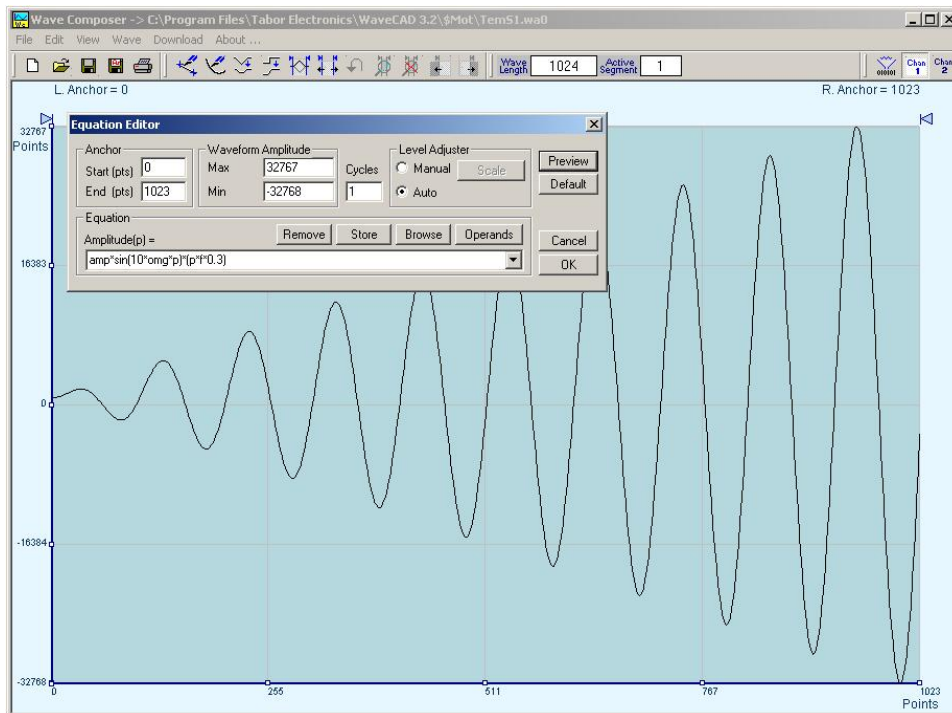
Figure 1-3, ArbConnection – The Wave Composer
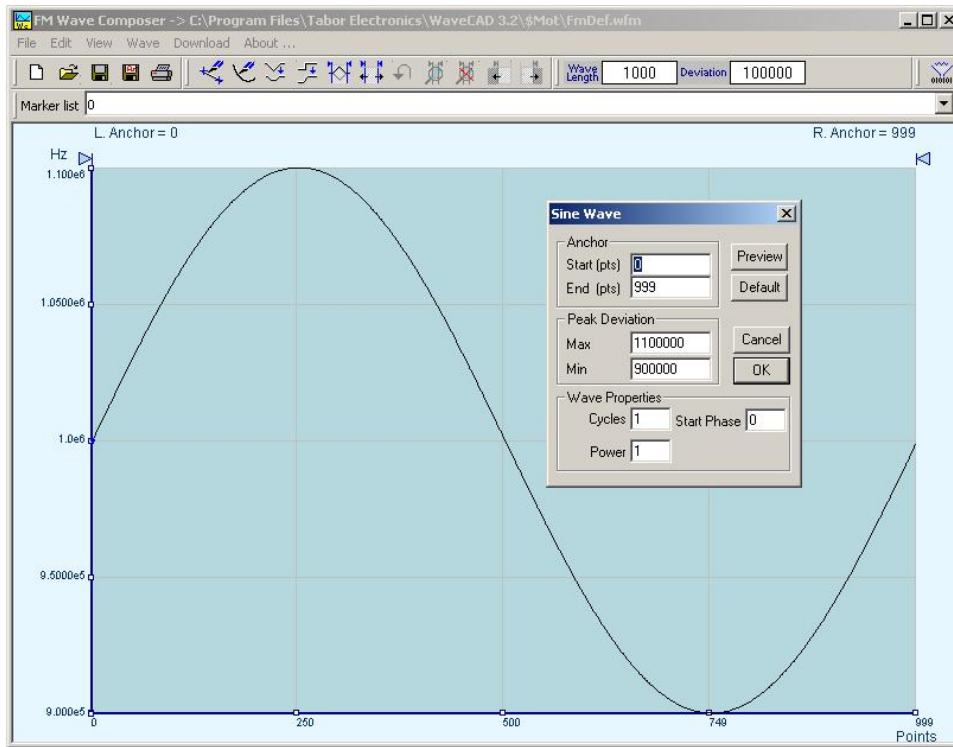
Figure 1-4, ArbConnection – The FM Wave Composer
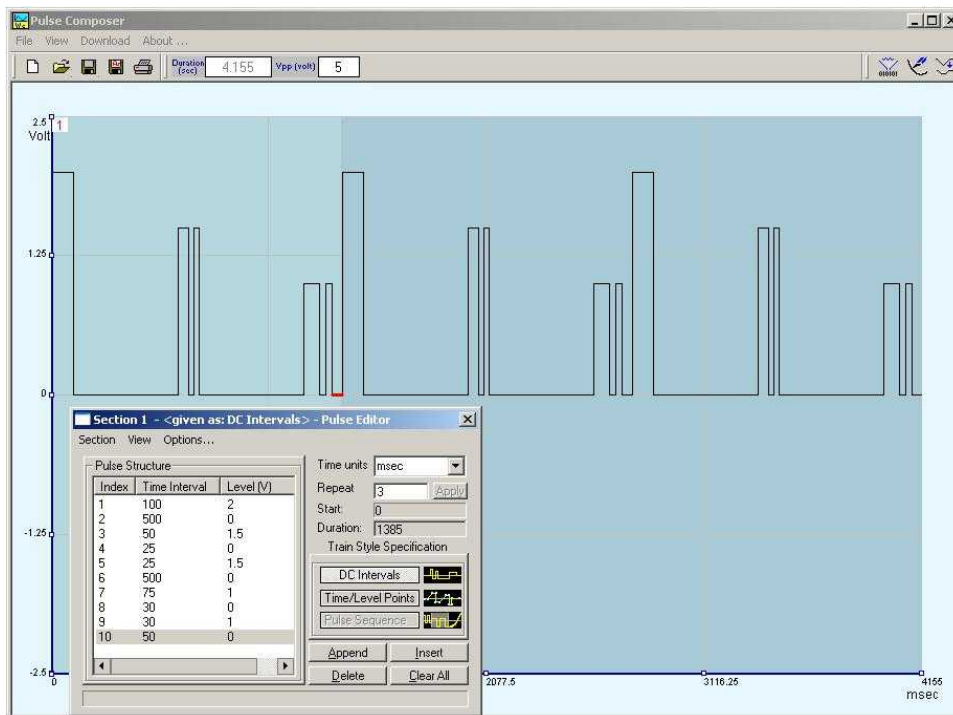
Figure 1-5, ArbConnection – The Pulse Composer

Description

Detailed functional description is given following the general description of the features, functions, and options available with the 1072.

Two Channels
The 1072 is a dual channel arbitrary waveform generator. Although the two channels share a single sample clock source, each channel can be controlled separately to generate different waveform, amplitude and waveforms sequence. Having a single sample clock source is an advantage in a dual-channel configuration because it allows tight control over inter-channel synchronization and leading edge start phase where the initial skew between the two channels is just a few nanoseconds.

Output Functions
Model 1072 is completely digital. There are no analog functions resident in its hardware circuits. Data has to be downloaded to the instrument for it to start generating waveforms. The instrument can generate a few standard functions such as sine wave, triangular wave and square wave. Each time that a standard function is required, the instrument calculates its coordinates and places them in the waveform memory. Therefore, every time a standard function is selected, minimal time is required for the controller to compute the function and load its data to the waveform memory.

Frequency
Waveform frequency is programmed with 9 digits. Frequency accuracy of the output waveform is determined by the clock reference. The internal reference oscillator provides 1ppm accuracy and stability over time and temperature. If higher accuracy and/or stability are required, you may connect an external frequency reference to the rear-panel reference input connector.

Amplitude
The output level may be programmed separately for each channel within from 20mV to 20Vp-p into an open circuit, or 10mV to 10V into 50Ω. Offset may be applied to the output to shift the signal either positive or negative. Offset and amplitude are inter-related, so make sure you understand the offset-amplitude ranges before you apply offset to your signal. A special fine offset generator is built into each channel, which allows programming of extremely small offset increments. This feature extends the offset resolution to 6 digits and is very useful in applications such as mixer balancing where few micro-volts could sway the balance either way.

Run Modes
Besides its normal continuous mode, the 1072 responds to a variety of trigger sources. The output waveform may be gated, triggered, or generate a counted burst of waveforms. A built-in trigger generator, having a programmable period can be used as a replacement of an external trigger source. The internal trigger generator can be programmed with resolution of 7 digits.

Arbitrary Waveforms
The Model 1072 generates arbitrary waveforms with 14 bits of vertical resolution. Any waveform it generates must first be downloaded to waveform memory. The arbitrary waveform memory is a bank of 14-bit words. Each word represents a point on

the horizontal waveform scale. Each word has a horizontal address that can range from 0 to 4,191,280 and a vertical address that can range from -8192 to +8191 (14 bits). Using a high speed clocking circuit, the digital contents of the arbitrary waveform memory are extracted and routed to the Digital to Analog Converter (DAC). The DAC converts the digital data to an analog signal, and the output amplifier completes the task by amplifying or attenuating the signal at the output connector.

Memory Segmentation   There is no need to use the complete memory every time an arbitrary waveform is generated. Waveform memory can be divided into up to 2048 smaller segments and different waveforms can be loaded into each segment. The various segments may then be loaded into a sequence table to generate long and complex waveforms. The sequence table can link up to 2048 segments, while each segment can loop up to 1 million times.

The instrument must be used in conjunction with a host computer. All of its functions, modes and parameters are fully programmable using SCPI commands and syntax. There are three ways to program the Model 1072, the first being low-level programming of each individual parameter using SCPI commands. The second alternative is to use ArbConnection for high-level programming. ArbConnection is a software package supplied with the 1072 that simulates a mechanical front panel. It has all the necessary push buttons, displays and dials to operate the instrument as if you were using it on the bench. The third alternative is using application specific drivers, such LabVIEW.

Frequency Agility   The instrument generates its sample clock from a DDS circuit (direct digital synthesis). The DDS circuit enables frequency agility through the complete frequency range of the 1072. Having such an enormous range opens the door for a wide range of applications such as wide band sweep, FSK and frequency modulation. The 1072 can generate FSK, Ramped FSK and Linear or Logarithmic sweep. The instrument can also frequency modulate its carrier using one of its built-in waveforms, or with any user-defined modulating signal, which can be downloaded using the FM wave composer.

Multi-Instrument Synchronization   There are applications requiring more than 2 synchronized channels, at time even 10 channels. Synchronization between completely independent, free-running instruments is not an easy task; Besides distribution of the sample clock to all instruments, each instrument has to be told when to start generating waveforms so that all start at the same point and with the same phase. Triggering multiple instruments to achieve synchronization is not enough because it will generate a jitter of ± 1 count. Multi-instrument synchronization is built into the 1072, where special connectors and cables were designed to eliminate jitter and to provide start phase control. There is not limit to the number of 1072's that can be daisy-chained, multiple instrument

synchronization is built into each instrument.

Remote Control The 1072 must be programmed to generate waveforms. Therefore, it is recommended that the user becomes familiar with its basic features, functions and programming concepts as described in this and the following chapters.

Safety Considerations

The instrument has been manufactured according to international safety standards. The instrument meets EN61010, VDE 0411/03.81 and UL 1244 standards for safety of commercial electronic measuring and test equipment for instruments with an exposed metal chassis that is directly connected to earth via the chassis power supply cable.

⚠️ *WARNING*

Do not remove instrument covers when operating or when the 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. Power cord and synchronization cable are also supplied as standard. USB and Ethernet cables 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 50Ω after 30 minutes of warm up time, and within a temperature range of 20°C to 30°C. Specifications outside this range are degraded by 0.1% per $^{\circ}$C.

Functional Description

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

Front Panel Connectors

The 1072 has 3 BNC connectors on its front panel: one main output for each channel and one SYNC output. These connectors are described below.

Channel 1 Output

The channel 1 output connector outputs fixed (standard) waveforms to 50MHz, user (arbitrary) and sequenced waveforms with sampling clock to 100MS/s. Output impedance is 50Ω, that is, the cable connected to this output should be terminated with 50Ω. Output amplitude accuracy is calibrated when connected to a 50Ω load. The output amplitude is doubled when the output impedance is above 1MΩ.

Channel 2 Output

The channel 2 output connector outputs fixed (standard) waveforms to 50MHz, user (arbitrary) and sequenced waveforms with sampling clock to 100MS/s. Output impedance is 50Ω, that is, the cable connected to this output should be terminated with 50Ω. Output amplitude accuracy is calibrated when connected to a 50Ω load. The output amplitude is doubled when the output impedance is above 1MΩ.

SYNC Output

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

Front Panel Indicators

There are three LED's on the front panel. When the output state is on, the light illuminates. There are two LED's, one for each channel and one LED for the SYNC output.

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.
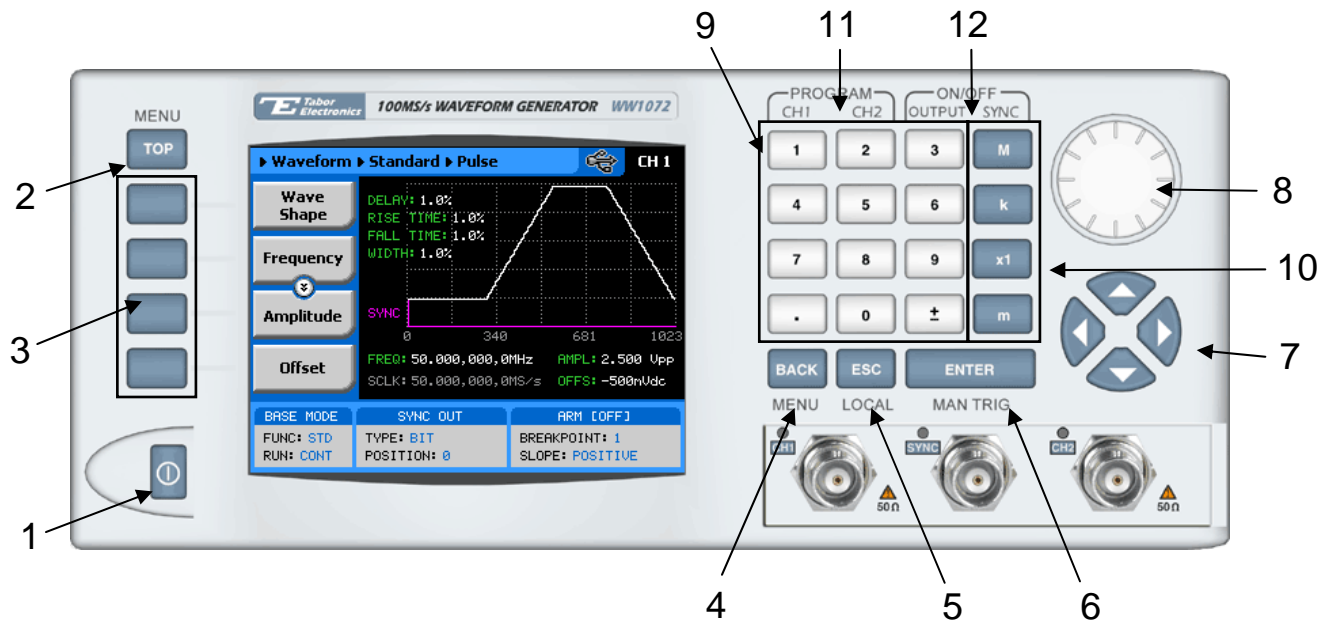
Figure 1-6, 1072 Front Panel Controls

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

1. *Power Switch* – Toggles 1072 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 1072 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 1072 is placed in "Triggered" run mode, the Man Trig button can be used to manually trigger the 1072

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. Program CH1, CH2 – Use Program CH1 to modify the screen to display channel 1 parameters. Use Program CH2 to modify the screen to display channel 2 parameters. These keys can be used only when the 1072 is not in edit mode

12. *ON/OFF Output, Sync* – These keys can be used only when the 1072 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 Connectors

The 1072 has a number of connectors on its rear panel. These connectors are described below. Figure 1-6 shows rear panel plugs, indicators, connectors and other parts.
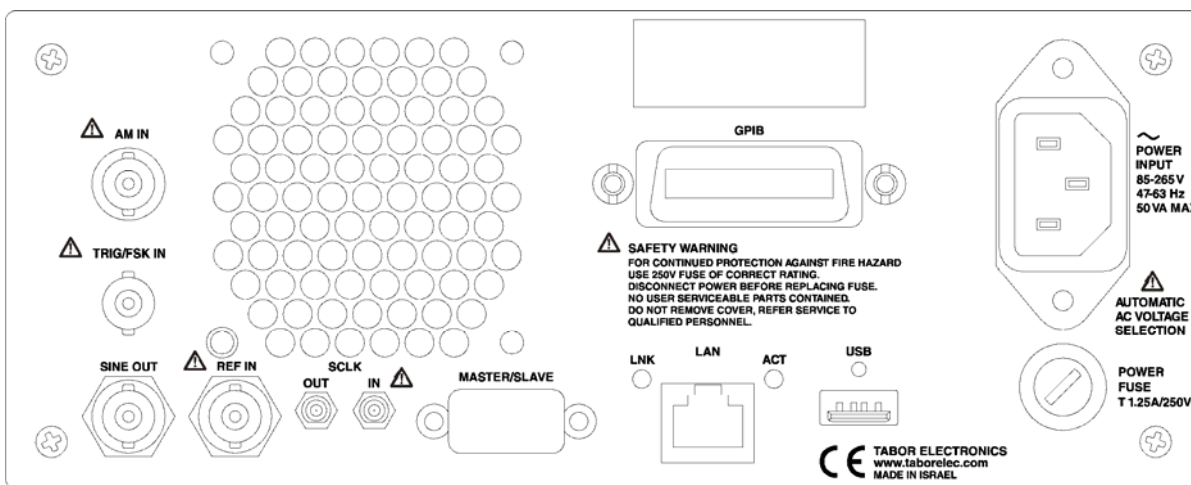
Figure 1-7, Model 1072 - Rear Panel

AM IN

This input accepts signals that amplitude modulates channel 1, 2, or both. The AM input becomes active only when the AM function is turned on; otherwise, it has no effect on the output signal.

TRIG/FSK IN

In general, this input accepts signals that stimulate generation of output waveforms. 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. In trigger and burst modes, the trigger input is edge sensitive, i.e., it senses transitions from high to low or from low to high. The direction of the transition is programmable. In gated mode, the trigger input is level sensitive, i.e., the generator is gated when the logic level is high and idle when the level is logic low. Trigger level for this input is TTL.

The trigger input is common to both channels. Therefore, if the 1072 is placed in trigger mode, both channels share the same mode and the trigger input causes both channels to start generating waveforms at the same time. Phase relationship between channels is tightly controlled in trigger mode. You should expect both channels to start generating waves with exactly the same start phase. Further control of leading edge offset between channels is also provided.

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

The trigger input is also used as stop and start input when the 1072 is placed in Arm mode.

SINE OUT

This BNC connector outputs dc coupled, fixed level (1Vpk-pk into 50Ω) sine waveforms. This output is derived directly from the sample clock generator and is active at all times, regardless of present operating mode of the 1072. The frequency of the sine output is programmed using the sample clock parameter. Frequency agility and modulation affect this output directly. The sine waveform output is programmed to 100MHz, so it may serve as an additional output to those available on the front panel.

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 reference than the one provided inside the 1072. The reference input is active only after selecting the external reference source mode.

SCLK OUT

This SMB connector outputs the programmed sample clock frequency. Output level is ECL, terminated into 50Ω to –2V. Note that correct termination is necessary for this output otherwise you will not see this signal at all. This output generates sample clock waveforms continuously, regardless if the 1072 is operating in continuous, trigger, or gated modes.

The sample clock output is used for multiple-instruments synchronization. In master mode, connect this output with an SMB to SNB connector to the adjacent slave instrument. You may also use this output to synchronize other components in your system to one master clock.

SCLK IN

This SMB connector accepts ECL level signal, terminated into 50Ω to –2V. The external clock input is available for those applications requiring synchronization to one sample clock source. Normally, this input is disabled. When enabled, the clock at this input replaces the internal clock generator and the 1072 generates waveforms having the external sample clock rate.

The sample clock output is also used for multiple-instruments synchronization. In slave mode, connect this input with an SMB to SMB connector to the adjacent master instrument.

MASTER/SLAVE

This 9-pin "D" connector is used when connecting master to slave units. The master/slave cable is supplied with your instrument. The master/slave mode must be activated from the front panel otherwise, this connector and the cable attached to it will have no affect on normal operation of the 1072.

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 cable. The connection to the host computer is automatic and does not require any address setting from within the 1072. The first time the 1072 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 load 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 1072 conforms to the IEEE-488.2 standard. Programming protocol is SCPI version 1993.0. GPIB cables are available separately from your Tabor Electronics dealer.

AC LINE

This 3-prong AC LINE connector accepts ac line voltage. The 1072 senses the line voltage and sets the appropriate range automatically. Therefore, 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 1072 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 LeCroy service center.

Run Modes

The 1072 can be programmed to operate in one of four run modes: continuous, triggered, gated and counted burst. These modes are described below. As was discussed above, both channels share common run mode and, if placed in trigger mode will simultaneously start generating waveforms when a valid trigger signal is received at the trigger input.

If you are using the one of the standard function, both waveforms will start and complete at exactly the same instance. In arbitrary mode, you may select different wavelength for each channel; In this case, if you have different waveform length, the trigger will initiate one output cycle and the outputs will generate one complete waveform. The 1072 will idle when the longest waveform has completed.

Continuous Mode

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

Triggered Mode

In triggered mode, the 1072 circuits are armed to generate one output waveform. The trigger circuit is sensitive to transitions at the trigger input. Select between positive or negative transitions to trigger the instrument. When triggered, the generator outputs one waveform cycle and remains idle at the last point of the waveform. The instrument can be armed to receive a trigger signal from either the front panel connector, remote command, or from an internal, free-running trigger generator. The period of the internal trigger generator is programmable with 7 digits.

The trigger signal, whether it comes from the front panel or from a remote command, has to pass through some electrical circuits. These circuits cause some small delay known as system delay. System delay cannot be eliminated completely and must be considered when applying a trigger signal. It defines how long it will take from a valid trigger edge to the moment that the output reacts.

Gated Mode

In gated mode, the 1072 circuits are armed to generate output waveforms as long as a gating signal is present. Unlike the triggered mode, the gated mode is level sensitive. When the gating signal goes low, the waveform at the output connector is first completed and the output reverts to an idle state. The idle amplitude level, after the gating signal goes low, is the last point on the waveform.

Burst Mode

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

Frequency Agility

Using the latest DDS (direct digital synthesis) technology, the 1072 is extremely agile. Operations like sweep, FSK and FM are directly derived from the DDS circuit by controlling its input bits. Frequency agility is described below.

 📝 *NOTE*

Sweep, FM and FSK modulate the sample clock frequency. The frequency of the signal at the output connector is only related to the sample clock frequency through the following relationship:

Output Frequency = SCLK / number of waveform points

Additional information on sample clock modulation can be found in Chapter 3.

Sweep

The 1072 can sweep from minimum to maximum sample clock frequency setting. Sweep time is programmable from 1ms to 1000 seconds with 7 digits. The sweep start and stop frequency program the rear-panel sine output connector. You may also use the sweep from the front panel as long as you do your own calculation of start and stop frequencies, depending on the present sample clock frequency and waveform length. Sweep can be used in continuous mode, triggered or gated run modes. The 1072 will also sweep up, or down, using linear or logarithmic increments.

FSK

FSK (frequency shift keying) function controls the sine output connector. The trigger input is used to flag the 1072 when to output carrier frequency (trigger false) or when it should switch to the shift frequency (trigger true). You may also use the FSK function from the front panel as long as you do your own calculation of carrier and shifted frequencies, depending on the present sample clock frequency and waveform length.

Ramped FSK

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

FM

The FM function modulates the 1072 sample clock frequency. You can frequency modulate the output either with built-in waveforms, or download complex waveforms to the modulation memory. Using the latest DDS technology, the modulation is wide band and extremely linear. FM can be used in continuous, triggered and gated modes. The 1072 can generate two types of frequency modulation: 1) Standard and 2) Arbitrary. In standard mode, the modulating waveform is selected from a built-in library of 4 standard waveforms: sine, triangle, square and ramped wave shapes. In arbitrary mode, the modulating signal is downloaded to the modulation waveform memory. There are 20,000 points allocated specifically for the arbitrary memory that is used for arbitrary frequency modulation.

Output Type

The 1072 can output three types of waveforms: standard (Fixed), arbitrary (User) and sequenced waveforms. Different waveform types may be assigned to each channel however the both channels must share the same output type. Description of the various output types that the instrument can generate is given below.

Standard (Fixed) Waveforms

The 1072 must pre-load its memory before it can generate waveforms. On power up, the waveform memory has no specific data. The sine waveform, being the default waveform on power on, is computed and loaded to the waveform memory as part of the reset procedure. If another waveform is required, it is being computed and loaded to the waveform memory. Waveforms are written from the same start address in the working memory and therefore, every time that a new waveform is selected, there is some minimal time for the processor to compute and download the data to the memory.

The 1072 can be programmed to output one of nine standard waveform shapes: sine, triangle, square, pulse/ramp, sine(x)/x pulse, gaussian pulse, rising/decaying exponential pulse, noise and dc. There are some parameters associated with each waveform, which modify the shape of the waveform to better suit your needs. For example, different start phase for the sine waveform can be programmed for each channel to create phase offsets between the two output channels.

Arbitrary (User) Waveforms

The 1072 working memory is capable of storing one or more user-defined waveforms. The 1072 is supplied with 4 Meg memory banks for each channel that can be allocated to one single waveform. On the other hand, there is no need to use the entire memory for only one waveform. The arbitrary memory can be divided into smaller segments and each segment loaded with different waveform then, the instrument can be programmed to output one segment at a time.

Loading data to arbitrary waveform memory can be a time-consuming task, especially if all 4 Meg points are loaded in one shot. The 1072 utilizes a DMA (direct memory access) concept that speeds data transfer from host computer to the instrument. In this mode, the memory bank is disconnected from the CPU circuit and re-routed to the remote bus for direct memory accessing by the host computer.

Sequenced Waveforms

The sequence generator is a powerful tool that lets you link and loop segments in any way you desire. As a simple example of a sequenced waveform, look at Figures 1-8 through 1-10. The waveforms shown in these figures were placed in memory

segments 1, 2 and 3, respectively. The sequence generator takes these three waveforms links and loops them in a predefined order to generate the waveform shown in Figure 1-11.

The sequence circuit is useful for generating long waveforms with repeated sections. The repeated waveform has to be programmed once and the repeater loops on this segment as many times as selected. When in sequenced mode, there is no loss of time between linked or looped segments.
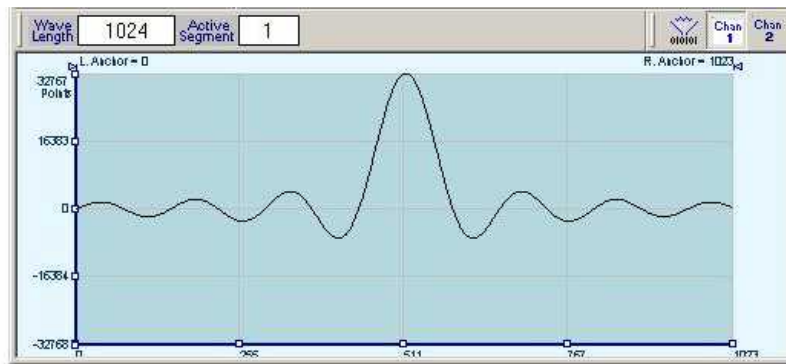
Figure 1-8, Segment 1 – Sin (x)/x Waveform
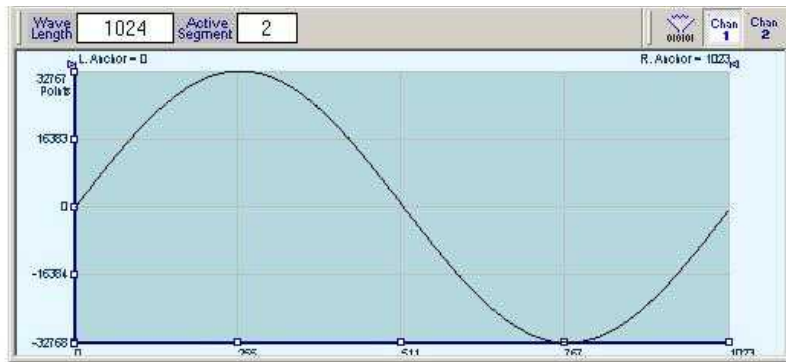
Figure 1-9, Segment 2 – Sine Waveform
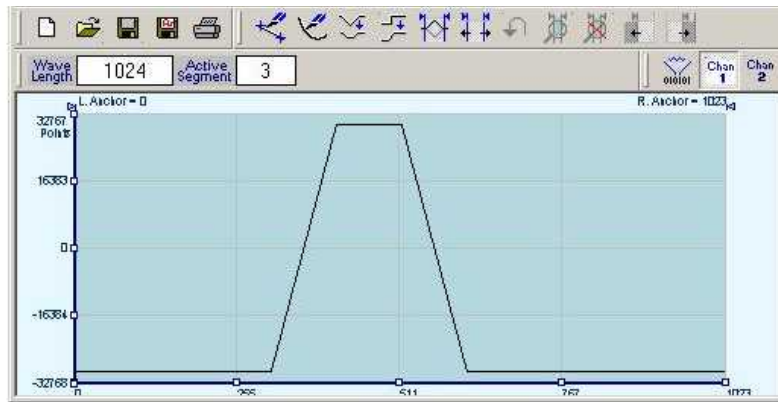
Figure 1-10, Segment 3 – Pulse Waveform

The following sequence was made of segment 2 repeated twice, segment 1 repeated four times, and segment 3 repeated two times.
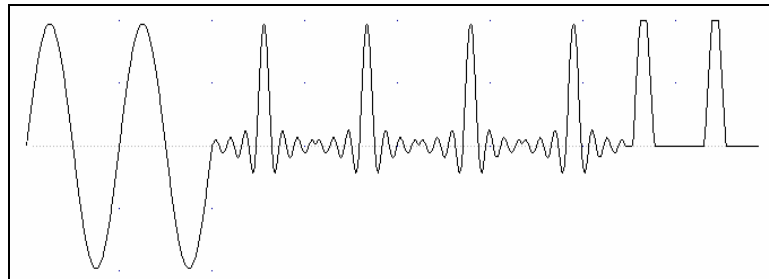
Figure 1-11, Sequenced Waveforms

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

Filters   Two filters for each channel are built into the 1072. These filters are available for use in various applications such as the creation of high frequency sine waves and removing the staircase effect from waveforms that are generated with high frequency clock rates. The filters are also used for reconstructing the standard sine waveform.

Programming The 1072

The 1072 has front panel control capability for most of its function, parameters, and modes. However, waveform data and sequence tables must be loaded to the 1072 from a host computer before it can be output arbitrary or sequenced waveforms. There are a number of ways to "talk" to the instrument. They all require that an appropriate software driver be installed in the host computer. The rest is a matter of practice and knowledge of the language in use. 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 1072 is accomplished using SCPI (Standard Commands for Programmable Instruments) language. Programming aspects are covered in Chapters 3 and 4.

Supplied with the 1072 is a PC software package called ArbConnection. This provides a user interface with a familiar windows interface which allows the user to interact with and control the 1072 directly. Details of how to use ArbConnection are supplied in the following pages.

Chapter 2
Configuring the Instrument

Installation Overview

This chapter contains information and instructions necessary to prepare the Model 1072 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.**

Power Requirements

The function generator may be operated from a wide range of mains voltage 85 to 265 Vac. Voltage selection is automatic and does not require switch setting. The instrument operates over the power mains frequency range of 48 to 63Hz. Always verify that the operating power mains voltage is the same as that specified on the rear panel.

The 1072 should be operated from a power source with its neutral at or near ground (earth potential). The instrument is not intended for operation from two phases of a multi-phase ac system or across the legs of a single-phase, three-wire ac power system. Crest factor (ratio of peak voltage to rms.) should be typically within the range of 1.3 to 1.6 at 10% of the nominal rms. mains voltage.

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 1072 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.

📝 *NOTE*

If the instrument is to be shipped to Tabor Electronics for calibration or repair, attach a tag to the instrument identifying the owner. Note the problem, symptoms, and service or repair desired. Record the model and serial number of the instrument. Show the 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 1072 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 1072 without proper airflow will result in damage to the instrument.

Installing Software Utilities

The 1072 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 1072 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 1072 from remote. Programming examples are also available to expedite your software development. The IVI driver comes free with the 1072 however, you'll need the IVI engine and visa32.dll run time utilities to be able to use the IVI driver. The additional utilities can be downloaded for free from NI's (National instrument) web site – www.ni.com.

ArbConnection is a user friendly program that lets you control the instruments functions and features from a remote computer. It also lets you generate and edit arbitrary waveforms on the screen, build sequence tables, modulating signals and much more and then download the signals to your 1072 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 1072 using SCPI commands, just as you will be using them in your program. Installation of ArbConnection is simple and intuitive and only requires that visa32.dll runtime file be added to your Windows system folder. Download the file from NI's (National instrument) web site – www.ni.com. Installation and operating instruction for ArbConnection are given in Chapter 4.

The *USB* driver is required if you intend to connect the 1072 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 1072 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 1072 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 Electronics 1072 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 1072 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 1072 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 Electronics 1072 to your PC using a standard USB cable and the interface will self configure. After you connect the 1072 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 1072 via twisted pair Ethernet cable. Take care that you use twisted pair wires designed for 10/100 BaseT network use (phone cables will not work). Refer interconnection issues to your network administrator. After you connect the 1072 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 1072 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 curser 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.
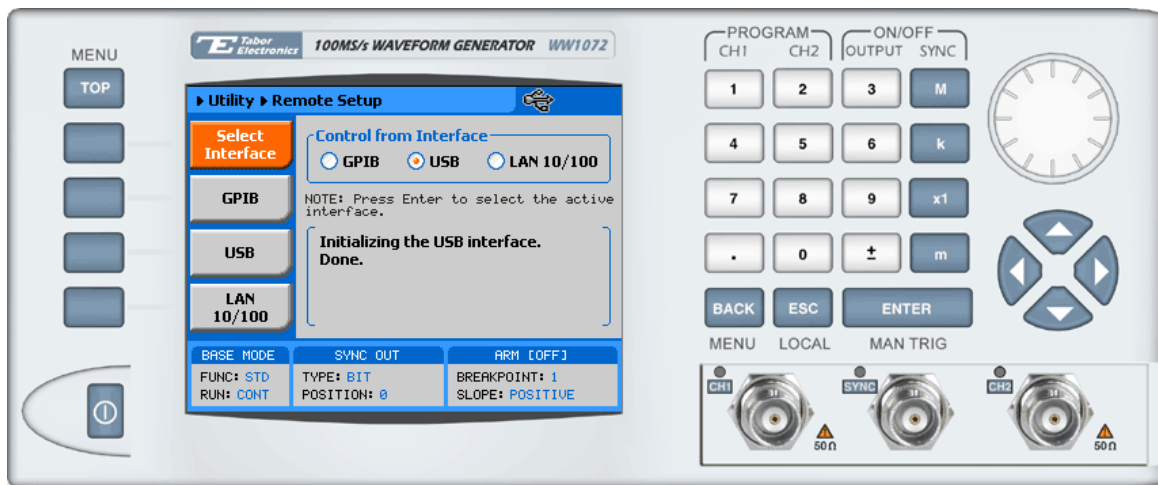
Figure 2-1, Selecting a Remote interface

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 1072 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 described on page 2-7.
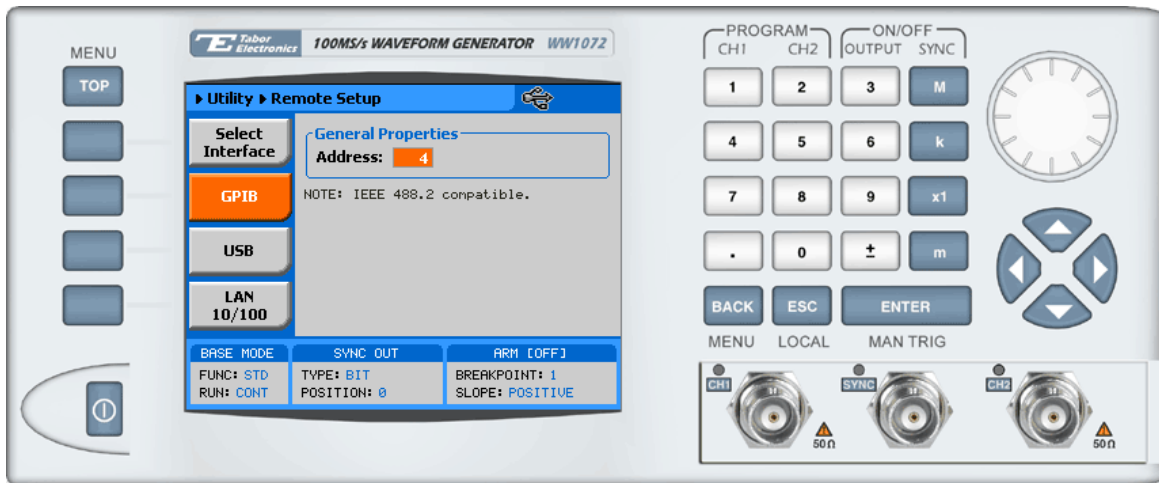
Figure 2-2, GPIB Configuration Screen

USB Configuration

The USB requires no front panel configuration parameters. Following simple installation steps as shown later, just connect your Tabor Electronics 1072 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:
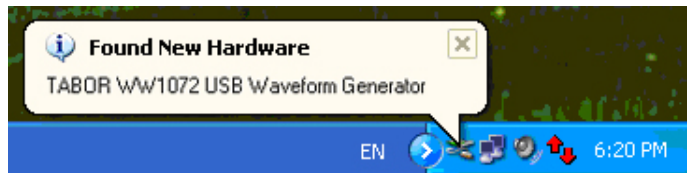
Figure 2-3, USB Device Detected

Figure 2-4, Found New Hardware Wizard

Immediately thereafter, the Found New Hardware Wizard will open, as shown in Figure 2-4. 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. 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. To complete the process press on Finish, as shown in Figure 2-6.
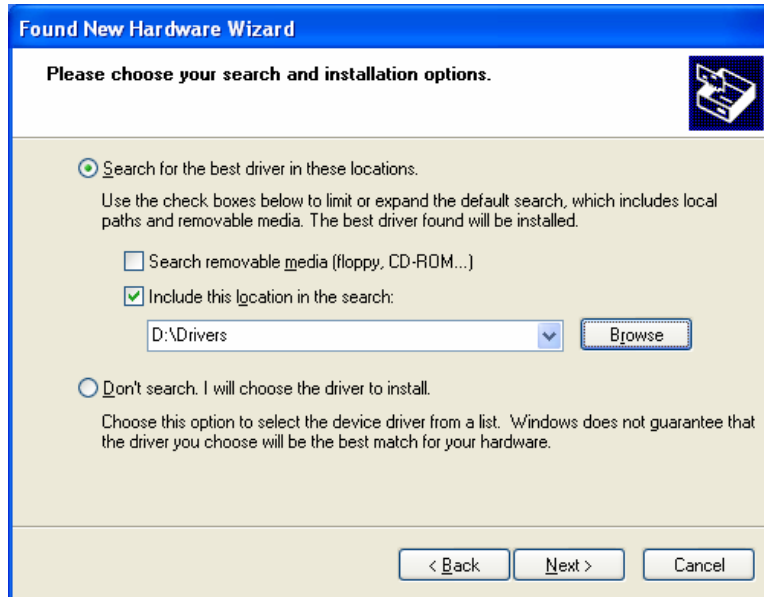
Figure 2-5, Choose Your Search and installation Options
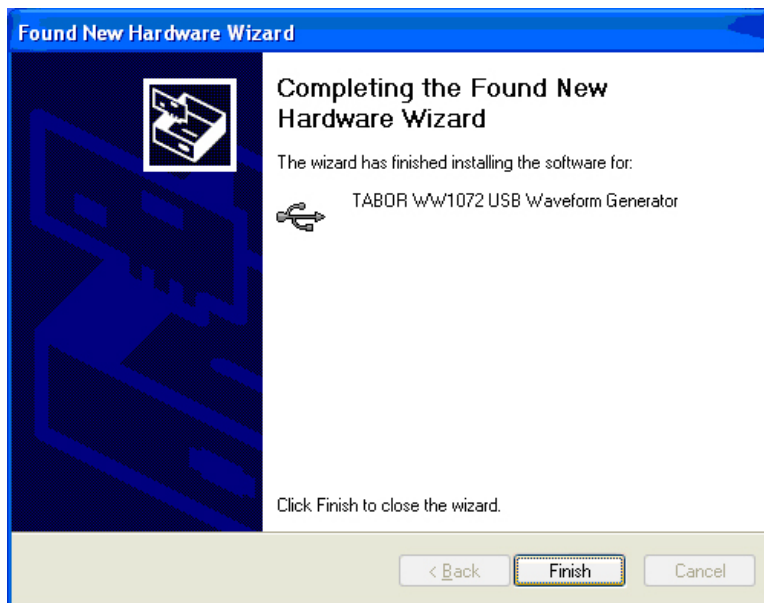
Figure 2-6, New Hardware Found and Software installed

Figure 2-6 shows that the Tabor Electronics 1072 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 2-7.

Figure 2-7, 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 Figure 2-8. To complete the process click on Finish.
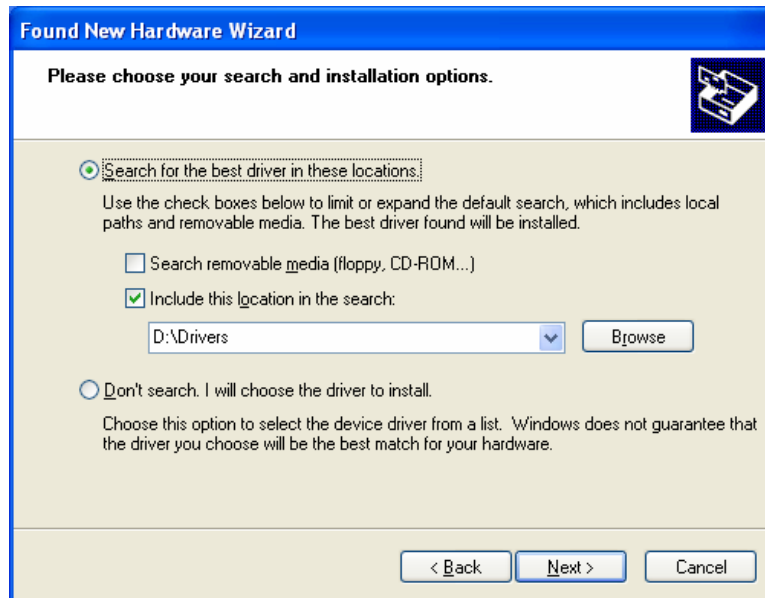
Figure 2-8, Choose Your Search and installation Options

Figure 2-9, 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 Electronics 1072 configured correctly, compare your Device Manager to the example in Figure 2-10.

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 described on page 2-7.
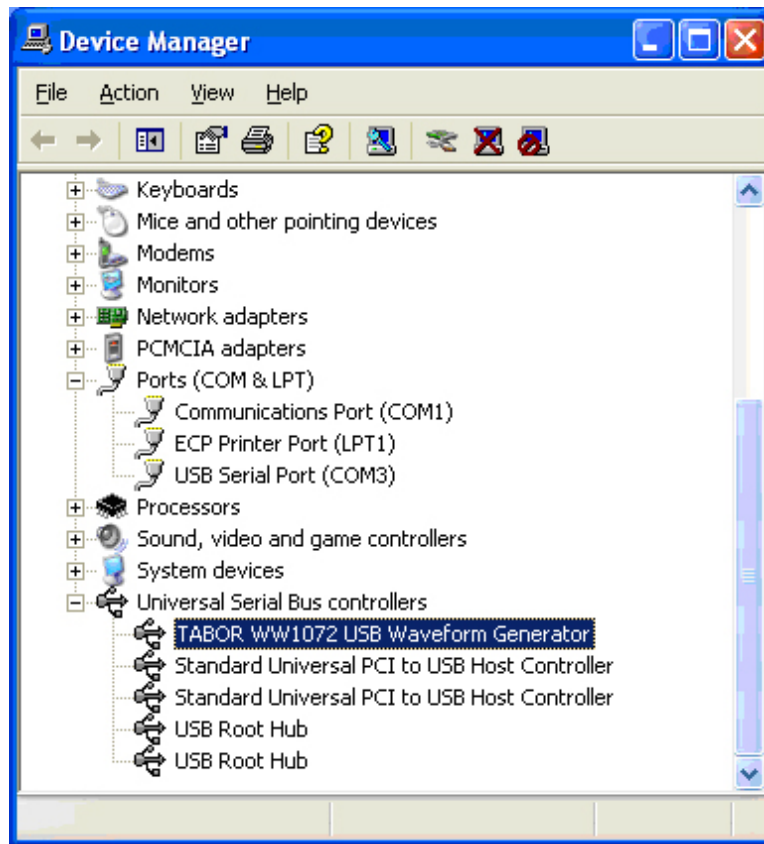
Figure 2-10, Model 1072 Configured for USB Operation

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 2-11. 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 described on page 2-7.
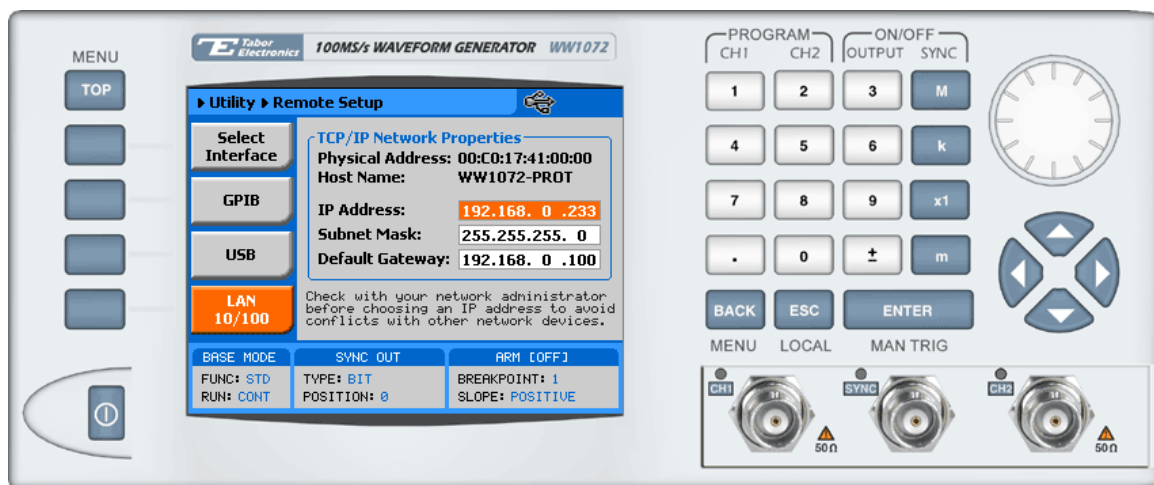
Figure 2-11, LAN Configuration Screen

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.

Chapter 3
Using the Instrument

Overview

This chapter contains information about how to operate the Tabor Electronics 1072. 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 using front panel sequences. The 1072 is supplied with Tabor Electronics, a PC based software package with a graphical user interface to allow users to program all of the functions directly. LabView 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 1072. The manual is organized by instrument function and instructions are given in each paragraph on how to use the function from both the front panel and Tabor Electronics.

Inter-Channel Dependency

The 1072 has two output channels. Although this is a two-channel instrument, many of the commands that set parameters and functions are common for both channels. For example, sample clock and run modes can not be set separately for each channel. On the other hand, you may set each channel to have different function shape, amplitude and offset. Table 3-1 lists the function and parameters and their related Inter-channel dependency.

Output Termination

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

Input / Output Protection

The Model 1072 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 1072 utilizes non-volatile memory backup that automatically stores the last setup before the generator was 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 1072.

After power on, the instrument displays information messages and updates the display with the last setup information. The 1072 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 1072, 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 4.
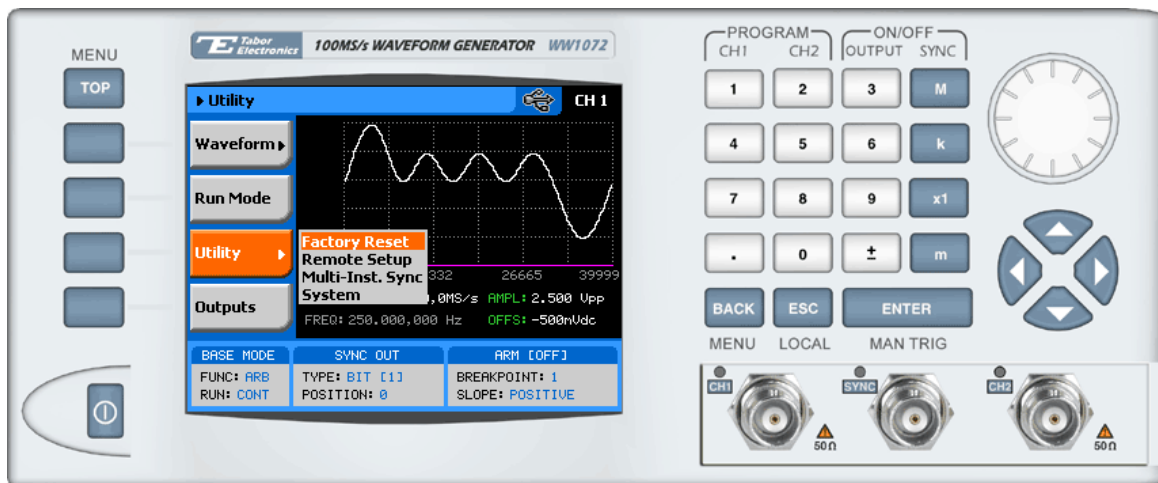
Figure 3-1, Reset 1072 to Factory Defaults

Table 3-1, Default Conditions After Reset

Function / Parameter	Default	Inter-Channel Dependency
Output State:	Off	Separate
Operating Mode:	Continuous	Common
SYNC State:	Off	Common
Output Function:	Standard	Separate
Output Function Shape:	Sine	Separate
Standard Wave Frequency:	1MHz	Common
User Wave Sample Clock:	10MS/s	Common
Sample Clock Source & Reference:	Internal	Common
Channel 2 Clock Divider:	1	Separate
Amplitude:	5V	Separate
Offset:	0V	Separate
Filter State:	Off	Separate
Filter Type:	Auto	Separate
Trigger Slope:	Positive	Common
Internal Trigger Rate:	1kHz	Common
Modulation State:	Off	Common
DMA State:	Off	Separate

Controlling the 1072

Controlling 1072 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 1072 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 1072 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, 1072 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 1072 is placed in "Triggered" run mode, the Man Trig button can be used to manually trigger the 1072

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. ***Program CH1, CH2*** – Use Program CH1 to modify the screen to display channel 1 parameters. Use Program CH2 to

modify the screen to display channel 2 parameters. These keys can be used only when the 1072 is not in edit mode

12. **ON/OFF Output, Sync** – These keys can be used only when the 1072 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	2nd Level Menu	3rd Level Menu	Notes
A	Waveform			
A		Standard		
A			Waveshape	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			Segment Number	Selects an active memory segment
↓D			Wave Composer	Creates custom waveforms
↓D			Delete Segments	Clears the entire arbitrary memory
C		Sequenced		
A			View Table	Displays table and provides editing options
B			Advance Mode	Programs the sequence advance mode
C			Sample Clock	Programs the sample clock frequency
D			Amplitude	Programs output amplitude
↓D			Offset	Programs output offset
↓D			Active Segment	Selects the active segment in the sequence
D		Modulated		
A			Modulation Type	Selects one of AM, FM, FSK and Sweep
B				Parameter depends on selected modulation
C				Parameter depends on selected modulation
D				Parameter depends on selected modulation
↓D				Parameter depends on selected modulation

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

Table 3-2, Front Panel Menus (continued)

Soft Key	TOP Menu	2nd Level Menu	3rd Level Menu	Notes
B	Run Mode			
A		Continuous		Provides access to continuous mode parameters
B		Triggered		Provides access to triggered mode parameters
C		Gated		Provides access to gated mode parameters
D		Burst		Provides access to burst mode parameters
C	Utility			Provides access to 1072 Factory Reset, Remote Setup, Multi-Instrument synchronization and System parameters
D	Outputs			Provides access to output parameters, sync properties and start phase offset between channels.

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 from the Output Menu. Observe Figure 3-3 and disable or enable the main outputs using the following procedure. 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.

1. While not editing any parameter, select the channel you want to turn on using the PROGRAM CH1 or CH2 keys
2. Press ON/OFF OUTPUT or SYNC to toggle main and sync output on and off
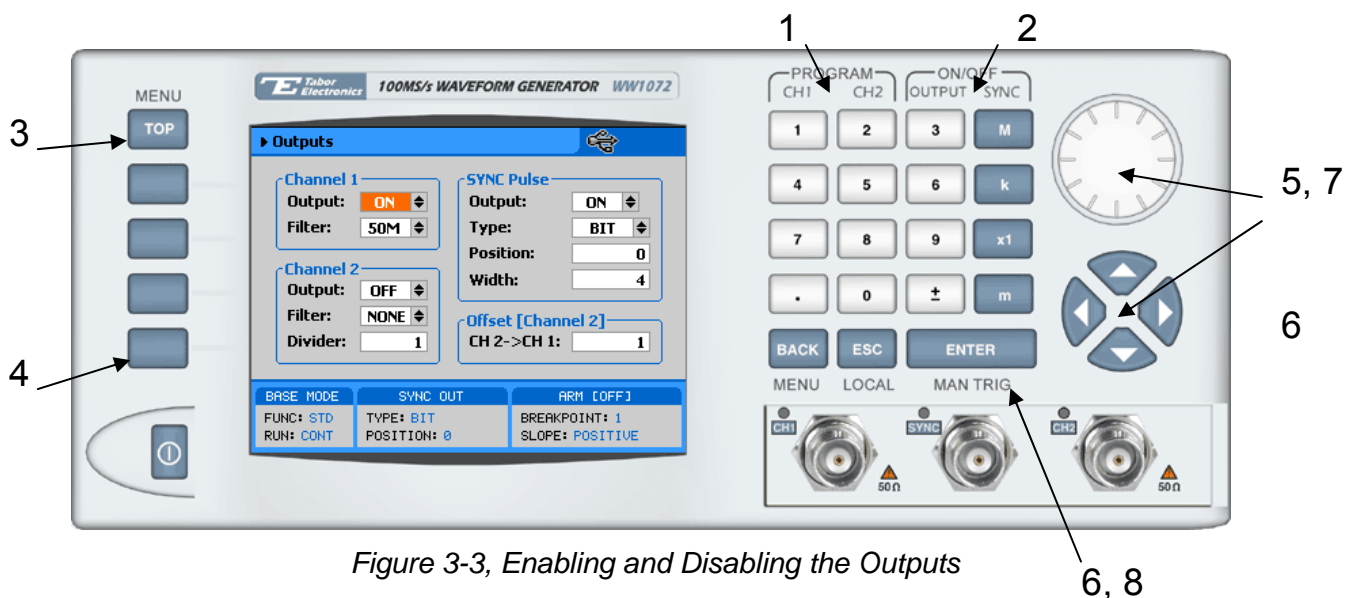
Figure 3-3, Enabling and Disabling the Outputs

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:

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

Selecting a Waveform Type

There are four main types of waveforms that the 1072 can produce: Standard, Arbitrary, Sequenced and Modulated waveforms. Standard and modulated waveforms are computed from equations and tables that are built into the program. The instrument can output arbitrary and sequenced waveforms 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.
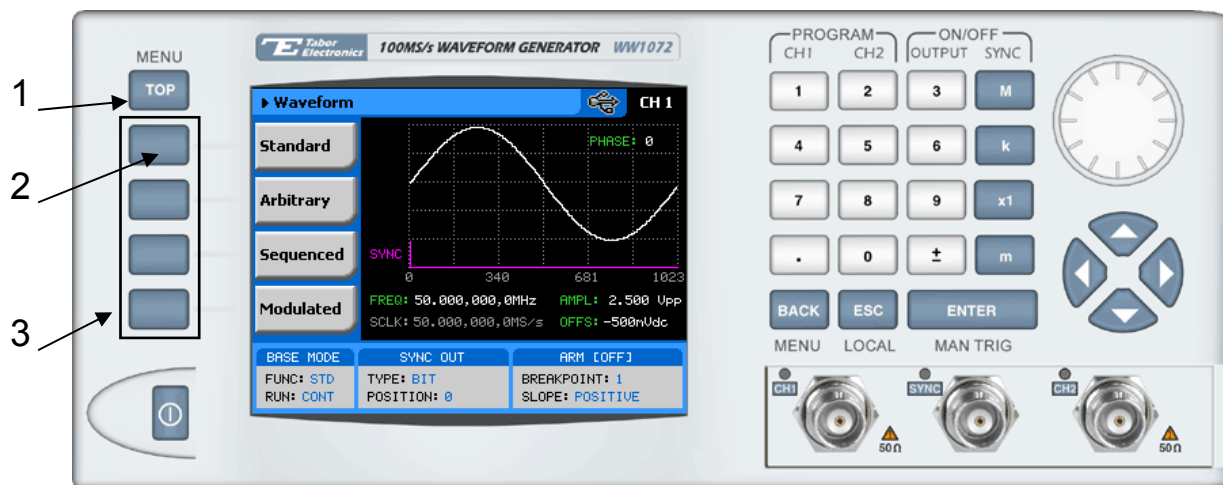
Figure 3-4, Selecting an Output Waveform Type

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 1072 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.
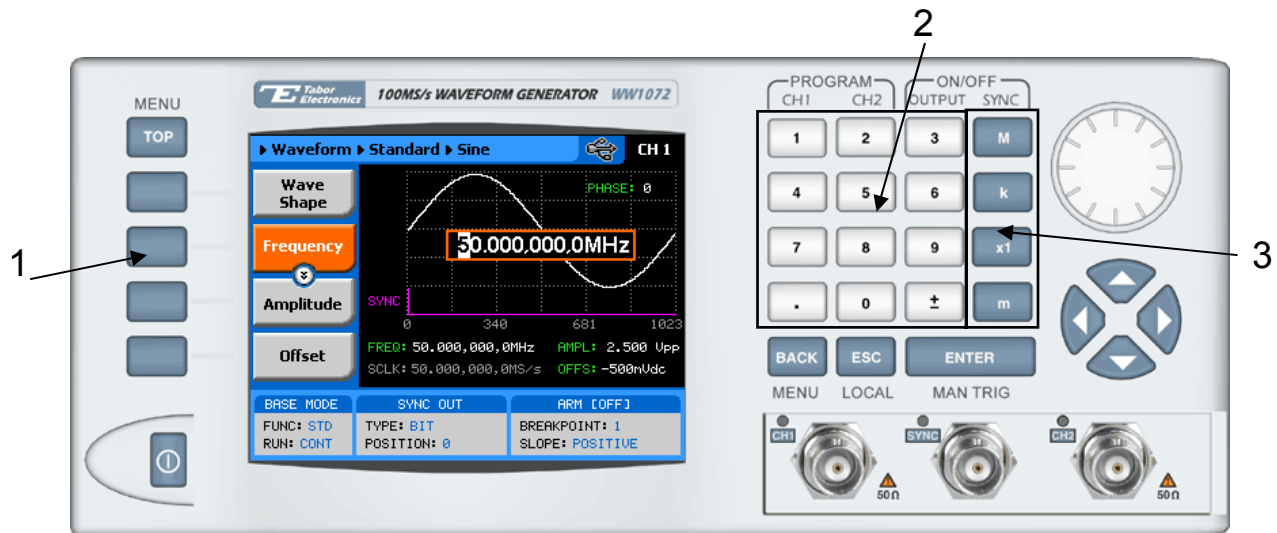
Figure 3-5, Modifying Output Frequency

📝 *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.
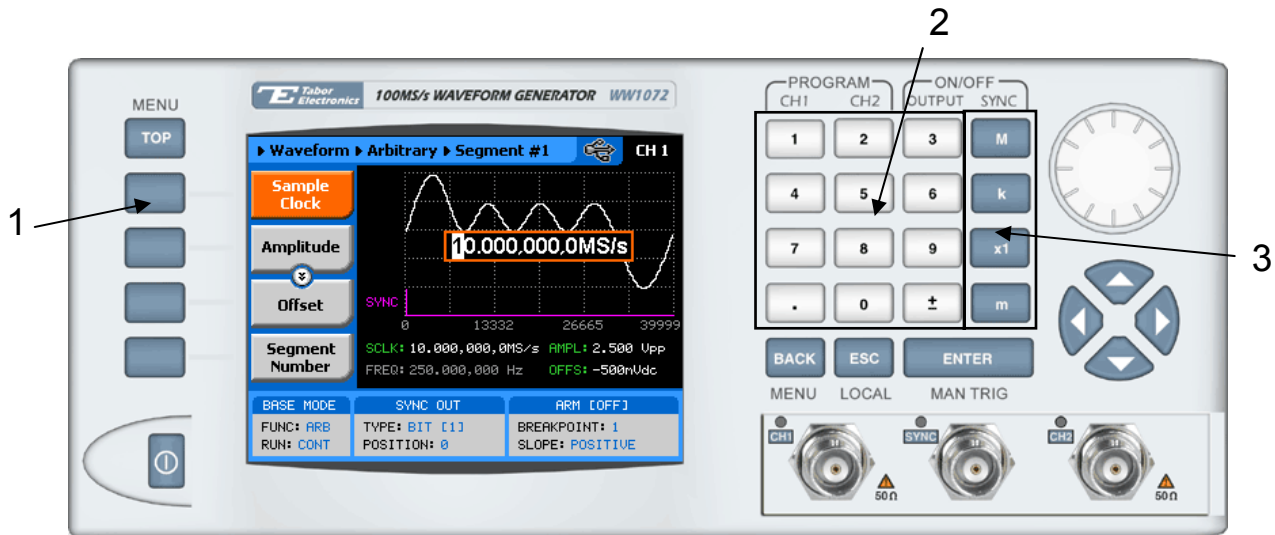
Figure 3-6, Modifying Sample Clock Frequency

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

---

Dividing the Sample Clock for Channel 2

The sample clock divider is used to divide the sample clock for channel 2. This way, each channel can have a different sample clock rate. The sample clock is divided using integer numbers only.

Observe Figure 3-7 and modify frequency and sample clock using the following procedure. The index numbers in Figure 3-7 correspond to the procedure steps in the following description.
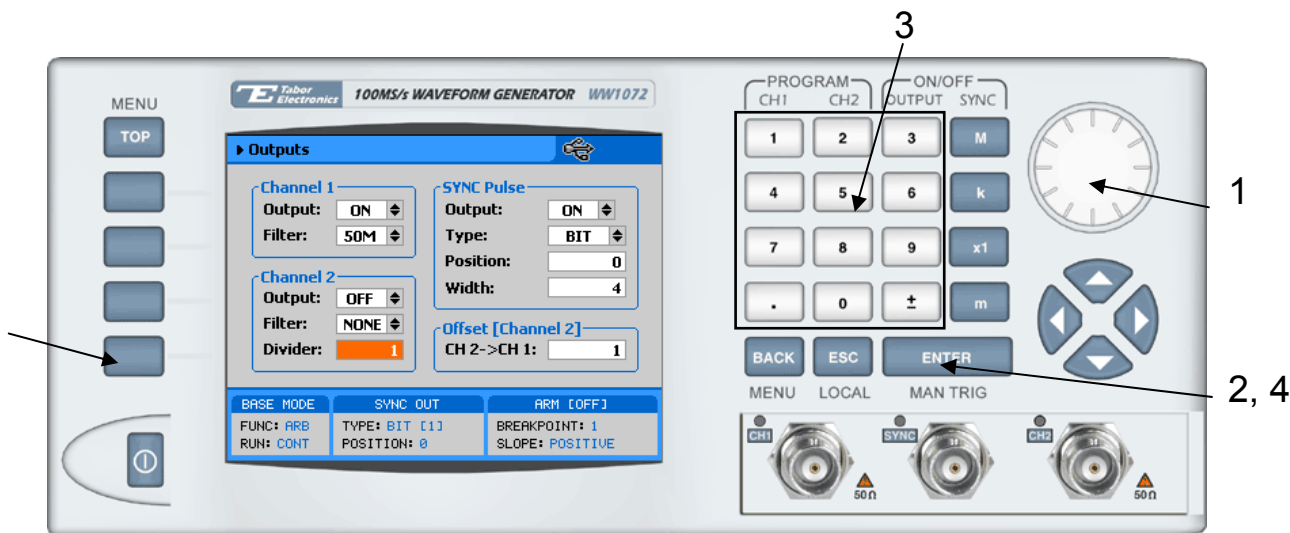
Figure 3-7, Programming Sample Clock Frequency Divider

First, select the Outputs menu to gain access to the Channel 2 sample clock frequency divider parameter, then

1. Using the dial scroll down to the Divider field
2. Press Enter to edit the Divider value
3. Use the numeric keypad to program the divider value. Use integer number only
4. Press Enter to lock in the value

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

Note

If you use the dial or arrow keys to modify the channel 2 sample clock frequency divider 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

Output amplitude and offset can be programmed independently and separately for each channel. Amplitude and offset are set within windows, so before you select values for these parameters, make sure you do not exceed the limits.

Offset for the 1072 can be adjusted with 6 digits of resolution (nearly 19 bits) and amplitude is programmed with 4 digits. 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 first thing you do before you program amplitude and offset setting is define which of the channels is being programmed. The active channel is displayed at the upper right corner of the LCD display.

When the display shows **CH 1** at the upper right corner, you are currently programming channel 1 parameters. Keypads "1" and "2" are used as hot keys for channel selection. While not editing any parameter, press key "2" to program channel 2 parameters.

When the display shows **CH 2** at the upper right corner, you can proceed with channel 2 programming.

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 3-8 and modify amplitude and offset using the procedure as described below. The index numbers in Figure 3-8 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

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

---
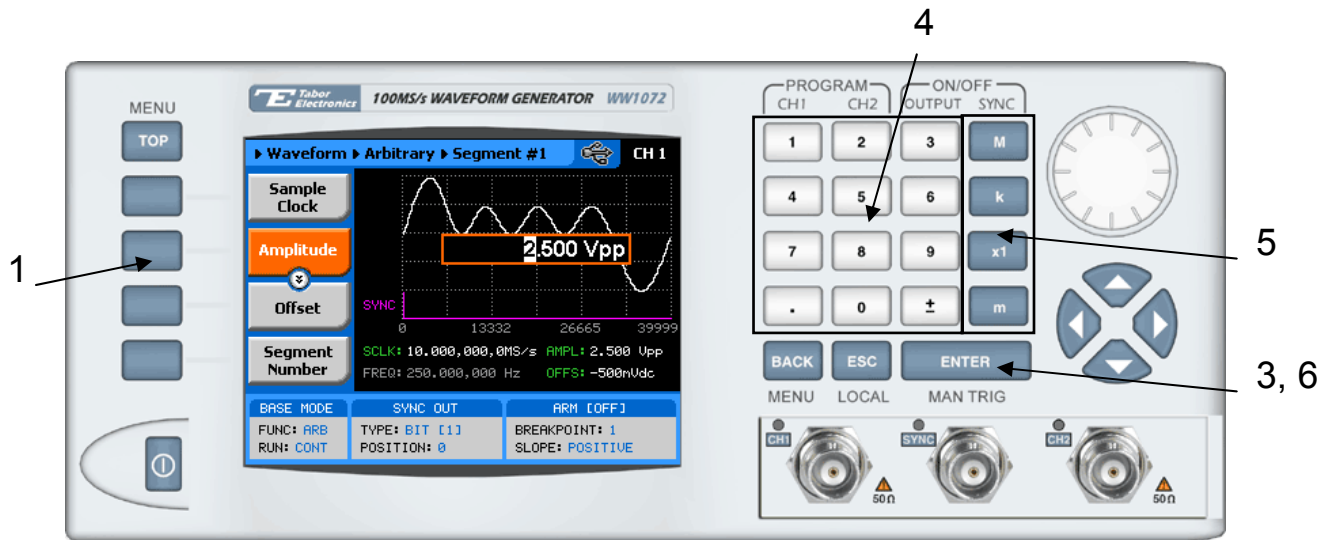
Figure 3-8, Programming Amplitude and Offset

Selecting a Run Mode

The Model 1072 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. In this mode, the 1072 does not require a trigger source to stimulate output cycles. 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 3-9 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.
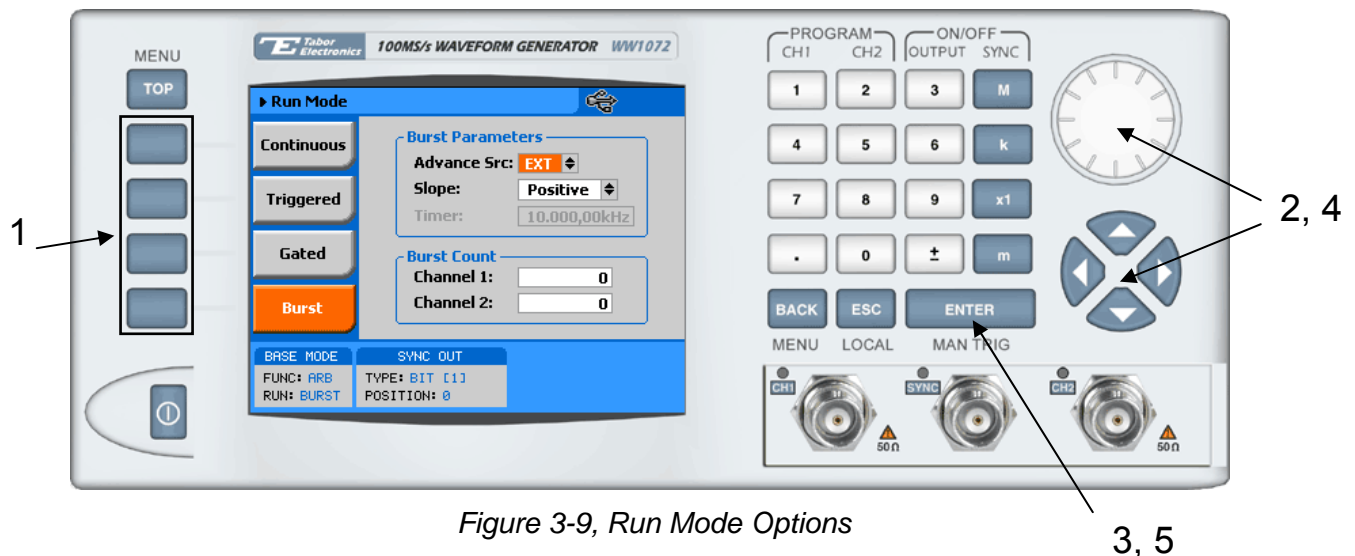
Figure 3-9, Run Mode Options

 Note

Burst run mode is shown in Figure 3-9 as an example however, the following description applies to all Run Modes.

In general, a specific run mode is selected from the Run Modes soft key menu. The screen as shown in Figure 3-9 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 Divider 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 zero DC level as long as the trigger signal to the rear-panel remains inactive. The trigger input is sensitive to either a rising edge or a falling edge of a trigger signal. Each time a transition occurs at the trigger input, the 1072 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. There are four parameters you can adjust for this mode:

Advance Source – Defines the trigger source. External enables the trigger input. Internal disables the trigger input and enables an internal free-running trigger generator that automatically triggers the output at programmable intervals

Slope – Defines edge sensitivity for the trigger input

Timer – Set the intervals for the internal trigger generator. This value is accessible only if you are using the internal trigger generator as the trigger source, and

Start Positions – Defines the start point on the waveform for the trigger signal. The start position parameter may serve as a trigger delay generator, where the delay is set in number of waveform points.

You may use the triggered mode to trigger standard, arbitrary and sequenced waveforms. The Trigger run mode parameters are shown in Figure 3-10.

Figure 3-10, Trigger Run Mode Parameters

Gated Mode

When set to gated mode, the 1072 output remains at a DC level as long as the rear-panel TRIG IN signal remains inactive. The gating signal can be programmed to be either active high or active low. The Model 1072 generates output waveforms as long as the proper level is present at the trigger input connector. When the gate signal is de-asserted, the output completes the last cycle and resumes position at a DC level equal to the last point of the waveform. There is only one parameter you can adjust for the gated mode:

> *Slope* – Defines if the generator is gating when the trigger signal is TTL high (Positive) or when the trigger signal is TTL low (Negative)

> *Start Positions* – Defines the start point on the waveform for the gating signal. The start position parameter may serve as a gate delay generator, where the delay is set in number of waveform points.

You may use the gated mode to gate standard waveforms, arbitrary waveforms, and sequences of waveforms. The gated run mode parameters are shown in Figure 3-11.

3-17

Figure 3-11, 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 the trigger signal at the rear panel remains inactive. The trigger input is sensitive to either the rising edge or the falling edge of the trigger signal. Each time a transition occurs at the trigger input, the 1072 generates preprogrammed number of waveform cycles. At the end of the burst, the output resumes position at a DC level equal to the last point of the waveform. The burst count is programmable from 1 to 1 million cycles. There are four parameters you can adjust for this mode:

Advance Source – Defines the trigger source. External enables the trigger input. Internal disables the trigger input and enables an internal free-running trigger generator that automatically triggers the output at programmable intervals

Slope – Defines edge sensitivity for the trigger input

Timer – Set the intervals for the internal trigger generator. This value is accessible only if you are using the internal trigger generator as the trigger source, and

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 waveforms can not be used in burst mode. The Burst run mode parameters are shown in Figure 3-12.

Figure 3-12, Burst Run Mode Parameters

Using the Arm Feature

The arm mode operates in conjunction with the continuous run mode only. This feature allows you to stop generating waveforms at a specific breakpoint location then, continue generating the waveform, only when you are ready, and the waveform will resume operation from the last breakpoint position. There are three parameters you can adjust for this function:

State – Turns arm mode on and off

Slope – Defines edge sensitivity for the trigger input, and

Breakpoint Position – Defines where the waveform will stop. Note that each channel can be programmed to stop at a unique breakpoint position.

The Arm parameters are shown in Figure 3-13.

Figure 3-13, Arm Parameters

Using the Manual Trigger

The manual trigger allows you to trigger or gate the 1072 directly from the front panel. This button is active only when the generator is placed in external trigger, or arm modes. 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 1072 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 3-14.

Figure 3-14, SYNC and Filter Parameters

There are four parameters you can adjust for this function:

State – 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 – Provides selection between two types of signals: BIT and LCOM. The BIT mode is recommended to be used in standard and arbitrary modes only. The sync output generates a single sync signal with every waveform cycle. The LCOM (loop complete) option generates a sync signal in sequenced mode only. The signal starts with the selected active segment and stops only after the sequence loop has completed.

Position – Lets you place the sync bit at any point along the

length of the waveform. Placement resolution is 4 points. As default, the sync signal is positioned at the beginning of the waveform. Position value is ignored when you select LCOM.

Width – Programs the width of the sync signal as percent of the output period. Width resolution is 4 points. Width value is ignored when you select LCOM.

The SYNC parameters are shown in Figure 3-14. The Menu is accessible by selecting the Outputs soft key as shown in Figure 3-3.

Applying Filters

Two filters are available for each channel. 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. More than 1 filter can be applied at any time, the effects being additive.

The built-in filters are available for the user in standard, arbitrary and sequenced modes. The only function where the Model 1072 does not allow external control is when standard sinusoidal waveform is selected.

Note

The default output function of the generator is the sine waveform. The instrument is using filters to generate this waveform 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 NONE. 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 3-14.

Selecting the SCLK Source and Reference

In cases where synchronization to other instruments in a system is needed, you have two options: Use an external clock source for the 10MHz reference clock or replace the internal sample clock generator entirely with an external clock source. Either way, this is a major twist in the 1072 basic operation because if, for any reason, you leave one or both source options on external and do not apply the necessary signal to the input, the operation of the generator will be impeded without visual references that something is wrong.

The SCLK and the 10MHz reference source menu were placed in

the System menu, as shown in Figure 3-15. Change these settings only if you are absolutely sure that another reference source is available at the appropriate inputs.

The SCLK input is located on the rear panel. Use this input to replace the internal sample clock generator. The external sample clock input accepts ECL level signals, terminated to –2V into 50Ω.

The 10MHz reference input is also located on the rear panel. It accepts TTL level signals only. Note that the 1072 internal reference is accurate to 1ppm.

The display and modify the SCLK or the 10MHz clock source, press TOP, then Utility and scroll down to the System option.

Figure 3-15, Modifying the SCLK and 10MHz Clock Source

Generating Arbitrary Waveforms

In general, the Model 1072 cannot by itself create arbitrary waveforms. If you want to use arbitrary waveforms, you must first load them into the instrument. The 1072 is supplied with waveform creation and editing, called – Tabor Electronics. Besides waveform generation, Tabor Electronics has instrument control features, sequence table generator, FM and pulse composers and many other features that will be described separately. Figure 3-16 shows an example of a waveform that was created with the Tabor Electronics. Once the waveform is created on the screen, downloading it to the 1072 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 1072 is given in Chapter 5. Information in this Chapter will give you some general idea what arbitrary waveforms are all about.
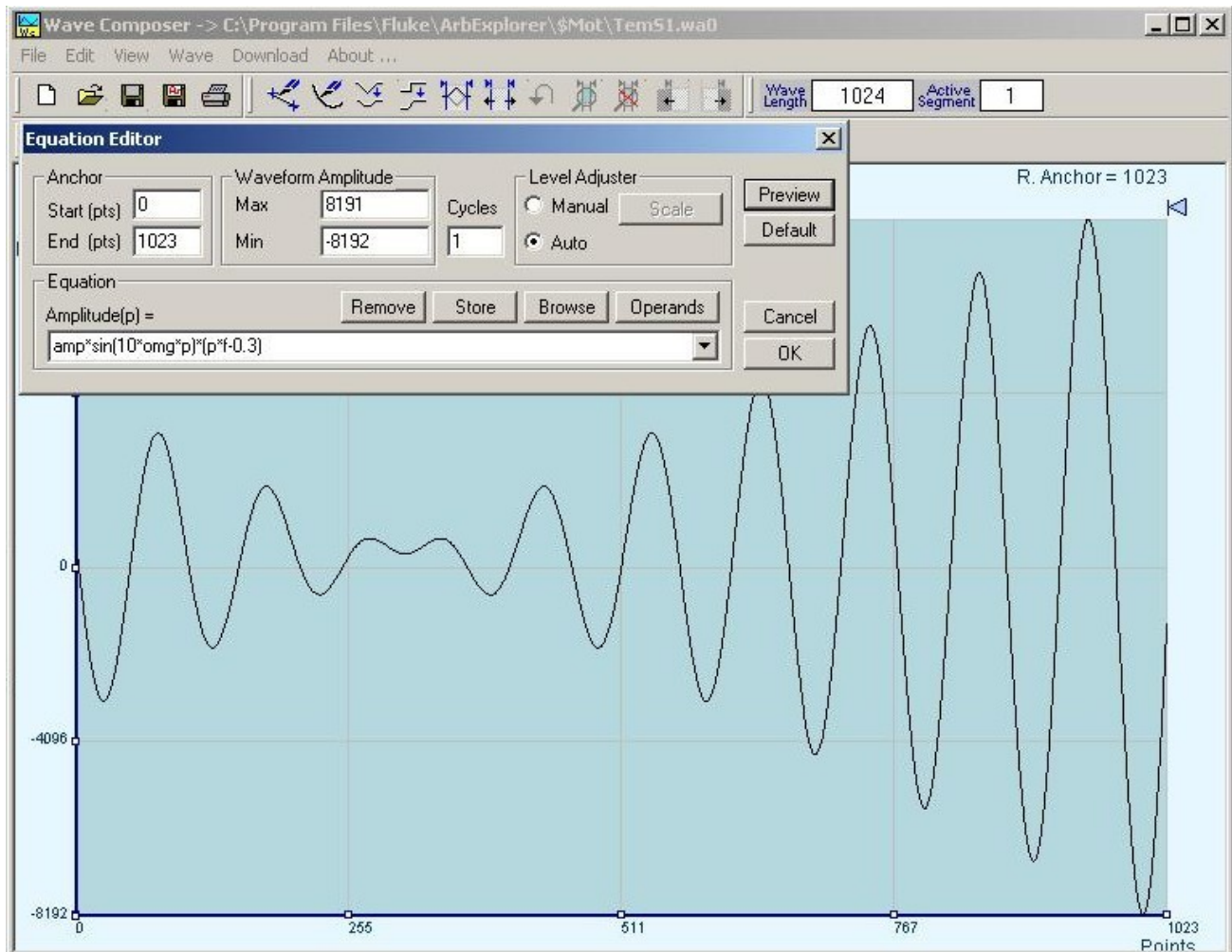
Figure 3-16, The Wave Composer Tool for Generating Arbitrary Waveforms

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 1072 is using 14-bit DAC's to generate arbitrary waveforms. Converting 14 bits to precision shows that each data point can be placed along the vertical axis with a precision of 1/16,384.

Memory Depth – Defines how many data points can be stored for a single waveform cycle. The 1072 has 2M 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 1072 lets you divide the memory bank to smaller segments and load different waveforms into each segment.

Generating Arbitrary Waveforms

Downloading waveforms to the 1072 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 3-17 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 3-17 will display and the output will already generate arbitrary waveforms. Note the channel you are currently program 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 14 bits.

Offset – Defines the offset value of the arbitrary waveform. The offset and the amplitude can be freely programmed within a 10V window (+5V to -5V rails).

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 2k 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 distractive removal of all segments from the memory. In fact, 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.
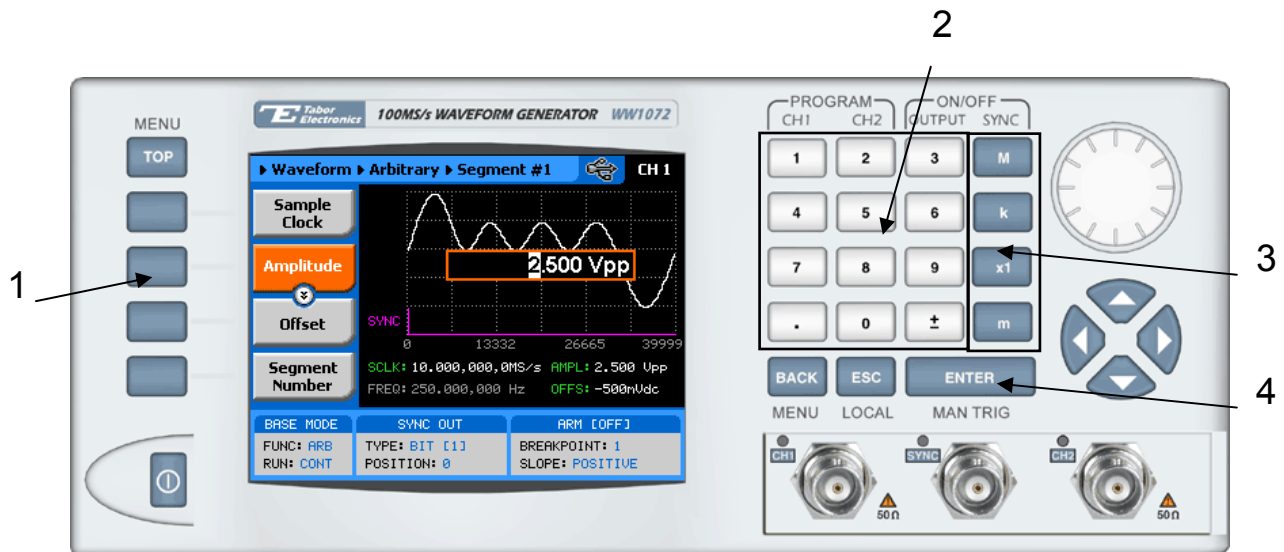
Figure 3-17, Programming Arbitrary Waveform Parameters

Generating Sequenced Waveforms

In general, the Model 1072 cannot by itself create sequenced waveforms. If you want to use sequenced waveforms, you must first load them into the instrument. The 1072 is supplied with waveform creation and editing, called – Tabor Electronics. Besides waveform creation, Tabor Electronics has instrument control features, sequence table generator, FM composer and many other features that will be described separately. To generate a sequence you must first download waveforms to the instrument, generate a sequence table and download the sequence table to the instrument. Sequences are generated easily using the waveform Studio as shown in Figure 3-18. Note that different sequences can be generated for each channel.

Detailed information on the structure of the arbitrary waveform and the commands that are needed to download arbitrary waveforms to the 1072 is given in Chapter 5. There, you can also find information how to create and download sequence tables using SCPI programming commands. Information in this chapter will give you some general idea what sequenced waveforms are all about.
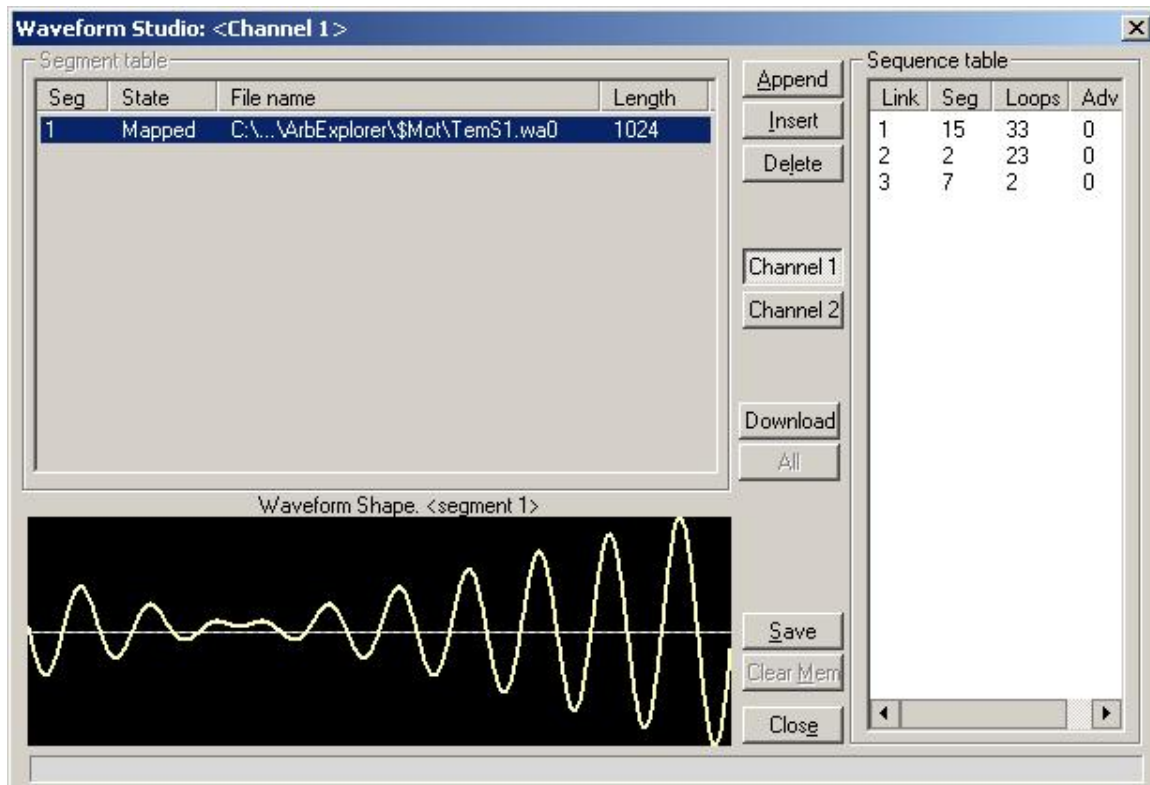
Figure 3-18, Using Tabor Electronics to Generate Sequences

What Are Sequenced Waveforms?

Sequenced waveforms are constructed from two or more arbitrary waveforms, which are linked and looped in any way you can imagine, as long as you observe the limitations set forth in the specification section of this manual.

The first thing to do before you can generate sequenced waveforms is download waveforms to the 1072. You may use Tabor Electronics or any other application to create waveform segments. Then, you can build your sequence table. An example of how sequenced waveforms work with three different waveforms is demonstrated in Chapter 1, Figures 1-8 through 1-11.

The sequence table, as shown in Figure 3-18, specifies: Link, Seg, Loops and Adv. Description of the various elements within the sequence table is given below.

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

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

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

Adv – This field is a special code that is used in conjunction with the mixed advance mode. This bit flags the 1072 if the selected link is continuous or stepped. Information on the Mixed sequence advance mode is given later. "0" flags continuous, "1" flags stepped.

Assuming that you already downloaded waveforms, created and downloaded sequence table, you can proceed now with the following description how to set the 1072 to output sequenced waveforms.

Refer to Figure 3-19 and use the following description to learn how to output sequenced waveforms and how to program sequence parameters. To select Sequenced waveforms as the output waveform type press Waveforms, then Sequenced. The screen as shown in Figure 3-19 will display and the output will already generate arbitrary waveforms. Note the channel you are currently program and make sure the icon at the upper right corner agrees with your required programming sequence.
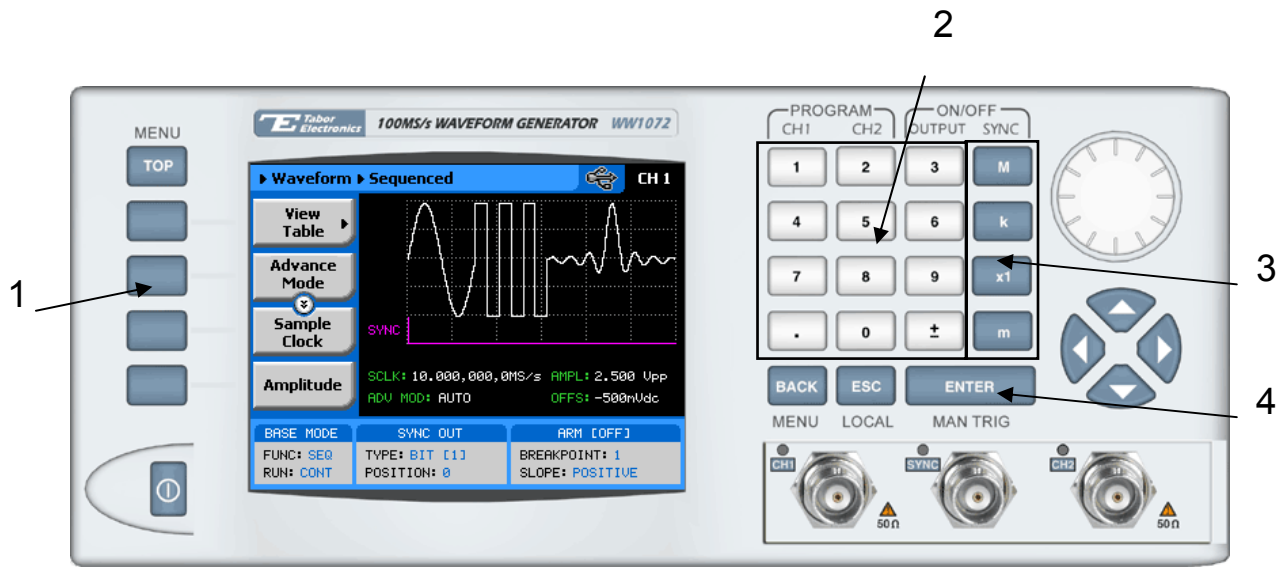
Figure 3-19, Sequence Parameters

Use the following procedure to modify the parameters that are associated with the Sequenced waveforms 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 seven parameters that are available for programming in this window:

View Table – Provides access to a sequence table. If no table was yet defined, you can define the sequence table from this menu. You can also edit an existing sequence table from this command. Information on editing the sequence table is given later.

Advance Mode – Defines the advance mode for the sequence. There are four advance mode options you can select from: Automatic, Stepped, Single and Mixed. Descriptions of the various advance modes is given later. Note that advance mode depend on run mode and therefore, if you selected continuous run mode for the 1072, you will not see the Single advance mode in the advance mode options list. Similarly, if you selected triggered run mode, Stepped and Mixed will be omitted from the list.

Advance Source – Defines which of the triggers inputs will advance the sequence. The advance source has no effect on Automatic advance source.

Sample Clock – Programs the sample clock frequency for the sequenced waveform. The final period of the complete sequence can be extracted from the following relationship:

Sequence Duration = 1 / (SCLK / n)

n = the number of waveform points in the sequence, including looped waveforms.

Amplitude – Defines the amplitude of the sequenced waveform.

Offset – Defines the offset of the sequenced waveform.

Active segment – Programs the active segment in a sequence. The SYNC will start at the active segment. There is no other purpose for this parameter in the sequence.

Tip

Use the arrow keys or the dial to scroll through the sequence parameters. The View Table will remain at the top while the others may be accessed selectively.

Editing the Sequence Table

If you select the View option as was described above, the sequence table will display as shown in Figure 3-20. If you already have a sequence table in place, you can edit the steps and modify the table per your new requirements. If you do not have a sequence table, you can construct the table from this screen however, you must make sure first that the segments you intend to use are loaded with waveforms.

Observe Figure 3-20 and note the commands that are available for editing and creating a sequence table.

Apply Changes – After you make modifications to the sequence table, you must use this command to update the internal registers with the new table settings and output updated immediately with the new settings. Changes, if made, in the table will be updated automatically when you exit the Edit Table screen however, the output will change to the new settings only after you re-enter the sequence function.

Edit Step – Provides entry point to the table. You may scroll between the fields using the arrow keys. If you want to edit a specific step, place the cursor on the step and press Enter. Edit the field as required and press Enter again to lock in the new value.

Insert Step – Allows adding another step to the sequence table. You have a choice of adding the step above or below the cursor line or at the end of the sequence table.

Go to Step – Provides entry point to the sequence table at a specific step number. Continue editing the step as described above.

Delete Step – Use this command to delete a specific step from the sequence. You'll be asked to confirm if you really want to delete the step before the final execution.

Delete Table – Use this command to delete the entire sequence table. You'll be asked to confirm if you really want to delete the step before the final execution.

Tip

Use the arrow keys or the dial to scroll through the edit parameters. The Apply Changes will remain at the top while the others may be accessed selectively.

Figure 3-20, Editing the Sequence Table

Selecting Sequence Advance Modes

As was explained above, the 1072 steps through an index of links; It may loop a few times on a designated link and eventually, after the last link, the process repeats itself. Stepping from link to link through the sequence table is done automatically by the instrument. However, there are applications requiring control when and how the link is stepped. The 1072 has a number of sequence advance options: Auto, Stepped, Single and Mixed. These advance modes are described in the following.

Automatic – specifies continuous advance where the generator steps continuously and automatically through the links to the end of the sequence table and then repeats the sequence from the start.

For example, if a sequence is made of three segments – 1, 2, and 3, and AUTO mode is used, the sequence will generate an infinite number of 1, 2, 3, 1, 2, 3, 1, 2, 3…waveforms. Of course, each link (segment) can be programmed with its associated loop (repeat) number. AUTO is the default sequence advance mode. Note, to use this mode, the 1072 must be in *continuous* operating mode.

Stepped – Using this advance mode, the sequence is advanced to the next link only when a valid trigger is received. The output of the 1072 generates the first segment continuously until a trigger signal advances the sequence to the next link. If repeats were selected for a segment, the loop counter is executed automatically. Note, although the trigger input controls advanced steps, to use this mode, the 1072 must be in *continuous* operating mode.

Single – Using this advance mode, the 1072 idles between steps until a valid trigger signal is sensed. The single advance mode requires that the 1072 be in trigger operating mode only. An attempt to select the Single advance mode when the instrument is in continuous operating mode can not be done. When triggered, the generator outputs one waveform cycle. Then, the output level idles at a DC level equal to the last point of the last generated waveform. If loops were programmed, the output will repeat this segment for n times automatically. Only after executing all of the programmed loops will the sequence step to the next assigned link. Note, to use this mode, the 1072 must be in *triggered* operating mode.

Mixed – This sequence advance mode allows combination of automatic and stepped links in one sequence table. To use this mode, in the sequence table, mark the Adv field "1" to flag stepped link or "0" for continuous link. Then, download the sequence table to the 1072. Note, to use this mode, the 1072 must be in *continuous* operating mode. Step with a "0" bit assigned to a step it will advance automatically to the next step. If "1" is assigned to a step, the instrument will generate this step and its associated number of repeats then, will wait for the next trigger to advance to the next step.

1. Refer to Figure 3-19 and select the Advance Mode with the appropriate soft key. The advance mode options, as shown in Figure 3-21 will display. Use the dial or arrow keys to scroll down to the required mode and press Enter to lock in the selected mode.
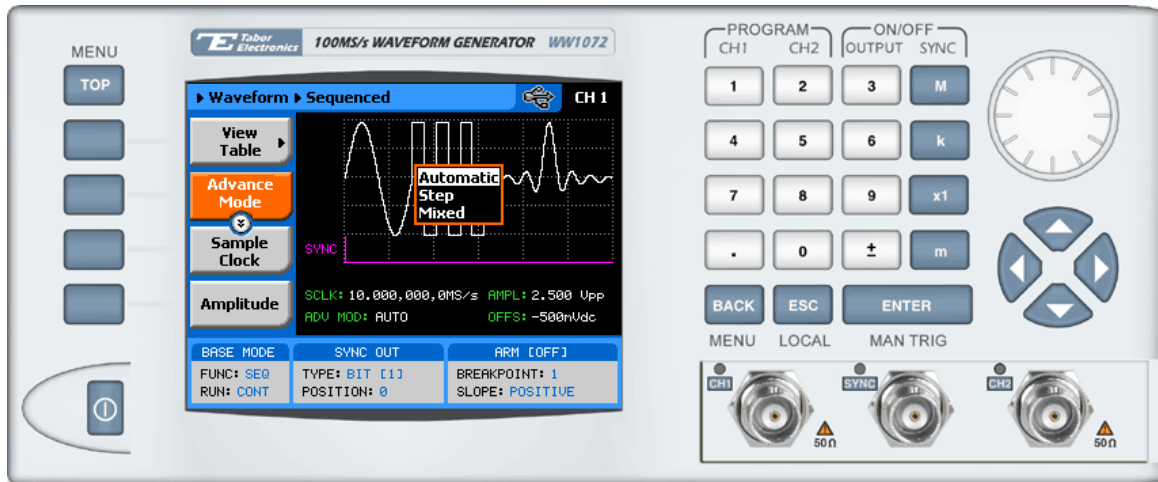
Figure 3-21, Sequence Advance Options

📝 *Note*

The operating mode of the instrument, as selected from the Run Modes menu, affects the way that the 1072 lets you access the sequence advance mode parameter. If you are in continuous mode, as shown in Figure 3-21, you can select one of: AUTO, STEP, or MIXED. If you already selected the triggered run mode, you'll be able to select from AUTO, or SINGLE only as advance modes.

Generating Modulated Waveforms

Utilizing DDS (direct digital synthesis) technology, the Model 1072 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 loosing linearity. For example, the 1072 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 1072 has the following modulation options: FM, FSK, Ramped FSK, Sweep and AM. These functions are described below.

Modulated waveforms are selected from the waveforms menu. Figure 3-22 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 3-22 and use the following procedure to select the

modulation type.

1. Press on the Modulation Type soft key. The following options will display: AM, FM, FSK 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.
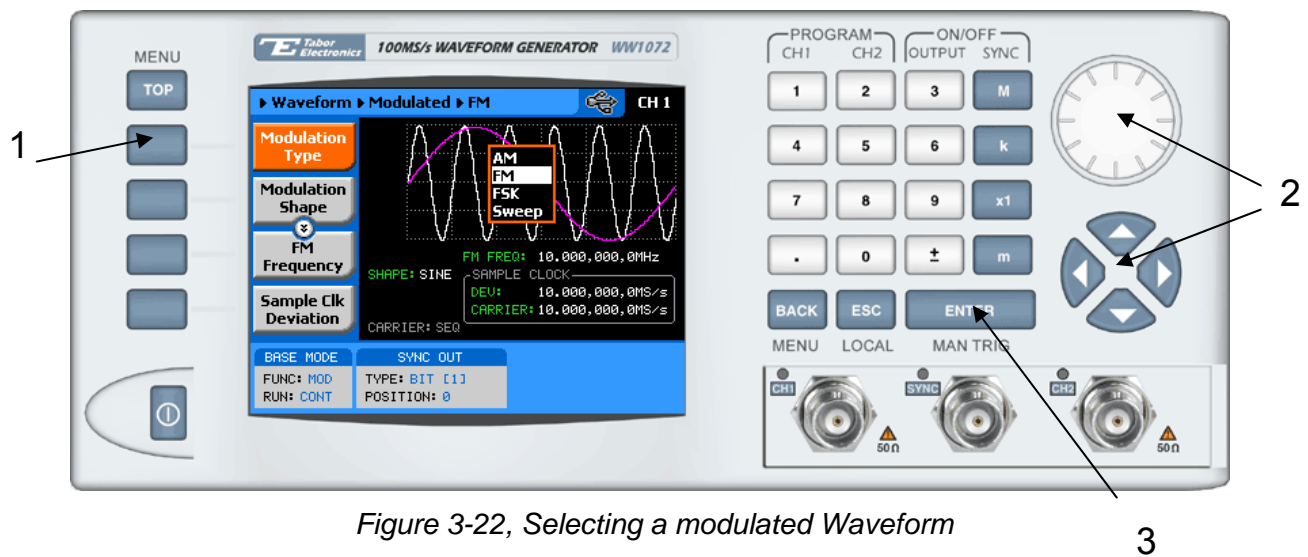
Figure 3-22, Selecting a modulated Waveform

FM Modulation

Frequency modulation is the most common modulation scheme used in telecommunications. In this mode, the sample clock frequency is modulated and placed at the rear-panel sine output. FM modulation is also available from the front panel outputs, except the frequency must be computed from the sample clock and the number of points that generate the output waveform. Confusing? Yes, a bit, but some examples below will remove your confusion.

When you select the FM modulation, the parameters, as shown in Figure 3-23 and described in the following paragraphs, will be available for modification:

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.
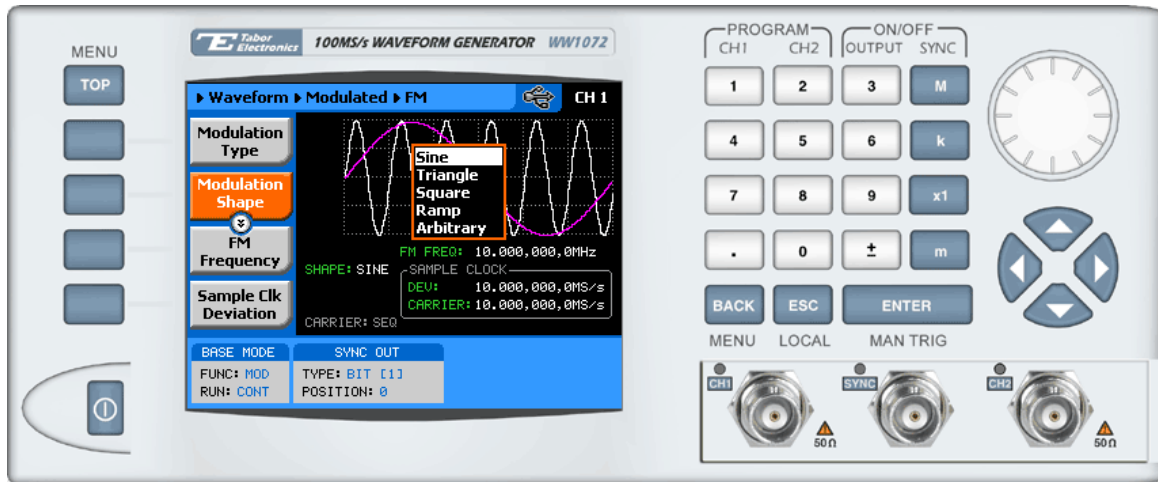
Figure 3-23, FM Modulation Parameters

1. Sine, Triangle, Square and Ramp are built in waveforms that modulate the carrier sample clock frequency with know and pre-defined parameters. Throughout the description in this manual, this modulation type will be referred to as "Standard FM Mode".

2. Arbitrary, is a special case of modulating waveform where the waveform is not actually resident in the instrument until downloaded from a remote interface to a special and dedicated modulating waveform memory. You may create and download the modulating waveform using external utilities such as Tabor Electronics, or any similar application that can generate mathematical coordinates. Throughout the description in this manual, this modulation type will be referred to as "Arbitrary FM Mode".

   The arbitrary waveform you will create and download to the 1072 resides in a separate and dedicated memory; It can be programmed to have variable length (10 to 20000 points) and has a separate and independent sample clock control (9 digits, 1mS/s to 2MS/s). The equivalent minimum and maximum modulating frequencies you can generate with the arbitrary FM are 50nHz to 200kHz. While the low frequency is very useful in applications like wander and slow drifting oscillators, the higher frequencies are as much needed for testing fast modems, PLL circuits and for wide-band digital modulation technology.

   FM Frequency – Defines the rate of the modulating frequency. If you use the standard FM mode, the maximum modulating frequency is 100kHz. Using the arbitrary FM mode, the maximum envelope frequency is increased to 200kHz.

   Sample Clk Deviation – This parameter specifies the range of which the sample clock frequency will deviate from the carrier frequency setting. The deviation range is symmetrical about the

carrier frequency. As was mentioned before, the 1072 has an extremely wide deviation range, without scarifying linearity. For example you can set 25MS/s carrier with 40MS/s deviation, that is, your carrier frequency will swing from 5 MS/s to 45MS/s.

Carrier Sample Clk – This is the frequency of the sample clock as programmed and displayed on the screen. In the case of 1072, the sample clock signal is equivalent to the carrier waveform frequency. This is the value that will be modulated and not the frequency of the waveform as generated at the front panel output connector. Direct output of the sample clock frequency is available at the rear panel SINE OUT connector.

Modulation Run mode – Defines the run mode for the modulated waveforms only. Note that run modes are not the same for modulated and non-modulated waveforms. The difference is as follows: When the 1072 generates Standard, Arbitrary or Sequenced waveforms and removed from continuous run mode, the output idles on a dc level until a valid trigger initiates an output cycle. On the other hand, when the 1072 generates a modulated waveform, modulation is generated continuously when the generator is placed in Continuous run mode however, when placed in trigger, burst or gate run modes, the output generates continuous carrier waveform until a valid trigger signal is received. If only one trigger is issued, the 1072 generates a single modulation cycle and resumes to output continuous carrier waveform only.

 Tip

Use the arrow keys or the dial to scroll through the FM parameters. The Modulation Type option will remain at the top while the others may be accessed selectively.

Three examples are given in the following paragraphs to show you how to generate various FM modes.

Example 1, Modulating Standard Waveforms Using the Standard FM Mode

This example will show how to generate frequency modulation using the standard waveforms and the Standard FM Mode. The output frequency will be set to 1MHz, Deviation Range to 100kHz and 100Hz sine as the modulating waveform. We'll monitor the frequency modulation from the front-panel outputs then, compare the results to the rear-panel sine output connector.

Before we start setting up the modulation parameters, we need to get some information from the instrument. Do the following:

Select the Sine waveform from the Standard Waveform library and then program the Frequency parameter to be 1MHz. Observe and note that the SCLK parameter is showing 64MS/s. Note that in the standard waveform mode, the SCLK parameter is set automatically by the instrument and cannot be modified directly. The information

that we need from this display is the number of points that the 1072 requires to generate 1MHz. We can find this out from SCLK/Frequency relationship = 64M/1M = 64 points. Note this number; It will be required later to compute the deviation range parameter. We are now ready to proceed with programming the FM parameters. Continue with the following procedure:

1. Press TOP soft key and press the following soft keys sequence: Waveforms >>Modulated>>Modulation Type FM. Note that the default modulating waveform is Sine. Leave this option as is for now. Later you can practice modifying the modulating waveform to other shapes.

2. Select the Freq parameter. This parameter sets the frequency of the modulating waveform. There is no need to compute and convert this parameter because the frequency is given in units of Hz. Use the cursor to point to the digit you want to change and rotate the dial to adjust the modulating frequency to 100Hz

3. Select the Sample Clk deviation parameter. This parameter sets the deviation range value. Remember that we computed the number of points that the 1072 is using for generating 1MHz? We need to use this number to program the deviation range. We want the front panel output to deviate by 100kHz, 50kHz above and 50kHz below the carrier frequency. Since the deviation range is controlling sample clock, the value that you have to put on the display is 100kHz x 64 = 6.4MS/s. Use the keypad and the dial to program the parameter. Press Enter and watch the value displayed at the bottom of the screen.

At this time, if you did not make any programming errors, the front panel outputs will generate frequency modulated waveforms having carrier frequency of 1MHz, deviation frequency of 100kHz and modulating frequency of 100Hz.

We'll now check the results at the rear-panel sine output connector and compare what we get there to what we see on the front panel. Remove the cable from the main output connector and connect to the rear-panel SINE OUT connector. Here is what you should expect to see when you check this output: Carrier waveform is around 1V (into 50Ω); carrier frequency is 64MHz, deviated 3.2MHz above and below the carrier frequency setting; modulating waveform frequency is 100Hz.

Example 2, Modulating Standard Waveforms Using the Arbitrary FM Mode

This example will show how to generate frequency modulation using the standard waveforms and the Arbitrary FM Mode. The output frequency will be set to 2MHz, Deviation Range to 100kHz and 100Hz sine as the modulating waveform. We'll monitor the frequency modulation from the front-panel outputs and then compare the results to the rear-panel sine output connector.

Before we start setting up the modulation parameters, we need to get some information from the instrument. Do the following:

Select the Sine waveform from the Standard Waveform library and then program the Frequency parameter to be 2MHz. Observe and note that the SCLK parameter is showing 64MS/s. Note that in the standard waveform mode, the SCLK parameter is set automatically by the instrument and cannot be modified directly. The information that we need from this display is the number of points that the 1072 requires to generate 2MHz. We can find this out from SCLK/Frequency relationship = 64M/2M = 32 points. Note this number; It will be required later to compute the deviation range parameter. We are now ready to proceed with programming the FM parameters. Continue with the following procedure:

1. Press TOP soft key and press the following soft keys sequence: Waveforms >>Modulated>>Modulation Type FM.

2. Press Modulation Shape and select the Arbitrary option.

3. Select the FM Sample Clock parameter and program it to 1MS/s. This sample clock frequency value will be needed for the following steps to calculate the frequency of the modulating waveform. This will be done from Tabor Electronics. Information how to use Tabor Electronics is given in Chapter 4.

4. Invoke Tabor Electronics and press the FM composer. The FM Composer screen is shown in Figure 3-24. Modify the Wavelength field to have 10,000 points and press the Wavelength button. The number of points is derived from the following relationship:

$$N = FM\ Sample\ Clock\ /\ 100Hz = 1M\ /\ 100 = 10,000$$

5. Now you have to program the deviation range. At the beginning of this example we computed and showed that the 1072 is using 32 points to generate this waveform. Note that the deviation range is given on sample per second and use the following relationship to compute the number for the deviation range:

$$Deviation\ Range = 100kHz\ x\ 32 = 3.2MS$$

After you complete updating the above field, the FM Composer will have the following coordinates:

The Y axis shows the frequency deviation range. The center line shows 64MS and the high and low limits are +65.6MS and -62.4MS, respectively. The X axis shows the length of the arbitrary modulating waveform. The length is in points. In our example, the first point is 0 and the last is 9999 (total of 10,000 points).

6. Now that you have the Y and X parameters set, you can generate the shape of the modulating waveform. Tabor Electronics has a library of standard waveform that include: Sine, Triangle, Square, Exponential, Pulse and Random Noise waveforms. You can use one of these waveforms, or import

coordinates from an external file to generate more complex waveforms. We'll use a simple sine waveform for this example. From the Waves menu select the Sine. Leave the parameters in the Sine dialog box as is and press OK.

7. The last step is to download the modulating waveform to the 1072. Press the download button to send the modulating waveform to the instrument.
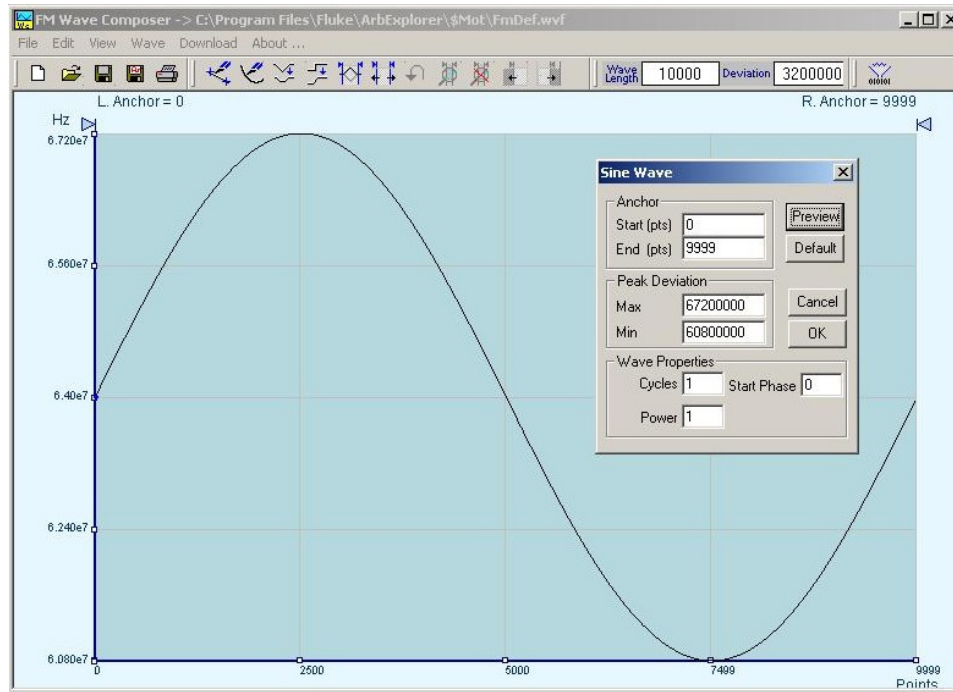
Figure 3-24, Using Tabor Electronics to Generate Arbitrary Modulating Waveforms

If you did not make any programming errors, the front panel outputs will generate frequency modulated waveforms having carrier frequency of 2MHz, deviation frequency of 100kHz and modulating frequency of 100Hz.

We'll now check the results at the rear-panel sine output connector and compare what we get there to what we see on the front panel. Remove the cable from the main output connector and connect to the rear-panel SINE OUT connector. Here is what you should expect to see when you check this output: Carrier waveform is around 1V (into 50Ω); carrier frequency is 64MHz, deviated 3.2MHz above and below the carrier frequency setting; modulating waveform frequency is 100Hz.

Example 3, Modulating Arbitrary waveforms Using the Arbitrary FM Mode

In Examples 1 and 2 above, we showed you how to frequency modulate standard waveforms. You can use these examples as guideline for modulating arbitrary waveforms. Generating arbitrary waveforms was discussed earlier in this chapter, so before you try modulating such waveforms, make sure that you first familiarize yourself with the arbitrary waveform generation techniques. In general, arbitrary waveforms are made of waveform data and sample clock. The rate of the sample clock determines the frequency of the output waveform. For example, if your sample clock is 1MS/s and your waveform segment is 1000 points long, the frequency of the waveform is 1M / 1000 = 1kHz.

The above example is somewhat oversimplified. What is important to remember is that regardless if you are generating standard or arbitrary waveforms, the FM function modulates the sample clock and the parameters that you program for FM affects the SINE OUT signal directly while the frequency characteristics for the front-panel outputs must be computed.

FSK

In Frequency Shift Keying (FSK), the output of the 1072 hops between two sample clock settings: Carrier Frequency and Shifted Frequency. Carrier frequency is the value of the sample clock frequency as programmed for the arbitrary waveform; Indirectly, it is the sample clock that is being automatically set when you select the frequency for the standard waveform.

FSK control is done from the rear-panel FSK IN. This input is level sensitive. When the FSK IN signal is low, the output generates carrier sample clock, changing the level to high, modifies the output to shifted sample clock.

FSK effects the sample clock frequency directly and indirectly, the frequency of the output waveform. If you are just using sine waveforms, then we recommend that you use the rear-panel SINE OUT waveform; Using this output, the sample clock and the shifted sample clock frequencies are used as nominal values. If you want to use the FSK function from the front panel, then you must compute the actual carrier and shifted frequencies in a similar way as was described above for the FM function.

When you select FSK modulation, the parameters, as shown in Figure 3-24 and described in the following paragraphs, will be available for modification:
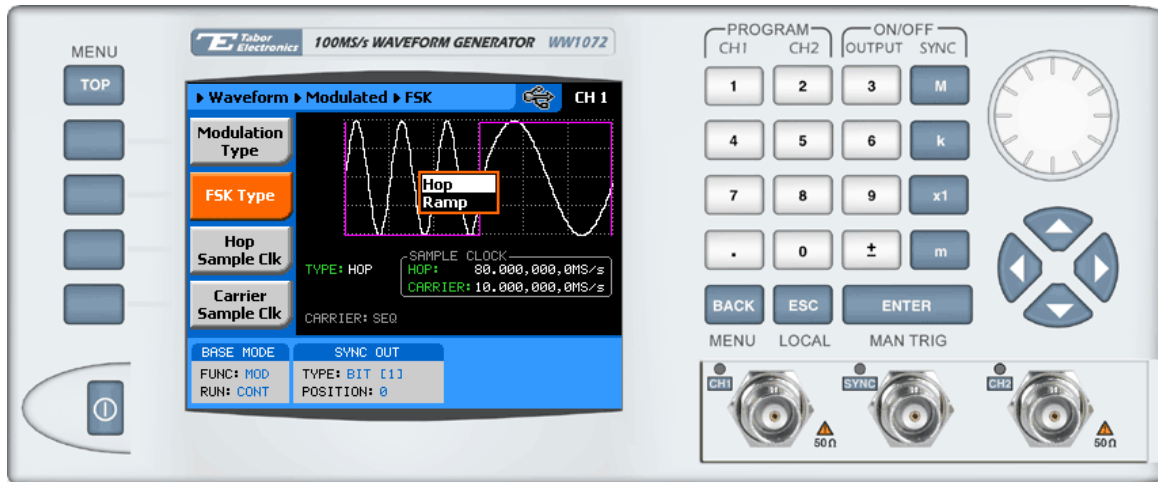
Figure 3-25, FSK Parameters

FSK Type – This provides selection between two transition types: Hop and Ramp. In Hop, frequency hops from carrier and back immediately as the waveform cycle is complete. Ramped is similar to Hop except, when the shift command is issued, the output ramps to the shifted frequency and back at a rate set by the ramp time generator. The ramp time is programmable from 10μs to 1 second.

Note

Shifted frequency value in Ramped FSK mode must always be higher than the carrier frequency. Reverse setting will not allow the 1072 to execute ramped FSK operation. Also, SCLK2 - SCLK1 ≥10KHz

---

The Hop FSK is the default function. To change to Ramped, press the FSK Type soft key and with the arrow down key select the Ramped option. Press Enter to lock in the modified parameter.

Hop Sample Clk – Defines the shifted frequency value. The 1072 will hop to the shifted frequency when commanded to do so. Note that the instrument changes the frequencies coherently, that is, after the shift command is accepted, the generator completes the waveform to its last point or phase and only then the next frequency is "kicking in". This way you can be sure that discontinuities in the output waveforms do not occur.

While using the FSK IN as hop control, the instrument will shift on positive-going transitions only. Note that the FSK input is level sensitive so, although the frequency shifts on transitions, the output remains at the shift frequency as long as the level remains true. The output will remain at carrier frequency as long as the FSK input remains TTL low (false) and at shifted frequency as long as the output remains TTL high (true).

Carrier Sample Clk – This is the frequency of the sample clock as displayed in the standard waveform screens. Note that SCLK value is shown in gray and will automatically change when you set up frequency of the standard waveform. There is no direct access to SCLK setting when you program standard waveform frequency. The SINE OUT connector at the rear panel generates sine waves only. This output is derived from the sample clock generator and therefore its output is directly proportional to the SCLK setting.

There are differences how you set up FSK operation for standard and arbitrary waveforms. These are explained and examples given in the following paragraphs.

Example 1, FSK Using Standard Waveforms

This example will show how to generate FSK modulation using the standard waveforms. The carrier frequency will be set to 1MHz and the shifted frequency to 1.5MHz. We'll monitor the FSK modulation from the front-panel outputs then, compare the results to the rear-panel sine output connector.

1. Select a standard waveform from the standard waveforms and press the Frequency button. Modify the frequency setting to display 1.000000MHz. Observe and note that the SCLK parameter is showing 64.00000MS/s. In standard waveform mode, the SCLK parameter is set automatically by the instrument and can not be modified directly. The information that we need from this display is the SCLK value and the number of points used for generating the current waveform. In this case, the number of points is computed from the relationship

$$N = SCLK/Freq = 64MS/1MHz = 64 \text{ points.}$$

2. Now it becomes a bit tricky. When generating standard waveforms, the Model 1072, depending on the output frequency, automatically sets the number of points and their associated sample clock. In FSK mode, only the sample clock hops between frequencies but, the number of points remain constant. This means that 64 waveform points will remain for the carrier and for the shifted waveforms. From this statement we can now compute the sample clock for the shifted frequency using the following equation:

$$F = 64 \text{ Pts x } 1.5MHz = 96MS/s.$$

1. Press TOP soft key and press the following soft keys sequence: Waveforms >>Modulated>>Modulation Type FSK. Make sure the FSK Type shown in this display is Hop and the Carrier frequency is 64MS/s.
2. Press Hop Sample Clk soft key and program the hop value to 96Ms/s. Press Enter to lock in the new value.
3. Apply your FSK control signal to the rear panel trigger input

If you did not make any programming errors, the front panel outputs

will generate FSK modulated waveforms having carrier frequency of 1MHz and shifted frequency of 1.5MHz.

We'll now check the results at the rear-panel sine output connector and compare what we get there to what we see on the front panel. Remove the cable from the main output connector and connect to the rear-panel SINE OUT connector. Here is what you should expect to see when you check this output: Carrier waveform is around 1V (into 50Ω); carrier frequency is 64MHz; Shifted frequency is 96MHz.

Example 2, FSK Using Arbitrary Waveforms

This example will show how to generate FSK modulation using arbitrary waveforms. The carrier frequency will be set to 10kHz and the shifted frequency to 25kHz. We'll monitor the FSK modulation from the front-panel outputs then, compare the results to the rear-panel sine output connector.

Before we start with our 1072 setting, we must know the length of the arbitrary segment that we'll use. To simplify matters, let's download a 1000-points, triangular waveform to the segment 1. You can use Tabor Electronics for this purpose. Information how to create and download waveforms to the arbitrary memory is given in Chapter 4.

From this point it is easy to compute the frequency and the sample clocks that we need for the above example. We want the carrier frequency to be 10kHz. Bearing in mind that the output frequency is equal to the sample clock frequency divided by the number of points, the sample clock must be programmed to be 10MS/s (10M / 1000 = 10kHz). Using the same method, the sample clock for the shift frequency is 25MS/s (25M / 1000 = 25kHz).

Now that we have both frequency values for the carrier and the shifted sample clock, we can go directly to front panel programming.

1. Press TOP soft key and press the following soft keys sequence: Waveforms >>Modulated>>Modulation Type FSK. Make sure the FSK Type shown in this display is Hop and the Carrier shows Arb. If the carrier waveform is showing Std. backup to the Top menu and select the Arbitrary waveform option.
2. Press Hop Sample Clk soft key and program the hop value to 25Ms/s. Press Enter to lock in the new value.
3. Press Carrier Sample Clk soft key and the value to 10MS/s. Press Enter to lock in the new value.
4. Apply your FSK control signal to the trigger input

If you did not make any programming errors, the front panel outputs will generate FSK modulated waveforms having carrier frequency of 10kHz and shifted frequency of 25kHz.

We'll now check the results at the rear-panel sine output connector and compare what we get there to what we see on the front panel.

Remove the cable from the main output connector and connect to the rear-panel SINE OUT connector. Here is what you should expect to see when you check this output: Carrier waveform is around 1V (into 50Ω); carrier frequency is 10MHz; Shifted frequency is 25MHz.

Sweep

In sweep modulation, the 1072 sweeps from start frequency set by the Sample Clk parameter to stop frequency set by Stop Sample Clk parameter.   Both the sweep start and the sweep stop frequencies control directly the sample clock generator at the rear-panel sine output and indirectly the front panel outputs. Sweep modulation is also available from the front panel outputs, except the frequency must be computed from the start sample clock and the number of points that generate the start output waveform.

When you select sweep modulation, the parameters, as shown in Figure 3-24 and described in the following paragraphs, will be available for modification:
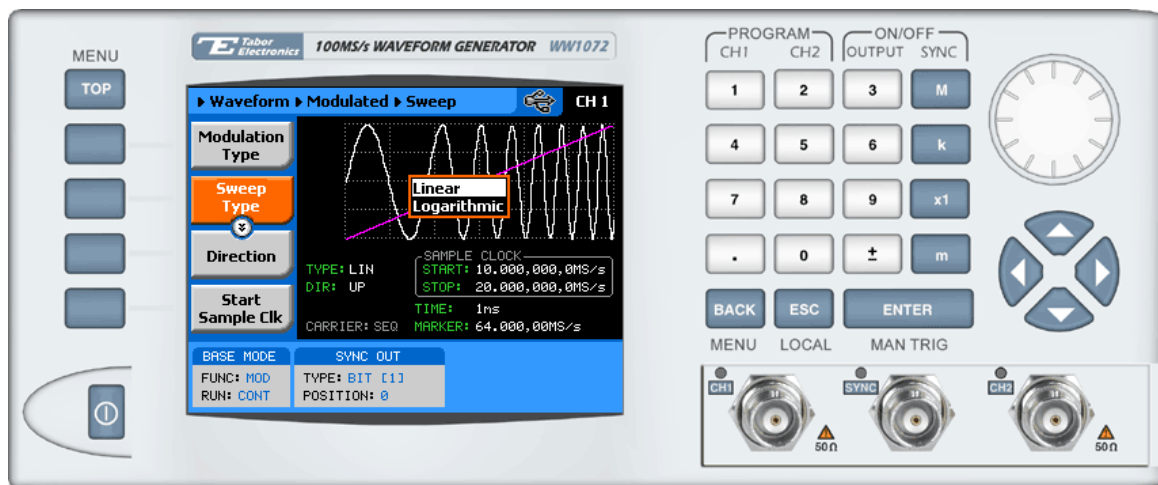
Figure 3-26, Sweep Parameters

Sweep Type – Defines the steps of which the sample clock increments, or decrements from start to stop frequencies. A choice is provided between linear and logarithmic steps. If you select linear sweep the frequency range is divided to 1000 linear increments and the sample clock steps through these frequency increments 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 divided by 1000 logarithmic steps.

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 Sample Clk – This is the frequency of the sample clock as displayed in the standard waveform screens. Note that SCLK value is shown in gray and will automatically change when you set up frequency of the standard waveform. There is no direct access to SCLK setting when you program standard waveform frequency. The SINE OUT connector at the rear panel generates sine waves only. This output is derived from the sample clock generator and therefore its output is directly proportional to the SCLK setting.

There are differences how you set up sweep operation for standard and arbitrary waveforms. These are explained and examples given in the following paragraphs.

Stop 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.

Tips

1.   In standard waveform mode, the SCLK parameter and the number of waveform points are set automatically by the instrument and can not be modified directly. During sweep modulation, only the sample clock is changing but the number of waveform points remain constant. Therefore, computing the number of waveform points used by the instrument is critical to correct sweep operation. For example, if you set your start frequency at 50MHz, the 1072 can use only two waveform points. While the instrument can generate a fairly nice sine waveform at 50MHz by using just two points (and special filters), the same two points will look like square waveforms if the sample clock is reduced below 10MS/s.

2.   As a reverse example, if you sweep modulate the output from a start frequency of 150kHz, the generator automatically sets the SCLK to 76.8MS/s and the number of waveform points to 512. If you try to sweep up from this point, then your maximum frequency will be 195,312kHz! (100MS/s / 512 Pts = 195,312kHz). Therefore and due to these limitations, it is recommended using the sweep modulation in conjunction with arbitrary waveforms because you are in complete control of the number of points and the sample clock frequency you are using to generate your waveform.

3.   It is also recommended to use the SINE OUT at the rear panel because the start and stop frequency settings are available at this output at nominal values, without the need to compute values for different waveform types.

Sweep Time – Defines the time interval that it takes for the 1072 output to execute one complete sweep. The sweep time is generated with an asynchronous free-running time interval generator that has programmable intervals from 1ms to 1000 seconds.

Marker – This defines a sample clock 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.

Modulation Run Mode – Defines the run mode for the swept waveform only. Note that run modes are not the same for modulated and non-modulated waveforms. The difference is as follows: When the 1072 generates Standard, Arbitrary or Sequenced waveforms and removed from continuous run mode, the output idles on a dc level until a valid trigger initiates an output cycle. On the other hand, when the 1072 generates a modulated waveform, modulation is generated continuously when the generator is placed in Continuous run mode however, when placed in trigger, burst or gate run modes, the output generates continuous carrier waveform until a valid trigger signal is received. If only one trigger is issued, the 1072 generates a single modulation cycle and resumes to output continuous carrier waveform only.

Tip

Use the arrow keys or the dial to scroll through the Sweep parameters. The Modulation Type option will remain at the top while the others may be accessed selectively.

Two examples are given in the following paragraphs to show you how to sweep using standard waveforms and how to sweep arbitrary waveforms.

Example 1, Generating Sweep Using Standard Waveforms

This example will show how to generate sweep modulation using the standard waveforms. The start frequency will be set to 100Hz and the stop frequency to 25kHz. We'll be using linear sweep in the down direction in 10ms. We'll monitor the sweep modulation from the front-panel outputs then, compare the results to the rear-panel sine output connector.

1. Select a standard waveform from the standard waveforms and

press the Frequency button. Modify the frequency setting to display 1.000000MHz. Observe and note that the SCLK parameter is showing 102.4000KS/s. In standard waveform mode, the SCLK parameter is set automatically by the instrument and can not be modified directly. The information that we need from this display is the SCLK value and the number of points used for generating the current waveform. In this case, the number of points is computed from the relationship

N = SCLK/Freq = 102.4kS/s / 100Hz = 1024 points.

2. Now it is time to check if the number of points will not conflict at the stop frequency. We can check this by dividing the maximum possible sample frequency by the number of points from the above calculations.

Fstop_max = 100MS/s / 1024Pts = 97.65625kHz

In this case we should be safe because we plan to sweep to 25kHz only.

3. Now we have to compute the sample clock frequency at the stop point. Knowing already the number of points we have in this waveform, the sample frequency at the stop point is computed using the following equation:

Fstop = 1024Pts x 25kHz = 25.6MS/s.

4. Press TOP soft key and press the following soft keys sequence: Waveforms >>Modulated>>Modulation Type Sweep.

5. Select and press the Sweep Time soft key and program the sweep time parameter to 10ns. Press Enter to lock in the new parameter value.

6. Select and press the Stop Sample Clk soft key and program the stop sample clock parameter to 25.6MS/s. Press Enter to lock in the new parameter value. Press Enter to lock in the new parameter value.

If you did not make any programming errors, the front panel outputs will generate linearly swept waveforms from 25kHz to 100Hz in 10ms.

We'll now check the results at the rear-panel sine output connector and compare what we get there to what we see on the front panel. Remove the cable from the main output connector and connect to the rear-panel SINE OUT connector. Here is what you should expect to see when you check this output: Carrier waveform is sine wave having fixed amplitude level of 1V into 50Ω; The waveform is swept from 25.6 MHz to 102.4kHz in 10ms; Sweep step is linear.

Example 2, Generating Sweep Using Arbitrary Waveforms

This example will show how to generate sweep modulation using the arbitrary waveforms. The start frequency will be set to 100Hz and the stop frequency to 25kHz. We'll be using linear sweep in the up direction in 10ms. We'll monitor the sweep modulation from the front-panel outputs then, compare the results to the rear-panel sine output connector.

Before we start with our 1072 setting, we must know the length of the arbitrary segment that we'll use. To simplify matters, let's download a 100 waveform points, triangular waveform to the segment 1. You can use Tabor Electronics for this purpose. Information how to create and download waveforms to the arbitrary memory is given in Chapter 4.

We want the start frequency to be 100Hz. Bearing in mind that the output frequency is equal to the sample clock frequency divided by the number of points, the start sample clock must be programmed to be 10kS/s (10k / 100 = 100Hz).

1. Press TOP soft key and press the following soft keys sequence: Waveforms >>Modulated>>Modulation Type Sweep. Make sure the Carrier shows Arb. If the carrier waveform is showing Std. backup to the Top menu and select the Arbitrary waveform option.
2. Press Start Sample Clk soft key and program the value to 10ks/s. Press Enter to lock in the new value.
3. Now it is time to check if the number of points will not conflict at the stop frequency. We can check this by dividing the maximum possible sample frequency by the number of points from the above calculations.

$$Fstop\_max = 100MS/s / 100Pts = 1MHz$$

In this case we should be safe because we plan to sweep to 25kHz only.

4. Now we have to compute the sample clock frequency at the stop point. Knowing already the number of points we have in this waveform, the sample clock frequency at the stop point is computed using the following equation:

$$Fstop = 100Pts \times 25KHz = 2.5MS/s.$$

5. Press Stop Sample Clk soft key and program the value to 2.5Ms/s. Press Enter to lock in the new value.
6. Select and press the Sweep Time soft key and program the sweep time parameter to 10ns. Press Enter to lock in the new parameter value.

If you did not make any programming errors, the front panel outputs will generate linearly swept waveforms from 100Hz to 25kHz in 10ms.

We'll now check the results at the rear-panel sine output connector

and compare what we get there to what we see on the front panel. Remove the cable from the main output connector and connect to the rear-panel SINE OUT connector. Here is what you should expect to see when you check this output: Carrier waveform is sine wave having fixed amplitude level of 1V into 50Ω; The waveform is swept from 10kHz to 2.5MHz in 10ms; Sweep step is linear.

AM

Amplitude modulation, unlike frequency modulation is not digital. Modulating waveform must be applied to a rear-panel connector to modulate the 1072 outputs. Amplitude modulation control is separate for each channel, so you can amplitude modulate one channel without affecting the other.

Before using the AM function, you should get yourself familiar with some of the terms:

Carrier – This term represents the modulated waveform before modulating signal has been applied. The carrier could be any type and shape that the 1072 can generate.

Carrier Frequency – This term defines the frequency of the carrier waveform. In arbitrary waveforms mode, the frequency of the output waveform is derived from the sample clock frequency and the number of points used to generate the active waveform segment.

Envelope Waveform – This is the signal that modulates the carrier waveform. In the 1072, the modulating signal is applied from an external source to the AM IN connector and must have specific amplitude to modulate the 1072 correctly

Envelope Frequency – This term defines the frequency of the modulating waveform. The envelope frequency is bandwidth limited, so make sure you are within the specified limits before you apply this signal to the AM input connector.

AM Depth or Modulation Index – This term defines how far the external generator can affect the main output signal. The depth is usually measured in units if percent.

The 1072 can be amplitude modulated from an external signal only. This means that besides the carrier frequency, all other parameters are supplied externally by the user. Therefore, make sure that the signal that you apply to the AM input complies with the specification requirements set forth in Appendix A.

When you select AM, the only parameter you can control is the AM State. Each channel has an independent state so make sure that you display the correct channel before you turn on and off the AM function. The AM screen is shown in Figure 3-27. To access this menu press Waveforms, and from the Modulated waveforms screen select the AM type. Modulation will start as soon as you apply your modulating signal to the rear panel AM IN connector. Note that AM

has no effect on the SINE OUT signal.
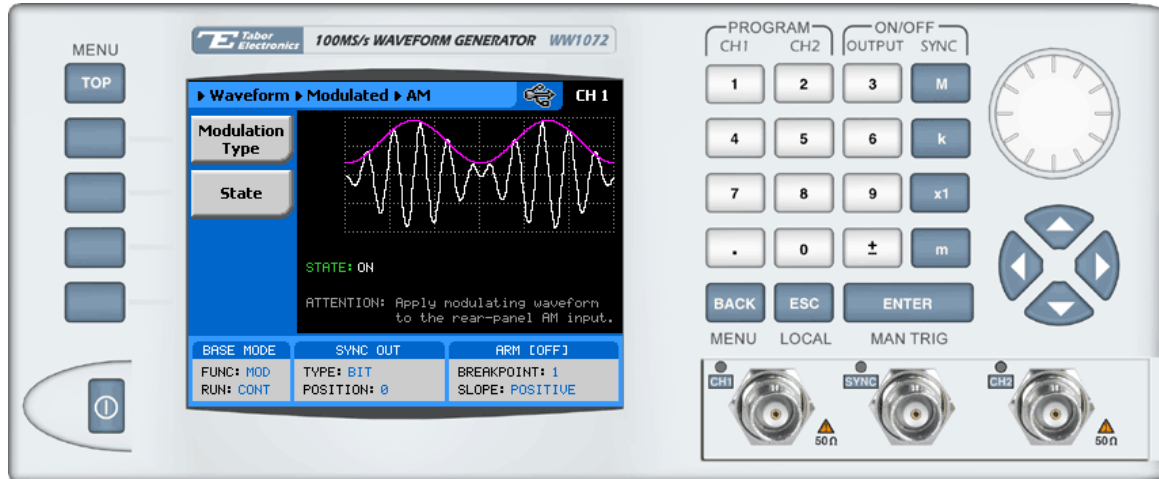
Figure 3-27, AM Parameters

Adjusting Phase Offset Between Channels

The 1072 has two output channels that can generate various and numerous waveforms. Although the control over waveform parameters is separate for each channel, the sample clock is derived from a single source. Having a single source for both channels is of great advantage because of two main reasons: 1) There is no jitter between the two channels and 2) If we ignore the initial skew, both waveforms start at exactly the same phase.

Understanding the initial skew term is very important. If you set both channels to output square waveforms and then connect these signals to an oscilloscope; If you then set the oscilloscope to its fastest time base setting, you'll see the two rising edges of the 1072 signals. They do not overlap because the instrument has a skew spec of ±2 ns. Skew is caused as a result of many factors. Although the two channels were designed exactly the same, small variations in printed circuit board layout or component values are enough to cause skew. These factors were known during the design phase and were minimized as practical. On the other hand, skew can also be generated from external factors that are controlled by the user alone. Examples for these factors are variation in cable length and quality, as well as, non-symmetrical end termination. Therefore, if you want to eliminate skew between channels, you have to use exactly the same cable type, the same cable length and the same termination on both channels.

There are times, however, that you do need to offset phase between channels. In that case, the 1072 lets you adjust phase-offset variations with resolution of one point. When you do, just keep in mind that the initial skew will escort your programmed

3-49

phase offset throughout the entire phase offset range.

Notice that phase offset resolution is given in points, not degrees. This is because the 1072 can generate arbitrary waveforms that you download from an external application. After you download waveforms, there is no way for the instrument to determine phase because all it has is just number of points and no further knowledge of the shape of your waveform. If you insist, you can convert points to degrees on your waveform from the following equation:

Phase (in °) = Phase point x 360 / number of waveform points

If you are using standard waveforms, you can determine the number of points that the 1072 is using from the standard waveform. Note the Freq and the SCLK values. The number of points is derived from the following relationship:

Number of Waveform Points = SCLK / Freq

Knowing the number of points, you can easily calculate the phase point from the above equation.

When you modify the phase offset parameter, you are offsetting the phase of channel 2 in reference to edge of channel 1. For example, if you program phase offset of 100 points and check the results on an oscilloscope, what you should expect to see is channel 2 start phase lagging channel 1 by 100 points.

Phase offset between channels is programmed in the Outputs menu, as shown in Figure 3-27. Place the cursor on the CH 2->CH 1 field and press Enter. Modify the value using the numeric keypad or the dial and then press Enter to lock in the new value.

Figure 3-28, Adjusting Phase Offset Between Channels

Synchronizing Multiple Instruments

The Tabor Electronics 1072 comes with two output channels. In applications requiring more output channels, as well as, complete control over inter-channel synchronization, you can not just use separate instruments because the output signals will not be synchronized. The 1072 has a special master/slave synchronization feature that allows connection of multiple instruments in a daisy chain. Not only that the channels are derived from the same master sample clock source but other signals are distributed from the master instrument, which tightly control start phase and jitter.

Connecting multiple instruments in master/slave configuration is extremely easy. All you need is two types of cables, the first being a standard BNC to BNC coax cable to feed the sample clock output and a 9-pin to 9-pin cable to feed the master-to-slave, or slave-to-slave controls. The master/slave cable is supplied with your instrument however, the BNC cable you can get from any store. Figure 3-29 shows the connection between master and slave instruments. Additional slave units can be daisy-chained in a similar way. What you have to remember is that SCLK OUT feeds an adjacent SCLK IN. Also, always have the last slave unit in the chain terminated with the special 9-pin terminator.
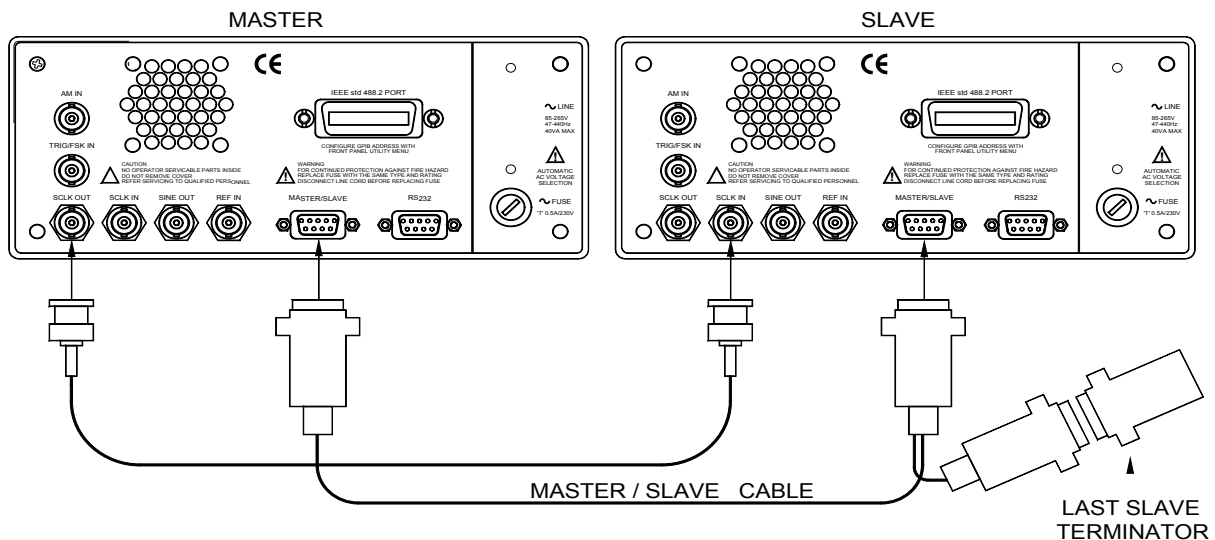
Figure 3-29, Wiring Diagram Master to Slave

Hard wiring the instruments from the back is not enough. You now have to set up the first instrument in the chain as master and the other instruments as slaves. Refer to Figure 3-30 and the following description to learn how to set 1072 instruments as master and slaves.

1. Connect your instruments as shown in Figure 3-29. Make sure you designate the first instrument in the chain as master. Also make sure the last slave is terminated with the 9-pin terminator.

2. Select the Utility menu and scroll down to the Multi-Inst. Sync option. Press Enter and the dialog box as shown in Figure 3-30 will appear.

3. By default, all instruments are designated – Master. On the slave units only, scroll down to the Synchronization Properties group and press Enter. Use the arrow keys to select the Slave option and press Enter to lock in the new state.

4. Finally, on the master unit only, scroll up to the Couple State between Instruments group and press Enter. Use the arrow keys to select the Active state and press Enter to lock in the new state.
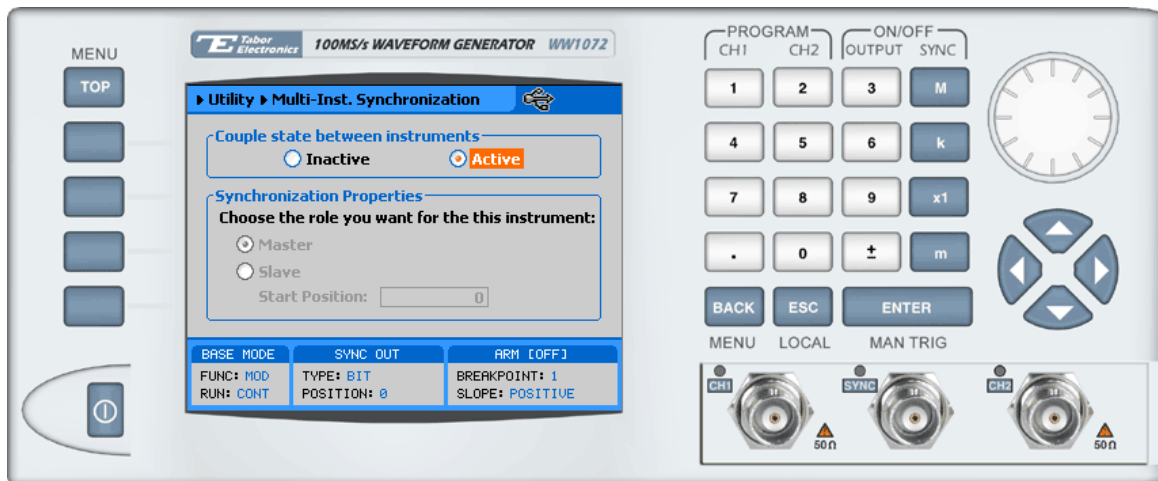
Figure 3-30, Setting up Master/Slave Parameters

If you executed the above procedure correctly, all slave units will automatically change their couple state to Active (ON) and from this moment onwards, all outputs will be synchronized. If you want to remove slave units from couple mode, all you have to do is change the Couple State on the master unit to Inactive (OFF).

After you have synchronized all of your instruments, you can further adjust the phase offset between the instruments. Select the Start Position field and program the parameter to the required phase offset. While modifying the edge offset, bear in mind that both channels are shifted simultaneously from the adjacent channel. Also note that the offset has 4 points resolution, so expect to have increments of sample clock period x 4.

Note

Due to cable connections and depending on the length of the cables you are using, it is possible that you'll notice some phase delays between the master and slave units. This is perfectly normal. If you are using 1-meter cables, you should expect about 2 ns delay between master and slave. Additional delays will accumulate as you add slave units. You can minimize the delay effect by using shorter cables, where practical however, it is impossible to eliminate this delay entirely. One way to compensate for inter-instrument delays is using different cable length at the output connectors. You can also use the edge-offset parameter to compensate for larger delays.

Chapter 4
ArbConnection

What's in This Chapter?

This Chapter contains information how to install, invoke and use ArbConnection. Introduction to ArbConnection and examples how to program instrument controls and parameters and how to generate waveforms and download them to the 1072 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 1072. ArbConnection has many functions and features of which all of them share a common purpose – controlling 1072 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 far you and creates a workgroup and icons to start ArbConnection.

Quitting ArbConnection

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

For the New and Advanced Users

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

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

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

Conventions Used in This Manual

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

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

[Esc] Press the Escape key.

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

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

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

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

The Opening Screen

Invoke ArbConnection by double clicking on the icon. If you cannot find the icon on your desktop, click on Start, Programs and ArbConnection. The opening screen will show. If you installed the program correctly, your screen should look as shown in Figure 4-1.
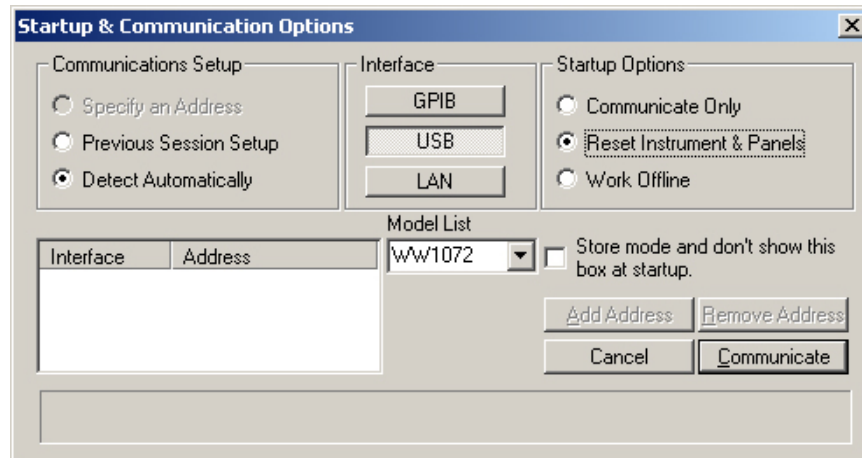
Figure 4-1, Startup & Communication Options

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.
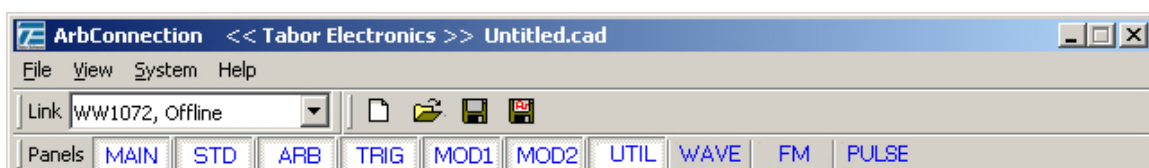
Figure 4-2, ArbConnection's Toolbars

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 1072 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 1072, Offline.

The **Panels** bar provides direct access to instrument control panels. The individual control panels are explained later in this chapter. The MAIN, STD, ARB, TRIG, MOD1 and the other buttons will bring up to the screen panels that are associated with these names. The WAVE and FM buttons will open the waveform and FM waveform 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 1072 functions and parameters. The 1072 can generate standard waveforms from a built-in library, arbitrary waveforms from user-downloaded coordinates, modulated waveforms, digital patterns and much more. The only way to access all of these features is through software utilities such as Plug & Play drivers, and soft front panels. ArbConnection is built to provide complete control over the 1072.

ArbConnection has four main screens: 1) Control panels, 2) Waveform composer 3) FM composer and 4) Pulse Composer. The various screens 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 1072 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 1072 parameters, just as you would use it on your instrument.

The Main Panel   The Main Panel, as shown in Figure 4-3, is the first panel you see
after invoking ArbConnection. Notice how buttons and LED's are
grouped; this is done specifically so that common parameters are
placed in functional groups. The Main Panel groups allow (from left
to right) adjustment of amplitude and offset, selection of waveform
mode, selection of run mode and control over SYNC and Main
output parameters. Controls, where applicable, are provided for
each channel separately.

Figure 4-3, 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 1072. It is different if you are
changing parameters on the display; Doing this, you'll have to press
the Execute button for the command to update the instrument. The
functional groups in the Main Panel are explained below.

Parameters   The Parameters group has two parameters for each channel:
Amplitude and Offset. To access the required parameter, click on
the LED or the text next to it to display the required parameter. The
value that is associated with the lit LED is displayed on the digital
display. You can use the dial, keyboard, or the [↑] [↓} keys to adjust
the readout to the required setting. After you modify the reading,
press Execute to update the 1072 with the new reading.

Note

**Normal color of the digital reading is dark blue. If you
modify the reading, the color changes to a lighter shade
of blue, indicating that the 1072 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.**

Waveforms The Waveforms group is used for selecting between waveform types. The 1072 provides three types of waveforms: Standard, Arbitrary and Sequenced. By pressing one of these buttons output waveform will change to the selected option. The default waveform 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 Output group controls SYNC type and state. It also sets the position of the sync and its width. The SYNC output is enabled when the State button is ON. The SYNC Type toggles between Bit and LCOM. The LCOM (loop Complete) qualifier is desirable in Sequenced wave mode where the sync will transition only once at the selected segment and will remain high throughout the duration of the sequence. The position parameter defines where on the waveform the sync will transition and the width define the width of the sync pulse. These two parameters are available for programming the Bit option. The LCOM will not change if you modify this parameter.

Output The Output group is used for controlling the state of the 1072 channel 1 and 2 outputs. Click on the State buttons to toggle the outputs on and off.

The Standard Waveforms Panel

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

Waveforms (Channel 1 and 2)

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 1072 output with this waveform shape.

Figure 4-4, The Standard Waveforms Panel

Frequency

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 1072 with the new reading.

🗒️ *Note*

Normal color of the digital reading is dark blue. If you modify the reading, the color changes to a lighter shade of blue, indicating that the 1072 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 Arbitrary & Sequence Panel

The Arbitrary & Sequence panel, as shown in Figure 4-5, is invoked by pressing the ARB button on the Panels bar. Note that if you invoke the Arbitrary & Sequence Panel from the Panels menu, the 1072 will not change its output type. On the other hand, if you select the arbitrary, or the sequenced options from the Main Panel, the 1072 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 two parameters for each channel: Amplitude and Offset. Actually, the values exhibited in this group are exactly the same as in the Main Panel, so every time you change amplitude and offset in the Parameters group, the other panels are updated automatically.

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 1072 with the new reading.

🗒️ *Note*

Normal color of the digital reading is dark blue. If you modify the reading, the color changes to a lighter shade of blue, indicating that the 1072 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.

Figure 4-5, The Arbitrary & Sequence Panel

Sample Clock The Sample Clock group is comprised of parameters that control the sample clock frequency. The sample clock setting affects the 1072 in arbitrary mode only. Note there is only one sample clock source inside the instrument however, in some case, where 2 different sample clock settings are required for each channel, the sample clock can be divided by an integer number before it is applied to the channel 2 circuits.

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

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 1072 with the new reading.

Sequence Advance The Sequence Advance group provides control over advance modes for the sequence generator. Advance options are: Auto, Stepped, Single and Mixed. Refer to the 1072 manual to find out more when and how to use these advance modes. You should be careful while selecting modes because it is possible to cause

settings conflict, for example, if you select the Single option before you modified the run mode to Triggered.

The Advance Source programs from where the sequence will receive its advance stimuli. If you select the Ext option, you must apply a trigger source to the trigger input. On the other hand, selecting Int will facilitate the internal trigger generator source.

Memory Management   The memory management group provides access to the memory partition and waveform studio screens. The Waveform Partition button opens a screen as shown in Figure 4-6 and the Waveform Studio button opens a screen as shown in Figure 4-7. Information how to use these screens is given in the following paragraphs.

Using the Memory Partition Table

If you want to learn more about waveform memory and segment control, you should refer to section 3 of this manual. In general, the 1072 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 1072 in a place designated as "waveform memory". The waveform memory has a finite size of 2M.

Having such long memory does not necessarily mean that you have to use the entire memory every time you download a waveform. On the contrary, the 1072 allows segmentation of the memory so that up to 4096 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.
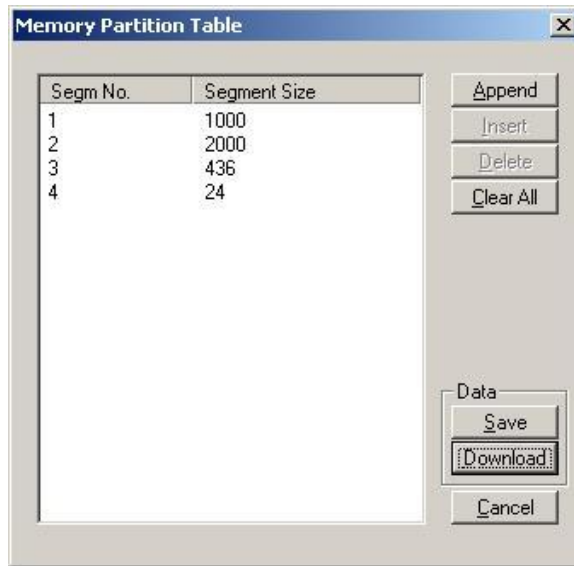
Figure 4-6, The Memory Partition Table

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 2048. The **Segment Size** is always associated with the segment number. You can program any segment size from 16 to 2M.

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 1072 with the present segment table settings.

TIP

The Memory Partition table does not download waveforms. Use the memory partition table only if you merged a few waveforms to one. The partition table then divides the memory to the individual and original size of

each waveform. If you download waveforms using the waveform studio, they already contain segment size and there is no need for further use of the memory partition table.

Using the Waveform Studio

The Waveform Studio, as shown in Figure 4-7 has two parts: 1) Segment Table and 2) Sequence Table. The purpose of the waveform studio is to provide access to waveform files that are already resident in the system. These files can be delegated to various segments and later be used as individual waveforms or combined into complex sequences.

The Segment Table

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

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

The Segment Table has four fields:

The **Seg** field contains numbers from 1 through 2048, designating the programmed memory segment. Note that memory segments are numbered from 1 to 2048.

The **State** field shows the current status of the memory segment. It can be *Free*, if no file has yet been assigned to this segment number, or *Mapped*, if file name has been assigned to the segment but the Download button has not been used yet to move the file to the 1072 memory, or *Loaded*, if the process has been completed by pressing either the Download button or the All (download all) button.

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

The **Length** field displays the length of the selected memory segment. Memory segments size may be programmed from 16 to 2M. Note that the length field is not accessible and shown for reference purpose only.
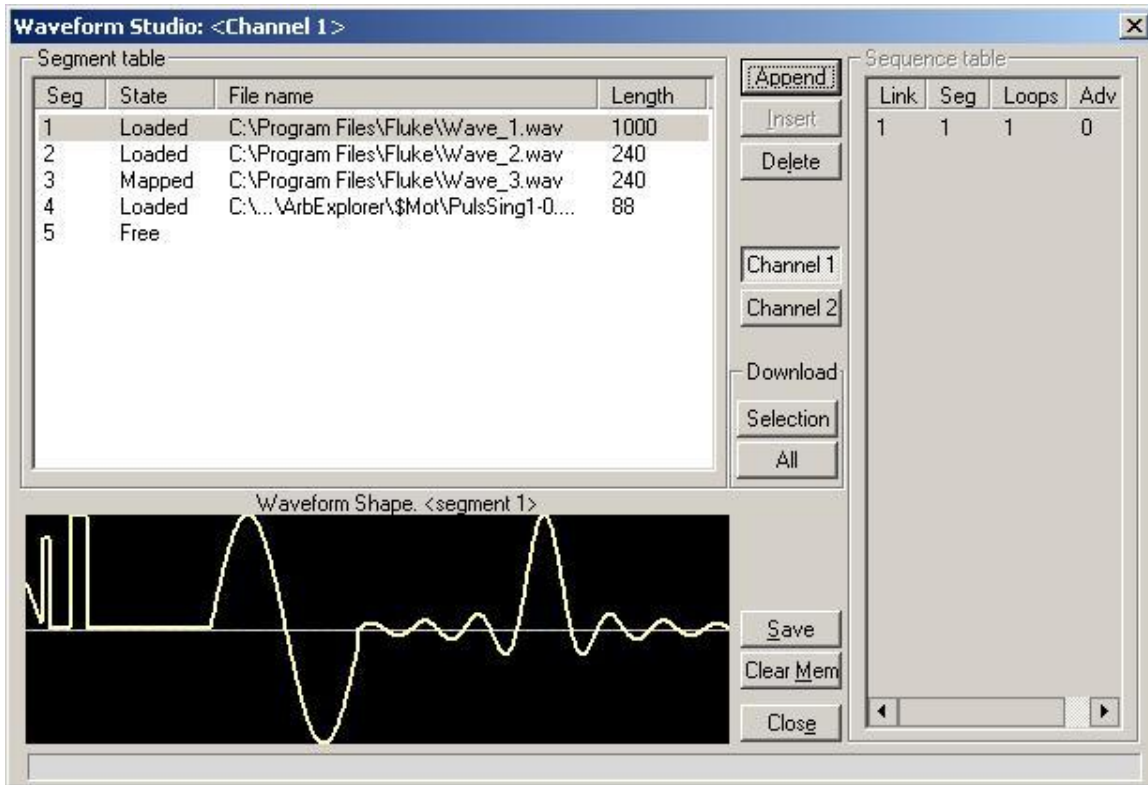
Figure 4-7, The Waveform Studio

💡 *TIP*

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

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

Append – adds segment number at the end of the table

Insert – adds a segment above a highlighted segment line

Delete – removes a highlighted segment

Channel 1 – shows segment table for channel 1 only

Channel 2 – shows segment table for channel 2 only

Save – saves current table settings

(Download) Selection – downloads a highlighted segment only to the 1072 memory

(Download) All – downloads the complete table to the 1072

memory

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

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

The Sequence Table   As was explained in the above, the waveform memory can be divided into smaller segments and up to 2048 segments can be defined and used as individual arbitrary waveforms. Having a limited size of waveform memory can, for some applications, pose a limitation however, if sections of the waveform are repetitive, one may use the sequence generator to take these segments and replay them as part of the complete waveform without loosing valuable memory space and without scarifying waveform coherences, or integrity. The tool for using repetitive and multiple segments in one long waveform is called Sequence Generator. The 1072 has two separate sequence generators, one for each channel and ArbConnection has a special dialog box where sequences are designed. This tool is called – Sequence Table.

Using the Sequence table you can use waveforms that you already downloaded to the 1072 from the Segment table, link and loop in random order to create one long and complex waveform that combines the individual memory segments.
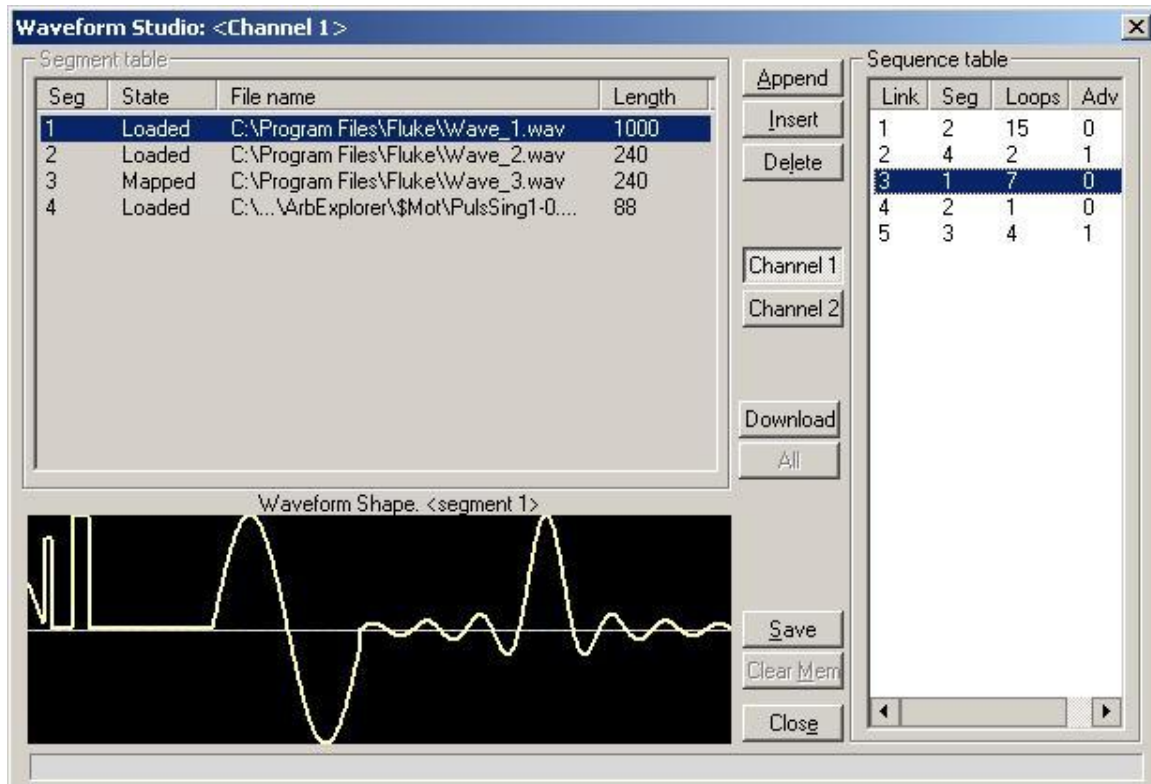
Figure 4-8, The Sequence Table

The Sequence Table is demonstrated in Figure 4-8. To access the Sequence table, click anywhere on the Sequence Table area. If it was not yet, it will turn white as opposed to the Segment Table area that turns gray.

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

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

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

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

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

Figure 4-8 shows an example of a 5-step sequence of which the first waveform is made of segment 2, which will loop 15 times; segment 4, looping 2 times; segment 1, looping 7 times; segment 2, once and segment 3, looping 4 times. The Adv bits on links 2 and 5 are set to 1 and therefore, external triggers are required for the sequencer to step through these links.

HINT

The 1072 has two separate sequence generators, one for each channel. If the 1072 is programmed to continuous run mode, make sure both channels have the same sequence length for inter-channel synchronization. For triggered run mode, each channel can be programmed for a unique sequence length.

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

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

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

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

The Trigger Panel

The Trigger panel, as shown in Figure 4-9, is invoked by pressing the TRIG button on the Panels bar. Note that if you invoke the Trigger Panel from the Panels menu, the 1072 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 1072 only if an appropriate run mode setting has been selected. The functional groups in the Trigger Panel are described below.

Figure 4-9, The Trigger Panel

Trigger Parameters
The Trigger Parameters group provides access to trigger phase start and burst count. To change trigger start phase or burst count, 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 1072 with the new reading.

Note

Normal color of the digital reading is dark blue. If you modify the reading, the color changes to a lighter shade of blue, indicating that the 1072 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.

Slope The Slope group lets you select edge sensitivity for the trigger input of the 1072. 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 1072 can accept triggers from a number of sources: External, Internal or software command. You must have a valid trigger signal applied to the rear-panel trigger input to use the external trigger source option. If you do not have an external source, you can always use the internal trigger generator, or press a front panel manual trigger to stimulate an output. Click on one of the trigger source option buttons to select the required trigger source. You can also program the internal trigger period after you point and click on Timer.

Arm The Arm group is almost an "orphan" on the Trigger Panel. This is the only function that actually will work in continuous mode only however, since the arm commands cause interruption of the 396 output and arm control is done with the trigger input, it was placed in the trigger section of ArbConnection. While modifying Arm commands, bear in mind that the instrument must be in continuous mode only. The arm function requires definition of breakpoints. Additional information on the arm function is given in Chapter 3. To turn ARM on and off, click on the **State** button. Select the Position LED to program **breakpoint** position. The **Positive** on **Negative** slope options will determine edge sensitivity for the trigger input.

**The Modulation
Panel 1**

The Modulation functions were designed over two separate panels, as shown in Figures 4-10 and 4-11. The panels are invoked by pressing the MOD1 or MOD2 buttons on the panels menu. These panels provide access to all modulation functions and their respective run modes and parameters. The modulation functions that are available on both panels are: FM (frequency modulation), AM (amplitude modulation), FSK (frequency shift keying) and Sweep. Using ArbConnection, modulation is programmed simultaneously for both channels except for AM where each channel can be programmed separately. When modulation run is other than continuous, the instrument generates non-modulated carrier frequency until a valid stimuli signal is applied.

Each of the modulation panels has a different set of functions and parameters. These groups are described below.

Figure 4-10, The Modulation Panel 1

FM

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

Wave   Determines 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 and 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

Parameters to the required modulating waveform shape to select it.

Allow adjustment of the parameters that are associated with the modulating waveform. Notice that the parameters are changing between standard and arbitrary waveforms.

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 1072 with the new reading.

Note

Normal color of the digital reading is dark blue. If you modify the reading, the color changes to a lighter shade of blue, indicating that the 1072 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.

Run Mode The Run Mode group provides access to the various trigger options of the modulation functions. Note that the run modes that are shown on this panel behave differently than the Main Panel run modes. For example, if you place the instrument in triggered FM, the instrument will idle on the carrier frequency and execute one FM cycle when triggered. Refer to the appropriate section in this manual to learn more about triggered FM.

Trig Slope The Trig Slope group let you select edge sensitivity for the trigger input of the 1072. 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.

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

group are described below.

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

Parameters Allow adjustment of Ramp Time, carrier sample clock frequency (SCLK) and shifted sample clock frequency (SCLK2) parameters. To access the required parameter, click on the button below parameters sub-group until the LED next to the required parameter turns on. The value that is associated with the lit LED is displayed on the digital display. You can use the dial, keyboard, or the [↑] [↓} keys to adjust the readout to the required setting. After you modify the reading, press Execute to update the 1072 with the new reading.

> *Note*
>
> **Normal color of the digital reading is dark blue. If you modify the reading, the color changes to a lighter shade of blue, indicating that the 1072 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 Modulation Panel 2

The Modulation Panel 2, as shown in Figure 4-11, controls Sweep and AM modulation. Description of the controls in this panel is given below. The panel is invoked by pressing the MOD2 button on the panels bar.

AM

The AM function requires an external modulating signal. The AM input is common to both channels however, modulation for each channel can be turned on and off separately. There are two buttons in this group, press Channel 1 or Channel 2 to turn on the modulation function for the required channel. Watch the limitations

of the modulating signal as specified in Appendix A.

Figure 4-11, The Modulation Panel 2

Sweep

The Sweep group contains parameters for controlling sweep options. To turn the Sweep function on and off, click on the *State* button in this 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 1072 with the new setting.

> ⬛ *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 LW120 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.

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.

Run Mode   The Run Mode keys define how the generator sweeps. You have a choice of continuous, triggered and gated sweep. Unlike the main trigger function, the run modes for the sweep function operate in continuous mode. For example, if you place the instrument in triggered sweep, the instrument will idle on the sweep start frequency and execute one sweep cycle when triggered. Refer to the appropriate section in this manual to learn more about triggered sweep.

Trig Slope   The Slope buttons let you select edge sensitivity for the trigger input of the 1072. 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.

The Utility Panel

The Utility panel, as shown in Figure 4-12, is invoked by pressing the UTIL button. The Utility panel provides access to general instrument references that are not directly related to waveform generation.

Also available in this panel are some system commands such as *Reset* Instrument and *CLS* (Clear Error Queue). 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.

There are five groups in the Utility panel: Multi Instrument Control, for synchronizing multiple instruments to one master instrument; Inter Channel Offset, for controlling phase offset between channels; Filter, for controlling the filter state at the output connectors; Reference Source, for controlling the reference source for the internal clocks that are used for generating the waveforms; and System, that has some initialization buttons that reset internal buffers. Description of the various controls on the Utility panel is given below.

Figure 4-12, The Utility Panel

Multi Instrument Control The Multi Instrument Control group has three buttons: Set Configuration, Activate and Deactivate. The Activate and Deactivate toggle the synchronization function on and off and are done from the master instrument only. The configuration of the master and slave units is done from the Set Configuration dialog box that is invoked after you press the Set Configuration button. To configure master/slave operation, press the Set Configuration button. The dialog box, as shown in Figure 4-13 will display.
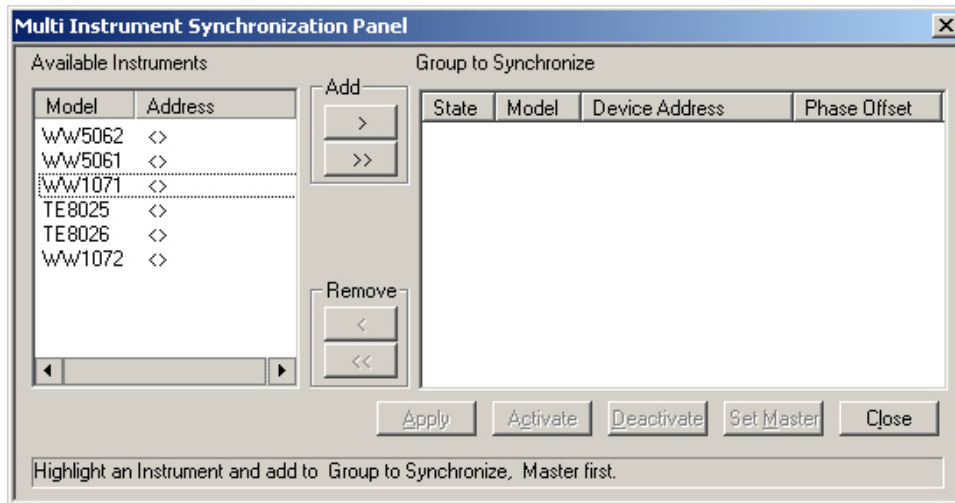
Figure 4-13, The Multi Instruments Synchronization Dialog Box

All instruments that were detected on the interface bus when ArbConnection was launched will be displayed in the Available Instruments list. Before you synchronize instruments, you must connect the synchronization cable between the master and the slave units. The hardware connection is shown in Chapter 3. The list of Group to Synchronize instruments must be arranged in the same order as you connected the synchronizing cables. Make sure that the last slave has the special termination connector attached to the cable.

When you finally have your list arranged in the right order, you can apply the setting to all instruments by pressing the Apply button. You can also activate and deactivate the synchronization from this dialog box by pressing the Activate and Deactivate buttons. These buttons are duplicates of the Utility buttons so you do not have to go back and forth between panels. Phase offset between instruments is programmed in the Phase Ofst field, for each instrument in the chain.

X-Ch The X-Ch group provides access to inter-channel offset adjustment. Offset is programmed in units of waveform points and therefore it is best utilized in arbitrary mode, where the number of waveform points is known. When offset is set to 0, the two channels will start at the same time and with the first transition exactly in the same phase. The start phase of channel 2 can be programmed to have a different start position so phase between the channels will be proportional to the programmed start position of the second channel. TO change the phase offset, point and click on the Offset LED, the value that is associated with Offset 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 1072 with the new setting.

Filter The Filter group lets you place filters at the output path. There are two sets of filters, one for each channel. Click on 25MHz, 50MHz or All to select both. Click on Off to disable all filters. Note that the 1072 is using the filters for generating the standard sine waveform and therefore, if you pres the filter buttons when the 1072 is generating sinewave, ArbConnection will prompt with an error message.

Clock Source The Clock Source group allows selection of the reference for the internal clocks. The reference source is important in applications requiring synchronization to larger system clocks. The 10MHz is sourcing the entire instrument. From this clock, the instrument is generating the frequency for the standard waveforms and the sample clock for the arbitrary waveforms.

The *10MHz* sub-group provides selection between internal or external reference options. Internal is the normal setting for the 1072. The internal reference has accuracy and stability of 1ppm. An external reference input is provided for applications requiring better accuracy and stability. Click on the Internal button to select the Internal reference, or the External button to activate the external reference input.

⚠️ *WARNING*

By selecting an external reference you are disabling the internal reference circuit. If you do not have a 10MHz reference connected to the instrument, the 1072 will generate erroneous frequencies.

The *SCLK* sub-group provides selection of internal or external reference for this clock. The internal option is the default and is recommended for most applications. If you select the external source for the SCLK signal, you must connect a valid signal to the rear panel SCLK input. Refer to Appendix A for information on valid SCLK clock parameters.

System Commands in this sub-group will let you *Reset* the entire instrument to factory defaults and clear the error queue *(CLS)*, if you made programming errors and want to remove the error list from the queue.

The Command Editor

The Command Editor is an excellent tool for learning low level programming of the 1072. Invoke the Command Editor from the System menu at the top of the screen. Dialog box, as shown in Figure 4-14 will pop up. If you press the Download button, the function call in the Command field will be sent to the instrument.
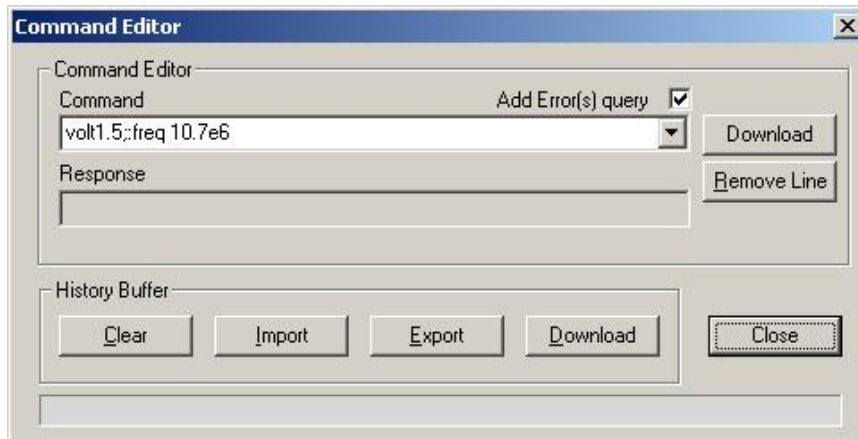
Figure 4-14, The Command Editor

Low-level SCPI commands and queries can be directly sent to the 1072 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 1072 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 1072 using the Waveform Composer.

To launch the wave composer point and click on the WAVE button in the Panels bar. Figure 4-15 shows an example of the wave composer. The Wave Composer has main sections: Commands bar, Toolbar and Waveform screen. Refer to Figure 4-15 throughout the description of these sections.

The Commands bar

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

System.

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

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

New Waveform
The New Waveform (Ctrl+N) command will remove the waveform from the screen. If you made changes to the waveform area and use the New Waveform command, you should save your work before clearing the screen. The New Waveform command is destructive to the displayed waveform.
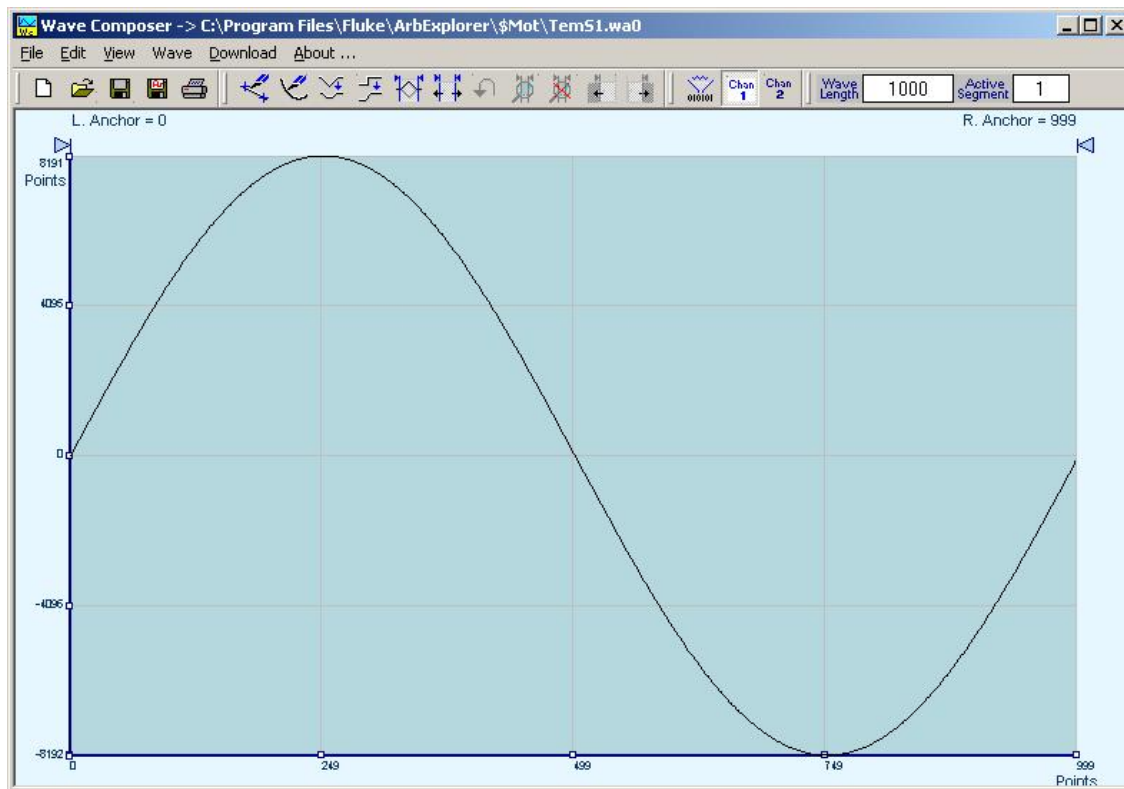
Figure 4-15, The Wave Composer Opening Screen

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 4-16 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.
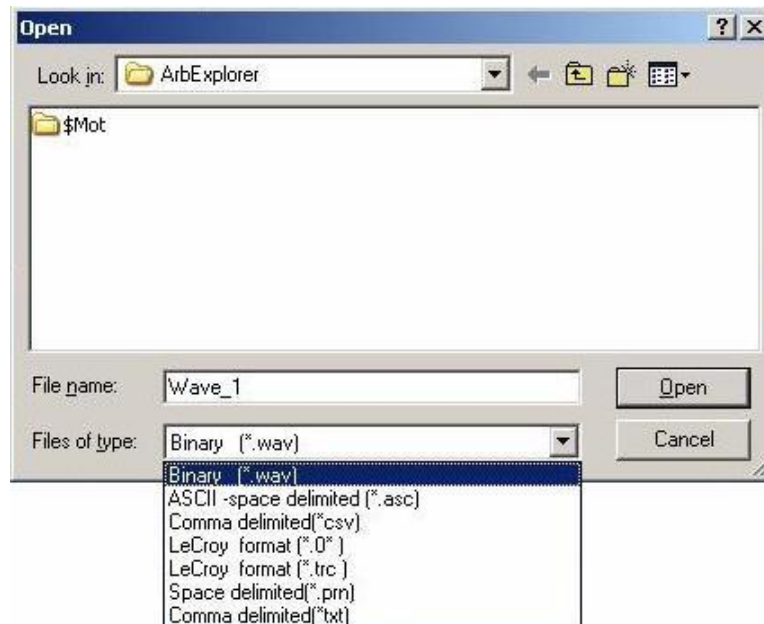
Figure 4-16, The Open Waveform Dialog Box

Save Waveform

The Save Waveform (Ctrl+S) command will store your active waveform in your 1072 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 ½ 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 4-17, 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.
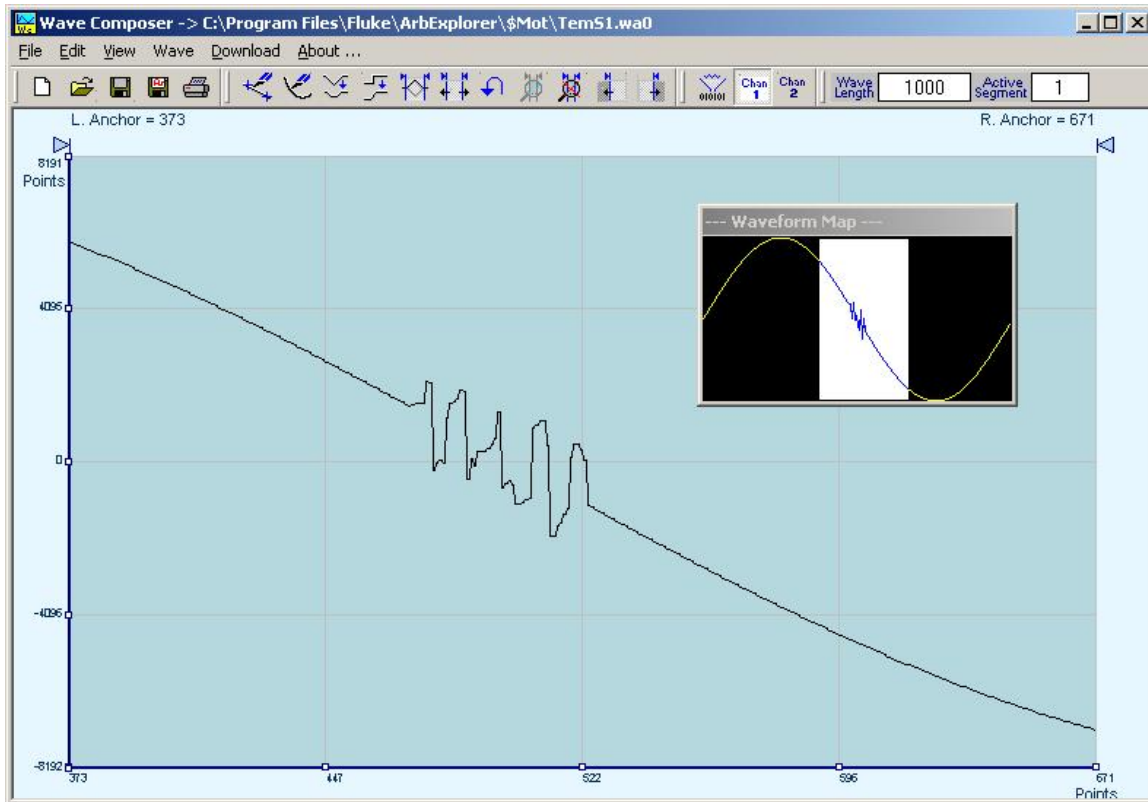
Figure 4-17, Zooming In on Waveform Segments

Channel 1

The Channel 1 Waveform command updates the waveform screen with the Channel 1 waveform. If you have not yet generated a waveform for channel 1, the waveform screen will show a dc level at vertical point 0.

Channel 2

The Channel 2 command updates the waveform screen with the Channel 2 waveform. If you have not yet generated a waveform for channel 2, the waveform screen will show a dc level at vertical point 0.

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 4-18. 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 4-18 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 – 14-bit of vertical define 16,384 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.
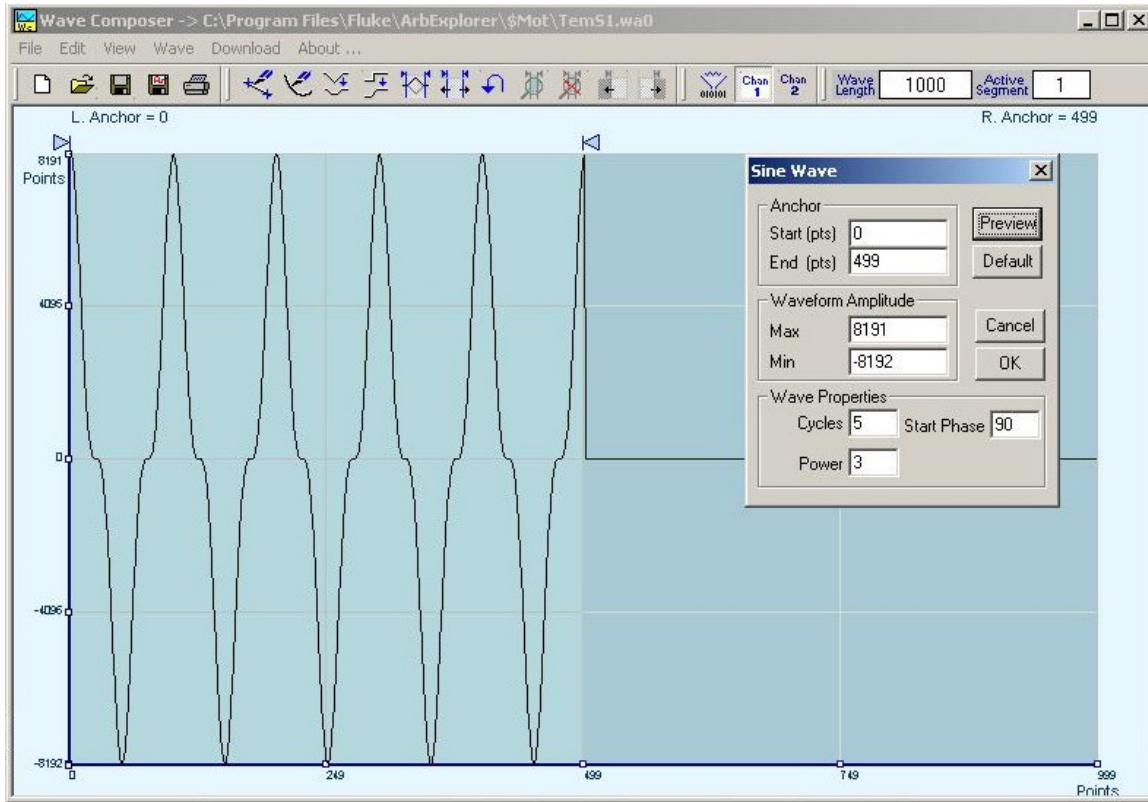
Figure 4-18, Generating Distorted Sine waves from the built-in Library

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 4-19. For the individual icons, refer to the descriptions above of the Wave Composer Menus.

Figure 4-19, The Toolbar Icons

The Waveform Screen

Waveforms are created and edited on the waveform screen. Figure 4-20 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 –8191 through 8192 for a total of 16,384 point. This number represents 14 bits of vertical resolution and cannot be changed because it is critical to the range of which

the 1072 operates.

The horizontal axis, by default has 1000 points (from point 0 to 999). This number can be changed using the Wave Length field in the Toolbar. The maximum length depends on the option installed in your instrument. The wave composer will let you define the horizontal axis to a maximum of 2M words).
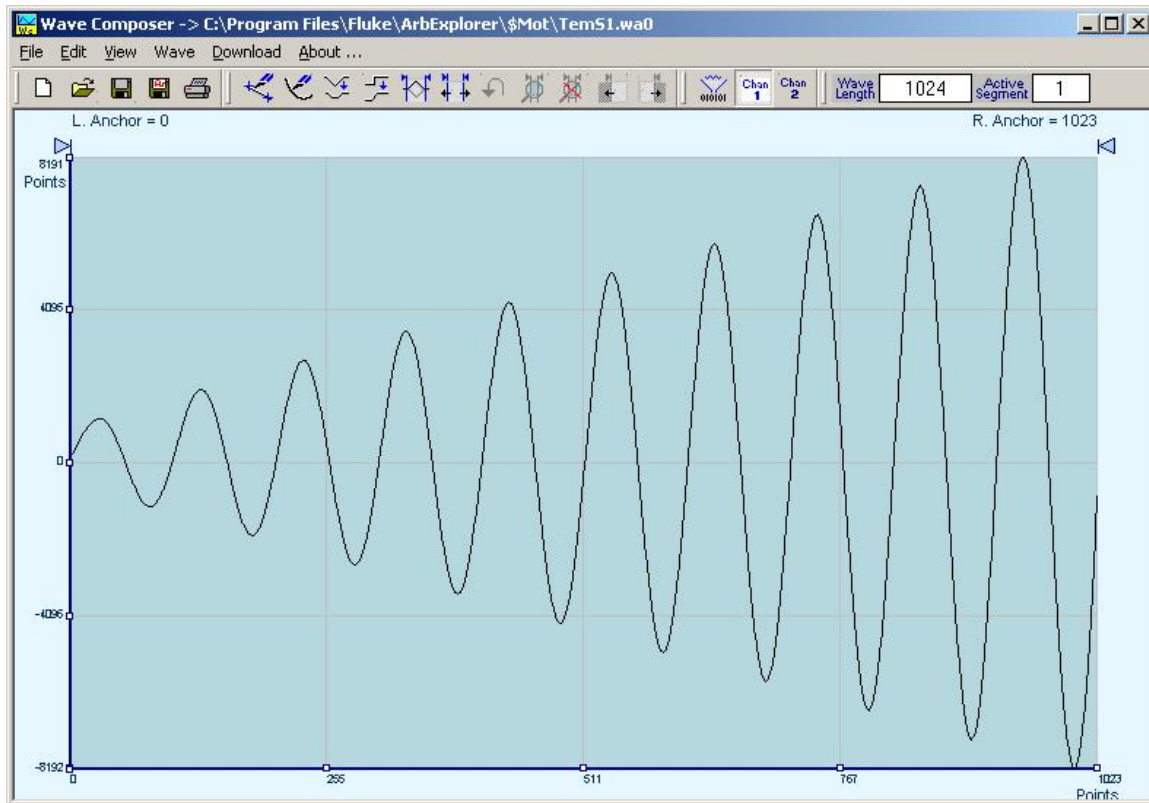
Figure 4-20, The Waveform Screen

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 4-18.

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.

The FM Composer

The FM Composer looks and feels almost like the waveform composer except there is a major difference in what it does. If you look at the opening screen as shown in Figure 4-21, you'll see that the vertical axis is marked with frequencies. You'll see later that as you draw waveforms on the FM composer screen, these waveforms represent frequency changes and not amplitude changes as are generated by the waveform composer.

The FM composer is a great tool for controlling frequency agility by generating the agility curve as an arbitrary waveform. For example, if you create a sine waveform, the 1072 will generate frequency-modulated signal that will follow the sine pattern. The resolution and accuracy of the modulated waveform is unsurpassed and can only be duplicated by mathematical simulation. The FM composer is loaded with many features and options so use the following paragraphs to learn how to create and download modulating waveforms to the 1072 using the FM Composer.

Invoke the FM Composer from Panels bar. The Wave Composer has three sections: Commands bar, Toolbar and Waveform screen. Refer to Figure 4-21 throughout the description of these parts.

The Commands bar

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

In general, clicking on one of the commands opens a dialog box with an additional list of commands. Then, clicking on an additional command, may open a dialog box, or generate an immediate action. For example, Clicking on File and then Exit will cause an immediate termination of the FM Composer. On the other hand, clicking on Wave and then on Square, will open a Square Wave dialog box that lets you program and edit square wave parameters. The various commands in the Commands bar are listed and described below.
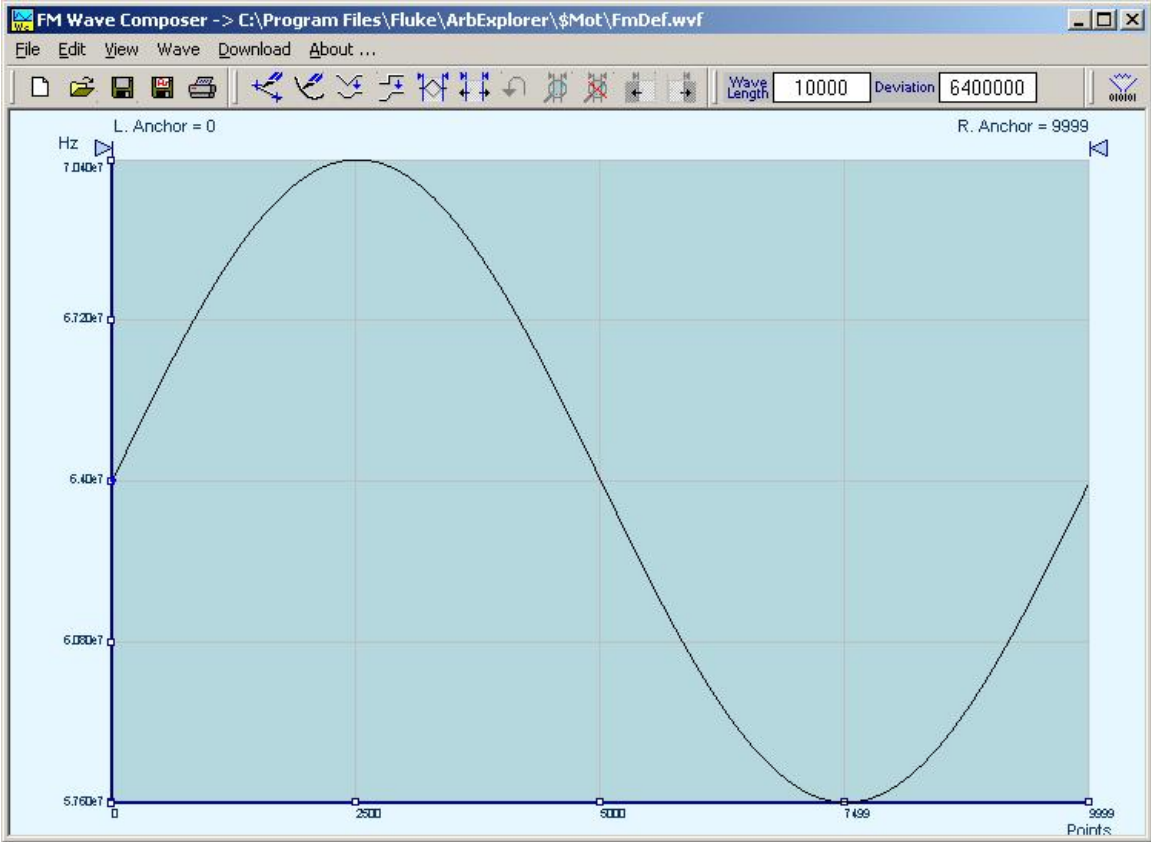
Figure 4-21, The FM Composer opening Screen

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

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

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

Save Waveform
The Save Waveform command will store your active waveform in your 1072 directory, as a binary file with a *.wvf extension. If this is the first time you save your waveform, the Save Waveform As… command will be invoked automatically, letting you select name, location and format for your waveform file.

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

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

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

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

Creating Waveforms From the Built-in Library
You can create any waveform from the built-in library using the Wave command. Clicking on one of the Wave options will open a dialog box. An example of the Sine waveform dialog box is shown in Figure 4-25. 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 4-22 will appear. You can now start programming parameters that are available in this box.

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

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

Max. Peak Deviation – This parameter defines the forward peak deviation. Note that the forward peak deviation cannot exceed the pre-defined Deviation parameter as shown on the Toolbar. In case you need to exceed the pre-defined peak value you must quit this box and modify the Deviation parameter to provide sufficient range for the forward peak deviation range.
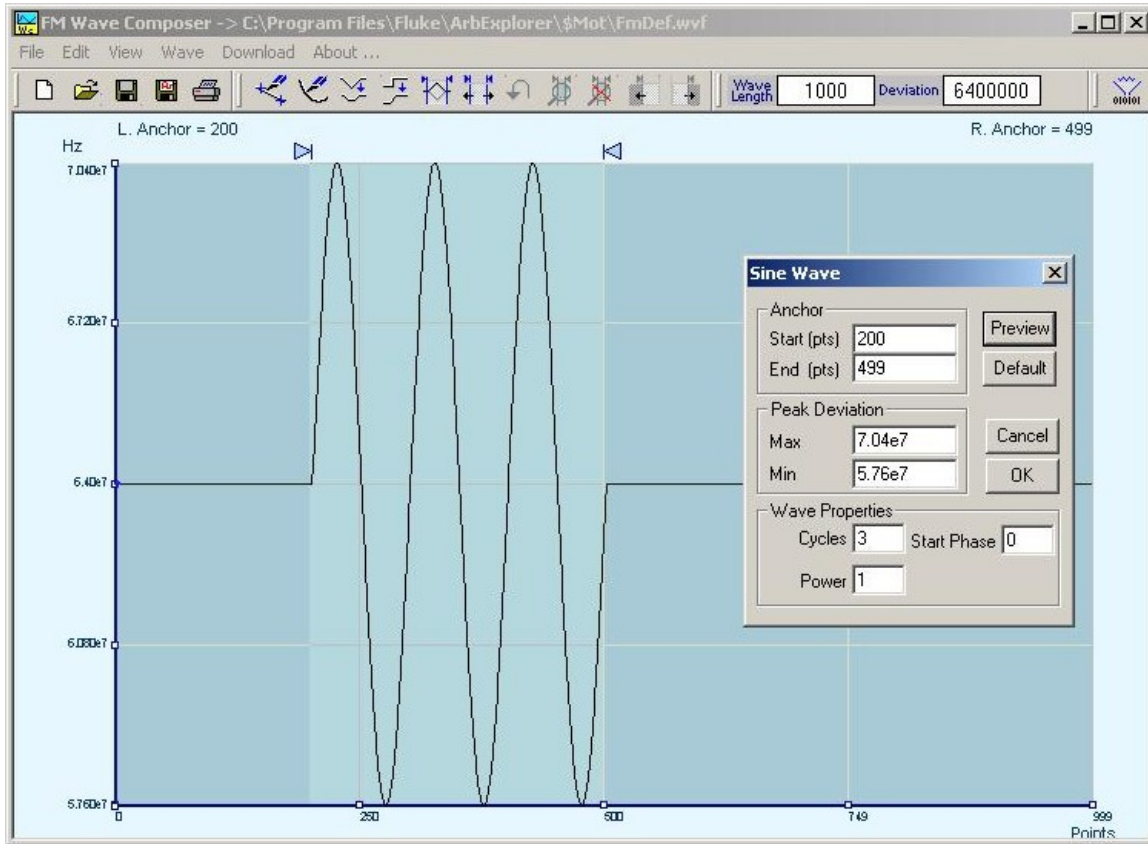
Figure 4-22, Generating Sine Modulation Using the FM Composer

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

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

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

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

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 4-23 will display. Use the following paragraphs to learn how to use this dialog box and how to write your equations.
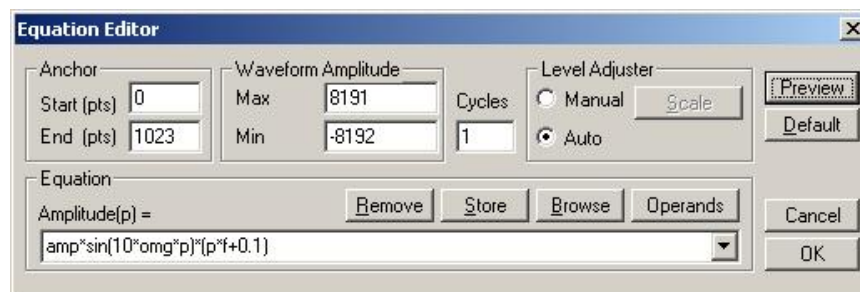
Figure 4-23, The Equation Editor Dialog Box

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 4-23. 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 1072 generates its waveforms exactly as shown on the screen but, if the waveform has many horizontal points, the steps get smaller and harder to see without magnification.

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

Equation 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 /per; omg, which equals 2 * pi / per, and numerals in the range of -1E^20 to 1E^20.

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

Equation Editor Operands

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

(*)x = argument mathematical expression

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

Typing Equations

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

Amplitude(p)=1000

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

Amplitude(p)=-2*p+2000

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

Amplitude(p)=sin(10)

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

💡 *REMEMBER*

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

Now try this:

Amplitude(p)=sin(omg*p)

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

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

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

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

Equation Samples

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

Amplitude(p)=3000*sin(omg*p*l0)-8*p+4000

Press [Preview]. Your screen should look like Figure 4-24.
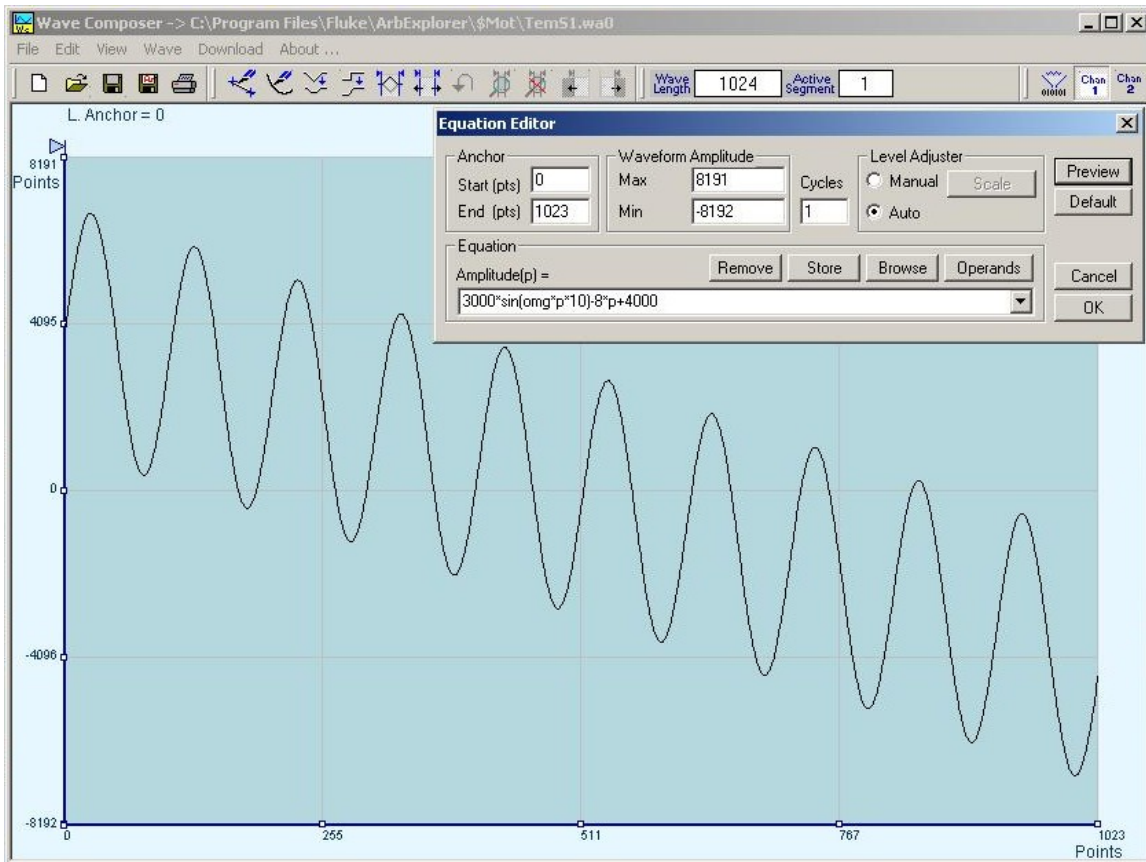
Figure 4-24, An Equation Editor Example

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

Amplitude(p)= 8000*sin(omg*p)*cos(omg*p*30)

Press [Preview]. Your screen should look like Figure 4-25.
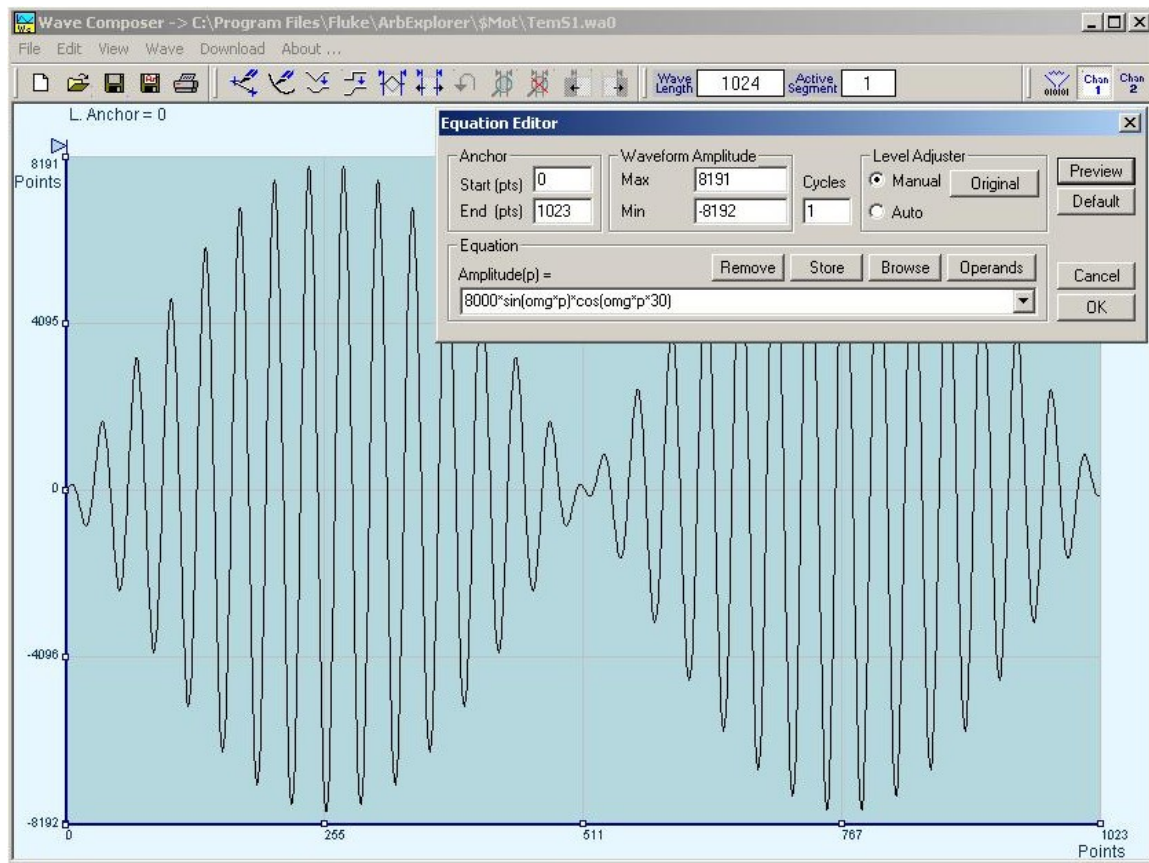
Figure 4-25, Using the Equation Editor to Modulate Sine Waveforms.

In the following example, as shown in Figure 4-29, 20% second harmonic distortion has been added to a standard sinewave. The original waveform had a peak-to-peak value of 6000 points so 20% second harmonic is equivalent to 4000 points. The frequency of the second harmonic is obviously double that of the fundamental, so term +1200*sin(2*omg*p) is added to the original sine wave equation. Use the following equation:

Amplitude(p)=6000*sin(omg*p)+1200*sine(2*omg*p)

Press [Preview]. Your screen should look like Figure 4-26.
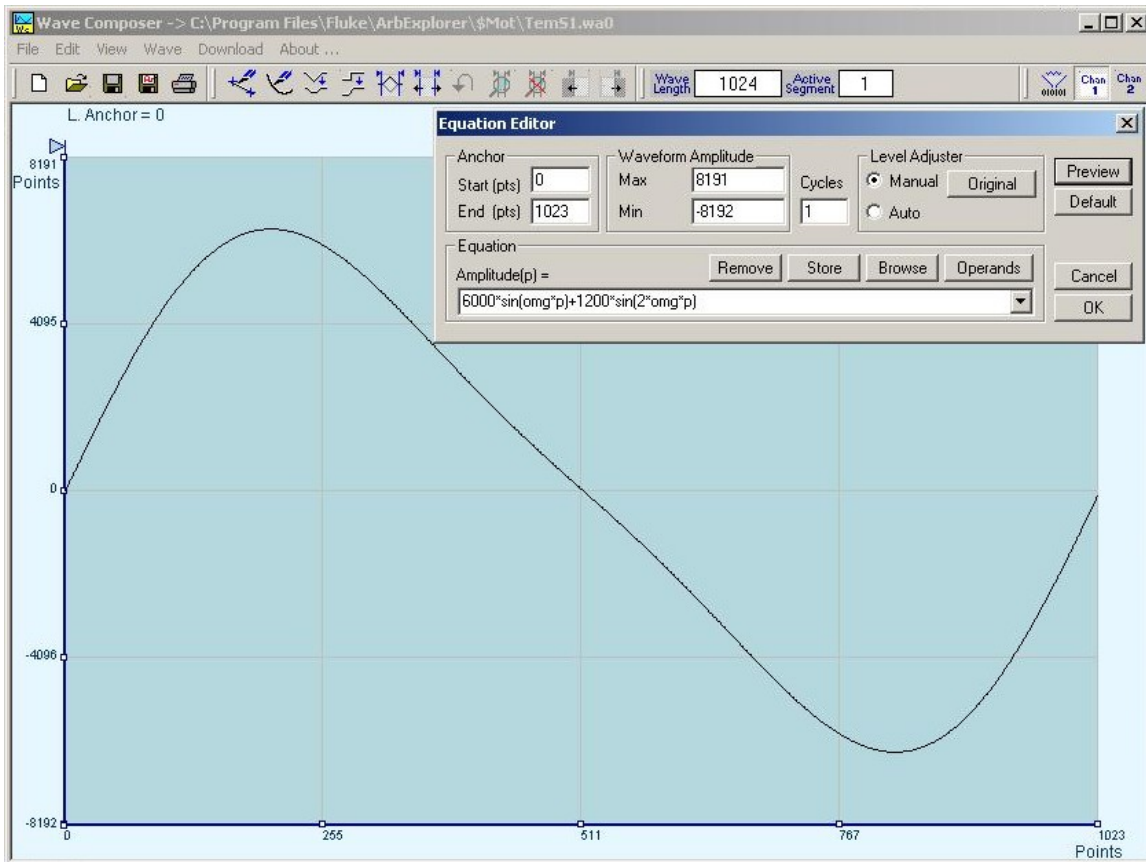
Figure 4-26, Using the Equation Editor to Add Second Harmonic Distortion.

In Figure 4-30 we created 10 cycles of sinewave made to decay exponentially. The original expression for a standard sinewave is multiplied by the term e^(-p/250). Increasing the value of the divisor (200 in this case) will slow down the rate of decay.

Use the following equation:

Amplitude(p)=8000*sin(omg*p*10)^e(p/-250)

Press [Preview]. Your screen should look like Figure 4-27.
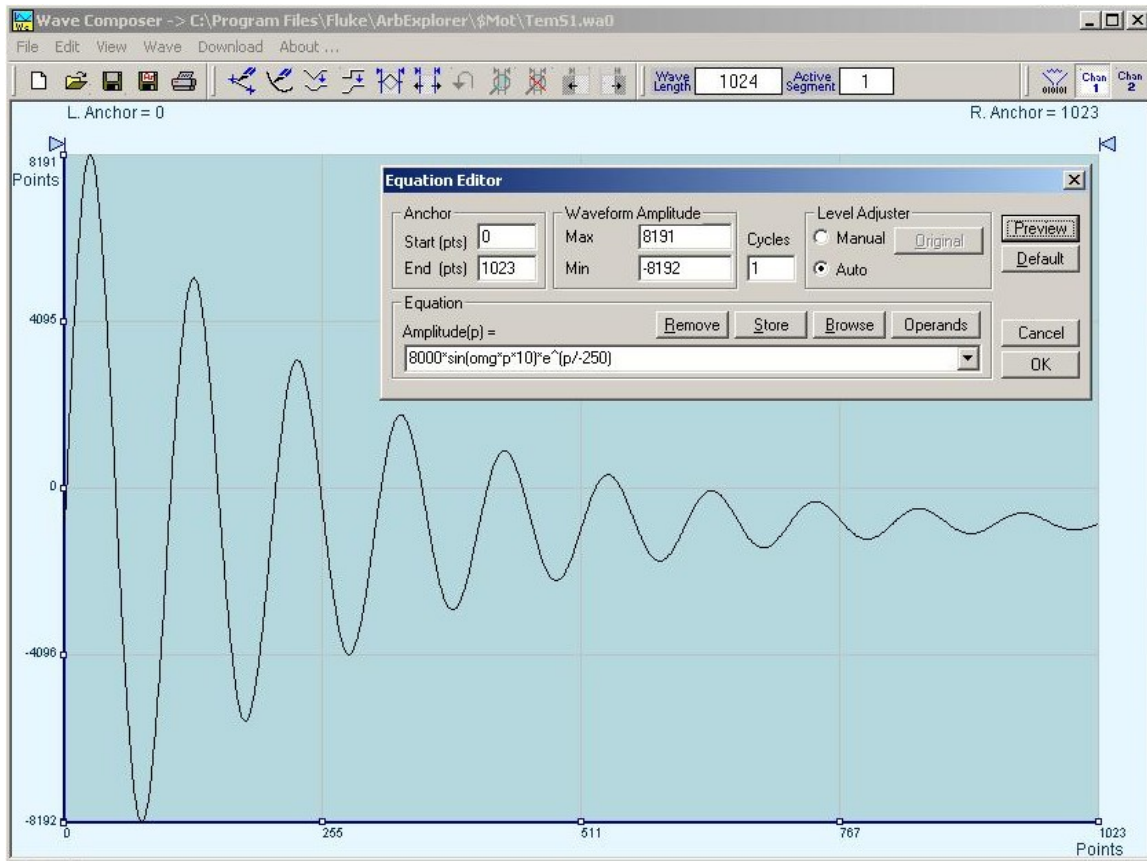
Figure 4-27, Using the Equation Editor to Generate Exponentially Decaying Sinewave

The last example as shown in Figure 4-28 is the most complex to be discussed here. Here, 100 cycles of sinewave are amplitude modulated with 10 cycles of sine wave with a modulation depth of 20%. To achieve this, the upper and lower sidebands are defined separately and added to the fundamental or carrier. The upper sideband is produced by the expression 100*cos(110*omg*p) and the lower sideband by the term 100*cos(90*omg*p).

Use the following equation:

Ampl(p)=8000*sin(100*omg*p)+1600*cos(110*omg*p)-1600*cos(90*omg*p)

Press [Preview]. Your screen should look like Figure 4-28.
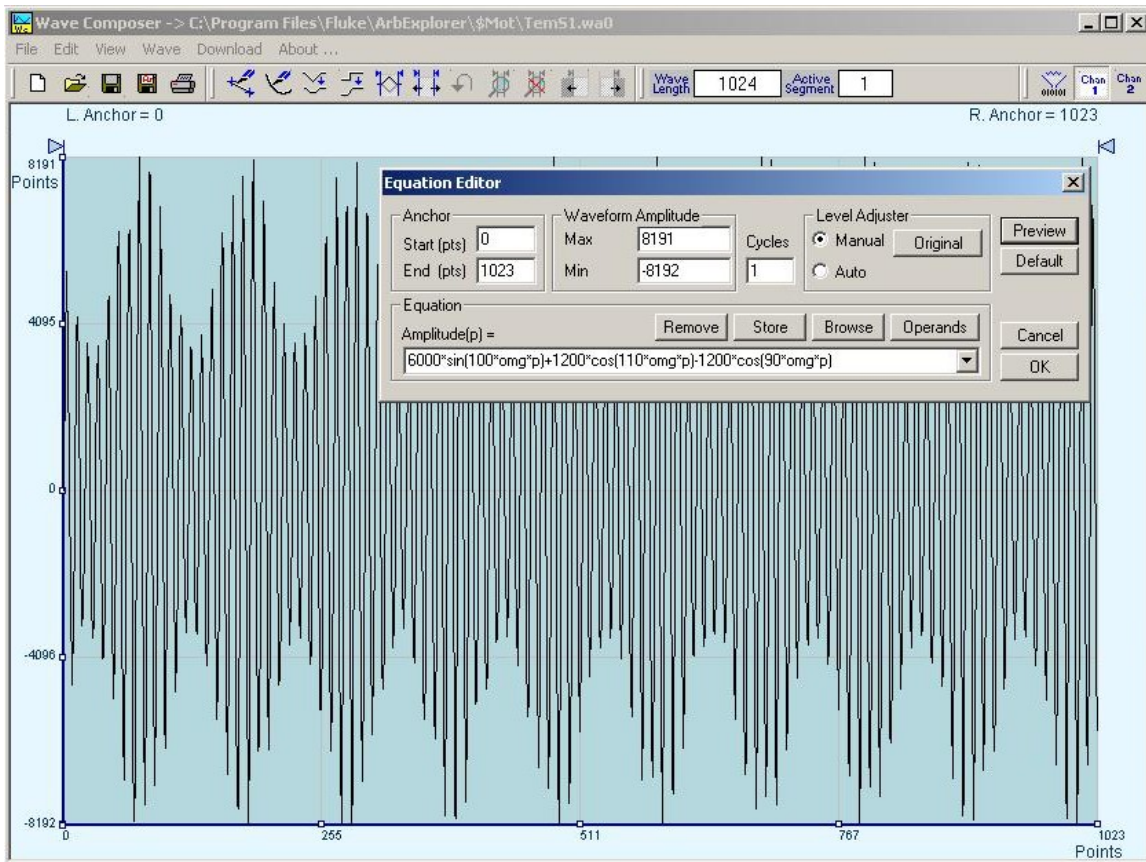
Figure 4-28, Using the Editor to Build Amplitude Modulated Signal With Upper and Lower Sidebands

Combining Waveforms

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

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

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

Step 1 – Create and store sine.wav. Invoke the Equation Editor and type the following equation:

Ampl(p)= 4000*sin(omg*p)

Press OK and then select the Save Waveform As… from the File command. Save this file using the name Sine.wav

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

Step 3 – Write and compute the original equation:

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

If you did not make any mistakes, your waveform screen should look as shown in Figure 4-29
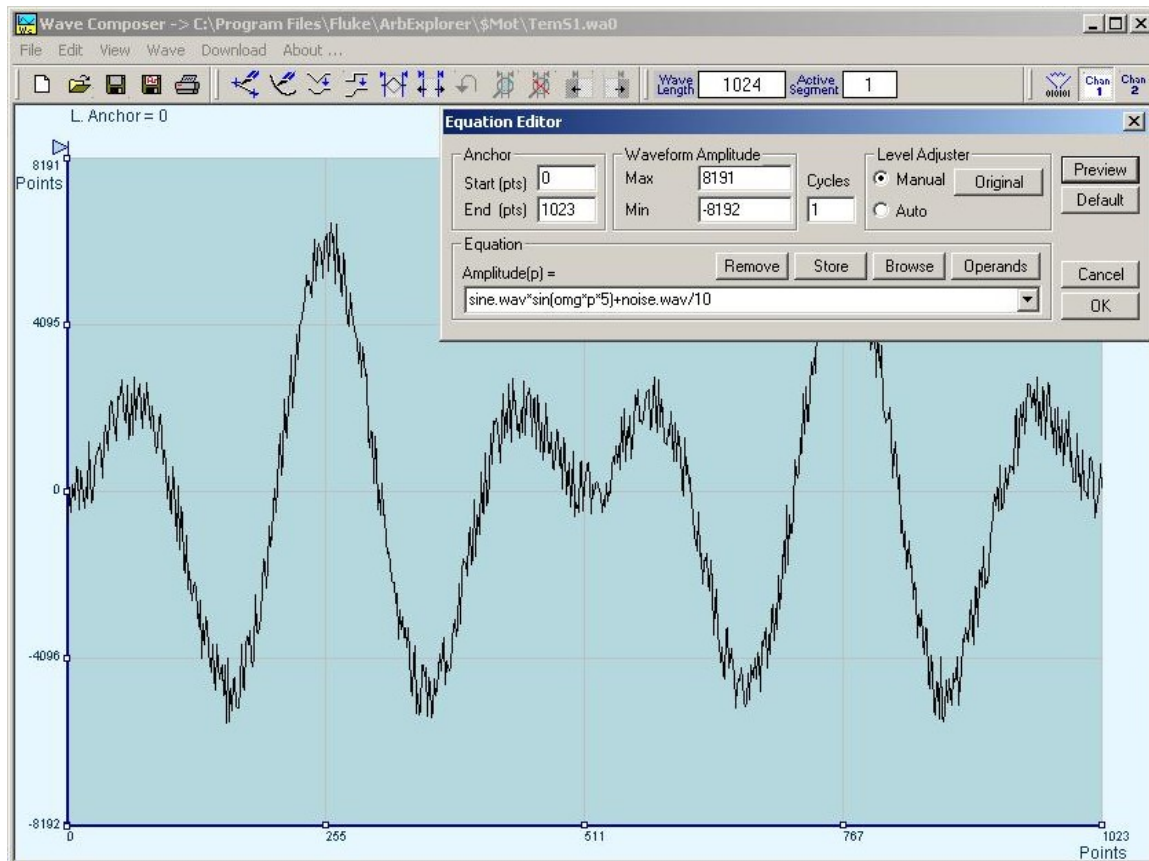
Figure 4-29, Combining Waveforms into Equations

The Pulse Composer

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

When you finally have your pulse design on the screen the program determines if the pulse design will fit in one memory segment or use multiple segments and employ the sequence generator for repeatable segments. In either case, bear in mind that if you already have some waveforms stored in memory segments, these will be erased to make room for the new pulse design. If you insist on keeping arbitrary waveforms and still download complex pulses, you can check the "Force pulse to one segment" option and the 1072 will do some extra "muscle flexing" to fit the pulse as required.

To launch the pulse composer point and click on the PULSE button in the Panels bar. Figure 4-30 shows an example of the pulse composer. The Pulse Composer has three main sections: Commands bar, Toolbar and Waveform screen. Refer to Figure 4-30 throughout the description of these sections.

The Pulse Composer Commands bar

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

In general, clicking on one of the commands opens a dialog box with an additional list of commands. Then, clicking on an additional command, may open a dialog box, or generate an immediate action. For example, Clicking on File and then Exit will cause an immediate termination of the Pulse Composer. The various commands in the Commands bar are listed and described below.
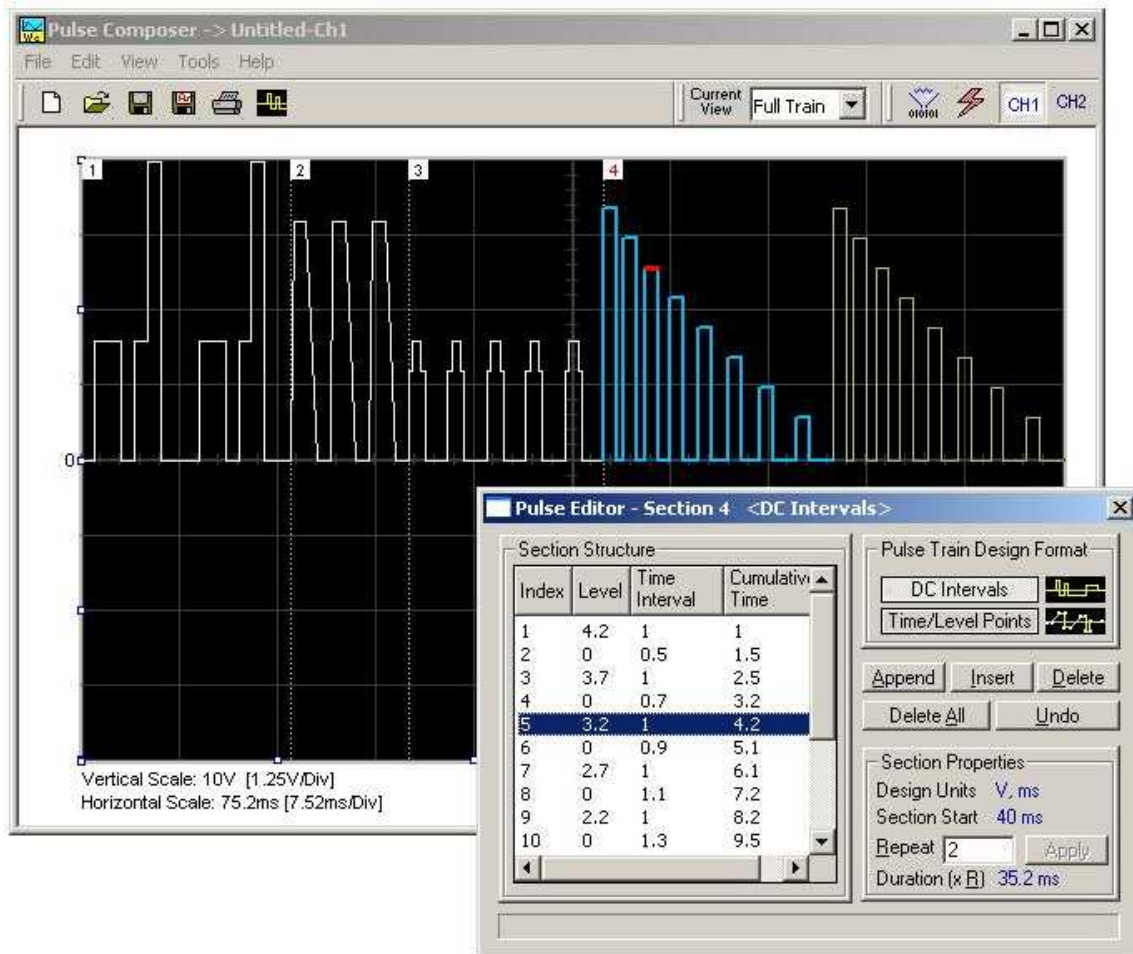
Figure 4-30, The Pulse Composer Screen

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 1072 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 4-31. 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.
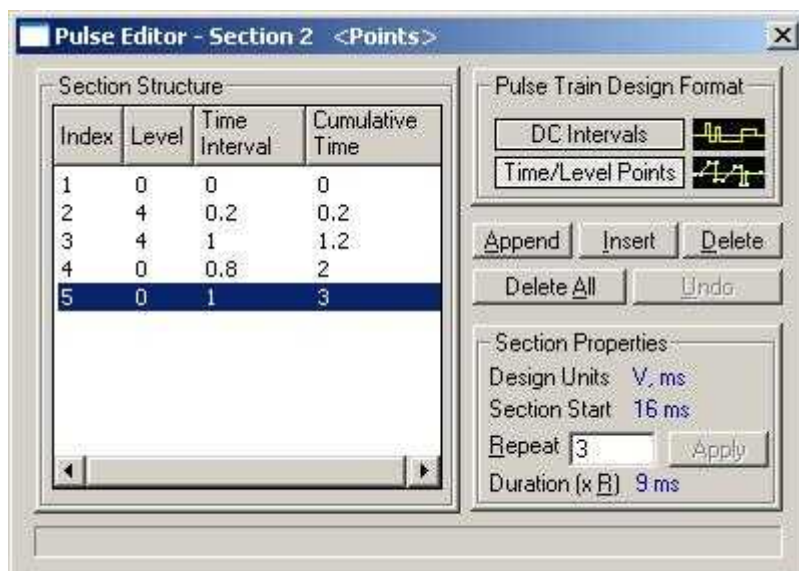
Figure 4-31, The Pulse Editor

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.

Channel 1

The view Channel 1 command updates the waveform screen with the Channel 1 pulse train. If you have not yet generated a waveform for channel 1, the waveform screen will show a clear display.

Channel 2

The view Channel 2 command updates the waveform screen with the Channel 2 pulse train. If you have not yet generated a waveform for channel 2, the waveform screen will show a clear display.

Options

The view options command opens the dialog box as shown in Figure 3-32. 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.
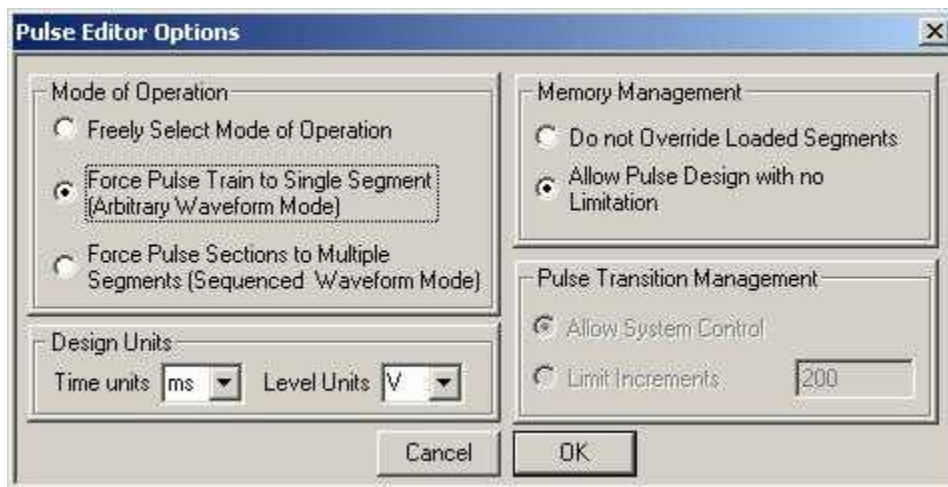
Figure 4-32, The Pulse Editor Options

Tools Commands   The Tools commands let you download pulse trains to either channel 1 or channel 2. 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 1072 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 4-33. The icons, from left to right operate the following functions: New waveform, Open an existing waveform file, Save pulse train, Save pulse train As, Print the screen and open the pulse editor dialog box. Other icons select the current view on the screen, shows channel 1 and channel 2 waveforms, clear the memory and download the displayed pulse train to the active channel.
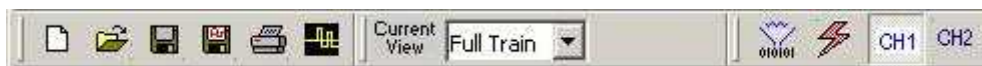
Figure 4-33, The Pulse Composer Toolbar Icons

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 4-31.

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 4-34 shows a complex pulse train which was made from five simpler sections and Figure 4-35 shows the design of the fifth section only of the pulse train.
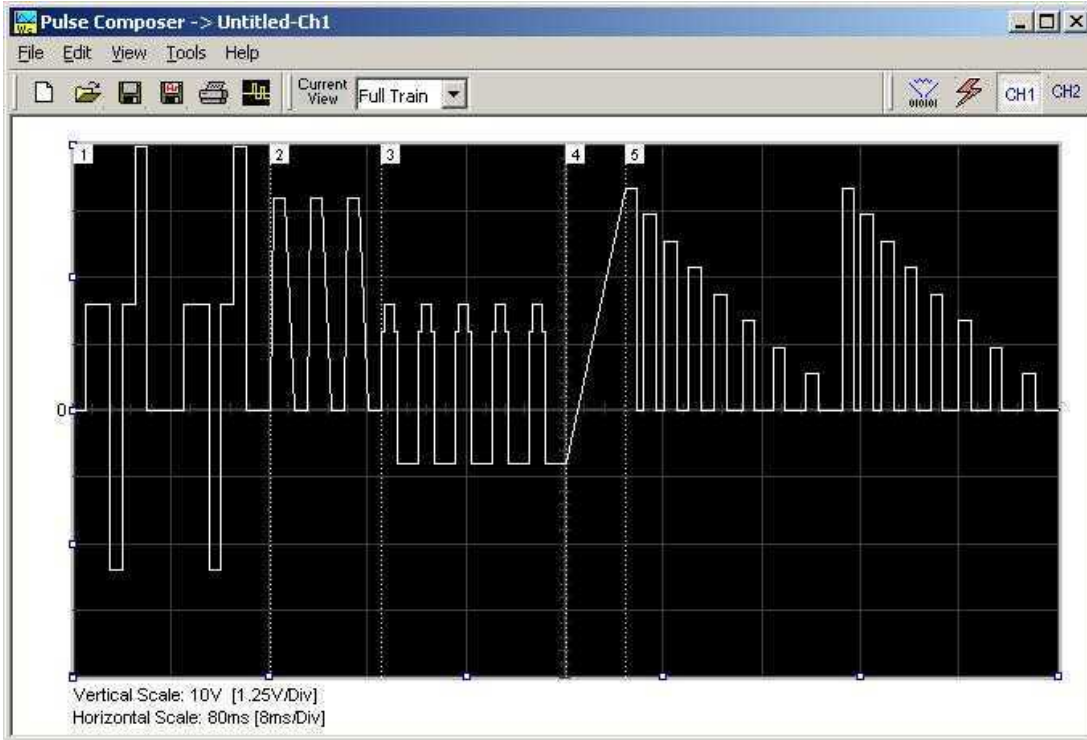
Figure 4-34, Complete Pulse Train Design
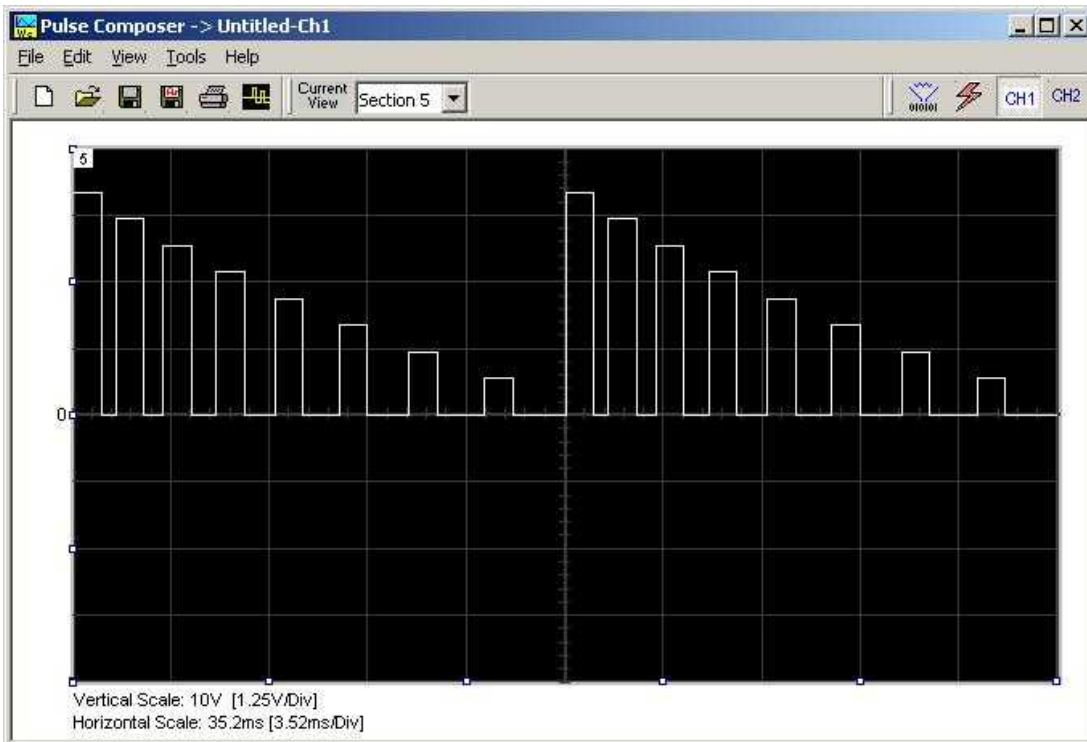
Figure 4-35, Section 5 of the Pulse Train Design

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 4-34. 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 4-36 throughout the following description.
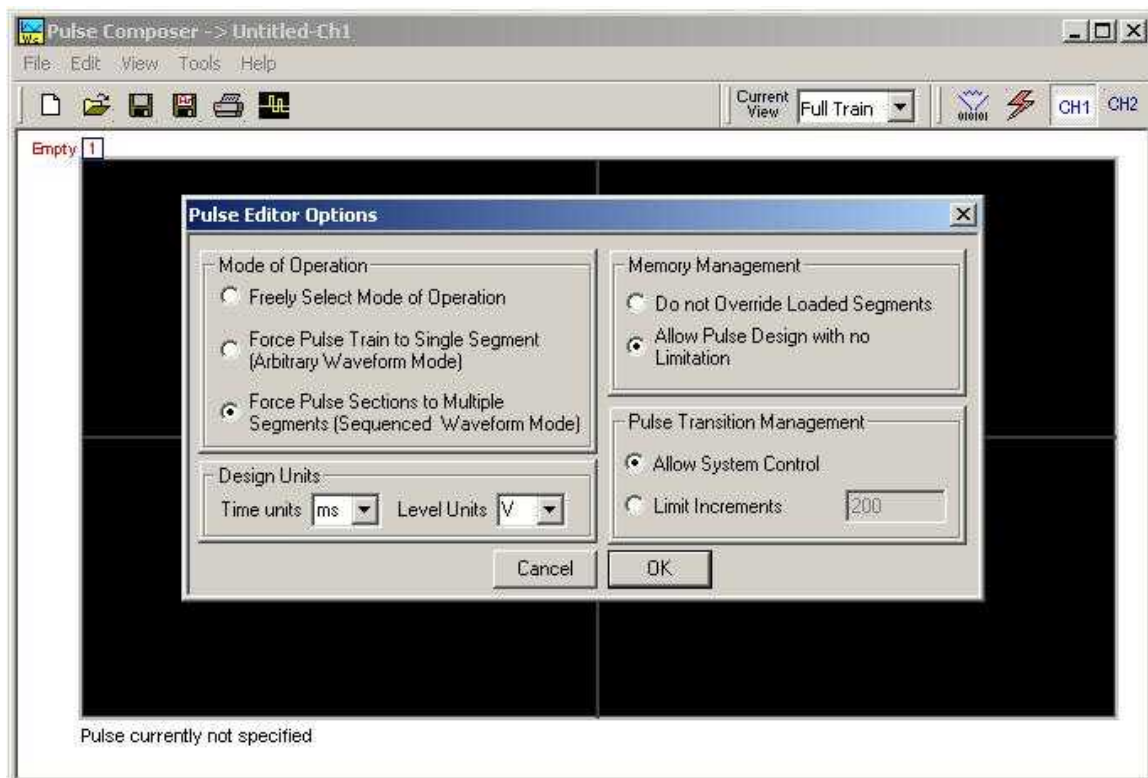
Figure 4-36, Selecting Pulse Editor Options

Setting the Pulse Editor Options

As shown in Figure 4-36, the pulse editor option dialog box is divided to functional groups: Mode of operation, Design Units, Memory Management and Pulse Transition Management. These groups are described below.

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

The force pulse train to single segment option is recommended if you are using one pulse section only. In this case, the pulse

waveform will occupy one segment only and the generator will automatically be set to operate in arbitrary mode.

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

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

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

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

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

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

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

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

Using the Pulse Editor

The prime tool for building pulse patterns on the pulse composer screen is the pulse editor. To invoke the pulse editor, point and click on the pulse editor icon on the tools bar. The editor as shown in Figure 4-37 will show. Refer to this figure for the following descriptions.
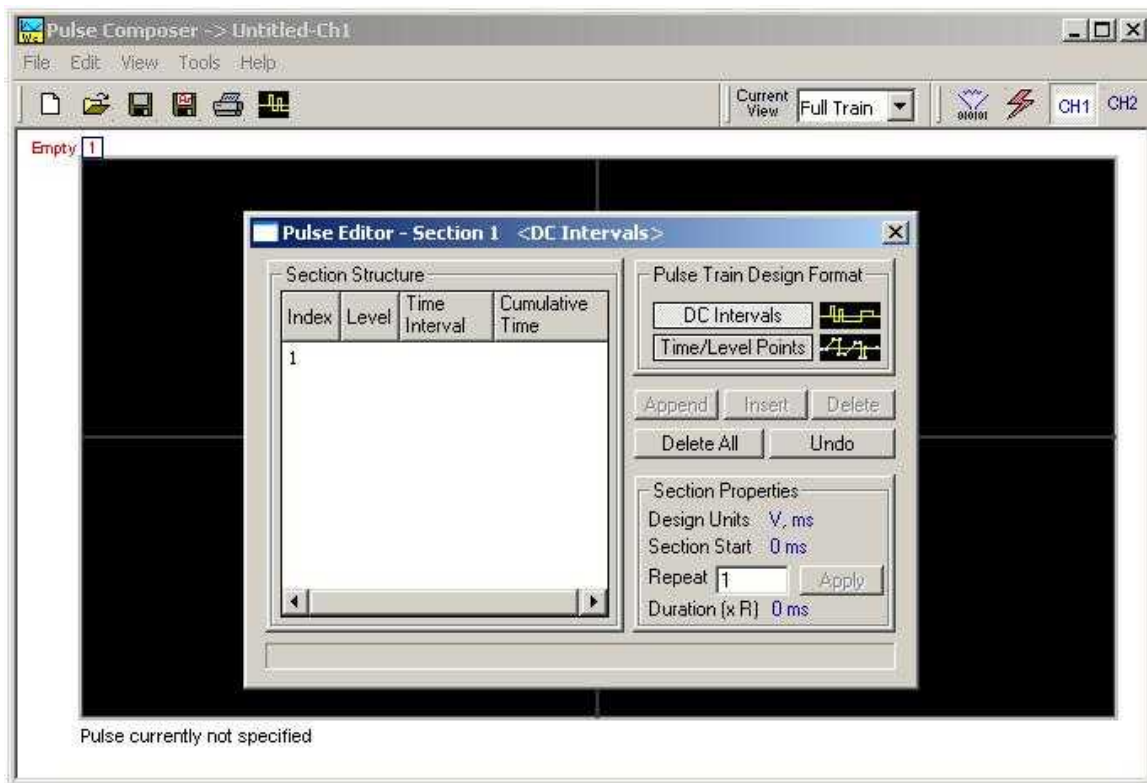
Figure 4-37, Using the Pulse Editor

The Pulse Editor as shown in Figure 4-37 has four groups: Section Structure, Pulse Train Design Format, Section Properties and control buttons. These groups are described below.

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

DC Intervals – programs pulse duration using DC levels only. Transition times for this format are at the maximum rate that the

generator can produce. For example, if you want to draw a simple square waveform that has 0V to 3.3V amplitude, 50% duty cycle and 1ms period, you enter the following parameters:

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

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

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

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

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

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

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

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

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

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

Section Properties

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

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

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

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

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

Control Buttons

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

Pulse Example, Section 1

Now that we are better familiar with the pulse editor and its options, we are ready to start building the first section of the pulse as shown in Figure 4-34. Point and click on the New icon and open the pulse editor. Type in the level and time intervals as shown in Figure 4-38. 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.**
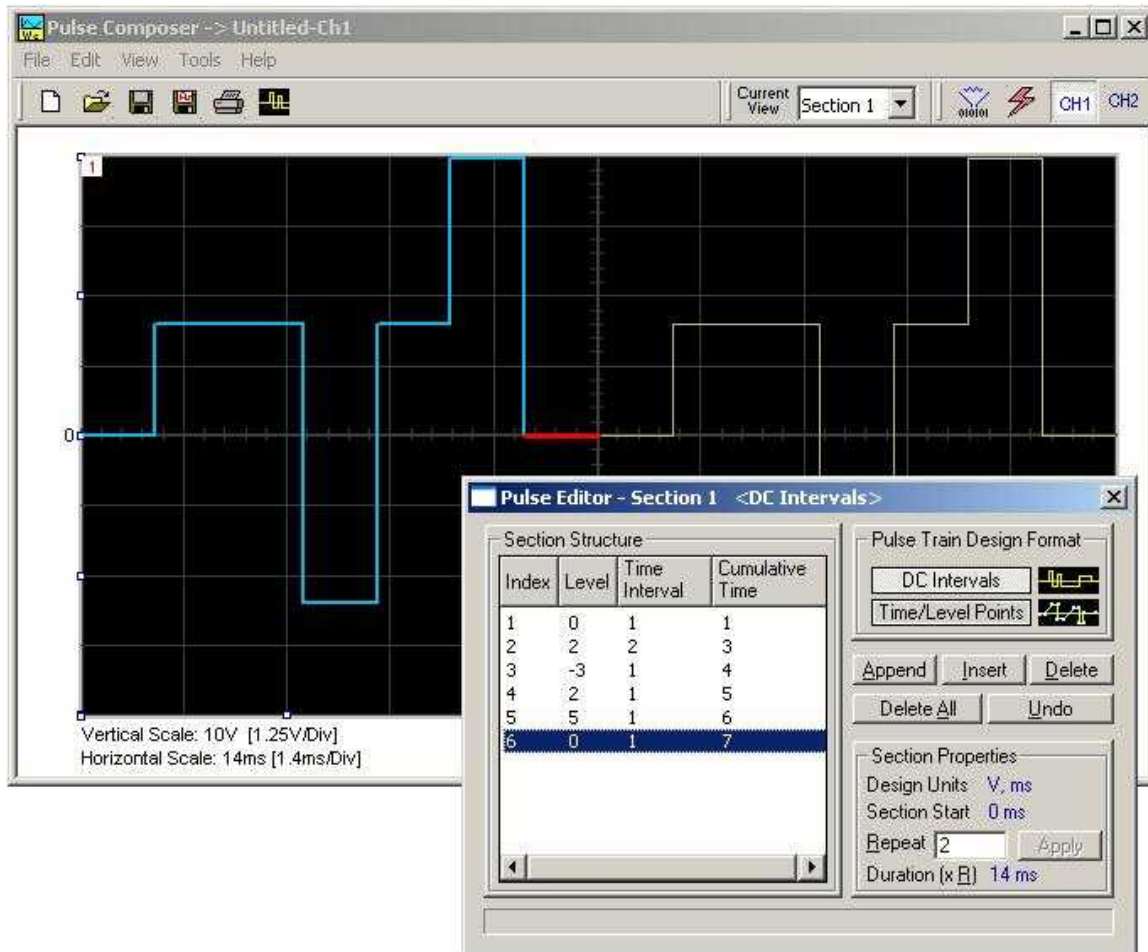
Figure 4-38, Building Section 1 of the Pulse Example

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 10V (1.25V/Div) and Horizontal Scale is showing 14ms (1.4ms/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.

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 4-34. 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 4-39.
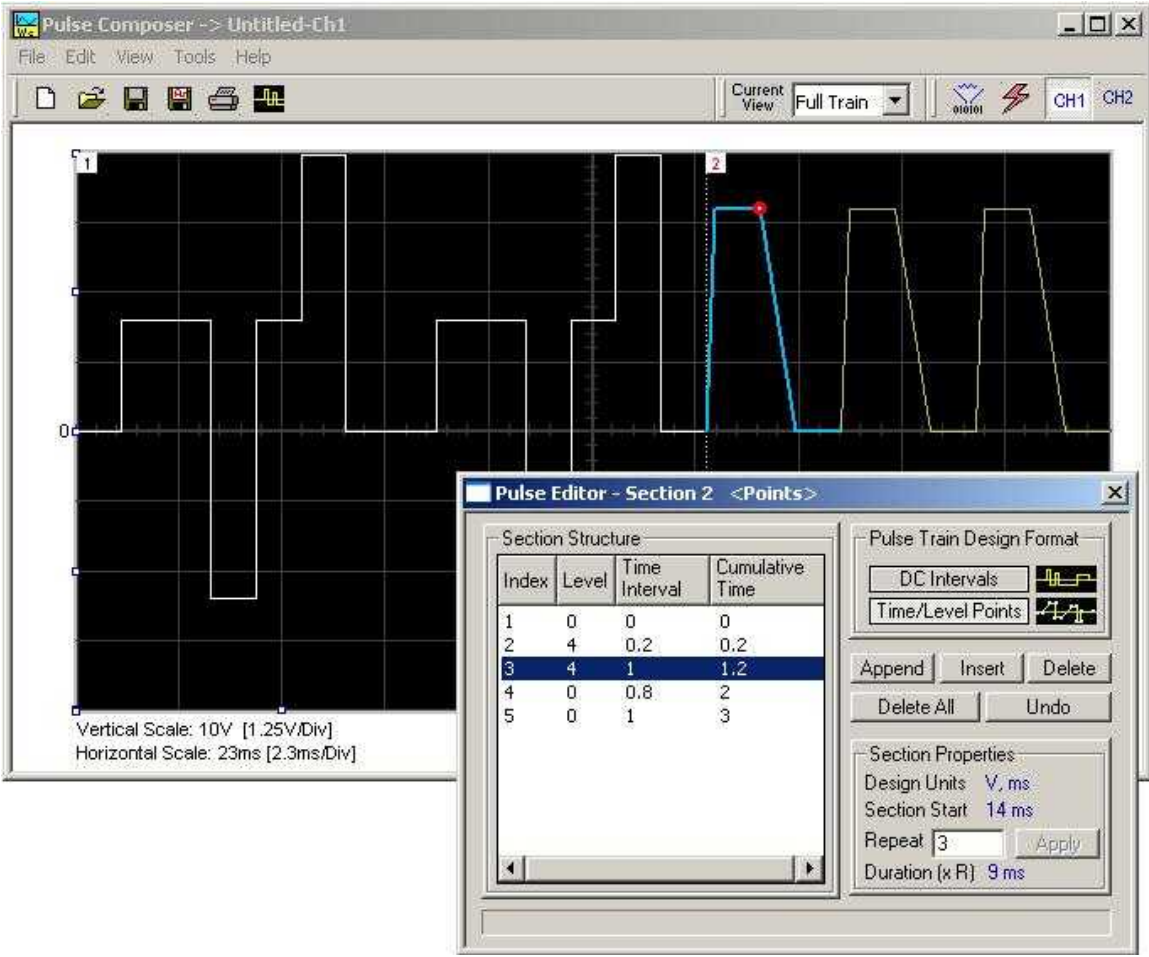
Figure 4-39, Building Section 2 of the Pulse Example

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 4-34. 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 4-40.
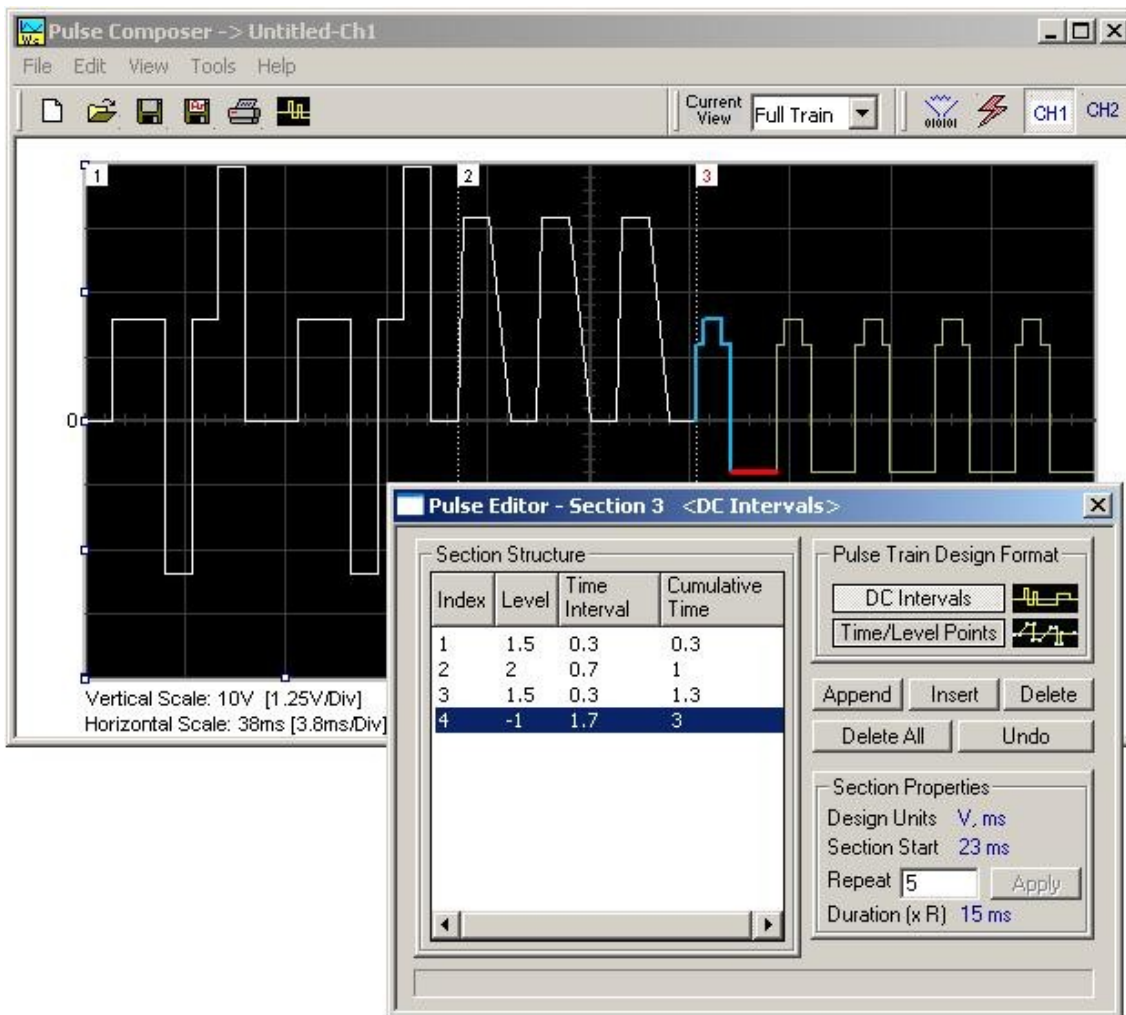
Figure 4-40, Building Section 3 of the Pulse Example

Pulse Example, Section 4

The third pulse section is complete. We are ready now to start building the forth section of the pulse as shown in Figure 4-34. 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 4-41.
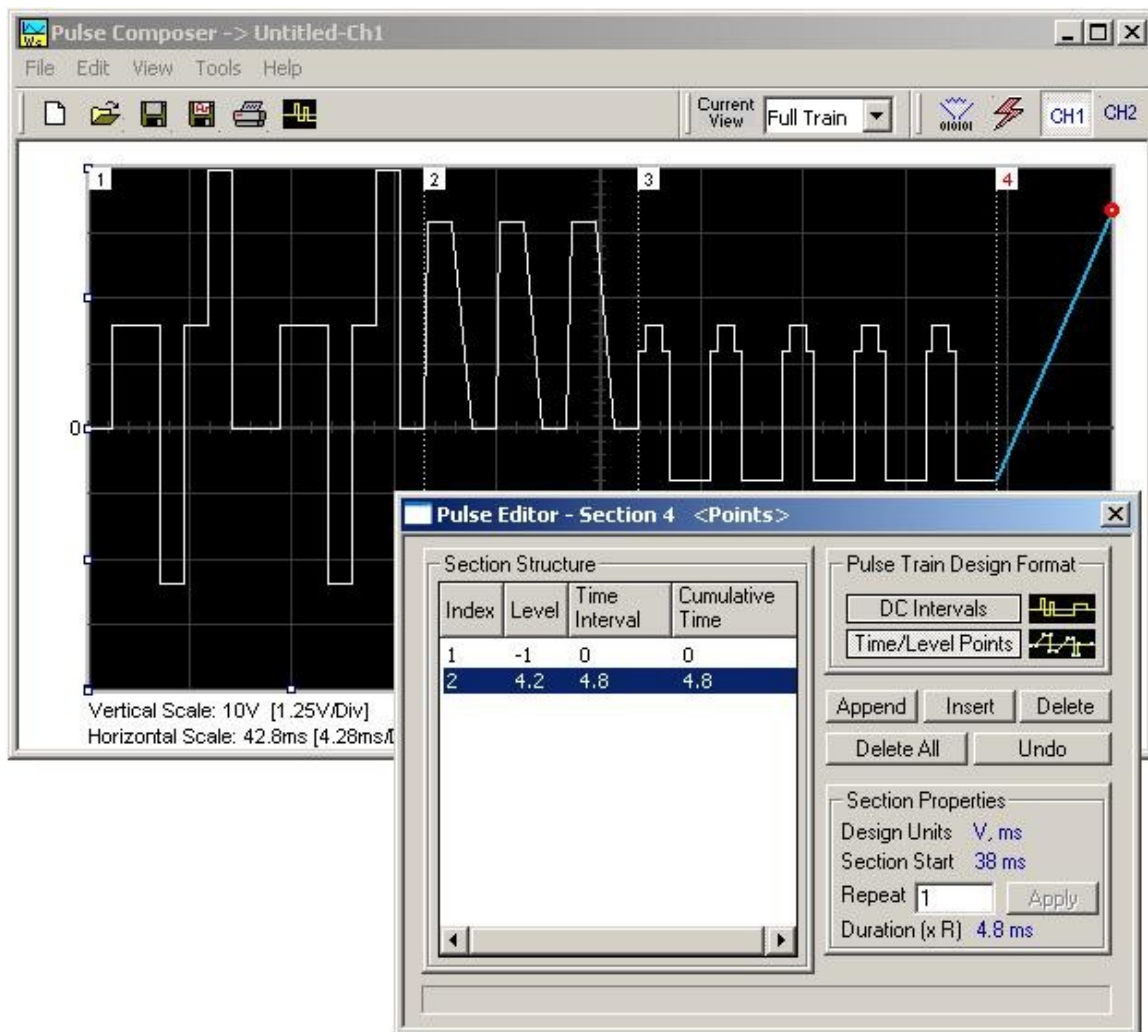
Figure 4-41, Building Section 4 of the Pulse Example

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 4-34. 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 4-42.
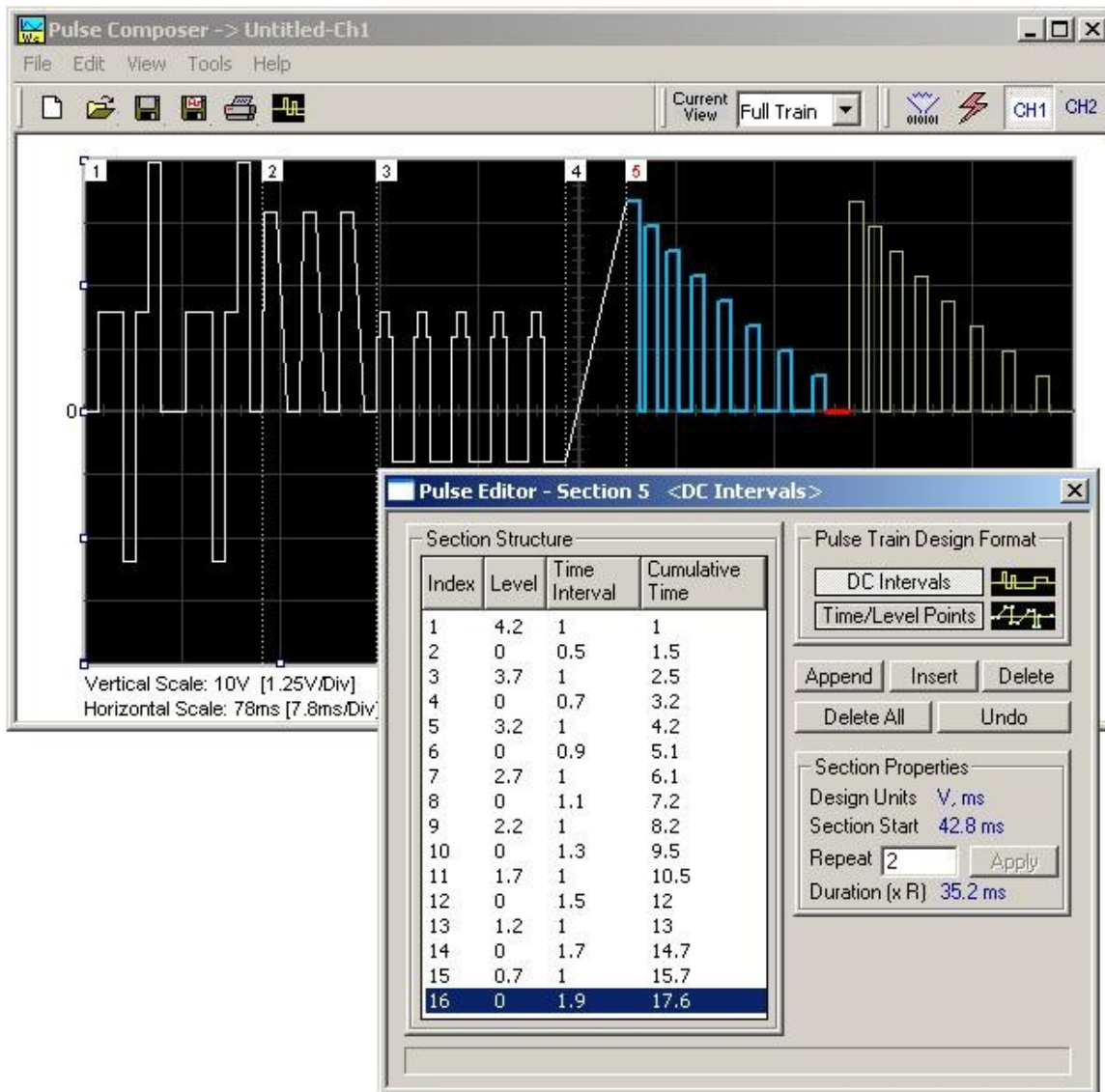
Figure 4-42, Building Section 5 of the Pulse Example

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.

Chapter 5
Remote Programming Reference

What's In This Chapter?

This Chapter lists and describes the set of SCPI-compatible (Standard Commands for Programmable Instruments) remote commands used to operate the 1072. 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 1072 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 SQU
```

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 SEQuence). They have short and long form command keywords. Upper and lowercase letters can be mixed. Query responses always return the short form in all uppercase letters. The following command uses discrete parameters:

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

Boolean Parameters

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

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

The same command can also be written as follows:

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

Arbitrary Block Parameters

Arbitrary block parameters are used for loading waveforms into the generator's memory. Depending on which option is installed, the Model 1072 can accept binary blocks up to 1M bytes. The following command uses an arbitrary block parameter that is loaded as binary data:

```
TRAC:DATA#564000<binary_block>
```

Binary Block Parameters

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

SCPI Syntax and Styles

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

The KEYWORD column provides the name of the command. The actual command consists of one or more keywords since SCPI commands are based on a hierarchical structure, also known as the tree system. Square brackets ([ ]) are used to enclose a **keyword** that is optional when programming the command; that is, the 1072 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 1072 SCPI Commands List Summary

Keyword	Parameter Form (Default in Bold)	Notes
:INSTRument		
[:SELect]	**1** | 2	
:COUPle		
[:STATe]	**OFF** | ON	
:MODE	**MASTer** | SLAVe	
:PHASe		
[:OFFSet]	(**0**,0,2M)	4 point increments
:OUTPut		
[:STATe]	**OFF** | ON	
:FILTer		
[:LPASs]	**NONE** | 25M | 50M | ALL	
:SYNC		
[:STATe]	**OFF** | ON	
:SOURce	**BIT** | LCOMplete	
:POSition		
[:POINt]	(**0**;0;2M)	4 point increments
:WIDTh	(4;4;100000)	4 point increments
[:SOURce]		
:APPLy	FREQ,AMPL,OFFS	
:SINusoid	FREQ,AMPL,OFFS,PHAS	
:TRIangle	FREQ,AMPL,OFFS,PHAS	
:SQUare	FREQ,AMPL,OFFS,DCYC	
:PULSe	FREQ,AMPL,OFFS,DEL,WIDT,LEAD,TRA	
:RAMP	FREQ,AMPL,OFFS,DEL,LEAD,TRA	
:SINC	FREQ,AMPL,OFFS, NCYC	
: GAUSsian	FREQ,AMPL,OFFS,EXP	
: EXPonential	FREQ,AMPL,OFFS,EXP	
: DC	DC_AMPL	
: USER	SEGM,SCLK,AMPL,OFFS	

Table 5-1. Model 1072 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	Notes
:FREQuency		
[:CW]	(**1e6**;100e-6;50e6) | MINimum | MAXimum	
:RASTer	(**1e7**;100e-3;100e6) | MINimum | MAXimum	
:SOURce	INTernal | EXTernal	
:DIVider	(**1**;1;65535)	Integers only
:ROSCillator		
:SOURce	**INTernal** | EXTernal	
:PHASe		
[:OFFSet]	(**0**;0;2M)	1 point increments
:VOLTage		
[:LEVel]		
[:AMPLitude]	(5.**000**;10E-3;10.00) | MINimum | MAXimum	
:OFFSet	(**0**;-4.5;+4.5)	
:FUNCtion		
:MODE	**FIXed** | USER | SEQuence	
:SHAPe	**SINusoid** | TRIangle | SQUare | PULSe | RAMP | SINC | GAUSsian | EXPonential | NOISe | DC	
:SINusoid		
:PHASe	(**0**;0;360)	
:TRIangle		
:PHASe	(**0**;0;360)	
:SQUare		
:DCYCle	(**50**;1;99)	
:PULSe		
:DELay	(**10**;0;99.9)	
:WIDth	(**10**;0;99.9)	
:TRANsition		
[:LEADing]	(**10**;0;99.9)	
:TRAiling	(**10**;0;99.9)	

Table 5-1. Model 1072 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	Notes
:RAMP		
:DELay	(**0**;0;99.9)	
:TRANsition		
[:LEADing]	(6**0**;0;99.9)	
:TRAiling	(**30**;0;99.9)	
:GAUSsian		
:EXPonent	(2**0**;10;200)	
:SINC		
:NCYCle	(**10**;4;100)	
:EXPonential		
:EXPonent	(**1**;-20.00;20.00)	
:DC		
[:AMPLitude]	(**100**;-100;100)	
:FM		
:DATA	<arbitrary_block>	
:DEViation	(**10e6**;100e-3;100e6)	
:FUNCtion		
:MODE	**FIXed** | USER	
:SHAPe	**SINusoidal** | TRIangle | SQUare | RAMP	
:FREQuency	(**1e3**;1e-3;100e3)	
:RASTer	(**1e6**;1e-3;2e6)	
[:STATe]	**OFF** | ON	
:TRIGger		
:MODE	**CONTinuous** | TRIGgered | GATed	
:SLOPe	**POSitive** | NEGative	
:FSK		
:FREQuency		
:RASTer	(**80e6**;100e-3;100e6)	
[:STATe]	**OFF** | ON	
:MODE	**HOP** | RAMP	
:RAMP		
:TIME	(1e-3;10e-6;1)	

Table 5-1. Model 1072 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	Notes
:SWEep		
[:FREQuency]		
:STOP	(**20e6**;100e-3;100e6)	
[:STATe]	**OFF** | ON	
:TIME	(**1e-3**;1e-3;1000)	
:DIRection	**UP** | DOWN	
:SPACing	**LINear** | LOGarithmic	
:TRIGger	**CONTinuous** | TRIGgered | GATed	
:MODE	**CONTinuous** | TRIGgered | GATed	
:SLOPe	**POSitive** | NEGative	
:MARKer	(64e6;100e-3;100e6)	
:AM		
[:STATe]	**OFF** | ON	
:TRACe		
[:DATA]	<arbitrary_block>	
DEFine	(1;1;2048,(16;16;2M)	Even number, divisible by 4
:DELete		
[:NAME]	(1;1;2048)	
:ALL		
:SELect	(**1**;1;2048)	
:SEGMent		
[:DATA]	<binary_block>	
:SEQuence		
[:DATA]	<binary_block>	
:ADVance	**AUTOmatic** | STEP | SINGle | MIXed	
:SOURce	**EXTernal** | INTernal	
:DEFine	(1;1;2048),(1;1;2048),(1;1;1E6),(0,0,1)	Step, segment, repeat, advance mode
:DELete		
:ALL		

Table 5-1. Model 1072 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	Notes
:INITiate		
[:IMMediately]		
:CONTinuous	**ON** | OFF	
:TRIGger		
:BURSt		
[:STATe]	**OFF** | ON	
:COUNt	(**1**;1;1E6)	
:SOURce		
:ADVance	**EXTernal** | INTernal	
:GATE		
[:STATe]	**OFF** | ON	
:SLOPe	**POSitive** | NEGative	
:TIMer	(**1e3**;10e-3;2e6)	In Hz units
:PHASe	(**0**;0;2M)	4 point increments
[:IMMediate]		
:ARM		
[:STATe]	**OFF** | ON	
:SLOPe		
[:STARt]	**POSitive | NEGative**	
:BREakpoint		
:POSition	(**0**;0;2M)	4 point increments
:RESet		
:SYSTem		
:ERRor?		Query only
:VERSion?		Query only, 1999.0

Table 5-1. Model 1072 SCPI Commands List Summary (continued)

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

SOURce Subsystem

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

Keyword Limit	Parameter Form	Default, Low Limit, High
[:SOURce]		
:AM (?)	{OFF|ON|0|1}	**OFF**
:APPLy (?)		
:SINusoid (?)	{<freq>,<ampl>,<offs>,<phase>}	
:TRIangle (?)	{<freq>,<ampl>,<offs>,<phase>}	
:SQUare (?)	{<freq>,<ampl>,<offs>,<duty_cycle>}	
:PULSe (?)	{<freq>,<ampl>,<offs>,<delay>,<rise>,<high>,<fall>}	
:RAMP (?)	{<freq>,<ampl>,<offs>,<delay>,<rise>,<fall>}	
:SINC (?)	{<freq>,<ampl>,<offs>,<N_cycles>}	
:EXPonential (?)	{<freq>,<ampl>,<offs>,<exp>}	
:GAUSsian (?)	{<freq>,<ampl>,<offs>,<exp>}	
:DC (?)	<%_ampl>	
:USER (?)	{<seg#>,<sclk>,<ampl>,<offs>}	
:PHASe		
:OFFSet (?)	<phase_offs>	**0**,0,2M
:FM (?)	{OFF|ON|0|1}	**OFF**
:DATA	#<header><binary_block>	
:DEViation (?)	<deviation>	**1e6**,100e-3,100e6
:FUNCtion		
:MODE (?)	{FIXed|USER}	**FIXed**
:SHAPe (?)	{SINusoid|TRIangle|SQUare|RAMP)	**SINusoid**
:FREQuency	<FM_freq>	1e3,1e-3,100e3
:RASTer (?)	<FM_sclk>	**1e6**,1e-3,2e6
:TRIGger		
:MODE (?)	{CONTinuous|TRIGgered|GATed}	**CONTinuous**
:SLOPe (?)	{POSitive|NEGative	**POSitive**
:FREQuency (?)	{<freq>|MINimum|MAXimum}	**1e6**,100e-6,50e6
:RASTer (?)	{<sclk>|MINimum|MAXimum}	**10e6**,100e-3,100e6
:SOURce (?)	{EXTernal|INTernal}	**INTernal**
:DIVider (?)	<divider>	**1**,1,65535
:FSK (?)	OFF|ON|0|1}	**OFF**
:FREQuency		
:RASTer (?)	<FSK_sclk>	**80e6**,100e-3,100e6
:MODE (?)	{HOP|RAMP}	**HOP**
:RAMP		
:TIME (?)	<time>	**1e-3**,10e-6,1
:FUNCtion		
:MODE (?)	{FIXed|USER|SEQuence}	**FIXed**
:SHAPe (?)	{SINusoid|TRIangle|SQUare|PULSe|RAMP	
	|SINC|EXPonential|GAUSsian|NOISe|DC}	**SINusoid**
:ROCSillator		
:SOURce (?)	(INTernal|EXTernal)	**INTernal**
:SWEep (?)	OFF|ON|0|1}	**OFF**
:STOP (?)	<stop_sclk>	**20e6**,100e-3,100e6
:TIME (?)	<time>	**1e-3**,1e-3,1000

```
        :DIRection (?)      (UP|DONW)                              UP
        :SPACing (?)        (LINear|LOGarithmic)                   LINear
        :TRIGger
        :MODE (?)           {CONTinuous|TRIGgered|GATed}           CONTinuous
        :SLOPe (?)          {POSitive|NEGative                     POSitive
  :MARKer (?)               <mark_sclk>                            64e6,100e-3,100e6
:VOLTage (?)                {<ampl>|MINimum|MAXimum}               5,10e-3,10
        :OFFSet (?)         <offs>                                 0,-4.5,4.5
  :SINusoid
        :PHASe (?)          <phase>                                0,0,360
  :TRIangle
        :PHASe (?)          <phase>                                0,0,360
  :SQUare
        :DCYCle (?)         <duty_cycle>                           50,1,99
  :PULSe
        :DELay (?)          <delay>                                10,0,99.9
        :WIDTh (?)          <pulse_width>                          10,0,99.9
        :TRANsition (?)     <rise>                                 10,0,99.9
          :TRAiling (?)     <fall>                                 10,0,99.9
  :RAMP
        :DELay (?)          <delay>                                0,0,99.9
        :TRANsition (?)     <rise>                                 60,0,99.9
          :TRAiling (?)     <fall>                                 30,0,99.9
  :SINC
        :NCYCle (?)         N_cycles>                              10,4,100
  :GAUSsian
        :EXPonent (?)       <exp>                                  20,10,200
  :EXPonential
        :EXPonent (?)       <exp>                                  -20,-100,+100
  :DC (?)                   <%_amplitude>                          100,-100,+100
```

AM{OFF|ON|0|1}

Purpose

This command turns the AM function on and off

- ON or 1 will set the AM on

- OFF or 0 will set the AM off

Parameter type

Boolean

AM?

Response and default

The 1072 will return 1 if the AM is on, or 0 if the AM is off. Default is 0.

APPLy:SINusoid{<freq>,<ampl>,<offs>,<phase>}

Purpose

This command is a high-level command that programs the 1072 to output sine waveform along with its associated parameters

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

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

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

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

Parameter type
Numeric

Parameter range
<freq>   100e-6 to 50e6
<ampl>   10e-3 to 10
<offs>   -4.5 to +4.5
<phase>   0 to 360

APPLy:SINusoid?
Response
The 1072 will return <freq>, <ampl>,<offs>,<phase>. Default values are 1e6,5,0,0

APPLy:TRIangle{<freq>,<ampl>,<offs>,<phase>}
Purpose
This command is a high-level command that programs the 1072 to output triangular waveform along with its associated parameters

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

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

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

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

Parameter type
Numeric

Parameter range
<freq>   100e-6 to 50e6
<ampl>   10e-3 to 10
<offs>   -4.5 to +4.5
<phase>   0 to 360

APPLy:TRIangle?
Response
The 1072 will return <freq>, <ampl>,<offs>,<phase>. Default values are 1e6,5,0,0

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

Purpose
This command is a high-level command that programs the 1072 to output square waveform along with its associated parameters

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

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

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

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

Parameter type
Numeric

Parameter range
<freq>   100e-6 to 50e6
<ampl>   10e-3 to 10
<offs>   -4.5 to +4.5
<duty_cycle> 0 to 360

APPLy:SQUare?
Response
The 1072 will return <freq>,<ampl>,<offs>,<duty_cycle>. Default values are 1e6,5,0,50

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

Purpose
This command is a high-level command that programs the 1072 to output pulse waveform along with its associated parameters

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

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

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

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

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

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

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

Parameter type
Numeric

Parameter range
<freq>   100e-6 to 50e6
<ampl>   10e-3 to 10
<offs>   -4.5 to +4.5
<delay> 0 to 99.9
<rise>   0 to 99.9
<high>   0 to 99.9
<fall>   0 to 99.9

APPLy:PULSe?
Response
The 1072 will return <freq>, <ampl>,<offs>,<delay>,<rise>,<high>,<fall>.
Default values are 1e6,5,0,10,10,10,10

APPLy:RAMP{<freq>,<ampl>,<offs>,<delay>,<rise>,<fall>}
Purpose
This command is a high-level command that programs the 1072 to output ramp waveform along with its associated parameters

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

- <ampl> sets the output amplitude in units of volts
- <offs> sets the output offset in units of volts
- <delay> sets the delay to the pulse rise transition in units of %
- <rise> sets the pulse rise time in units of %
- <fall> sets the pulse fall time in units of %

Parameter type
Numeric

Parameter range
<freq>   100e-6 to 50e6
<ampl>   10e-3 to 10
<offs>   -4.5 to +4.5
<delay>   0 to 99.9
<rise>   0 to 99.9
<fall>   0 to 99.9

APPLy:RAMP?
Response
The 1072 will return <freq>, <ampl>,<offs>,<delay>,<high>,<fall>. Default values are 1e6,5,0,10,10,10

APPLy:SINC{<freq>,<ampl>,<offs>,<N_cycles>}
Purpose
This command is a high-level command that programs the 1072 to output sinc waveform along with its associated parameters

- <freq> sets the output frequency in units of hertz
- <ampl> sets the output amplitude in units of volts
- <offs> sets the output offset in units of volts
- <N_cycles> sets the number of zero crossing

Parameter type
Numeric

Parameter range
<freq>   100e-6 to 50e6
<ampl>   10e-3 to 10
<offs>   -4.5 to +4.5
<N_cycle>   4 to 100

APPLy:SINC?
Response
The 1072 will return <freq>, <ampl>,<offs>,<N_cycle>. Default values are 1e6,5,0,10

APPLy:EXPonential{<freq>,<ampl>,<offs>,<exp>}
Purpose
This command is a high-level command that programs the 1072 to output exponential waveform along with its associated parameters

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

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

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

- <exp> sets the exponent value

Parameter type
Numeric

Parameter range
<freq>   100e-6 to 50e6
<ampl>   10e-3 to 10
<offs>   -4.5 to +4.5
<exp>   -20 to +20

APPLy:EXPonential?
Response
The 1072 will return <freq>, <ampl>,<offs>,<exp>. Default values are 1e6,5,0,1

APPLy:GAUSsian{<freq>,<ampl>,<offs>,<exp>}
Purpose
This command is a high-level command that programs the 1072 to output gaussian waveform along with its associated parameters

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

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

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

- <exp> sets the exponent value

Parameter type
Numeric

Parameter range
<freq>   100e-6 to 50e6
<ampl>   10e-3 to 10
<offs>   -4.5 to +4.5
<exp>   10 to 200

APPLy:GAUSsian?
Response
The 1072 will return <freq>, <ampl>,<offs>,<exp>. Default values are 1e6,5,0,20

APPLy:DC{<%_ampl>}

Purpose

This command is a high-level command that programs the 1072 to output DC level along with its associated parameter

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

Parameter type

Numeric

Parameter range

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

APPLy:DC?

Response to query version

The 1072 will return <%_ampl>. Default values are 100

APPLy:USER{<seg# >,<sclk>,<ampl>,<offs>}

Purpose

This command is a high-level command that programs the 1072 to output user-defined waveform along with its associated parameters

● <seg# > selects the active segment number
● <sclk> sets the sample clock frequency in units of samples per second
● <ampl> sets the output amplitude in units of volts
● <offs> sets the output offset in units of volts

Parameter type

Numeric

Parameter range

<seg#>   1 to 2048
<sclk>   10e-6 to 100e6
<ampl>   10e-3 to 10
<offs>   -4.5 to +4.5

APPLy:USER?

Response

The 1072 will return <seg#>,<sclk>, <ampl>,<offs>. Default values are 1,10e6,5,0

PHASe:OFFSet<phase_offs>

Purpose

This command programs the start phase offset between channels 1 and 2 in units of waveform points. Phase offset resolution when using this command is 1 point.

● <phase_offs> sets the phase offset between the channels. Phase offset is in waveform points

Parameter type

Numeric

Parameter range

<phase_offs>   0 to 2M

PHASe:OFFSet?
Response and default
The 1072 will return the present phase offset value. Default value is 0.

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

- ON or 1 will set the FM on

- OFF or 0 will set the FM off

Parameter type
Boolean

FM?
Response and default
The 1072 will return 1 if the FM is on, or 0 if the FM is off. Default is 0.

FM:DATA#<header><binary_block>
Purpose
This command will download FM modulating waveform data in binary download. Using this command, Arbitrary FM waveform table data is loaded to the 1072 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.

```
FM:DATA#3100<binary_block>
```

This command causes the transfer of 10 bytes of data to the arbitrary FM waveform memory. The <header> is interpreted this way:

- The ASCII "#" ($23) designates the start of the binary data block.
- "3" designates the number of digits that follow.
- "100" is the number of bytes to follow. This number must divide by 5.

The generator accepts binary data as 40-bit integers, which are sent in five-byte words. Therefore, the total number of bytes is always five times the number of arbitrary FM waveform points. For example, 100 bytes are required to download 20 arbitrary FM waveform points. The IEEE-STD-488.2 definition of Definite Length Arbitrary Block Data format is demonstrated in Figure 5-1 (refer to the TRACe subsystem). 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 sequence data and will not cause unexpected termination of the arbitrary block data.

- <binary_block>   Represents arbitrary FM waveform data.

Downloading data to the arbitrary FM waveform memory is very different than loading arbitrary waveform data. Waveform data programs amplitude domain therefore, every point programs an amplitude level. On the other hand, FM modulating waveform data programs frequency domain therefore, every point sets different sample clock frequency. The FM modulating waveform data is made of 40-bit words. However, the GPIB link has 8 data bas lines and accepts 8-bit words only. Therefore, the data has to be prepared as 40-bit words and rearranged as five 8-bit words before it can be used by the 1072 as FM modulating waveform data.

There are a number of points you should be aware of before you start preparing the data:

1. The FM function is shared by both channels
2. The number of bytes in a complete FM modulating waveform data must divide by 5. The Model 1072 has no control over data sent to its FM waveform during data transfer. Therefore, wrong data and/or incorrect number of bytes will cause errors
3. The LSBit on the last byte sets marker position. "0" = sets no marker and "1" sets marker. You can set as many markers as you want.
4. The SYNC output serves as marker output when you have the 1072 set to operate in FM mode. Normal SYNC level is TTL low. The SYNC output is set to TTL high when the marker bit is true. This way you can use the SYNC output to mark frequency occurrences during FM operation.
5. Data download is terminated with the MSBit of the last byte set to 1.

The following sequence should be used for downloading arbitrary FM Waveforms:

1. Prepare your FM waveform data points using the following relationship:

   N = SCLK [Hz] x 14.31655765

2. Convert the result from 1 above to 4-byte (32-bit) binary word and union with an 8-bit control word.

3. Use an I/O routine such as ViMoveAsync (from the VISA I/O library) to transfer binary blocks of data to the generator.

4. Last data point is sent with MSB bit set to "1"; Data transfer is completed and CPU resumes control.

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

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

Parameter type
Numeric

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

FM:DEViation?
Response and default
The 1072 will return the present frequency deviation value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100E-3 – positive numbers are unsigned). Default value is 1e3. Default value is 1e6.

FM:FUNCtion:MODE(FIXed|USER}
Purpose
This command will set the frequency modulating waveform mode to FIXed (standard) and USER (arbitrary) waveforms.

● FIXed will enable a library of built in standard waveforms

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

Parameter type
Discrete

FM:FUNCtion:MODE?
Response and default
The 1072 will return FIX, or USER depending on its present setting. Default is FIX.

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

● SINusoid will select sine shape as modulating waveform

● TRIangle will select triangular shape as modulating waveform

● SQUare will select square shape as modulating waveform

● RAMP will select ramp shape as modulating waveform

Parameter type
Discrete

FM:FUNCtion:SHAPe?
Response and default
The 1072 will return SIN, TRI, SQU, or RAMP depending on its present setting. Default is SIN.

FM:FREQuency<FM_freq>
Purpose
This command will set the modulating wave frequency. This parameter affects the 1072 when set to operate in FM:FUNC:MODE FIX

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

Parameter type
Numeric

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

FM:FREQuency?
Response and default
The 1072 will return the present modulating waveform frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100E-3 – positive numbers are unsigned). Default value is 1e3.

FM:FREQuency:RASTer(?)<FM_sclk>
Purpose
This command will set the modulating wave sample clock frequency. This parameter affects the 1072 when set to operate in FM:FUNC:MODE USER

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

Parameter type
Numeric

Parameter range
<FM_sclk>   1e-3 to 2e6 in units of samples per second

FM:FREQuency:RASTer?
Response and default
The 1072 will return the present modulating waveform sample clock frequency value. The returned value will be in standard scientific format (for example: 1kHz would be returned as 1E3 – positive numbers are unsigned). Default value is 1e6.

FM:TRIGger:MODE(CONTinuous|TRIGered|GATEd}
Purpose
This command will select one of the FM modes.
- CONTinuous will select continuous modulation
- TRIGered will select triggered modulation
- GATEd will select gated modulation

Parameter type
Discrete

FM:TRIGger:MODE?
Response and default
The 1072 will return CONT, TRIG, or GATE depending on its present setting. Default is CONT.

FM:TRIGger:SLOPe(POSitive|NEGative}
Purpose
This command will select slope sensitivity for the FM trigger input.
- POSitive will select rising edge
- NEGative will select falling edge

Parameter type
Discrete

FM:TRIGger:SLOPe?
Response and default
The 1072 will return POS, or NEG depending on its present setting. Default is POS.

FREQuency{<freq>|MINimum|MAXimum}
Purpose
This command modifies the frequency of the standard waveform in units of hertz (Hz). It has no affect on arbitrary waveforms.

- <freq> sets the waveform frequency

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

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

Parameter type
Numeric

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

FREQuency?
Response and default
The 1072 will return the present frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100E-3 – positive numbers are unsigned). Default value is 1e6.

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

- <sclk> sets the sample clock frequency

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

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

Parameter type
Numeric

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

FREQuency:RASTer?
Response and default
The 1072 will return the present sample clock frequency value. The returned value will be in standard scientific format (for example: 100MHz would be returned as 100e6 – positive numbers are unsigned). Default value is 10e6.

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

- <EXTernal> selects an external source

- <INTernal> selects the internal source

Parameter type
Discrete

FREQuency:RASTer:SOURce?
Response and default
The 1072 will return EXT if an external source is selected, or INT if the internal source is selected. Default value is INT.

FREQuency:RASTer:DIVider<divider>
Purpose
The sample clock frequency for channel 2 can be divided by n. In this case, the sample clock for channel 1 will be X and the sample clock for channel 2 will be X/n. This command sets the dividing ratio for channel 2.

- <divider> sets the dividing ratio for channel 2

Parameter type
Numeric

Parameter range
<divider>   1 to 65535

FREQuency:RASTer:DIVider?
Response and default
The 1072 will return the present channel 2 sample clock frequency divider value. Default value is 1.

FSK:FREQuency:RASTer<FM_sclk>
Purpose
This command will set the shift sample clock frequency. When set to operate in FSK mode, the 1072 will hop from carrier sample clock frequency to shifted sample clock frequency.

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

Parameter type
Numeric

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

FSK:FREQuency:RASTer?
Response and default
The 1072 will return the present shifted sample clock frequency value. The returned value will be in standard scientific format (for example: 1kHz would be returned as 1E3 – positive numbers are unsigned). Default value is 80e3.

FSK:MODE(HOP|RAMPed}

Purpose
This command will select one of the FSK modes.

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

- RAMPed will select ramped shifts from carrier sclk to shifted sclk

Parameter type
Discrete

FSK:MODE?
Response and default
The 1072 will return HOP, or RAMP depending on its present setting. Default is HOP.

FSK:RAMP:TIME<time>
Purpose
This command will set the time it takes for the sample clock frequency to ramp up and down from carrier to shifted frequencies and back. This parameter will effect the 1072 only when the instrument is set to operate in ramped FSK mode.

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

Parameter type
Numeric

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

FSK:RAMP:TIME?
Response and default
The 1072 will return the present ramp time value. The returned value will be in standard scientific format (for example: 10ms would be returned as 10E-3 – positive numbers are unsigned). Default value is 1e-3.

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

- <FIXed> selects standard waveforms

- <USER> selects arbitrary waveforms

- <SEQuence> selects sequenced waveforms

Parameter type
Discrete

FUNCTion:MODE?
Response and default
The 1072 will return FIX, USER, or SEQ depending on the present 1072 setting. Default value is FIX.

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

Purpose

This command defines the shape of waveform that will be available at the output connector. This command has no affect if present 1072 setting is USER or SEQ.

- <SINusoid> selects sine waveform

- <TRIangle> selects triangular waveform

- <SQUare> selects square waveform

- <PULSe> selects pulse waveform

- <RAMP> selects ramp waveform

- <SINC> selects sinc waveform

- <EXPonential> selects exponential waveform

- <GAUSsian selects gaussian waveform

- <NOISe> selects random noise waveform

- <DC> selects dc waveform

Parameter type

Discrete

FUNCtion:SHAPe?

Response and default

The 1072 will return SIN, TRI, SQU, PULS, RAMP, SINC, EXP, GAUS, NOIS, or DC depending on the present 1072 setting. Default value is SIN.

ROSCillator:SOURce{INTernal|EXTernal}

Purpose

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

- <INTernal> selects an internal source. The internal source could be either the standard 100 ppm oscillator, or the optional 1 ppm TCXO

- <EXTernal> activates the external reference input. An external reference must be connected to the 1072 for it to continue normal operation

Parameter type

Discrete

ROSCillator:SOURce?

Response and default

The 1072 will return INT, or EXT depending on the present 1072 setting. Default value is INT.

SWEep:STOP<stop_sclk>

Purpose

This command will set the stop sample clock frequency. When set to operate in sweep mode, the 1072 will sweep from carrier sample clock frequency to sweep stop sample clock frequency.

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

Parameter type

Numeric

5-28

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

SWEep:STOP?
Response and default
The 1072 will return the present sweep stop sample clock frequency value. The returned value will be in standard scientific format (for example: 1kHz would be returned as 1E3 – positive numbers are unsigned). Default value is 20e6.

SWEep:TIME<time>
Purpose
This command will set the time it takes for the sample clock frequency to sweep from carrier to stop frequencies. This parameter will effect the 1072 only when the instrument is set to operate in sweep mode.

- <time>   will set the sweep time

Parameter type
Numeric

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

SWEep:TIME?
Response and default
The 1072 will return the present sweep time value. The returned value will be in standard scientific format (for example: 10ms would be returned as 10E-3 – positive numbers are unsigned). Default value is 1e-3.

SWEep:DIRection{UP|DOWN}
Purpose
This command will select the sweep direction up and down.
- <UP> selects an up direction. The sample clock will sweep from start frequency set by the sclk parameter to stop frequency set by the stop sclk parameter
- <DOWN> selects the down direction. The sample clock will sweep from stop frequency set by the stop sclk parameter to start frequency set by the sclk parameter

Parameter type
Discrete

SWEep:DIRection?
Response and default
The 1072 will return UP, or DOWN depending on the present 1072 setting. Default value is UP.

SWEep:SPACing{LINear|LOGarithmic}
Purpose

This command will select the sweep spacing from linear spacing and logarithmic spacing.

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

Parameter type
Discrete

SWEep:SPACing?
Response and default
The 1072 will return LIN, or LOG depending on the present 1072 setting. Default value is LIN.

SWEep:TRIGger:MODE(CONTinuous|TRIGered|GATEd}
Purpose
This command will select one of the sweep modes.

- CONTinuous will select continuous sweep modulation
- TRIGered will select triggered sweep modulation
- GATEd will select gated sweep modulation

Parameter type
Discrete

SWEep:TRIGger:MODE?
Response and default
The 1072 will return CONT, TRIG, or GATE depending on its present setting. Default is CONT.

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

- POSitive will select rising edge
- NEGative will select falling edge

Parameter type
Discrete

SWEep:TRIGger:SLOPe?
Response and default
The 1072 will return POS, or NEG depending on its present setting. Default is POS.

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

- <mark_sclk>   will set the marker sample clock frequency

Parameter type
Numeric

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

SWEep:MARKer?
Response and default
The 1072 will return the present sweep sample clock frequency value. The returned value will be in standard scientific format (for example: 1kHz would be returned as 1E3 – positive numbers are unsigned). Default value is 64e6.

VOLTage{<ampl>|MINimum|MAXimum}
Purpose
This command programs the peak to peak amplitude of the output waveform. The amplitude is calibrated when the source impedance is 50Ω.

● <ampl> sets the amplitude

● <MINimum> sets the amplitude to its lowest value

● <MAXimum> sets the amplitude to its highest value

Parameter type
Numeric

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

VOLTage?
Response to query version
The 1072 will return the present amplitude value. The returned value will be in standard scientific format (for example: 100mV would be returned as 100E-3 – positive numbers are unsigned). Default value is 5.

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

● <offs> sets the amplitude offset

Parameter type
Numeric

Parameter range
<offs>   -4.5 to +4.5 in units of volts

VOLTage:OFFSet?
Response and default
The 1072 will return the present offset value. The returned value will be in standard scientific format (for example: 100mV would be returned as 100E-3 – positive numbers are unsigned). Default value is 0.

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

* <phase> sets the start phase

Parameter type
Numeric

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

SINusoid:PHASe?
Response and default
The 1072 will return the present start phase value. Default is 0.

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

* <phase> sets the start phase

Parameter type
Numeric

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

TRIangle:PHASe?
Response and default
The 1072 will return the present start phase value. Default value is 0.

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

* <duty_cycle> sets the duty cycle value

Parameter type
Numeric

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

SQUare:DCYCle?
Response and default
The 1072 will return the present duty cycle value. Default value is 50.

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

● <delay> sets the delay parameter

Parameter type
Numeric

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

PULSe:DELay?
Response and default
The 1072 will return the present delay value. Default value is 10.

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

● <pulse_width> sets the high time parameter

Parameter type
Numeric

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

PULSe:WIDTh?
Response and default
The 1072 will return the present width value. Default value is 10.

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

● <rise> sets the rise time parameter

Parameter type
Numeric

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

PULSe:TRANsition?
Response and default
The 1072 will return the present rise time value. Default value is 10.

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

● <fall> sets the fall time parameter

Parameter type
Numeric

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

PULSe:TRANsition:TRAiling?
Response and default
The 1072 will return the present fall time value. Default value is 10.

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

● <delay> sets the delay parameter

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

RAMP:DELay?
Response and default
The 1072 will return the present delay value. Default value is 0.

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

● <rise> sets the rise time parameter

Parameter type
Numeric

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

RAMP:TRANsition?
Response and default
The 1072 will return the present rise time value. Default value is 60.

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

● <fall> sets the fall time parameter

Parameter type
Numeric

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

RAMP:TRANsition:TRAiling?
Response and default
The 1072 will return the present fall time value. Default value is 30.

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

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

Parameter type
Numeric (integer only)

Parameter range
<N_cycle>   4 to 100 zero crossings

SINC:NCYCle?
Response and default
The 1072 will return the present number of zero-crossing value. Default value is 10.

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

● <exp > sets the exponent parameter

Parameter type
Numeric

Parameter range
<exp>   10 to 200

GAUSsian:EXPonent?
Response and default
The 1072 will return the present exponent value. Default value is 20.

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

- <exp > sets the exponent parameter

Parameter type
Numeric

Parameter range
<exp>   -100 to 100

EXPonential:EXPonent?
Response and default
The 1072 will return the present exponent value. Default value is –20.

DC<%_amplitude>
Purpose
This command programs the amplitude of the standard DC waveform. This command has no affect on arbitrary waveforms.

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

Parameter type
Numeric

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

DC?
Response and default
The 1072 will return the present dc value. Default value is 100.

OUTPut Subsystem

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

Keyword Limit	Parameter Form	Default,Low Limit,High
:OUTPut (?)	{OFF|ON|0|1}	**OFF**
:FILTer (?)	{NONE|25M|50M|ALL}	**NONE**
:SYNC (?)	{OFF|ON|0|1}	**OFF**
:SOURce (?)	{BIT|LCOMplete}	**BIT**
:POSition (?)	<position>	**0**,0,2M
:WIDTh (?)	<width>	**4**,4,100000

OUTPut{OFF|ON|0|1}
Purpose
This command will turn the 1072 output on and off.

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

Parameter type
Discrete

OUTPut?
Response and default
The 1072 will return 1 if the output is on, or 0 if the output is off. Default value is 0.

OUTPut:FILTer{NONE|25M|50M|ALL}
Purpose
This command will select which filter is connected to the 1072 output. Observe the following restrictions when you try to use this command:

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

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

Parameter type
Discrete

OUTPut:FILTer?
Response and default
The 1072 will return NONE, 25M, 50M, or ALL depending on the type of filter presently connected to the output. Default value is NONE.

OUTPut:SYNC{OFF|ON|0|1}
Purpose
This command will turn the 1072 SYNC output on and off. The SYNC output state is programmable per channel.

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

Parameter type
Discrete

OUTPut:SYNC?
Response and default
The 1072 will return 1 if the SYNC output is on, or 0 if the SYNC output is off. Default value is OFF.

OUTPut:SYNC:SOURce{BIT|LCOMplete}
Purpose
This command will select the 1072 SYNC option.

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

Parameter type
Discrete

OUTPut:SYNC:SOURce?
Response and default
The 1072 will return BIT, or LCOM depending on the present setting of the SYNC source. Default value is BIT.

OUTPut:SYNC:POSition<position>
Purpose
This command will program the 1072 SYNC position. This command is active in arbitrary (USER) mode only. The SYNC position is programmable per channel.

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

Parameter type
Numeric (integer only)

Parameter range

    <position>   0 to 2M in units of waveform points. The sync position can be programmed in increments of 4 points minimum.

OUTPut:SYNC:POSition?

Response and default

The 1072 will return the present SYNC position value. Default value is 0.

OUTPut:SYNC:WIDTh<width>

Purpose

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

- <width> will set the SYNC width

Parameter type

Numeric (integer only)

Parameter range

    <width>   4 to 100000 in units of waveform points. The width cannot exceed the segment size setting.

OUTPut:SYNC:WIDTh?

Response and default

The 1072 will return the present SYNC width value. Default value is 4.

INSTrument Subsystem

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

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

INSTrument{1|2}
Purpose
This command will set the active channel for future programming sequences. Subsequent commands affect the selected channel only.

- 1 will set channel 1 active
- 2 will set channel 2 active

Parameter type
Discrete

INSTrument?
Response and default
The 1072 will return 1, or 2 depending on the present active channel setting. Default value is 1.

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

1) 9-pin master/slave cable must be connected between the instruments. The Master end of the cable connected to the master unit and the slave end of the cable connected to the slave unit.
2) The SCLK OUT connector from the master unit is connected to the SCLK IN on the slave unit
3) The master unit is selected as master and the slave unit is selected as slave.
4) The command is sent from the master unit only.

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

Parameter type
Discrete
INSTrument:COUPle?

Response and default
The 1072 will return 0, or 1 depending on the present instrument couple setting. Default value is 0.

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

● MASTer will set the master instrument

● SLAVe will set the slave instrument

Parameter type
Discrete

INSTrument:COUPle:MODE?
Response and default
The 1072 will return MAST, or SLAV depending on the present instrument couple setting. Default value is MAST.

INSTrument:COUPle:PHASe<phase>
Purpose
This command will program the phase offset between master and slave units. This command has no effect on the instrument in modes other than instrument couple. The phase command requires that at least one segment be defined for channel B.

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

Parameter type
Numeric (integer only)

Parameter range
<phase>   0 to 2M in units of waveform points. The phase offset can be programmed in increments of 4 points.

INSTrument:COUPle:PHASe?
Response to query version
The 1072 will return the present phase offset value. Default value is 0.

TRIGger Subsystem

The TRIGger subsystem is used to synchronize device actions with external events. These commands control the trigger modes of the Model 1072. The generator can be placed in Triggered, Gated or Burst mode. Trigger source is selectable from an external source, an internal trigger generator or a software trigger. Optional nodes were omitted from these commands. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable.

Keyword Limit	Parameter Form	Default,Low Limit,High
:ARM (?)	{OFF|ON|0|1}	**ON**
:SLOPe	(POSitive|NEGative)	**POSitive**
:BREakpoint		
:POSition (?)	\<position\>	**0**,0,2M
:INITiate		
:CONTinuous (?)	{OFF|ON|0|1}	**ON**
:TRIGger		
:BURSt (?)	{OFF|ON|0|1}	**OFF**
:COUNt ?	\<count\>	**1**,1,1e6
:GATE (?)	{OFF|ON|0|1}	**OFF**
:PHASe (?)	\<phase\>	**0**,0,2M
:SLOPe (?)	{POSitive|NEGative}	**POSitive**
:SOURce		
:ADVance (?)	{EXTernal|INTernal}	**INTernal**
:TIMer (?)	\<interval\>	**1e3**,100e-3,2e6
:IMMediate		
*TRG		

ARM{OFF|ON|0|1}

Purpose

This command will arm the 1072 to stop and start generating output waveforms. The instrument will stop at a breakpoint set with one of the arm command. This mode will operate in continuous run mode only.

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

Parameter type

Discrete

ARM?

Response and default

The 1072 will return 1 if the arm mode is on, or 0 if the arm mode is off. Default value is 0.

ARM:SLOPe{POSitive|NEGative}

Purpose

This command will set the edge sensitivity of which the 1072 will stop in arm mode. The stop and start commands are applied at the rear-panel TRIG IN connector.

● POSitive will set the positive edge

● NEGative will set the negative edge

Parameter type

Discrete

ARM:SLOPe?

Response and default

The 1072 will return POS, or NEG depending on the present setting. Default value is POS.

ARM:BREakpoint:POSition<position>

Purpose

This command will program the breakpoint position for the arm function.

● <position> will set the breakpoint position

Parameter type

Numeric (integer only)

Parameter range

<position>   0 to 2M in units of waveform points. The breakpoint position can be programmed in increments of 4 points minimum.

ARM:BREakpoint:POSition?

Response and default

The 1072 will return the present breakpoint value. Default value is 0.

INITiate:CONTinuous{OFF|ON|0|1}

Purpose

This command will set the output in continuous operation and interrupted operation. The trigger subsystem commands will affect the 1072 only after it will be set to interrupted operation.

● ON or 1 will set the continuous mode

● OFF or 0 will set the interrupted mode

Parameter type

Discrete

INITiate:CONTinuous?
Response to query version
The 1072 will return 0 if the output is interrupted, or 1 if the output is continuous. Default value is 1.

TRIGger:BURSt{OFF|ON|0|1}
Purpose
This command will set the burst mode. This command will affect the 1072 only after it will be set to interrupted operation with the command INIT:CONT OFF.

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

Parameter type
Discrete

TRIGger:BURSt?
Response and default
The 1072 will return 1 if the burst is on, or 0 if the burst is off. Default value is 0.

TRIGger:COUNt<count>
Purpose
This command will set the burst counter.

- <count> will set the count number

Parameter type
Numeric (integer only)

Parameter range
  <count>   1 to 1 Meg

TRIGger:COUNt?
Response and default
The 1072 will return the present count value. Default value is 1.

TRIGger:GATE{OFF|ON|0|1}
Purpose
This command will set the gate mode. This command will affect the 1072 only after it will be set to interrupted operation with the command INIT:CONT OFF.

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

Parameter type
Discrete

TRIGger:GATE?
Response and default
The 1072 will return 1 if the gate is on, or 0 if the gate is off. Default value is 0.

TRIGger:SLOPe{POSitive|NEGative}
Purpose
This command will set the edge sensitivity for the trigger input.

- <POSitive> will set the positive edge

- <NEGative> will set the negative edge

Parameter type
Discrete

TRIGger:SLOPe?
Response and default
The 1072 will return POS, or NEG depending on the present trigger setting. Default value is POS.

TRIGger:SOURce:ADVance{EXTernal|INTernal}
Purpose
This command will set the advance source for the trigger mode.

- <EXTernal> will select the external input

- <INTernal > will select the internal trigger generator

Parameter type
Discrete

TRIGger:SOURce:ADVance?
Response and default
The 1072 will return EXT, or INT depending on the present trigger source setting. Default value is INT.

TRIGger:TIMer<interval>
Purpose
This command will set the period for the internal trigger generator.

- <interval> will set the timer of the internal trigger generator

Parameter type
Numeric

Parameter range
<interval>   100e-3 to 2e6 in units of Hz

TRIGger:TIMer?
Response and default
The 1072 will return the present internal trigger timer value. The returned value will be in standard scientific format (for example: 10ms would be returned as 10E-3 – positive numbers are unsigned). Default value is 1e3.

TRIGger:IMMediate
Purpose
This command will stimulate the 1072 output once. This command will affect the 1072 only after it will be set to interrupted operation.

*TRG
Purpose
This common command has the same affect as the TRIG:IMM command.

TRACe Subsystem

The TRACe subsystem contains commands, which allow definition of segments and their corresponding lengths, addition and deletion of segments, and the loading of waveform data. Sequence commands control segments link and loops.. Optional nodes were omitted from these commands. Defaults are shown in bold.

Keyword Limit	Parameter Form	Default,Low Limit,High
:TRACe	#<header><binary_block>	
:DEFine	<segment_number>,<length>	
:DELete	<segment_number>	
:DELete:ALL		
:SELect (?)	<segment_number>	
:SEQuence	#<header><binary_block>	
:ADVance (?)	{AUTOmatic|STEP|SINGle|MIXed}	**AUTOmatic**
:SOURce (?)	{EXTernal|INTernal}	**EXTernal**
:DEFine	<link>,<seg_#>,<loop>,<mode>	
:DELete:ALL		

Generating Arbitrary Waveforms

Arbitrary waveforms are generated from digital data points, which are stored in memory. Each data point has a vertical resolution of 14 bits (16384 points), i.e., each sample is placed on the vertical axis with a precision of 1/16384. The Model 1072 has the following waveform memory capacity:

4 Meg – standard memory configuration

Each horizontal point has a unique address - the first being 00000 and the last depends on the memory option. In cases where smaller waveform lengths are required, the waveform memory can be divided into smaller segments.

When the instrument is programmed to output arbitrary waveforms, the clock samples the data points (one at a time) from address 0 to the last address. The rate at which each sample is replayed is defined by the sample clock rate parameter. The 1072 provides programmable sample clock rates from 100mS/s to 100MS/s.

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 in comprised of a finite length of words. The maximum size arbitrary waveform that can be loaded into memory is 2M. Waveforms are created using small sections of the arbitrary memory. The memory can be partitioned into smaller segments (up to 2048) and different waveforms can be loaded into each segment, each having a unique length. Minimum segment size is 16 points, as long as its playback time is more than 10µs. Information on how to partition the memory, define segment length and download waveform data to the 1072 is given in the following paragraphs.

TRACe#<header>

Purpose

This command will download waveform data to the 1072 memory. Waveform data is loaded to the 1072 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.

The generator accepts binary data as 14-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.

- <binary_block>   Represents waveform data.

The waveform data is made of 16-bit words however, the GPIB link has 8 data bas lines and accepts 8-bit words only. Therefore, the data has to be prepared as 16-bit words and rearranged as two 8-bit words before it can be used by the 1072 as waveform data points. The following description shows you how to prepare the data for downloading to the 1072. There are a number of points you should be aware of before you start preparing the data:

1. Each channel has its own waveform memory. Therefore, make sure you selected the correct active channel before you download data to the generator
2. Waveform data points have 14-bit values
3. Data point range is 0 to 16,383 decimal
4. Data point 0 to data point 16,383 corresponds to full-scale amplitude setting. For example, if your amplitude setting is 5V$_{pk-pk}$, your generator will output waveforms from –2.5V to +2.5V. The corresponding level in waveform points is decimal 0 (0x0000) for –2.5V and decimal 16,393 (0x3FFF) for 2.5V. Similarly, the 0V point will correspond to decimal 8191 (0x1FFF)
5. The two most significant bits – D14 and D15 are control bits and are not available for normal programming. They must be set to "0" at all times.

Figure 5-2 shows how to initially prepare the 16-bit word for a waveform data point. Note that there are 14 bits used for data representation. The other two bits are used for control purpose and must be set to "0". Also note that the 1072 can not accept formats as shown in Figure 5-2; Data has to be further manipulated to a final format that the instrument can accept and process as waveform point.

MSB		high-byte								low-byte					LSB
D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0

14-bit binary value (0 to 16383 decimal)

2 control bits. Must be set to 0, initially
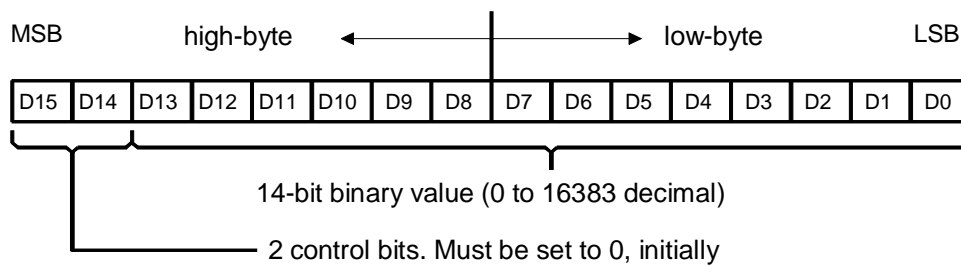
Figure 5-2. 16-bit Initial Waveform Data Point Representation

Figure 5-3 shows the same 16-bit word as in Figure 5-2, except the high and low bytes are swapped. This is the correct format that the 1072 expects as waveform point data. The first byte to be sent to the generator is the low-byte and then high-byte.

low-byte								high-byte							
D7	D6	D5	D4	D3	D2	D1	D0	D15	D14	D13	D12	D11	D10	D9	D8

2 control bits. Must be set to 0, initially
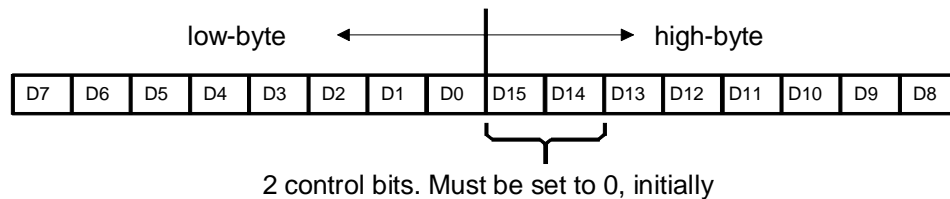
Figure 5-3. 16-bit Waveform Data Point Representation

As an example, Figure 5-4 shows word value of decimal 8025 (0x1F59) in a correct format for downloading to the 1072. The byte containing 59 is sent first and then the byte containing 1F.
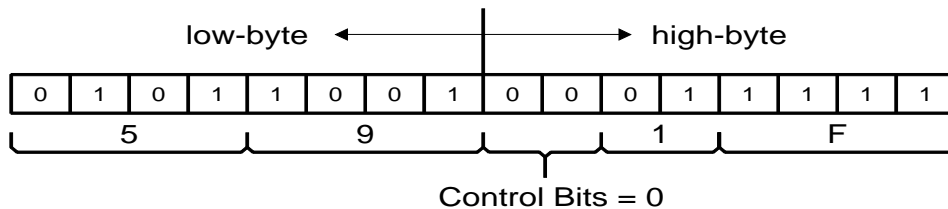
Figure 5-4. 0x1F59 Data Point Representation

TRACe:DEFine<segment_number>,<length>
Purpose

This command will define waveform segments and their relative length. Note that if you are using the TRAC:DATA# header to download waveform data, there is no need for this command because the header contains segment size information and therefore, the segment will resize automatically. The use of this command is absolutely a must if you truncate waveforms and download to the instrument as one waveform.

- <segment_number> will set the selected segment
- <length> will assign length to the above selected segment. Minimum segment length is 16 points, the maximum is limited by the memory size - 2M.

Note

The 1072 operates in interlaced mode where four memory cells generate one byte of data. Therefore, segment size can be programmed in numbers evenly divisible by four only. For example, 2096 bytes is an acceptable length for a binary block. 2002 is not a multiple of 4, therefore the generator will generate an error message if this segment length is used.

TRACe:DELete<segment_number>
Purpose

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.

● <segment_number> will select the segment number that will be deleted

TRACe:DELete:ALL
Purpose
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 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>
Purpose
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. This behavior is especially important for sequence operation, where multiple segments form a large sequence. In this case, you can synchronize external devices exactly to the segment of interest

● <segment_number> will set the active waveform segment number

Parameter type
Numeric (integer only)

Parameter range
<segment_number>   1 to 2048

TRACe:SELect?
Response
The 1072 will return the active segment number.

SEGment#<header>

Purpose

This command will divide 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 1072 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 two segments with 12 bytes of data that contains start address and segment size information.

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

This command causes the transfer of 12 bytes of data (2 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 6.

The generator accepts binary data as 64-bit integers, which are sent as long. Therefore, the total number of bytes is always eight times the number of segments. For example, 48 bytes are required to download 6 segments to the segment table. The IEEE-STD-488.2 definition of Definite Lengt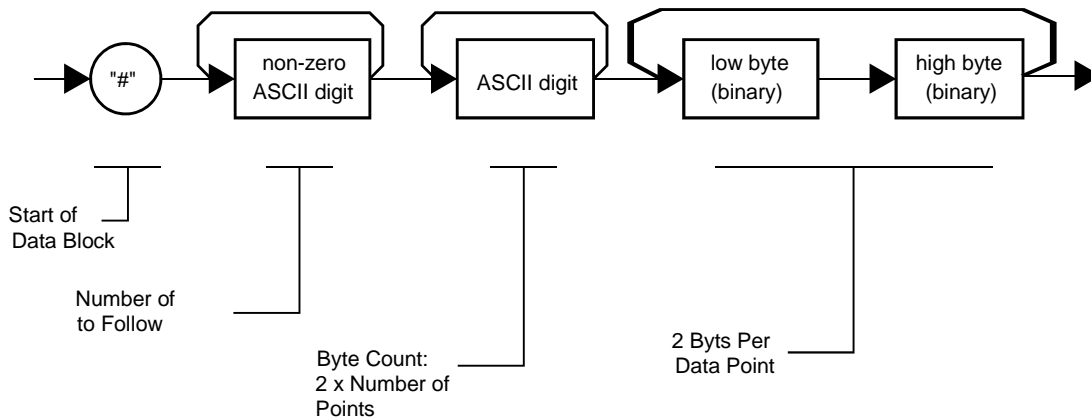h Arbitrary Block Data format is demonstrated in Figure 5-1. The transfer of definite length arbitrary block data must terminate with the EOI bit set. This way, carriage-return (CR – 0dH) and line feed (LF – 0aH) characters can be used as segment table data points and will not cause unexpected termination of the arbitrary block data.

- <binary_block>   Represents segment table data.

The segment table data is made of 48-bit words however, the GPIB link has 8 data bas lines and accepts 8-bit words only. Therefore, the data has to be prepared as 48-bit words and rearranged as six 8-bit words before it can be used by the 1072 as segment table data. There are a number of points you should be aware of before you start preparing the data:

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 2048
3. Maximum segment size depends on segment size. With the basic 1072 you can program maximum 2M in one segment.
4. Segment table data has 64-bit values of which 32 bits are used for start address and 32 bits are used for segment size. Therefore, Data for each segment must have 8 bytes
5. The number of bytes in a complete segment table must divide by 8. The Model 1072 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
6. First segment address starts at 256 decimal or **0x100** in hex
7. Compute the start address for segment "n" using the following equation:

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

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

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

$$= 256 + 10,000 / 4 = 256 + 2,500 = 2756; \text{ and in hex}$$

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

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

Generating Sequenced Waveforms

Sequenced waveforms are made of a number of arbitrary waveforms, which can be linked and looped in user-programmable order. Sequenced waveforms are generated from waveforms stored in the 1072 as memory segments. Therefore, before a sequence can be used, download waveform segments to the arbitrary memory using TRAC# . Information on how to partition the memory and how to download waveforms is given in the section entitled **Generating Arbitrary Waveforms**.

An example of how sequenced waveforms work is demonstrated in figure 1-8 through 1-11. The sequence generator lets you link and loop segments in user-defined order. Figure 1-11 shows a sequence of waveforms that were stored in three different memory segments.

There are a number of tools that you can use to build a sequence table. The easiest way is of course to use the ArbConnection program. Information how to use the ArbConnection program is given in a later chapter. In other cases, SCPI programming allows low-level programming of sequence tables.

In general, sequences can be build one step at a time using the SEQ:DEF command. The one step method is slow and tedious however, it allows better control for one who just begins his first sequence programming. Advanced users can download a complete sequence table using the binary sequence download option. The later being much faster for applications requiring large sequence tables. Use the information below to understand sequence commands and how to implement them in your application.

SEQuence#<header><binary_block>
Purpose
This command will build a complete sequence table in one binary download. In this way, there is no need to define and download individual sequencer steps. Using this command, sequence table data is loaded to the 1072 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 long sequences that use a large number of segment and sequence steps. As an example, the next command will generate two-step sequence with 12 bytes of data that contains segment number, repeats (loops) and mixed mode flag option.

```
SEQuence#212<binary_block>
```

This command causes the transfer of 12 bytes of data (2-step sequence) to the sequence 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 8.

The generator accepts binary data as 48-bit integers, which are sent in two-byte words. Therefore, the total number of bytes is always six times the number of sequence steps. For example, 12 bytes are required to download 2 sequence steps to the sequence 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 sequence data and will not cause unexpected termination of the arbitrary block data.

- <binary_block>   Represents sequence table data.

The segment table data is made of 48-bit words however, the GPIB link has 8 data bas lines and accepts 8-bit words only. Therefore, the data has to be prepared as 48-bit words and rearranged as six 8-bit words before it can be used by the 1072 as sequence table data.

There are a number of points you should be aware of before you start preparing the data:

1. Each channel has its own sequence table buffer. Therefore, make sure you selected the correct active channel (with the INST:SEL command) before you download sequence table data to the generator
2. Minimum number of sequencer steps is 1; maximum number is 2048
3. The number of bytes in a complete sequence table must divide by 8. The Model 1072 has no control over data sent to its sequence table during data transfer. Therefore, wrong data and/or incorrect number of bytes will cause erroneous sequence partition
4. The LSB bit is the only bit used in the mode byte. This bit has an affect on the operation of the sequence only when Mixed Step Advance mode is active. With the LSB bit set to "0", the sequence generator will advance to the next step automatically. With the LSB bit set to "1", the sequence generator will advance to the next step only when a valid trigger signal will be sensed at the trigger input.

SEQuence:ADVance(?){AUTOmatic|STEP|SINGle|MIXed}
Purpose

This command will select the sequence advance mode. The way the instrument advances through the sequence links can be specified by the user.

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

- In **STEP** advance mode, the sequence is advanced to the next waveform only when a valid trigger is received. The output of the 1072 generates the first segment continuously until a trigger signal advances the sequence to the next segment. If repeats were selected for a segment, the loop counter is executed automatically.

- In **SINGle** advance mode, the generator idles between steps until a valid trigger signal is sensed. This mode operates with trigger mode only. An attempt to select the SING advance mode when the 1072 is in continuous operating mode will generate an error. After trigger, the generator outputs one waveform cycle. Then, the output level idles at a DC level equal to the last point of the last generated waveform. If loops (repeats) were programmed, the output will repeat this segment every time a trigger is received. Only after executing all of the programmed loops will the sequence step to the next assigned segment.

- **MIXed** mode is a special mode, which combines continuous step advance with single step advance in a sequence. There are three conditions for the sequence generator to operate in this mode:

1) The 1072 must be set to operate in continuous mode
2) Select the MIX sequence advance mode
3) Assign the mixed mode bits for each sequence step in your SEQ:DEF command. "0" programs

normal advance, "1" programs trigger advance. Step with a "0" bit assigned to it will advance automatically to the next step. If "1" is assigned to a step, the instrument will generate this step and its associated number of repeats continuously and only a valid trigger signal will advance this step to the next step.

SEQuence:ADVance?
Response and default
The 1072 will return the AUTO, STEP, SING, or MIX depending on the present sequence advance mode setting. Default value is AUTO

SEQuence:ADVance:SOURce(?){EXTernal|INTernal}
Purpose
This command will select the sequence advance source. The source of the event causing sequence advance can be specified by the user.

● <EXTernal> will set the external advance mode

● <INTernal> will set the internal advance mode

SEQuence:ADVance:SOURce?
Response and default
The 1072 will return the EXT, or INT depending on the present single-sequence advance source setting. Default value is INT.

SEQuence:DEFine <step_#>,<segment_#>,<#_repeat>,<mode>
Purpose
This command will define sequence steps and their associated advance mode.

● <step_#> will define the link number

● <segment_#> will select the segment for the above link

● <#_repeat> will define how many times the selected segment will loop

● <mode> will assign the mixed mode bits for this sequence step. "0" programs normal advance, "1" programs trigger advance. Step with a "0" bit assigned to it will advance automatically to the next step. If "1" is assigned to a step, the instrument will generate this step and its associated number of repeats continuously and only a valid trigger signal will advance this step to the next step. Note that the <mode> parameter has no affect when the sequence advance mode is set to SING.

To understand better the way the <mode> switch affects a sequence, consider the following sequence setting:

```
SEQ:DEF 1,1,1,0        (Step 1 = segment 1, no loops, mode 0)
SEQ:DEF 2,2,1,1        (Step 2 = segment 2, no loops, mode 1)
SEQ:DEF 3,3,10,1       (Step 3 = segment 3, 10 loops, mode 1)
SEQ:DEF 4,4,1,0        (Step 4 = segment 4, no loops, mode 0)
```

After selecting the sequence mode, the generator will generate segment 1 and automatically advance to segment 2. It will continue to generate segment 2 until a valid trigger is received. After it has received a

trigger, the generator will complete segment 2 and advance to segment 3. It will continue to generate and loop segment 2 until a valid trigger is received. After it has received a trigger, the generator will complete 10 loops of segment 3 and will advance to segment 4. From segment 4 the generator will automatically advance to the beginning of the sequence and will repeat the above.

Note

Although trigger signals are used to advance mixed mode, the mixed mode operates in continuous mode only. The <mode> parameter will be ignored if you will use SING as advance mode for the sequence table.

Tip

Every time you use the SEQ:DEF command while your 1072 is in sequenced operating mode, the instrument attempts to rebuild the sequence table and restart the sequence. Therefore, sending this command in sequenced mode will slow the programming process and the operation of the generator. Using the SEQ:DEF command in FIX or USER mode will greatly speed up programming time.

SEQuence:DELete:ALL
Purpose
This command will erase the sequence table.

SYSTem Subsystem

The system-related commands are not related directly to waveform generation but are an important part of operating the 1072. These commands can reset or test the instrument, or query the instrument for system information.

Keyword	Parameter Form	Default,Low Limit,High
Limit		

```
:SYSTem
  :ERRor?
  :VERSion?
RESet
*RST
TEST?
*IDN?
```

SYSTem:ERRor?

Purpose
This query will interrogate the 1072 for programming errors.

Response to query
The 1072 will return error code. Error messages are listed later in this manual.

SYSTem:VERSion?

Purpose
This query will interrogate the 1072 for SCPI version.

Response to query
The 1072 will return 1999.0.

RESet, *RST

Purpose
This command will reset the 1072 to factory defaults.

*IDN?

Purpose
This query will interrogate the identity of the 1072.

Response to query
The 1072 will return Tabor Electronics,1072,0,1.0.

IEEE-STD-488.2 Common Commands and Queries

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 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 1072

*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 1072 response to *IDN? is:

Tabor Electronics,1072,0,1.0

*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 1072 with no options.

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

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

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

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

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

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

The SCPI Status Registers

The Model 1072 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.
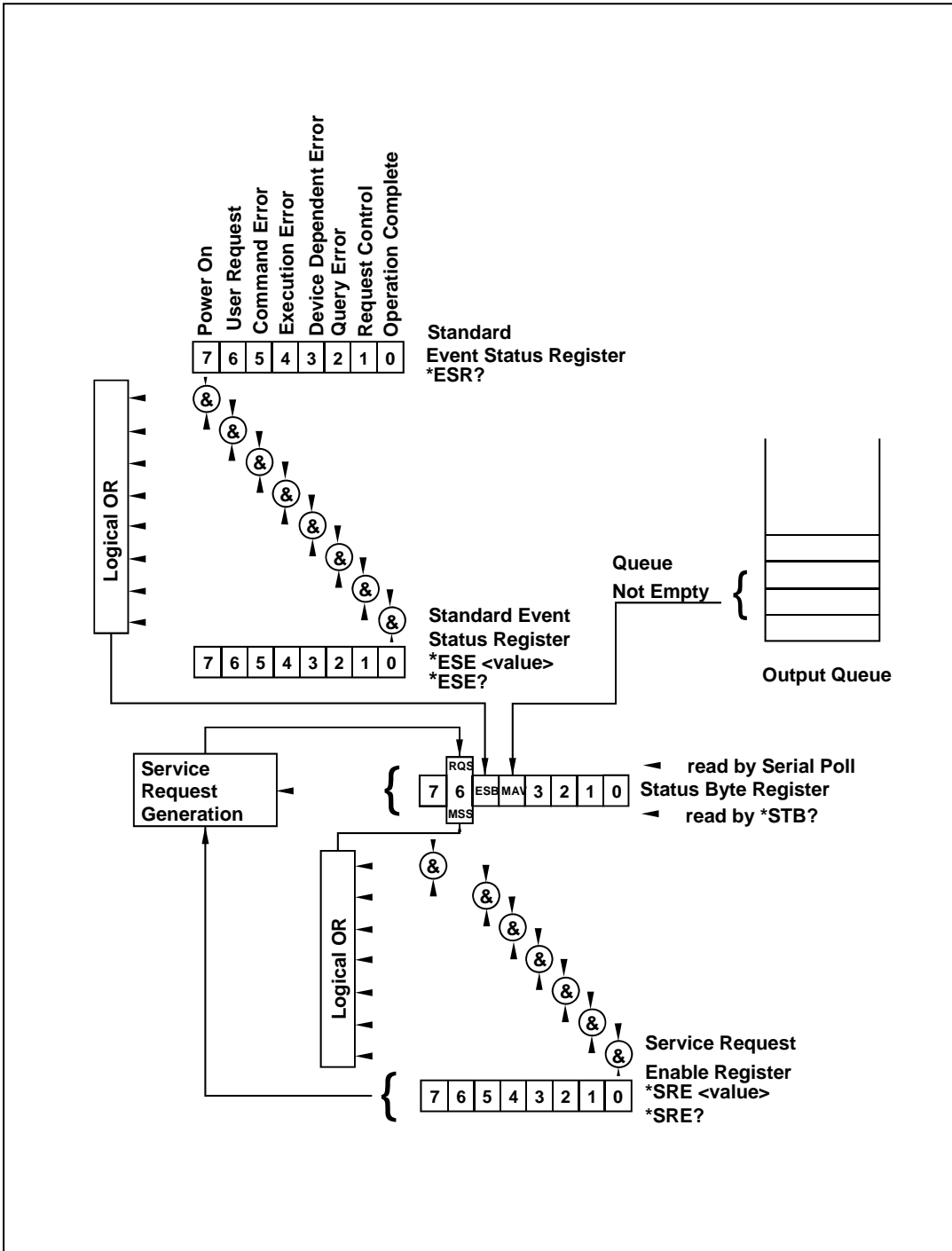
Figure 5-5. SCPI Status Registers

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 1072.

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 an amplitude and offset combination.

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

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

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

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

Standard Event Status Enable Register (ESE)

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

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

The Standard Event Status Enable Register is written using the *ESE command followed by a decimal value representing the bit values of the Register. A bit value one indicates an enabled condition. Consequently, a bit value of zero indicates a disabled condition. The Standard Event Status Enable Register is cleared by setting *ESE0. Summary of *ESE messages is given 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 1072 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. ampl/2 + |offset| is more than 5. Corrective action: Reduce offset to 0, then change amplitude-offset values to correct the problem.

3. Activating filters when the 1072 is set to output the built-in sine waveform, or activating the built-in sine waveform when one of the 1072 filters is turned on. Corrective action: If in sine, select another function and activate the filter(s).

4. Activating burst mode when the 1072 is set to sequence mode, or activating sequence mode when the 1072 is set to burst mode. Corrective action: Remove the 1072 from burst or sequence and then selected the desired mode.

5. Changing operating mode from triggered to continuous when the 1072 is set to single sequence advance, or changing the operating mode from continuous to triggered when the 1072 is set to automatic sequence advance mode. Corrective action: Observe the 1072 advance mode while setting sequence advance.

-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. For example, if memory size exceeds the minimum or maximum allowable memory size limits.

-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
Maintenance and Performance Checks

What's in This Chapter?

This chapter provides maintenance and service information, performance tests, and the procedures necessary to adjust and troubleshoot the Model 1072 Universal Waveform Generator.

WARNING

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

CAUTION

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

Disassembly Instructions

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

1. Using a Phillips head screwdriver, remove the screws from the top and bottom covers.

2. Carefully lift the top cover from its back end and slide the cover to the rear to clear the front panel spring latch. Do the same for the bottom. After removing the covers from the instrument, access the component side for calibration and checks, and the solder side when replacing components.

3. When replacing the top and bottom covers, reverse the above procedure.

Special Handling of Static Sensitive Devices

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

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

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

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

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

5. Use only anti-static type solder suckers.

6. Use only grounded soldering irons.

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

Cleaning

The Model 1072 should be cleaned as often as operating conditions require. To clean the instrument, use the following procedure:

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

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

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

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

Repair and Replacement

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

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

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

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

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

Performance Checks

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

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

2. As part of the troubleshooting procedure;

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

Environmental Conditions

Tests should be performed under laboratory conditions having an ambient temperature of 25°C, ±5°C and at relative humidity of less than 80%. If the instrument has been subjected to conditions outside these ranges, allow at least one additional hour for the instrument to stabilize before beginning the adjustment procedure.

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 1072 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 1072 to factory defaults, use the Factory Reset option in the Utility menu.

Recommended Test Equipment

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

Table 6-1, Recommended Test Equipment

Equipment	Model No.	Manufacturer
Oscilloscope (with jitter package)	LT342	LeCroy
Distortion Analyzer	6900B	Krohn Hite
Digital Multimeter	2000	Keithley
Freq. Counter	6020-2-4	Tabor Electronics
Spectrum Analyzer	E4411	HP
Pulse Generator (with manual trigger)	8500	Tabor Electronics

Performance Check Procedures

Use the following procedures to check the Model 1072 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 **Equipment**: Counter

Preparation:

1. Configure the counter as follows:
   Measurement function: Freq A
   Termination: 50Ω, DC coupled
2. Connect the 1072 Channel 1 output to the counter input –
   channel A
3. Configure the 1072, channel 1 as follows:
   Reset
   Frequency: As specified in Table 6-2
   Waveform: Square wave
   Amplitude: 1V
   Output: On

Test Procedure
1. Perform frequency Accuracy tests using Table 6-2

Table 6-2, Frequency Accuracy

1072 Setting	Error Limits	Counter Reading CH 1	Pass	Fail
10.00000Hz	±1ppm			
100.0000Hz	±1ppm			
1.000000kHz	±1ppm			
10.00000kHz	±1ppm			
100.0000kHz	±1ppm			
1.000000MHz	±1ppm			
10.00000MHz	±1ppm			
25.00000MHz	±1ppm			
50.00000MHz	±1ppm			

2. Configure model 1072 to accept external 10MHz reference.
   Make sure that the external reference accuracy is better than
   1ppm.
3. Perform Frequency Accuracy tests using Table 6-3.

Table 6-3, Frequency Accuracy Using External 10MHz Reference

1072 Setting	Error Limits	Counter Reading CH 1	Pass	Fail
10.00000MHz	±0.1ppm			
25.00000MHz	±0.1ppm			
50.00000MHz	±0.1ppm			

Amplitude Accuracy

Equipment: DMM

Preparation:

1. Configure the DMM as follows:
   Termination: 50Ω feedthrough at the DMM input
   Function: ACV
2. Connect 1072 Channel 1/2 output to the DMM input
3. Configure the 1072 channels 1/2 as follows:
   Reset
   Frequency: 1KHz
   Amplitude: As specified in Table 6-4
   Output: On

Test Procedure
4. Perform amplitude Accuracy tests on both channels using Table 6-4

Table 6-4, Amplitude Accuracy

1072 Setting	Error Limits	DMM Reading		Pass	Fail
		CH 1	CH 2		
10.00V	3.534V, ±53.0mV				
5.000V	1.767V, ±35.3mV				
1.000V	353.4mV, ±21.1mV				
100.0mV	35.34mV, ±3.88mV				
10.00mV	3.534mV, ±1.449mV				

Offset Accuracy

Equipment: DMM

Preparation:

1. Configure the DMM as follows:
   Termination: 50Ω feedthrough at the DMM input
   Function: DCV
2. Connect 1072 Channel 1/2 output to the DMM input
3. Configure the 1072 channels 1/2 as follows:
   Reset
   Frequency: 1MHz
   Amplitude: 10mV
   Offset: As specified in Table 6-5
   Output: On

Test Procedure
1. Perform Offset Accuracy tests on both channels using Table 6-5

Table 6-5, Offset Accuracy

1072 Setting	Error Limits	DMM Reading		Pass	Fail
		CH 1	CH 2		
+4.000V	±40mV				
+400mV	±4mV				
-400mV	±4mV				
-4.000V	±40mV				

Square wave Characteristics

Equipment: Oscilloscope

Preparation:

1. Configure the Oscilloscope as follows:
   Termination: 50Ω feedthrough at the oscilloscope input
   Setup: As required for the test
1. Connect 1072 Channel 1/2 output to the oscilloscope input
2. Configure the 1072 channels 1/2 as follows:
   Reset
   Frequency: 1MHz
   Waveform: Square wave
   Amplitude: 5V
   Output: On

Test Procedure
1. Perform Square wave Characteristics tests on both channels using Table 6-6

Table 6-6, Square wave Characteristics Tests

1072 Setting	Error Limits	DMM Reading		Pass	Fail
		CH 1	CH 2		
Rise/Fall Time	≤ 10 ns				
Ringing	< 5%				
Over/undershoot	< 5%				

Sine Wave Characteristics

Sine Wave Distortion

Equipment: Distortion Analyzer, ArbConnection

Preparation:

1. Connect 1072 Channel 1/2 outputs to the distortion analyzer input. Use 50Ω feedthrough termination at the distortion analyzer input
2. Configure the 1072 channels 1/2 as follows:
   Reset
   SCLK: As required by the test
   Waveform: Arbitrary
   Amplitude: 5V
   Output: On
3. Using ArbConnection prepare and download the following waveform:
   Wavelength: As required by the test
   Waveform: Sine wave

Test Procedure

1. Perform Sine wave distortion tests on both channels using Table 6-7

Table 6-7, Front Panel Sine wave Distortions Test

1072 Setting	SCLK	Reading Limits	Distortion Reading		Pass	Fail
			CH 1	CH 2		
10.00Hz	40kS/s	< 0.1%				
100.0Hz	400kS/s	< 0.1%				
1.000kHz	4MS/s	< 0.1%				
10.00kHz	40Ms/s	< 0.1%				
100.00kHz	100Ms/s	< 0.1%				

2. Remove the cables from the front panel outputs and connect one cable to the rear-panel SINE OUT connector
3. Perform sine wave distortion tests using Table 6-8

Table 6-8, Rear Panel Sine wave Distortions Test

Sine Freq	SCLK Setting	Reading Limits	Distortion Reading Rear Panel Sine Out	Pass	Fail
10.00Hz	10S/s	< 0.05%			
100.0Hz	100S/s	< 0.05%			
1.000kHz	1kS/s	< 0.05%			
10.00kHz	10kS/s	< 0.05%			

| 100.0kHz | 100kS/s | < 0.05% | | | |

Sine wave Spectral Purity

Equipment: Spectrum Analyzer

Preparation:

1. Connect 1072 Channel 1/2 outputs to the spectrum analyzer input. Use 50Ω and 20dB feedthrough termination at the spectrum analyzer input
2. Configure the 1072 channels 1/2 as follows:
   Reset
   Frequency: As required by the test
   Waveform: Sine wave
   Amplitude: 5V
   Output: On

Test Procedure

1. Perform front panel sine wave spectral purity tests using Table 6-9

Table 6-9, Front Panel Sine wave Spectral Purity Test

		Spectrum Analyzer					
Sine Freq	**Reading Limits**	**Start**	**Stop**	**CH 1**	**CH 2**	**Pass**	**Fail**
1MHz	>50dBc	100K	10M				
5MHz	>40dBc	1M	20M				
10MHz	>35dBc	1M	50M				
50MHz	>22dBc	10M	300M				

2. Remove the cables from the front panel outputs and connect one cable to the rear-panel SINE OUT connector
3. Change function shape to arbitrary and perform rear panel spectral purity tests using Table 6-10

Table 6-10, Rear Panel Sine wave Spectral Purity Test

		Spectrum Analyzer				
SCLK Freq	**Reading Limits**	**Start**	**Stop**	**Rear Panel Out**	**Pass**	**Fail**
1MHz	>50dBc	100k	50M			
5MHz	>45dBc	1M	50M			
10MHz	>45dBc	1M	50M			
100MHz	>25dBc	10M	300M			

Trigger Operation

Trigger, Gate and Burst

Equipment: Oscilloscope, function generator, counter

Preparation:

1. Configure the Oscilloscope as follows:
   Termination: 20dB, 50Ω feedthrough attenuator
   Setup: As required for the test
2. Connect 1072 Channel 1/2 outputs to the oscilloscope input. Place the feedthrough attenuator at the oscilloscope inputs
3. Configure the function generator as follows:
   Frequency: 1kHz
   Run Mode: As required by the test
   Wave: TTL level Square from the main output.
4. Connect the function generator output to the 1072 TRIG IN connector
5. Configure the 1072 channels 1/2 as follows:
   Reset
   Frequency: 1.5625MHz
   Burst Count: 10e6 counts, each channel
   Internal Trigger: 1ms
   Amplitude: 5V
   Output: On

Test Procedure

1. Perform trigger and gate tests using Tables 6-11
2. Configure the counter to TOTB Measurements and perform burst tests using Tables 6-11

Table 6-11, Trigger, gate, and burst Characteristics

1072 Setting	External Trigger Signal	Oscilloscope Reading	Pass	Fail
Triggered	1kHz, TTL, 20 ns width	Triggered waveform		
Gated	1kHz, TTL, 50% duty cycle	Gated Waveform		
Burst 10e6 counts	Single shot TTL, 20 ns width	10e6 waveforms, triggered		
Internal Trigger	None	One cycle every 1 ms		

Trigger Slope

Equipment: Oscilloscope, function generator

Preparation:

1. Configure the Oscilloscope as follows:
   Termination: 20dB, 50Ω feedthrough attenuator
   Setup: As required for the test
   Trigger Source: External

2. Connect 1072 Channel 1/2 output to the oscilloscope input. Place the feedthrough attenuator at the oscilloscope inputs
3. Configure the function generator as follows:
    Frequency   1kHz
    Run Mode: Continuous
     Waveform: TTL Output
4. Connect the function generator TTL output to the 1072 TRIG IN connector
5. Connect the function generator main output to the 2nd channel of the oscilloscope
6. Configure the 1072 channels 1/2 as follows:
    Reset
    Frequency: 10kHz
    Run Mode: Triggered
    Output: On

Test Procedure

7. Toggle 1072 trigger slope from positive to negative visa versa
1. Verify on the oscilloscope that the 1072 transitions are synchronized with the slope of the trigger

Test Results	Pass		Fail	

Trigger Phase

Equipment: Oscilloscope, function generator

Preparation:

1. Configure the Oscilloscope as follows:
    Termination: 20dB, 50Ω feedthrough attenuator
    Setup: As required for the test
    Trigger Source: External
2. Connect 1072 Channel 1/2 output to the oscilloscope input. Place the feedthrough attenuator at the oscilloscope inputs
3. Configure the function generator as follows:
    Frequency   1kHz
    Run Mode: Continuous
     Waveform: TTL Output
4. Connect the function generator TTL output to the 1072 TRIG IN connector
5. Connect the function generator main output to the 2nd channel of the oscilloscope
6. Configure the 1072 channels 1/2 as follows:
    Reset
    Frequency: 10kHz
    Run Mode: Triggered
    Output: On

Test Procedure
1. Modify phase start from 0 to 256, 512 and 768 points
2. Verify on the oscilloscope that the 1072 start phase changes from 0° to 90°, 180° and 270° accordingly

Test Results	Pass		Fail	

Internal Trigger Accuracy

Equipment: Counter

Preparation:

1. Configure the counter as follows:
   Function: Freq A
   Coupling: DC, 50Ω
2. Connect 1072 Channel 1 output to the counter input
3. Using ArbConnection prepare and download the following waveform:
   Wavelength: 16 points
   Waveform: Square wave
4. Configure the 1072 channel 1 as follows:
   Reset
   Waveform: Arbitrary
   Run Mode: Triggered
    Trigger Source: internal
   Internal Trig: As required by the test
   Output: On

Test Procedure
1. Set trigger as required in Table 6-12
2. Verify trigger reading as shown in Table 6-12

Test Results	Pass		Fail	

Table 6-12, Internal Trigger Generator Operation

Int. Trigger Setting	Counter Reading (Freq)	Pass	Fail
2MHz	2MHz ±2kHz		
100kHz	100kHz ±100Hz		
1kHz	1kHz ±1Hz		
1Hz	1Hz ± 1mHz		

Sequence Operation

Automatic Advance

Equipment: Counter

Preparation:

1. Configure the counter as follows:
    Function: TOTB Measurement
2. Connect the counter channel B to the 1072 output
3. Configure the 1072 channels 1/2 as follows:
    Reset
    SCLK   100MS/s
    Waveform: Sequence
    Run Mode: Triggered
    Amplitude: 2V
    Output: On
4. Using ArbConnection prepare and download the following waveform:
    Segments: 1 to 5
    Wavelength: 100 points
    Waveform: 1 cycle square
5. Using ArbConnection, build and download the following sequence table:
    Step 1:   Segment 1, loop 100,000
    Step 2:   Segment 2, loop 100,000
    Step 3:   Segment 3, loop 100,000
    Step 4:   Segment 4, loop 100,000
    Step 5:   Segment 5, loop 100,000

Test Procedure

1. From ArbConnection, press manual trigger and observe that counter reading is 500,000 counts. Reset counter and repeat the test a few times. Every time the counter reading should be 500,000 counts exactly

Test Results	Pass		Fail	

2. Remove the cable from 1072 channel 1 and connect to channel 2
3. Repeat the test procedure as above for channel 2

Test Results	Pass		Fail	

Step Advance

Equipment: Oscilloscope, function generator

Preparation:
1. Configure the Oscilloscope as follows:
Termination:	20dB, 50Ω feedthrough attenuator
Setup:	As required for the test
2. Connect 1072 Channel 1 output to the oscilloscope input
3. Configure the function generator as follows
Frequency	10kHz
Run Mode:	Triggered
Waveform:	Square wave.
Amplitude:	Adjust for TTL level on 50Ω
4. Connect the function generator output to the 1072 rear-panel TRIG IN connector
5. Connect 1072 Ch1 to the Oscilloscope input
6. Configure the 1072 channels 1/2 as follows:
Reset	
SCLK	100MS/s
Waveform:	Sequence
Seq Advance:	Step
Run Mode:	Continuous
Triggered Source:	External
Amplitude:	2V
Output:	On
7. Using ArbConnection prepare and download the following waveform:
Segment 1:	Sine, 1000 points
Segment 2:	Triangle, 1000 points
Segment 3:	Square, 1000 points
Segment 4:	Sinc, 1000 points
Segment 5:	Gaussian Pulse, 1000 points
8. Using ArbConnection, build and download the following sequence table:
Step 1:	Segment 1, loop 1
Step 2:	Segment 2, loop 1
Step 3:	Segment 3, loop 1
Step 4:	Segment 4, loop 1
Step 5:	Segment 5, loop 1

Test Procedure
1. Press the manual trigger button on the function generator and observe that the waveforms advance through the sequence table repeatedly

Test Results	Pass		Fail	

2. Remove the cable from 1072 channel 1 and connect to channel 2
3. Repeat the test procedure as above for channel 2

Test Results	Pass		Fail	

NOTE

Leave the same setup for the next test

Single Advance

Equipment: Oscilloscope, function generator

Preparation:

1. Use the same preparations as for step advance, except change mode to single sequence advance
2. Change function generator run mode to triggered
3. Change Oscilloscope configuration to single

Test Procedure

1. Press the manual trigger button on the function generator and observe that one cycle waveform advances through the sequence table repeatedly with each external trigger signal. Note that you need to press the Single mode on the oscilloscope for each trigger advance

Test Results	Pass		Fail	

2. Remove the cable from 1072 channel 1 and connect to chan 2
3. Repeat the test procedure as above for chan 2

Test Results	Pass		Fail	

Modulated Waveforms Characteristics

FSK

Equipment: Oscilloscope (LeCroy LT342, fitted with jitter package), function generator

Preparation:

1. Configure the oscilloscope as follows:
   Time Base: 0.5 ms
   Memory: 250k
   Sampling Rate: 50MS/s at least.
   Trace A View: Jitter, Type: FREQ, CLK.
   Trigger source: Channel 2, positive slope
   Amplitude: 1V/div
2. Connect 1072 Channel 1 output to the oscilloscope input, chan 1
3. Connect the function generator SYNC output to the oscilloscope input, chan 2
4. Configure the function generator as follows:
   Frequency   1kHz
   Waveform: Square wave.
   Amplitude: Adjust for TTL level on 50Ω
5. Connect the function generator output to the 1072 rear-panel TRIG IN connector
6. Configure the 1072 channels 1/2 as follows:
   Reset
   Modulation Mode: FSK ON
   Output: On

Test Procedure

1. Verify FSK operation on the oscilloscope as follows:
   Waveform: Square wave
   Period: 1ms
   Max A: 1.25MHz
   Min A: 1MHz

Test Results	Pass		Fail	

2. Remove the cable from 1072 channel 1 and connect to chan 2
3. Repeat the test procedure as above for chan 2

Test Results	Pass		Fail	

 NOTE

Leave the same setup for the next test

Ramped FSK

Equipment: Oscilloscope (LeCroy LT342, fitted with jitter package), function generator

Preparation:

Use the same preparation as in the previous test except make the following changes in the setup:
1. Change the 1072 FSK Type to RAMP
2. Change function generator output frequency to 200Hz

Test Procedure
1. Verify FSK operation on the oscilloscope as follows:
   - Waveform: Ramped square
   - Period: 5ms
   - Rise/Fall Time: 1ms
   - Max A: 1.25MHz
   - Min A: 1MHz

Test Results	Pass		Fail	

2. Remove the cable from 1072 channel 1 and connect to chan 2
3. Repeat the test procedure as above for channel 2

Test Results	Pass		Fail	

Sweep

Equipment: Oscilloscope (LeCroy LT342, fitted with jitter package)

Preparation:

1. Configure the oscilloscope as follows:
   - Time Base: 0.5 ms
   - Sampling Rate: 50MS/s at least.
   - Trace A View: Jitter, Type: FREQ, CLK.
   - Trigger source: Channel 2, positive slope

Amplitude: 1V/div
2. Connect 1072 Channel 1 output to the oscilloscope input, chan 1
3. Connect the 1072 SYNC output to the oscilloscope input, chan 2
4. Configure the 1072 channels 1/2 as follows:
   Reset
   Modulation Mode: Sweep ON
   Sync: On
   Output: On

Test Procedure
1. Verify Sweep operation on the oscilloscope as follows:
   Waveform: Ramp Down
   Period: 1ms
   Max A: 1MHz
   Min A: 312.5kHz

Test Results	Pass		Fail	

2. Move 1072 sweep marker position to 42MS/s and verify marker position at the middle of the ramp
3. Change oscilloscope time base to 1µs and verify marker width = 2µs

Test Results	Pass		Fail	

4. Reverse between Start and Stop frequencies and verify oscilloscope reading as before except the ramp is up

Test Results	Pass		Fail	

5. Change sweep step to logarithmic and verify oscilloscope exponential up waveform

Test Results	Pass		Fail	

6. Remove the cable from 1072 channel 1 and connect to chan 2
7. Repeat the test procedure as above for channel 2

Test Results	Pass		Fail	

FM – Std. Waveforms

Equipment: Oscilloscope (LeCroy LT342, fitted with jitter package)

Preparation:
1. Configure the oscilloscope as follows:
   - Time Base: 0.5 ms
   - Memory: 250k
   - Trace A View: Jitter, Type: FREQ, CLK.
   - Trigger source: Channel 2, positive slope
   - Amplitude: 1V/div
2. Connect 1072 Channel 1 output to the oscilloscope input, chan 1
3. Connect the 1072 SYNC output to the oscilloscope input, chan 2
4. Configure the 1072 channels 1/2 as follows:
   - Reset
   - Modulation Mode: FM ON
   - Deviation: 60MS/s
   - Sync: On
   - Output: On

Test Procedure
1. Verify FM operation on the oscilloscope as follows:
   - Waveform: Sine
   - Period: 1ms
   - Max A: 1.468MHz
   - Min A: 531kHz

Test Results	Pass		Fail	

2. Modify 1072 modulating waveform to triangle, then square and ramp and verify FM waveforms as selected

Test Results	Pass		Fail	

3. Remove the cable from 1072 channel 1 and connect to chan 2
4. Repeat the test procedure as above for channel 2

Test Results	Pass		Fail	

FM – Arb. Waveforms

Equipment: Oscilloscope (LeCroy LT342, fitted with jitter package)

Preparation:

1. Configure the oscilloscope as follows:
   Time Base: 0.5 ms
   Memory: 250k.
   Trace A View: Jitter, Type: FREQ, CLK.
   Trigger source: Channel 2, positive slope
   Amplitude: 1V/div
2. Connect 1072 Channel 1 output to the oscilloscope input, chan 1
3. Connect the 1072 SYNC output to the oscilloscope input, chan 2
4. Configure the 1072 channels 1/2 as follows:
   Reset
   Modulation Mode: FM ON
   Modulating Wave: Arbitrary
   Sync: On
   Output: On
5. Using ArbConnection, open the FM Composer and download the following waveform:
   Wavelength: 1000 points
   Waveform: Sine wave
   Deviation: 72MS/s

Test Procedure

1. Verify FM operation on the oscilloscope as follows:
   Waveform: Sine
   Period: 1ms
   Max A: 1.5625MHz
   Min A: 437.5kHz

Test Results	Pass		Fail	

2. Remove the cable from 1072 channel 1 and connect to chan 2
3. Repeat the test procedure as above for channel 2

Test Results	Pass		Fail	

AM

Equipment: Oscilloscope, function generator

Preparation:

1. Configure the oscilloscope as follows:
   Time Base: 0.5 ms
   Trigger source: Channel 2, positive slope
   Amplitude: 1V/div
2. Connect 1072 Channel 1 output to the oscilloscope input, chan 1
3. Connect the function generator SYNC output to the oscilloscope input, chan 2
4. Configure the function generator as follows:
   Waveform: Sine wave
   Frequency: 1 kHz
   Amplitude: 5Vp-p
   Offset   2.5V
5. Connect the function generator output to the 1072 rear panel AM input
6. Configure the 1072 channels 1/2 as follows:
   Reset
   Modulation Mode: AM ON
   Output: On

Test Procedure

1. Verify AM operation on the oscilloscope as follows:
   Waveform: Amplitude Modulated Sine
   Modulation Depth: 100%, ±10%

Test Results	Pass		Fail	

2. Remove the cable from 1072 channel 1 and connect to chan 2
3. Repeat the test procedure as above for channel 2

Test Results	Pass		Fail	

Adjustments

Introduction

This document contains the calibration procedure for the 100MS/s dual–channel Universal Waveform Generator Model 1072. A list of specifications is given in Appendix A of the Operations Manual. The calibration procedures that are described in this document are for use by qualified service personnel only. Do not perform these procedures unless qualified to do so. This procedure is intended to be used once before complete and final performance verification to verify that the 1072 meets or exceeds its published specifications.

Description

The 1072 is a bench-type instrument. The output can generate a standard set of waveforms. These waveforms include Sine, Triangle, Square, Pulse, Ramp, Sinc, Gaussian, Exponential Decaying/Rising Pulse, Noise, and DC. Arbitrary waveforms are generated by downloading data to memory. Large waveform memories are provided so that multiple waveforms can be loaded at once. Powerful sequencing allows the waveform segments to be generated in any order. Communicating with the 1072 is done via ENET, USB, or GPIB.

Environmental Conditions

The 1072 can operate from 0°C to 50°C. Calibration should be performed under laboratory conditions having an ambient temperature of 25°C, ±5°C and at relative humidity of less than 80%. Turn on the power to the 1072 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.

Required Equipment

Recommended equipment for calibration is listed in Table 6-12. 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 6-13, Required Equipment

Instrument	Manufacturer	Model
DMM	Keithley	2000
Oscilloscope	LeCroy	LT342
10MHz Reference	Oscilloquarz	10MHz
Counter/Timer	Tabor	6030
Accessories	BNC to BNC cable	
	50Ω Feedthrough termination	
	Dual banana to BNC adapter	
	500Ω probe	

Initial Instrument Setting

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

Adjustment Procedures

Use the following procedures to calibrate the Model 1072. The following paragraphs show how to set up the instrument for calibration and what the acceptable calibration limits are.

DDS Duty Cycle Adjustment

Equipment:

Oscilloscope, 500Ω probe

Procedure:

1. Modify 1072 Waveform to Arbitrary and set SCLK to 100MS/s
2. Connect a 500Ω probe to U50 pin 17 and adjust RV13 (DUTY CYCLE) for a approximately 50% duty cycle waveform
3. Connect the probe to U50 pin 20 and re-adjust RV13 for approximately 50% duty cycle waveform
4. Repeat steps 2 and 3 until you achieve the smallest error at these two points

Sine Out Offset Adjustment

Equipment:

DMM, BNC to BNC cable, Dual banana to BNC adapter

Procedure:

1. Modify 1072 frequency setting to 1kHz
2. Modify the DMM setting to DCV/2V measurements and connect the rear-panel SINE OUT connector to the DMM input
3. Adjust RV12 (SINE OFFS) for 0V $\pm$5 mV reading

TCXO Frequency Adjustment

Equipment:

Counter, 10MHz External Reference BNC to BNC cable

Procedure:

1. Modify 1072 frequency setting to 10.00000MHz, amplitude to 2V and output function to square waveform
2. Modify the counter setting to frequency measurements and connect the front-panel CHAN 1 connector to the counter input. Use external frequency reference to drive the counter clock
3. Adjust RV7 (10MHz ADJ) for 10.000000 $\pm$1Hz reading

Channel 1, Amplitude and Balance Adjustment

Equipment:

DMM, BNC to BNC cable, 50Ω Feedthrough termination, Dual banana to BNC adapter,

Procedure:

1. Modify 1072 frequency setting to 1KHz and channel 1 amplitude to 3.161V
2. Modify the DMM setting ACV/10V and connect the front-panel CHAN 1 connector, to the DMM input. Use 50Ω Feedthrough termination at the DMM side of the BNC cable
3. Note and record the DMM reading
4. Modify 1072 amplitude setting to 3.162V
5. Adjust RV9 (LIN1) for a DMM reading as was recorded in step 3, ±10 mV
6. Repeat steps 1 through 5 for a few times until the reading is balanced to within ±10mV
7. Modify the DMM setting to DCV
8. Modify 1072 frequency to 10kHz. Repeat the sequence above but this time measuring DC voltage and adjust RV5 (ZERO CH!) until you balance the readings between the two amplitude settings to within ±10mV
9. Modify 1072 amplitude setting to 1V
10. Modify 1072 frequency to 1MHz. Adjust RV1 (NULL1) for a DMM reading of 0V, ±2mV
11. Modify 1072 amplitude setting to 10 V
12. Modify DMM setting to ACV and adjust RV15 (AMPL1) for a DMM reading of 3.535V, ±20mV
13. Modify 1072 amplitude setting to 6V
14. Re-adjust RV15 (AMPL1) for a DMM reading of 2.121V, ±10 mV
15. Repeat the sequence above from 11 through 14 until you balance the readings between 10V and 6V settings to within ±10mV

Channel 1, Offset Fine Adjustment

Equipment:

DMM, BNC to BNC cable, 50Ω Feedthrough termination, Dual banana to BNC adapter,

Procedure:

1. Modify 1072 channel 1 amplitude setting to 1V and offset to -4.46484V
2. Modify the DMM setting DCV/10V and connect the front-panel CHAN 1 connector, to the DMM input. Use 50Ω Feedthrough termination at the DMM side of the BNC cable
3. Note and record the offset reading on the DMM
4. Modify 1072 channel 1 offset to -4.46483V
5. Adjust RV16 (FINE OFFS1) for offset reading as was recorded in step 3, ±1mV

Channel 1, Offset Adjustment

Equipment:

DMM, BNC to BNC cable, 50Ω Feedthrough termination, Dual banana to BNC adapter,

Procedure:

1. Modify 1072 channel 1 amplitude setting to 1V and offset to 4V
2. Modify the DMM setting DCV/10V and connect the front-panel CHAN 1 connector, to the DMM input. Use 50Ω Feedthrough termination at the DMM side of the BNC cable
3. Adjust RV4 (OFFS1) for a DMM reading of 4V, ±10mV. Note and record the value
4. Modify 1072 channel 1 offset to -4V
5. Adjust RV1 (NULL1) for a DMM reading as was recorder in step 3, except disregard the polarity
6. Repeat steps 1 through 5 until positive and negative readings are within ±10mV

Channel 1, Offset Compensation

Equipment:

DMM, BNC to BNC cable, 50Ω Feedthrough termination, Dual banana to BNC adapter,

Procedure:

1. Modify 1072 channel 1 amplitude setting to 50mV and frequency to 1MHz
2. Modify the DMM setting DCV/100mV and connect the front-panel CHAN 1 connector, to the DMM input. Use 50Ω Feedthrough termination at the DMM side of the BNC cable
3. Adjust RV2 (OFFS COMP1) for a DMM reading of 0V, ±10mV.

Channel 2, Amplitude and Balance Adjustment

Equipment:

DMM, BNC to BNC cable, 50Ω Feedthrough termination, Dual banana to BNC adapter,

Procedure:

1. Modify 1072 frequency setting to 1kHz and channel 2 amplitude to 3.161V
2. Modify the DMM setting ACV/10V and connect the front-panel CHAN 2 connector, to the DMM input. Use 50Ω Feedthrough termination at the DMM side of the BNC cable
3. Note and record the DMM reading
4. Modify 1072 amplitude setting to 3.162V
5. Adjust RV3 (LIN2) for a DMM reading as was recorded in step 3, ±10mV
6. Repeat steps 1 through 5 for a few times until the reading is balanced to within ±10mV
7. Modify the DMM setting to DCV
8. Modify 1072 frequency to 10kHz. Repeat the sequence above but this time measuring DC voltage and adjust RV6 (ZERO CH2) until you balance the readings between the two amplitude settings to within ±10mV
9. Modify 1072 amplitude setting to 1V
10. Modify 1072 frequency to 1MHz. Adjust RV10 (NULL2) for a DMM reading of 0 V, ±2mV
11. Modify 1072 amplitude setting to 10V
12. Modify DMM setting to ACV and adjust RV14 (AMPL2) for a DMM reading of 3.535 V, ±20mV
13. Modify 1072 amplitude setting to 6V
14. Re-adjust RV14 (AMPL2) for a DMM reading of 2.121 V, ±10mV
15. Repeat the sequence above from 11 through 14 until you balance the readings between 10V and 6V settings to within ±10mV

Channel 2, Offset Fine Adjustment

Equipment:

DMM, BNC to BNC cable, 50Ω Feedthrough termination, Dual banana to BNC adapter,

Procedure:

1. Modify 1072 channel 2 amplitude setting to 1V and offset to -4.46484V
2. Modify the DMM setting DCV/10V and connect the front-panel CHAN 2 connector, to the DMM input. Use 50Ω Feedthrough termination at the DMM side of the BNC cable
3. Note and record the offset reading on the DMM
4. Modify 1072 channel 2 offset to -4.46483V
5. Adjust RV17 (FINE OFFS2) for offset reading as was recorded in step 3, ±1mV

Channel 2, Offset Adjustment

Equipment:

DMM, BNC to BNC cable, 50Ω Feedthrough termination, Dual banana to BNC adapter,

Procedure:

1. Modify 1072 channel 2 amplitude setting to 1V and offset to 4V
2. Modify the DMM setting DCV/10V and connect the front-panel CHAN 2 connector, to the DMM input. Use 50Ω Feedthrough termination at the DMM side of the BNC cable
3. Adjust RV11 (OFFS2) for a DMM reading of 4V, ±10mV. Note and record the value
4. Modify 1072 channel 1 offset to -4V
5. Adjust RV10 (NULL2) for a DMM reading as was recorder in step 3, except disregard the polarity
6. Repeat steps 1 through 5 until positive and negative readings are within ±10mV

Channel 2, Offset Compensation

Equipment:

DMM, BNC to BNC cable, 50Ω Feedthrough termination, Dual banana to BNC adapter,

Procedure:

1. Modify 1072 channel 2 amplitude setting to 50mV and frequency to 1MHz
2. Modify the DMM setting DCV/100mV and connect the front-panel CHAN 2 connector, to the DMM input. Use 50Ω Feedthrough termination at the DMM side of the BNC cable
3. Adjust RV8 (OFFS COMP2) for a DMM reading of 0V, ±10mV.

Updating 1072 Firmware

⚠️ *CAUTION*

Only qualified persons may perform Firmware updates. DO NOT even attempt to perform this operation unless you were trained and certified by Tabor Electronics 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 1072, 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 6-1. 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 6-1, Software Version Screen

📝 *NOTE*

Firmware updates are performed with the LAN set as the active interface and with the 1072 communicating with the PC through the network.

To update the 1072 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. Power on your device.

2. Click on NETConfig shortcut on the desktop or select Start »Programs» Tabor Electronics» NETConfig» NETConfig 1.0

The NETConfig window lists Tabor Electronics devices found on your subnet. Figure 6-2 shows an example of this display.
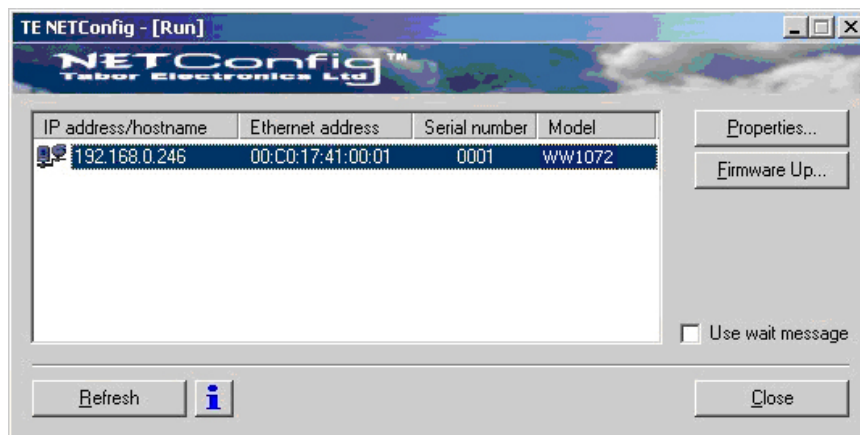
Figure 6-2, The NETConfig Utility

📝 *NOTES*

Click Refresh if you do not see your device in the list of Ethernet devices, or to discover a device that your NETConfig utility recently added to the subnet. You can only update instruments 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 6-3 appears.
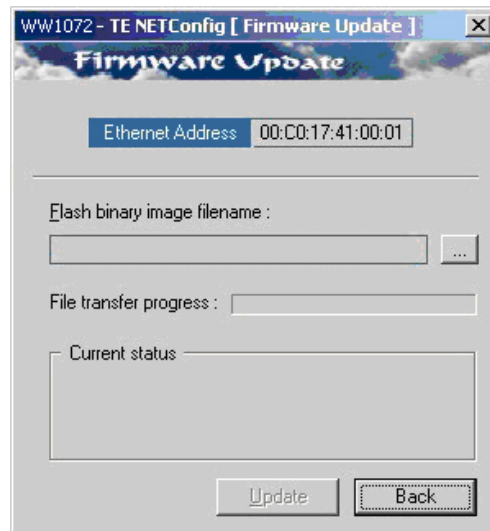
Figure 6-3, The Firmware Update Dialog Box

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 6-4. 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.

Click on Back to close NETConfig Firmware Update dialog box and turn off the power to the 1072. The next time you power up the instrument, the device automatically reboots with the new firmware in effect.
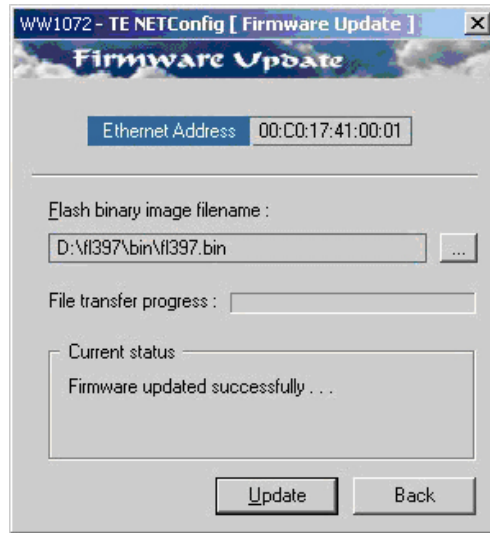
Figure 6-4, Firmware update Path

Appendices

Appendix	Title	Page

Appendix A
Specifications

Configuration
Output Channels	2, semi-independent

Inter-Channel Control

Leading Edge Offset
Description	Channel 2 edge trails channel 1 edge by a programmable number of points.
Offset Units	Waveform points
Range	0 to 1 Meg points (2 Meg optional)
Resolution and Accuracy	1 point, or 1 sample clock period of channel 2
Initial Skew	<±2ns, with sclk divider = 1

Channel 2 Sample Clock Divider
Description	The sample clock source is common to both channels 1 and 2. The sample clock for the slave channel can be divided down coherently from 1 to 64k.
Range	1 to 65,535
Resolution	1

Inter-Channel Dependency
Separate controls	Output on/off, amplitude, AM, offset, standard waveforms, user waveforms, user waveform size, sequence table, channel 2 clock divider, trigger start phase, breakpoints
Common Controls	Sample clock, frequency, reference source, trigger modes, sequence advance mode, SYNC output, FM, FSK, sweep, arm start/stop

Multiple Instrument synchronization
Description	Multiple instruments can be connected together and synchronized to provide multi-channel synchronization. Phase (leading edge) offset between master and slave units is programmable.

Leading Edge Offset
Description	Leading edge of master output trails the leading edge of the slave output by a programmable number of points. Each slave can be programmed to have individual offset
Phase Units	Waveform points
Range	0 to 1 Meg points (2 Meg optional)

Resolution and Accuracy	4 point
Initial Skew	<±20ns, depending on cable length and quality, typically with 20 cm coax cables

SAMPLE CLOCK

Sources:
Internal

Range	100mS/s to 100MS/s
Resolution	9 digits, limited by 1μS/s
Accuracy	Same as internal reference
Stability	Same as internal reference
Reference	
Standard	≥0.0001% (1 ppm TCXO) initial tolerance over a 19°C to 29°C temperature range; 1ppm/°C below 19°C and above 29°C; 1ppm/year aging rate
External	10MHz TTL, 50% ±2% duty cycle
External	From rear panel BNC, DC to 100MHz
Level	ECL 100K compatible

SAMPLE CLOCK MODULATION

FM – Built-in Standard Waveforms

Description	Sample clock can be frequency modulated by internal waveforms that are resident in internal memory (fixed waveforms).
Modulation Source	Internal sine square, triangle and ramp
Modulation Frequency Range	1mHz to 100kHz
Resolution	9 digits
Accuracy	0.1%
Modulating Frequency Distortion	<0.1%
Deviation Range	100mS/s to 100MS/s
Advance	Automatic, triggered, gated or software command
Marker	
Output and Level	Same as SYNC output.
Position	Programmable for selected frequency

FM – Downloaded Arbitrary Waveforms

Description	Sample clock can be frequency modulated arbitrary waveforms that are downloaded by the user (user waveforms.
Modulation Source	User waveform, any shape, 10 to 20000 waveform points
Modulation Sample Clock Range	1mS/s to 2MS/s
Resolution	9 digits
Accuracy	0.1%
Modulating Frequency Distortion	<0.1%
Sample Clock Deviation Range	100mS/s to 100MS/s
Advance	Automatic, triggered, gated or software command
Marker	
Output and Level	Same as SYNC output.
Position	Programmable for selected frequency
Waveform Download	Through USB, ENET, or DMA channel through GPIB

FSK

Description	Current segment is sampled continuously. External low TTL level programs carrier sample clock, external high TTL level programs shifted sample clock frequency. FSK operates in user shape (arbitrary) waveforms only.
Carrier Sample Clock Range	100mS/s to 100MS/s
FSK Source	
External	Rear panel Trigger input BNC. Low level = carrier sample clock; High level = hop frequency
Frequency Range	From 10MHz to DC
FSK Delay	Minimum 1 waveform cycle + 50ns

Ramped FSK

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

Sweep (*)

Description	Sample Clock sweeps continuously from start to stop, at a rate defined by the sweep time. More complex sweep modes and types can be generated using the FM mode in conjunction with the FM composer program.
Type	Linear or logarithmic
Direction	Up or down, depending on the start and stop setting
Range	100mS/s to 100MS/s
Time	1 ms to 1000s, 4 digits, $\pm$0.1%
Advance	Automatic, triggered, gated or software command
Marker	
Output and Level	Same as SYNC output.
Position	Programmable for selected frequency

OPERATING MODES

Normal	Continuous waveform is generated
Triggered	Each input cycle generates a single output cycle.
Gated	External signal enables generator. First output cycle synchronous with the active slope of the triggering signal. Last cycle of output waveform always completed
External Burst	Preset number from 1 to 1M cycles stimulated by an external or manual trigger. This mode is not available in SEQ mode.
Internal Burst	An internal timer repeatedly generates a burst from 1 to 1M counted cycles. This mode is not available in SEQ mode.

Trigger Sources

External	
Input	Front panel BNC
Level	TTL
Slope Sensitivity	Positive or negative, programmable
Frequency	2MHz to DC
Internal	
Range	100mHz to 2MHz
Resolution	7 digits
Accuracy	0.1%
Software	IEEE 488.2 command

Trigger Start Phase

	Waveform starts from point n and completes at point n-1.
Programmable Units	Waveform points
Range	0 to 1 Meg waveform points (2 Meg optional)
Resolution	4 points

Breakpoint

	Waveform starts after trigger and stops at breakpoint position. Each channel can be programmed with its unique breakpoints
Range	0 to 1 Meg waveform points (2 Meg optional)
Event to cause stop at breakpoint	SCPI command or valid stop signal at the TRIG input.
Event to cause start from breakpoint	SCPI command or valid start signal at the TRIG input.
Breakpoint Error	±4 points

Start/Stop Control

Description	Valid signal at the Trigger input stops the waveform at a programmed breakpoint. The Stop signal operates simultaneously on both channels. Channel stop occurs separately and independently at a breakpoint uniquely programmed for each channel. If breakpoint has not been programmed, the waveform will stop after the last point.
Start/Stop control	Rear Panel Trigger Input BNC, USB ENET or GPIB commands

System Delay

Trigger to waveform output	1 Sample Clock+150ns

STANDARD WAVEFORMS

Frequency Range	Waveform dependent
Source Internal synthesizer	
Resolution	9 digits, limited by 1μHz
Accuracy	Same as internal SCLK reference
Stability	Same as internal SCLK reference

Sine

Frequency Range	100μHz to 50MHz
Band Flatness	5% to 10MHz; 20%, to 50MHz
Programmable Parameters	Start phase, 0 to 360°

Triangle

Frequency Range:	100μHz to 15MHz, usable above 15MHz
Adjustable Parameters	Start phase, 0 to 360°

Square

Frequency Range	100μHz to 50MHz
Adjustable Parameters	Duty cycle, 1% to 99%

Pulse/Ramp

Frequency Range	100μHz to 15MHz, usable above 15MHz
Adjustable Parameters	
Delay	0% to 99.9% of period
Rise Time	0% to 99.9% of period
High Time	0% to 99.9% of period
Fall Time	0% to 99.9% of period

Sinc (Sine(x)/x)
Frequency Range	100μHz to 6.25 MHz, usable above 6.25 MHz
Adjustable Parameters	
Cycles	4 to 100 cycles

Gaussian Pulse
Frequency Range	100μHz to 6.25 MHz, usable above 6.25 MHz
Adjustable Parameters	
Time Constant	10 to 200

Exponential Decaying/Rising Pulse
Frequency Range	100μHz to 6.25 MHz, usable above 6.25 MHz
Adjustable Parameters	
Time Constant	-100 to 100

DC
Range	-100% to 100% of amplitude

ARBITRARY WAVEFORMS
Waveform Memory	1 Meg points standard, 2 Meg points optional
Memory Segmentation	
Number of Segments	1 to 2048
Min Segment Size	16 points
Memory Interleave	4 (All trace lengths must be multiples of 4)
Vertical Resolution	14 bits (16,384 points)
Waveform Download	Through USB, ENET, or DMA channel through GPIB

Sine Wave Performance
Description	Sine wave performance is measured using the maximum sample clock rate, at 5Vp-p, the maximum amplitude resolution of the DAC (14-bit) and without filters. Spectrum analyzer settings: Start frequency = 0MHz; stop frequency = 50MHz (Nyquist frequency)
Sinewave Total Harmonic Distortion	0.1% to 100 KHz
Harmonics and non-related spurious	
below 10MHz	< -50dBc for carrier frequencies ≤1MHz
	< -40dBc for carrier frequencies ≤5MHz
	< -35dBc for carrier frequencies ≤10MHz
	< -22dBc for carrier frequencies ≤50MHz

SEQUENCED ARBITRARY WAVEFORMS
Operation	Permits division of the memory bank into smaller segments. Segments may be linked, and repeated in user-selectable fashion to generate extremely long waveforms.
Advance Modes	
Automatic Sequence Advance	No triggers required to step from one segment to the next. Sequence is repeated continuously through a pre-programmed sequence table
Stepped Sequence Advance	Current segment is sampled continuously, external trigger advances to next programmed segment. Control input is TRIG IN connector.

Single Sequence Advance	Current segment is sampled to the end of the segment including repeats and idles there. Next trigger advances to next segment. Control input is TRIG IN connector.
Mixed Sequence Advance	Each step of a sequence can be programmed to advance either a) automatically (Automatic Sequence Advance), or b) with a trigger (Stepped Sequence Advance)
Advance Source	External, rear panel BNC; Internal; GPIB
Sequencer steps	From 1 to 2048
Segment loops	From 1 to 1 Meg (2 Meg optional)
Segment Duration	Minimum 1µs for more than one loop.

OUTPUTS

Channels 1 and 2 Output
Connector	Front panel BNC
Stand-by	Output Off or Normal
Impedance	50Ω, ±1%
Protection	Protected against temporary short to case ground
Amplitude	
Range	10mV to 10Vp-p, into 50Ω; Double into open circuit
Resolution	3.5 digits
Accuracy (1 KHz)	±(1% + 25mV), 1.000V to 10Vp-p
	±(1% + 5mV), 100mV to 999.9mVp-p
	±(1% + 2mV), 10mV to 99.99mVp-p

Offset
Offset	Offset is independent to amplitude setting as long as |amplitude/2| + |offset| does not exceed 5Vp-p
Range	0 to ±4.5V
Resolution	1mV
Accuracy	±1%
Filters	50 MHz Elliptic
	25 MHz Elliptic

Square Wave, Pulse
Rise/Fall time	<10 ns, 10% to 90% of amplitude
Aberration	<5%

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 sample clock frequencies.
Connector	Front panel BNC
Impedance	50Ω, ±1%
Level	>2V into 50Ω, 4V nominal into 10kΩ
Protection	Protected against temporary short to case ground
Validators	BIT, LCOM
Position	Point 0 to n, Programmable with 4-point resolution
Width Control	Programmable
Range	4 to 100000 waveform points
Resolution	4 points
Source	Channel 1

Sinewave Output

Description	An output that is directly derived from the sample clock generator and has an output frequency equal to the programmed sample clock frequency. This output generates sine waveforms that corresponds to sample clock setting, including modulated waveform, such as FM, sweep, FSK and Ramped FSK
Connector	Rear panel BNC
Impedance	50Ω, ±1%
Level	1V into 50Ω
Protection	Protected against temporary short to case ground
Source	Sample clock frequency
Frequency Range and Resolution	Same as Sample clock
Harmonics and Spurious	
Total Harmonic Distortion	0.05% to 100kHz
Harmonics and non-related	
spurious to 100 MHz	<25dBc

Multi-Instrument Synchronization Connectors

Description	These connectors are used for synchronizing one master instrument to multiple slave units, thereby creating a multi channel, fully synchronized and jitter free system. There are three connectors in this group, which must be connected between the instruments to achieve synchronization: SCLK output, SCLK input and 9-pin DSUB connector labeled Master/Slave.
Interconnecting Cables	Optional, consult factory at the time of purchase

SCLK Output

Connector	Rear panel SMB
Level	ECL into 50Ω, terminated to –2V

SCLK Input

Connector	Rear panel SMB
Input Level	ECL
Impedance	50Ω, terminated to –2V
Minimum Pulse Width	4ns

Master/Slave

Connector	Rear panel 9-pin DSUB

INPUTS

TRIG Input

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

10 MHz Reference Input

Connector	Rear panel BNC
Impedance	10kΩ, ±5%
Threshold Level	TTL
Duty Cycle	50%, ±5%

AM Input

Modulation Input	Rear panel BNC
Impedance	1MΩ, ±5%
Max Input Voltage	±12V
Sensitivity	0V to +5V (5Vp-p) produce 100% modulation
Source	External
Modulation Range	0 to 100%
Bandwidth	DC to 500kHz

GENERAL

GPIB Information

GPIB Revision	IEEE-488.2
SCPI Revision	1993.0
Logical Address Settings	1 - 31, configured via front panel programming
DMA	Downloads arbitrary waveform data, arbitrary FM waveform data and sequence table data. DMA support is required by the controller

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. IP address programmed through USB port.

USB

Connector	Type A receptacle
Specifications	Version 1.0/version 2.0
Protocol	SCPI commands over USB.

Front Panel Display

Color LCD, 3.5" reflective, 320 x 240 pixels, back-lit

Front Panel Indicator LED's

Output On	Green – Output on / off (Separate for each channel)
SYNC On	Green – SYNC on / off

Power Requirements

Mains Input Range	85 to 265Vac, 48-63 Hz
Maximum Total Module Power	60W

EMC Certification

CE marked

Mechanical

Dimensions   212 x 88 x 415 mm (W x H x D)
Weight   Approximately 7 lb

Environmental

Operating temperature   0 °C - 50 °C
Humidity (non-condensing)   11 °C - 30 °C   85%
                                   31 °C - 40 °C   75%
                                   41 °C - 50 °C   45%

Safety   EN61010-1, 2nd revision