User Manual

Models 8351/8352

350MHz Single / Dual
Arbitrary Function Generators

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FOR YOUR SAFETY

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

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

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

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

Maintenance and calibration procedures sometimes call for operation of the unit with power applied and protective covers removed. Read the procedures and heed warnings to avoid “live” 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
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declare, that the 350MHz Arbitrary Function Generators

Models 8351 and 8352

complies with the requirements of the Electro Magnetic Compatibility 2004/108/EC, class A and the Low Voltage Directive 2006/95/EC, according to testing performed at HERMON LABRATORIES (#EN21151, Aug. 2010). 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:

IEC 61326-1:2006	Class A Radiated and Conducted Emission
EN 61000-4-2	ESD
EN 61000-4-3	Radiated Immunity
EN 61000-4-4	Burst/fast transients
EN 61000-4-5	Surge
EN 61000-4-6	Conducted Immunity
EN 61000-4-8	Power frequency magnetic field
EN 61000-4-11	Voltage dips and fluctuations
EN 55011	Radiated and conducted Emissions

Models 8351 and 8352 are built on the same platform and share specifications and features except the 8351 is a single channel version and while the 8352 has two channels. The tests were performed on a typical configuration.

Table of Contents

Chapter	Title	Page
1	**Getting Started**	**1-1**
	What's in This Chapter	1-4
	Conventions Used in this Manual	1-4
	Safety Symbols	1-4
	WS8351/2 Feature Highlights	1-5
	Introduction	1-6
	General	1-6
	Two Synchronized Channels	1-6
	Stable and Accurate Output Signals	1-6
	Signal Integrity	1-6
	Versatile Run Modes	1-7
	Arbitrary Waveforms and Memory Segmentation	1-8
	Built-in Waveform Gallery	1-8
	Modulated Waveforms	1-8
	Pulse Waveforms	1-8
	Pulse Patterns	1-9
	Local Operation	1-9
	Remote Operation	1-9
	Remote Calibration	1-9
	Specifications	1-9
	Manual Changes	1-10
	Safety Considerations	1-10
	Supplied Accessories	1-10
	Functional Description	1-11
	Front Panel Connectors and Indicators	1-11
	Main Output - Channels 1 and 2	1-11
	SYNC Output	1-11

TRIG IN....1-12
USB....1-12
Front Panel Controls....1-12
Rear Panel Input & Output Connectors....1-15
Sample Clock In....1-15
Event In....1-15
Ref In....1-16
LAN....1-16
USB....1-16
GPIB....1-16
AC Line In....1-16
AC Fuse....1-16
Run Modes....1-17
Continuous Run Mode....1-17
Arming the Generator in Continuous Run Mode....1-17
Triggered Run Mode....1-18
Trigger Run Mode Extensions....1-19
Delayed Trigger....1-20
Trigger Override....1-20
Internal Timer....1-20
Delay Timer....1-20
Counted Burst....1-20
Smart Trigger....1-21
Trigger Source....1-21
Trigger Input....1-21
Manual Button....1-21
Remote Command....1-21
Event Input....1-22
Internal Timer....1-22
Gated Run Mode....1-24
Output Type....1-24
Standard Waveforms....1-25
Arbitrary Waveforms....1-26
Modulated Waveforms....1-28
Modulation Off....1-28
AM....1-28
FM....1-28
Sweep....1-29
Chirp....1-29
FSK....1-29
ASK....1-29
Frequency Hop....1-29

Amplitude Hop 1-29
(n)PSK 1-30
(n)QAM 1-30
Pulse Waveforms 1-31
Pattern Waveforms 1-32
Output State 1-32
Programming the WS8352 1-32

2 Configuring the Instrument 2-1

Installation Overview 2-2
Unpacking and Initial Inspection 2-2
Safety Precautions 2-2
Performance Checks 2-3
Power Requirements 2-3
Grounding Requirements 2-3
Long Term Storage or Repackaging for Shipment 2-4
Preparation for Use 2-4
Installation 2-4
Installing Software Utilities 2-5
Controlling the Instrument from Remote 2-5
Connecting to a Remote interface 2-5
Selecting a Remote interface 2-6
GPIB Configuration 2-7
USB Configuration 2-8
LAN Configuration 2-11
Choosing a Static IP Address 2-12
LAN Configuration Initialize (LCI) 2-14
LAN eXtension for Instruments (LXI) 2-15

3 Using the Instrument 3-1

Overview 3-4
Inter-Channel Dependency 3-4
Output Termination 3-4
Input / Output Protection 3-5
Power On/Reset Defaults 3-5
Controlling the WS8352 3-7
WS8352 Front Panel Menus 3-9
Pulse and Pattern Menus 3-13
Control Menus 3-15
Enabling the Outputs 3-17
Selecting a Function Shape 3-17

Changing the Output Frequency 3-18
Changing the Sample Clock Frequency 3-19
Programming the Amplitude and Offset 3-20
Selecting a Run Mode 3-21
  Continuous Run Mode 3-22
  Triggered Run Mode 3-23
    Using the Delayed Trigger 3-25
    Using the Built-in Auto-Trigger Generators 3-25
  Gated Run Mode 3-26
  Abort 3-27
Using the Manual Trigger 3-28
Using the SYNC Output 3-28
Synchronizing Channel 1 and Channel 2 3-30
Controlling Cross-Channel Propagation 3-31
Using External Clock References 3-31
  Using an External SCLK Source 3-32
  Using an External Clock Reference Source 3-33
Generating Standard Waveforms 3-35
  Sine Wave 3-36
  Triangle Wave 3-36
  Square Wave 3-37
  Ramp Wave 3-37
  Sinc Wave 3-38
  Gaussian Wave 3-39
  Exponential Wave 3-39
  DC Wave 3-40
  Noise Wave 3-40
  Standard Waveforms and Run Mode Options 3-41
Generating Arbitrary Waveforms 3-43
  What Are Arbitrary Waveforms? 3-43
  Generating Arbitrary Waveforms 3-44
  Arbitrary Waveforms and Run Mode Options 3-46
Generating Modulated Waveforms 3-48
  Off 3-49
  FM 3-50
  FSK 3-51
  Frequency Hop 3-53
  Sweep 3-55
  Chirp 3-56
  AM 3-58
  ASK 3-59
  Amplitude Hop 3-61

(n)PSK 3-63
User PSK 3-64
(n)QAM 3-65
User QAM 3-67
Modulated Waveforms and Run Mode Options 3-69
Generating Pulse Waveforms 3-71
Pulse Parameters 3-73
Understanding Pulse Parameters 3-73
Pulse Modes 3-75
Single Pulse Mode 3-76
Delayed Pulse Mode 3-77
Double Pulse Mode 3-78
Programming Pulse Polarity 3-79
Applying Linear Transitions 3-80
Programming the Amplitude Level Mode 3-82
Pulse Design Limitations 3-84
Settings Conflict Errors 3-85
Amplitude Errors 3-85
Pulse Timing Errors 3-86
Pulse Linear Transition Errors 3-86
Pulse Delay Errors 3-86
General Pulse Errors 3-87
Generating User Composed Patterns 3-87
Building “Fast” Transitions Patterns 3-89
Building “Linear” Transitions Patterns 3-91
Generating Pattern waveforms 3-93
Generating PRBS Patterns 3-93
Using Store/Recall 3-97
Storing Instrument Setups and Waveforms 3-98
Recalling Instrument Setups and Waveforms 3-99
Listing Storage Memory Contents 3-100
Store/Recall Considerations 3-101
Store/Recall Messages 3-102

4 Remote Programming Reference 4-1

What’s in This Chapter 4-3
Introduction to SCPI 4-3
Command Format 4-3
Command Separator 4-4
The MIN and MAX Parameters 4-4
Querying Parameter Setting 4-4

Query Response Format....4-5
SCPI Command Terminator....4-5
IEEE-STD-488.2 Common Commands....4-5
SCPI Parameter Type....4-5
Numeric Parameters....4-5
Discrete Parameters....4-6
Boolean Parameters....4-6
Arbitrary Block Parameters....4-6
Binary Block Parameters....4-6
SCPI Syntax and Styles....4-6
WS8352 Commands....4-7
Channel & Group Control Commands....4-16
Run Mode Commands....4-19
Analog Output Control Commands....4-31
Standard Waveforms Control Commands....4-39
Arbitrary Waveforms Control Commands....4-44
Modulated Waveforms Global Control Commands....4-52
Modulation Control Commands....4-55
AM Programming....4-57
FM Programming....4-58
Sweep Modulation Programming....4-60
Chirp Modulation Programming....4-62
FSK Modulation Programming....4-66
ASK Modulation Programming....4-67
Frequency Hopping Modulation Programming....4-70
Amplitude Hopping Modulation Programming....4-72
PSK Modulation Programming....4-75
QAM Modulation Programming....4-80
Pulse Waveform Programming....4-83
Pulse Pattern Programming....4-94
LAN System Configuration Commands....4-105
LXI Configuration Commands....4-109
Store/Recall Commands....4-112
The Store/Recall Folder Structure....4-115
The Store/Recall File Names....4-116
The Store/Recall File Structure....4-117
Recall Setup3 Example....4-118
Store Setup1 Example....4-120
System Commands....4-130
Error Messages....4-131
LAN, USB and GPIB Programming Considerations....4-136
IEEE-STD-488.2 Common Commands and Queries....4-148

5 Performance Checks 5-1

What's in This Chapter 5-3
Performance Checks 5-3
Environmental Conditions 5-3
Warm-up Period 5-3
Initial Instrument Setting 5-4
Recommended Test Equipment 5-4
Frequency Accuracy 5-4
Test Procedures 5-4
Frequency Accuracy, Internal Reference 5-5
Frequency Accuracy, External 100 MHz Reference 5-5
Frequency Accuracy, External Sample Clock 5-6
Amplitude Accuracy 5-7
Amplitude Accuracy 5-7
Offset Accuracy 5-8
Offset Accuracy 5-8
Square Wave Characteristics 5-9
Square Wave Checks 5-9
Sine Wave Characteristics 5-10
Sinewave Spectral Purity 5-10
Inter-Channel Propagation Characteristics 5-11
Offset Between Channels 5-11
Skew Between Channels 5-12
Run Mode Tests 5-13
Continuous Run Mode Test 5-13
Triggered Run Mode Test 5-14
Gated Run Mode Test 5-15
Trigger Inputs Tests 5-16
Front Panel Trigger Input Test 5-16
Rear Panel Event Input Test 5-17
Delayed Trigger Characteristics 5-18
Timed Internal Trigger Tests 5-19
Delayed Internal Trigger Tests 5-20
SYNC Output Operation 5-21
SYNC Output – Pulse 5-21
SYNC Output - WCOM 5-21
SYNC Source 5-22
SYNC Position Checks 5-22
SYNC Width Checks 5-23
Waveform Memory Operation 5-24
Waveform Memory 5-24

Internal Waveform 5-24
GPIB Control 5-25
USB Control 5-25
LAN Control 5-26

6 Adjustments and Firmware Update 6-1

What's in This Chapter 6-2
Performance Checks 6-2
Environmental Conditions 6-2
Warm-up Period 6-2
Recommended Test Equipment 6-3
Adjustment Procedures 6-3
Reference Oscillators Adjustments 6-6
Baseline Offset Adjustments 6-7
Amplitude Adjustments 6-8
Offset Adjustments 6-8
Pulse Response Adjustments 6-12
High Frequency Delay Chain Adjustments 6-13
Baseline Offset Adjustments 6-14
Amplitude Adjustments 6-15
Offset Adjustments 6-15
Pulse Response Adjustments 6-19
High Frequency Delay Chain Adjustments 6-20
Channel 1 to Channel 2 Skew Balance 6-21
Channel 1 to Channel 2 Skew Adjustment 6-24
Inter channels Jitter Adjustment 6-24
Updating WS8352 Firmware 6-26

Appendices

A Specifications A-1

List of Figures

Chapter	Title	Page
1-1, Model WS8352		1-5
1-2, WS8352 Front Panel Controls		1-12
1-3, WS8352 Rear Panel		1-15
1-4, Typical WS8352 Standard Waveforms Display		1-25
1-5, Typical WS8352 Arbitrary Waveforms Display		1-26
1-6, Segment 1-Waveform – Sinc		1-27
1-7, Segment 2 Waveform - Sine		1-27
1-8, Segment 3-Waveform - Pulse		1-27
1-9, Typical WS8352 Modulated Waveform Display		1-28
1-10, Typical WS8352 Pulse Generator Display		1-31
1-11, Typical WS8352 Pulse Pattern Generator Display		1-32
2-1, Selecting a Remote Interface		2-7
2-2, GPIB Configuration Screen		2-7
2-3, USB Device Detected, 1st Message		2-8
2-4, USB Device Detected, 2nd Message		2-8
2-5, Found New Hardware Wizard		2-9
2-6, New Hardware Found and Software installed		2-9
2-7, Model WS8352 Configured for USB Operation		2-10
2-8, LAN Configuration Screen		2-11
2-9, LAN Configuration Initilalize		2-14
2-10, Welcome page for a Web-controlled WS8352		2-15
3-1, Reset WS8352 to Factory Defaults		3-6
3-2, WS8352 Front Panel Operation		3-7
3-3, Enabling and Disabling the Outputs		3-17
3-4, Modifying the Output Frequency		3-18
3-5, Modifying the Sample Clock Frequency		3-19
3-6, Programming Channel 1 Amplitude Example		3-21

3-7, The Typical Run Mode Display (Continuous Mode Shown) 3-22
3-8, Trigger Run Mode Parameters.....3-24
3-9, Gated Run Mode Parameters 3-27
3-10, Typical Continuous Run Mode Display with the Abort Soft Key.....3-28
3-11, SYNC and Filter Parameters.....3-29
3-12, Modifying the SCLK Feed to Common.....3-30
3-13, Controlling Cross-Channel Propagation.....3-31
3-14, Modifying the SCLK and 10MHz Clock Source 3-32
3-15, Using an External Sample Clock Example 3-33
3-16, Using an External Sample Clock Example 3-34
3-17, Built-in Standard Waveforms Menu.....3-35
3-18, Wave Composer Tool Example for Generating Arbitrary Waveforms.....3-43
3-19, Arbitrary Parameters Display Example 3-45
3-20, The Wave Composer Display 3-46
3-21, The Modulation Function Main Screen.....3-48
3-22, Modulation OFF Parameters.....3-49
3-23, FM Menus.....3-50
3-24, Modulation Waveform Shapes 3-51
3-25, ArbConnection FSK Control Data String Example 3-52
3-26, FSK Menus.....3-52
3-27, Frequency Hop Menus.....3-53
3-28, Variable Dwell Time Frequency Hop Table Example 3-54
3-29, Sweep Menus.....3-55
3-30, Chirp Menus 3-56
3-31, AM Menus 3-59
3-32, Modulating Waveform Shapes 3-59
3-33, ArbConnection ASK Control Data String Example 3-60
3-34, ASK Menus.....3-61
3-35, Amplitude Hop Menus 3-61
3-36, ArbConnection Variable Dwell Time Amplitude Hop Table Example 3-62
3-37, QPSK Modulation Display Example 3-64
3-38, ArbConnection QPSK Data Entry Table Example 3-64
3-39, User PSK Display Example 3-65
3-40, ArbConnection User PSK Data Entry Table Example 3-65
3-41, 64QAM Display Example 3-66
3-42, ArbConnection 64QAM Data Entry Table Example 3-67
3-43, QAM User Display Example 3-67
3-44, ArbConnection User QAM Data Entry Table Example 3-68
3-45, Pulse Function Menus 3-72
3-46, Pulse Configuration Menus 3-73

3-47, Standard Interpretation of Pulse Parameters 3-74
3-48, WS8352 Interpretation of Pulse Parameters 3-75
3-49, Pulse Mode Options 3-75
3-50, Single Pulse Parameters Summary 3-76
3-51, Delayed Pulse Mode 3-77
3-52, Programming the Single Pulse Delay Parameter 3-78
3-53, Double Pulse Mode 3-78
3-54, Programming the Double Pulse Delay 3-79
3-55, Pulse Polarity Options 3-79
3-56, Programming the Pulse Polarity 3-80
3-57, Fast and Linear Transitions, Compared 3-81
3-58, Programming the Transition Type 3-81
3-59, Leading Edge Programming Example 3-82
3-60, Amplitude Level Modes Options 3-82
3-61, Programming the Amplitude Level Mode 3-83
3-62, User-composed Pulse Patterns Menus 3-88
3-63, Access the Pulse Composer Menus 3-88
3-64, Pulse Composer Menus Example 3-88
3-65, Selecting the Proper Pulse Composer Configuration 3-89
3-66, “Fast” Transition Pulse Example 3-90
3-67, “Linear” Transition Pulse Example 3-91
3-68, Linear Transition Pulse Composer Example 3-92
3-69, Pattern Menus 3-94
3-70, PRBS 2 Level Pattern Example 3-96
3-71, PRBS 3-Level Pattern Example 3-96
3-72, PRBS 4-Level Pattern Example 3-96
3-73, PRBS 5 Level Pattern Example 3-96
3-74, Store/Recall Menus 3-97
3-75, Store Menus 3-98
3-76, Recall Menus 3-99
3-77, Stored Memory Cells Listed 3-100
3-78, Stored setting to USB memory 3-102
3-79, Recalled setting from USB memory 3-102
3-80, Unrecognized file structure or file contents 3-102
3-81, Unplugged USB error 3-102
3-82, Missing USB memory stick error 3-102
4-1, Definite Length Arbitrary Block Data Format 4-45
4-2, 16-bit Data Point Representation 4-46
4-3, Waveform Data Word Representation 4-46

4-4, Segment Size Array Example 4-49
4-5, Multiple Segment Download Array Example 4-50
4-6, Single Segment Download Array Example 4-51
4-7, Single Pulse Parameters 4-83
4-8, Delayed Pulse Parameters 4-83
4-9, Double Pulse Parameters 4-84
4-10, Composed Pulse Pattern with Mixed Fast and Linear transitions 4-94
4-11, PRBS 2 Level Pattern Example 4-95
4-12, PRBS 3-Level Pattern Example 4-95
4-13, PRBS 4-Level Pattern Example 4-95
4-14, PRBS 5 Level Pattern Example 4-95
4-15, Composed “FAST” Pulse - Level Data Representation 4-101
4-16, Composed Linear Pulse - Data Representation 4-102
4-17, Composed Linear Pulse - Level Data Representation 4-103
4-18, Store/Recall Folders Structure Example 4-115
4-19, Setup3-Example Folder 4-118
6-1, Calibration Password 6-4
6-2, Calibration Panel Example 6-4
6-3, Software Version Screen 6-26
6-4, The NETConfig Utility 6-27
6-5, Check for Progress Bar Movement 6-28
6-6, WS8352 has been Detected on the LAN Network 6-28
6-7, The Firmware Update Dialog Box 6-29
6-8, Firmware Update Path 6-30
6-9, Firmware Update Completed 6-30

List of Tables

Chapter **Title** **Page**

1-1, Arming the WS8352 in Continuous Run Mode 1-18
1-2, WS8352 Triggered Run Mode Controls 1-19
1-3, Run Modes and Trigger Source Options Summary 1-22
1-4, Trigger Sources and Trigger Features Options Summary 1-23
1-5, WS8352 Gated Run Mode Controls 1-24
2-1, Valid and Invalid IP Addresses for Subnet Mask 255.255.255.0 2-13
2-2, LAN default Settings 2-14
3 1, Default Conditions after Reset 3-6
3-2, Front Panel Function Menus 3-9
3-3, Front Panel Pulse and Pattern Function Menus 3-14
3-4, Front Panel Control Menus 3-15
3-4, Front Panel Control Menus (continued) 3-16
3-5, Standard Waveforms in Various Run Mode Options 3-41
3-7, Arbitrary Waveforms in Various Run Mode Options 3-46
3-9, Modulated Waveforms in Various Run Mode Options 3-69
4 1: Model WS8352 Commands List Summary 4-8
4 2: Channel & Group Control Commands Summary 4-16
4 3: Run Mode Commands Summary 4-20
4 4: Analog Output Commands Summary 4-31
4 5: Standard Waveforms Control Commands Summary 4-39
4 6: Arbitrary Waveforms Commands Summary 4-45
4 7: Modulated Waveforms Global Commands 4-52

4 8: Modulated Waveforms Control Commands 4-55
4 9: Pulse Pattern Commands Summary 4-96
4 10: LAN Commands Summary 4-105
4- 11: LXI configuration commands 4-109
4 12: Store/Recall Commands Summary 4-112
4 13: System Commands Summary 4-130
5-1, Recommended Test Equipment 5-3
5-2, Frequency Accuracy 5-4
5-3, Frequency Accuracy Using External 100 MHz Reference 5-5
5-4, Frequency Accuracy Using External Sample Clock 5-5
5-5, Amplitude Accuracy 5-6
5-6, Offset Accuracy 5-7
5-7, Square Wave Characteristics 5-8
5-8, Sinewave Harmonics Test 5-9
5-9, Sinewave Spurious Test 5-9
5-10, Trigger Input Characteristics 5-15
5-11, Trigger Input Characteristics Checks, Continued 5-16
5-12, Trigger Input Counted Burst Checks 5-16
5-13, Event Input Characteristics 5-17
5-14, Event Input Characteristics Checks, Continued 5-17
5-15, Trigger Delay Tests 5-18
5-16, Trigger Delay Tests 5-18
5-17, Trigger Delay Tests 5-19
5-18, SYNC Position Tests 5-22
5-19, SYNC Width Tests 5-22
6 1, Recommended Calibration for Adjustments 6-3

Chapter 1
Getting Started

Title **Page**

What's in This Chapter....1-4
Conventions Used in this Manual....1-4
Safety Symbols....1-4
WS8351/2 Feature Highlights....1-5
Introduction....1-6
  General....1-6
  Two Synchronized Channels....1-6
  Stable and Accurate Output Signals....1-6
  Signal Integrity....1-6
  Versatile Run Modes....1-7
  Arbitrary Waveforms and Memory Segmentation....1-8
  Built-in Waveform Gallery....1-8
  Modulated Waveforms....1-8
  Pulse Waveforms....1-8
  Pulse Patterns....1-9
  Local Operation....1-9
  Remote Operation....1-9
  Remote Calibration....1-9
Specifications....1-9
Manual Changes....1-10
Safety Considerations....1-10
Supplied Accessories....1-10
Functional Description....1-11
  Front Panel Connectors and Indicators....1-11
    Main Output - Channels 1 and 2....1-11
    SYNC Output....1-11
    TRIG IN....1-12
    USB....1-12
  Front Panel Controls....1-12
  Rear Panel Input & Output Connectors....1-15
    Sample Clock In....1-15

Event In 1-15
Ref In 1-16
LAN 1-16
USB 1-16
GPIB 1-16
AC Line In 1-16
AC Fuse 1-16
Run Modes 1-17
Continuous Run Mode 1-17
Arming the Generator in Continuous Run Mode 1-17
Triggered Run Mode 1-18
Trigger Run Mode Extensions 1-19
Delayed Trigger 1-20
Trigger Override 1-20
Internal Timer 1-20
Delay Timer 1-20
Counted Burst 1-20
Smart Trigger 1-21
Trigger Source 1-21
Trigger Input 1-21
Manual Button 1-21
Remote Command 1-21
Event Input 1-22
Internal Timer 1-22
Gated Run Mode 1-24
Output Type 1-24
Standard Waveforms 1-25
Arbitrary Waveforms 1-26
Modulated Waveforms 1-28
Modulation Off 1-28
AM 1-28
FM 1-28
Sweep 1-29
Chirp 1-29
FSK 1-29
ASK 1-29
Frequency Hop 1-29
Amplitude Hop 1-29
(n)PSK 1-30
(n)QAM 1-30

Pulse Waveforms.....1-31
Pattern Waveforms.....1-32
Output State.....1-32
Programming the WS8352.....1-32

What's in This Chapter

This chapter contains a general description of the WS8352 **Waveform Generator**, including an overall functional description of the instrument. Additionally, the front and rear panel connectors and indicators are explained in detail.

NOTE

This manual is shared by both single and dual channel versions. Therefore, if you purchased the WX2181B, please ignore all references to the second channel in this manual.

Conventions Used in this Manual

The following icons may appear in this manual:

NOTE

A Note contains information relating to the use of this product

TIP

A Tip containing recommendation relating to the use of a feature

CAUTION

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

WARNING

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

Safety Symbols

The following safety symbols may appear in this manual and on this product:

Alternating current

Standby supply. Unit is not completely disconnected from ac mains when switch is off.

WS8351/2 Feature Highlights

- 2 GS/s, single or dual channel configuration with fully independent waveform control
- Tight phase offset control between channels (10 ps resolution)
- Operational in each of the following modes:
  - Function generator
  - Arbitrary waveform generator
  - Modulation generator
  - Pattern generator
  - Pulse generator
- 14 Bit vertical resolution
- 1 ppm clock stability
- Extremely low- phase noise-carrier
- 512K waveform memory
- Up to 4Vp-p DC-Coupled
- Interrupted run modes such as, re-triggered and delayed trigger
- 4” high resolution color LCD display
- Ethernet, USB and GPIB interfaces
- Remote calibration without removing case covers
- LXI C compliant

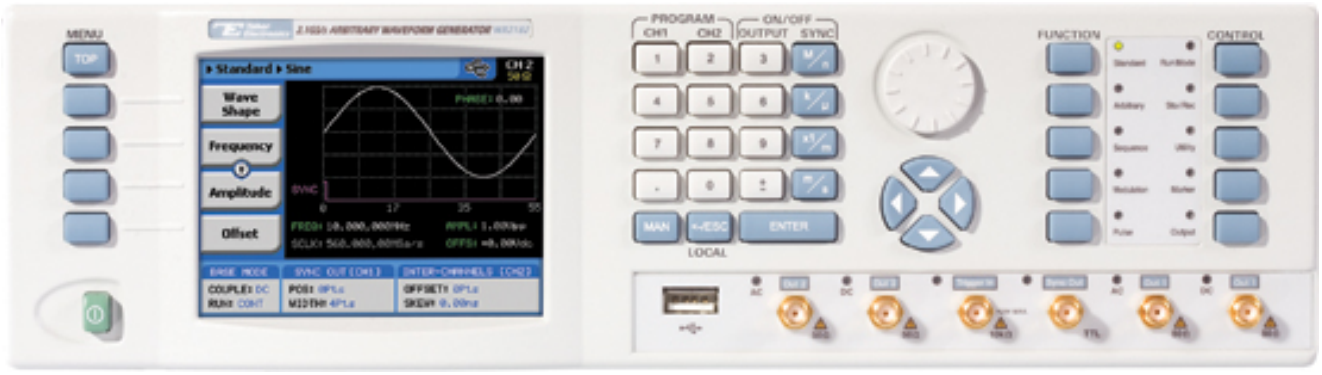

Figure 1-1, Model WS8352

Introduction

Detailed functional description is provided, following the general description of the features and functions available with the WS8352**.**

General

The WS8352 is a dual-channel arbitrary function generator. In addition to its standard ability to generate arbitrary shapes, functions or modulation, it can also be used as a full-featured pulse generator, as well as a wireless signal source. The WS8352 offers unmatched performance, even when compared to instruments designed to generate fewer types of signals. Its affordable footprint saves space and cost without compromising bandwidth and signal integrity. Cutting-edge technology is utilized to assure that this will be the only source needed for many years to come.

Two Synchronized Channels

The WS8352 has two output channels, both of which can operate either independently, or synchronized to share the same sample clock source. As two separate channels, one has the advantage of having two separate instruments in one box, with each having the ability to be programmed to output different function shapes, amplitude levels and/or to operate in different run modes.

Alternatively, the advantage of having two synchronized channels is very significant in applications that require an accurate and controlled phase between the two channels. Many applications require X-Y modes and I&Q outputs and the WS8352 is ideal for this usage.

Stable and Accurate Output Signals

As standard, the instrument is equipped with a frequency reference that has 1ppm accuracy and stability over a period of 1 year. An external frequency reference input is provided on the rear panel for applications requiring greater accuracy and stability.

Signal Integrity

As technology evolves and new devices are continuously developed, faster and more complex signals are needed to simulate and stimulate these new devices. The WS8352 has the highest bandwidth in its class, enabling it to accurately duplicate and simulate high frequency test signals. With its wide sample clock generator range (up to 2 GS/s), 14-bit vertical resolution, 4 Vp-p and over 700 MHz output bandwidth, it is simple to create mathematical profiles, download the coordinates to the instrument and regenerate waveforms without compromising signal fidelity or system integrity.

Versatile Run Modes

Having a waveform generator that has such an enormous waveform creation capability without the ability to control how waveforms start and stop is unlikely to perform as desired in a real-life environment. For this purpose, the WS8352 is equipped with a highly sophisticated mechanism that allows precise control over the start and stop timing, which is exactly what is required for interactive systems. When the instrument is operated on the bench, most applications require that the output is generated continuously or triggered from an external source, but as a system component and as part of a large array of other equipment, the waveform can be halted for a specified time, then operated for another period of time and stopped when it is no longer required. The enable/disable sequence is available when the WS8352 is placed in armed remote operation only and the start and stop commands can be programmed to come through different inputs.

Besides armed operation, the waveform generator responds to various trigger sources such as: external trigger signal from the trigger input, button press on the front panel, external signal which is applied through the event input and finally, if none of the external stimuli are available, an internal trigger generator with a programmable trigger period can be utilized to generate repeated triggers.

As well as the above-described trigger facilities, the WS8352 has two additional trigger modes that enhance its performance. The first is an override mode, where each trigger stops the running waveform and overrides the output to start over, and the second is a re-trigger mode, where the stop of the waveform triggers the next start after a predefined and programmable interval. While the first mode assures that every trigger starts a new cycle, the second mode assures that no new cycle is initiated before the previous cycle has been completed and a pre-programmed interval has lapsed before the next cycle is started.

Besides its trigger facilities, the WS8352 can be gated to generate waveforms only when a specific level of the trigger input is reached. It also can be programmed to generate a counted burst of waveform cycles upon request, whether it comes from a trigger signal or from a remote command.

The WS8352 also employs a delay circuit, where an external event triggers a delay which only after its programmed interval, the output is allowed to start generating waveforms.

Finally, to make sure no trigger slips away; the WS8352 has a smart trigger detection that inhibits triggers if they are below or above a certain trigger pulse width and also holds off all triggers that are considered false, before the true signal appears and does the work.

Arbitrary Waveforms and Memory Segmentation

Waveform memory is the internal scratchpad where the waveforms reside. Larger memory banks provide for longer waveforms. One can use the entire memory for a single waveform or split the length to smaller segments. In this case, many waveforms can be stored in the same memory and replayed, one at a time, when recalled to the output.

Built-in Waveform Gallery

Care to use the instrument as a function generator? No need to calculate complex waveforms, as the WS8352 does the work for you. Select the standard waveforms button and start generating any of ten waveforms that are pre-computed and available for immediate use.

Included are: sine, triangle, square, pulse, ramp, sinc and others. Remember that waveforms are created from sampled waveform points, and therefore some of the waveforms cannot be generated above certain frequencies, where the number of points is insufficient to draw a perfect shape. Nevertheless, by using advanced techniques, the WS8352 generates standard sine and square waveforms at frequencies up to 350MHz and 250 MHz.

Modulated Waveforms

The WS8352 is capable of producing an array of modulation, which places it in-line with stand-alone, high performance modulation generators. AM, FM, Sweep, Chirps, FSK, PSK, ASK, and Frequency and amplitude Hops are just few examples of the available modulation schemes available on the WS8352. The WS8352 can also generate many types of (n)PSK and (n)QAM schemes, which makes it very useful in the IQ domain. The various modulation schemes are described below.

Pulse Waveforms

Need to generate fast and accurate and jitter-free pulses? Just set the main operating mode to pulse generator and the instrument will be transformed into a full-featured pulse generator. Need to control pulse transitions and placement? Just program each channel to output pulses with linear or fast transitions and control-edge placement with ns resolution. Further, if your application requires more than just a fixed duty cycle or programmable pulse width, then modulate and control your leading edge with any standard or arbitrary waveform shape. Combine all of these and you have an extremely versatile pulse generation tool. While using the pulse generator, do not forget that the WS8352 is a digital instrument and as such, creates the pulses from a digital memory. Therefore, be sure to observe the limitations that have evolved in the creation of such an advanced instrument: while most of analog pulse generators can be emulated with the WS8352, one should observe

the number of points that are required to generate the pulse shape, and take into consideration the time that is required to compute and output the waveform.

Pulse Patterns

Major consideration has been given to build in the capability to design special and complex pulse patterns, such as user-defined pulse patterns and Pseudo Random Bit Sequence (PRBS).

The WS8352 pattern functionality is implemented as an extension of the Pulse Mode. In addition to RZ pulses, it allows the generation of pattern sequences that are using NRZ formatting with adjustable transition times

Local Operation

Operating the WS8352 from the front panel is intuitive and extremely easy. A large and user-friendly 4" back-lit color LCD display facilitates browsing through menus, updating parameters and displaying detailed waveform information. Combined with a numeric keypad, cursor position control and a knob, the front panel controls simplify the operation of this universal waveform source.

Remote Operation

Access speed is an increasingly important requirement for test systems. Ethernet, USB and GPIB interfaces are available so that the most suitable interface for the application may be selected. Remote control of instrument functions, parameters and waveform downloads is easily tailored to specific system environments, regardless of whether control is via a laptop computer or full-featured ATE system. IVI drivers and factory support will speed up system integration and minimize test development time and costs.

Remote Calibration

Normal calibration cycles in the industry range from one to three years, where instruments are sent to a service center, opened to allow access to trimmers, calibrated and certified for repeated usage. Leading-edge technology was employed on the WS8352 to allow calibration from any WS8352 remote interface such as USB, GPIB or LAN. Calibration factors are stored in a flash memory, thus eliminating the need to open instrument covers.

Specifications

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

Manual Changes

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

Safety Considerations

The WS8352 has been manufactured according to international safety standards. The instrument meets IEC 61010-1, EN61010-1, CSA C22.2 No. 61010-1 and UL 61010-1 (Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements). It has a metal chassis that is directly connected to earth via the chassis power supply cable (Safety Class I).

Only qualified, service-trained personal should remove instrument covers. Always disconnect the power cable and any external circuits before removing the instrument cover. Any adjustment, maintenance and repair of an opened, powered-on instrument must be performed by authorized service personal.

Do not use this product in any manner not specified by the manufacturer. The protective features of this product may be impaired if it is used in a manner not specified in the operation instructions.

WARNING

When the WS8352 is turned off with the front panel power switch, the instrument is placed in standby mode but is still connected to the mains. To disconnect the mains from the instrument, remove the power cord.

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

Only qualified, service-trained personal should remove instrument covers. Always disconnect the power cable and any external circuits before removing the instrument cover. Any adjustment, maintenance and repair of an opened, powered-on instrument must be performed by authorized service personal.

Do not use this product in any manner not specified by the manufacturer. The protective features of this product may be impaired if it is used in a manner not specified in the operation instructions.

Supplied Accessories

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

Functional Description

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

Front Panel Connectors and Indicators

The WS8352 has six SMA connectors on its front panel: two for each main output, one used for accepting triggers and one for the SYNC output. Each connector on the front panel has a LED associated with it, indicating when the output or input is active (LED on), or when inactive (LED off). The function of each of the front panel connectors is described in the following paragraphs.

Main Output - Channels 1 and 2

There are two connectors for each output channel, marked Normal and Inverted. When using the DC couple mode, the output is generated differentially through these two connectors. The AC couple mode is single-ended and consequently, only the Normal connector outputs AC signals. The main output connectors generate standard waveforms to 350 MHz and arbitrary waveforms with 2 GS/s sampling rate. These outputs generate modulated and pulse waveforms, as well. Output source impedance is 50Ω, therefore the cable connected to this output should be terminated with 50 Ω load resistance. For different load resistance, determine the actual amplitude from the following equation:

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

The output amplitude is doubled when the output impedance is above roughly 10 kΩ. Also, the output can be turned on and off. However, turning the output off stops the signal, but leaves low impedance on the output terminals.

SYNC Output

The SYNC output generates single or multiple TTL pulses for synchronizing other instruments (i.e., an oscilloscope) to the output waveform. The SYNC signal always appears at a fixed point relative to the waveform. The location of the sync pulse along the waveform is programmable. Since there is only one SYNC output, the output is associated with the channel 1 output, but can be changed to be sourced and synchronized to channel 2.

Note that the SYNC output is also used as a frequency marker when the WS8352 is set to generate one of the modulation functions.

TRIG IN

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

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

The trigger input is common to both channels. Therefore, if one of the WS8352 channels is placed in trigger mode, the trigger input will affect this same channel. If both channels are placed in trigger mode the trigger input will affect both channels simultaneously.

USB

This connector accepts standard USB-1 disk-on-key memory sticks. The main purpose of this interface is to provide for external storage and download of setups and waveforms. This I/O cannot be used for controlling the instrument from remote.

Front Panel Controls

The front panel controls and keys are grouped in logical order to provide efficient and quick access to instrument functions and parameters. Refer to Figure 1-2 throughout the following description to understand the purpose and effect of each front panel control.

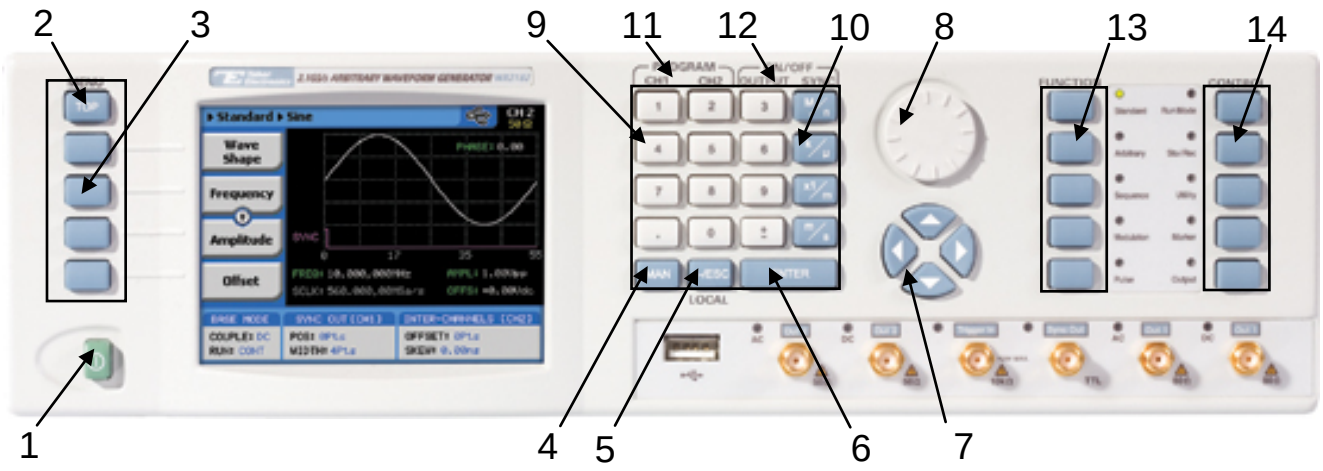

Figure 1-2, WS8352 Front Panel Controls

Note

The index in the following paragraphs point to the numbered arrows in Figure 1-2.

1. *Power Switch* – Toggles WS8352 power ON and OFF
2. *Menu Top* – For certain functions, selects the root menu. This button is disabled during parameter editing
3. *Menu Soft Keys* – Select parameters to be audited.

   These buttons are disabled during parameter editing.
4. *MAN* – Manual trigger button, used in lieu of an external trigger signal.
5. *<-Esc (Local)* – Has two functions:
   1) When in edit mode, cancels edit operation, restores last value and returns to the main function screen
   2) When operating the WS8352 from a remote interface, none of the front panel buttons are active except the Local button. When depressed, it restores control to front panel buttons
6. *Enter* – 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 a parameter is modified, Enter can be used to replace the x1 suffix key
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 a parameter is selected for editing, cursor buttons right or left move the cursor accordingly. Cursor buttons up or down modifies parameter value accordingly.
8. *Dial* – Has similar functionality as the cursor UP and Down keys.
9. *Numeric keypad* – These keys are used for modifying an edited parameter value.
10. *Parameter Suffixes (M/n, k/μ, x1/m and m/s)* – These keys are used to place a 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 WS8352 is not in edit mode
12. *ON/OFF Output, Sync* – These keys can be used only when the WS8352 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
13. *Function* – These keys select one of 5 function menus that the WS8352 can generate. The output functions are: Standard, Arbitrary, Modulated, Pulse and Pattern. A LED lights next to the selected function.
14. *Control* – These keys select control menus that program the WS8352 operating modes. The control menus are: Run Mode, Store/Recall, Utility, Remote and Output.

Rear Panel Input & Output Connectors

The WS8352 has a number of connectors on its rear panel. These connectors are described below. Figure 1-3 shows rear panel plugs, indicators, connectors and other parts.

Figure 1-3, WS8352 Rear Panel

Sample Clock In

This SMB connector accepts an external signal that will replace the internal sample clock generator. This input accepts signals from 2 GHz to 4 GHz, with an input power of 0 dBm to 10 dBm. The sample clock input is available for those applications requiring improved phase noise characteristics for the output signal. With a suitable source, the overall phase noise can be improved by a factor of up to 20 dBc/Hz. The sample clock input is active only after selecting the external SCLK source option.

NOTE

The internal sample clock generator is sensitive to noise that might be injected through the Sample Clock input. Any signal that is connected to this input may impair the operation of the internal clock. Therefore, connect a cable to the Sample Clock In connector only if you intend to use it as an external clock source. For system applications, where cables are always connected to the Sample Clock In, make sure that the external source signal is turned off at all times when the internal sample clock source is in use.

Event In

This BNC connector duplicates the operation of the front panel trigger input, except it is used for synchronizing WS8352 operation with external events. The effect of the event input is shown in various tables of this chapter.

The event input is level and edge sensitive and can be programmed just as the trigger input for trigger level and trigger slope. The event input affects both channels simultaneously if they are programmed to sense transitions from this input.

Ref In

This BNC connector accepts signals within the range of 10 MHz to 100 MHz that reference the sample clock generator. This input is normally used for synchronizing system components to a single clock reference. The WS8352 has to be programmed to reference frequency value and placed in external reference mode before it will use this input as reference.

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 on 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-2 cable. The connection to the host computer is automatic and does not require any address setting from within the WS8352.

GPIB

This 24-pin connector accepts standard GPIB cable. The GPIB address is configured using the front panel Utility menu. The WS8352 conforms to the IEEE-488.2 standard. Programming protocol is SCPI version 1993.0. GPIB cables are available separately from your Tabor dealer.

AC Line In

This 3-prong AC LINE connector accepts AC line voltage. The WS8352 senses the line voltage and sets the appropriate range automatically. Therefore, the traditional line voltage selector is not available on the rear panel. To avoid potentially hazardous situations, always connect the center pin to mains ground using the line cord that is supplied with the instrument.

AC Fuse

The AC fuse protects the WS8352 from excessive current. Always replace the fuse with the exact type and rating as printed on the rear panel. The fuse value is T1.25AH/250V. If the fuse blows again after replacement, we strongly recommend that you refer your instrument immediately to the nearest Tabor service center.

Run Modes

The WS8352 can be programmed to operate in one of three basic run modes: Continuous, Triggered and Gated. There are features associated with each basic run mode, such as: arming the output for an event to enable generation, delayed trigger, smart trigger and more. The WS8352 can also be prepared to accept triggers from various sources, such as: front panel trigger input, rear panel event input, an internal trigger generator and more. In addition, the generator can be programmed to respond differently to a trigger in a way that each trigger can override preceding triggered cycles or launch a continuous trigger burst where the waveform stop triggers a new waveform start after a pre-programmed interval.

Summary of all run modes, trigger sources and trigger features is given below.

Continuous Run Mode

Bench operation usually requires that a continuous waveform is available at the output terminals when the instrument is powered up and the output is turned on. On the other hand, for system applications that tolerate signals only at a specific time frame, the WS8352 can be armed from remote to generate waveforms only after it receives an enable command, and then aborted when the signal is no longer required. Table 1-1 summarizes the conditions in which the WS8352 can operate when set to continuous run mode. Armed operation is described below.

Arming the Generator in Continuous Run Mode

Arming the WS8352 is an operation that is normally carried out when the generator is operated from remote. For this reason, only a remote command can modify the arm option to Armed. When armed, the output can be enabled using valid events that are sensed by one of the front panel trigger input the rear panel event input or a remote enable command. Once enabled, the waveform can be stopped by a remote abort signal only.

Table 1-1 summarizes the various controls for each output function of which the WS8352 can be operated when set to continuous run mode. The various controls are explained below.

Waveform – basic output function that the WS8352 can generate. There are five output functions available: Standard, Arbitrary, Modulated, Pulse and Pattern.

Arm Options – bench operation normally defaults to self-armed where the output generates waveforms immediately after turning it on. Arming the WS8352 places the outputs in a wait-for-valid-enable signal before waveforms are generated through the output connectors.

Idle Waveform – defines the shape of the waveform when the generator is self-armed or when armed but has not been enabled yet.

Enable Signal – defines the source of the enable signal. Trigger defines the trigger input as the source for the enable signal. Event defines the event input as the source for the enable signal. The BUS option disables the event and trigger inputs and only a remote command will enable the output. Only one source is active at a time.

Abort Signal – defines the source of the abort signal. In this case, either the Front Panel or BUS will cause the signal to stop.

Table 1-1, Arming the WS8352 in Continuous Run Mode

Waveform	Advance Mode	Arm Options	Idle Waveform	Enable Signal	Abort Signal
Standard	-	Self Armed	Wave	- (*)	-
	-	Armed	DC	Trigger | BUS | Event	BUS | F.P
Arbitrary	-	Self Armed	Wave	-	-
	-	Armed	DC	Trigger | BUS | Event	BUS | F.P
Modulated	-	Self Armed	-	-	-
	-	Armed	Wave	Trigger | BUS | Event	BUS | F.P
Pulse/Pattern	-	Self Armed	-	-	-
	-	Armed	Wave	Trigger | BUS | Event	BUS | F.P

(*) defines not relevant for this mode

Triggered Run Mode

In triggered mode, the WS8352 circuits are always armed to generate one output waveform. The trigger circuit is sensitive to transitions at the trigger input. Select between positive, negative or either transitions to trigger the instrument. You may also program the trigger level to the desired threshold level. When triggered, the generator outputs one waveform cycle and remains idle at the last point of the waveform.

The WS8352 can be triggered from a number of sources:

1) Front panel connector, designated as TRIG IN
2) Rear panel connector, designated as Event IN,
3) Front panel button marked as MAN TRIG, and
4) Bus commands that are applied to the instrument from any interface, LAN, USB or GPIB.

Descriptions of the various trigger source options are detailed in the following paragraphs.

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

Table 1-2 summarizes the various controls for each output function of which the WS8352 can be operated, when set to triggered run mode. The various controls are explained below.

Waveform – basic output function that the WS8352 can generate. There are five output functions available: Standard, Arbitrary, Modulated, Pulse and Pattern.

Arm Options – bench operation normally defaults to self armed where the output generate waveforms immediately after turning it on. Arming the WS8352 places the outputs in a wait-for-valid-enable signal before waveforms are generated through the output connectors.

Idle Waveform – defines the shape of the waveform when the generator is self-armed or when armed but hasn't been enabled yet.

Initiate Signal – defines the source from where a trigger is expected to initiate a waveform cycle. F.P defines the front panel MAN button as a trigger source. Event defines the rear panel Event In as a trigger source. The BUS option disables the trigger and event inputs and only a remote command will enable the output. Trigger defines the trigger input as the source for the trigger signal. Only one source is active at a time.

Abort Signal – defines the source of the abort signal. In this case, only BUS will cause the signal to stop.

Table 1-2, WS8352 Triggered Run Mode Controls

Waveform	Advance Mode	Arm Options	Idle Waveform	Initiate Signal	Abort Signal
Standard	-	Self Armed	-(*)	-	-
		Armed	DC	F.P.|BUS|Trigger|Event	BUS
Arbitrary	-	Self Armed	-	-	-
		Armed	DC	F.P.|BUS|Trigger|Event	BUS
Modulated	-	Self Armed	-	-	-
		Armed	DC	F.P.|BUS|Trigger|Event	BUS
Pulse/Pattern	-	Self Armed	-	-	-
		Armed	DC	F.P.|BUS|Trigger|Event	BUS

(*) defines not relevant for this mode

Trigger Run Mode Extensions

Trigger operation is available to assure that waveforms start only when a valid trigger is sensed at the trigger input connector. So it is with most waveform generators. However, the WS8352 provides further refinement of this function in a way that the trigger circuit can receive triggers from multiple sources, arbitrate and delegate the signal to the main trigger circuit and also delay the start of the waveform by a pre-defined period. This is to make sure events are not wasted and waveforms re-played only when they are absolutely required in the system. The various trigger-run mode extensions are described below.

Delayed Trigger

The delayed trigger function is exactly the same as the trigger mode, except a programmable delay circuit inhibits the generation of the output waveform for a pre-determined interval following a valid trigger event. The programmed delay time defines the time that will lapse from a valid trigger (hardware or software) to output. The delay is programmable in steps of sample clock period and can be set from 0 to 8e6 sample clock periods. Delayed trigger can be used in conjunction with external trigger, front panel manual trigger, or remote trigger command. It has no effect on the internal trigger timer, nor does it affect the event input.

Trigger Override

Normal trigger sequence requires that a waveform completes its cycle before the generator can be triggered to generate another waveform. Some applications, however, cannot wait for the end of the waveform, but must initiate another trigger cycle. The WS8352 features an override mode that ignores the output and upon trigger, initiates a fresh output waveform, whether the last one has been completed or not. Note that the override trigger must precede the end of the signal by at least 64 sample clock periods.

Internal Timer

The internal timer generator operates as a free-running asynchronous trigger generator. It may be used for applications that require periodical and constant generation of output cycles, or to replace external trigger devices. The internal trigger generator is programmed in units of time through the range of 200 ns to 20 seconds. Note: in order to prevent errors, the period of the internal generator must be larger than the period of the output waveform.

Delay Timer

Contrary to the trigger override mode that was described before, certain applications cannot tolerate new cycles before the last one comes to a halt. The WS8352 features a special re-trigger mode that is very similar to the internal trigger generator where the output is self-triggered by an internal trigger generator, but the new waveform starts only after a programmed delay interval, and therefore assures that triggers are spaced equally and never override active sequences. The delay value is programmed in units ranging from 152 to 8e6 sample clock periods.

Counted Burst

Counted burst is an extension of the trigger run mode. It allows generation of a counted number of output cycles, which are triggered by a single trigger event. The burst counter can be used in conjunction with all waveform functions that the WS8352 generates. The burst counter is programmed from 1 to 1,000,000.

Smart Trigger

Smart trigger is an additional extension of the trigger capability, where it narrows down to a specific pulse event. The trigger circuit can detect: a pulse having a pulse width larger than a programmed time value (<time), a pulse having a pulse width smaller than a programmed time value (>time), or a pulse having a pulse width between two limits (<>time).

An additional feature of the smart trigger is the holdoff function where the output is held idle after the first trigger and starts a waveform cycle only with the first valid trigger after a holdoff interval has lapsed.

Trigger Source

The WS8352 can be stimulated to produce waveform functions from a number of trigger sources. These are described in the following paragraphs.

Summary of trigger source options and trigger features are listed in Tables 1-3 and 1-4, identifying legal run modes, trigger sources and trigger features and listing possible setting conflicts.

Trigger Input

When selecting the External trigger source, the front panel TRIG IN connector becomes active and every valid signal that is applied to this input is stimulating the WS8352 to generate a new waveform cycle. When the external trigger source is active, all other sources are disabled, except the MAN front panel button. The characteristics of the trigger input are listed in Appendix A. The trigger input is sensitive to transitions and may be programmed to react on positive, negative or both positive and negative transitions. It can also be programmed to a specific trigger levels setting from -5 V to 5 V.

Manual Button

Alternately, if an external signal is not available, the front panel MAN button may also be used to trigger the instrument. This button is active only when EXT trigger option is selected.

Remote Command

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

Event Input

The event input is a rear-panel connector that duplicates functionality of the front panel trigger input, but can be used for detecting events. For most applications, this input should not be used as a second trigger input. One of the main applications for this input is to serve as an enable port for armed operation in continuous run mode.

Similar to the front panel trigger input, the event input is sensitive to transitions and may be programmed to react on positive or negative transitions. It can also be programmed to a specific trigger levels setting from -5 V to 5 V.

Internal Timer

The internal timer is normally used when an external source trigger is not available and an application requires triggers at constant intervals. The internal trigger generator can be programmed for start-to-start trigger intervals, using time units and for stop-to-start trigger intervals, using sample clock period units.

When one of the internal timers is activated, all external and remote triggers are blocked to prevent interference to the internal timer from external devices.

Table 1-3, Run Modes and Trigger Source Options Summary

Run Mode	Trigger Option	Status
Continuous (Armed)	External – TRIG IN	Active
	External – EVENT IN	Active
	Internal	Disabled
	Front panel MAN button	Disabled
	Remote command	Active
Triggered	External – TRIG IN	Active
	External – EVENT IN	Active
	Internal	Active
	Front panel MAN button	Active
	Remote command	Active
Gated	External – TRIG IN	Active
	External – EVENT IN	Active
	Internal	Disabled
	Front panel MAN button	Disabled
	Remote command	Disabled

Table 1-4, Trigger Sources and Trigger Features Options Summary

Trigger Source	Trigger Feature	Status
TRIG IN	Self armed / Armed	Disabled
	Delayed trigger	Active
	Burst counter	Active
	Internal timer	Disabled
	Internal delay (re-trigger)	Disabled
	Normal / Override	Active
	<>time pulse width detector	Active
	Holdoff	Active
EVENT IN	Self armed / Armed	Active
	Delayed trigger	Active
	Burst counter	Active
	Internal timer	Active
	Internal delay (re-trigger)	Active
	Normal / Override	Disabled
	<>time pulse width detector	Disabled
	Holdoff	Disabled
Internal	Self armed / Armed	Disabled
	Delayed trigger	Disabled
	Burst counter	Active
	Internal timer	Active
	Internal delay (re-trigger)	Active
	Normal / Override	Disabled
	<>time pulse width detector	Disabled
	Holdoff	Disabled
Bus	Self armed / Armed	Active
	Delayed trigger	Active
	Burst counter	Active
	Internal timer	Disabled
	Internal delay (re-trigger)	Disabled
	Normal / Override	Active
	<>time pulse width detector	Active
	Holdoff	Active
MAN	Self armed / Armed	Disabled
	Delayed trigger	Active
	Burst counter	Active
	Internal timer	Disabled
	Internal delay (re-trigger)	Disabled
	Normal / Override	Active
	<>time pulse width detector	Disabled
	Holdoff	Disabled

Gated Run Mode

In gated mode, the WS8352 generates output waveforms on a stable gate level between two gate transitions. The gate opens on the first trigger transition and closes on the second transition. Gate level and transition slopes are programmable. Trigger delay and re-trigger do not apply to the gated run mode.

Table 1-5 summarizes the various controls for each output function of which the WS8352 can be operated when set to gated run mode. The various controls are explained below.

Table 1-5, WS8352 Gated Run Mode Controls

Waveform	Advance Mode	Arm Options	Idle Waveform	Initiate Signal	Abort Signal
Standard	-	Self Armed	-(*)	-	-
		Armed	DC	Trigger|Event	BUS
Arbitrary	-	Self Armed	-	-	-
		Armed	DC	Trigger|Event	BUS
Modulated	-	Self Armed	-	-	-
		Armed	DC	Trigger|Event	BUS
Pulse/Pattern	-	Self Armed	-	-	-
		Armed	DC	Trigger|Event	BUS

(*) defines not relevant for this mode

Waveform – basic output function that the WS8352 can generate. There are five output functions available: Standard, Arbitrary, Modulated, Pulse and Pattern.

Arm Options – bench operation normally defaults to self-armed when the output generates waveforms immediately after turning it on. Arming the WS8352 places the outputs in a wait-for-valid-enable signal before waveforms are generated through the output connectors. Self-armed is not optional for gate operation.

Idle Waveform – defines the shape of the waveform when the generator is armed, but has not been enabled yet.

Initiate Signal – defines the source from where a gating signal is expected to initiate an output. F.P defines the front panel MAN button as a manual gating source.

Abort Signal – defines the source of the abort signal. In this case, only BUS will cause the signal to stop.

Smart Trig – defines if smart trigger controls can be applied to the active trigger function

Output Type

The WS8352 can output various types of waveforms, including: Standard, Arbitrary, Modulated, Pulse and Pattern. The various output types are described in the following paragraphs.

Standard Waveforms

An array of built-in standard waveforms is available when the WS8352 is placed in its standard waveforms mode. The waveforms are calculated mathematically from known equations and converted to waveform coordinates that are then downloaded to the working memory. Unlike analog function generators that use electrical circuits to produce waveform shapes, the WS8352 must compute its waveform coordinates every time a new function is selected or every time that parameters of the function change.

The WS8352 can produce 11 standard waveforms: sine, triangle, square, ramp and pulse, sinc, gaussian and exponential pulses, DC and Pseudo-random noise. Some of the waveform parameters can be modified, such as: start phase for sine and triangle, duty cycle for square, rise and fall times for pulses, etc. The standard waveforms are the most commonly used wave shapes and therefore, were collected to a library of standard waveforms that can be used without the need to do off-product computation and use remote devices to download waveform coordinates.

The repetition rate of the standard waveforms is given in units of Hz. Since each channel has its own clock source, different waveforms, frequencies and run modes can be generated from its two outputs. On the other hand, when a common sample clock feed is selected, the two outputs must share the same run mode, but can still generate different waveforms and a unique set of parameters for each channel without interference between the channels. When synchronization between channels is turned on, minimal skew of the waveform starting edges is maintained between the two channels.

Figure 1-4 shows typical display for the standard waveforms function.

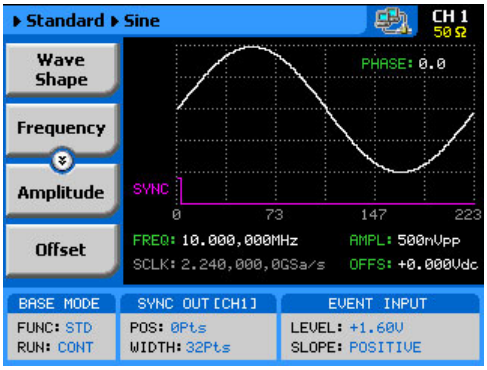

Figure 1-4, Typical WS8352 Standard Waveforms Display

Arbitrary Waveforms

One of the main functions of the WS8352 is generating real-life waveforms. These are normally not sine waves and squares, but user specific waveforms. Generating such waveforms requires external utilities such as MATLAB or even spreadsheets, but having the program alone is not enough for the WS8352. Once the waveform is computed and defined, it must be converted to coordinates and then to a format, which the instrument can accept.

Arbitrary waveforms are stored as digital XY coordinates in a special memory, normally referred to as working memory. Each coordinate is referred to as waveform point, or waveform sample. The waveform is better defined if it has many waveform points. For example: with only 8 points, a sine waveform will hardly resemble the shape of a sine wave and will look more like an up and down staircase, but with 100 points, the same sine waveform will look almost perfect.

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

The size of the working memory is limited to the way the hardware was designed. The WS8352 has 512K points available to build one or more waveforms. There is no need to use the entire memory for only one waveform, as the memory can be divided into smaller segments and loaded with different waveforms. The generator can be then programmed to output one segment at a time.

The WS8352 has separate arbitrary waveform memories for each channel and each channel can be loaded with different waveforms. Channels are not limited by the number of segments and by the shape of the waveforms.

Figure 1-5 shows a typical display for the arbitrary waveform function.

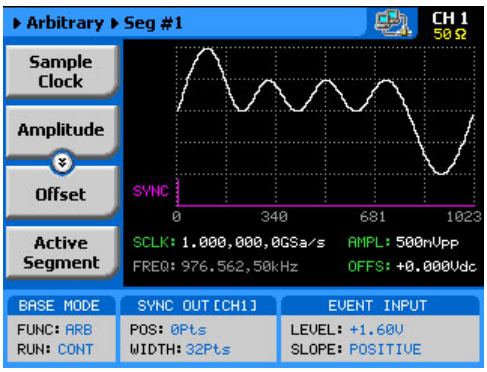

Figure 1-5, Typical WS8352 Arbitrary Waveforms Display

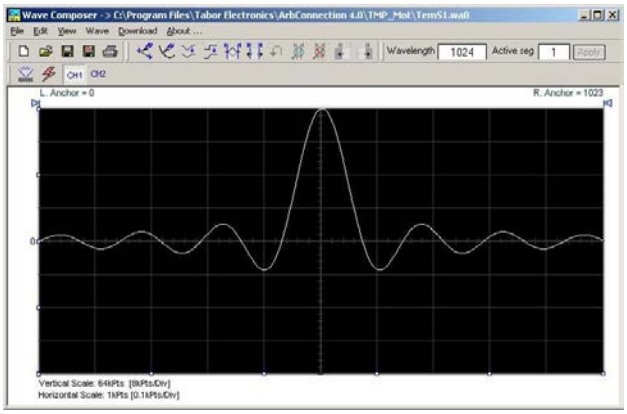

Figure 1-6, Segment 1 Waveform – Sinc

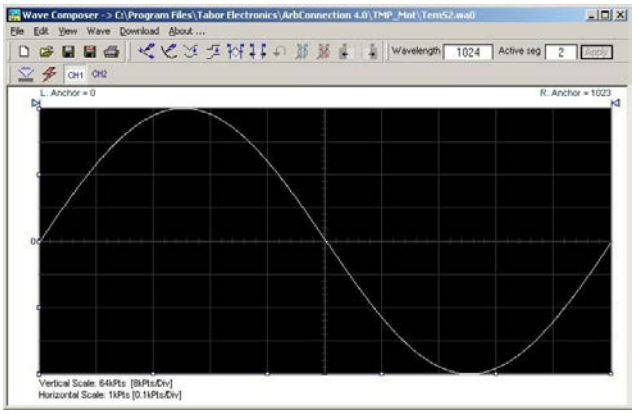

Figure 1-7, Segment 2 Waveform - Sine

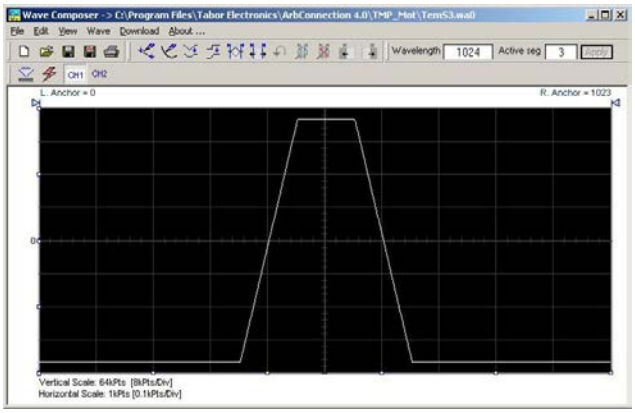

Figure 1-8, Segment 3 Waveform - Pulse

Modulated Waveforms

Modulated waveforms are computed mathematically and downloaded to the arbitrary waveform memory and generated at the output connector as an arbitrary waveform. The WS8352 is capable of producing an array of modulation, which places this generator in-line with stand-alone, high performance modulation generators. The WS8352 can produce: AM, FM, Sweep, Chirps, FSK, PSK, ASK, and Frequency and amplitude Hops. The WS8352 can also generate many types of (n)PSK and (n)QAM schemes. The various modulation schemes are described below.

Figure 1-9 shows a typical display for the modulated waveform function. General description of all modulation functions is given in the following.

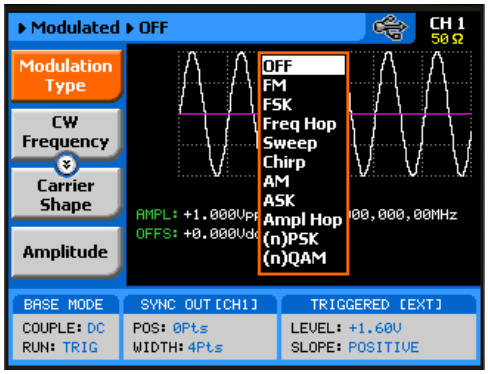

Figure 1-9, Typical WS8352 Modulated Waveform Display

Modulation Off

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

AM

The AM function enables amplitude modulation of a carrier waveform (CW). The carrier waveform is sine wave and it is being modulated by an internal waveform, normally referred to as envelope waveform. The envelope waveform can be selected from sine, triangle square or ramp shapes.

FM

The FM function allows frequency modulation of a carrier waveform (CW). The carrier waveform is sine wave and it is being modulated by an internal waveform, normally referred to as modulating waveform. The modulating waveform can be selected from sine, triangle or square waveforms.

Sweep

Sweep modulation allows carrier waveform (CW) to sweep from one frequency, defined by the sweep start parameter to another frequency, defined by the sweep stop parameter. Note that CW is sine wave only. The start and stop frequencies can be programmed throughout the entire frequency range of the instrument.

Chirp

Chirp modulation allows carrier waveform (CW) to sweep from one frequency, defined by the chirp start parameter to another frequency, defined by the chirp stop parameter. And at the same time swing from a certain amplitude level defined by the start amplitude to another amplitude level, defined by the stop amplitude. One may select to sweep the frequency and amplitude using linear steps but can also define logarithmic steps or mix of both.

The start and stop frequencies, as well as, the start and stop amplitude levels can be programmed throughout the entire frequency and amplitude ranges of the instrument.

FSK

FSK (Frequency Shift keying) modulation allows frequency hops between two pre-programmed frequencies: Carrier Waveform Frequency and Shifted Frequency. Note that CW is sine wave only and that the switch between two frequencies is always coherent.

ASK

ASK (Amplitude Shift keying) modulation allows amplitude hops between two pre-programmed amplitude levels. Note that CW is sine wave only. The signal level can hop between two amplitude levels throughout the entire amplitude range without crossing range or relay ranges.

Frequency Hop

In frequency hop mode, the output waveform (sine wave) hops from frequency to frequency in a sequence defined by the hop table. There are two hop types:

1. Frequency hops with fixed dwell time and
2. Frequency hops with variable dwell time

Amplitude Hop

In amplitude hop mode, the output waveform (sine wave) hops from amplitude to amplitude in a sequence defined by the hop table. There are two hop types:

1. Amplitude hops with fixed dwell time and
2. Amplitude hops with variable dwell time

(n)PSK

The (n)PSK function is very similar to the standard PSK function except the output can shift to multiple phase and amplitude positions to form phase shift constellations. There are 7 different types of phase shift keying that the WS8352 can generate: PSK, BPSK, QPSK, OQPSK, pi/4DQPSK, 8PSK, 16PSK and User defined PSK.

(n)QAM

The (n)QAM function is similar to the standard ASK function except the output can shift to multiple amplitudes and phase positions to form an amplitude/phase shift constellations. There are 4 different types of Quadrature Amplitude Modulation that the WS8352 can generate: 16QAM, 64QAM, and 256QAM. If another constellation scheme is required, one can use the User QAM to design his/her own symbol list and constellation.

Pulse Waveforms

The pulse generator function transforms the instrument into a pulse generator with the capability to generate pulses, exactly as they would be generated by a stand-alone pulse generator instrument. However, one should not forget that the WS8352 is a digital instrument and therefore the pulses are computed and placed in the waveform memory and then replayed at the output as arbitrary waveforms. When using this pulse function, one could program all pulse parameters in units of time (seconds) just as it would have been done on an analog instrument, but as a digital instrument, some of the parameters may take time to be computed and placed at the output connector.

All pulse parameters are programmable, including: period, pulse width, rise and fall times, delay, polarity and more. As a dual channel instrument, you may program different pulse settings for each channel, operate each channel separately or synchronize the two channels so that both outputs transition at the same time. Operating instructions for the pulse generator are given in Chapter 3.

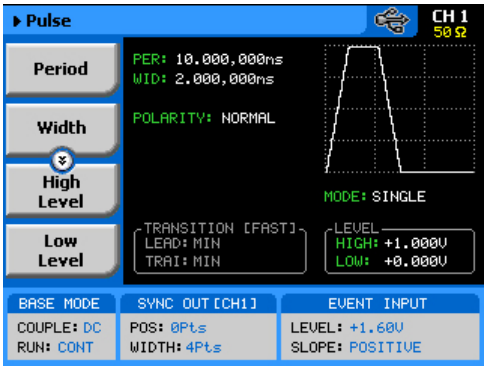

Figure 1-10, Typical WS8352 Pulse Generator Display

Pattern Waveforms

The pattern generator function transforms the instrument into a pulse generator with the capability to generate pulse patterns, exactly as they would be generated by a stand-alone pattern generator instrument. This includes user defined or PRBS random patterns, multi-level pattern for generating PAM signals and initialization or preamble pattern definition. However, one should not forget that the WS8352 is a digital instrument and therefore the patterns must be downloaded to the pattern memory and then replayed at the output as arbitrary waveforms.

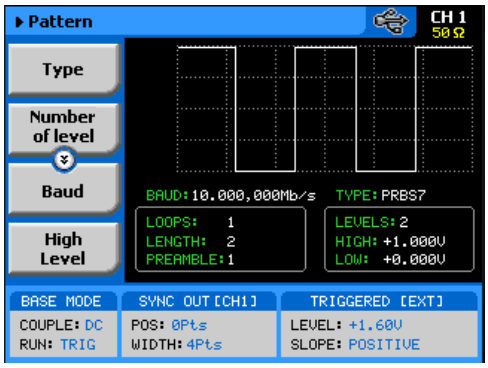

Figure 1-11, Typical WS8352 Pulse Pattern Generator Display

Output State

The main outputs can be turned on or off. However, the internal circuit is left connected to the output connector and so the impedance on this output remains low. If you do not intend to use a specific output, always remove the cables from this connector to prevent accidental application of externals signals to the output circuit. For application safety reason, when the instrument is powered up, the outputs are always off. For the same reason, when front panel settings are recalled from a stored setup, the outputs are always off.

Programming the WS8352

Some of the WS8352 functionality can be operated from the front panel and is mostly done with built-in libraries of waveforms. However, most applications require that waveforms are downloaded from a host computer and therefore, remote operation is essential for this class of instrument. Programming the WS8352 requires that the appropriate software utilities be installed in the computer and the rest is a matter of practice and knowledge of the language in use. There are other system considerations, such as address selection, that have to be settled before programming the instrument. These topics are discussed in later chapters.

Low level programming of the WS8352 is done using SCPI commands. Programming aspects are covered in Chapters 4. High-level drivers like IVI drivers are beyond the scope of this manual. Contact your Tabor representative for more information about high level drivers for the WS8352.

Chapter 2
Installation

Title **Page**

Installation Overview 2-2
Unpacking and Initial Inspection 2-2
Safety Precautions 2-2
Performance Checks 2-3
Power Requirements 2-3
Grounding Requirements 2-3
Long Term Storage or Repackaging for Shipment 2-4
Preparation for Use 2-4
Installation 2-4
Installing Software Utilities 2-5
Controlling the Instrument from Remote 2-5
Connecting to a Remote interface 2-5
Selecting a Remote interface 2-6
GPIB Configuration 2-7
USB Configuration 2-8
LAN Configuration 2-11
Choosing a Static IP Address 2-12
LAN Configuration Initialize (LCI) 2-14
LAN eXtension for Instruments (LXI) 2-15

Installation Overview

This chapter contains information and instructions necessary to prepare the WS8352 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 standard precautions and procedures applicable to handling of all sensitive electronic equipment. The contents of all shipping containers should be gone through to be sure that all accessories are included and checked against the packing slip to determine that the shipment is complete.

Safety Precautions

CAUTION

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

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 handle the instrument with dry hands.

WARNING

Always keep the lid closed when power is applied to the device under test conditions. Carefully read the Safety Precautions instructions that are supplied with your test fixtures. Any adjustment, maintenance and repair of an opened, powered-on instrument must be performed by authorized service personnel.

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 possible damage in transit and perform the electrical procedures outlined in the section entitled Unpacking and Initial Inspection.

Power Requirements

The waveform generator may be operated from a wide range of mains voltage from 100 to 240 Vac. Voltage selection is automatic and does not require switch setting. The instrument operates over the power mains frequency range of 50 to 60Hz. Always verify that the operating power mains voltage is the same as that specified on the rear panel. The instruments power consumption is 150VA max.

The WS8352 should be operated from a power source with neutral 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 WS8352 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 Representative, or the Tabor 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 similar 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 addresses on two sides of the box.

NOTE

If the instrument is to be shipped to Tabor 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 WS8352 TO TABOR.

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 the intention is to mount the instrument 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 so it is clear of any obstructions to the rear fan, to ensure proper airflow.

CAUTION

Using the WS8352 without proper airflow will result in damage to the instrument.

Installing Software Utilities

The WS8352 is supplied with a CD that contains an IVI 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 want to use the WS8352 from a host computer or a system in the future.

The *IVI driver* is a useful utility that provides standard communication and commands structure to control the WS8352 from remote. Programming examples are also available to expedite your software development. The IVI driver comes free with the WS8352**.** 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 Tabor's web site – www.taborelec.com.

The *USB* driver is required if you intend to connect the WS8352 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 WS8352 can be controlled from remote, using one of the following interfaces: USB, Ethernet or GPIB. Only USB remote interface cable is supplied with the instrument, so if you plan on using one of the other remote programming options, make sure you have a suitable cable to connect to your host computer. The following paragraphs describe how to connect and configure the WS8352 to operate from remote. The description is given for computers fitted with Windows XP, but installing software on other Windows versions is quite similar.

Connecting to a Remote interface

You can connect your Tabor WS8352 to GPIB, USB, or LAN adapters, depending on the application and requirements from your system. Installing interface adapters on your computer are not described in this manual, since the installation procedures for these adapters change frequently. Follow the instructions supplied with your particular adapter. Before proceeding with the remote interface installation, install an adapter card and follow the instructions as follows:

GPIB Connection

Direct connection between a host computer and a single device with GPIB is not recommended, since GPIB adapters are usually expensive and not really required for direct connection. Use a GPIB connection in cases where download speed is critical to the system or when you already have a GPIB system in place and you are adding the WS8352 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 WS8352 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 recommended, as this does not require any specific considerations or device configurations. Just connect your WS8352 to your PC using a standard USB cable and the interface will self-configure. After you connect the WS8352 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 10/100/1000 Base-T 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 WS8352 via twisted-pair Ethernet cable. Be sure to use twisted-pair wires designed for 10/100/1000 Base-T network use (phone cables will not work). Refer interconnection issues to your network administrator. After you connect the WS8352 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 WS8352 is supplied by the factory with the active remote interface set to USB. If you intend to use USB connection, 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 configure the USB port (first connection only). If you already used your instrument in various platforms and want to re-select your interface, you need to access the Select Interface screen as shown in Figure 2-1. To access this screen, press the Utility key in the Control group, then select the Remote Interface soft key and then the Select Interface soft key button.

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.

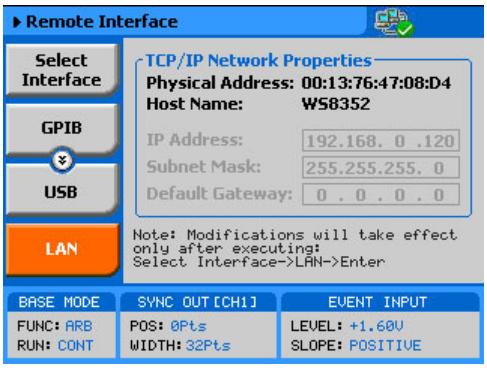

Figure 2-1, Selecting a Remote Interface

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 Utility control button, then press the Remote Interface soft key button and then select the GPIB soft key button. The display will be updated with the current GPIB address. 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 WS8352 to accept the new address setting.

Note

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

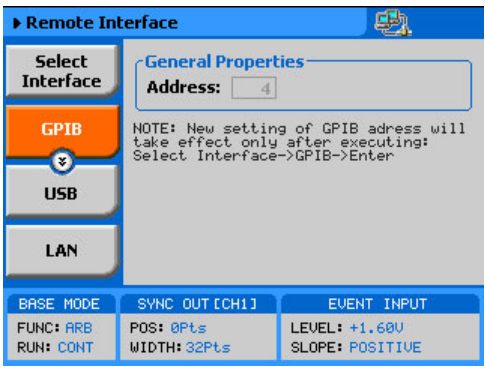

Figure 2-2, GPIB Configuration Screen

USB Configuration

Make sure you select USB as the Remote Interface from the front panel of the WS8352. Otherwise, the USB requires no front panel configuration parameters. Following the simple installation steps as shown later in this chapter, just connect your Tabor WS8352 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. After a few seconds, the message, as shown in Figure 2-4, will appear.

Figure 2-3, USB Device Detected, 1st Message

Figure 2-4, USB Device Detected, 2nd Message

Immediately thereafter, the Found New Hardware Wizard will open, as shown in Figure 2-5. Select the Install the software automatically (Recommended) option and click on next. Note that either the Agilent I/O library or the NI-VISA must be installed on your computer for the driver to install automatically. When the new driver has been detected and installed, expect to see the following dialog box on the computer screen:

Figure 2-5, Found New Hardware Wizard

Figure 2-6 shows that the Tabor WS8352 USB Waveform Generator has been found and the software driver installed. To make sure your USB port and the Tabor WS8352 configured correctly, compare your Device Manager to the example in Figure 2-7.

Figure 2-6, New Hardware Found and Software installed

Figure 2-7, Model WS8352 Configured for USB Operation

Figure 2-6 shows that the Tabor WS8352 USB Waveform Generator has been found and the 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, in this case it found a USB serial port, as shown in Figure 2-7.

Note

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

LAN Configuration

There are several parameters that you may have to set, in order 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 screen, as shown in Figure 2-8.

To access this screen, press the Utility control button, then press the Remote Interface soft key button and select the LAN soft key button. The display will be updated with the current LAN settings.

Note: there are some parameters that are shown on the display that cannot be accessed or modified: Physical Address and Host Name. These parameters are set in the factory and are unique for this specific 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 on how to change them is given in the following.

Note

Configuring your LAN setting does not automatically update LAN parameters or select the LAN as your active remote interface. Setting a remote interface is done from the Select interface menu. LAN parameters will be updated only after re-selecting the LAN interface from the Select Interface menu. Information how to select and Interface is given earlier in the chapter.

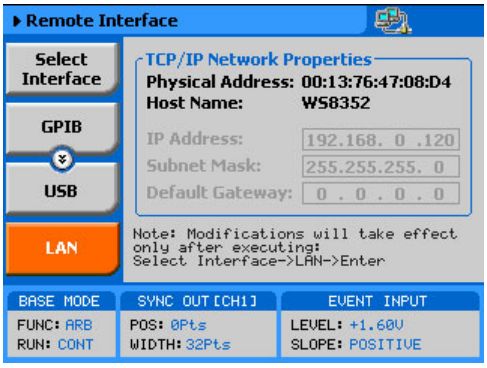

Figure 2-8, LAN Configuration Screen

There are three LAN parameters in this screen that can be modified and adjusted specifically to match your network setting, as 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 2000/XP/Win7**

  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.

LAN Configuration Initialize (LCI)

The LCI Mechanism resets the instrument LAN settings to its default state. To access the LCI button, as shown in figure 2-9, press the utility button, select remote interface, then press the Top button and then scroll down.

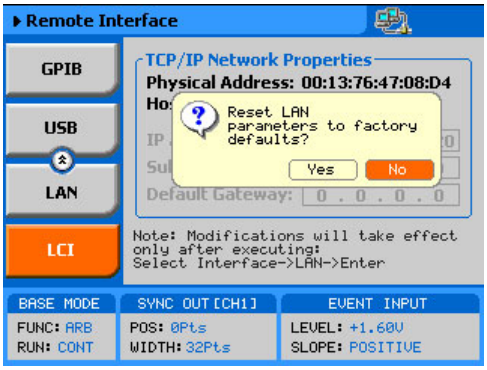

Figure 2-9, LAN Configuration Initilalize

The LAN default settings are shown below in Table 2-2

Table 2-2, LAN default Settings

Item	Value
IP Address Configuration: • DHCP • Static IP	 Enabled 192.168.0.223
Subnet Mask	255.255.255.0
Default Gateway	0.0.0.0
Hostname	TEDevice
Username	admin
Password	password

LAN eXtension for Instruments (LXI)

Aside from the front panel and the ability to control the unit via a remote interface using SCPI commands, the WS8352 offers a built-in web interface. The web interface provides a convenient way of controlling and configuring the instrument simply by entering the instruments IP address in your web browser. Once this is done a welcome page will appear as shown in Figure 2-10. .

Figure 2-10, Welcome page for a Web-controlled WS8352

On the upper left side of the welcome page there are 6 tabs, Browser Web Control, Instrument Utilities, Configure Network, Network Status, Print Page, and Help with this Page. Each tab is described and explained in the following paragraph.

Note

When trying to access some of the functionality of the web interface the user will be prompted to enter a user name and password. The factory default user name is "admin" and password is "password". You are strongly advised to change the user name and password to restrict the access to the instrument only to authorized users. The login settings can be changed under the Configure Network tab.

Browser Web Control - opens a screen where you can choose how to control and access the instrument, whether remote front panel or remote programming.

The remote front panel link opens a new browser window where a simulation of the instruments front panel will be presented. Note, you will be prompted to install ActiveX plug-in and a Tabor Electronics application. The user can then control the instrument through this remote front panel as if the instrument was in front of him. Detailed information on how to use the instrument is given in Chapter 3 of this manual.

The remote programming link opens a new browser window with a command editor field for entering the SCPI commands and a Response field for reading the instrument's response to queries. Detailed information on programming the instrument and its SCPI commands is given in chapter 4 of this manual.

Instrument Utilities - The instrument utilities tab allows the user to view different properties of the instrument. These include, the installed options, Firmware version, and calibration status.

Configure Network - To configure the various network properties click on the Configure Network tab. The main screen will show the current network configuration. To change the configuration click on the Modify Configuration button. Here you will be able to modify the different properties of the network environment or restore the factory default settings. Furthermore, this is where the factory default login settings can be changed.

Network Status – The network status tab provides an updated information on the network speed and packets exchange.

Print Page – enables the user to print out a copy of the current screen being displayed.

Help with this page – open a help screen with information on the current page.

Chapter 3
Using the Instrument

Title **Page**

Overview....3-4
Inter-Channel Dependency....3-4
Output Termination....3-4
Input / Output Protection....3-5
Power On/Reset Defaults....3-5
Controlling the WS8352....3-7
WS8352 Front Panel Menus....3-9
  Pulse and Pattern Menus....3-13
  Control Menus....3-15
Enabling the Outputs....3-17
Selecting a Function Shape....3-17
Changing the Output Frequency....3-18
Changing the Sample Clock Frequency....3-19
Programming the Amplitude and Offset....3-20
Selecting a Run Mode....3-21
  Continuous Run Mode....3-22
  Triggered Run Mode....3-23
    Using the Delayed Trigger....3-25
    Using the Built-in Auto-Trigger Generators....3-25
  Gated Run Mode....3-26
  Abort....3-27
Using the Manual Trigger....3-28
Using the SYNC Output....3-28
Synchronizing Channel 1 and Channel 2....3-30
Controlling Cross-Channel Propagation....3-31
Using External Clock References....3-31
  Using an External SCLK Source....3-32
  Using an External Clock Reference Source....3-33
Generating Standard Waveforms....3-35
  Sine Wave....3-36

Triangle Wave 3-36
Square Wave 3-37
Ramp Wave 3-37
Sinc Wave 3-38
Gaussian Wave 3-39
Exponential Wave 3-39
DC Wave 3-40
Noise Wave 3-40
Standard Waveforms and Run Mode Options 3-41
Generating Arbitrary Waveforms 3-43
What Are Arbitrary Waveforms? 3-43
Generating Arbitrary Waveforms 3-44
Arbitrary Waveforms and Run Mode Options 3-46
Generating Modulated Waveforms 3-48
Off 3-49
FM 3-50
FSK 3-51
Frequency Hop 3-53
Sweep 3-55
Chirp 3-56
AM 3-58
ASK 3-59
Amplitude Hop 3-61
(n)PSK 3-63
User PSK 3-64
(n)QAM 3-65
User QAM 3-67
Modulated Waveforms and Run Mode Options 3-69
Generating Pulse Waveforms 3-71
Pulse Parameters 3-73
Understanding Pulse Parameters 3-73
Pulse Modes 3-75
Single Pulse Mode 3-76
Delayed Pulse Mode 3-77
Double Pulse Mode 3-78
Programming Pulse Polarity 3-79
Applying Linear Transitions 3-80
Programming the Amplitude Level Mode 3-82
Pulse Design Limitations 3-84
Settings Conflict Errors 3-85
Amplitude Errors 3-85

Pulse Timing Errors 3-86
Pulse Linear Transition Errors 3-86
Pulse Delay Errors 3-86
General Pulse Errors 3-87
Generating User Composed Patterns 3-87
Building “Fast” Transitions Patterns 3-89
Building “Linear” Transitions Patterns 3-91
Generating Pattern waveforms 3-93
Generating PRBS Patterns 3-93
Using Store/Recall 3-97
Storing Instrument Setups and Waveforms 3-98
Recalling Instrument Setups and Waveforms 3-99
Listing Storage Memory Contents 3-100
Store/Recall Considerations 3-101
Store/Recall Messages 3-102

Overview

This chapter contains information about how to operate the Tabor WS8352. 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 operate the arbitrary waveform generator using front panel sequences.

The following paragraphs describe the various modes of operation and give examples of how to program the WS8352. The manual is organized by instrument function, and instructions are given in each paragraph on how to use this function from the front panel.

Inter-Channel Dependency

The WS8352 has two completely independent output channels. Each channel can be programmed to output a unique set of functions and parameters, which can be generated using separate run modes. As each channel is completely separate, there is no influence from one channel on its adjacent channel. There are a few controls that are shared by the two channels including: trigger and event inputs, sync output and remote interface connections.

On the other hand, there are many applications that require two (or more) channels. These are normally expected to share output frequency, sample clock and retain a controllable phase dependency. In this case, the WS8352 can be placed in a common sample clock feed mode and transform its operation to a dual channel generator where run mode and output function are shared, but each channel remains independent to generate different waveforms and amplitudes.

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 50 Ω termination at the far end of the cables.

The WS8352 has two output connectors for each channel, marked “Normal” and “Inverted”. If single-ended output is required, the other output must be terminated with a 50 Ω plug termination, right at the output connector.

Note that the display reading of the amplitude level is calibrated to show the actual level on the load, when the load impedance is roughly 50 Ω. In cases where the load has different impedance, the display will indicate a reading that does not match the actual amplitude level on the load.

Input / Output Protection

The WS8352 provides protection for the internal circuitry that is 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.

WARNING

The outputs can only be connected to resistive loads. Connecting the WS8352 to inductive or capacitive loads may damage the output and void the warranty on the instrument.

Power On/Reset Defaults

The WS8352 utilizes non-volatile memory backup that automatically stores the last setup before the generator has been turned off. Every time you turn on the instrument, the non-volatile memory updates the front panel setting with modes, parameters and waveforms from its last setting with only one exception. For safety reasons, the outputs remain off even if they were turned on before powering down the WS8352.

After power on, the instrument displays information messages and updates the display with the last setup information. The WS8352 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 WS8352, 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.

As seen below in Figure 3-1 you can reset parameters to factory defaults as follows:

1. Press the Utilities control key
2. Press the Factory Rests soft key
3. Select Yes or No in the pop-up dialog box

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

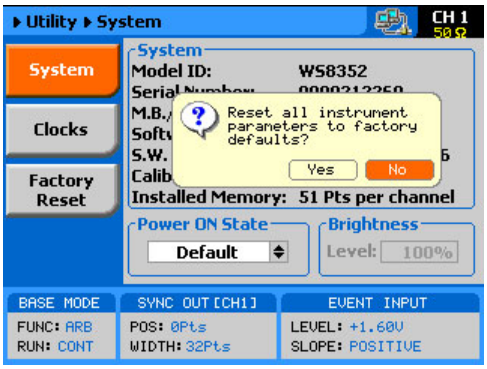

Figure 3-1, Reset WS8352 to Factory Defaults

Table 3-1, Default Conditions after Reset

Function / Parameter	Default
Outputs State	Off
SYNC State	Off
Operating Mode	Continuous
Active Channel	1
Output Function	Standard
Output Function Shape	Sine
Standard Wave Frequency	10 MHz
User Wave Sample Clock	1 GSa/s
Sample Clock Feed	Separate
Sample Clock Source & Reference	Internal
Amplitude	0.5 V
Trigger Slope:	Positive
Trigger Level:	1.6 V
Trigger Source:	External

Controlling the WS8352

Controlling WS8352 function, modes and parameters is simply a matter of pressing once or twice on the appropriate button as described in the following paragraphs. Refer to Figure 3-2 throughout this description.

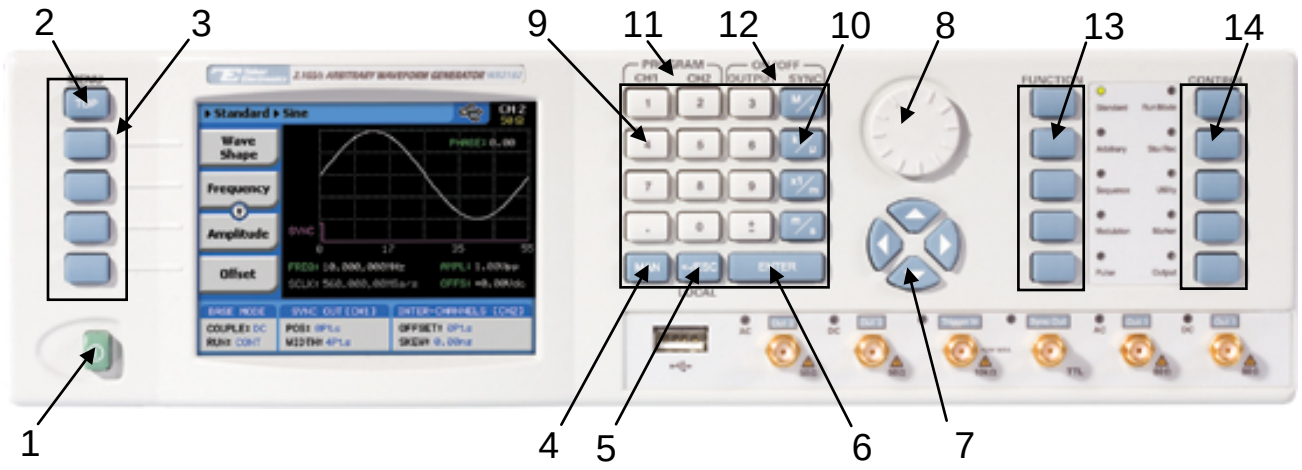

Figure 3-2, WS8352 Front Panel Operation

Note

The index in the following paragraphs point to the numbered arrows in Figure 1-2.

1. ***Power Switch*** – Toggles WS8352 power ON and OFF
2. ***Menu Top*** – For certain functions, selects the root menu. This button is disabled during parameter editing
3. ***Menu Soft Keys*** – These select parameter to be audited

   These buttons are disabled during parameter editing
4. ***MAN*** – Manual trigger button, used in lieu of an external trigger signal
5. ***<-Esc / (Local)*** – Has two functions:
   1) When in edit mode, cancels edit operation, restore last value and returns to the main function screen
   2) When operating the WS8352 from a remote interface, none of the front panel buttons are active except the Local button. When pressed, it restores control to front panel buttons

6. ***Enter*** – 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 a parameter is modified, Enter can be used to replace the x1 suffix key
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 modifies 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/n, k/μ, x1/m and m/s)* – These keys are used to place suffix at the end of the parameter. They are also used for terminating an edit operation.
11. ***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 WS8352 is not in edit mode.
12. ***ON/OFF Output, Sync*** – These keys can be used only when the WS8352 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.
13. ***Function*** – These keys select one of 5 function menus that the WS8352 can generate. The output functions are: Standard, Arbitrary, Modulated, Pulse and Pattern. An LED lights next to the selected function.
14. ***Control*** – These keys select control menus that program the WS8352 operating modes. The control menus are: Run Mode, Store/Recall, Utility, Remote and Output.

WS8352 Front Panel Menus

The WS8352 has over 150 parameters that control functions, modes, waveforms and auxiliary functions and an enormous combination of these parameters to define an appropriate function for a specific application. Due to the complexity of the product, the functions were divided into logical groups and sub-groups and access to these groups is provided using the soft key menus.

On the right side of the instrument there are two groups of buttons: Function and Control. The function buttons select one of five waveforms to be generated at the output connectors and cause the display to show parameters that are associated with the output function.

The other group is marked Control. These buttons control operating features and auxiliary functions that are complementary to the Function buttons. On the left, there is a group of five soft-key buttons. These are used for accessing a specific parameter associated with the output function.

Tables 3-2 and 3-3 list all menus that are accessible from the Function group and Table 3-3 lists all menus that are accessible from the Control group. Short explanation of the various menus is also given. Note that the descriptions in these tables are given to provide a general understanding of what is available in terms of operating the instrument. For detailed instructions, check the appropriate section of the manual.

Table 3-2, Front Panel Function Menus

Soft Key	Function Menu	2nd Level Menu	3rd Level Menu	Notes
Top	Standard			
A		Wave Shape	Waveform list	Select from a wave shapes list
B		Frequency	Value	Programs standard waveform frequency
C		Amplitude	Value	Programs output amplitude
D		Offset	Value	Programs output amplitude offset
↓(D) *		Phase	Value	Parameters depend on selected shape
Top	Arbitrary			
A		Sample Clock	Value	Programs sample clock frequency
B		Amplitude	Value	Programs output amplitude
C		Offset	Value	Programs output amplitude offset
D		Active Segment	Value	Selects the active arbitrary waveform segment
↓D**		Wave Composer	Waveform studio	Provides access to the waveform composer
↓D		Delete Segments	Value	

* () Denotes conditional menu, not always shown. Available in conjunction with a specific mode only

**↓ 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 Waveform Menus (continued)

Soft Key	Function Menu	2nd Level Menu	3rd Level Menu	Notes
Top	Modulation			
A	OFF	Modulation Type	OFF/AM/FM/Sweep/ Chirp/FSK/ASK/ Freq Hop/Ampl Hop/(n)PSK/(n)QAM	Select from a modulation type list
B		CW Frequency	Value	Programs the modulation carrier frequency
C		Carrier Shape	Sine/tri/squ	
C		Amplitude	Value	Programs output amplitude
↓D		Offset	Value	Programs output amplitude offset
A	AM	Modulation Type	OFF/AM/FM/Sweep/ Chirp/FSK/ASK/ Freq Hop/Ampl Hop/(n)PSK/(n)QAM	Select from a modulation type list
B		Modulation Shape	Sine/tri/squ/ramp	Programs the modulating waveform shape
C		Modulation Depth	Value	Programs the modulation depth
D		Modulation Freq	Value	Programs the modulating frequency
↓D **		CW Frequency	Value	Programs the modulation carrier frequency
↓D		Carrier Shape	Sine/Triangle/Square	Selects the shape of the carrier waveform
↓D		Amplitude	Value	Programs output amplitude
↓D		Offset	Value	Programs output amplitude offset
A	FM	Modulation Type	OFF/AM/FM/Sweep/ Chirp/FSK/ASK/ Freq Hop/Ampl Hop/(n)PSK/(n)QAM	Select from a modulation type list
B		Modulation Shape	Sine/tri/squ/ramp	Programs the modulating waveform shape
C		CW Frequency	Value	Programs the modulation carrier frequency
D		Freq. Deviation	Value	Programs FM frequency deviation
↓D		Modulation Freq	Value	Programs the modulating frequency
↓D		Marker	Value	Programs marker frequency position
↓D		Carrier Shape	Sine/Triangle/Square	Selects the shape of the carrier waveform
↓D		Amplitude	Value	Programs output amplitude
↓D		Offset	Value	Programs output amplitude offset
A	Sweep	Modulation Type	OFF/AM/FM/Sweep/ Chirp/FSK/ASK/ Freq Hop/Ampl Hop/(n)PSK/(n)QAM	Select from a modulation type list
B		Sweep Type	Linear/Logarithmic	Selects the sweep step
C		Direction	Up/Down	Selects the sweep direction
D		Start Frequency	Value	Programs the start frequency
↓D		Stop Frequency	Value	Programs the stop frequency
↓D		Sweep Time	Value	Programs the sweep time
↓D		Marker	Value	Programs marker frequency position
↓D		Carrier Shape	Sine/Triangle/Square	Selects the shape of the carrier waveform
↓D		Amplitude	Value	Programs output amplitude
↓D		Offset	Value	Programs output amplitude offset

* () Denotes conditional menu, not always shown. Available in conjunction with a specific mode only

**↓ 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 Waveform Menus (continued)

Soft Key	Function Menu	2nd Level Menu	3rd Level Menu	Notes
A	Chirp	Modulation Type	OFF/AM/FM/Sweep/ Chirp/FSK/ASK/ Freq Hop/Ampl Hop/(n)PSK/(n)QAM	Select from a modulation type list
B		Sweep Type	Linear/Logarithmic	Selects the sweep step
C		Sweep Direction	Up/Down	Selects the sweep direction
D		AM Shape	Linear/Logarithmic	Selects the amplitude steps
↓D		AM Direction	Up/Down	Selects the amplitude direction
↓D		Start Frequency	Value	Programs the start frequency
↓D		Stop Frequency	Value	Programs the stop frequency
↓D		Pulse Width	Value	Programs width of entire chirp pulse
↓D		Pulse Repetition	Value	Programs chirp pulse repetition rate
↓D		AM Depth	Value	Programs the modulation depth
↓D		Carrier Shape	Sine/Triangle/Square	Selects the shape of the carrier waveform
↓D		Amplitude	Value	Programs output amplitude
↓D		Offset	Value	Programs output amplitude offset
A	FSK	Modulation Type	OFF/AM/FM/Sweep/ Chirp/FSK/ASK/ Freq Hop/Ampl Hop/(n)PSK/(n)QAM	Select from a modulation type list
B		FSK Data	Data	Program the sequence of frequencies
C		CW Frequency	Value	Programs the modulation carrier frequency
D		Shifted Frequency	Value	Programs the shifted frequency of logic level ‘1’
↓D		Baud	Value	Programs the bit rate
↓D		Marker	Value	Programs marker position
↓D		Carrier Shape	Sine/Triangle/Square	Selects the shape of the carrier waveform
↓D		Amplitude	Value	Programs output amplitude
↓D		Offset	Value	Programs output amplitude offset
A	ASK	Modulation Type	OFF/AM/FM/Sweep/ Chirp/FSK/ASK/ Freq Hop/Ampl Hop/(n)PSK/(n)QAM	Select from a modulation type list
B		ASK Data	Data	Program the sequence of frequencies
C		CW Frequency	Value	Programs the modulation carrier frequency
D		Start Amplitude	Value	Programs the initial amplitude level
↓D		Shifted Amplitude	Value	Programs the shifted amplitude level of logic level ‘1’
↓D		Baud	Value	Programs the bit rate
↓D		Carrier Shape	Sine/Triangle/Square	Selects the shape of the carrier waveform
↓D		Marker	Value	Programs marker position
↓D		Offset	Value	Programs output amplitude offset

* () Denotes conditional menu, not always shown. Available in conjunction with a specific mode only

** ↓ 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 Waveform Menus (continued)

Soft Key	Function Menu	2nd Level Menu	3rd Level Menu	Notes
A	Freq Hop	Modulation Type	OFF/AM/FM/Sweep/ Chirp/FSK/ASK/ Freq Hop/Ampl Hop/(n)PSK/(n)QAM	Select from a modulation type list
B		Hop Data	Data	Program the frequency hop table
C		Dwell Type	Fixed/Variable	Selects fixed or variable dwell time
D		Dwell time	Value	Programs the lapse of time for a hop step
↓D		Marker	Value	Programs marker position
↓D		Carrier Shape	Sine/Triangle/Square	Selects the shape of the carrier waveform
↓D		Amplitude	Value	Programs output amplitude
↓D		Offset	Value	Programs output amplitude offset
A	Ampl Hop	Modulation Type	OFF/AM/FM/Sweep/ Chirp/FSK/ASK/ Freq Hop/Ampl Hop/(n)PSK/(n)QAM	Select from a modulation type list
B		Hop Data	Data	Program the frequency hop table
C		CW Frequency	Value	Programs the modulation carrier frequency
D		Dwell Type	Fixed/Variable	Selects fixed or variable dwell time
↓D		Dwell time	Value	Programs the lapse of time for a hop step
↓D		Carrier Shape	Sine/Triangle/Square	Selects the shape of the carrier waveform
↓D		Marker	Value	Programs marker position
↓D		Offset	Value	Programs output amplitude offset
A	(n)PSK	Modulation Type	OFF/AM/FM/Sweep/ Chirp/FSK/ASK/ Freq Hop/Ampl Hop/(n)PSK/(n)QAM	Select from a modulation type list
B		PSK Type	PSK/BPSK/QPSK/ OQPSK/pi/4DQPSK/ 8PSK/16PSK/USER	selects the type of PSK modulation
C		PSK Data	Data	Programs the PSK symbols table
(D)		CW Frequency	Value	Programs the modulation carrier frequency available for PSK modulation only
D		CW Control	CW OFF/CW ON	Select whether CW is on or off
(↓D)		Start Phase	Value	Programs the initial phase available for PSK modulation only
(↓D)		Shifted Phase	Value	Programs the shifted phase of logic level ‘1’ available for PSK modulation only
↓D		Baud	Value	Programs the bit rate
↓D		Marker	Marker	Programs marker position
↓D		Amplitude	Value	Programs output amplitude
↓D		Offset	Value	Programs output amplitude offset

* () Denotes conditional menu, not always shown. Available in conjunction with a specific mode only

** ↓ 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 Waveform Menus (continued)

Soft Key	Function Menu	2nd Level Menu	3rd Level Menu	Notes
A	(n)QAM	Modulation Type	OFF/AM/FM/Sweep/ Chirp/FSK/ASK/ Freq Hop/Ampl Hop/(n)PSK/(n)QAM	Select from a modulation type list
B		QAM Type	16QAM/64/QAM/256 QAM/USER	selects the type of QAM modulation
C		nQAM Data	Data	Programs the QAM symbols table
D		CW Control	CW OFF/CW ON	Select whether CW is on or off
↓D		Baud	Value	Programs the bit rate
↓D		Marker	Marker	Programs marker position
↓D		Amplitude	Value	Programs output amplitude
↓D		Offset	Value	Programs output amplitude offset

* () Denotes conditional menu, not always shown. Available in conjunction with a specific mode only

** ↓ Denotes you have to scroll down to access the menu. Scroll using the arrows up or down or the dial.

Pulse and Pattern Menus

The menus that are described in Table 3-2 are somewhat different than the pulse menus as they are relatively straightforward as each menu controls a separate, single parameter. There is a slight difference when it comes to operating a pulse generator; simple pulse generation requires just a few parameters such as: period, pulse width, and hi and low levels however, it gets complicated when the application requires transition times, pulse delays and different level control. For this purpose, the start-up menu for the pulse function is the simplest and provides access to the commonly used parameters, but as you select more complex modes, other menus are automatically turned on, allowing access to mode parameters.

The following table is presented not to show you how to use the pulse generator, but to give you a general overview of all menus available for this function. A detailed description on the pulse function is given later in this chapter.

Table 3-3, Front Panel Pulse and Pattern Function Menus

Soft Key	Function Menu	2nd Level Menu	3rd Level Menu	Notes
Top	Pulse			
A		Period	Value	Programs pulse repetition rate
B		Width	Value	Programs the pulse width
(C)*		Delay	Value	Programs delay for the delayed/double pulse mode
C		High Level	Value	Programs the pulse high level
(C)		Amplitude	Value	Programs amplitude for the level control mode
D		Low Level	Value	Programs the pulse low level
(D)		Offset	Value	Programs offset for the level control mode
↓(D)**		Leading Edge	Value	Programs rise time for the linear/symmetrical transition type
↓(D)		Trailing Edge	Value	Programs fall time for the linear/symmetrical transition type
↓D		Config	Pulse Configuration	Opens a new set of configuration menus.
		Pulse Composer	Pulse Composer table	Opens a table for creating pulses and pulse trains
		Pattern	Pattern Composer	Opens a menu for crating Patterns
	Config			
A		Pulse Parameters	Time / Percent	Pulse parameter settings in time or percent of period
B		Pulse Mode	Single / Delayed / Double	Programs pulse mode
C		Polarity	Normal / Complemented / Inverted	Selects pulse polarity
D		Transition Type	Fast / Linear	Programs pulse transitions
↓D		Level Control	High / Low / Amplitude / Offset / Positive / Negative	Defines how the pulse levels are programmed
TOP	Pattern			
A		Type	PRBS7/9/11/15/23/31/ USER	Select pattern type
B		High Level	Value	Programs the pattern high level
C		Low Level	Value	Programs the pattern low level
D		Number of levels	Value	Programs the number of levels
↓D		Baud	Value	Programs the bit rate
↓D		Length	Value	Programs the length of the pattern
↓D		Preamble	Value	Programs the preamble bit
↓D (*)	Ampl/Offset	Offset	Value	Programs offset for the level control mode

* () Denotes conditional menu, not always shown. Available in conjunction with a specific mode only

** ↓ Denotes you have to scroll down to access the menu. Scroll using the arrows up or down or the dial.

Control Menus

The Control menus buttons, unlike the Function menus buttons, display menus and parameters that modify the output to various run modes, turns the outputs on and off, and provides access to utility functions. You may also use these buttons to store and recall instrument settings and waveforms.

Table 3-4 lists all menus that are accessible from the Control group. A short explanation of the various menus is also given. Note that the descriptions in these tables are provided to give you a general overview of what is available in terms of operating the instrument. For detailed instructions, check the appropriate section of the manual.

Table 3-4, Front Panel Control Menus

Soft Key	Control Menu	2nd Level Menu	3rd Level Menu	Notes
TOP	Run Mode			
A		Continuous	Enable Mode	Selects between Self Armed and Armed
			Enable Source	Selects between BUS, Event or Trigger inputs
			Event Input Level	Programs the event threshold level
			Event Input Slope	Selects Positive, Negative or, Either transition
B		Trigger	Trigger Mode	Selects between Normal and Override
			Trigger Source	Selects between BUS, Event or Trigger inputs
			Trigger Level	Programs the trigger threshold level
			Trigger Slope	Programs the trigger slope
			Trigger Delay	Programs the delayed trigger and re-trigger timer
			Trigger Timer	Programs the internal timer period
			Trigger Count	Programs the burst counter value
			Smart Trigger >time	Programs the more than pulse period value
			Smart Trigger <time	Programs the less than pulse period value
			Trigger Hold off	Programs trigger hold off time
C		Gated	Gated Level	Programs the gate threshold level
			Gated Slope	Selects Positive or Negative levels
TOP	Sto/Rec			
A		Store	Target	Toggles between internal and USB
			Memory Cell	Selects the active memory cell
			Store	Defines what will be stored
B		Recall	Source	Selects the source to recall setups
			Memory Cell	Selects the active memory cell
C		List	Source	Toggles between internal and USB
(D)		Clear Cell	Value	In list view Select cell number to be deleted
D		Update		Executes the store or recall

* () Denotes conditional menu, not always shown. Available in conjunction with a specific mode only

** ↓ Denotes you have to scroll down to access the menu. Scroll using the arrows up or down or the dial

Table 3-5, Front Panel Control Menus (continued)

Soft Key	Control Menu	2nd Level Menu	3rd Level Menu	Notes
TOP	Utility			
A		System	Power on State	Selects between Default and Setup
			Brightness	Programs display brightness
B		Clocks		
			Sample Clock Feed	Programs separate or common feed
			Ext. SCLK Freq.	Prepares the external sample frequency range
			CH1 Source	Selects between Internal and External source
			CH1 Divider	Programs a dividing ratio for the external clock
			CH2 Source	Grayed out. Selection is automatic, depending on the Sample Clock Feed setting
			Ref Clock Source	Selects between Internal and External source
			Ref Clock Ext. Freq.	Prepares the external reference frequency range
C		Factory Reset		Resets all instrument parameters to factory defaults
TOP	Remote			
A		Remote Interface	Select Interface	Provides access to interface setup: GPIB / USB / LAN
			GPIB	GPIB address setting
			USB	No parameter setting
			LAN	Programs LAN IP address, subnet mask and gateway
			LCI	Initialize LAN setting
TOP	Output			
A		Main Output	Output CH1	Toggles the main output ON and OFF
			Output CH2	Toggles the main output ON and OFF
B		SYNC Output	State	Toggles the SYNC output ON and OFF
			Source	Selects between CH1 and CH2
			Type	Selects between Pulse and WCOM
			Position	Programs the SYNC position value
			Width	Programs the SYNC width value
C		X-Channel	Offset CH2->CH1	Programs CH2 2 offset value referenced to CH1
			Skew CH2->CH1	Programs CH2 2 skew value referenced to CH1

* () Denotes conditional menu, not always shown. Available in conjunction with a specific mode only

** ↓ Denotes you have to scroll down to access the menu. Scroll using the arrows up or down or the dial

Enabling the Outputs

For safety reasons, the main outputs default setting is OFF. The outputs can be turned on and off using either the hot keys, or the Output Menu. Please see Figure 3-3 and disable or enable the main outputs using the procedure described below. The same procedure can be used for enabling and disabling the SYNC output.

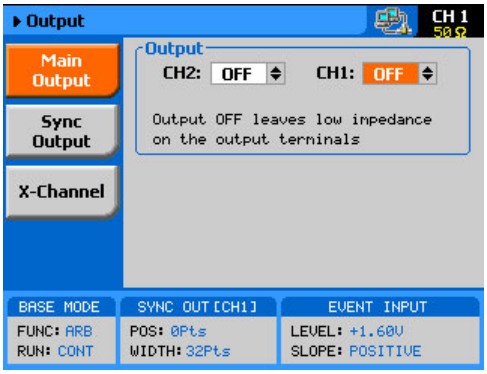

Figure 3-3, Enabling and Disabling the Outputs

1. Press the Output button in the Control group buttons. Observe the Output display, as it appears in Figure 3-3.
2. Use the dial or arrow keys to access the required field, which will appear orange.
3. To edit the field press Enter. The edited field will turn white with orange borders
4. Use the dial or arrow keys to change the field
5. Press Enter again to lock in the setting

Alternately, the outputs can be turned on and off using the hot-key buttons as marked above the keypad.

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

Selecting a Function Shape

There are five function shapes that the WS8352 can produce: Standard, Arbitrary, Modulated, Pulse and Pattern. The standard, modulated pulse and pattern waveforms are computed from equations and tables that are built into the program, but for the arbitrary functions, waveform coordinates must first be loaded into its working memory. To generate one of the function types, simply press one of the Function buttons on the right side of the product. The display will change to display parameters that are associated with the selected function. For standard, modulated, pulse and pattern functions, the output will immediately generate the selected function. Arbitrary waveforms will be generated only after waveform coordinates have been downloaded to the working memory.

Note

The picture in the WS8352 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. Frequency applies to standard waveforms only and controls waveform frequency at the output connector. The sample clock frequency parameter is valid for arbitrary waveforms only, and defines the frequency of the generator clocks data points.

Pulse waveform period is measured in units of seconds. Standard waveform frequency is measured in units of Hz and Arbitrary waveform sample clock frequency is measured in units of Sa/s (samples per second). The frequency of a given arbitrary waveform at the output connector is dependent 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.

Please see Figure 3-4 and modify frequency using the following procedure:

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/n, k/µ, x1/m or m/s to terminate the modification process.

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

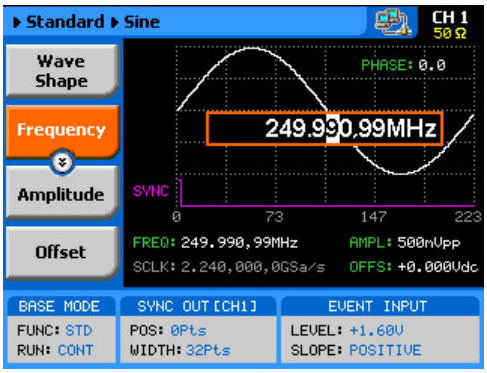

Figure 3-4, Modifying the Output Frequency

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 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 waveforms are generated. First, select an arbitrary waveform as described earlier and then proceed with sample clock frequency modification.

Please see Figure 3-5 to modify the sample clock using the following procedure:

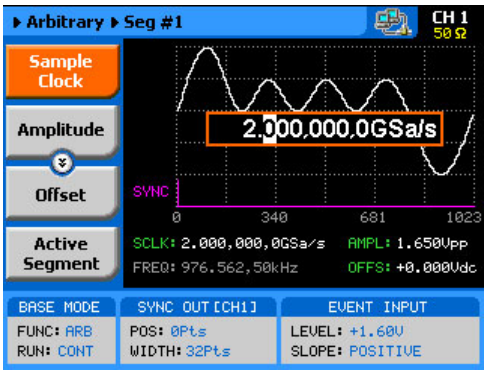

Figure 3-5, Modifying the Sample Clock Frequency

1. Press the Sample Clock soft key to select the Sample Clock parameter.
2. Use the numeric keypad to dial the new sample clock frequency value.
3. Press “M/n”, “k/μ”, “x1/m” or “m/s” to terminate the modification process. To select GSa/s enter the value in MSa/s (i.e. 2000 MSa/s will program 2 GSa/s).

Alternatively, 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 any change made to this parameter.

Programming the Amplitude and Offset

Output amplitude and offset can be programmed independently and separately for each channel. The active channel is displayed on the upper right corner of the LCD display.

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

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

The amplitude and offset parameters are duplicated in multiple screens. When changed for a specific function shape, the new value is updated on all screens, regardless of the selected function shape. Figure 3-6 shows an example of how to program the amplitude for channel 1. The same procedure can be used for channel 2 and for the offset parameter. Note that the example is given for a standard waveform function, but the same procedure will be used for all other functions.

1. Press the Standard button in the Function group.
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.

Alternatively, you can modify the amplitude value with the dial and arrow keys, but then the process must be terminated by pressing Enter.

Offset is programmed the same way as amplitude, except select Offset from the soft key menus to access the offset parameter. Amplitude and offset values are programmed in units of volts.

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 any change made to this parameter.

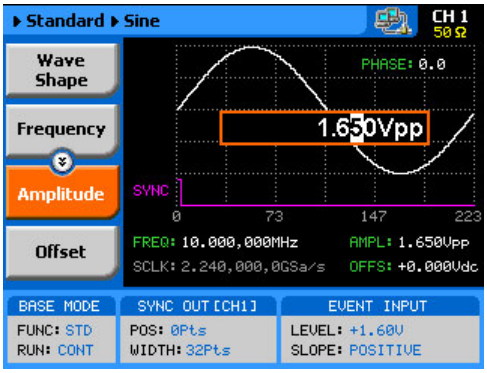

Figure 3-6, Programming Channel 1 Amplitude Example

Selecting a Run Mode

The WS8352 offers three run modes: Continuous, Triggered and Gated.

The selected waveform is repeated continuously, when the instrument is set to operate in Continuous mode. The continuous output can be armed to turn on and off using an Event input and a remote interface, consequently controlling the timing of the waveform from external sources. The operating mode defaults to continuous and self-armed mode after reset. The continuous signal can be aborted at any time, using a remote command.

Triggered and Gated modes require an external signal to initiate output cycles. In some cases, an internal trigger generator is available to generate the required trigger stimuli, without the need to connect to external devices. Figure 3-7 shows the run mode options screen. Press the Run Mode key in the Control group and then select the required run mode option using one of the soft keys on the left of the screen.

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

Note

A selected run mode option applies to all of the available function shapes. For Separate SCLK feed mode, each channel can be programmed to a different run mode option. For Common SCLK feed mode, where both channels are synchronized, selecting a specific run mode option for one channel automatically updates the mode to match the other channel.

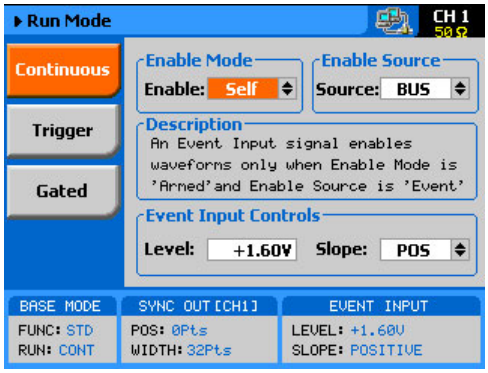

Figure 3-7, The Typical Run Mode Display (Continuous Mode Shown)

Continuous Run Mode

The continuous run mode is useful for applications that require continuous generation of waveforms. The continuous run mode is the factory default setting, so every time the instrument defaults to this mode.

Using the continuous run mode, the WS8352 generates waveforms at its output terminals without control when the waveform starts or stops. This is a normal requirement for most applications, however, some test routines require precise control over waveform timing and in this case the instrument has two enable modes: Self-Armed and Armed.

The self-armed is the standard continuous mode that is widely used and is customary on most waveform generators. This mode does not require special handling, as the output will commence with waveform generation as soon as the output is turned on. The Armed mode needs an event signal to begin waveform generation.

Description of the various controls in the Continuous Run Mode display is given below. Refer to Figure 3-7 throughout this description. To access the required parameters, use the dial or the up/down buttons. When the selected parameter is highlighted, press the enter key and use the up/down buttons to select the required option. Press Enter to complete the action and lock the selected mode.

Enable mode – defines if the generator will be self-armed or armed to commence with waveform generation. Control signals are disabled during self-armed operation, so waveforms are generated continuously at the output terminals as soon as the output function is selected and the output is turned on.

When selecting the Armed mode, the generator goes into the idle state, where the output resides on either a DC level or waveform segment depending on the selected output function. The generator will transition from idle to waveform generation immediately upon receipt of an enable signal, and will cease waveform generation immediately after receipt of an abort signal. Table 1-1 in Chapter 1 lists the idle waveform for the various output functions as well as the source options of the enable and abort signals.

Enable Source – this parameter affects the generator only when placed in Armed mode. It defines from where the WS8352 is expected to receive the enable signal. It has three options: BUS – a remote command from the host computer, EVENT – a valid signal at the rear-panel event input, and TRIG – a valid signal at the front-panel trigger input. Note that the parameters for the event input are programmed from the continuous menu and therefore, it is highly recommended that the continuous armed mode be used in conjunction with the event input. The trigger input parameters are programmed from the trigger run mode display and so it is less convenient to use this input with the continuous armed run mode.

Event Input Control – this group is used for programming the threshold level and the edge sensitivity for the rear-panel event input. The threshold level is programmable from -5 V to 5 V and the slope can be selected from positive, negative or either transitions.

Triggered Run Mode

In Triggered mode, the output remains at a DC level and waits for a valid trigger event to initiate an output cycle. Each time a trigger occurs, the WS8352 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 first point of the waveform.

The instrument may be triggered from one of the following sources: front panel TRIG IN, front panel Manual button, rear panel event input and a remote command such as *TRG. When placed in EXT (external) trigger source, remote commands are ignored and the instrument monitors the TRIG IN connector or the MAN TRIG control. When in BUS, the hardware inputs are ignored and only remote commands can trigger the instrument. Once initiated, the waveform can be left alone to complete its output cycle or aborted using a remote command. Table 1-2 in Chapter 1 lists the idle waveform for the various output functions as well as the source options of the initiate and abort signals.

Description of the various controls in the Triggered Run Mode display is given below. Refer to Figure 3-8 throughout this

description. To access the required parameters, use the dial or the up/down buttons. When the selected parameter is highlighted, press the enter key and use the up/down buttons to select the required option. Press Enter to complete the action and to lock the selected mode.

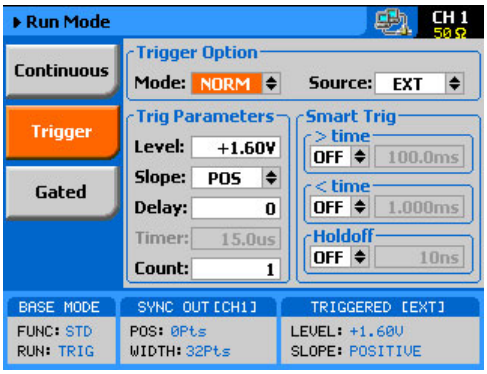

Figure 3-8, Trigger Run Mode Parameters

Trigger Options – has two fields: Mode and Source. These two fields are explained below.

Mode – the mode field selects between NORM and OVER. NORM defines the normal trigger sequence where every trigger generates a waveform cycle however, triggers are ignored for the duration of the output waveform. OVER defines a trigger override mode where triggers are accepted, regardless if the waveform has been completed or not, and a new cycle initiated.

Source – defines for the instrument from where it should expect to receive the trigger signal. Only one source for a trigger signal is legal and therefore, all other inputs are disabled automatically. The source options are: EXT, BUS, INT and EVENT. EXT enables the front panel trigger input, BUS enables remote commands, INT turns on one of the internal timed auto-triggers and EVENT enables the rear panel event input. Additional description of the internal timed auto-trigger generators is given below.

Trigger Parameters – has five fields: Level, Slope, Delay, Timer and Count. These fields are explained below.

Level – use this field to program the threshold level for the trigger input. This adjustment is necessary if your trigger signal is riding on a DC offset, positive or negative. The level is programmable from -5 V to 5 V.

Slope – defines edge sensitivity for the trigger input. The trigger input can be programmed to trigger on the rising, trailing or even both edges.

Delay – "0" setting defines no delay, any other number turns on the delayed trigger function. The delay field is used for the delayed trigger function, when the instrument is using external triggers but it is also used for the delayed auto-trigger function when the instrument is programmed to its internal trigger timer. The delayed trigger function is explained in detail in the following section.

Timer – programs the period of the internal timed auto-trigger generator. Additional information is given below.

Count – defines how many cycles will execute from a single trigger event. The counter can be programmed to generate a burst of 1 to 1,000,000 output cycles

Smart Trig – has three fields: >time, <time and Holdoff. The smart trigger filter can zoom in on a certain pulse widths featuring only values below, above or in-between to be regarded as valid trigger signals. The smart trigger fields are explained below.

>time – use this field to program the "more than" pulse width time that will pass through the filter as a valid trigger event. OFF disables this filter.

<time – use this field to program the "less than" pulse width time that will pass through the filter as a valid trigger event. OFF disables this filter.

Note that if both filters are ON, the smart trigger will consider pulse width values "less than" and "more than" as a gate entry for legal trigger events.

Holdoff – use this field to program a holdoff period where first trigger disables the input for the programmed holdoff value and only then allows entry to a legal trigger event.

Using the Delayed Trigger

The delayed trigger function, when enabled, delays the start of the output waveform for a pre-determined period following a valid trigger. The delay time value is programmed in units of sample clock periods from 0 to 8,000,000 samples. When the delay value is set to "0", the delayed trigger function is turned off.

Note that even with the delay set to OFF, the output is always delayed from the trigger signal by a value that is specified as "system delay". The system delay is normally small, but should always be considered as part of the overall delay period. Refer to Appendix A for the system delay specification.

Using the Built-in Auto-Trigger Generators

The correct way of using the WS8352 in applications that require synchronization between system components is in conjunction with external trigger events. In this case, another component in the system generates a trigger signal, either hardware or software that stimulates the output of the generator exactly at the time that the signal is required in the loop. In addition, the WS8352 can be used

as a system administrator that generates stimulating signals to the rest of the system For this purpose the instrument has a built-in timer that generates internal triggers at pre-determined intervals. The built-in trigger generator has no reference from the main sample clock and therefore, the clock is asynchronous with the output waveform. In fact, there are two built-in auto-trigger generators within the WS8352 that behave differently, but both are derived from the same trigger generator circuit. These are: *Timed* internal trigger generator and *Delayed* internal trigger generator.

Timed Internal Trigger Generator – generates equally spaced periodical and asynchronous triggers. The Timer field in the Trigger Run Mode displays programs on the timer interval in units of seconds ranging from 200 ns to 2 seconds. When programmed to this mode, all other inputs to the trigger circuit are disabled to prevent interference from external devices. The timer interval is measured from waveform start to waveform start and therefore, the period of the internal timer value must be larger than the period of the output signal.

Delayed Internal Trigger Generator – this function is similar to the timed internal trigger generator in the way that it generates periodical and asynchronous triggers that are equally spaced, however, the delay is programmed in units of sample clock periods and measured between waveforms. Using the delayed internal trigger generator, there is no need to worry about waveform period vs. delay period because the delay is always measured from the end of one waveform to the start of the next one. There is also another advantage when using this function, because although the trigger generator is asynchronous with the output waveform, the delay is synchronous and therefore there is no jitter of ±1 sample clock period due to the digital error common to all other systems. The delayed internal trigger generator can be programmed from 152 sample clock periods to 8,000,000 sample clock periods, provided that the numbers are integers and divisible by 8.

Gated Run Mode

In gated mode, the output remains at a DC level and waits for a valid gate event to initiate an output cycle. Each time a gate opens the WS8352 generates output waveforms. When the gate closes, the output completes the waveform and resumes position at a DC level that is equal to the amplitude of the first point of the waveform.

The instrument may be gated from one of the following sources: front panel TRIG IN or rear panel event input. Once initiated, the waveform can be left alone to complete its output cycle or aborted using a remote command. Table 1-3 in Chapter 1 lists the idle waveforms for the various output functions, as well as the source options of the initiate and abort signals.

Description of the various controls in the Gated Run Mode display is given below. Refer to Figure 3-9 throughout this description. To

access the required parameters, use the dial or the up/down buttons. When the selected parameter is highlighted, press the enter key and use the up/down buttons to select the required option. Press Enter to complete the action and lock the selected mode.

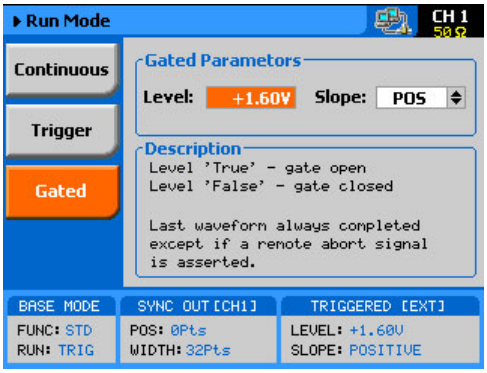

Figure 3-9, Gated Run Mode Parameters

Gated Parameters – has two fields: Level and Slope. These fields are explained as follows:

Level – use this field to program the threshold level for the trigger input. This adjustment is necessary if your gating signal is riding on a DC offset, positive or negative. The level is programmable from -5 V to 5 V.

Slope – defines polarity of the gate. The trigger input can be programmed to gate on positive levels or on negative levels. Note that the positive and negative slope definition does not apply to absolute levels, but to relative levels. For example, if the trigger level is set at 1 V and the slope is set to positive, any level at the trigger input that is above 1 V is considered true (gate open) and anything below 1 V is considered false (gate closed).

Abort

The abort button appears only in continuous run mode and when the Enable Mode is set to Armed and the Enable Source is either BUS or EVENT or TRIG. The function of the abort soft key is to stop the waveform at a specific time. The waveform can be aborted using a remote command as well, but then the enable source must be set to BUS.

The Abort button and the Continuous Run Mode display that makes this button operational is shown in Figure 3-10. Place the instrument in Continuous run mode, select Armed as the Enable Source and select EVENT as the source for the enable signal. The generator will commence with waveform generation immediately after a valid event signal is applied to the Event input. The waveform will stop at the output immediately after you press the Abort soft key.

Figure 3-10, Typical Continuous Run Mode Display with the Abort Soft Key

Using the Manual Trigger

The manual trigger allows you to trigger or gate the WS8352 directly from the front panel. This button is active only when the generator is programmed to accept trigger stimuli from an external trigger source. In triggered run mode, a single push on the button initiates an output waveform. In gate run mode, the output generates waveforms as long as you press and hold the MAN button. The waveforms will cease to generate immediately after you release the button.

Using the SYNC Output

For safety reasons, every time you toggle the power to the WS8352 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 menu shown in Figure 3-11. To access the SYNC output menus press the Output button in the Control group on the right of the instrument and then select the SYNC OUTPUT soft key.

The SYNC output has parameters that you can modify: State, Source, Type, Position and Width. The functions of these parameters are explained below.

State – controls the state of the SYNC output ON and OFF. When the SYNC output is turned on, the LED next to the output terminal is lit, indicating that a SYNC signal is present at this output. OFF turns off the light, but leaves a low impedance path from the output terminal.

Source – selects the channel from where the SYNC output is derived, CH1 or CH2. Single channel versions do not have this control.

Type – defines the shape of the SYNC waveform. There are two options to select from this field: Pulse or WCOM. The pulse has a minimum width of 16 waveform points and its position along the waveform can be adjusted, as well as its width. The WCOM type SYNC output (waveform Complete) has a fixed width that cannot be modified, nor moved from its original position.

Position – applied to the pulse type only. This parameter defines the position of the SYNC pulse along the output waveform. The position is programmed in units of waveform points (or sample clock periods). Placement resolution is 16 points. As default, the sync signal is positioned at the beginning of the waveform.

Width – applies to the pulse type only. This parameter can modify the width of the SYNC pulse from a minimum of 16 waveform points to the maximum length of the waveform in increments of 16 points.

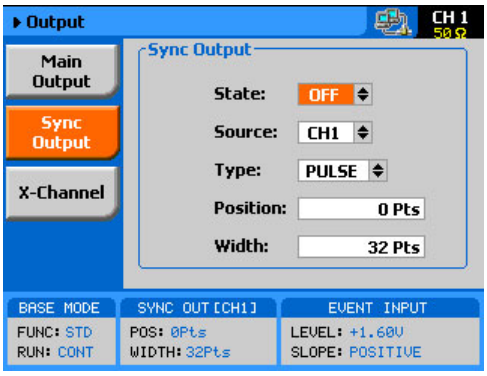

Figure 3-11, SYNC and Filter Parameters

Synchronizing Channel 1 and Channel 2

The model WS8352 comes with two channels, each of which can be operated as a stand-alone waveform generator. There are very few circuits and controls that are shared by the two channels, namely: display, remote interfaces, external sample clock and trigger input connectors and the SYNC output. In addition, each channel can be programmed to operate uniquely in terms of functions, modes and parameters. For example, channel 1 can generate continuous segment of an arbitrary waveform and channel 2 can generate triggered pulse patterns. There are no limitations how one channel is programmed, compared to the other channel, as long as the connectors that are shared by the channels do not interfere in the way they are used.

The two channels can be synchronized to operate from a single sample clock source and in this case, the output frequency is identical and the generator provides a tight relationship between phase offset and waveform start. Still, while synchronized, the two channels can generate different waveform functions, amplitudes and DC offsets, but the same run mode option should be selected.

Synchronizing the two channels requires a single operation – modifying the SCLK Feed from separate to common. This is done from the Utility ->Clock ->Sample Clock Feed field as shown in Figure 3-12. When the selected parameter is highlighted, press the enter key and use the up/down buttons to select the required option. Press Enter to complete the action and to lock the mode.

The cross-channel parameters that control phase offset and skew are discussed in the following paragraphs. There are other parameters in this display that relate to the EXT SCLK Source and Divider and the external reference clock; these are discussed later in the relevant sections of this chapter. Notice, however, that when the Common SCLK Feed is selected, access to CH2 parameters are denied because there is only one sample clock source left to control in this mode.

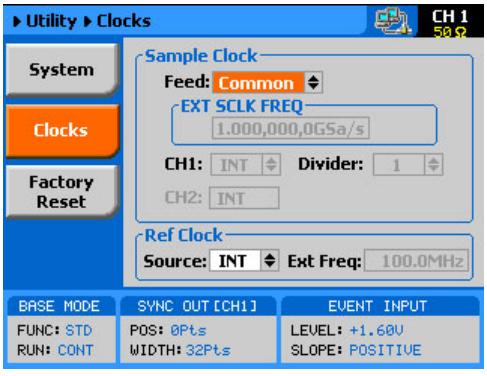

Figure 3-12, Modifying the SCLK Feed to Common

Controlling Cross-Channel Propagation

Cross-channel propagation is relevant only after the two channels have been synchronized and are fed from the same sample clock source. To access the Cross-Channel Propagation menu, press the Output key in the Function group and then press the X-CHANNEL soft key button. The display, as shown in Figure 3-13, now provides access to the synchronization parameters. If you did not synchronize the two channels, this display will be grayed out and you will have no access to the fields. Use the up/down buttons to highlight the required parameter and then press Enter. Modify the parameter and press Enter again to complete the action and to lock the selected value. There are two parameters that you can modify from this display: Offset CH2 ->CH1and Skew CH2 ->CH1. These parameters are explained below.

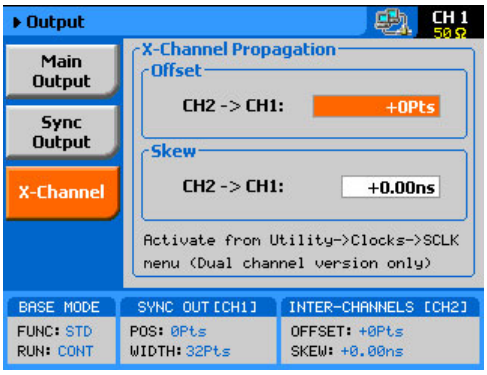

Figure 3-13, Controlling Cross-Channel Propagation

Offset CH2 -> CH1 – with channel 1 as reference, this allows programming of an offset value in units of waveform points (or sample clock periods). The CH2 -> offset can be programmed from 0 to the ±full length of the output waveform.

Skew CH2 -> CH1 – with channel 1 as reference, it defines the skew between the channels in units of ns. The skew is programmable from 0 ns to±3 ns with increments of 10 ps.

Using External Clock References

In cases where synchronization to other instruments in a system is required, you have two options: use an external clock source for the reference clock or replace the internal sample clock generator entirely with an external clock generator. Either way, this is a major twist in the WS8352 basic operation because, if for any reason, you leave one or both parameters selected from an external source 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 reference clock source menus were placed in the Utility menu, as shown in Figure 3-14. Change these settings only if you are absolutely sure that another reference source is available at the appropriate inputs. Note that the sample display shows that all clocks are internal and therefore, some of the fields that are associated with the external references are grayed out.

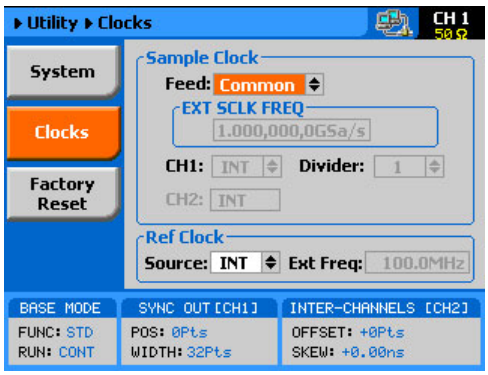

Figure 3-14, Modifying the SCLK and 10MHz Clock Source

Using an External SCLK Source

The SCLK input is useful for applications requiring improved phase noise or clock stability. Normally, by using a near-perfect source, the phase noise of the WS8352 can typically be improved by a factor of >20 dBc/Hz. The external sample clock input is an SMA connector that is located on the rear panel. It accepts signals within the frequency range of 2,000 GHz to 4,000 GHz (double the internal SCLK). There is only one input that can be used for one channel or another and by both channels simultaneously. Note that the channels do not have to be synchronized to use a single external clock feed. In addition, the EXT SCLK option is available only in Arbitrary function mode.

As was described before and shown in Figure 3-14, access the External Sample Clock parameters from the Utility menu. When the selected parameter is highlighted, press the enter key and use the up/down buttons to select the required option. Press Enter to complete the action and to lock the selected mode.

As shown in Figure 3-15, there are three parameters that can be accessed in the Sample Clock Source group: EXT SCLK FREQ and CH1 Source and Divider. These are explained below.

EXT SCLK FREQ – this field becomes active only after you select an external source feed to one of the channels. This field is necessary for the instrument to establish a frequency range for the internal phase lock loops and therefore must programmed near or exactly as the external source frequency. Figure 3-15 shows an example of a setup that provides external feed to channel 1 with an external frequency of 2.000,000 GHz.

CH1 Source – use this field to select between INT (internal) or EXT (external) sample clock feeds. Updating the EXT SCLK FREQ field with the external frequency value is necessary for the external sample clock feed function to operate correctly.

CH1 Divider – since there is only one input for the external sample clock, feeding the same frequency to both channels is somewhat limiting if different frequencies need to be generated from each channel. The divider field accepts values in the form of 2n, from 1 to 256, that will divide the external sample clock frequency before it is applied to the internal circuits.

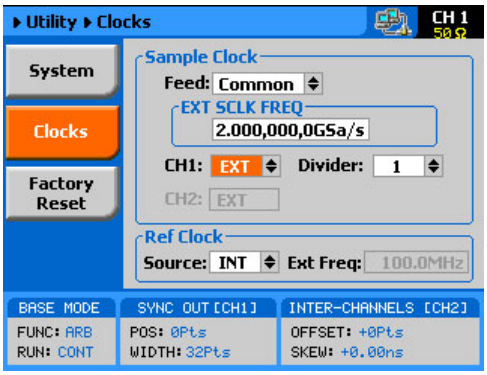

Figure 3-15, Using an External Sample Clock Example

Using an External Clock Reference Source

The External Reference input is useful for applications requiring synchronization to other components in a system, and can be used to improve clock stability and accuracy, but it does not necessarily improve phase noise. The external reference input is a BNC connector that is located on the rear panel. It accepts signals within the frequency range of 10 MHz to 100 MHz. There is only one input that feeds both sample clock generators simultaneously. Note that the channels do not have to be synchronized to use the external reference feed.

As was described before and shown in Figure 3-14, access the External Reference Clock parameters from the Utility menu. When the selected parameter is highlighted, press the enter key and use the up/down buttons to select the required option. Press Enter to complete the action and to lock the selected mode.

As shown in Figure 3-16, there are two parameters that can be accessed in the Reference Clock group: Source and EXT FREQ. These are explained below.

Source – use this field to select between INT (internal) or EXT (external) reference clock feeds. Note that updating the EXT FREQ field with the external frequency value is necessary for the external reference clock feed function to operate correctly.

EXT FREQ – this field becomes active only after you select an external reference feed. This field is necessary for the instrument to establish a frequency range for the internal phase lock loops and therefore must programmed near or exactly as the external reference source frequency. Figure 3-16 shows an example of a setup that provides external feed frequency of 20 MHz.

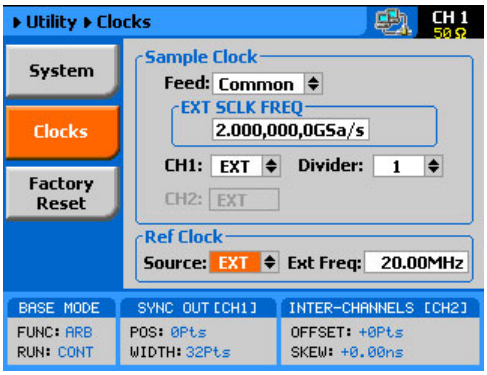

Figure 3-16, Using an External Sample Clock Example

TIP

The internal reference frequency is 100 MHz and therefore, any lower frequency that will be used as an external reference will degrade the phase noise of the output signal. It is therefore recommended that frequencies near 100 MHz be used as reference.

Generating Standard Waveforms

The majority of applications require the use of common waveforms such as: sinusoidal, triangular and square. In fact, these are the only waveforms that function generators can produce and therefore, one should expect that these waveforms be available even in a complex generator such as this. The WS8352, being a completely digital instrument, has a library of built-in waveforms that allow generation of these basic waveforms, plus many more.

By default, the WS8352 is programmed to generate standard waveforms so when you reset the generator, it will commence with generating a standard sine waveform as soon as the output is turned on. Besides the standard sine waveform, the instrument has a built-in library of waveforms referred to as Standard Waveforms. The meaning of this term is that these waveforms have standard characteristics, commonly associated with these waveforms. For example, sine waveform has known spectral and power distribution that could be compared to published mathematical equations. The quality of the generator determines the proximity of the waveform generation to its pure mathematical expression.

Figure 3-17 shows a list of waveforms that the instrument can generate, however, don't forget that the waveforms are generated digitally on "real-time" from standard equations, utilizing maximum possible SCLK to achieve maximum frequency resolution and therefore, each time a new waveform is selected, there's a slight delay between the time the waveform was selected to when it is being generated at the output connector.

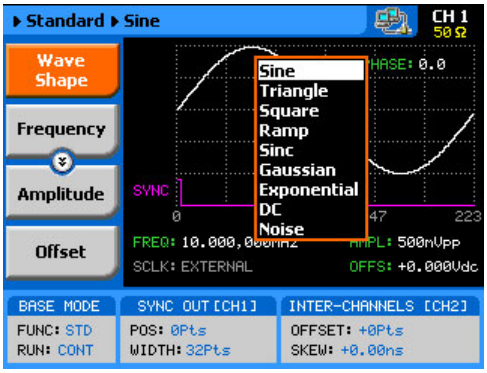

Figure 3-17, Built-in Standard Waveforms Menu

The WS8352 has a library of 9 standard waveforms: Sine, Triangle, Square, Ramp, Sinc, Gaussian, Exponential, DC and Noise. Some of the parameters for these waveforms can be modified to fine-tune the waveforms for specific applications. For example, changing the sine start phase of the 2nd channel can create a 2-phase sine system.

Sine Wave

The sine waveform is the most commonly used waveform. There are certain menus that provide access to sine waveform parameters. These are:

Frequency – programs the frequency of the sine waveform. Note that the waveform has to be re-computed every time and therefore, when you modify the frequency, the output wanders until the waveform is re-computed and restored to full accuracy.

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

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

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

Triangle Wave

The triangle waveform is a commonly used waveform. There are specific menus providing access to triangle waveform parameters. These are:

Frequency – programs the frequency of the triangle waveform. Note that the waveform has to be recomputed every time and therefore, when you modify the frequency, the output wanders until the waveform is recomputed and then restored to full accuracy.

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

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

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

Square Wave

The square waveform is a commonly used waveform. There are specific menus that provide access to square waveform parameters. These are:

Frequency – programs the frequency of the square waveform. Note that the waveform has to be recomputed every time and therefore, when you modify the frequency, the output wanders until the waveform is recomputed and then restored to full accuracy.

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

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

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

Ramp Wave

The ramp waveform is a special instance of the triangular waveform with a slight difference: the ramp can be adjusted for its rise and fall times. The ramp waveform is a very common waveform and is required for numerous applications. There are specific menus that provide access to ramp waveform parameters. These are:

Frequency – programs the frequency of the ramp waveform. Note that the waveform has to be recomputed every time and therefore, when you modify the frequency, the output wanders until the waveform is recomputed and then restored to full accuracy.

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

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

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

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

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

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

Sinc Wave

The sinc pulse (sine x/x) waveform is a very common waveform and is required in many applications. There are specific menus that provide access to sinc pulse waveform parameters. These are:

Frequency – programs the frequency of the sinc waveform. Note that the waveform has to be re-computed every time and therefore, when you modify the frequency, the output wanders until the waveform is recomputed and then restored to full accuracy.

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

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

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

Gaussian Wave

The gaussian pulse waveform is useful in many applications. There are specific menus that provide access to gaussian pulse waveform parameters. These are:

Frequency – programs the frequency of the gaussian waveform. Note that the waveform has to be recomputed every time and therefore, when you modify the frequency, the output wanders until the waveform is recomputed and then restored to full accuracy.

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

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

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

Exponential Wave

The exponential pulse waveform is useful in applications simulating capacitor charge or discharge. There are specific menus that provide access to exponential pulse waveform parameters. These are:

Frequency – programs the frequency of the exponential waveform. Note that the waveform has to be recomputed every time and therefore, when you modify the frequency, the output wanders until the waveform is recomputed and then restored to full accuracy.

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

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

Exponent – sets the exponent factor for the exponential function. Setting the exponent to a negative value inverts the exponential function. Changing the default exponent value to a different number

requires recalculation of the waveform and it may take a few seconds until the waveform is computed and generated at the output connector.

DC Wave

The DC waveform is a useful application simply requiring an accurate DC level.

There are specific menus that provide access to the DC waveform parameters. These are:

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

Noise Wave

The noise waveform is useful in applications requiring generation of simple noise. The spectral spread of the noise is pseudo-random and is limited in its bandwidth by the bandwidth parameter. There are specific menus that provide access to noise waveform parameters. These are:

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

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

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

Note that while generating noise, keep in mind that the noise is generated in a certain memory size and is repeated over and over until the function is disabled. Therefore, the noise is not really random, in the purest meaning of the word.

Standard Waveforms and Run Mode Options

Run Mode options define if the standard waveforms will be generated continuously, triggered, or gated. Refer to the Selecting Run Modes section of this manual to learn more about these functions. Table 3-5 provides information on the standard waveform function in conjunction with the run mode options. This table is useful, as it summarizes all the controls that start and stop the waveforms. The Glossary defines the terms used in this table.

Table 3-6, Standard Waveforms in Various Run Mode Options

Run Mode	Waveform	Arm Options	Idle Waveform	Enable Signal	Abort Signal	Initiate Signal	Wave Loops	Smart Trig
Continuous	Standard	Self Armed	Wave	- (*)	-	-	-	-
		Armed	DC	Trigger | BUS | Event	BUS | F.P.	-	-	-
Triggered	Standard	Self Armed	-	-	-	-	-	-
		Armed	DC	-	BUS	F.P.| BUS | Trigger | Event	1-1M	Yes
Gated	Standard	Self Armed	-	-	-	-	-	-
		Armed	DC	-	BUS	Trigger | Event	-	-

- (*) – Not Relevant

Glossary of Terms

Run Mode – defines basic instrument run mode options:

Continuous – waveform is generated continuously.

Triggered – output waits for trigger, waveform is generated once.

Gated – output waits for gating signal, waveform is generated as long as the gating signal is true

Waveform – standard, built-in library of standard waveforms.

Arm Options – defines if a waveform is self-enabled or requires a control signal to initiate.

Self Armed – the output does not require a control signal to generate waveforms.

Armed – a control signal is required to enable waveform generation.

Idle Waveform – defines the state of the output waveform before an event (enable, trigger or gate) initiates a waveform.

DC – first waveform point.

Wave – the selected waveform.

Enable Signal – defines the source, from where an enable signal is expected. Affects the output only when Arm Option is set to Armed.

BUS – a remote command enables the output.

Event – a transition at the event input enables the output.

Trigger – a valid signal at the trigger input enables the output.

Abort Signal – defines the source from where an abort signal is expected.

BUS – a remote command aborts all output activities. This signal does not affect the generator when set to operate in self- armed mode.
F.P. – a front panel push button is used to abort all outputs activities

Initiate Signal – defines the wait for the trigger entry port to initiate a waveform. Relevant for trigger and gated run modes only.
F.P. – a front panel push button is used to initiate a waveform.
BUS – a remote command initiates a waveform. Selecting this option automatically disables front panel operation.
Trigger – a valid signal at the trigger input initiates a waveform.
Event – a transition at the event input initiates the waveform

Wave Loops – defines how many times the waveform repeats after a valid Initiate Signal.

Smart Trigger – defines if smart trigger features are available for a specific function.

Generating Arbitrary Waveforms

In general, the WS8352 cannot create arbitrary waveforms by itself. If you want to use arbitrary waveforms, you must first load them into the instrument. The WS8352 is supplied with waveform creation and editing software, called **ArbConnection**. Figure 3-18 shows an example of a waveform that was created with an external utility. Once the waveform is created on the screen, downloading it to the WS8352 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 WS8352 are given in the programming chapter of this manual. Information in this Chapter will give you a general idea of what arbitrary waveforms are all about.

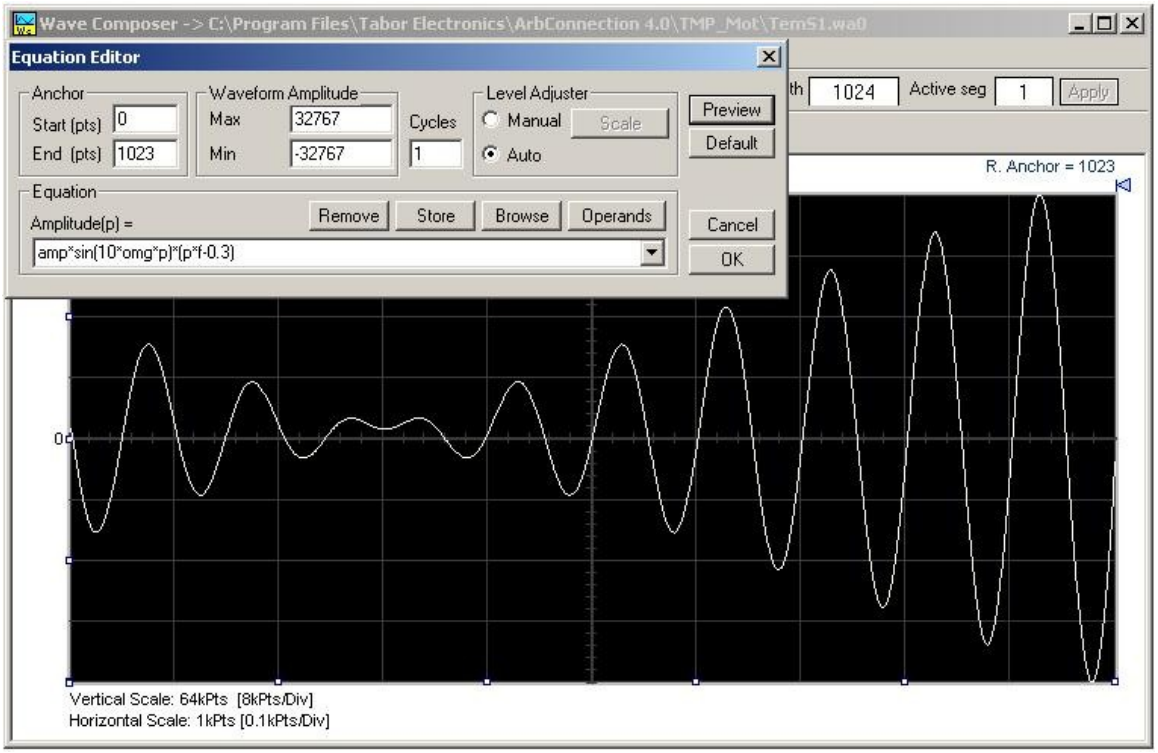

Figure 3-18, Wave Composer Tool Example for Generating Arbitrary Waveforms

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 clocks 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 WS8352 uses 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 WS8352 has a 512K basic 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 WS8352 lets you divide the memory bank to smaller segments and load different waveforms into each segment.

Generating Arbitrary Waveforms

Downloading waveforms to the WS8352 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 3-19 and use the following description to learn how to output arbitrary waveforms, as well as how to program arbitrary waveform parameters. To access the Arbitrary display, press on the Arbitrary button in the Function group. The output will immediately resume with arbitrary waveform generation and the display will be updated with arbitrary waveform parameters, as shown in Figure 3-19.

Note the channel you are currently programming and make sure the icon on 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.

Alternatively, 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 didn't make programming errors and didn't make any mistakes while downloading your waveform segment(s), then the output should generate your desired waveform.

There are several parameters that are available for programming in this window: Sample Clock, Amplitude, Offset, Active Segment, Jump Event, Jump Timing, Wave Composer and Delete Segments. These parameters are explained as follows:

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

Amplitude – Defines the amplitude of the arbitrary waveform. Note that regardless of the amplitude setting, the vertical resolution of the generated waveform is always 14 bits.

Offset – defines the offset value of the arbitrary waveform.

Active Segment – Defines which of the segments in the working memory is currently active at the output connector. As was discussed earlier, the working memory can be divided to 1k segments and different waveforms loaded in each segment. Any segment is available at the output connector, only if it has been selected to be the active segment. The segment selection field lets you select any segment, 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.

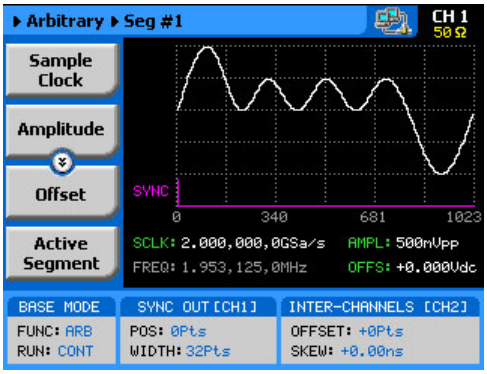

Figure 3-19, Arbitrary Parameters Display Example

Wave Composer – opens a new display that allows creation of simple arbitrary waveforms from the front panel. The Wave Composer display is shown in Figure 3-20.

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 addresses for each segment location. If you have recorded your segment sizes you can always redefine the segment table, which will restore the original waveforms in each segment. There is, however, no way back to the original waveforms if you perform a new download action after deleting the segment table.

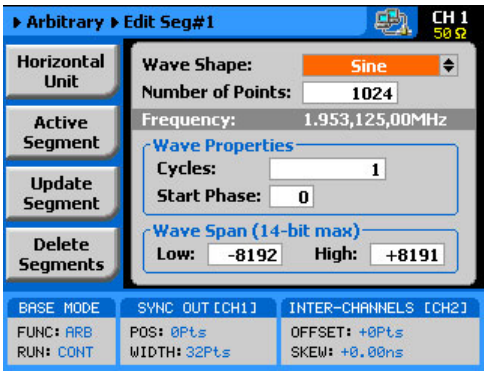

Figure 3-20, The Wave Composer Display

Arbitrary Waveforms and Run Mode Options

Run Mode options define if the arbitrary waveforms will be generated continuously, triggered, or gated. Refer to the Selecting Run Modes section of this manual to learn more about these functions. Table 3-7 provides information on the arbitrary waveform function in conjunction with the run mode options. This table is useful, as it summarizes all the controls that start and stop the waveforms. The Glossary defines the terms that were used in this table.

Table 3-7, Arbitrary Waveforms in Various Run Mode Options

Run Mode	Waveform	Arm Options	Idle Waveform	Enable Signal	Abort Signal	Initiate Signal	Wave Loops	Smart Trig
Continuous	Arbitrary	Self Armed	Wave	- (*)	-	-	-	-
		Armed	DC	Trigger | BUS | Event	BUS | F.P.	-	-	-
Triggered	Arbitrary	Self Armed	-	-	-	-	-	-
		Armed	DC	-	BUS	F.P.| BUS | Trigger | Event	1-1M	Yes
Gated	Arbitrary	Self Armed	-	-	-	-	-	-
		Armed	DC	-	BUS	Trigger | Event	-	-

- (*) – Not Relevant

Glossary of Terms

Run Mode – defines basic instrument run mode options:

Continuous – waveform is generated continuously.

Triggered – output waits for trigger, waveform is generated once.

Gated – output waits for gating signal, waveform is generated as long as the gating signal is true.

Waveform – arbitrary waveform, waveform coordinates must be downloaded to the instrument to generate these waveforms.

Arm Options – defines if a waveform is self-enabled or requires a control signal to initiate.

Self Armed – the output does not require a control signal to generate waveforms.

Armed – a control signal is required to enable waveform generation.

Idle Waveform – defines the state of the output waveform before an event (enable, trigger or gate) initiates a waveform.

DC – first waveform point.

Wave – loaded waveform.

Enable Signal – defines the source from where an enable signal is expected. Affects the output only when Arm Option is set to Armed.

BUS – a remote command enables the output.

Event – a transition at the event input enables the output.

Trigger – a valid signal at the trigger input enables the output

Abort Signal – defines the source from where an abort signal is expected.

BUS – a remote command aborts all output activities. This signal does not affect the generator when set to operate in self- armed mode.

F.P. – a front panel push button is used to abort all outputs activities

Initiate Signal – defines the wait for trigger entry port to initiate a waveform. Relevant for trigger and gated run modes only.

F.P. – a front panel push button is used to initiate a waveform.

BUS – a remote command initiates a waveform. Selecting this option automatically disables front panel operation.

Trigger – a valid signal at the trigger input initiates a waveform.

Event – a transition at the event input initiates a waveform.

Wave Loops – defines how many times the waveform repeats after a valid Initiate Signal.

Smart Trigger – defines if smart trigger features are available for a specific function.

Generating Modulated Waveforms

The WS8352**,** being a digital instrument, has the advantage of being able to generate almost any waveform through its DAC, provided that there are enough waveform points to compute the function. Normally, complex modulation schemes will be computed on an external computer and downloaded to the generator as waveform points, but for simpler modulation schemes, the equation already resides in the instrument. The WS8352 can generate AM, FM, Sweep, Chirp, FSK, ASK, Frequency and Amplitude hops, (n)PSK and (n)QAM. The advantage of these waveforms is that they are commonly used and when produced, they are extremely accurate.

The main point to keep in mind is that the modulation waveforms are computed and recomputed, every time a parameter is modified. This is a bit different from analog instruments in the way that the output must stop to re-compute the waveform, and then it comes back to life. The next point to consider is the modulation barriers, because the longer and finer the modulation is, the more waveform points are required to generate the function and therefore, it takes more time to compute the waveform and load it to the memory. Normal computation time is around a few milliseconds, but for lower frequencies, it might take a few seconds.

The modulation function is turned on immediately after you press the Modulation button in the Functions group on the right side of the generator. By default, modulation is turned off and therefore, the output generates carrier wave (CW). The first modulation screen is shown in Figure 3-21. The modulation functions and their parameters are described as follows:

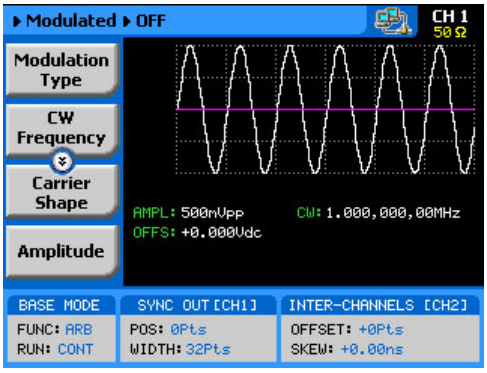

Figure 3-21, The Modulation Function Main Screen

Tip

The values of the three parameters shown in the Modulation Off display are duplicated in all modulation panels.

Off

The Modulation Off is a special instance of the modulation function, where the output is not modulated, but generates carrier waveform (CW) frequency only. CW can be sine, triangle, or square waveforms. When placed in Modulation Off, the CW is generated from the main outputs continuously. The CW parameter does not change when you switch from one modulation function to another. Figure 3-22 shows the Modulation Off menus.

While in the Off option, there are some parameters that can be programmed for the carrier waveform:

Modulation Type – defines the type of modulation scheme that will modulate the carrier waveform: Off, FM, FSK, Frequency Hop, Sweep, Chirp, AM, ASK, Amplitude Hop, (n)PSK or (n)QAM. The selected modulation scheme is generated immediately at the output terminals.

CW Frequency – defines the frequency of the carrier waveform. The CW parameter, as programmed in this menu is shared by all other modulation options.

Carrier Shape – defines the shape of the carrier waveform. The carrier shape can be selected from Sine, Triangle and Square. Note that the Carrier Shape parameter is used in all of the modulation displays, so if you change the shape for one function, it affects the other modulation displays as well.

Amplitude – defines the carrier amplitude level. The same level is used throughout the instrument when you move from waveform shape to another. The Amplitude parameter, as programmed in this menu, is shared by all other waveform options.

Offset – defines the offset level for the carrier waveforms. The same level is used throughout the instrument when you move from one waveform shape to another. The Offset parameter, as programmed in this menu, is shared by all other waveform options.

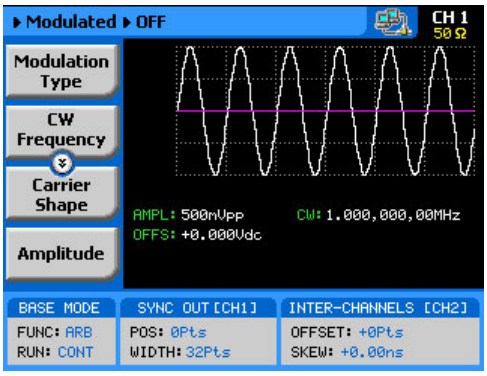

Figure 3-22: Modulation OFF Parameters

FM

The FM function allows frequency modulation of a carrier waveform (CW). The carrier waveform is modulated by an internal waveform, normally referred to as modulating waveform. The shape of the modulating waveform can be selected from sine, triangle, square or arbitrary waveforms.

The FM function has a number of menus that control the modulation parameters. These are shown in Figure 3-23 and described in the following paragraphs:

Modulation Type – defines the type of modulation scheme that will modulate the carrier waveform: Off, FM, FSK, Frequency Hop, Sweep, Chirp, AM, ASK, Amplitude Hop, (n)PSK or (n)QAM. The selected modulation scheme is generated immediately at the output terminals.

Modulation Shape – Defines the shape and type of the modulating waveform: Sine Triangle, Square and Ramp. The Modulation Shape menu that provides access to the selection of the envelope waveform is shown in Figure 3-24.

CW Frequency – defines the frequency of the carrier waveform. Using this standard FM function, the shape of the carrier waveform is always sine.

Frequency Deviation – defines the range of frequencies that the modulation will go through. The peak value is symmetrical around the value of the carrier waveform frequency.

Modulation Frequency – defines the frequency of the modulating waveform. **Marker**– programs a unique frequency where the SYNC output generates a pulse to mark this frequency.

Carrier Shape – defines the shape of the carrier waveform. The carrier shape can be selected from Sine, Triangle and Square. Note that the Carrier Shape parameter is used in all of the modulation displays, so if you change the shape for one function, it affects the other modulation displays as well.

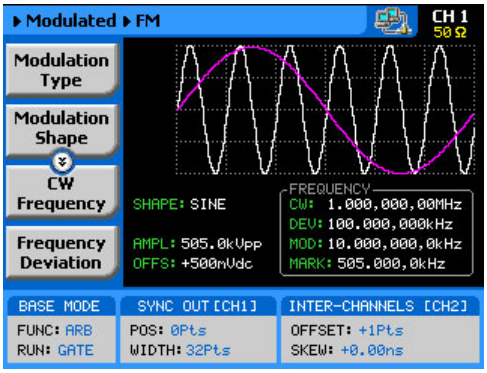

Figure 3-23, FM Menus

Amplitude – defines the carrier amplitude level. The same level is used throughout the instrument, when you move from one waveform shape to another.

Offset – defines the offset level for the carrier waveforms. The same level is used throughout the instrument when you move from one waveform shape to another.

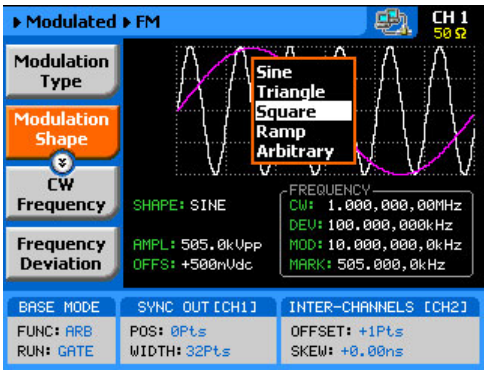

Figure 3-24, Modulation Waveform Shapes

FSK

FSK (Frequency Shift keying) modulation allows frequency hops between two pre-programmed frequencies: Carrier Waveform Frequency and Shifted Frequency. Note that CW is sinewave only and that the switch between two frequencies is always coherent.

The CW and shifted frequencies can be programmed with 10 digits throughout the entire frequency range of the instrument. The FSK sequence is designed in an FSK table that can either be loaded from the front panel or downloaded from a remote interface from a utility such as ArbConnection. An example of the FSK table, as created in ArbConnection, is shown in Figure 3-25.

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

Modulation Type – defines the type of modulation scheme that will modulate the carrier waveform: Off, FM, FSK, Frequency Hop, Sweep, Chirp, AM, ASK, Amplitude Hop, (n)PSK or (n)QAM. The selected modulation scheme is generated immediately at the output terminals.

FSK Data – defines the sequence of which the frequencies will toggle. FSK data is stored in an external table. The FSK Data table contains a list of “0”s and “1”s which determine the sequence. “0” defines CW and “1” defines shifted frequency.

CW Frequency – defines the frequency of the carrier waveform. In this case, the CW frequency will also be used as the idle frequency. Using this standard FSK function, the shape of the carrier waveform is always sine.

Shifted Frequency – defines the frequency to which the generator will shift when logic level "1" is sensed at the trigger input.

Baud – defines the rate at which the frequencies are toggled. The rate can be programmed within the range of 0.1 bits/s to 350 Mbits/s.

Marker – defines an index point in the FSK sequence where the SYNC output will generate a marker pulse.

Carrier Shape – defines the shape of the carrier waveform. The carrier shape can be selected from Sine, Triangle and Square. Note that the Carrier Shape parameter is used in all of the modulation displays, so if you change the shape for one function, it affects the other modulation displays as well.

Amplitude – defines the carrier amplitude level. The same level is used throughout the instrument when you move from waveform shape to another.

Offset – defines the offset level for the carrier waveforms. The same level is used throughout the instrument when you move from waveform shape to another.

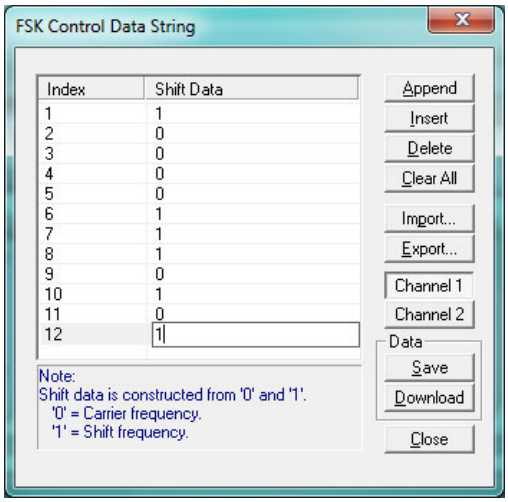

Figure 3-25, ArbConnection FSK Control Data String Example

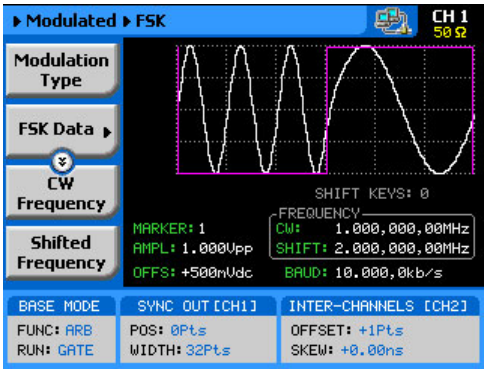

Figure 3-26, FSK Menus

Frequency Hop

In frequency hop mode, the output waveform (sinewave) hops from frequency to frequency in a sequence defined by the hop table. Frequencies can be programmed with 11 digits resolution throughout the entire range of the instrument. There are two frequency hop types:

1. Frequency hops with fixed dwell time and
2. Frequency hops with variable dwell time

Dwell time defines the time that the frequency will remain stable and will change at the end of this interval. With the fixed dwell time, the waveform hops from frequency to frequency at constant intervals, defined by the fixed dwell time parameter. When the variable dwell time is selected, each hop can be programmed to have a unique dwell interval.

When you select frequency hop modulation, the menus, as shown in Figure 3-27 and described in the following paragraphs, will be available for modification:

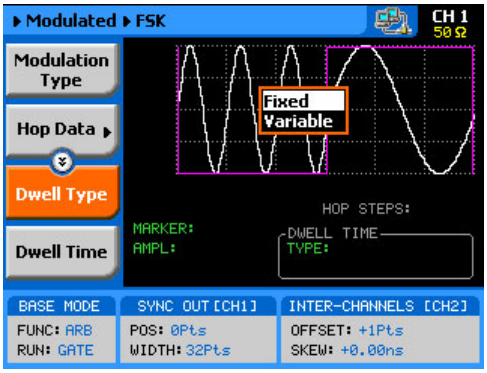

Figure 3-27, Frequency Hop Menus

Modulation Type – defines the type of modulation scheme that will modulate the carrier waveform: Off, FM, FSK, Frequency Hop, Sweep, Chirp, AM, ASK, Amplitude Hop, (n)PSK or (n)QAM. The selected modulation scheme is generated immediately at the output terminals.

Hop Data – allows programming and editing of the frequency hop table. The hop data table contains a list of frequencies and the generator will hop through these frequencies in the same order and at a rate defined by the dwell time setting. Hop data length and frequency range as specified in Appendix A.

The frequency hop table depends on the Dwell Type selection and will display the dwell time parameter only if the variable dwell time option has been selected. The hop table as shown in Figure 3-28 is an example how such table are programmed from ArbConnection.

Dwell Type – defines if each hop step will have constant or variable dwell times. Using the variable time option, each step can be programmed to have a unique dwell time value.

Dwell Time – defines the lapse of time for a hop step, when the variable dwell time option has been selected.

Marker– programs a unique index point where the SYNC output generates a pulse to mark a specific hop step.

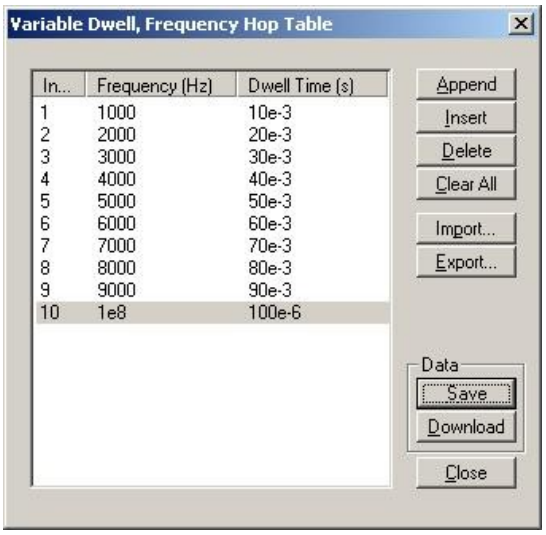

Figure 3-28, Variable Dwell Time Frequency Hop Table Example

Carrier Shape – defines the shape of the carrier waveform. The carrier shape can be selected from Sine, Triangle and Square. Note that the Carrier Shape parameter is used in all of the modulation displays, so if you change the shape for one function, it affects the other modulation displays as well.

Amplitude – defines the carrier amplitude level. The same level is used throughout the instrument when you move from waveform shape to another.

Offset – defines the offset level for the carrier waveforms. The same level is used throughout the instrument when you move from waveform shape to another.

Sweep

Sweep modulation allows carrier waveform (CW) to sweep from one frequency, as defined by the sweep start parameter, to another frequency, as defined by the sweep stop parameter.

When you select sweep modulation, the menus, as shown in Figure 3-29 and described in the following paragraphs, will be available for modification.

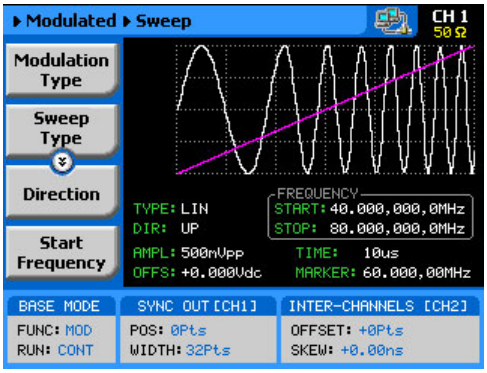

Figure 3-29, Sweep Menus

Modulation Type – defines the type of modulation scheme that will modulate the carrier waveform: Off, FM, FSK, Frequency Hop, Sweep, Chirp, AM, ASK, Amplitude Hop, (n)PSK or (n)QAM. The selected modulation scheme is generated immediately at the output terminals.

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

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

Start Frequency – defines the frequency value of which the generator will start its sweep. Note that the sweep start can be at a higher frequency value, depending on the sweep direction setting.

Stop Frequency – defines the frequency value of which the generator will stop its sweep. Note that the sweep stop can be at a lower frequency value, depending on the sweep direction setting.

Sweep Time – defines the time that will lapse from sweep start to sweep stop frequencies.

Marker – defines a frequency of which, when transitioned through, will output a marker pulse at the SYNC output connector.

Carrier Shape – defines the shape of the carrier waveform. The carrier shape can be selected from Sine, Triangle and Square. Note that the Carrier Shape parameter is used in all of the modulation displays so if you change the shape for one function, it affects the other modulation displays as well.

Amplitude – defines the carrier amplitude level. The same level is used throughout the instrument when you move from waveform shape to another.

Offset – defines the offset level for the carrier waveforms. The same level is used throughout the instrument when you move from waveform shape to another.

Chirp

Chirp modulation allows carrier waveform (CW) to sweep from one frequency, as defined by the sweep start parameter, to another frequency, as defined by the sweep stop parameter while, at the same time, swing through an amplitude range, as defined by the amplitude and AM Depth index.

When you select chirp modulation, the menus, as shown in Figure 3-30 and described in the following paragraphs, will be available for modification.

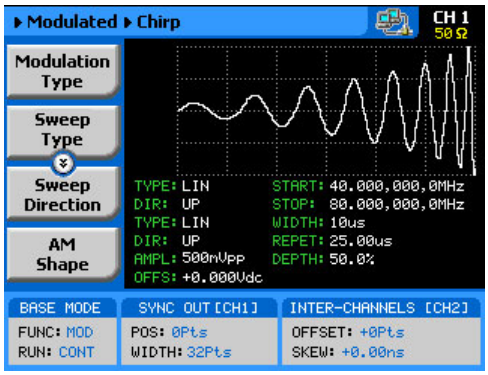

Figure 3-30, Chirp Menus

Modulation Type – defines the type of modulation scheme that will modulate the carrier waveform: Off, FM, FSK, Frequency Hop, Sweep, Chirp, AM, ASK, Amplitude Hop, (n)PSK or (n)QAM. The selected modulation scheme is generated immediately at the output terminals.

Sweep Type – defines the sweep steps of which the frequency increments or decrements from start to stop frequencies. A choice is provided between linear and logarithmic. If you select linear sweep, the carrier waveform frequency steps through the

frequencies within a time interval, which is set by the sweep time parameter. Likewise, using the logarithmic sweep type, the frequency span between the start and stop frequencies is stepped through using logarithmic steps.

Sweep 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.

AM Shape – defines the amplitude steps of which the amplitude increments or decrements from amplitude setting to the depth index value. A choice is provided between linear and logarithmic. If you select linear step, the amplitude steps linearly through the amplitude range. Likewise, using the logarithmic step type, the amplitude steps through the amplitude span using logarithmic steps.

AM Direction – defines the sweep direction. UP sets sweep direction from index value to amplitude setting. DOWN reverses the process.

Start Frequency – defines the frequency value of which the generator will start its sweep. Note that the sweep start can be at a higher frequency value, depending on the sweep direction setting.

Stop Frequency – defines the frequency value of which the generator will stop its sweep. Note that the sweep stop can be at a lower frequency value, depending on the sweep direction setting.

Pulse Width – defines the time that will lapse from sweep start to sweep stop frequencies. In other words, it defines the width of the entire chirp pulse.

Pulse Repetition – defines the time that will lapse from the start of one chirp sequence to the start of the next chirp sequence.

AM Depth – defines an index number of which references to the amplitude level value. 100% defines full amplitude span and 0% defines no signal (dc value).

Carrier Shape – defines the shape of the carrier waveform. The carrier shape can be selected from Sine, Triangle and Square. Note that the Carrier Shape parameter is used in all of the modulation displays so if you change the shape for one function, it affects the other modulation displays as well.

Amplitude – defines the carrier amplitude level. The same level is used throughout the instrument when you move from waveform shape to another.

Offset – defines the offset level for the carrier waveforms. The same level is used throughout the instrument when you move from waveform shape to another.

AM

The AM function enables amplitude modulation of a carrier waveform (CW). The carrier waveform is modulated by an internal waveform, normally referred to as envelope waveform. The envelope waveform can be selected from sine, triangle square or ramp shapes. When AM is selected, the menus that are associated with AM become accessible. These are shown in Figure 3-31.

There are other parameters that control how the CW is amplitude modulated. These are:

Modulation Type – defines the type of modulation scheme that will modulate the carrier waveform: Off, FM, FSK, Frequency Hop, Sweep, Chirp, AM, ASK, Amplitude Hop, (n)PSK or (n)QAM. The selected modulation scheme is generated immediately at the output terminals.

Modulation Shape – defines the envelope function. There are four shapes that can be used: Sine, Triangle, Square and Ramp. The Modulation Shape menu that provides access to the selection of the envelope waveform is shown in Figure 3-32.

Modulation depth – programmed in units of % and defines the depth of the modulating envelope. Modulation depth is programmed from 0% to 100%.

Modulation Frequency – defines the frequency of the modulating waveform. The modulating waveform is programmed from 10mHz to 100kHz.

CW Frequency – defines the frequency of the carrier waveform.

Carrier Shape – defines the shape of the carrier waveform. The carrier shape can be selected from Sine, Triangle and Square. Note that the Carrier Shape parameter is used in all of the modulation displays, so if you change the shape for one function, it affects the other modulation displays as well.

Amplitude – defines the carrier amplitude level. The same level is used throughout the instrument when you move from waveform shape to another.

Offset – defines the offset level for the carrier waveforms. The same level is used throughout the instrument when you move from one waveform shape to another.

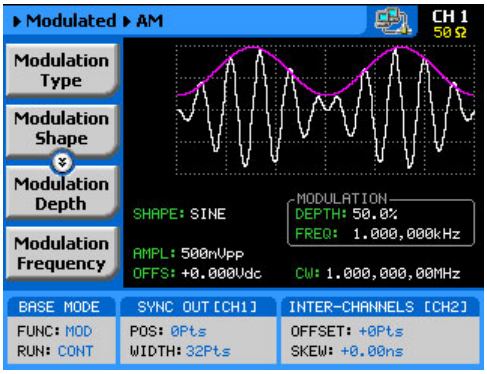

Figure 3-31, AM Menus

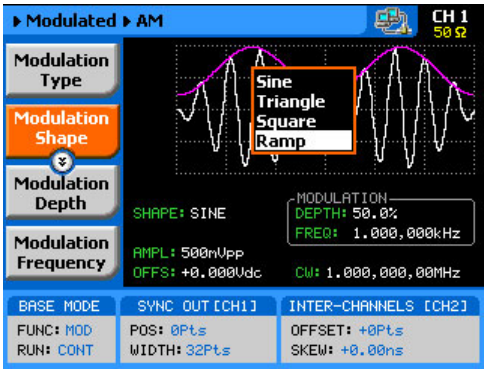

Figure 3-32, Modulating Waveform Shapes

ASK

ASK (Amplitude Shift keying) modulation allows amplitude hops between two pre-programmed amplitude levels. Note that sine wave CW only is hopped. The signal level can hop between two amplitude levels throughout the entire amplitude range without crossing range or relay ranges. Amplitude is programmed with 4 digits of resolution.

The ASK sequence is designed in an ASK table that can either be loaded from the front panel or downloaded from a remote interface from a utility such as ArbConnection. An example of the ASK table, as created in ArbConnection, is shown in Figure 3-33.

When you select ASK modulation, the parameters, as shown in Figure 3-34 and described in the following paragraphs, will be available for modification:

Modulation Type – defines the type of modulation scheme that will modulate the carrier waveform: Off, FM, FSK, Frequency Hop, Sweep, Chirp, AM, ASK, Amplitude Hop, (n)PSK or (n)QAM. The selected modulation scheme is generated immediately at the output terminals.

ASK Data – defines the sequence of which the amplitudes will toggle. ASK data is stored in an external table. The length of the table is limited from 1 to 4096 toggle sequences. The ASK Data table contains a list of “0”s and “1”s which determine the sequence. “0” defines the initial amplitude and “1” the shifted amplitude.

CW Frequency – defines the frequency of the carrier waveform. In this case, the CW frequency will also be used as the idle frequency. Using this standard ASK function, the shape of the carrier waveform is always sine.

Start Amplitude – defines the initial amplitude level. Note that the start amplitude does not necessarily define lower value than the stop amplitude.

Shifted Amplitude – defines the amplitude level of which the generator will shift when logic level “1” is sensed at the trigger input. Note that the stop amplitude does not necessarily define higher value than the start amplitude.

Baud – defines the rate of which the amplitude is toggled. The rate can be programmed within the range 0.1 bits/s to 350 Mbits/s..

Marker – defines an index point in the ASK sequence where the SYNC output will generate a marker pulse.

Offset – defines the offset level for the carrier waveforms. The same level is used throughout the instrument when you move from waveform shape to another.

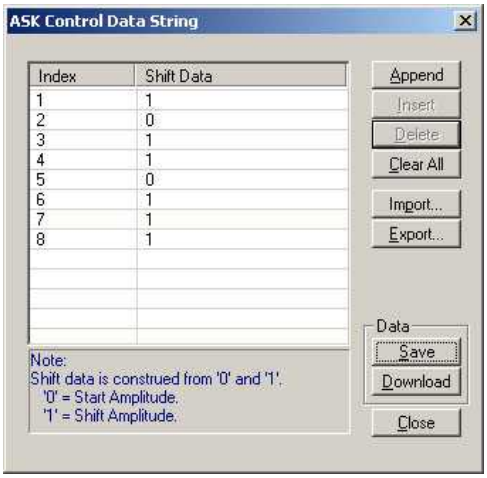

Figure 3-33, ArbConnection ASK Control Data String Example

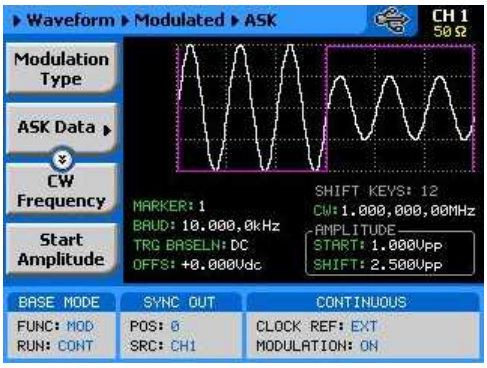

Figure 3-34, ASK Menus

Amplitude Hop

In Amplitude hop mode, the output waveform (sinewave) hops from amplitude to amplitude in a sequence defined by the hop table. Amplitude hop modulation allows amplitude hops throughout the entire range of the instrument. The base signal is always CW (sine waveform).

There are two amplitude hop types:

1. Amplitude hops with fixed dwell time and
2. Amplitude hops with variable dwell time

Dwell time defines the time that the amplitude will remain stable and will change at the end of this interval. With the fixed dwell time, the waveform hops from amplitude to amplitude at constant intervals, defined by the fixed dwell time parameter. When the variable dwell time is selected, each hop can be programmed to have a unique dwell interval.

When you select the amplitude hop modulation, the menus, as shown in Figure 3-35 and described in the following paragraphs, will be available for modification.

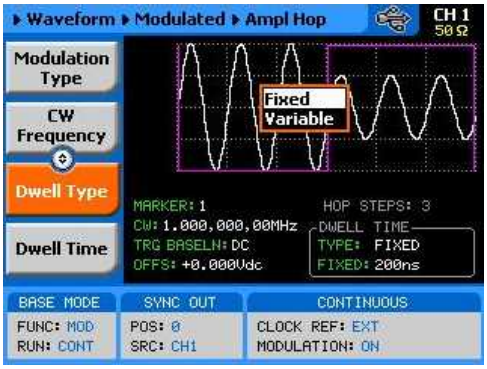

Figure 3-35, Amplitude Hop Menus

Modulation Type – defines the type of modulation scheme that will modulate the carrier waveform: Off, FM, FSK, Frequency Hop, Sweep, Chirp, AM, ASK, Amplitude Hop, (n)PSK or (n)QAM. The selected modulation scheme is generated immediately at the output terminals.

Hop Data – allows programming and editing of the amplitude hop table. The hop data table contains a list of amplitudes and the generator will hop through these amplitudes in the same order and at a rate defined by the dwell time setting.

The amplitude hop table depends on the Dwell Type selection and will display the dwell time parameter only if the variable dwell time option has been selected. The hop table as shown in Figure 3-36 is an example how such table are programmed from ArbConnection.

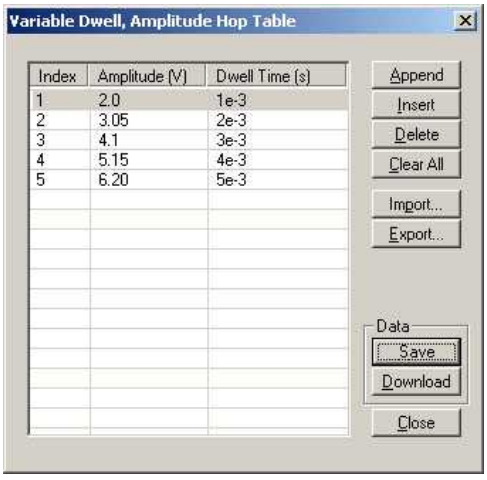

Figure 3-36, ArbConnection Variable Dwell Time Amplitude Hop Table Example

CW Frequency – defines the frequency of the carrier waveform. The shape of the carrier waveform is always sine.

Dwell Type – defines if each hop step will have constant or variable dwell times. Using the variable time option, each step can be programmed to have a unique dwell time value.

Dwell Time – defines the lapse of time for a hop step, when the variable dwell time option has been selected. Dwell time is programmable in steps of 1 ns from 2 ns to 10 seconds.

Carrier Shape – defines the shape of the carrier waveform. The carrier shape can be selected from Sine, Triangle and Square. Note that the Carrier Shape parameter is used in all of the modulation displays so if you change the shape for one function, it affects the other modulation displays as well.

Marker– programs a unique index point where the SYNC output generates a pulse to mark a specific hop step.

Offset – defines the offset level for the carrier waveforms. The same level is used throughout the instrument when you move from waveform shape to another.

(n)PSK

The (n)PSK modulation function can shift between multiple phase and amplitude positions to form phase shift constellations. There are 7 different types of phase shift keying that the WS8352 can generate: PSK, BPSK, QPSK, OQPSK, pi/4DQPSK, 8PSK and 16PSK. If another constellation scheme is required, one can use the User PSK to design a unique symbol list and constellation. An example of a QPSK display is shown in Figure 3-37.

There are other parameters that control the (n)PSK function, these are:

PSK Type – selects from one of PSK BPSK, QPSK, OQPSK, pi/4DQPSK, 8PSK and 16PSK. Once a type is selected the associated parameters are automatically available on the display for adjustments.

PSK Data – provides access to the PSK data symbols. By default the table is empty so the symbols must be loaded into the table before the (n)PSK function can be used. For testing and/or demonstration purpose, a default table is available to download from the front panel however, this table must be converted for different applications. An example of the QPSK data entry table is given in figure 3-38.

CW Control – can turn the carrier waveform on and off. Use the carrier off position when directly driving vector generators.

CW Frequency – defines the frequency of the carrier waveform. Using this PSK function, the shape of the carrier waveform is always sine.

Baud – programs the rate at which symbols step through. The rates can be programmed from 0.1 Symbols/s to 350 MSymbols/s when symbol length is a single bit. The limitations change accordingly as symbol length is increased..

Marker – defines an index point where the SYNC output generates a synchronization pulse. The marker can be programmed within the range of the symbol list.

Amplitude – defines the carrier amplitude level. The same level is used throughout the instrument when you move from waveform shape to another.

Offset – defines the offset level for the carrier waveforms. The same level is used throughout the instrument when you move from waveform shape to another.

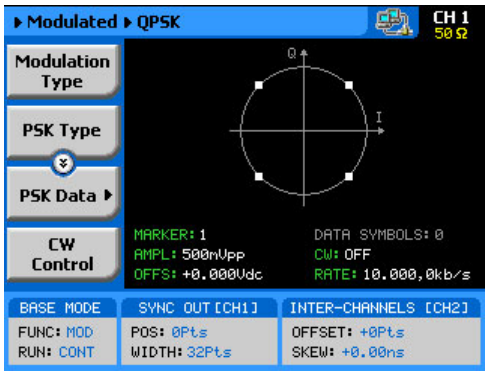

Figure 3-37, QPSK Modulation Display Example

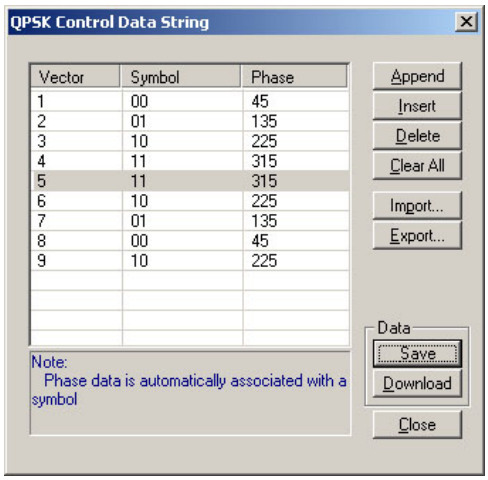

Figure 3-38, ArbConnection QPSK Data Entry Table Example

User PSK

The User PSK function is similar to the (n)PSK function except the symbols and their associated vector positions can be freely designed at locations that are non-standard. The user PSK display is shown in figure 3-39. The symbols can be designed on the 2572A display, or on the User PSK Control Data String dialog box as shown in figure 3-40.

After you design the symbols and generate the control data string, the definition and the modification of the other parameters are done exactly as you would do for the other PSK functions.

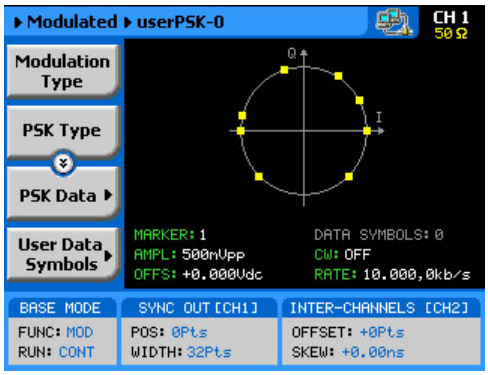

Figure 3-39, User PSK Display Example

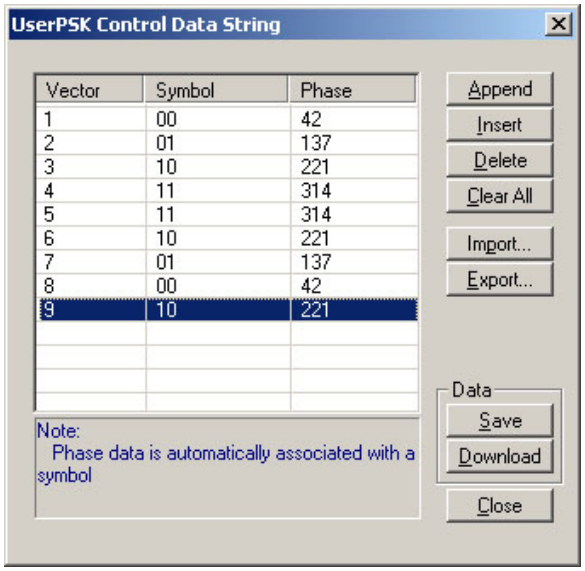

Figure 3-40, ArbConnection User PSK Data Entry Table Example

(n)QAM

The (n)QAM function is similar to the standard ASK function except the output can shift to multiple amplitudes and phase positions to form an amplitude/phase shift constellations. There are 4 different types of Quadrature Amplitude Modulation that the WS8352 can generate: 16QAM, 64QAM and 256QAM. If another constellation scheme is required, one can use the User QAM to design his/her own symbol list and constellation. An example of a 64QAM display is shown in Figure 3-41.

There are other parameters that control the (n)QAM function, these are:

QAM Type – selects from one of 16QAM, 64QAM, 256QAM and User QAM. Once a type is selected the associated parameters are automatically available on the display for adjustments.

QAM Data – provides access to the QAM data symbols. By default the table is empty so the symbols must be loaded into the table before the (n)QAM function can be used. For testing and/or demonstration purpose, a default table is available to download from the front panel however, this table must be converted for different applications. An example of the 64QAM data entry table is shown in figure 3-42.

CW Control – can turn the carrier waveform on and off. Use the carrier off position when directly driving vector generators.

CW Frequency – defines the frequency of the carrier waveform. Using this QAM function, the shape of the carrier waveform is always sine.

Baud – programs the rate of which symbols step through. The rates can be programmed from 0.1 Symbols/s to 350 MSymbols/s when symbol length is a single bit. The limitations change accordingly as symbol length is increased..

Marker – defines an index point where the SYNC output generates a synchronization pulse. The marker can be programmed within the range of the symbol list.

Amplitude – defines the carrier amplitude level. The same level is used throughout the instrument when you move from waveform shape to another.

Offset – defines the offset level for the carrier waveforms. The same level is used throughout the instrument when you move from waveform shape to another.

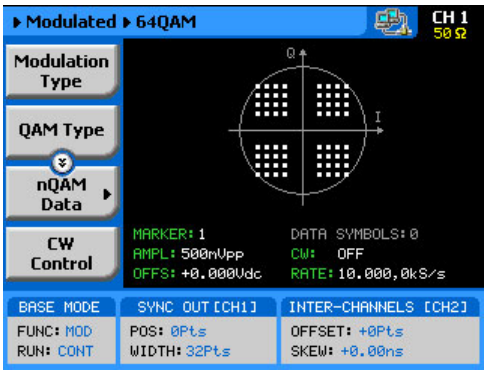

Figure 3-41, 64QAM Display Example

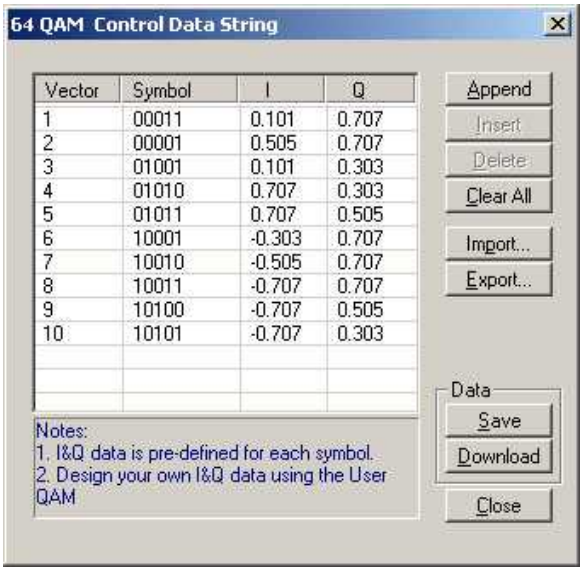

Figure 3-42, ArbConnection 64QAM Data Entry Table Example

User QAM

The User QAM function is similar to the (n)QAM function except the symbols and their associated vector positions can be freely designed at locations that are non-standard. The user QAM display is shown in figure 3-43. The symbols can be designed on the WS8352 display, or on the User QAM Control Data String dialog box as shown in figure 3-44.

After you design the symbols and generate the control data string, the definition and the modification of the other parameters are done exactly as you would do for the other QAM functions.

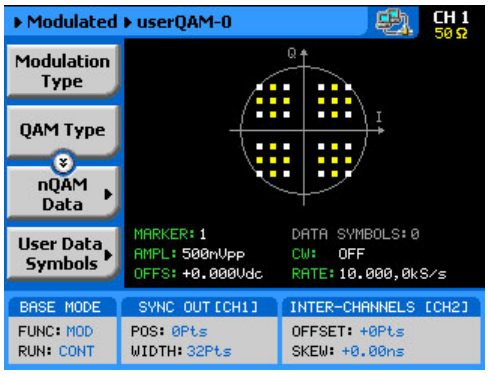

Figure 3-43, QAM User Display Example

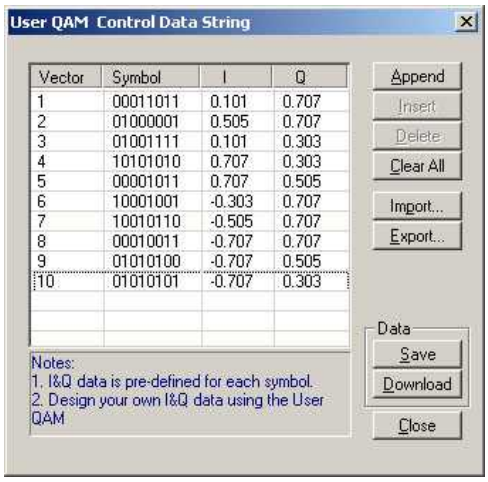

Figure 3-44, ArbConnection User QAM Data Entry Table Example

Modulated Waveforms and Run Mode Options

Run Mode options define if the modulated waveforms will be generated continuously, triggered, or gated. Refer to the Selecting Run Modes section of this manual to learn more about these functions. Table 3-9 provides information on the modulated waveform function in conjunction with the run mode options. This table is useful, as it summarizes all the controls that start and stop the waveforms. The Glossary defines the terms used in this table.

Table 3-8, Modulated Waveforms in Various Run Mode Options

Run Mode	Waveform	Arm Options	Idle Waveform	Enable Signal	Abort Signal	Initiate Signal	Wave Loops	Smart Trig
Continuous	Modulated	Self Armed	Wave	- (*)	-	-	-	-
		Armed	DC	Trigger | BUS | Event	F.P. | BUS	-	-	-
Triggered	Modulated	Self Armed	-	-	-	-	-	-
		Armed	DC	-	BUS	F.P.| BUS | Trigger | Event	1-1M	Yes
Gated	Modulated	Self Armed	-	-	-	-	-	-
		Armed	DC	-	BUS	Trigger | Event	-	-

- (*) – Not Relevant

Glossary of Terms

Run Mode – defines basic instrument run mode options:

Continuous – waveform is generated continuously.

Triggered – output waits for trigger, waveform is generated once.

Gated – output waits for gating signal, waveform is generated as long as the gating signal is true.

Waveform – modulated waveform is generated at the output.

Arm Options – defines if a waveform is self-enabled or requires a control signal to initiate.

Self Armed – the output does not require a control signal to generate waveforms.

Armed – a control signal is required to enable waveforms.

Idle Waveform – defines the state of the output waveform before an event (enable, trigger or gate) initiates a waveform.

DC – first waveform point.

Wave – Selected waveform.

Enable Signal – defines the source from where an enable signal is expected. Affects the output only when Arm Option is set to Armed.

BUS – a remote command enables the output.

Event – a transition at the event input enables the output.

Trigger – a valid signal at the trigger input enables the output.

Abort Signal – defines the source from where an abort signal is expected.

BUS – a remote command aborts all output activities. This signal does not affect the generator, when set to operate in self- armed mode.

F.P. – a front panel push button is used to abort all outputs activities.

Initiate Signal – defines the wait for trigger entry port to initiate a waveform. Relevant for trigger and gated run modes only.

F.P. – a front panel push button is used to initiate a waveform.

BUS – a remote command initiates a waveform. Selecting this option automatically disables front panel operation.

Trigger – a valid signal at the trigger input initiates a waveform.

Event – a transition at the event input initiates a waveform.

Wave Loops – defines how many times the waveform repeats after a valid Initiate Signal.

Smart Trigger – defines if smart trigger features are available for a specific function.

Generating Pulse Waveforms

The WS8352 employs a complete set of menus that are dedicated to the pulse/pattern function. Press on the Pulse in the Function group and the output will immediately be updated with the pulse waveform and the display will be modified to show pulse parameters, as shown in Figure 3-45.

The pulse function provides the means for designing pulses and their associated parameters, exactly as would be done on a stand-alone analog pulse generator. Note, however, that the pulse is built in the same memory as the arbitrary waveforms are being stored and therefore, changing from arbitrary to digital pulse mode and vice versa may overwrite waveforms that were downloaded to the memory.

If this is the first time that you enter this menu, the output will generate a pulse with the following properties:

Pulse Mode: Single
Period = 10 ms
Pulse Width = 2 ms
High Level = 1 V
Low Level = 0 V
Polarity = Normal
Transitions = Fast

By default, pulse timing is set in units of time (seconds). However, this can be changed so that some parameters are set as ratios between the parameter to the pulse period. This option will be discussed later in this section of the manual.

Note

The pulse shape on the WS8352 LCD display is an icon only. The actual waveform at the output terminals may look entirely different.

The pulse generator menus provide access to all pulse parameters, just as they would be programmed on an analog pulse generator. To access the pulse parameters, use one of the soft keys. If you do not see a required parameter on the screen, press the key up or down to scroll through the menus.

There are many pulse parameters that can be displayed on the screen. However, most applications do not require that all pulse parameters be displayed and therefore, the menus were built in a way that show all of the parameters that are absolutely necessary to program the selected pulse mode. For example, if single pulse mode with fast transitions is required, the delay, rise and fall time parameters will not be shown on the screen. Information on how to program simple and complex pulse modes is given in the following paragraphs.

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

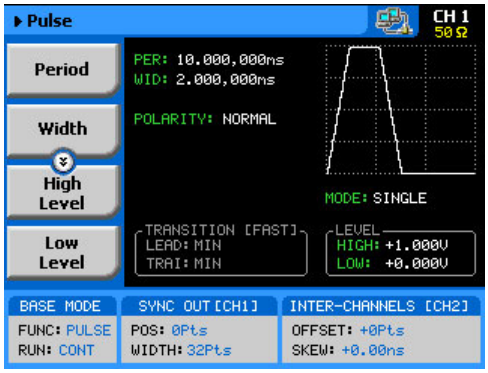

Figure 3-45, Pulse Function Menus

Adjusting the pulse shape with the required characteristics can only be done if all of its parameters can be adjusted both in the time and amplitude domains. The WS8352 provides all the necessary controls to do just that. However, always keep in mind that some parameters may interfere during the programming sequence and cause setting conflicts. These setting conflicts will be discussed later in this chapter. Below you will find a list of all pulse parameters that you can access though the soft key menus.

The main menu, as shown in Figure 3-45, provides access to five soft key buttons: Period, Width, High Level, Low level Config and Pulse Composer. Pressing the TOP soft key from anywhere in the pulse menus will restore the display to the one shown in Figure 3-46.

Period – programs the pulse period in unit of seconds.

Width – programs the pulse width in units of seconds. The pulse width can be set as a percent of the period when the Pulse Parameters option in the Config menu has been modified from Time to Percent.

High Level – programs the pulse high-level value in units of volts.

Low Level – programs the pulse low-level value in units of volts.

Config – provides access to a new menu that has pulse configuration controls. The configuration menu is shown in Figure 3-46 and its controls are described below. There are five control parameters in this menu: Pulse Parameters, Pulse Mode, Polarity, Transition Type and Level Control. Each of these controls has a major impact on pulse.

Pulse Composer - opens a table that programs pulse patterns that have mixed transition times

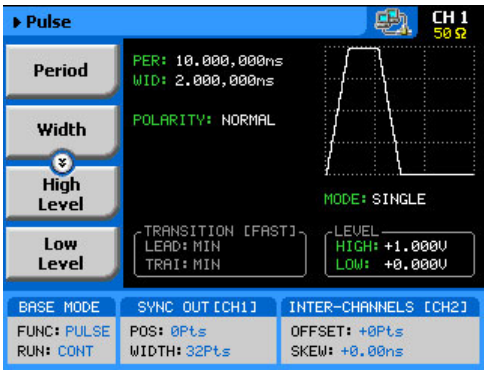

Figure 3-46, Pulse Configuration Menus

Pulse Parameters

The Pulse Parameters control lets you select if you want the pulse parameters programmed in units, time or as percent ratios to the pulse period. Pulse parameters are normally programmed in units of time and this is the default condition after reset or the first time you access this function. The advantage of using ratio is that the instrument computes the timing and keeps a fixed ratio of period-to-width whenever you change the period. The parameters available in this mode are: pulse width, pulse delay and pulse transition times. Amplitude and offset values are not affected when you select the ratio mode.

Understanding Pulse Parameters

Standard definitions of pulse parameters are not within the scope of this manual, but it is important to understand how the WS8352 interprets these definitions and how you should expect to see the pulse shape on monitoring devices, such as oscilloscopes.

Figure 3-47 depicts a common pulse shape as understood by most hardware engineers. The standard interpretation implies that the pulse width is measured between the edges, at the middle of the amplitude level and transitions are often specified from 10% to 90%. However, this is not always the case and some engineers, for example, prefer the 20% to 80% value as transitions and measure the high time of the pulse as the pulse width.

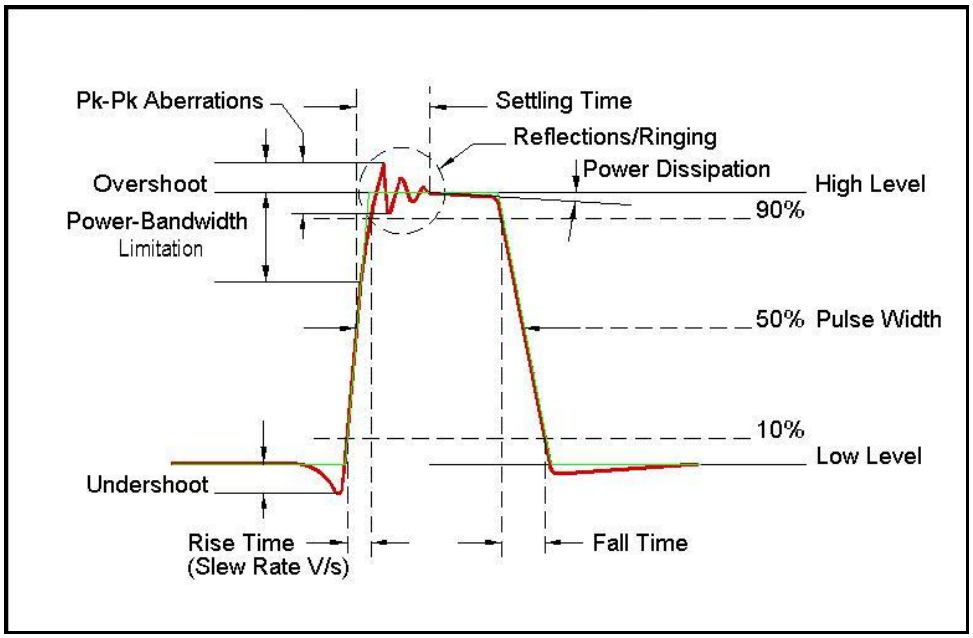

Figure 3-47, Standard Interpretation of Pulse Parameters

As mentioned above, the pulse function is computed and generated from the arbitrary memory and therefore, some of the parameters are interpreted differently, because it will take too long to compute and build digital waveforms the same way that analog components do. Standard or WS8352 interpretation, once the commonality and differences are defined, will be equally simple to design pulse characteristics with the pulse generator that is available in the WS8352.

Figure 3-48 shows how the WS8352 interprets the programmed pulse parameters. The differences are painted blue to highlight them. One major difference from standard analogy, is that the pulse width includes the time it take to transition from low level to the time it take to transition from high level.

The rest of the parameters were derived from these characteristics and should present little difficulty, especially when most of the pulse applications do not contain linear transitions, anyway.

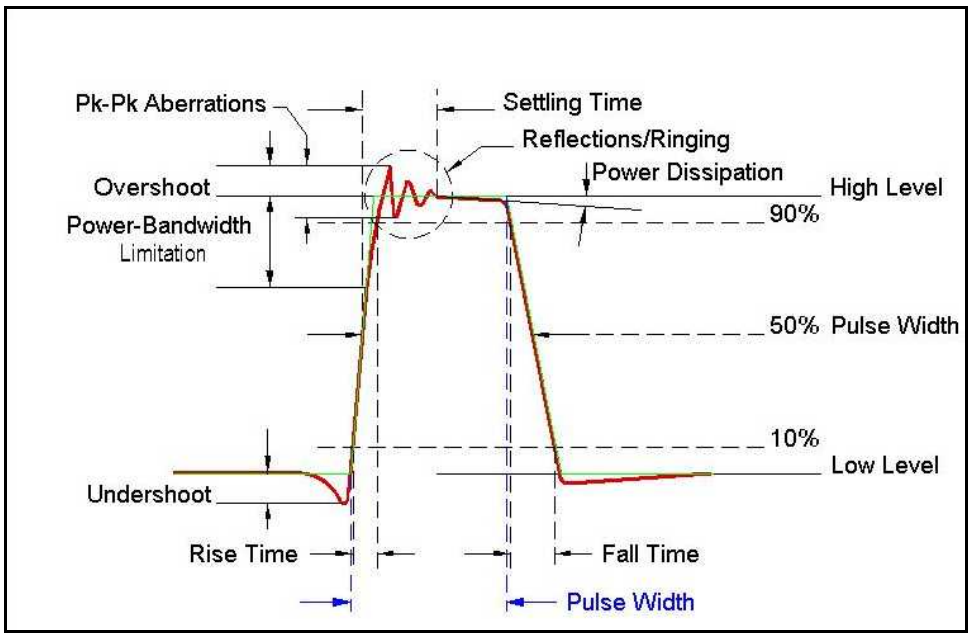

Figure 3-48, WS8352 Interpretation of Pulse Parameters

Pulse Modes

The pulse mode menu provides access to modifying the basic shape of the pulse waveform. These are: Single Pulse, Double Pulse and Delayed Pulse. These modes and their associated parameters are discussed below. To access the Pulse Modes options, press the soft key next to this parameter. The pulse mode options will become available, as shown in Figure 3-49. Scroll up or down the list and press enter to complete the selection process.

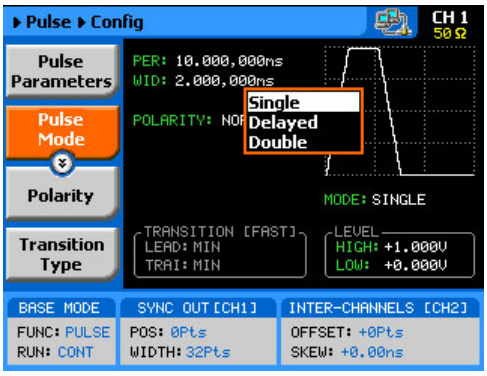

Figure 3-49, Pulse Mode Options

Single Pulse Mode

The basic pulse mode is the Single Pulse. Single pulse defines the shape of a single pulse only. In continuous operating mode, it may appear as a string of pulses that have constant period, width and amplitude. However, the meaning of this mode is that is you place the instrument in triggered run mode and only one pulse is initiated with every trigger. The menus that are associated with the simplest configuration of the single pulse mode are: Period, Width, High and Low Levels. These parameters are discussed below. With more complex configuration, you can select linear transitions and width and amplitude modes. However, these are described separately.

Figure 3-50 shows a typical single pulse shape and highlights all of its relevant parameters. While most of the parameters that are shown in Figure 3-50 can be programmed and adjusted for a specific application, some characteristics of the pulse are derived from the quality of the generator and its output stage. These are specified and can be found in Appendix A.

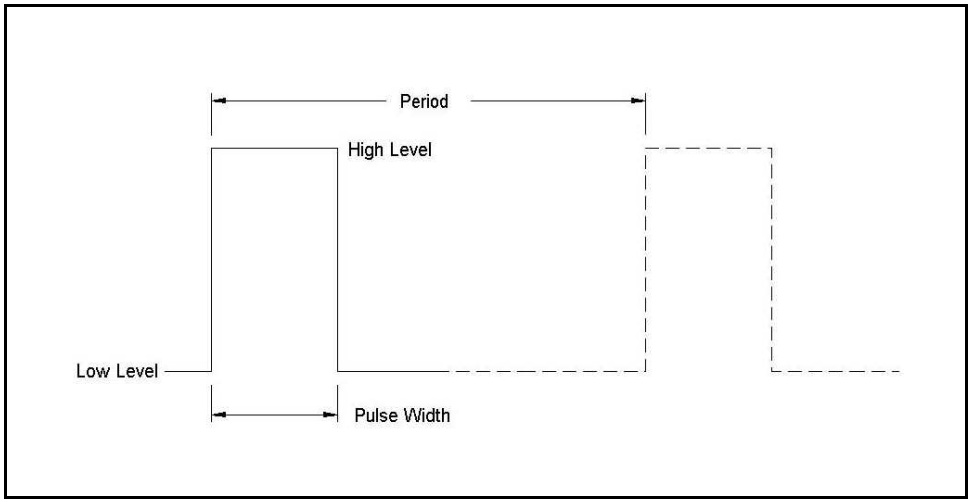

Figure 3-50, Single Pulse Parameters Summary

Note

Before you start programming pulse parameters, keep in mind that incorrect planning of your entries may cause setting conflicts that may, in turn, cause the instrument to ignore some parameters. A common example is if you try to program pulse width that is wider than the period. Therefore, always program the period first and enter other pulse parameters in descending order. A list of setting conflicts is given later in this chapter.

When Single Pulse mode option has been selected, the main pulse menus will allow access to the following pulse parameters:

Period – programs the pulse period in unit of seconds.

Width – programs the pulse width in units of seconds. The pulse width can be set as a ratio to the period when the Pulse Parameters option in the Config menu has been modified from Time to Percent.

High Level – programs the pulse high-level value in units of volts.

Low Level – programs the pulse low-level value in units of volts.

Delayed Pulse Mode

The Delayed Pulse mode is a special mode that delays the pulse output after a trigger is issued. To modify the pulse mode to delayed pulse, use the procedure as given above under the Pulse Modes heading.

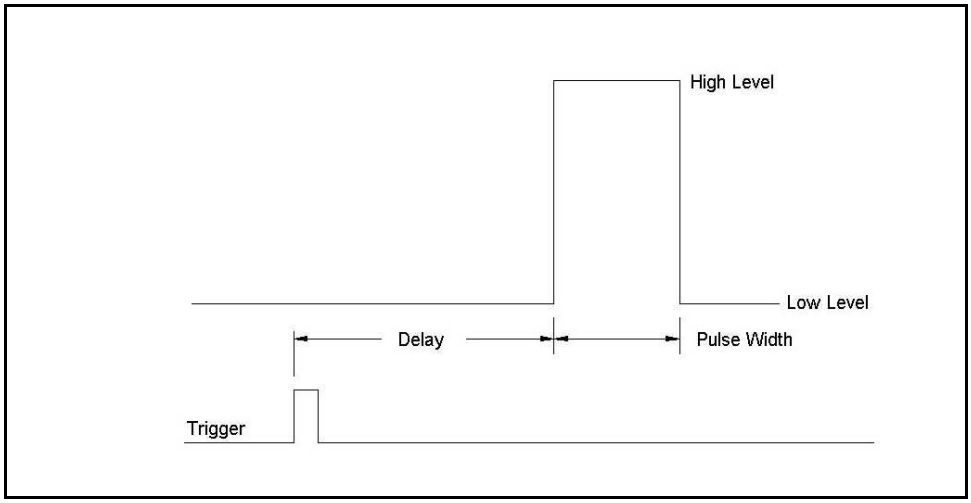

Figure 3-51, Delayed Pulse Mode

The menus that are associated with the simplest delayed pulse configuration are: Period, Width, High and Low Levels and Pulse Delay. The pulse delay is measured from the trigger edge to the first transition of the pulse leading edge, as shown in Figure 3-51.

The Pulse Delay parameter becomes available in the main pulse parameters screen only after you select the delayed pulse mode.

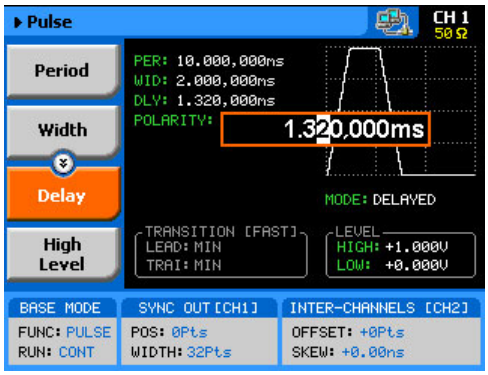

Figure 3-52, Programming the Single Pulse Delay Parameter

Double Pulse Mode

The Double Pulse mode is a special mode that doubles pulse output into a pair of two pulses at a time. In continuous run mode, the output will appear as a string of pulse pairs, separated by an interval set by the period parameter. If you place the instrument in triggered run mode, a pair of pulses is initiated with every trigger. To modify the pulse mode to double pulse, use the procedure as given above under the Pulse Modes heading.

The menus that are associated with the simplest double pulse configuration are: Period, Width, High and Low Levels and Double Pulse Delay, which sets the delay between the pairs of pulses. The double pulse delay is measured from the first pulse transition to the next pulse transition, as shown in Figure 3-53.

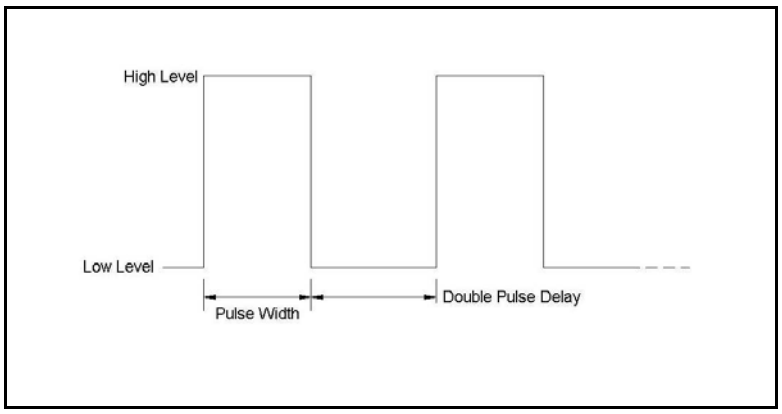

Figure 3-53, Double Pulse Mode

The double pulse delay parameter becomes available in the main pulse parameters screen, as shown in Figure 3-54, only after you select the double pulse mode. Note that the delay is programmed from pulse-end to pulse-start.

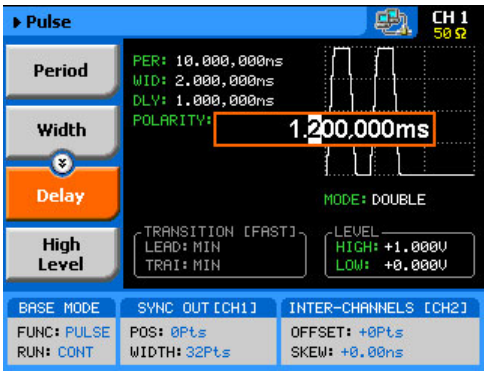

Figure 3-54, Programming the Double Pulse Delay

Programming Pulse Polarity

The pulse polarity parameter determines if the pulse is generated In Normal, Complemented, or Inverted shape. Pulse polarity can be selected in conjunction with any of the pulse modes. The various polarity options are shown in Figure 3-55.

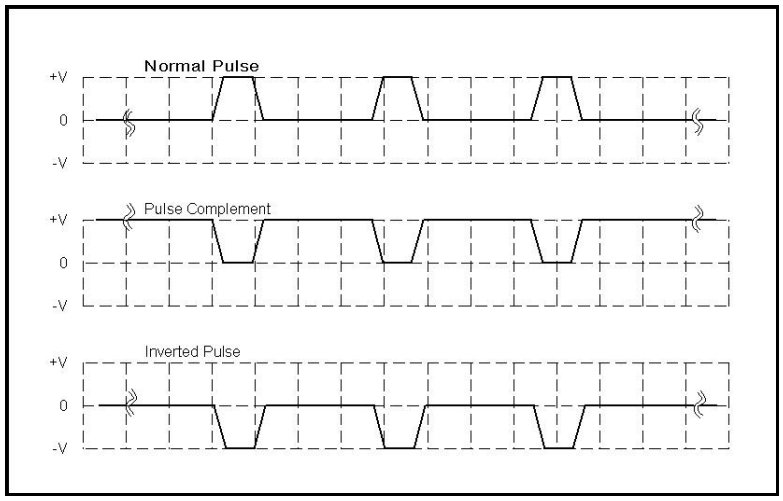

Figure 3-55, Pulse Polarity Options

As shown in this figure, the complemented shape is mirrored around the horizontal axis in a way that the high level becomes low and similarly, the low level becomes high. In complemented mode, the inversion process is symmetrical to about 50% of the value of the pulse amplitude.

In Inverted mode, the normal pulse is mirrored about the 0 V horizontal axis, positive values are converted to negative and negative values are converted to positive.

The normal pulse and the pulse complement are specifically valuable for applications requiring differential signals and therefore a dual channel like the WS8352 that has this feature can easily be programmed to generate these signals. Simply set one channel to

Normal and the second channel to Complemented and both signals will be generated differentially, perfectly synchronized, with no phase offset and without the slightest jitter.

Use Figure 3-56 to access and modify the pulse polarity parameter. Note that the pulse polarity can be programmed separately for each channel and therefore, before you modify this parameter, make sure that you program the correct channel.

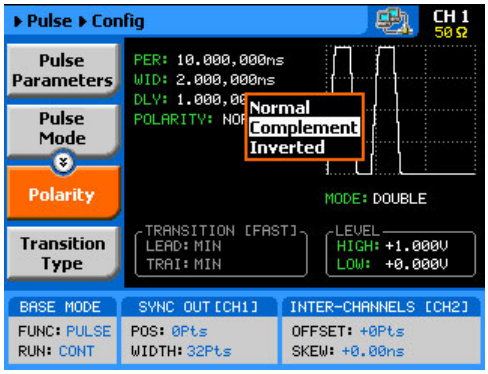

Figure 3-56, Programming the Pulse Polarity

Applying Linear Transitions

Most of the applications that use pulse generation require that the transitions from low-to-high and from high-to-low be as fast as possible. Such transitions are normally created as a by-product of the output amplifier. General-purpose amplifiers that can drive 50 Ω loads with high amplitudes are rare, and usually the products that you can buy off the shelf either have poor drive capabilities or uncontrolled aberration capability.

For a pulse generator that generates pulses with fast transitions only, the problem is simpler, because the designer can use a switching amplifier at the output amplifier stage. It takes a very different approach to design an output stage that slows the transitions of the leading and trailing edges. To this extent, the WS8352 has a unique output amplifier stage that allows full control over pulse transitions over a very high dynamic range of amplitudes and offsets, without the slightest degradation of the integrity of the signal. A comparison between pulses with fast and linear transitions is shown in Figure 3-57. As you can see, the top train has fast transitions. These are normally in the range of <1 ns and are expected to be very fast and without aberrations. The bottom pulse has linear transitions that are expected to have good linearity and slew-rate accuracy. Observe that the pulse width on the pulses that have linear transitions is measured from the first transition to high. Also note that the leading and the trailing edges can be programmed to have different transitions times.

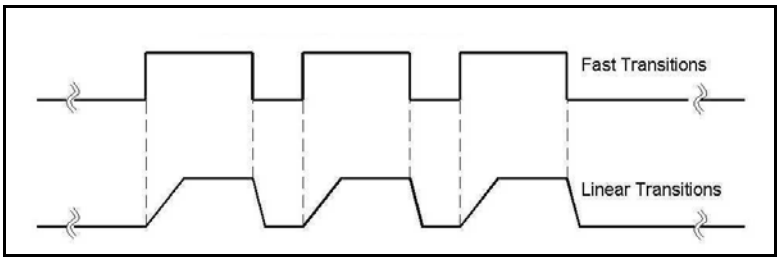

Figure 3-57, Fast and Linear Transitions, Compared

The menu that selects between fast and linear transitions is shown in Figure 3-58. The application of linear transitions affects all pulse modes. Note that you may select symmetrical transitions and in this case, programming the lead time automatically adjusts the fall time to the same value and vice versa: programming the fall time will automatically adjust the rise time value.

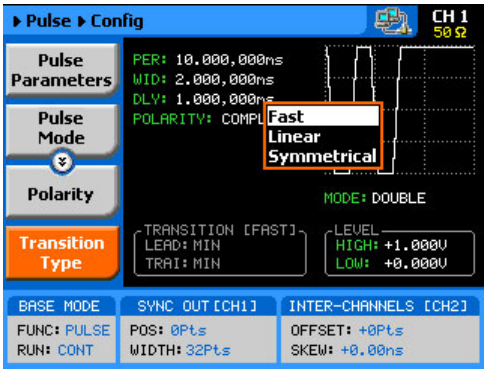

Figure 3-58, Programming the Transition Type

After you select the linear transition option, you'll probably want to program the transition times for the leading and trailing edges. There are some considerations to observe before you program the transitions. First, note the limits, as specified in Appendix A. Then you have to make sure that the transition settings do not conflict with the pulse width settings. For example, if you set the pulse width to 100 ns and the leading edge transition time to 120 ns, the instrument will not allow you to do the change. A list of setting conflicts is given later in this chapter.

Finally, you have to bear in mind that the transitions are programmed digitally, so there is no limitation on ranges, but if you select long transition cycles, there is danger that the generator will not have enough waveform memory to complete the waveform. These limitations are summarized in Appendix A and some are listed as errors in the following paragraphs.

TIP

Although not a design limitation, setting conflict may occur if the leading and trailing edges are not programmed within the same range.

After you configure the WS8352 to have linear transitions, the Leading Edge and the Trailing Edge soft buttons will be visible on the main pulse display, as shown in Figure 3-59.

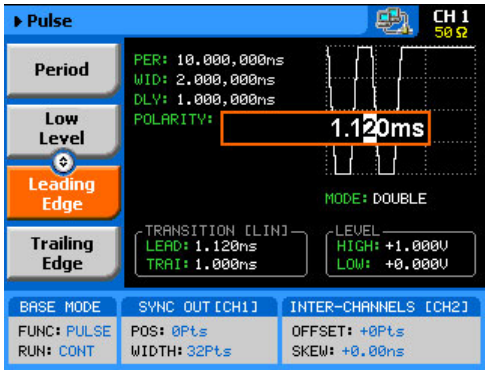

Figure 3-59, Leading Edge Programming Example

Programming the Amplitude Level Mode

Common waveform generators allow adjustment of the peak-to-peak amplitude plus offset, in cases where the required level is none symmetrical about the 0 V level. While this is normally acceptable for generating standard waveforms, pulsed waveform applications require additional flexibility in the way that the levels are set. For example, one may want the baseline to stay on 0V, regardless of the top or the low peaks settings. Other applications could require separate adjustments of each level and so on.

Using the WS8352 as your pulse source, you have four options to set up the pulse levels, as shown in Figure 3-60 and explained below:

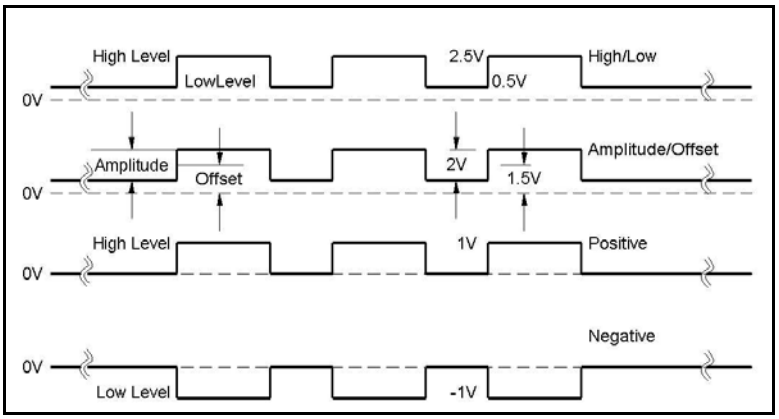

Figure 3-60, Amplitude Level Modes Options

1. ***High/Low Levels.*** This is the default option. Using this mode, you can program the high and the low levels directly, while allowing the instrument to set the internal amplitude and offset according to your selection. The maximum amplitude that can be programmed is 4 V peak-to-peak. To achieve this level, program the low level to -1.5 V and the high level to +1.5 V. Note that the amplitude level is specified when the pulse is applied on a 50Ω load impedance. The only way to exceed the peak-to-peak rail limitation is by increasing the load impedance, but then expect degradation of the pulse shape. The example in Figure 3-72 shows the high level set at 2.5 V and the low level set at 0.5 V and therefore, the resulting peak-to-peak level is 2 V.
2. ***Amplitude/Offset.*** This option allows separate modification of the amplitude and the offset. This option is very useful when you want to vary the vertical position of the pulse, but hold the peak-to-peak amplitude level fixed. The example in Figure 3-60 shows the amplitude set at 2.5 V and the low level set at 1.5 V and therefore, the resulting waveform is exactly as was programmed in the high/low level programming example.
3. ***Positive.*** This option is very useful when you want to vary the positive position of the pulse, but hold the low level fixed at the 0 V level. The example in Figure 3-60 shows the high level set at 1 V and the low level fixed at 0 V. Modification of the high level will not alter the low level position.
4. ***Negative.*** This option is very useful when you want to vary the negative position of the pulse, but hold the high level fixed at the 0 V level. The example in Figure 3-60 shows the low level set at -1 V and the high level fixed at 0 V. Modification of the low level will not alter the high level position.

The amplitude level options are selected in the configuration menu, after you select the Level Control tab, as shown in Figure 3-61.

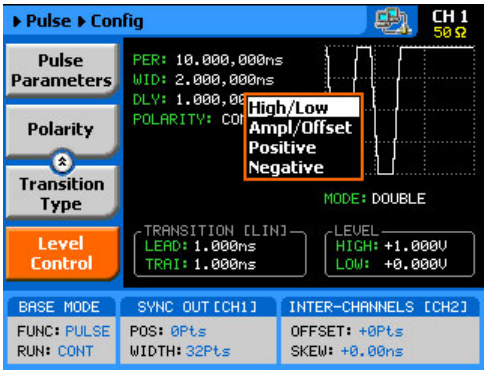

Figure 3-61, Programming the Amplitude Level Mode

Pulse Design Limitations

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

1. Step increment defines resolution and period
The pulse is being created digitally, using a sample clock generator that clocks memory points. The rate of the sample clock defines the incremental resolution. Consider that you want to generate 100 ms pulse rates with 1 ms high time pulse and the rest of the period low. In this case, the generator can select the 1 kSa/s to 10 kSa/s clock rates, because this is enough for generating a high signal of 1 ms using just 100 to 1000 memory points. However, when you want to define much smaller pulse widths at larger rep rates, the number of points that are used for the generation increases as a function of the period. The limitation is set by the number of memory points. With the standard memory model, the incremental resolution is 1 in 512,000.

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

3. Only single and double pulse can be designed
As a stand-alone pulse generator, the capability that is built into the digital pulse generator allows generation of these two waveforms. This allows generation of single or double pulse patterns having a fixed high and low amplitude values. In case you need to design complex trains of pulse waveforms, you can always do it using an external utility.

4. Pulse peaks cannot exceed the supply voltage rails.
The maximum peak-to-peak amplitude span for a given pulse design is 4 V and a further limitation is that the positive and negative settings cannot exceed the output amplifier rails of +2.5 V and -2.5 V.

The paragraphs below summarize possible settings conflicts and devise options to undo the lockup. In case you try to program a parameter that will cause a setting conflict, the instrument will automatically detect the problem and issue an error message. In this case, the output may appear distorted and generate uncontrolled signals. Under no circumstances should you use the output when an error is displayed, even if the signal appears to look somewhat as expected, because there is no control over accuracy and signal integrity when an error message is displayed.

Settings Conflict Errors

Settings conflict errors may involve one or more parameters and there is also a chance that more than one error is embedded in the settings. For simplicity, the WS8352 displays the first error it detects. In this case, the output is updated, but a red asterisk is displayed on the message bar. This symbol will remain on the top message bar until the error is cleared. A detailed description for each of the conflicting settings is given below.

Note

The following abbreviations are used throughout the following setting conflicts descriptions:

PER – Period setting

HIL – High-level setting

LOL – Low-level setting

WID – Pulse-width setting

DEL – Delay-edge setting

TRE – Trailing-edge setting

ITRG – Period-of-internal-trigger setting

Amplitude Errors

Amplitude errors occur when attempting to program amplitude outside the specified window level. This error will occur in all run mode options. The generator will detect the following conditions:

HIL - LOL < 50 mV
HIL + LOL > 2 V
HIL > 2.5 V
LOL < -2.5 V

The minimum and maximum amplitude levels are absolute values that the WS8352 can accept. The same will occur if you reverse the high and low levels, because the instrument will sense it as a negative voltage, which is obviously less than the minimum 50 mV limit.

Corrective Actions
Evaluate the required amplitude level and change the high and low levels accordingly.

Pulse Timing Errors

Pulse timing errors occur when attempting to program the period value outside the specified limits or when there is a setting conflict between the period and the leading edge transition values. The generator will detect the following conditions:

PER > 1.6 s
PER < 5 ns
LEE > WID

While the first two conditions are easy to grasp, as they are simply a matter of how the pulse parameters are specified, the last condition evolves from the way that the WS8352 interprets the pulse width parameter. If you look at earlier sections of the pulse generator description, you'll notice that the pulse width includes the leading edge transition time and therefore, if you fail to take this into consideration, the generator will issue an error flag.

Corrective Actions

1. Make sure the period limits are observed
2. Reduce the leading-edge value

Pulse Linear Transition Errors

Pulse linear transition errors occur when attempting to program the leading and trailing edge values outside the specified limits. The generator will detect the following conditions:

LEE/TRE < 1 ns
LEE/TRE > 100 ms
WID+TRE > 1.6 s

While the first two conditions are easy to grasp, as they are simply a matter of how the pulse parameters are specified, the last condition evolves from the way that the WS8352 interprets the pulse width parameter. If you look at earlier sections of the pulse generator description, you'll notice that the pulse width includes the leading edge transition time and therefore, if you fail to take this into consideration, the generator will issue an error flag.

Corrective Actions

1. Make sure the leading- and trailing-edge limits are observed
2. Reduce the leading-edge value
3. Reduce the trailing-edge value

Pulse Delay Errors

Pulse delay errors occur when attempting to program pulse or double pulse delay values outside the specified limits. The generator will detect the following conditions:

DEL < 1 ns
DEL > 1 s
DEL+WID+TRE > 1.6 s (single pulse mode)
DEL+2*WID+2*TRE > 1.6s (Double pulse mode)

While the first two conditions are easy to grasp, as they are simply a matter of how the pulse parameters are specified, the last condition evolves from the way that the WS8352 interprets the pulse width parameter. If you look at earlier sections of the pulse generator description, you'll notice that the pulse width includes the leading-edge transition time and therefore, if you fail to take this into consideration, the generator will issue an error flag.

Corrective Actions

1. Make sure the delay limits are observed
2. Reduce the delay value
3. Reduce the leading-edge value
4. Reduce the trailing-edge value

General Pulse Errors

Bearing in mind that the pulse is generated mathematically and replayed as an arbitrary waveform, it is very easy to get into tight corners that do not let the generator compute the waveform efficiently. This may come from the following conditions:

Required waveform resolution is < 500 ps
Required memory length > 512,000
The computed SCLK > 2 GSa/s
System memory allocation limitations

The general pulse errors are hard to define. However, if reasonable parameters range and ratio-to-period are kept, the WS8352 should have no problem computing and generating the required pulse shape.

Generating User Composed Patterns

Composed pattern is a rubber-band method of generating patterns that have mixed transition times. One can generate a pattern that has simple and fast transitions from high level to low level or, generate a very complex pattern that has mixture of fast and linear transitions plus control the amplitude level for each transition. From the front panel, pulses are created by stretching a line from last point to the next. It is of course much simpler when programming such a pulse using the available commands for composed pulse waveforms, as described in the programming chapter of this manual.

The WS8352 offers two methods of creating user-defined pulse patterns, the first is pulse patterns that transition from high level to low level using the fastest transition time that the generator offers. This type is nomenclature as "Fast". The second option is the "Linear" pulse pattern that allows slower transitions from high to low amplitude levels. In both cases, the high and low amplitude levels can be designed as unique values for each transition as will be explained in the following paragraphs.

Do the following to access the pulse composer menus:

1. Push the Pulse button in the Function group keys. The pulse dialog box, as shown in Figure 3-62 will be displayed.

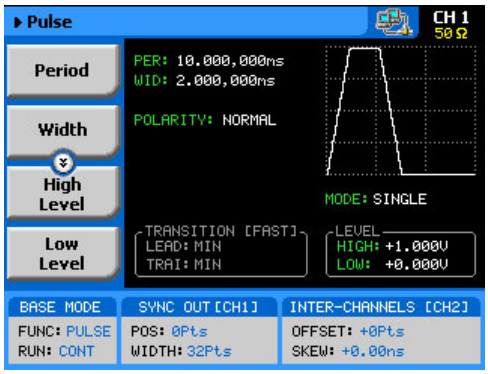

Figure 3-62, User-composed Pulse Patterns Menus

2. Using the down key, scroll down with the menus to access the Pulse Composer menu tab, as shown in Figure 3-63.
3. Press the Pulse Composer soft key and observe the Pulse Composer editing fields as demonstrated in Figure 3-64.

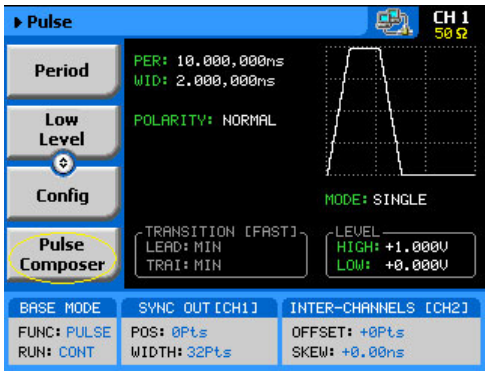

Figure 3-63, Access the Pulse Composer Menus

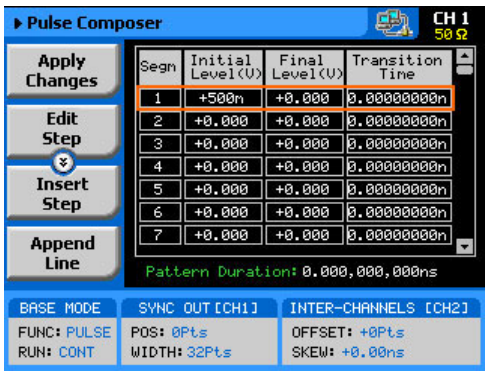

Figure 3-64, Pulse Composer Menus Example

The following parameters can be accessed and modified from the pulse editor menus. Step, Level, Segment Duration Pattern Duration that is automatically cumulated while building the pulse pattern. As explained above, there are two types of transitions that the pulse composer can build and generate: Fast and Linear. Description how to use the composer to build these two pulse patterns is given below.

Always, as the first step before you start building your patterns, make sure that you are building the correct configuration, fast or linear. Scroll down to the Transition Type, as shown in Figure 3-65 and select the proper pulse composer configuration setting. The default setting is “Fast” so you need not do any action if this is what you intend to create.

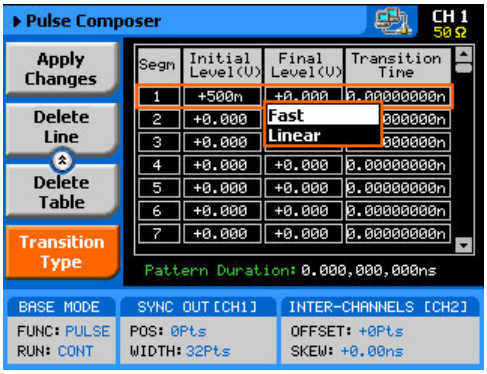

Figure 3-65, Selecting the Proper Pulse Composer Configuration

Building “Fast” Transitions Patterns

Patterns that have “fast” transitions are those that use the fastest transition times (rise and fall times) that the generator can deliver. Transition times are specified in Appendix A, but are usually around 500 ps. It is recommended that when building a pulse pattern that those transition times is taken into account because the duration of the segment, as will be explained later, includes the transitions.

Figure 3-65 demonstrates a simple fast transition pulse pattern. Notice that the pattern is built from segments, each having level and duration. Levels are specified in volts and duration is specified in seconds. Each level can have a unique amplitude level and duration as long as these reside within the range that is specified in Appendix A. Also note that the table entries in Figure 3-64 were not used to build the pulse pattern as shown in Figure 3-66.

Pattern pulses are computed and generated in the arbitrary memory and therefore, refrain from using extreme values. For example, a single 2 ns pulse and a period of 1000 seconds will present a huge problem for the algorithm because the composer will attempt to use the smallest sample clock increments, say 1 nSa/s and will have to use the same increments for the rest of the duration.

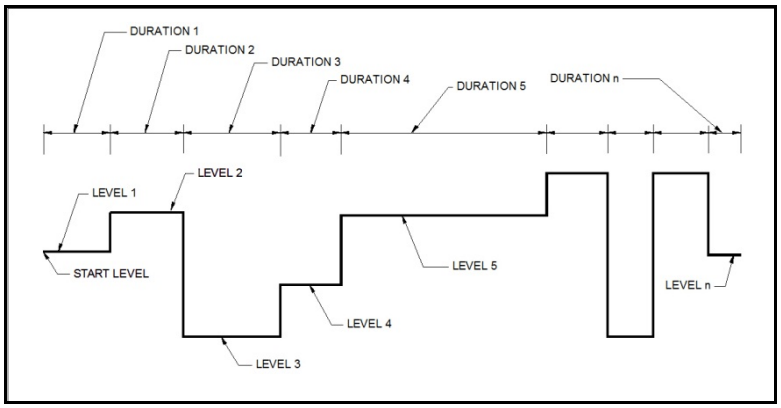

Figure 3-66, "Fast" Transition Pulse Example

To access the pulse composer tab menus, simply press one of the tabs and modify or select the parameters that are associated with this specific tab. When the pulse composer has been selected, the composer tabs, as shown in Figure 3-64, will allow access to the following parameters:

Apply Changes – this button must be pressed to complete the process of building the pulse pattern table. Modifications made to the composer table will not be computed unless this tab has been depressed.

Edit Step – if you already entered steps but made an error in one of its parameters, you can access this specific step instantly and modify the required value. Select the step to edit, press the enter button to highlight the parameter, modify the value and press enter again to lock the new parameter value. While in the table, you can scroll up or down with the cursor keys to access other steps. Remember to press the Apply Changes soft key button to complete the process.

Insert Step – lets you add a pulse segment above or below the highlighted line. If you want to add lines at the end of the table, use the Append Line soft key instead. Remember to press the Apply Changes soft key button to complete the process.

Append Line – will add a line at the end of the table and will automatically highlight this line. Proceed to modify the parameters as explained in the Edit Step paragraph above. Remember to press the Apply Changes soft key button to complete the process.

Delete Line – in case you just want to remove pattern segments, use this soft key to select and remove the wanted line item. Remember to press the Apply Changes soft key button to complete the process.

Delete Table – removes all table entries and clears the fields for new entries.

Building "Linear" Transitions Patterns

Patterns that have "linear" transitions are those that use the slow transition times (rise and fall times). Figure 3-65 demonstrates a simple linear transition pulse pattern. The pattern is built from segments, each having an initial and final level and transition time. Levels are specified in volts and transition times are specified in seconds. Each segment can have a unique amplitude level and transition time as long as these reside within the range that is specified in Appendix A. Note that the table entries in Figure 3-85 were not used to build the pulse pattern as shown in Figure 3-67.

When you start building a pattern table, only the first segment allows access to the Initial level. The final level of step 1 will automatically become the start level of the second segment and will not be accessible when you edit the second segment and so on for the rest of the segments. Therefore, if you look at the composer table in Figure 3-68, the Final Level value is the same as the Initial Level of the following segment transition.

Pattern pulses are computed and generated in the arbitrary memory and therefore, refrain from using extreme values. For example, a single 50 ns pulse that has transitions of 10 ns and a period of 1000 seconds will present a huge problem for the algorithm because the composer will attempt to use the smallest sample clock increments, say 1 nSa/s and will have to use the same increments for the rest of the duration. Note that the default option for the pulse composer is "Fast" so before you start adding values to the pulse composer table, make sure that the selected option is "Linear", as explained earlier in this section.

To select the linear transition option, scroll down to the Transition Type and select the "Linear" option, as shown in Figure 3-65. The linear pulse composer table is shown in Figure 3-68.

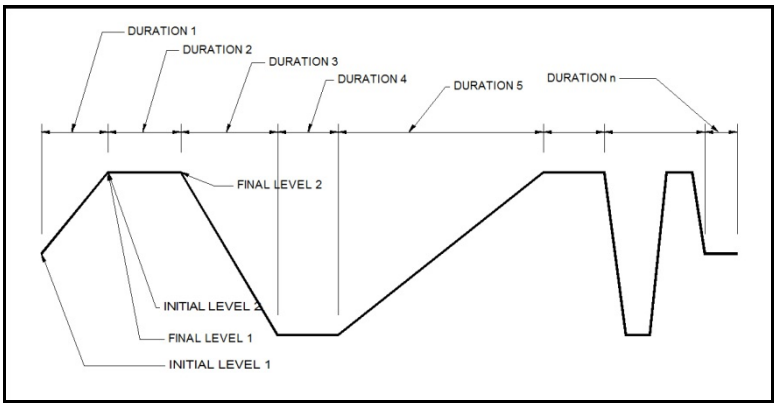

Figure 3-67, "Linear" Transition Pulse Example

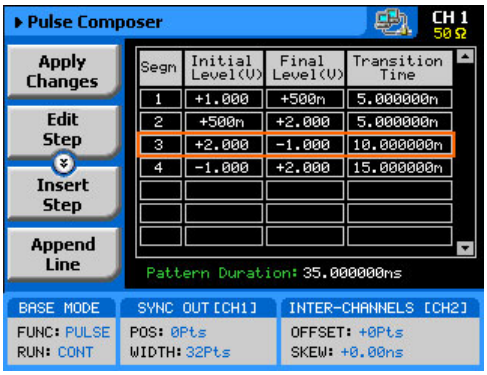

Figure 3-68, Linear Transition Pulse Composer Example

To access the pulse composer tab menus, simply press one of the tabs and modify or select the parameters that are associated with this specific tab. When the pulse composer has been selected, the composer tabs, as shown in Figure 3-68, will allow access to the following parameters:

Apply Changes – this button must be pressed to complete the process of building the pulse pattern table. Modifications made to the composer table will not be computed unless this tab has been depressed.

Edit Step – if you already entered steps but made an error in one of its parameters, you can access this specific step instantly and modify the required value. Select the step to edit, press the enter button to highlight the parameter, modify the value and press enter again to lock the new parameter value. Note that the only values that can be modified are the Transition Time and the Final Level because the Initial level is updated automatically with the amplitude level of the previous segment. While in the table, you can scroll up or down with the cursor keys to access other steps. Remember to press the Apply Changes soft key button to complete the process.

Insert Step – lets you add a pulse segment above or below the highlighted line. If you want to add lines at the end of the table, use the Append Line soft key instead. Remember to press the Apply Changes soft key button to complete the process.

Append Line – will add a line at the end of the table and will automatically highlight this line. Proceed to modify the parameters as explained in the Edit Step paragraph above. Remember to press the Apply Changes soft key button to complete the process.

Delete Line – in case you just want to remove pattern segments, use this soft key to select and remove the wanted line item. Remember to press the Apply Changes soft key button to complete the process.

Delete Table – removes all table entries and clears the fields for new entries.

Generating Pattern waveforms

The WS8352 pattern functionality is accessed by pressing the Pattern function button. In addition to RZ pulses, it allows the generation of pattern sequences that are using NRZ formatting with adjustable transition. The pattern generation itself allows the definition of pattern sequences with 2, 3, 4 or 5 different level settings, which allows the emulation of electrical idle sequences as being required in several serial data protocols.

There are two patterns that can be generated by the WS8352: PRBS (Pseudo Random Bit Sequence) and user-composed pulse patterns. The patterns are created digitally. However, they closely simulate an analog pulse generator, so pulse pattern parameters are programmed just as they would be programmed on a dedicated pattern generator instrument. Just keep in mind that since this is a digital instrument, there are some limitations to the pattern design that evolve from the fact that the best resolution is one sample clock interval. Also, remember that the patterns are created digitally in the arbitrary memory and therefore, their smallest incremental step has a maximum value limitation, depending on the memory length, as specified in Appendix A.

Information how to create and generate PRBS patterns and user-composed pulse patterns is given below.

Generating PRBS Patterns

Pseudo Random Bit Sequences (PRBS) are commonly used for bit error rate measurements. PRBS sequences are extremely beneficial for many applications that generate sequences in a transmitter side and later evaluated for their error contents in the receiver side.

When using PRBS, certain number of bits are required for synchronization (preamble) and only after bit synchronization is achieved, received sequence is compared with the reference and errors are detected.

PRBS is a sequence of nearly random distributed 1's and 0's which is repeated after a defined number of bits. It is usually generated using a linear feedback shift register (LFSR). The LFSR has two basic parameters determining properties of the generated sequence: length of shift register and feedback configuration. The length of the shift register determines maximum achievable length (period) of non-repetitive PRBS sequence according to the following equation:

$$L_{PRBS} = 2^n - 1$$

Where n is the length of LFSR register (number of bits).

The maximum length of PRBS is called M-sequences and is commonly used in many applications like spread spectrum systems, scramblers, bit error rate testers etc.

The maximum length of generated PRBS for certain length of the shift register can be achieved by proper configuration of the feedback. There are basically two possible realizations of LFSR – Fibonacci (many-to-one) and Galois (one-to-many). Both versions can be based either on XOR or XNOR gates using various number and combination of feedback taps – outputs of particular registers of the shift register. By changing the feedback configuration (number of taps and their position) it is possible to find more different M sequences for certain length of the shift register.

To access the PRBS generator menus, press on the Pulse button in the Function group, scroll down the menus and push the Pattern button. The display will be modified to show pattern parameters, as shown in Figure 3-69.

Note

The Pattern shape on the WS8352 LCD display is an icon only. The actual waveform at the output terminals may look entirely different.

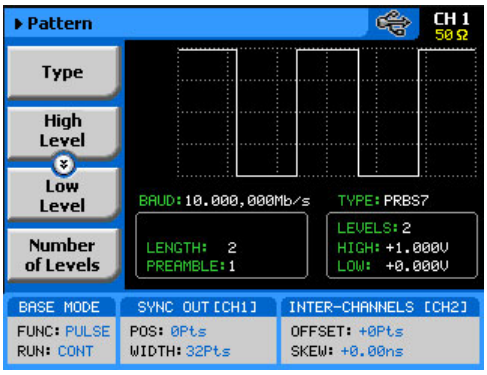

Figure 3-69, Pattern Menus

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

When PRBS mode option has been selected, the main Pattern tabs, as shown in Figure 3-69, will allow access to the following parameters:

Type – programs the PRBS type sequence that the instrument calculates and generates at the output connector. There are 6 PRBS types: PRBS 2^7, PRBS 2^9, PRBS 2^{11}, PRBS 2^{15}, PRBS 2^{23}, PRBS 2^{31} and an additional user-defined PRBS type. In continuous run mode, the sequence is repeated continuously but in triggered mode, the sequence is repeated until the loop number has been reached. Information on the user defined PRBS is given in the programming chapter; note however that user PRBS cannot be defined from the front panel menus.

High Level – programs the pattern high-level value in units of volts.

Low Level – programs the pattern low-level value in units of volts.

Number of Levels – programs the level configuration of the PRBS pattern. The effect of levels 2 to 5 are demonstrated in Figures 3-70 to 3-78. The high and low levels provide references for the level setting. In all cases, the maximum and minimum amplitude levels are programmed in the high and low level menus.

Baud – programs the pulse pattern sample sequence in in units of bits per second.

Length – programs the pulse length of the PRBS pattern in units of bits.

Preamble – programs a synchronization interval in units of bits. The generator will repeat the preamble length continuously until a trigger signal is received. After trigger, the generator will jump to the PRBS patterns that follow the preamble and will repeat the sequences continuously without branching back to the preamble. If predetermined number of PRBS loops is required, modify the WS8352 run mode setting to triggered and you'll be allowed access to the loop counter.

Loop – This menu tab appears only when selecting the trigger run mode. The loop number determines how many times the PRBS pattern repeats itself following a trigger command. The loop number does not affect the generator in continuous run mode.

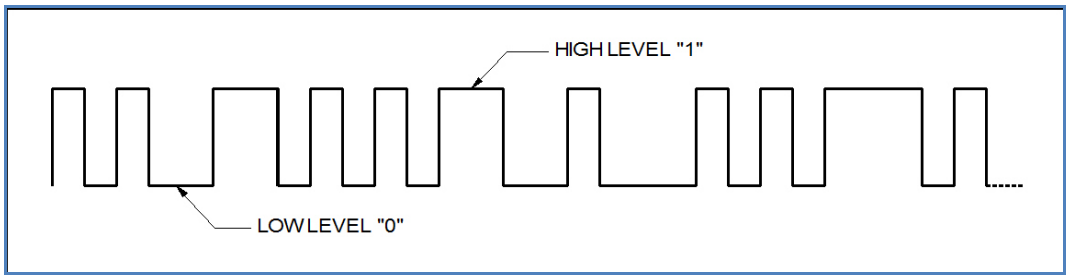

Figure 3-70: PRBS 2 Level Pattern Example

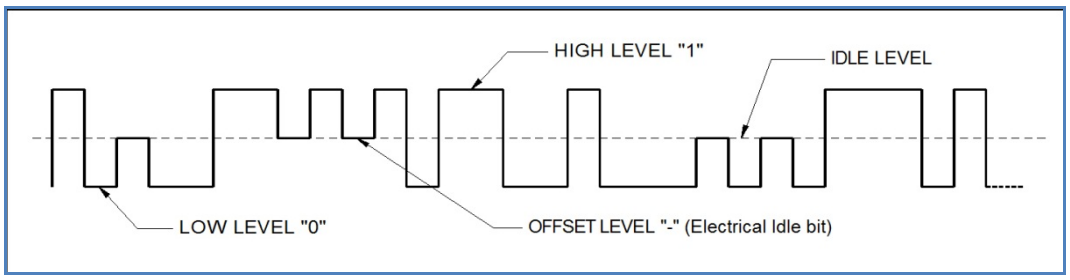

Figure 3-71: PRBS 3 Level Pattern Example

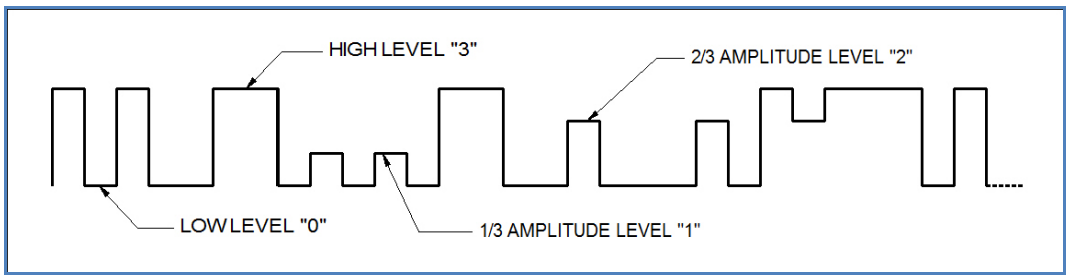

Figure 3-72: PRBS 4 Level Pattern Example

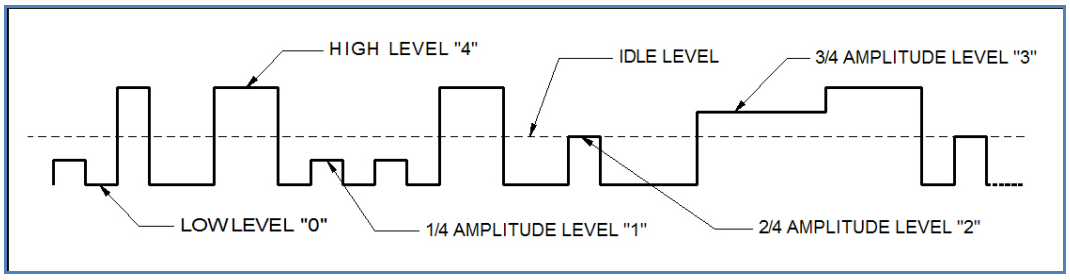

Figure 3-73: PRBS 5 Level Pattern Example

Using Store/Recall

The store and recall functions allow you to save important waveforms and front panel settings and recall them later, when they are needed for a specific application. If you are using external utilities and control the instrument remotely, then it will be best to store all instrument settings and waveforms on the computer's media. However, if local operation is desired, you may still store settings, but bear in mind that the internal memory is limited on what can be saved. Instrument settings and waveforms can also be stored on a disk-on-key that is connected to a front-panel host USB connector (type 1).

The front-panel store/recall function allows access to 10 memory cells. One or more cells can be used for this operation, but you need to observe the limitations. The internal memory has a capacity to store a total of 1G of waveform points.

Press the Store/Recall button in the Control group on the right side of the instrument. This will cause the display to show the Store/Recall panel, as shown in Figure 3-74. There are four soft-key buttons in this display: Store, Recall, List and Update. Information on how to use the keys to store and recall setups on different media options is given below.

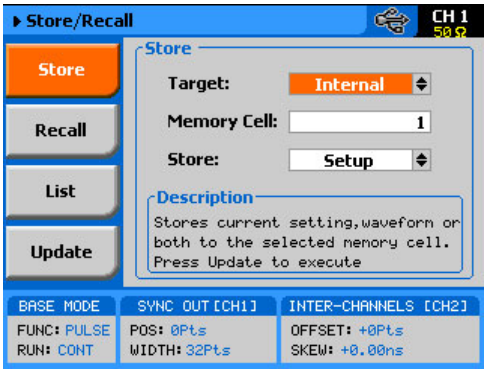

Figure 3-74, Store/Recall Menus

Storing Instrument Setups and Waveforms

The Store display is shown in Figure 3-75. This is the first display you enter after pressing the Store/Recall button in the Control group on the right side of the WS8352. The Store display has three fields that you can program: Target, Memory Cell and Store. The operation of these is described below. Note that the selected memory cell will be updated with the information that is shown on the display only after you hit the Update soft key button.

Target – will provide the path to the selected memory target. There are two options: Internal and USB. When you select the Internal option, setups and waveform data will be stored on an internal flash memory. The USB option will route the setups and waveform data to the front panel USB host connector.

Memory Cell – use this field to select the active memory cell. There are 10 memory cells that you may access and each of these cells can be used to store different setups and different waveforms.

Store – use this field to select what you want to store. You may select between Setup, Waveform and All. Setup stores the current front panel settings, including parameters, as well as operating and output modes. Waveform will store just waveform segments and All will store both the front panel setting and all waveform segments.

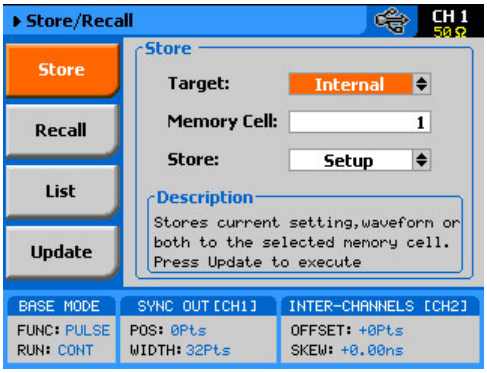

Figure 3-75, Store Menus

Regardless of what you select for each field, the operation will be completed only after you press the Update Soft Key button.

Recalling Instrument Setups and Waveforms

The Recall display is shown in Figure 3-76. Just like the Store display, the Recall display has three fields that you can program: Target, Memory Cell and Store. The operation of these is described below. Note that the front panel will be updated with the information that is shown on the display only after you hit the Update soft key button.

Target – will provide the path to the selected memory target. There are two options: Internal and USB. When you select the Internal option, setups an d waveform data will be recalled from an internal flash memory. Note that the size of this if case you intend to store large banks of waveform memory. The USB option will route the setups and waveform data from the front-panel USB host-connector. There you may connect a disk-on-key that can store very large waveforms.

Memory Cell – use this field to select the active memory cell. There are 10 memory cells that you may access and each of these cells can be used to recall different setup and a different waveform.

Recall –this field shows what you are about to recall. The field is grayed-out and does not allow access to the selected option since the contents of the memory cell is programmed in the store menu.

Regardless of what you select for each field, the operation will be completed only after you press the Update Soft Key button.

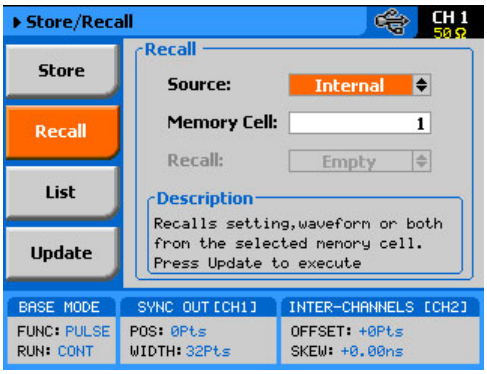

Figure 3-76, Recall Menus

Listing Storage Memory Contents

If you are not sure what is stored in each of the memory cells, you can press the List Soft Key button. The list has no function other than showing what is stored in the memory cells. Press the List Soft Key button and the panel as shown in Figure 3-77 will be displayed. Note that the List display provides access to the storage media. You may select between USB and Internal and the panel will show the parameters that are stored on this specific media.

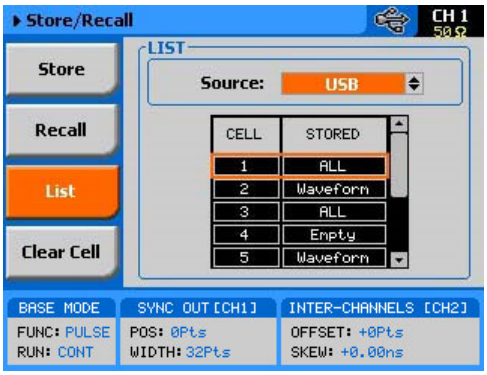

Figure 3-77, Stored Memory Cells Listed

Note that the dialog box can display the contents of five cells only. To see the rest, use the dial or the cursor up and down buttons to navigate to the required cell. To modify the Source media, press the cursor up button till the Source field is selected, press the enter key and again use the cursor up or down key to select the required storage media; then, press Enter again to select and the display will be updated with the contents of the source.

From the List dialog box you may also clear memory cells that you want to discard of. Press the Clear Cell soft key button, using the cursor up and down, or the dial, select the cell number you want to clear and press Enter. In the example above, Cell number 4 has been cleared and shows “Empty” in the stored options.

Store/Recall Considerations

The WS8352 is using Linux as its operating system. Although the displays and menus have the feeling of Windows operating system, some of the privileges that are associated with Windows OS are not available in the WS8352. For example, do not expect the same behavior as plugging a stick to a Windows based operating system; There are no messages and no confirmation when a USB has been mounted or removed.

The following are some considerations that you should bear in mind when using the USB stick to store waveforms and setups out of the WS8352.

When plugging a USB stick to the WS8352 allow between 5 to 10 seconds for the operating system to mount the device. An attempt to access the stick before it has been mounted generates an error.

When downloading setups and waveforms on a USB stick, the setups and waveforms can be used reliably on another WS8352 instrument only if the firmware revision is the same. The reason is because an instrument image is never the same across firmware versions.

Waveform data is stored in a working memory that is extremely fast because it feeds the DAC however, in contrary, the flash memory that is used for storing waveforms is much slower and therefore, moving large chunks of waveforms from the working memory to the flash memory is a slow process because the data is transferred one word at a time. For this reason, refrain from storing or recalling large waveforms regardless if you use the internal memory or an external USB stick; Keeping your large waveforms on a hard drive is a much faster method to recall waveforms to the working memory.

It is possible to copy files that were stored on a USB stick to a host computer however, before copying files from a computer to another USB stick make sure that the files have names like setup1 and wave1 with no added characters or extensions. Sometimes, Linux adds strange characters to file names but these can be renamed in Windows environment to remove the extra characters.

When powered down, the WS8352 can be programmed to power on with its last setup or with all parameters set to the factory defaults. The Power ON State, as shown in Figure 3-1 provides access to this selection. When the Setup option is selected, just before the instrument turns off, it performs an automatic storage to its internal flash memory of its last state, along with the entire bank of waveforms.

Store/Recall Messages

Some messages may appear when you perform store and recall operations on the WS8352. These messages are described below. The following messages will appear after performing a successful store or recall operations using the internal flash memory:

Figure 3-78, Stored setting to USB memory

Figure 3-79, Recalled setting from USB memory

There are also some USB error messages that may appear in case an illegal operation has been performed. A general error such as unrecognized file structure or file contents will generate the following error:

Figure 3-80, Unrecognized file structure or file contents

The following error message will display in the event that one attempts to use the external USB stick but has not yet plugged it to the instrument or the device is not yet mounted on the system,

Figure 3-81, Unplugged USB error

And finally, if you pull the USB out of its socket before the store or recall operation has been fully executed, expect the following message to appear. In most case, recovery from this error is possible only after recycling the WS8352 power.

Figure 3-82, Missing USB memory stick error

Chapter 4
Programming Reference

Title **Page**

What's in This Chapter....4-3
Introduction to SCPI....4-3
Command Format....4-3
Command Separator....4-4
The MIN and MAX Parameters....4-4
Querying Parameter Setting....4-4
Query Response Format....4-5
SCPI Command Terminator....4-5
IEEE-STD-488.2 Common Commands....4-5
SCPI Parameter Type....4-5
Numeric Parameters....4-5
Discrete Parameters....4-6
Boolean Parameters....4-6
Arbitrary Block Parameters....4-6
Binary Block Parameters....4-6
SCPI Syntax and Styles....4-6
WS8352 Commands....4-7
Channel & Group Control Commands....4-16
Run Mode Commands....4-19
Analog Output Control Commands....4-31
Standard Waveforms Control Commands....4-39
Arbitrary Waveforms Control Commands....4-44
Modulated Waveforms Global Control Commands....4-52
Modulation Control Commands....4-55
AM Programming....4-57
FM Programming....4-58
Sweep Modulation Programming....4-60
Chirp Modulation Programming....4-62
FSK Modulation Programming....4-66
ASK Modulation Programming....4-67

Frequency Hopping Modulation Programming 4-70
Amplitude Hopping Modulation Programming 4-72
PSK Modulation Programming 4-75
QAM Modulation Programming 4-80
Pulse Waveform Programming 4-83
Pulse Pattern Programming 4-94
LAN System Configuration Commands 4-105
LXI Configuration Commands 4-109
Store/Recall Commands 4-112
The Store/Recall Folder Structure 4-115
The Store/Recall File Names 4-116
The Store/Recall File Structure 4-117
Recall Setup3 Example 4-118
Store Setup1 Example 4-120
System Commands 4-130
Error Messages 4-131
LAN, USB and GPIB Programming Considerations 4-136
IEEE-STD-488.2 Common Commands and Queries 4-148

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 Tabor WS8352**.** 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. In conclusion, the effects of individual keywords and parameters are described. The complete listing of all commands used for programming the WS8352 is given in Table 4-1.

Introduction to SCPI

Commands to program the instrument over the GPIB are defined by the SCPI 1993.0 standard. The SCPI standard classifies 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, consequently forming subsystems.

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

```
:OUTPut
  :FILTer
     [:LPASs] {NONE|25M|50M|ALL}
        [:STATe] OFF | ON
```

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

Command Format

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

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

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

For example, in the above syntax statement, FREQ and FREQUENCY are both acceptable forms. Use upper or lowercase

letters. Therefore, FREQ, FREQUENCY, freq, and Freq are all acceptable. Other forms such as FRE and FREQUEN will generate an error.

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

Some parameters are enclosed in square brackets ([ ]). The brackets indicate that the parameter is optional and can be omitted. The brackets are not sent with the command string.

Command Separator

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

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

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

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

is the same as sending the following three commands:

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

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

```
OUTP:STATE ON;:TRIG:BURS ON
```

The MIN and MAX Parameters

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

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

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

Querying Parameter Setting

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

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

Query the output function by executing:

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

Query Response Format

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

SCPI Command Terminator

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

IEEE-STD-488.2 Common Commands

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

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

SCPI Parameter Type

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

Numeric Parameters

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

Engineering units using 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 MODulation). 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 | MODulation}
```

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 WS8352 can accept binary blocks up to 16 M bytes (32 M bytes with option -1). 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 chapter.

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, Default and HS command equivalent.

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. Therefore, the WS8352 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 a 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 (pay attention to be sure 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.

WS8352 Commands

Table 4-1 lists all of the WS8352 SCPI commands. The commands are arranged in logical groups that provide similar functionality, even if they branch from different hierarchy headers, and make it easier to understand the various commands.

The WS8352 commands are described in 12 different groups, each describing a different type of operation. The groups are:

- Channel and group control commands
- Run mode commands
- Analog output control commands
- Standard waveforms commands
- Arbitrary waveforms commands
- Modulated waveforms commands
- Pulse waveforms commands
- Pulse Pattern Commands
- LAN configuration commands
- LXI configuration commands
- Store/Recall Commands
- System commands

Detailed descriptions of each of the various WS8352 commands are given as follows. Note that Table 4-1 lists all of the commands that control two channels. For a single-channel version, ignore all of the commands that are irrelevant for a single-channel type.

Table 4-1, Model WS8352 Commands List Summary

Keyword	Parameter Form	Default	Notes
1. Channel and Group Control Commands			
:INSTrument			
[:SELect]	CH1 | CH2 | 1 | 2	CH1	Select channel for prog
:COUPle			
:OFFSet	0 to ±(n-128) (n = waveform length)	0	Course offset adjustment
:SKEW	-3e-9 to 3e-9	0	Fine skew adjustment
:STATe	OFF | ON | 0 | 1	0	
2. Run Mode Commands			
:ABORt			Unconditional abort
:ARM			Applies to Event Input
[:SEQuence]			
:ECL			Sets ECL level
:LEVel	-5 to +5	1.6	
:SLOPe	POSitive | NEGative | EITHer	POS	
:TTL			Sets TTL level
:ENABle			Unconditional enable
:INITiate			
:CONTinuous			
:ENABle	SELF | ARMed	SELF	
:SOURce	BUS | EVENt | TRIGger	BUS	Defines enable source
[:STATe]	OFF | ON | 0 | 1	1	
:GATE			
[:STATe]	OFF | ON | 0 | 1	0	
:TRIGger			Applies to trigger input
[:IMMediate]			Same as *trg
[:SEQuence]			
:COUNt	1 to 1,000,000	1	Counted bursts
:DELay	0 to 8e6 (integers divisible by 4)	0	0 = OFF
:ECL			Sets ECL level
:FILTer			
:HPASs			Sets high pass width
:WIDTh	10e-9 to 2	100e-3	
[:STATe]	OFF | ON | 0 | 1	0	
:LPASs			Sets low pass width
:WIDTh	10e-9 to 2	1e-3	
[:STATe]	OFF | ON | 0 | 1	0	
:HOLDoff	0, 100e-9 to 2	0	0 = Off
:STATe	OFF | ON | 0 | 1	0	
:LEVel	-5 to +5	1.6	

Table 4-1, Model WS8352 Commands List Summary (continued)

Keyword	Parameter Form	Default	Notes
:MODE	NORMal | OVERride	NORM	Normal or retriggerable
:SLOPe	POSitive | NEGative | EITHer	POS	
:SOURce			
[:ADVance]	EXTernal | BUS | TIMer | EVENt	EXT	Selects trigger source
:TIMer			
:MODE	TIME | DELay	TIME	
:DELay	76 to 8e6 (integers divisible by 8)	76	Stop to start delay
:TIME	200e-9 to 2	15e-6	
:TTL			Sets TTL level
3. Analog Output Control Commands			
:OUTPut			
[:STATe]	OFF | ON | 0 | 1	0	Toggles output(s) on/off
:SYNC			
:FUNCtion	PULSe | WCOMplete	PULS	Selects sync out shape
:POSition			
[:POINt]	0 to 512e3	0	Programs sync position
:WIDTh	16 to n-16	16	Sync width (Pulse only)
:SOURce	CH1 | CH2 | 1 | 2	CH1	Sync source
[:STATe]	OFF | ON | 0 | 1	0	Toggles sync on/off
[:SOURce]			
:FREQuency			
[:CW]	10e3 to 350e6 | MINimum | MAXimum	10e6	Std waveforms frequency
:RASTer	10e6 to 2e9 | MINimum | MAXimum	1e9	Arb waveforms frequency
:SOURce	INTernal | EXTernal	INT	Selects SCLK source
:DIVider	1 to 256 (integers, 2^n only)	1	External clock divider
:FUNCtion			
:MODE	FIXed | USER | MODulation | PULse | PATTern	FIX	Selects function type
:ROSCillator			
:SOURce	INTernal | EXTernal	INT	
[:EXTernal]			
:FREQuency	10e6 to 100e6	10e6	
:VOLTage			DC coupled output
[:LEVel]			
[:AMPLitude]	50e-3 to 4 | MINimum | MAXimum	500e-3	DC amplitude in volts
:OFFSet	-1.5 to 1.5 | MINimum | MAXimum	0	DC offset in volts
4. Standard Waveforms Commands			
[:SOURce]			
:FUNCtion			
:SHAPe	SINusoid | TRIangle | SQUare | RAMP | SINC | GAUSsian | EXPonential | DC | NOISe	SIN	Standard function shapes
:SINusoid			
:PHASe	0 to 360.00	0	
:TRIangle			
:PHASe	0 to 360.00	0	
:SQUare			
:DCYCle	0 to 99.99	50	

Table 4-1, Model WS8352 Commands List Summary (continued)

Keyword	Parameter Form	Default	
:RAMP			
:DELay	0 to 99.99	10	
:TRANsition			
[:LEADing]	0 to 99.99	60	
:TRAiling	0 to 99.99	30	
:SINC			
:NCYCle	4 to 100	10	
:GAUSsian			
:EXPonent	10 to 200	10	
:EXPonential			
:EXPonent	-100 to 100	-10	
:DC			
[:OFFSet]	-1.5 to 1.5, DC	0	
5. Arbitrary Waveforms Commands			
:TRACe			
[:DATA]	<data_array>		Waveform data array
:DEFine	<segment_#>,<192 to 512e3>		Segment and length
:DEFine<n>?	<1 to 1,000>		Query length of seg <n>
:DELete			
[:NAME]	1 to 1,000		Delete segment <n>
:ALL			Delete all segments
:POINts?			Queries waveform length
:SELect	1 to 1,000	1	
:SEGMent			
[:DATA]	#<header><binary_block>		Segment data array
6. Modulated Waveforms Commands			
[:SOURce]			
:MODulation			
:TYPE	OFF | AM | FM | SWEep | CHIRp | FSK | ASK | FHOPping | AHOPping | PSK | QAM	OFF	
:CARRier			
[:FREQuency]	10e3 to 350e6	1e6	
:FUNCtion	SINusoid | TRIangle | SQUare	SIN	
[:SOURce]			
:AM			
:FUNCtion			
[:SHAPe]	SINusoid | TRIangle | SQUare | RAMP	SIN	
:INTernal			
:FREQuency	100 to 1e6	1e3	Maximum Carrier to internal frequency ration is 1e6
:DEPTh	0 to 200	50	

Table 4-1, Model WS8352 Commands List Summary (continued)

Keyword	Parameter Form	Default	
:FM			
:DEViation	10e-3 to 175e6	500e3	
:FUNCtion			
[:SHAPe]	SINusoid | TRIangle | SQUare | RAMP	SIN	
:FREQuency	10e-3 to 35e6	10e3	
:MARKer			
[:FREQuency]	10e3 to 350e6	505e3	
:SWEep			
:FREQuency			
[:STARt]	10e3 to 350e6	40e6	
:STOP	10e3 to 350e6	80e6	
:TIME	1.4e-6 to10e-3	10e-6	
:DIRection	UP | DOWN	UP	
:SPACing	LINear | LOGarithmic	LIN	
:MARKer			
[:FREQuency]	10e3 to 350e6	60e6	
:CHIRp			
:WIDTh	1.4e-6 to 0.01	10e-6	
:REPetition	200e-9 to 2	25e-6	
:FREQuency			
[:STARt]	10e3 to 350e6	40e6	
:STOP	10e3 to 350e6	80e6	
:DIRection	UP | DOWN	UP	
:SPACing	LINear | LOGarithmic	LIN	
:AMPLitude			
:DEPTh	0 to 100%	50%	
:DIRection	UP | DOWN	UP	
:SPACing	LINear | LOGarithmic	LIN	
:FSK			
:FREQuency			
:SHIFted	10e3 to 350e6	2e6	
:BAUD	0.1 to 350e6	10e3	
:MARKer	1 to 10,000	1	
:DATA	<data_array>		
:ASK			
[:AMPLitude]			
[:STARt]	0 to 2	0.5	
:SHIFted	0 to 2	1	
:BAUD	0.1 to 350e6	10e3	
:MARKer	1 to 10,000	1	
:DATA	<data_array>		

Table 4-1, Model WS8352 Commands List Summary (continued)

Keyword	Parameter Form	Default	
:FHOPping			
:DWELl			
:MODe	FIXed | VARiable	VAR	
[:TIMe]	2e-9 to 10	5e-6	
:FIXed			
:DATA	<data_array>		
:VARiable			
:DATA	<data_array>		
:MARKer	1 to 10,000	1	
:AHOPping			
:DWELl			
:MODe	FIXed | VARiable	VAR	
[:TIMe]	2e-9 to 10	5e-6	
:FIXed			
:DATA	<data_array>		
:VARiable			
:DATA	<data_array>		
:MARKer	1 to 10,000	1	
:PSK			
:TYPE	PSK | BPSK | QPSK | OQPSK | DQPSK | 8PSK | 16PSK | USER	PSK	
:PHASe			
[:STARt]	0 to 360	0	
:SHIFted	0 to 360	180	
:DATA	<data_array>		
:MARKer	1 to 10,000	1	
:BAUD	0.1 to 350e6	10e3	
:CARRier			
:STATe	OFF | ON | 0 | 1	1	
:USER			
:DATA	<data_array>		
:QAM			
:TYPE	16QAM | 64QAM | 256QAM | USER	QAM	
:CARRier			
:STATe	OFF | ON | 0 | 1	1	
:BAUD	0.1 to 350e6	10e3	
:DATA	<data_array>		
:MARKer	1 to 10,000	1	
:USER			
:DATA	<data_array>		

Table 4-1, Model WS8352 Commands List Summary (continued)

Keyword	Parameter Form	Default	Notes
7. Pulse Commands			
:PULse			
:CONFigure	TIME | PERCent	TIME	
:DELay	0 |1e-9 to 1s	1e-3	Delay in sec
:PERCent	0 .01 to 99.99	10	Delay in %
:DOUBle			
:DELay	0 |1e-9 to 1s	1e-3	Double del in sec
:PERCent	0 .01 to 99.99	10	Delay in %
:LEVel			
[:CONTrol]	HLOW | AOFFset | POSitive | NEGative	HLOW	
:HIGH	-2.25 to 2.25	1	
:LOW	-2.25 to 2.25	0	
:AMPLitude	50e-3 to 2 | MINimum | MAXimum	0.5	Amplitude in V
:OFFSet	-1.5 to 1.5 | MINimum | MAXimum	0	DC offset in volts
:MODE	SINGle | DELayed | DOUBle	SING	
:POLarity	NORMal | COMPlement | INVerted	NORM	
:PERiod	5e-9 to 1e6	10e-3	
:TRANsition			
[:STATe]	FAST | LINear | SYMMetrical	FAST	Transition type
[:LEADing]	1e-9 to 100e-3	1e-3	Rise time in sec
:PERCent	0 .01 to 99.99	10	Rise time in %
:TRAiling	1e-9 to 100e-3	1e-3	Fall time in sec
:PERCent	0 .01 to 99.99	10	Fall time in %
:WIDTh	2e-9 to 1s	2e-3	Width in sec
:PERCent	0 .01 to 99.99	20	Width in %
8.Pulse Pattern Commands			
:PATTern			
:MODE	PRBS | COMPosed	PRBS	
[: PRBS]			
:TYPE	PRBS7 | PRBS9 | PRBS11 | PRBS15 | PRBS23 | PRBS31 | USER	PRBS7	
:BAUD	10e-3 to 350e6	10e6	
:LEVel	2 | 3 | 4 | 5	2	
:HIGH	-2.5 to 2.5	1	
:LOW	-2.5 to 2.5	-1	
:LOOPs	1 to 1e6	1	
:PREamble	1 to 512e3	1	
:LENGth	1 to 512e3	32	
:DATA	#<header><data_array>		
:COMPosed			
:TRANsition			
:TYPe	FAST | LINear	FAST	Transition type

Table 4-1, Model WS8352 Commands List Summary (continued)

Keyword	Parameter Form	Default	Notes
:FAST			
[:DATA]	#<header><data_array>		
:LINear			
:STARt	- 2 to +2	0.5	
[:DATA]	#<header><data_array>		
:RESolution	500e-12 to 100e-9	1e-9	
:TYPE	AUTO | USER	AUTO	
9. LAN Configuration Commands			
:SYSTem			
:IP			
[:ADDRess]	<IP_address>		
:MASK	<mask>		
:GATeway	<gate_way>		
:BOOTp	OFF | ON | 0 | 1	0	
HOSTname:	<host_name>		
:KEEPalive			
:STATe	OFF | ON | 0 | 1	1	
:TIMEout	2 to 300	45	
:PROBes	2 to 10	2	
10. LXI configuration commands			
:SYSTem			
:IP			
:MAC?			
:LXI			
:CLASs?			
:VERSion?			
:IDENtify			
[:STATE]	OFF | ON | 0 | 1		
:MDNS			
:ENABle	OFF | ON | 0 | 1		
:HNAMe			
[:RESolved]?			
:SNAMe			
:DESired	<Sname>		
[:RESolved]?			
:RESet			Reset the LAN settings
:RESTart			Restart the LAN interface
11. Store/Recall Commands			
:SYSTem			
:STORe			
[:STATe]	ENABle | DISable	ENAB	
:CELL	1 to 9	1	

Table 4-1, Model WS8352 Commands List Summary (continued)

Keyword	Parameter Form	Default	Notes
:CLEar			Clear cell
:CONFig	SETup | WAVE | ALL	ALL	
:TARGet	INTernal | USB	INT	
:UPDate			
:RECall			
[:STATe]	ENABle | DISable	ENAB	
:CELL	1 to 9	1	
:TARGet	INTernal | USB	INT	
:UPDate			
:CONFig	SETup | WAVE | ALL | EMPTy	EMPTy	Query only
12. System Commands			
:RESet			
:SYSTem			
:ERRor?			
:TEMPerature?			
:POWerup	DEFault | SETup	SET	
:VERSion?			
:INFormation			
:CALibration?			
:MODel?			
:SERial?			
:HARDware?			
*CLS			
*OPC			
*RST			
*TRG			
*IDN?			
*OPC?			
*OPT?			
*STB?			

Channel & Group Control Commands

Commands that are listed in Table 4-2 control parameters that group and synchronize two or more channels, as well as their relative offset and skew parameters. Factory defaults after *RST are shown in the Default column. Parameter range and low and high limits are listed, where applicable.

Note the command *inst ch1* / *ch2.* The default parameter is *ch1*, which means that commands that are sent to the WS8352 affect channel 1 settings only. Select the *inst ch2* parameter if you want to program channel 2 parameters.

Tip

The Model WS8351 has only one output channel and therefore, the command *inst:sel* is not required for correct programming sequences however, for the Model WS8352, it is mandatory to select the proper channel before commands are being streamed to the product. The WS8352 has two completely separate channels and therefore, each of the commands that are listed in the following tables should be preceded by the *inst:sel 1* or *inst:sel 2* commands.

There are some commands that affect both channels simultaneously and do not require that a specific channel is selected; these are LAN configuration commands, Store/recall commands, System Commands and common commands.

Note that the two channels can operate in synchronized mode where both channels share the same output waveform type, the same run mode option and a common sample clock feed. In this case, the sample clock value should be programmed for channel 1 only but the other commands still require the use of *inst:sel* command.

Table 4-2, Channel & Group Control Commands Summary

Keyword	Parameter Form	Default	Notes
:INSTrument			
[:SELect]	CH1 | CH2 | 1 | 2	CH1	Select channel for programming
:COUPle			
:OFFSet	0 to ±(n-128) (n = waveform length)	0	Course offset adjustment
:SKEW	-3e-9 to 3e-9	0	Fine skew adjustment
:STATe	OFF | ON | 0 | 1	0	

:INSTrument{CH1|CH2|1|2}(?)

Description

This command will set the active channel for future programming command sequences. Subsequent commands affect the selected channel only.

Parameters

Range	Type	Default	Description
CH1-CH2 or 1-2	Discrete		Sets the active channel for programming from remote.

Response

The WS8352 will return 1 or 2 depending on the present active channel setting.

:INSTrument:COUPle:OFFSet{<ch_offset>}(?)

Description

When couple state is ON, this command sets or queries the offset between the start phase of the master channel (CH1) and the start phase of the slave channel (CH2).

Parameters

Name	Range	Type	Default	Description
<ch_offset>	0 to n-128	Numeric (integer only)	0	Defines a coarse phase offset between two channels. When offset is applied to one channel it is always in reference to the other channel. For example, offsetting channel 2 by 1024 points and then offsetting channel 1 by 2048 points will cause channel 2 waveform to lag channel 1 by 1024 points. Offset can be programmed in increments of 8 sample clock periods. The two channels must have the same waveform length in order for the phase offset parameter to be meaningful. Offset range is programmable in units of waveform points from 0 to the maximum length of the channel waveform, less 128 waveform points. Fine adjustment of phase offset between channels is achieved using the *inst:coup:skew* command. Note that this parameter is operating in conjunction with the continuous run mode and only when the two channels are synchronized.

Response

The WS8352 will return the present value of the coarse offset setting in units of waveform points.

:INSTrument:COUPle:SKEW{<ch_skew>}(?)

Description

When couple state is ON, this command sets or queries the skew between the two channels. Skew defines fine offset between channels in units of time. Only channel 2 has the skew computed in reference to channel 1. The inst:coupl:skew command is applied automatically to channel 2 and does not require that you use the inst:sel 2 command.

Parameters

Name	Range	Type	Default	Description
<ch_skew>	-3e-9 to 3e-9	Numeric	0	Defines channel 2 skew in reference to channel 1. The two channels must have the same waveform length in order for the phase skew parameter to be meaningful. The skew range is programmable in units of seconds throughout the range of ±3 ns. Coarse adjustment of phase offset between channels is achieved using the *inst:coup:offs* command. Note that this parameter is operating in conjunction with the continuous run mode and only when two or more channels are synchronized.

Response

The *WS8352* will return the present value of the skew setting in units of seconds.

:INSTrument:COUPle:STATe{OFF|ON|0|1}(?)

Description

Sets or queries the couple state of the synchronized channels. Use this command to cause the two channels to synchronize. Following this command, the sample clock of channel 1 will feed the channel 2 and the start phase of the channel 2 channels will lock to the channel 1 waveform.

Parameters

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

Response

The WS8352 will return 1 if the couple state is ON, or 0 if the couple state is OFF.

Run Mode Commands

The Run Mode Commands group is used to synchronize device actions with external or internal events.

The WS8352 can operate in two basic modes: self-armed and armed-for -enable.

Self-armed mode is the default option where waveforms are generated at the output connector, immediately after the output function has been selected.

In armed mode, the WS8352 requires an enable command or an external analog event to cause the output to generate waveforms and when already armed, a remote abort command will cease the generation of the signal and the output will return to a known idle state. This mode is very useful to control how and when the waveform will start and stop for systems that require precise control of waveform timing.

Other commands in this group control the basic run modes of the waveform generator. The available run modes are:

- continuous, where waveforms are generated continuously at the output connector and triggered and gated.
- conditional, where waveforms are generated on conditional events, regardless if they are generated internally from a built-in trigger generator or applied externally to the trigger and event inputs.

Also use the commands in this group to control the sensitivity, the polarity and other conditions of which external signals will affect the trigger and event inputs.

A built-in counter is available to control a precise number of cycles for applications requiring a burst of waveforms that follows a trigger event.

Additional information on the run mode options and how the generator behaves under the various run mode options is given in Chapter 3. Factory defaults after *RST are shown in the default column. Parameter low and high limits are given where applicable. Use the commands in Table 4-3 to set up the WS8352 run mode and for setting up the input conditions for the various trigger inputs.

Table 4-3, Run Mode Commands Summary

Keyword	Parameter Form	Default	Notes
:ABORt			Unconditional abort
:ARM			Applies to Event Input
[:SEQuence]			
:ECL			Sets ECL level
:LEVel	-5 to +5	1.6	
:SLOPe	POSitive | NEGative | EITHer	POS	
:TTL			Sets TTL level
:ENABle			Unconditional enable
:INITiate			
:CONTinuous			
:ENABle	SELF | ARMed	SELF	
:SOURce	BUS | EVENt | TRIGger	BUS	Defines enable source
[:STATe]	OFF | ON | 0 | 1	1	
:GATE			
[:STATe]	OFF | ON | 0 | 1	0	
:TRIGger			Applies to trigger input
[:IMMediate]			Same as *trg
[:SEQuence]			
:COUNt	1 to 1,000,000	1	Counted bursts
:DELay	0 to 8e6 (integers divisible by 8)	0	0 = OFF
:ECL			Sets ECL level
:FILTer			
:HPASs			Sets high pass width
:WIDTh	10e-9 to 2	100e-3	
[:STATe]	OFF | ON | 0 | 1	0	
:LPASs			Sets low pass width
:WIDTh	10e-9 to 2	1e-3	
[:STATe]	OFF | ON | 0 | 1	0	
:HOLDoff	0, 100e-9 to 2	0	0 = Off
:STATe	OFF | ON | 0 | 1	0	
:LEVel	-5 to +5	1.6	
:MODE	NORMal | OVERride	NORM	Normal or retriggerable
:SLOPe	POSitive | NEGative | EITHer	POS	
:SOURce			
[:ADVance]	EXTernal | BUS | TIMer | EVENt	EXT	Selects trigger source
:TIMer			
:MODE	TIME | DELay	TIME	
:DELay	76 to 8e6 (integers divisible by 8)	32,768	Stop to start delay
:TIME	200e-9 to 2	15e-6	
:TTL			Sets TTL level

:ABORt

Description

Use this command for an immediate and unconditional termination of the output waveform. A prerequisite condition that makes this command effective is to place the WS8352 in continuous and armed run mode and then enable the output using the *enab* command. This command is also effective in all triggered run mode options. Following the abort command, the WS8352 stops generating waveforms and the output starts generating an idle DC waveform. The abort command ignores the trac:sel:tim and the sequ:sel:tim settings. The resulting scenarios of the abort command are summarized in the Run Modes Summary table in Chapter 3.

:ARM:ECL

Description

Use this command to set the event input to accept ecl (negative) signals. The threshold level is automatically set to -1.3 V, which is the mid-level for negative ecl logic. Other related commands are: *arm:ttl* to set the threshold level for TTL signals and *arm:lev* to program a threshold level between -5 V to 5 V. Note that commands that start with *ARM* affect the conditions for the event input only.

:ARM:LEVel<level>(?)

Description

This command programs the threshold level for the event input signals. Other related commands are: *arm:ttl* to set the threshold level for TTL signals and *arm:ecl* to program a threshold level for ECL signals. Note that commands that start with *ARM* affect the conditions for the event input only.

Parameters

Name	Range	Type	Default	Description
<level>	-5 to 5	Numeric	1.6	Programs the threshold level for the invent input.

Response

The WS8352 will return the present threshold level setting in units of volts.

:ARM:SLOPe{POSitive|NEGative|EITHer}(?)

Description

Use this command to define the edge that will affect the event input. Positive going transitions will affect the event input when the POS option is selected. Negative transitions will affect the event input when the NEG option is selected. Both transitions will affect the event input when the EITH option is selected. Note that commands that start with *ARM* affect the conditions for the event input only.

Parameters

Name	Type	Default	Description
POSitive	Discrete	POS	Selects the positive going edge.
NEGative	Discrete		Selects the negative going edge.
EITHer	Discrete		Selects both positive and negative going edges.

Response

The WS8352 will return POS, NEG, or EITH depending on the current slope setting.

:ARM:TTL

Description

Use this command to set the event input to accept ttl signals. The threshold level is automatically set to 1.6 V, which is the mid-level for ttl logic. Other related commands are: *arm:ecl* to set the threshold level for ECL signals and *arm:lev* to program a threshold level between -5 V to 5 V. Note that commands that start with *ARM* affect the conditions for the event input only.

:ENABle

Description

Use this command for an immediate and unconditional generation of the selected output waveform. Prerequisite condition that makes this command effective is to place the WS8352 in continuous and armed run mode. This command has no effect in triggered run mode options. Generation of the output waveform can be terminated abruptly using the *abor* command. Following the abort command, the WS8352 stops generating waveforms and the output starts generating an idle DC waveform. The resulting scenarios of the enable and abort commands are summarized in the Run Modes Summary table in Chapter 3.

:INITiate:CONTinuous:ENABle{SELF|ARMed}(?)

Description

Use this command to set or query the state of the enable mode. This command is effective in continuous mode only and has no effect when the *init:cont 0* or *init:gate 1* (triggered or gated modes) were executed.

Parameters

Name	Type	Default	Description
SELF	Discrete	SELF	In continuous run mode, waveforms are generated at the output connector as soon as they are selected.
ARMed	Discrete		The WS8352 generates waveforms at the output connector only after an *enab* command is executed. For an immediate and unconditional termination of the output waveform use the *abor* command.

Response

The WS8352 will return SELF, or ARM depending on the current enable mode setting.

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

Use this command to set or query the gated run mode status.

Parameters

Range	Type	Default	Description
1-0	Discrete	1	"1" selects the continuous run mode. "0" disables the continuous operation and forces the triggered run mode. Trigger signal is applied to the trigger input only and output waveforms will be generated only when the trigger signal is valid and true. The slope and level of the trigger input are programmable.

Response

The WS8352 will return 1 or 0 depending on the current run mode setting.

:INITiate:CONTinuous:ENABle:SOURce{BUS|EVENt|TRIGger}(?)

Description

Use this command to set or query the source of the enable signal. This command is effective in continuous mode only and has no effect when the *init:cont 0* or *init:gate 1* (triggered or gated modes) were executed.

Parameters

Name	Type	Default	Description
BUS	Discrete	BUS	Defines the source of the enable signal as a remote command sent over one of the interfacing controllers (USB, LAN or GPIB). Signals at the event input will be ignored. In continuous run mode, waveforms are generated at the output connector as soon as a remote enable command is executed. For an immediate and unconditional termination of the output waveform use the *abor* command.
EVENt	Discrete		Defines the source of the enable signal as the event input connector. Remote enable commands will be ignored. In continuous run mode, waveforms are generated at the output connector as soon as a valid event signal is sensed at the event input connector. For an immediate and unconditional termination of the output waveform use the *abor* command.
TRIGger	Discrete		Defines the source of the enable signal as the front panel trigger input connector. Remote enable commands will be ignored. In continuous run mode, waveforms are generated at the output connector as soon as a valid event signal is sensed at the event input connector. For an immediate and unconditional termination of the output waveform use the *abor* command.

Response

The WS8352 will return BUS, EVEN, or TRIG depending on the current enable source setting.

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

Description

Use this command to set or query the gated run mode status.

Parameters

Range	Type	Default	Description
0-1	Discrete	0	"0" forces the continuous run mode. "1" selects the gated run mode. Gating signal is applied to the trigger input only and output waveforms will be generated only when the gate signal is valid and true. The slope and level of the gating entry are programmable.

Response

The WS8352 will return 1 or 0, depending on the current run mode setting.

:TRIGger

Description

Use this command to trigger the WS8352 from a remote computer. You may also use the common command *trg that will have the same effect. This command will affect the WS8352 only after you program the instrument to operate in triggered run mode (*init:cont 0*) and select the trigger source BUS option. Note that commands that start with *TRIG* affect the conditions for the trigger input only.

:TRIGger:COUNt<burst>(?)

Description

Use this command to set or query the burst counter setting. This command is effective only when the WS8352 is programmed to operate in triggered run mode (*init:cont 0*).

Parameters

Name	Range	Type	Default	Description
<burst>	1 to 1,000,000	Numeric (integer only)	1	Programs the burst count. Following a valid trigger signal, the WS8352 generates a pre-programmed number of waveform cycles and then resumes an idle state. The counted burst can be initiated using one of the following: front panel MANUAL push button, remote command such as *trg, or a transition at the trigger input connector.

Response

The WS8352 will return the present burst count value.

:TRIGger:DELay<interval>(?)

Description

Use this command to set or query the trigger delay setting. The trigger delay parameter defines the interval that will elapse from a valid trigger signal to the initiation of the first output waveform. Trigger delay is turned off using the *trig:del 0* command. The trigger delay command affects the generator only after it has been programmed to operate in triggered run mode. Modify the WS8352 to triggered run mode using the *init:cont 0* command. The delay interval is programmed in sample clock period increments.

Parameters

Name	Range	Type	Default	Description
<interval>	0 to 8e6	Numeric (integer only)	0	"0" turns OFF the delayed trigger function. Delay is programmed in sample clock period increments, so expect the delay time to change if you modify your sample clock setting. Program the delay interval using integer numbers divisible by 4 only.

Response

The WS8352 will return the present trigger delay interval value.

:TRIGger:ECL

Description

Use this command to set the trigger input to accept ecl (negative) signals. The threshold level is automatically set to -1.3 V, which is the mid-level for negative ecl logic. Other related commands are: trig*:ttl* to set the threshold level for TTL signals and trig*:lev* to program a threshold level between -5 V to 5 V.

:TRIGger:FILTer:HPASs:WIDTh<width>(?)

Description

Use this command to set or query the trigger high pass filter value. Trigger signal having pulse width below the programmed settings will not trigger the generator. The trigger filter has three options: high pass filter, which will trigger the WS8352 only if the width is larger than the programmed value, low pass filter, which will trigger the generator only if the width is smaller than the programmed value, and window pass filter, which will trigger the generator only if the width is within a certain range specified by the high and low pass filters.

The *trig:fil:hpas:wid* command sets a high pass threshold for the trigger signal and the *trig:fil:lpas:wid* command sets a low pass threshold for the trigger signal. If both the high and low pass filters are turned on, signals having a pulse width smaller than the low pass setting and larger that the high pass setting will trigger the generator.

Parameters

Name	Range	Type	Default	Description
<time>	10e-9 to 2	Numeric	100e-3	Programs the high pass pulse width value in units of second.

Response

The WS8352 will return the present high pass value in units of seconds.

:TRIGger:FILter:HPASs{OFF|ON|0|1}(?)

Description

Use this command to set or query the status of the high pass filter.

Range	Type	Default	Description
0-1	Discrete	0	Turns the high pass filter on and off.

Response

The WS8352 will return 0, or 1 depending on the present high pass filter state.

:TRIGger:FILTer:LPASs:WIDTh<width>(?)

Description

Use this command to set or query the trigger low pass filter value. Trigger signal having pulse width above the programmed setting will not trigger the generator. The trigger filter has three options: high pass filter, which will let trigger the WS8352 only if the width is larger than the programmed value, low pass filter, which will trigger the generator only if the width is smaller than the programmed value, and window pass filter, which will trigger the generator only if the width is within a certain range specified by the high and low pass filters.

The *trig:fil:hpas:wid* command sets a high pass threshold for the trigger signal and the *trig:fil:lpas:wid* command sets a low pass threshold for the trigger signal. If both the high and low pass filters are turned on, signals having pulse width smaller than the low pass setting and larger that the high pass setting will trigger the generator.

Parameters

Name	Range	Type	Default	Description
<time>	10e-9 to 2	Numeric	1e-3	Programs the high pass pulse width value in units of seconds.

Response

The WS8352 will return the present high pass value in units of seconds.

:TRIGger:FILter:LPASs{OFF|ON|0|1}(?)

Description

Use this command to set or query the status of the low pass filter.

Range	Type	Default	Description
0-1	Discrete	0	Turns the low pass filter on and off.

Response

The WS8352 will return 0 or 1 depending on the current low pass filter state.

:TRIGger:HOLDoff<holdoff>(?)

Description

Use this command to set or query the trigger holdoff period. The trigger holdoff filter defines a period that starts with the first valid trigger input and ends with the holdoff setting of which all triggers within this range, valid or not, are ignored, but the first valid signal after the holdoff range will cause the WS8352 to generate a waveform.

Parameters

Name	Range	Type	Default	Description
<time>	0, 100e-9 to 2	Numeric	10e-9	Programs the trigger holdoff period in units of second.

Response

The WS8352 will return the present holdoff value in units of second.

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

Description

Use this command to set or query the status of the holdoff filter.

Range	Type	Default	Description
0-1	Discrete	0	Turns the holdoff filter on and off.

Response

The WS8352 will return 0 or 1 depending on the present holdoff filter state.

:TRIGger:LEVel<level>(?)

Description

Use this command to program or query the threshold level for the trigger input signals. Other related commands are: trig*:ttl* to set the threshold level for TTL signals and trig*:ecl* to program a threshold level for ECL signals. Note that commands that start with trig affect the conditions for the trigger input only.

Parameters

Name	Range	Type	Default	Description
<level>	-5 to 5	Numeric	1.6	Programs the threshold level for the trigger input.

Response

The WS8352 will return the present threshold level setting in units of volts.

:TRIGger:MODE{NORMal|OVERride}(?)

Description

Use this command to define or query the trigger mode. In normal mode, the first trigger activates the output and consecutive triggers are ignored for the duration of the output waveform. In override mode, the first trigger activates the output and consecutive triggers restart the output waveform, regardless if the current waveform has been completed or not.

Parameters

Name	Type	Default	Description
NORMal	Discrete	NORM	Selects the normal trigger mode.
OVERride	Discrete		Selects the override trigger mode.

Response

The WS8352 will return NORM or OVER, depending on the current trigger mode setting.

:TRIGger:SLOPe{POSitive|NEGative|EITher}(?)

Description

Use this command to define or query the edge that will affect the trigger input. Positive going transitions will affect the trigger input when the POS option is selected. Negative transitions will affect the trigger input when the NEG option is selected and both positive and negative transitions will affect the trigger input when the EIT option is selected. Note that commands that start with *ARM* affect the conditions for the event input only.

Parameters

Name	Type	Default	Description
POSitive	Discrete	POS	Selects the positive going edge.
NEGative	Discrete		Selects the negative going edge.
EITher	Discrete		Selects both positive and negative going edges.

Response

The WS8352 will return POS, NEG, or EIT depending on the current slope setting.

:TRIGger:SOURce:ADVance{EXTernal|BUS|TIMer|EVENt}(?)

Description

Use this command to set or query the source of the trigger event that will stimulate the WS8352 to generate waveforms. The source advance command will affect the generator only after it has been programmed to operate in trigger run mode. Modify the WS8352 to trigger run mode using the *init:cont off* command.

Parameters

Name	Type	Default	Description
EXTernal	Discrete	EXT	Selects the TRIG IN connector as the input source. The front panel MANUALcan be used in case external triggers are not available. All other inputs are ignored.
BUS	Discrete		Selects the remote controller as the trigger source. Only software commands are accepted; TRIG IN, Event IN and manual triggers are ignored.
TIMer	Discrete		Activates the built in internal trigger generator. BUS and external trigger are ignored. The period of the internal trigger is programmable and can be used to replace an external trigger source.
EVENt	Discrete		Selects the Event IN connector as the input source. All other inputs are ignored.

Response

The WS8352 will return EXT, BUS, TIM, or EVEN depending on the selected trigger source advance setting.

:TRIGger:TIMer:MODE{TIME|DELay}(?)

Description

Use this command to set or query the mode that the internal trigger generator will operate. Timed defines start-to-start triggers and Delayed defines end-to-start triggers. The timer commands will affect the generator only after it has been programmed to operate in timer mode. Modify the WS8352 to trigger run mode using the *init:cont off* command and program the internal timer using the *trig:tim* command.

Parameters

Name	Type	Default	Description
TIME	Discrete	TIME	Selects the timed internal trigger generator. The generator will automatically issue periodical triggers that stimulate the output to generate single cycle waveforms. The periods are programmed in units of seconds from waveform start to waveform start.
DELay	Discrete		Selects the delayed internal trigger generator. The generator will automatically issue periodical triggers that stimulate the output, to generate single cycle waveforms. The periods are programmed in units of waveform points from waveform end to waveform start.

Response

The WS8352 will return TIME or DEL depending on the selected internal trigger timer mode setting.

:TRIGger:TIMer:DELay<timer>(?)

Description

Use this command to set or query the delay setting of the internal delayed trigger generator. This value is associated with the internal trigger run mode only and has no effect on other trigger modes. The internal delayed trigger generator is a free-running oscillator, asynchronous with the frequency of the output waveform. The timer intervals are measured from waveform stop to waveform start.

Parameters

Name	Range	Type	Default	Description
<timer>	76 to 8e6	Numeric	76	Programs the internal delayed trigger generator period in units of waveform points. Program the value using integers divisible by 8.

Response

The WS8352 will return the present internal delayed trigger period value in units of waveform points.

:TRIGger:TIMer:TIME<timer>(?)

Description

Use this command to set or query the period of the internal timed trigger generator. This value is associated with the internal trigger run mode only and has no effect on other trigger modes. The internal trigger generator is a free-running oscillator, asynchronous with the frequency of the output waveform. The timer intervals are measured from waveform start to waveform start.

Parameters

Name	Range	Type	Default	Description
<timer>	200e-9 to 2	Numeric	15e-6	Programs the internal timed trigger generator period in units of seconds.

Response

The WS8352 will return the present internal timed trigger period value in units of seconds.

:TRIGger:TTL

Description

Use this command to set the trigger input to accept ttl signals. The threshold level is automatically set to 1.6 V, which is the mid-level for ttl logic. Other related commands are: *trig:ecl* to set the threshold level for ECL signals and *trig:lev* to program a threshold level between -5 V to 5 V.

Analog Output Control Commands

The Analog Output Control Commands group is used for programming the characteristics of the output waveform. Notice that there are two main subsystems that control output functions: OUTPut and SOURce. The output subsystem commands control parameters that are related directly to the output terminals (main and sync outputs) and the source subsystem commands program parameters that control waveform shape, frequency and level.

Other commands in this group control the SYNC parameters: type, position and width. Also use the commands in this group to control the shape of the output waveform, its frequency, its output level (or power) and the source of the clock reference.

Additional information on the various output functions and how the generator generates the different waveforms is given in Chapter 3. Factory defaults after *RST are shown in the default column. Parameter low and high limits are given where applicable. Use the commands in Table 4-4 to set up the WS8352 output waveforms, and their associated characteristics.

Table 4-4, Analog Output Commands Summary

Keyword	Parameter Form	Default	Notes
:OUTPut			
[:STATe]	OFF | ON | 0 | 1	0	Toggles output(s) on/off
:SYNC			
:FUNCtion	PULSe | WCOMplete	PULS	Selects sync out shape
:POSition			
[:POINt]	0 to 512e3	0	Programs sync position
:WIDTh	16 to -16	16	Sync width (Pulse only)
:SOURce	CH1 | CH2 | 1 | 2	CH1	Sync source
[:STATe]	OFF | ON | 0 | 1	0	Toggles sync on/off
[:SOURce]			
:FREQuency			
[:CW]	10e3 to 350e6 | MINimum | MAXimum	10e6	Std waveforms frequency
:RASTer	10e6 to 2e9 | MINimum | MAXimum	1e9	Arb waveforms frequency
:SOURce	INTernal | EXTernal	INT	Selects SCLK source
:DIVider	1 to 256 (integers, 2^n only)	1	External clock divider
:FUNCtion			
:MODE	FIXed | USER | MODulation | PULse| PATTern	FIX	Selects function type
:ROSCillator			
:SOURce	INTernal | EXTernal	INT	
[:EXTernal]			
:FREQuency	10e6 to 100e6	10e6	
:VOLTage			DC coupled output
[:LEVel]			
[:AMPLitude]	50e-3 to 4 | MINimum | MAXimum	500e-3	DC amplitude in volts
:OFFSet	-1.5 to 1.5 | MINimum | MAXimum	0	DC offset in volts

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

Description

This command will set or query the output state of the WS8352. Note that for safety, the outputs always default to off, even if the last instrument setting before power down was on. Also note that the offsetting leaves the output connector connected to the amplifier path but no signal is being generated while in the off state.

Parameters

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

Response

The WS8352 will return 1 if the output is on, or 0 if the output is off.

:OUTPut:SYNC:FUNCtion{PULSe|WCOMPlete}(?)

Description

Use this command to set or query the shape of the sync pulse. Pulse output can be programmed for position and width and the WCOM (wave complete) as fixed and cannot be moved from its origin.

Parameters

Name	Type	Default	Description
PULSe	Discrete	PULS	Selects the pulse shape as the output waveform for the sync output. The minimum pulse width is 16 sample clock periods. However, the width can be expanded to the full length of the waveform in increments of 16 points. Program the sync pulse width using the *outp:sync:wid* command and its relative position to the start of the waveform using the *outp:sync:pos* command.
WCOMplete	Discrete		This will select the waveform complete pulse option. The sync output will transition high at the beginning of the waveform and will return to low after the waveform cycle has been completed. Width and position control of the sync pulse is not available when this option is selected.

Response

The WS8352 will return PULS or WCOM, depending on the selected SYNC waveform function.

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

Description

This command will program the WS8352 SYNC position. This command is active in arbitrary (USER) mode only.

Parameters

Name	Range	Type	Default	Description
<position>	0 to 512e3	Numeric (Integer only)	0	Will set the SYNC position in waveform points. The sync position can be programmed in increments of 16 points to the maximum length of the waveform providing that the number is divisible by 16.

Response

The WS8352 will return the present SYNC position value.

:OUTPut:SYNC:WIDTh<width>(?)

Description

This command will program the WS8352 SYNC width. This command is active in arbitrary (USER) mode only.

Parameters

Name	Range	Type	Default	Description
<width>	16 to n-16	Numeric (Integer only)	16	Will set the SYNC width in waveform points. The sync width can be programmed in increments of 16 points minimum. “n” designates the length of the segment.

Response

The WS8352 will return the present SYNC width value.

:OUTPut:SYNC:SOURce{CH1|CH2|1|2}(?)

Description

Use this command to set or query the source of the sync pulse. There is only one sync output connector on the front panel and this connector can be programmed to source from channel 1 or channel 2 waveforms. This command does not affect the single channel version. Channel 1 position and width and channel 2 position and width are programmed individually for each channel.

Parameters

Name	Type	Default	Description
CH1 | 1	Discrete	CH1	This will select channel 1 as the source for generating the sync pulse.
CH2 | 2	Discrete		Defines channel 2 as the source for generating the sync pulse.

Response

The WS8352 will return CH1 or CH2 depending on the selected SYNC source option.

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

Description

This command will set or query the state of the sync output. Note that for safety, the outputs always default to off, even if the last instrument setting before power down was on. Also note that the offsetting leaves the sync output connector connected to the amplifier path, but no signal is being generated while in the off state.

Parameters

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

Response

The WS8352 will return 1 if the sync output is on, or 0 if the sync output is off.

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

Description

Use this command to set or query the frequency of the standard waveforms in units of hertz (Hz). This parameter has no effect on arbitrary waveforms.

Parameters

Name	Range	Type	Default	Description
<freq>	10e-3 to 350e6	Numeric	10e6	Will set the frequency of the standard waveform in units of Hz. The frequency command can be used with resolutions up to 8 digits.
<MINimum>		Discrete		Will set the frequency of the standard waveform to the lowest possible frequency (10e3).
<MAXimum>		Discrete		Will set the frequency of the standard waveform to the highest possible frequency (350e6).

Response

The WS8352 will return the present frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

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

Description

Use this command to set or query the sample clock frequency of the arbitrary waveform in units of samples per second (Sa/s). This parameter has no effect on standard waveforms.

Parameters

Name	Range	Type	Default	Description
<sclk>	10e6 to 2e9	Numeric	1e9	Will set the sample clock frequency of the arbitrary waveform in units of Sa/s. The sample clock command can be programmed with resolutions up to 8 digits.
<MINimum>		Discrete		Will set the sample clock frequency to the lowest possible frequency (10e6).
<MAXimum>		Discrete		Will set the frequency of the standard waveform to the highest possible frequency (2e9).

Response

The WS8352 will return the present sample clock frequency value. The returned value will be in standard scientific format (for example: 1 GHz would be returned as 1e9 – positive numbers are unsigned).

:FREQuency:RASTer:SOURce{INTernal|EXTernal}(?)

Description

Use this command to select or query the source of the sample clock generator. This command affects all of the waveforms, as the internal clock is removed and external clock is applied. Make sure that a valid clock is applied to the external clock input before you change the option to external, because the generator can not generate waveforms without a valid source of sample clock generator. Note that the internal sample clock generator is unique for each channel however, when an external clock source is selected, the same source is applied to both channels. Use the *freq:rast:sour:div* command for applications that require different sample clock frequencies per channel.

Parameters

Name	Type	Default	Description
INTernal	Discrete	INT	Selects the internal clock generator as the main clock source.
EXTernal	Discrete		Activates the external sample clock input. A valid signal must be applied from the external signal to the WS8352 for the generator to continue generating waveforms. Observe the input level and limitations before connecting an external signal to the external sample clock input.

Response

The WS8352 will return INT, or EXT depending on the current sample clock source setting.

:FREQuency:RASTer:DIVider<divider>(?)

Description

Use this command to set or query the sample clock frequency divider. The same external sample clock signal is fed to both channels, so if different frequencies are required, use the sample clock divider to get different sample clocks to each channel.

Parameters

Name	Range	Type	Default	Description
<sclk>	1 to 256	Numeric (integer only)	1	Will set the external sample clock frequency divider. Except 1 (no divider), all divider values must be integers - (2^n). Each channel may be programmed separately to have a different divider value.

Response

The WS8352 will return the present external clock divider value in integer number.

:FUNCTion:MODE{FIXed|USER|MODulation| PULSe|PATTern}(?)

Description

Use this command to set or query the type of waveform that will be available at the output connector.

Parameters

Name	Type	Default	Description
FIXed	Discrete	FIX	Selects the standard waveform shapes. There is an array of waveforms that is built into the program. You can find these waveform shapes in the standard waveforms section.
USER	Discrete		Selects the arbitrary waveform shapes. Arbitrary waveforms must be loaded to the WS8352 memory before they can be replayed. You can find information on arbitrary waveforms in the appropriate sections in this manual.
MODulated	Discrete		Selects the modulated waveforms. There is an array of built-in modulation schemes. However, you can also build custom modulation schemes using the arbitrary function.
PULSe	Discrete		Selects the digital pulse function. The digital pulse function behaves and reacts to the programming sequence as a regular pulse generator, except the waveforms are digitally constructed and generated from the arbitrary memory.
PATTern	Discrete		Selects the pulse pattern function. The pulse pattern function behaves and reacts to the programming sequence as a regular pattern generator, except the waveforms are digitally constructed and generated from the arbitrary memory.

Response

The WS8352 will return FIX, USER, MOD, PULS, or PATT depending on the present output function mode setting.

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

Description

Use this command to set or query the source of the 10 MHz reference. This source defines the accuracy and stability of the clock generator. The internal reference has an accuracy and stability of 1 ppm; applications requiring higher accuracy or stability can use the external reference option and apply there an improved 10 MHz signal.

Parameters

Name	Type	Default	Description
INTernal	Discrete	INT	Selects an internal source. The internal source is a TCXO (temperature compensated crystal oscillator) device that has 1ppm accuracy and stability over the operating temperature range.
EXTernal	Discrete		Reroutes the 10 MHz source to the external reference input. An external reference must be connected to the WS8352 for it to continue with its normal operation.

Response

The WS8352 will return INT, or EXT depending on the present 10 MHz clock reference source setting.

:ROSCillator:FREQuency<frequency>(?)

Description

Use this command to set or query the frequency range that will be applied to the reference oscillator input. The frequency value must be close to the value of the external frequency, because it sets up the PLL's for the reference oscillator to accept and lock on the correct external frequency value.

Parameters

Name	Range	Type	Default	Description
<frequency>	10e6 to 100e6	Numeric	100e6	Will set frequency range for the internal PLL that locks the external frequency reference.

Response

The WS8352 will return the present reference frequency value. The returned value will be in standard scientific format (for example: 10 MHz would be returned as 10e6).

:VOLTage: {<voltage>|MINimum|MAXimum}(?)

Description

Use this command to set or query the amplitude of the waveform when routed through the HV path. This parameter affects the HV output paths only. Use the command *outp:coup hv* to modify the output path to hv-coupled. The WS8352 displays a calibrated value when on load impedance of 50 Ω. Offset and amplitude settings are independent providing that the |offset + amplitude/2| value does not exceed the specified voltage window.

Parameters

Name	Range	Type	Default	Description
<Voltage>	50e-3 to 4	Numeric	500e-3	Will set the offset of the output waveform in units of volts. The display shows the correct amplitude level only when the output cable is terminated into 50 Ω.
<MINimum>		Discrete		Will set the amplitude to the lowest possible level (50e-3).
MAXimum>		Discrete		Will set the amplitude to the highest possible level (4).

Response

The WS8352 will return the present dac amplitude value. The returned value will be in standard scientific format (for example: 100 mV would be returned as 100e-3 – positive numbers are unsigned).

:VOLTage:OFFSet{<offset>|MINimum|MAXimum}(?)

Description

Use this command to set or query the dc offset of the output waveform. The WS8352 displays a calibrated value when on load impedance of 50 Ω. Offset and amplitude settings are independent providing that the |offset + amplitude| value does not exceed the specified amplitude window.

Parameters

Name	Range	Type	Default	Description
<offset>	-1.5 to 1.5	Numeric	0	Will set the offset of the output waveform in units of volts. The display shows the correct amplitude level only when the output cable is terminated into 50 Ω.
<MINimum>		Discrete		Will set the offset to the lowest possible level (-1.5).
<MAXimum>		Discrete		Will set the offset to the highest possible level (1.5).

Response

The WS8352 will return the present dc offset value. The returned value will be in standard scientific format (for example: 100 mV would be returned as 100e-3 – positive numbers are unsigned).

Standard Waveforms Control Commands

Use this group to control the shape and parameters of the standard waveforms functions. The commands in this group will affect the output only when the WS8352 has been programmed to generate standard waveforms. In standard waveform mode, some waveform coordinates are stored in tables and some are computed every time a waveform is being selected or modified. Expect small delays after the commands have been sent, because the waveform is recomputed and refreshed with every command.

Factory defaults after *RST are shown in the Default column. Parameter range and low and high limits are listed, where applicable. Use the commands in Table 4-5 to set up the WS8352 standard waveforms and their associated parameters.

Table 4-5, Standard Waveforms Control Commands Summary

Keyword	Parameter Form	Default	Notes
[:SOURce]			
:FUNCtion			
:SHAPe	SINusoid | TRIangle | SQUare | RAMP | SINC | GAUSsian | EXPonential | NOISe | DC	SIN	Standard function shape
:SINusoid			
:PHASe	0 to 360	0	
:TRIangle			
:PHASe	0 to 360	0	
:SQUare			
:DCYCle	0 to 99.9	50	
:RAMP			
:DELay	0 to 99.99	10	
:TRANsition			
[:LEADing]	0 to 99.99	60	
:TRAiling	0 to 99.99	30	
:SINC			
:NCYCle	4 to 100	10	
:GAUSsian			
:EXPonent	1 to 200	10	
:EXPonential			
:EXPonent	-100 to 100	-10	
:DC			
[:OFFSet]	-1.5 to 1.5	0	

:FUNCtion:SHAPe{SINusoid|TRIangle|SQUare|RAMP|SINC|GAUSsian|EXPonential|DC|NOISe}(?)

Description

Use this command to set or query the type of waveform that will be available at the output connector. This command will affect the WS8352 only when the standard waveforms output has been programmed. Select the standard waveforms using the *func:mode fix* command.

Parameters

Name	Type	Default	Description
SINusoid	Discrete	SIN	Selects the built-in sine waveform.
TRIangle	Discrete		Selects the built-in triangular waveform.
SQUare	Discrete		Selects the built-in square waveform.
RAMP	Discrete		Selects the built-in ramp waveform.
SINC	Discrete		Selects the built-in sinc waveform.
EXPonential	Discrete		Selects the built-in exponential waveform.
GAUSsian	Discrete		Selects the built-in gaussian waveform.
DC	Discrete		Selects the built-in DC waveform.
NOISe	Discrete		Selects the built-in noise waveform.

Response

The WS8352 will return SIN, TRI, SQU, SPUL, RAMP, SINC, GAUS, EXP, DC, or NOIS depending on the selected waveform setting.

:SINusoid:PHASe<phase>(?)

Description

Use this command to set or query the start phase for the standard sine waveform.

Parameters

Name	Range	Type	Default	Description
<phase>	0 to 360	Numeric	0	Programs the start phase parameter in units of degrees. Sine phase resolution is 0.01° limited however at high frequencies, depending on the number of waveform points that are used to create the sine shape.

Response

The WS8352 will return the present start phase value in units of degrees.

:TRIangle:PHASe<phase>(?)

Description

Use this command to set or query the start phase for the standard triangular waveform.

Parameters

Name	Range	Type	Default	Description
<phase>	0 to 360	Numeric	0	Programs the start phase parameter in units of degrees. Triangle phase resolution is 0.01° limited however at high frequencies, depending on the number of waveform points that are used to create the shape.

Response

The WS8352 will return the present start phase value in units of degrees.

:SQUare:DCYCle<duty_cycle>(?)

Description

Use this command to set or query the duty cycle of the standard square waveform.

Parameters

Name	Range	Type	Default	Description
<duty_cycle>	0 to 99.99	Numeric	50	Programs the duty cycle of the standard square waveform in units of percent. Duty cycle setting resolution is limited to 0.01% of the square wave period.

Response

The WS8352 will return the present duty cycle value in units of percent.

:RAMP:DELay<delay>(?)

Description

Use this command to set or query the delay of the standard ramp waveform. The delay parameter defines the time that will lapse from the waveform start to the first transition of the ramp period.

Parameters

Name	Range	Type	Default	Description
<delay>	0 to 99.99	Numeric	10	Programs the ramp delay parameter in units of percent

Response

The WS8352 will return the present ramp delay value in units of percent.

:Ramp:TRANsition<rise>(?)

Description

Use this command to set or query the ramp transition time from low to high. The rise time parameter defines the time that will lapse from the first transition to high, until the ramp reaches its high-level value.

Parameters

Name	Range	Type	Default	Description
<rise>	0 to 99.99	Numeric	60	Programs the ramp rise time parameter in units of percent.

Response

The WS8352 will return the present rise time value in units of percent.

:RAMP:TRANsition:TRAiling<fall>(?)

Description

Use this command to set or query the ramp transition time from high to low. The fall time parameter defines the time that will lapse from the first transition to low, until the ramp reaches its low level value.

Parameters

Name	Range	Type	Default	Description
<fall>	0 to 99.99	Numeric	30	Programs the ramp fall time parameter in units of percent

Response

The WS8352 will return the present fall time value in units of percent.

:SINC:NCYCle<N_cycles>(?)

Description

Use this command to set or query the number of “0-crossings” of the standard SINC pulse waveform.

Parameters

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

Response

The WS8352 will return an integer number depending on the current number of zero-crossing value.

:GAUSsian:EXPonent<exp>(?)

Description

Use this command to set or query the exponent for the standard Gaussian pulse waveform.

Parameters

Name	Range	Type	Default	Description
<exp>	1 to 200	Numeric (Integer only)	10	Programs the exponent parameter.

Response

The WS8352 will return an integer number depending on the present exponent value.

:EXPonential:EXPonent<exp>(?)

Description

Use this command to set or query the exponent for the standard exponential pulse waveform.

Parameters

Name	Range	Type	Default	Description
<exp>	-100 to 100	Numeric (Integer only)	-10	Programs the exponent parameter.

Response

The WS8352 will return an integer number, depending on the present exponent value.

:DC<offset>(?)

Description

Use this command to set or query the offset of the DC function in units of volts.

Parameters

Name	Range	Type	Default	Description
<offset>	-1.5 to 1.5	Numeric	0	Programs the DC offset parameter in units of volts. Output amplifier path is automatically set to DC.

Response

The WS8352 will return the present DC offset value in units of volts.

Arbitrary Waveforms Control Commands

This group is used to control the arbitrary waveforms and their respective parameters. This will allow you to create segments and download waveforms. Using these commands, you can also define segment size and delete some or all unwanted waveforms from your memory.

Generating Arbitrary Waveforms

Arbitrary waveforms are generated from digital data points, which are stored in a dedicated waveform memory. Each data point has a vertical resolution of 14 bits (16,384 points), i.e., each sample is placed on the vertical axis with a precision of 1/16,384. The WS8352 has a waveform memory capacity of 512K points.

Each horizontal point has a unique address - the first being 00000 and the last depending 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.

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 depends on the option that is installed in your instrument. The various options are listed in Chapter 1 of this manual.

Waveforms are created using small sections of the arbitrary memory. The memory can be partitioned into smaller segments (up to 1k) and different waveforms can be loaded into each segment, each having a unique length. Minimum segment size is 192 points and can be increased by increments of 16 points. Information on how to partition the memory, define segment length and download waveform data to the WS8352 is given in the following paragraphs. The arbitrary waveform commands are listed in Table 4-6. Factory defaults after *RST are shown in the Default column. Parameter range and low and high limits are listed, where applicable.

Table 4-6, Arbitrary Waveforms Commands Summary

Keyword	Parameter Form	Default	Notes
:TRACe			
[:DATA]	#<header><binary_block>		Waveform data array
:DEFine	<segment_#>,<192 to 512e3>		Segment and length
:DELete			
[:NAME]	1 to 1,000		Delete one segment
:ALL			Delete all segments
:POINts?			Queries waveform length
:SEGMent			
[:DATA]	#<header><binary_block>		Segment data array

:TRACe#<header><binary_block>

Description

This command will download waveform data to the WS8352 waveform memory. Waveform data is loaded to the WS8352 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 1,024 points

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

This command causes the transfer of 2,048 bytes of data (1,024 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.
- "2,048" is the even number of bytes to follow.

The generator accepts waveform samples as 16-bit integers, which are sent in two-byte words. Therefore, the total number of bytes is always twice the number of data points in the waveform. For example, 20000 bytes are required to download a waveform with 10,000 points. The IEEE-STD-488.2 definition of Definite Length Arbitrary Block Data format is demonstrated in Figure 4-1.

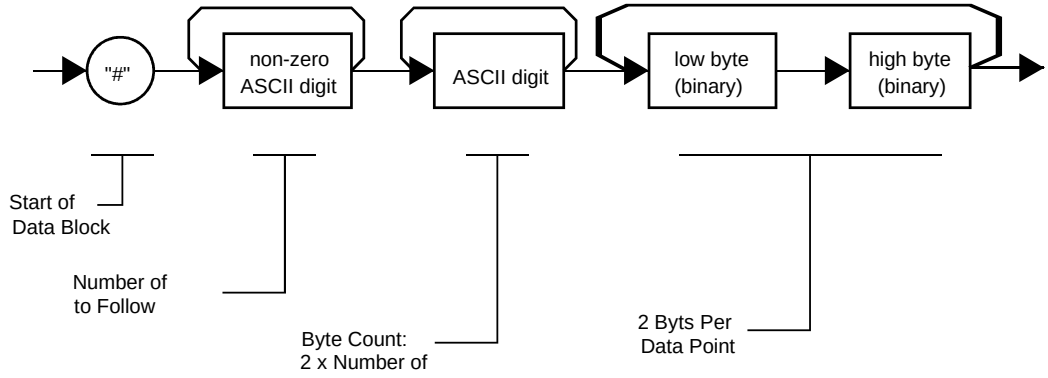

Figure 4-1, Definite Length Arbitrary Block Data Format

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, programmers may choose to prepare the data in two bytes and arrange to download these two bytes in a sequence. Figure 4-2 shows a waveform word that is acceptable for the WS8352. There are a number of points you should be aware of before you start preparing the data:

1. Waveform data points have 14-bit values - 0x000 to 3xFFF.
2. Data point range is 0 to 16,383 decimal for the WS8352. 0x000 corresponds to -2 V and 3xFFF corresponds to +2 V.
3. WS8352 data point 16,383 corresponds to full-scale amplitude setting. Point 8,192 corresponds to 0 V amplitude setting.

Figure 4-2 shows how to prepare the 16-bit word for a data point representation and Figure 4-3 shows how this data represents waveform.

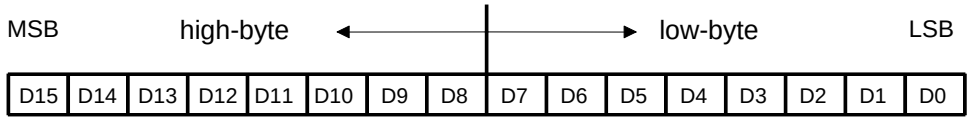

Figure 4-2, 16-bit Data Point Representation

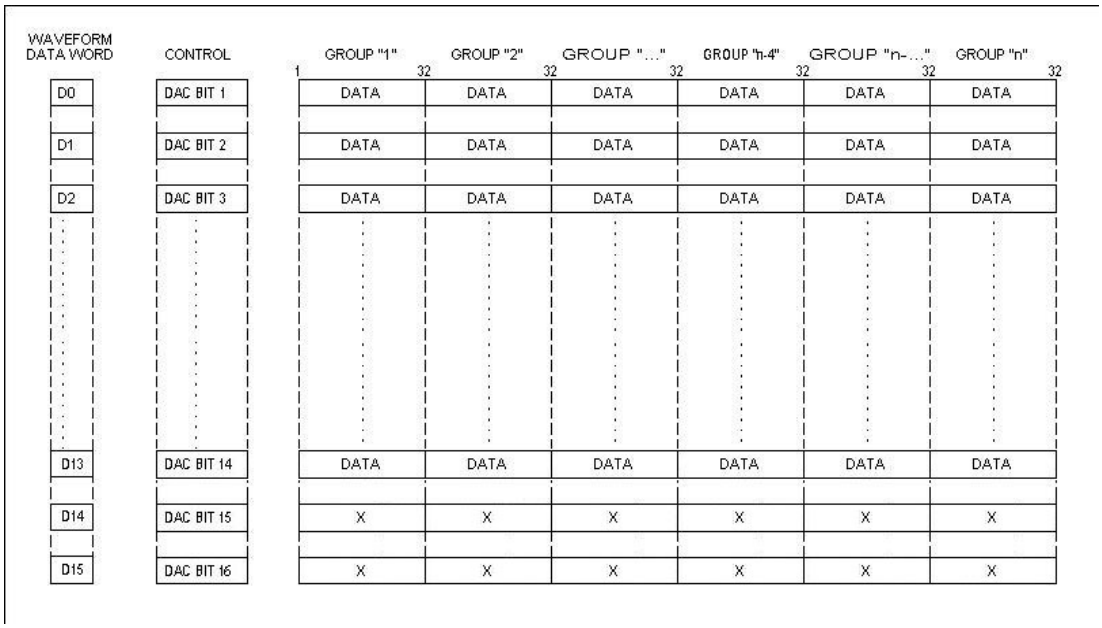

Figure 4-3, Waveform Data Word Representation

Notes:

1. Each group of data contains 32 words and therefore, waveform data is programmed in multiples of 32 words.
2. "X" data in D14 and D15 implies "don't care" data.

Parameters

Name	Type	Description
<header>	Discrete	Contains information on the size of the binary block that contains waveform coordinates.
<binary_block>	Binary	Block of binary data that contains waveform data points (vertical coordinates), as explained above.

:TRACe:DEFine<segment_#>,<length>

Description

Use this command to define the size of a specific memory segment. The final size of the arbitrary memory is 512,000 points. The memory can be partitioned to smaller segments, up to 1,000 segments. The total length of memory segments cannot exceed the size of the waveform memory.

NOTE

The WS8352 operates in interlaced mode where sixteen memory cells generate one byte of data. Therefore, segment size can be programmed in numbers evenly divisible by 16 only. For example, 2112 bytes is an acceptable length for a binary block. 2110 is not a multiple of 16 and therefore the generator will generate an error message if this segment length is used.

Parameters

Name	Range	Type	Default	Description
<segment_#>	1 to 1k	Numeric (integer only)	1	Selects the segment number of which will be programmed using this command.
<length>	192 to n	Numeric (integer only)		Programs the size of the selected segment. Minimum segment length is 192 points. The maximum (n) is limited by the size of the installed memory. Segment size can be programmed with increments of 16 points.

:TRACe:DELete<segment_#>

Description

This command will delete a predefined segment from the working memory. 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's consider two segments: the first being a 1024-point waveform and the second with 320 points. If you delete segment 1, you can reprogram another waveform to segment 1 with size to 1024 points. If you reprogram segment 1 with more than 1024 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, you can reprogram this segment with waveforms having length limited only by the size of the remaining memory space.

Parameters

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

:TRACe:DELete:ALL

Description

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

:TRACe:POINts?

Description

This command will query the number of points that were used for building up the active waveform.

Response

The WS8352 will return the active waveform length as an integer number.

:TRACe:SELect<segment_#>(?)

Parameters

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

Response

The WS8352 will return the active waveform segment number.

:SEGMent#<header><binary_block>

Description

This command will partition the waveform memory to smaller segments hence speeding 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 memory 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 WS8352 using high-speed binary transfer in a similar way to downloading waveform data with the trace command. High-speed binary transfer allows any 8-bit bytes (including extended ASCII code) to be transmitted in a message. This command is particularly useful for large number of segment. As an example, the next command will generate three segments with 12 bytes of data that contains segment size information.

SEGment#212<binary_block>

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

- The ASCII "#" ($23) designates the start of the binary data block.
- "2" designates the number of digits that follow.
- "12" is the number of bytes to follow. This number must divide by 4.

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

The segment table data is made of 32-bit words however, the GPIB link has 8 data bus lines and accepts 8-bit words only. Therefore, the data has to be prepared as 32-bit words and rearranged as six 8-bit words before it can be used by the WS8352 as segment table data. Figure 4-4 shows how to prepare the 32-bit word for the segment start address and size. Actually, only size is required because the segments are automatically numbered and their relative start address is automatically placed at the end of the last memory segment.

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

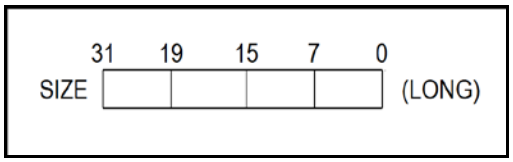

Figure 4-4, Segment Size Array Example

1. Each channel has its own segment table buffer. Therefore, make sure you selected the correct active channel (with the INST:SEL command) before you download segment table data to the generator.
2. SEGM# command overrides segment definitions, similar to the TRAC:DEL:ALL command.
3. Minimum number of segments is 1; maximum number of segments is 1,000
4. Maximum segment size is 512K.
5. Segment table data has 32-bit values of which are used for segment size. Therefore, Data for each segment must have 4 bytes.
6. The number of bytes in a complete segment table must divide by 4. The WS8352 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.
7. The sample program below demonstrates the usage of the SEGM# command. This example generates a segment table with four entries: Segment 1 = 640 points, segment 2 = 1,024 points, segment 3 = 2,048 and segment 4 = 20,480 points. Regardless if you previously had any segments defined previously, the segment index will start from 1 to n.

```
UINT_32  seg_data_inf[4], total_buff_bytes_num;
seg_data_inf[0] = 640;
seg_data_inf[1] = 1024;
seg_data_inf[2] = 2048;
seg_data_inf[3] = 20480;
total_buff_bytes_num = 4 * num_of_segments;
digits_num = (UINT_32)(log10((double) total_buff_bytes_num) +1.0);
sprintf(cmd_str,":segm #%d%d", digits_num, total_buff_bytes_num);
sendCmdNoNL (cmd_str);
h_vi.dwlData((unsigned char *)seg_data_inf, total_buff_bytes_num);
```

8. SEGM# command is extremely useful in case you need to define and download waveforms to a large number of segments otherwise, you would be using the TRAC:DEF command to define individual segments. In this case, you can further save programming sequences and download time by combining and downloading all of your waveform segments in one download command. Since segment definition does not modify memory contents, you can either download the waveform and then slice the memory segments or reverse the procedure; Either way, the process of downloading one waveform and then define the entire segment table with one command makes this process extremely efficient.
9. Unlike downloading individual waveforms to individual segments, one has to prepare a combined waveform for this one-shot download of multiple waveform segments. Information and considerations are provided in the trac#.

Consider the three segments as shown in the next figure, marked as segment 1, 400 points long, segment 2, 3,000 points long and segment 3, 5,000 points long. You can define each segment separately using the trac:def command and then, download waveform data to each defined memory segment.

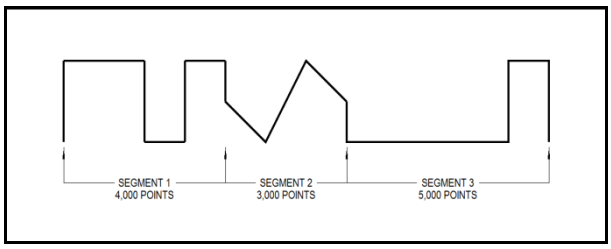

Figure 4-5, Multiple Segment Download Array Example

Now consider that you intend to use the SEGM# command and therefore you'd like to combine the three waveform segments into one single waveform. The following figure demonstrates how the new waveform looks like:

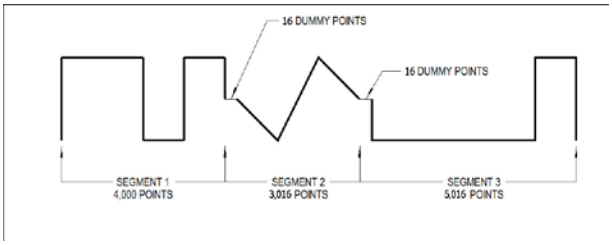

Figure 4-6, Single Segment Download Array Example

Notice that besides the first waveform, each of the following waveforms is artificially expanded by 16 dummy points right at the beginning of the segment. The value of these points should be the same as the value of the first point of the waveform segment. So now, the combined length of the three waveform segments is 4,000+3,000+5,000+32 = 12,032 points. And the header for the data download command should look as follows:

TRACe#624064<binary_block>

Where 6 defines that 6 digits will follow and 24064 is the number of bytes that will be downloaded using the binary download process. Explanation on the TRACe# command is given in the Arbitrary Waveform Commands section of this manual.

Parameters

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

Modulated Waveforms Global Control Commands

This group is used to set up the instrument in modulated waveforms mode and to select the general parameters that control all modulation functions. Note that the modulation can be turned off to create continuous carrier waveforms (CW). The following modulation schemes can be selected and controlled: AM, FM, Sweep, Chirp, FSK, ASK, Frequency Hopping, Amplitude Hopping, (n)PSK and (n)QAM. The modulated waveforms global control commands are summarized in Table 4-7. Factory defaults after *RST are shown in the Default column. Parameter range and low and high limits are listed, where applicable.

Table 4-7, Modulated Waveforms Global Commands

Keyword	Parameter Form	Default	Notes
[:SOURce]			
:MODulation			
:TYPE	OFF | AM | FM | SWEep | CHIRp | FSK | ASK | FHOPping | AHOPping | PSK | QAM	OFF	
:CARRier			
[:FREQuency]	10e3 to 350e6	1e6	
:FUNCtion	SINusoid | TRIangle | SQUare	SIN	

:MODulation:TYPE{OFF|AM|FM|SWEep|CHIRp|FSK|ASK|FHOPping|AHOPping|PSK|QAM }(?)

Description

This command selects the modulation type. All modulation types are internal, so external signals are not required for producing modulation.

Parameters

Name	Type	Default	Description
OFF	Discrete	OFF	Modulation off is a special mode where the output generates continuous, non-modulated sinusoidal carrier waveforms (CW).
AM	Discrete		This turns on the AM function. Program the AM parameters to fine-tune the function for your application.
FM	Discrete		This turns on the FM function. Program the FM parameters to fine-tune the function for your application.
SWEep	Discrete		This turns on the sweep function. Program the sweep parameters to fine-tune the function for your application.
CHIRp	Discrete		This turns on the chirp function. Program the chirp parameters to fine-tune the function for your application.

FSK	Discrete	This turns on the FSK function. Program the FSK parameters to fine tune the function for your application.
ASK	Discrete	This turns on the ASK function. Program the ASK parameters to fine tune the function for your application.
FHOPping	Discrete	This turns on the frequency hopping function. Program the hop parameters to fine tune the function for your application.
AHOPping	Discrete	This turns on the amplitude hopping function. Program the amplitude hopping parameters to fine tune the function for your application.
PSK	Discrete	This turns on the PSK function. Program the PSK parameters to fine tune the function for your application.
QAM	Discrete	This turns on the QAM function. Program the QAM parameters to fine tune the function for your application.

Response

The WS8352 will return OFF, FM, AM, SWE, FSK, ASK, HOP, AHOP, 3D, PSK, or QAM depending on the present modulation type setting.

:MODulation:CARRier<frequency>(?)

Description

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

Parameters

Name	Range	Type	Default	Description
<frequency>	10e3 to 350e6	Numeric	1e6	Programs the frequency of the carrier waveform in units of Hz. Note that the CW waveform is sine only and its frequency setting is separate from the standard sine waveform.

Response

The WS8352 will return the current carrier frequency value.

:MODulation:CARRier:FUNCtion(SINusoid|TRIangle|SQUare}(?)

Description

This specifies the carrier function. There are three functions that can be modulated: Sine, Triangle and Square. The sine, triangle and the square are computed and placed in the memory as complete waveforms and the modulation schemes are computed and replayed as arbitrary waveforms.

Parameters

Name	Type	Default	Description
SINusoid	Discrete	SIN	Selects sine as the modulated waveform
TRIangle	Discrete		Selects triangle as the modulated waveform
SQUare	Discrete		Selects square as the modulated waveform

Response

The WS8352 will return SIN, TRI, or SQU depending on the selected waveform setting.

Modulation Control Commands

This group is used to control parameters for individual modulation schemes. Control parameters are available for: AM, FM and Sweep. The modulation control commands are summarized in Table 4-8. Factory defaults after *RST are shown in the Default column. Parameter range and low and high limits are listed, where applicable.

Table 4-8, Modulated Waveforms Control Commands

Keyword	Parameter Form	Default	Notes
[:SOURce]			
:AM			Amplitude modulation
:FUNCtion			
[:SHAPe]	SINusoid | TRIangle | SQUare | RAMP	SIN	
:INTernal			
:FREQuency	100 to 1e6	1e3	Maximum Carrier to internal freq ration is 1e6
:DEPTh	0 to 200	50	
:FM			Frequency modulation
:DEViation	10e-3 to 175e6	500e3	
:FUNCtion			
[:SHAPe]	SINusoid | TRIangle | SQUare | RAMP	SIN	
:FREQuency	100 to 35e6	10e3	
:MARKer			
[:FREQuency]	10e3 to 350e6	505e3	
:SWEep			Sweep modulation
:FREQuency			
[:STARt]	10e3 to 350e6	40e6	
:STOP	10e3 to 350e6	80e6	
:TIME	1.4e-6 to 0.01	10e-6	
:DIRection	UP | DOWN	UP	
:SPACing	LINear | LOGarithmic	LIN	
:MARKer			
[:FREQuency]	10e3 to 350e6	60e6	
:CHIRp			Chirp modulation
:WIDTh	1.4e-6 to 0.01	10e-6	
:REPetition	200e-9 to 2	25e-6	
:FREQuency			
[:STARt]	10e3 to 350e6	40e6	
:STOP	10e3 to 350e6	80e6	
:DIRection	UP | DOWN	UP	
:SPACing	LINear | LOGarithmic	LIN	
:AMPLitude			
:DEPTh	0 to 100%	50%	
:DIRection	UP | DOWN	UP	
:SPACing	LINear | LOGarithmic	LIN	
:FSK			Frequency shift keying
:FREQuency			
:SHIFted	10e3 to 350e6	2e6	
:BAUD	0.1 to 350e6	10e3	
:MARKer	1 to 10,000	1	
:DATA	<data_array>		

Table 4-8, Modulated Waveforms Control Commands (Continued)

Keyword	Parameter Form	Default	Notes
:ASK			
[:AMPLitude]			Amplitude shift keying
[:STARt]	0 to 2	0.5	
:SHIFted	0 to 2	1	
:BAUD	0.1 to 350e6	10e3	
:MARKer	1 to 10,000	1	
:DATA	<data_array>		
:FHOPping			Frequency hopping
:DWELl			
:MODe	FIXed | VARiable	VAR	
[:TIMe]	2e-9 to 10	5e-6	
:FIXed			
:DATA	<data_array>		
:VARiable			
:DATA	<data_array>		
:MARKer	1 to 10,000	1	
:AHOPping			Amplitude hopping
:DWELl			
:MODe	FIXed | VARiable	VAR	
[:TIMe]	2e-9 to 10	5e-6	
:FIXed			
:DATA	<data_array>		
:VARiable			
:DATA	<data_array>		
:MARKer	1 to 10,000	1	
:PSK			Phase shift keying
:TYPE	PSK | BPSK | QPSK | OQPSK | DQPSK | 8PSK | 16PSK | USER	PSK	
:PHASe			
[:STARt]	0 to 360	0	
:SHIFted	0 to 360	180	
:DATA	<data_array>		
:MARKer	1 to 10,000	1	
:BAUD	0.1 to 350e6	10e3	
:CARRier			
:STATe	OFF | ON | 0 | 1	1	
:USER			
:DATA	<data_array>		
:QAM			Quadrature amplitude mod
:TYPE	16QAM | 64QAM | 256QAM | USER	16QAM	
:CARRier			
:STATe	OFF | ON | 0 | 1	0	
:BAUD	0.1 to 350e6	10e3	
:DATA	<data_array>		
:MARKer	1 to 10,000	1	
:USER			
:DATA	<data_array>		

AM Programming

Use the following command for programming the AM parameters. AM control is internal. The commands for programming the amplitude modulation function are described below. Note that the carrier waveform frequency (CW) setting is common to all modulation schemes.

:AM:FUNCtion:SHAPe(SINusoid|TRIangle|SQUare|RAMP}(?)

Description

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

Parameters

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

Response

The WS8352 will return SIN, TRI, SQU, or RAMP depending on the selected function shape setting.

:AM:INTernal:FREQuency<am_freq>(?)

Description

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

Parameters

Name	Range	Type	Default	Description
<am_freq>	100 to 1e6	Numeric	1e3	Programs the frequency of the modulating waveform in units of Hz. The frequency of the built-in standard modulating waveforms only is affected. Note that maximum carrier-to-internal-frequency-ratio is 1e6.

Response

The WS8352 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).

:AM:DEPth<depth>(?)

Description

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

Parameters

Name	Range	Type	Default	Description
<depth>	0 to 200	Numeric	50	Programs the depth of the modulating waveform in units of percent.

Response

The WS8352 will return the present modulating depth value.

FM Programming

Use the following command for programming the FM parameters. FM control is internal. There are two types of waveforms that can be used as the modulating waveforms: Standard and Arbitrary. The standard waveforms are built in a library of waveforms and can be used anytime, without external control.

:FM:DEViation<deviation>(?)

Description

This programs the deviation range around the carrier frequency. The deviation range is always symmetrical about the carrier frequency.

Parameters

Name	Range	Type	Default	Description
<deviation>	10e-3 to 175e6	Numeric	500e3	Programs the deviation range around the carrier frequency in units of Hz.

Response

The WS8352 will return the present deviation frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

:FM:FUNCtion:SHAPe(SINusoid|TRIangle|SQUare|RAMP}(?)

Description

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

Parameters

Name	Type	Default	Description
SINusoid	Discrete	SIN	Selects the sine shape as the modulating waveform
TRIangle	Discrete		Selects the triangular shape as the modulating waveform

SQUare	Discrete	Selects the square shape as the modulating waveform
RAMP	Discrete	Selects the ramp shape as the modulating waveform

Response

The WS8352 will return SIN, TRI, SQU, or RAMP depending on the selected function shape setting.

:FM:FREQuency<fm_freq>(?)

Description

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

Parameters

Name	Range	Type	Default	Description
<fm_freq>	100 to 35e6	Numeric	10e3	Programs the frequency of the modulating waveform in units of Hz. Only the frequency of the built-in standard modulating waveforms is affected.

Response

The WS8352 will return the present modulating waveform frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

:FM:MARKer<frequency>(?)

Description

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

Parameters

Name	Range	Type	Default	Description
<frequency>	10e3 to 350e6	Numeric	505e3	Programs the marker frequency position in units of Hz.

Response

The WS8352 returns the present marker frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

Sweep Modulation Programming

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

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

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

:SWEep:FREQuency<start_freq>(?)

Description

This specifies the sweep start frequency. The WS8352 will normally sweep from start-to-stop frequencies. However, if the sweep direction is reversed, the output will sweep from stop-to-start frequencies. The start-and-stop frequencies may be programmed freely throughout the frequency of the standard waveform frequency range.

Parameters

Name	Range	Type	Default	Description
<start_freq>	10e3 to 350e6	Numeric	40e3	Programs the sweep start frequency. Sweep start is programmed in units of Hz.

Response

The WS8352 will return the present sweep start frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

:SWEep:FREQuency:STOP<stop_freq>(?)

Description

This specifies the sweep stop frequency. The WS8352 will normally sweep from start-to-stop frequencies. However, if the sweep direction is reversed, the output will sweep from stop-to-start frequencies. The start-and-stop frequencies may be programmed freely throughout the frequency of the standard waveform frequency range.

Parameters

Name	Range	Type	Default	Description
<stop_freq>	10e3 to 350e6	Numeric	80e6	Programs the sweep stop frequency. Sweep stop is programmed in units of Hz.

Response

The WS8352 will return the present sweep stop frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

:SWEep:TIMe<time>(?)

Description

This specifies the time that will take the WS8352 to sweep from start-to-stop frequencies. The time does not depend on the sweep boundaries, as it is automatically adjusted by the software to the required interval. At the end of the sweep cycle, the output waveform maintains the sweep stop frequency setting, except if the WS8352 is in continuous run mode, where the sweep repeats itself continuously.

Parameters

Name	Range	Type	Default	Description
<time>	1.4e-6 to 0.01	Numeric	10e-6	Programs the sweep time. Sweep time is programmed in units of s.

Response

The WS8352 will return the present sweep time. The returned value will be in standard scientific format (for example: 100ms would be returned as 100e-3 – positive numbers are unsigned).

:SWEep:DIRection(UP|DOWN}(?)

Description

This specifies if the WS8352 output will sweep from start-to-stop (UP) or from stop-to-start (DOWN) frequencies. Sweep time does not affect the sweep direction and frequency limits. At the end of the sweep cycle, the output waveform normally maintains the sweep stop frequency setting, but will maintain the start frequency if the DOWN option is selected, except if the WS8352 is in continuous run mode where the sweep repeats itself continuously.

Parameters

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

Response

The WS8352 will return UP, or DOWN depending on the selected direction setting.

:SWEep:SPACing(LINear|LOGarithmic}(?)

Description

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

Parameters

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

Response

The WS8352 will return LIN or LOG, depending on the selected spacing setting.

:SWEep:MARKer<frequency>(?)

Description

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

Parameters

Name	Range	Type	Default	Description
<frequency>	10e3 to 350e6	Numeric	60e6	Programs the marker frequency position in units of Hz.

Response

The WS8352 will return the present marker frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

Chirp Modulation Programming

Use the following command for programming the chirp parameters. Chirp control is internal. Within a single chirp, one can sweep the frequency from start to stop settings and modulate the amplitude from 0% to 100% simultaneously. Other chirp parameters are fully controlled by these commands

The commands for programming the chirp function are described below.

:CHIRp:WIDth<width>(?)

Description

Use this command to set or query the time that will lapse from chirp start to chirp end.

Parameters

Name	Range	Type	Default	Description
<width>	1.4e-6 to 0.01	Numeric	10e-6	Programs the width of the chirp in units of seconds.

Response

The WS8352 will return the present chirp width value. The returned value will be in standard scientific format. (for example: 100ms would be returned as 100e-3 – positive numbers are unsigned).

:CHIRp:REPetition<interval>(?)

Description

Use this command to set or query the time interval between consecutive chirp cycles. The time is measured between two adjacent chirp starts.

Parameters

Name	Range	Type	Default	Description
<interval>	200e-9 to 2	Numeric	25e-6	Programs the intervals between adjacent chirp cycles. Chirp repetition is programmed in units of seconds.

Response

The WS8352 will return the present chirp repetition value. The returned value will be in standard scientific format (for example: 100ms would be returned as 100e-3 – positive numbers are unsigned).

:CHIRp:FREQuency[:STARt]<start_freq>(?)

Description

Use this command to set or query the start frequency within the chirp cycle. Start and stop frequencies can be identical for non-swept chirps but could also be different is frequency sweep is required within a single chirp cycle.

Parameters

Name	Range	Type	Default	Description
<start_freq>	10e3 to 350e6	Numeric	40e6	Programs the chirp start frequency. Chirp start frequency is programmed in units of seconds.

Response

The WS8352 will return the present chirp start frequency value. The returned value will be in standard scientific format (for example: 100ms would be returned as 100e-3 – positive numbers are unsigned).

:CHIRp:FREQuency:STOP<stop_freq>(?)

Description

Use this command to set or query the stop frequency within the chirp cycle. Start and stop frequencies can be identical for non-swept chirps but could also be different is frequency sweep is required within a single chirp cycle.

Parameters

Name	Range	Type	Default	Description
<start_stop>	10e3 to 350e6	Numeric	80e6	Programs the chirp stop frequency. Chirp start frequency is programmed in units of seconds.

Response

The WS8352 will return the present chirp stop frequency value. The returned value will be in standard scientific format (for example: 100ms would be returned as 100e-3 – positive numbers are unsigned).

:CHIRp:DIRection(UP|DOWN}(?)

Description

Use this command to set or query the chirp frequency direction. This specifies if the WS8352 output will sweep from start-to-stop (UP) or from stop-to-start (DOWN) frequencies. Chirp width does not affect the sweep direction and frequency limits.

Parameters

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

Response

The WS8352 will return UP, or DOWN depending on the selected direction setting.

:CHIRp:SPACing(LINear|LOGarithmic}(?)

Description

Use this command to set or query the chirp frequency steps. Two options are available: logarithmic or linear. In linear, the incremental steps between the frequencies are uniform throughout the sweep range. Logarithmic type defines logarithmic spacing throughout the sweep start and stop settings.

Parameters

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

Response

The WS8352 will return LIN or LOG, depending on the selected spacing setting.

:CHIRp:AMPLitude:DEPTh<index>(?)

Description

Use this command to set or query the chirp amplitude modulation index. Chirp amplitude can be modulated up or down, depending on the chirp direction setting.

Parameters

Name	Range	Type	Default	Description
<index>	0 to 100	Integer	50	Programs the chirp amplitude modulation index in units of %.

Response

The WS8352 will return the present amplitude modulation index value. The returned value will be an integer.

:CHIRp:AMPLitude:DIRection(UP|DOWN}(?)

Description

Use this command to set or query the chirp amplitude direction. The start and stop amplitude settings is determined by the chirp amplitude modulation depth.

Parameters

Name	Type	Default	Description
UP	Discrete	UP	Selects the chirp amplitude modulation up direction
DOWN	Discrete		Select the chirp amplitude modulation down direction

Response

The WS8352 will return UP or DOWN, depending on the selected chirp amplitude direction setting.

:CHIRp:AMPLitude:SPACing(LINear|LOGarithmic}(?)

Description

Use this command to set or query the chirp amplitude spacing. Two options are available: logarithmic or linear. In linear, the incremental steps between the amplitudes are uniform throughout the chirp range. Logarithmic type defines logarithmic amplitude spacing throughout the chirp start and stop settings.

Parameters

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

Response

The WS8352 will return LIN or LOG, depending on the selected chirp amplitude spacing setting.

FSK Modulation Programming

Use the following command for programming the FSK parameters. FSK control is internal. The frequency will shift from carrier to shifted frequency setting at a rate determined by the baud value and controlled by a sequence of bits in the FSK data table. The commands for programming the frequency shift keying function are described below. Note that the carrier waveform frequency (CW) setting is common to all modulation schemes.

:FSK:FREQuency:SHIFted<shift_freq>(?)

Description

This programs the shifted frequency. The frequency shifts when the pointer in the data array points to “1”.

Parameters

Name	Range	Type	Default	Description
<shift_freq>	10e3 to 350e6	Numeric	2e6	Programs the shifted frequency value in units of Hz.

Response

The WS8352 will return the present shifted frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

:FSK:FREQuency:BAUD<baud>(?)

Description

This allows the user to select FSK word rate. The word rate is the interval of which the bit streams in the FSK data array are clocked causing the output frequency to hop from carrier to shifted frequency values and vice versa.

Parameters

Name	Range	Type	Default	Description
<baud>	0.1 to 350e6	Numeric	10e3	Programs the rate of which the frequency shifts from carrier to shifted frequency in units of Hz.

Response

The WS8352 will return the present baud value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

:FSK:FREQuency:MARKer<index>(?)

Description

Programs where on the data stream the WS8352 will generate a pulse, designated as FSK marker, or index

point. The marker pulse is generated at the SYNC output connector. Note that if you intend to program marker position, you must do it before you load the FSK data list.

Parameters

Name	Range	Type	Default	Description
<index>	1 to 10,000	Numeric (integer only)	1	Programs a marker pulse at an index bit position.

Response

The WS8352 will return the present marker position.

:FSK:DATA<fsk_data>

Description

Loads the data stream that will cause the WS8352 to hop from carrier to shifted frequency and vice versa. Data format is a string of "0" and "1" which define when the output generates carrier frequency and when it shifts frequency to the FSK value. "0" defines carrier frequency,"1" defines shifted frequency. Note that if you intend to program marker position, you must do it before you load the FSK data list.

Below you can see how an FSK data table is constructed. The sample below shows a list of 10 shifts. The WS8352 will step through this list, outputting either carrier or shifted frequencies, depending on the data list: Zero will generate carrier frequency and One will generate shifted frequency. Note that the waveform is always sinewave and that the last cycle is always completed.

Sample FSK Data Array

0 1 1 1 0 1 0 0 0 1

Parameters

Name	Type	Description
<fsk_data>	ASCII	Block of ASCII data that contains information for the generator when to shift from carrier to shifted frequency and visa versa.

ASK Modulation Programming

Use the following command for programming the ASK parameters. ASK control is internal. The amplitude will toggle between two amplitude settings at a rate determined by the baud value and controlled by a sequence of bits in the ASK data table. The commands for programming the amplitude shift keying function are described below. Note that the carrier waveform frequency (CW) setting is common to all modulation schemes.

:ASK<amplitude>(?)

Description

This programs the normal amplitude setting. The amplitude shifts when the pointer in the data array points to “1”.

Parameters

Name	Range	Type	Default	Description
<amplitude>	0 to 2	Numeric	0.5	Programs the amplitude setting in units of volt.

Response

The WS8352 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).

:ASK:SHIFted<shift_ampl>(?)

Description

This programs the shifted amplitude. The amplitude shifts when the pointer in the data array points to “1”.

Parameters

Name	Range	Type	Default	Description
<shift_ampl>	0 to 2	Numeric	1	Programs the shifted amplitude setting in units of volt.

Response

The WS8352 will return the present shifted amplitude value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

:ASK:BAUD<rate>(?)

Description

This allows the user to select ASK word rate. The word rate is the interval of which the bit streams in the ASK data array are clocked causing the output amplitude to hop from one level to shifted amplitude level values and visa versa.

Parameters

Name	Range	Type	Default	Description
<rate>	0.1 to 350e6	Numeric	10e3	Programs the rate of which the frequency shifts from carrier to shifted frequency in units of Hz.

Response

The WS8352 will return the present baud value. The returned value will be in standard scientific format (for example: 100kHz would be returned as 100e3 – positive numbers are unsigned).

:ASK:FREQuency:MARKer<index>(?)

Description

Programs where on the data stream the WS8352 will generate a pulse, designated as ASK marker, or index point. The marker pulse is generated at the SYNC output connector. Note that if you intend to program marker position, you must do it before you load the ASK data list.

Parameters

Name	Range	Type	Default	Description
<index>	1 to 10,000	Numeric (integer only)	1	Programs a marker pulse at an index bit position.

Response

The WS8352 will return the present marker position.

:ASK:DATA<ask_data>

Description

Loads the data stream that will cause the WS8352 to hop from one amplitude level to shifted amplitude level and vice versa. Data format is a string of "0" and "1" which define when the output generates base level and when it shifts amplitude to the ASK value. "0" defines base level amplitude,"1" defines shifted amplitude level. Note that if you intend to program marker position, you must do it before you load the ASK data list.

Below you can see how an ASK data table is constructed. The sample below shows a list of 10 shifts. The 2572A will step through this list, outputting either base or shifted amplitudes, depending on the data list: Zero will generate base level and One will generate shifted amplitude. Note that the waveform is always sinewave and that the last cycle is always completed.

Sample ASK Data Array

0 1 1 1 0 1 0 0 0 1

Parameters

Name	Type	Description
<ask_data>	ASCII	Block of ASCII data that contains information for the generator when to shift from base to shifted amplitude and vice versa.

Frequency Hopping Modulation Programming

Use the following command for programming the frequency hop parameters. Hop control is internal. The frequency will hop from frequency to frequency at a rate determined by the dwell time value and controlled by a sequence of frequencies in the HOP data table.

There are two hop modes: Fixed Dwell, where the rate of which the generator hops from frequency to frequency is constant and Variable Dwell, where the rate of which the generator hops from frequency to frequency is programmable for each hop.

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

:FHOP:DWELl:MODe(FIXed|VARiable}(?)

Description

This selects between fixed or variable dwell-time for the frequency hops. Select the fixed option if you want each frequency to dwell equally on each step. The variable option lets you program different dwell times for each frequency hop. The WS8352 output hops from one frequency to the next according to a sequence given in a hop table. The variable dwell time table contains dwell time data for each step however, the fixed dwell time table does not contain any dwell time information and therefore, if you select the fixed option, make sure your dwell time is programmed as required.

Parameters

Name	Type	Default	Description
FIXed	Discrete	VAR	Selects the fixed dwell time frequency hops mode
VARiable	Discrete		Select the variable dwell time frequency hops mode

Response

The WS8352 will return FIX, or VAR depending on the selected dwell setting.

:FHOP:DWELl<dwell_time>(?)

Description

This selects the dwell time for frequency hops when the selected mode is Fixed dwell time hops. The dwell time table in this case does not contain the dwell time per step parameters and therefore, the value which is programmed with this command remains constant for the entire hop sequence.

Parameters

Name	Range	Type	Default	Description
<dwell_time>	2e-9 to 10	Numeric	5e-6	Programs dwell time for the fixed dwell-time frequency hop function. The same dwell time will be valid for each frequency hop. Dwell time is programmed in units of s.

Response

The WS8352 will return the present dwell time value. The returned value will be in standard scientific format (for example: 100 ms would be returned as 100e-3 – positive numbers are unsigned).

:FHOP:FIX:DATA<fix_hop_data>

Description

This command will download the data array that will cause the instrument to hop through the frequency list. The dwell time for each frequency list item is fixed and can be programmed using the HOP:DWEL command. Note that if you intend to program marker position, you must do it first and then load the frequency hops list.

Below you can see how a hop table is constructed. The file sample below shows a list of 10 frequencies. The WS8352 will hop through this list, outputting the next frequency each time it hops. Note that the carrier waveform is always sinewave and that the last cycle is always completed even if the dwell time is shorter than the period of the waveform. For example, if you program dwell time of 1ms and the frequency step has frequency of 1Hz (1s period), the frequency step will last 1 second although the dwell time is 1ms.

Sample Frequency Hops Data Array

1e+6 2e+6 3e+3 4e+6 5e+5 6e+2 7e+1 8e+6 9e+3 10e+5

Parameters

Name	Type	Description
<fix_hop_data>	Double	Block of binary data that contains information of frequency values.

:FHOP:VARiable:DATA<var_hop_data>

Description

This command will download the data array that will cause the instrument to hop through the frequency list. The dwell time for each frequency list item is variable and is supplied in the variable hop table data array. Note that the HOP:DWEL command has no effect on this sequence. Also note that if you intend to program marker position, you must do it first and then load the frequency hops list.

Below you can see how a hop table is constructed. The file sample below shows a list of 10 frequencies and their associated dwell times. The WS8352 will hop through this list, outputting the next frequency each time it hops. Note that the carrier waveform is always sinewave and that the last cycle is always completed even if the dwell time is shorter than the period of the waveform. For example, if you program dwell time of 1 ms and the frequency step has frequency of 1Hz (1s period), the frequency step will last 1 second although the dwell time is 1 ms.

Sample Frequency Hops Data Array

1e+6 100e-6 2e+6 200e-6 3e+3 3e-4 4e+6 40e-2 5e+5 5e-3 6e+2 600e-6 7e+1 0.7 8e6 1e-6 9e+3 90e-6 10e+5 100e-6

In the above example, the first number is the frequency value and the second number is its dwell time. Therefore, only even number of sets can be located in this table.

Parameters

Name	Type	Description
<var_hop_data>	Double	Block of binary data that contains information of frequency hop values and their respective dwell time.

:FHOP:MARKer<index>(?)

Description

Programs where on the frequency list the WS8352 will generate a pulse, designated as Hop marker, or index point. The marker pulse is generated at the SYNC output connector.

Parameters

Name	Range	Type	Default	Description
<index>	1 to 10,000	Numeric (integer only)	1	Programs a marker pulse at an index frequency hop position.

Response

The WS8352 will return the present marker position.

Amplitude Hopping Modulation Programming

Use the following command for programming the amplitude hop parameters. Hop control is internal. The amplitude will hop from amplitude level to amplitude level at a rate determined by the dwell time value and controlled by a sequence of amplitudes in the HOP data table.

There are two hop modes: Fixed Dwell, where the rate of which the generator hops from amplitude level to amplitude level is constant and Variable Dwell, where the rate of which the generator hops from amplitude level to amplitude level is programmable for each hop.

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

:AHOP:DWELl:MODe(FIXed|VARiable}(?)

Description

This selects between fixed or variable dwell-time for the amplitude hops. Select the fixed option if you want each amplitude level to dwell equally on each step. The variable option lets you program a different dwell time value for each amplitude hop. The WS8352 output hops from one amplitude level to the next according to a sequence given in a hop table. The variable dwell time table contains dwell time data for each step however, the fixed dwell time table does not contain any dwell time information and therefore, if you select the fixed option, make sure your dwell time is programmed as required.

Parameters

Name	Type	Default	Description
FIXed	Discrete		Selects the fixed dwell time amplitude hops mode
VARiable	Discrete	VAR	Select the variable dwell time amplitude hops mode

Response

The WS8352 will return FIX, or VAR depending on the selected dwell setting.

:AHOP:DWELl<dwell_time>(?)

Description

This selects the dwell time for amplitude hops when the selected mode is Fixed dwell time hops. The dwell time table in this case does not contain the dwell time per step parameters and therefore, the value which is programmed with this command remains constant for the entire hop sequence.

Parameters

Name	Range	Type	Default	Description
<dwell_time>	2e-9 to 10	Numeric	5e-6	Programs dwell time for the fixed dwell-time amplitude hop function. The same dwell time will be valid for each amplitude hop. Dwell time is programmed in units of s.

Response

The WS8352 will return the present dwell time value. The returned value will be in standard scientific format (for example: 100 ms would be returned as 100e-3 – positive numbers are unsigned).

:AHOP:FIX:DATA<fix_hop_data>

Description

This command will download the data array that will cause the instrument to hop through the amplitude list. The dwell time for each amplitude list item is fixed and can be programmed using the HOP:DWEL command. Note that if you intend to program marker position, you must do it first and then load the amplitude hops list.

Below you can see how a hop table is constructed. The file sample below shows a list of 10 amplitudes. The WS8352 will hop through this list, outputting the next amplitude each time it hops. Note that the carrier waveform is always sinewave and that the last cycle is always completed even if the dwell time is shorter than the period of the waveform. For example, if you program dwell time of 1ms and the amplitude step has frequency of 1Hz (1s period), the frequency step will last 1 second although the dwell time is 1ms.

Sample Amplitude Hops Data Array

0 1 1.2 1.3 1.4 1.5 100e-3 200e-3 300e-3 400e-3 500e-3

Parameters

Name	Type	Description
<fix_hop_data>	Double	Block of binary data that contains information of amplitude values.

;AHOP:VARiable:DATA<var_hop_data>

Description

This command will download the data array that will cause the instrument to hop through the amplitude list. The dwell time for each amplitude list item is variable and is supplied in the variable hop table data array. Note that the HOP:DWEL command has no effect on this sequence. Also note that if you intend to program marker position, you must do it first and then load the amplitude hops list.

Below you can see how a hop table is constructed. The file sample below shows a list of 10 amplitudes and their associated dwell times. The WS8352 will hop through this list, outputting the next amplitude each time it hops. Note that the carrier waveform is always sinewave and that the last cycle is always completed even if the dwell time is shorter than the period of the waveform. For example, if you program dwell time of 1ms and the amplitude step has frequency of 1Hz (1s period), the amplitude step will last 1 second although the dwell time is 1ms.

Sample Amplitude Hops Data Array

0.1 5e-6 1.2 10e-6 1.3 20e-6 1.4 50e-6 1.5 1e-6 100e-3 100e-9 200e-3 200e-9 300e-3 300e-9 400e-3 400e-9 500e-3 500e-9

In the above example, the first number is the amplitude value and the second number is its dwell time. Therefore, only even number of sets can be located in this table.

Parameters

Name	Type	Description
<var_hop_data>	Double	Block of binary data that contains information of amplitude hop values and their respective dwell time.

:AHOP:MARKer<index>(?)

Description

Programs where on the amplitude list the WS8352 will generate a pulse, designated as Hop marker, or index point. The marker pulse is generated at the SYNC output connector.

Parameters

Name	Range	Type	Default	Description
<index>	1 to 10,000	Numeric (integer only)	1	Programs a marker pulse at an index amplitude hop position.

Response

The WS8352 will return the present marker position.

PSK Modulation Programming

Use the following command for programming the PSK parameters. The following commands will be divided into two groups: PSK commands and (n)PSK commands. The PSK function can shift from start to shifted phase setting, within the range of 0 to 360°, at a frequency determined by the rate value and controlled by a sequence of bits in the PSK data table. The (n)PSK functions use pre-defined table settings. In case the standard table does not suit the application you can design your own (n)PSK data using the User PSK data table entry option. Note that the carrier waveform frequency (CW) setting is common to all modulation schemes.

:PSK:TYPE{PSK|BPSK|QPSK|OQPSK|8PSK|16PSK|USER}(?)

Description

This selects between the various (n)PSK modulation schemes. Note that PSK and BPSK are almost identical functions except PSK can be programmed to shift from any phase to any phase and the BPSK toggles between two pre-determined values only – 0° and 180°.

Parameters

Name	Type	Default	Description
PSK	Discrete	PSK	Selects the PSK modulation function. In this mode, the instrument shifts from any phase to any phase as programmed by the PSK:PHAS and PSK:PHAS:SHIF commands. The rate of which the PSK toggles phase values is programmed using the PSK:RATE command.
BPSK	Discrete		Selects the Binary Phase Shift Keying (BPSK) modulation type. In this mode, the instrument shifts from 0° to 180° at a rate determined by the PSK:BAUD command and in a sequence as programmed by the PSK:DATA table.

QPSK	Discrete	Selects the Quadrature Phase Shift Keying (QPSK) modulation type. In this mode, the instrument responds to 2 input bits that correspond to four phases of the carrier wave. The symbols are shifts at a rate determined by the PSK:BAUD command and in a sequence as programmed by the PSK:DATA table.
OQPSK	Discrete	Selects the Offset Phase Shift Keying (OPSK) modulation type. The mapping is the same as for the QPSK except the element of I is moved first and then the element of Q is moved if the status changes from one to another. These two steps are carried out within the time of one step of QPSK. By shifting the movement of the Q element, the status can be changed without going through the origin even if a change of 180° occurs. Because one symbol period is calculated in two steps, an even value must be used for oversampling. The symbols are shifts at a rate determined by the PSK:BAUD command and in a sequence as programmed by the PSK:DATA table.
DQPSK	Discrete	Selects the Π/4-shifted Differentially encoded QPSK modulation type. In this mode, the symbol is located at the position where the phase is shifted from the current symbol position by 45° from the value of the next data symbol. The first symbol position is defined by QPSK. pre-defined values. Π/4DQPSK uses both the QPSK and another four-point table rotated by 45°.The symbols are shifts at a rate determined by the PSK:BAUD command and in a sequence as programmed by the PSK:DATA table.
8PSK	Discrete	Selects the 8-phase Shift Keying (8PSK) modulation type. In this mode, the instrument shifts through eight symbols with 3 bits. The symbols are shifts at a rate determined by the PSK:BAUD command and in a sequence as programmed by the PSK:DATA table.
16PSK	Discrete	Selects the 16-phase Shift Keying (16PSK) modulation type. In this mode, the instrument shifts through sixteen symbols with 4 bits. The symbols are shifts at a rate determined by the PSK:BAUD command and in a sequence as programmed by the PSK:DATA table.
USER	Discrete	Selects the User PSK modulation type. There are no pre-assigned symbols for this mode and therefore, the symbols must first be designed using the PSK:USER:DATA table. The number of bits are user definable. The symbols are shifts at a rate determined by the PSK:BAUD command and in a sequence as programmed by the PSK:DATA table.

Response

The WS8352 will return PSK, BPSK, QPSK, OQPSK, DQPSK, 8PSK, 16PSK, or USER on the selected PSK type setting.

:PSK:PHASe:<start_phase>(?)

Description

This programs the start phase of the carrier waveform. The start phase shifts when the pointer in the data array points to “0”.

Parameters

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

Response

The WS8352 will return the present start phase value.

:PSK:PHASe:SHIFted<shift_phase>(?)

Description

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

Parameters

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

Response

The WS8352 will return the present shift phase value.

:PSK:DATA<psk_data>

Description

Loads the data stream that will cause the WS8352 to hop from phase to phase. Data format is a string of "0" and "1" which define when the output generates the various phases. The size of the data word depends on the PSK function. For PSK and BPSK there are only two bits - "0" defines start phase,"1" defines shifted phase. 16PSK has 4 bits of which 0000 defines the first phase vector 0001 defines the second, 0000 the third and 1111 defines the 16th phase vector. Note that if you intend to program marker position, you must do it before you load the PSK data list.

Below you can see how an PSK data table and a 16PSK data table are constructed. The PSK data table sample below shows a list of 10 shifts. The WS8352 will step through this list, outputting either start or shifted phases, depending on the data list: Zero will generate start phase and One will generate shifted phase. Note that the output waveform is always sinewave and that the last cycle is always completed. The 16PSK data array has 10 shifts as well except this time the shifts are a bit more complex.

Sample PSK Data Array

0 1 1 1 0 1 0 0 0 1

Sample 16PSK Data Array

0000 0100 1010 0111 1111 0001 0010 0111 0101 1111

Parameters

Name	Type	Description
<psk_data>	ASCII	Block of ASCII data that contains information for the generator when to step from one phase setting to another.

:PSK:MARKer<index>(?)

Description

Programs where on the data stream the WS8352 will generate a pulse, designated as PSK marker, or index point. The marker pulse is generated at the SYNC output connector. Note that if you intend to program marker position, you must do it before you load the PSK data list. The PSK:MARK command is common to all PSK modulation functions.

Parameters

Name	Range	Type	Default	Description
<index>	1 to 10,000	Numeric (integer only)	1	Programs a marker pulse at an index bit position.

Response

The WS8352 will return the present marker position.

:PSK:BAUD<baud>(?)

Description

This allows the user to select (n)PSK baud. The baud is the interval of which the symbols stream in the (n)PSK data array as they are clocked with the baud generator. Note that this command is dedicated for programming the (n)PSK modulation function only and will have no effect on the PSK function.

Parameters

Name	Range	Type	Default	Description
<baud>	0.1 to 350e6	Numeric	10e3	Programs the baud of which the symbols stream in the (n)PSK data table. Baud is programmed in units of Hz.

Response

The WS8352 will return the present baud value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

:PSK:CARRier:STATe{OFF|ON|0|1}(?)

Description

This command will toggle the carrier waveform (CW) on and off. This command affects all (n)PSK function and has no effect on the PSK function. The carrier off function is especially useful as direct input for I & Q vector generators that need the digital information only and supply the carrier information separately.

Parameters

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

Response

The WS8352 will return 1 if the output is on, or 0 if the output is off.

:PSK:USER:DATA<user_data>

Description

Loads the user phase data for the (n)PSK modulation function. The data contains a list of phase values within the range of 0° to 360°. The user data table is associated with the User PSK function only where symbols can be freely designed as non-standard vectors. After you enter the symbol data in this table, you must generate the symbol sequence using the PSK:DATA command, as shown earlier in this section.

Below you can see an example of the User PSK data table. The symbol index is automatically incremented from 0 to n so there is no need to provide index numbers in this table.

Sample User PSK Symbols Data Array

5.5 50 95 120 150 190.4 210 225.8 265 280 307 90.7 180.2

Parameters

Name	Type	Description
<user_data>	Binary	Block of binary data that contains phase information for the (n)PSK modulation function.

QAM Modulation Programming

Use the following command for programming the QAM parameters. The QAM commands allow selection of the (n)QAM type, programming the QAM baud, placing the marker position, turning the carrier waveform (CW) on and off function and designing data symbols.

:QAM:TYPE{16QAM|64QAM|256QAM|USER}(?)

Description

This selects between the various (n)QAM modulation schemes. The 16QAM, 64QAM and 256QAM types have standard symbol configuration. In case you need a non-standard symbol constellations, use the User QAM to design your own symbol data.

Parameters

Name	Type	Default	Description
16QAM	Discrete	16QAM	Selects the 16 Quadrature Amplitude Modulation (16QAM) modulation type. 16QAM is a 4-level modulation method that uses 16 phases/amplitude symbols. The first two bits define at which event of the IQ plane the phase exists (00: upper right, 01: upper left, 10: lower left, 11: lower right) and the rest of the 2 bits defines the position of the symbol in each event. The instrument steps through these events in a sequence as listed in the QAM:DATA table and at a frequency which is programmed using the QAM:BAUD parameter.
64QAM	Discrete		Selects the 64 Quadrature Amplitude Modulation (64QAM) modulation type. 64QAM is a 6-level modulation method that uses 64 phases/amplitude symbols. The first two bits define at which event of the IQ plane the phase exists (00: upper right, 01: upper left, 10: lower left, 11: lower right) and the rest of the 4 bits defines the position of the symbol in each event. The instrument steps through these events in a sequence as listed in the QAM:DATA table and at a frequency which is programmed using the QAM:BAUD parameter.
256QAM	Discrete		Selects the 256 Quadrature Amplitude Modulation (256QAM) modulation type. 64QAM is a 8-level modulation method that uses 256 phases/amplitude symbols. The first two bits define at which event of the IQ plane the phase exists (00: upper right, 01: upper left, 10: lower left, 11: lower right) and the rest of the 6 bits defines the position of the symbol in each event.

		The instrument steps through these events in a sequence as listed in the QAM:DATA table and at a frequency which is programmed using the QAM:BAUD parameter.
USER	Discrete	Selects the User QAM modulation type. There are no pre-assigned symbols for this mode and therefore, the symbols must first be designed using the QAM:USER:DATA table. The instrument will then step through the programmed symbols in a sequence as listed in the QAM:DATA table and at a frequency which is programmed using the QAM:BAUD parameter.

Response

The WS8352 will return 16QAM, 64QAM, 256QAM, or USER depending on the selected QAM type setting.

:QAM:BAUD<baud>(?)

Description

This allows the user to select (n)QAM baud. The baud is the interval of which the symbols stream in the (n)QAM data array as they are clocked with the baud generator.

Parameters

Name	Range	Type	Default	Description
<baud>	0.1 to 350e6	Numeric	10e3	Programs the baud of which the symbols stream in the (n)QAM data table. Baud is programmed in units of Hz.

Response

The WS8352 will return the present baud value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100e-3 – positive numbers are unsigned).

:QAM:CARRier:STATe{OFF|ON|0|1}(?)

Description

This command will toggle the carrier waveform (CW) on and off. The carrier off function is especially useful as direct input for I & Q vector generators that need the digital information only and supply the carrier information separately.

Parameters

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

Response

The WS8352 will return 1 if the output is on, or 0 if the output is off.

:QAM:DATA<qam_data>

Description

Loads the data stream that will cause the WS8352 to hop from vector to vector. Data format is a string of "0's" and "1's" which define when the output generates the various vectors. The size of the data word depends on the QAM type. For 16QAM there are only four bits and for 256QAM there are 8 bits. Note that if you intend to program marker position, you must do it before you load the PSK data list.

Below you can see how a 16QAM data table is constructed. The 16QAM data table sample below shows a list of 10 shifts. The WS8352 will step through this list, outputting the various vectors in a sequence as defined by the data list.

Sample 16QAM Data Array

0000 0100 1010 0111 1111 0001 0010 0111 0101 1111

Parameters

Name	Type	Description
<qam_data>	ASCII	Block of ASCII data that contains information for the generator when to step from one vector setting to another.

:QAM:MARKer<index>(?)

Description

Programs where on the data stream the WS8352 will generate a pulse, designated as QAM marker, or index point. The marker pulse is generated at the SYNC output connector. Note that if you intend to program marker position, you must do it before you load the QAM data list. The QAM:MARK command is common to all QAM modulation types.

Parameters

Name	Range	Type	Default	Description
<index>	1 to 10,000	Numeric (integer only)	1	Programs a marker pulse at an index bit position.

Response

The WS8352 will return the present marker position.

Pulse Waveform Programming

Use the following commands for programming pulse waveforms and pulse parameters. The pulse is created digitally. However, it closely simulates an analog pulse generator, so pulse parameters are programmed just as they would be programmed on a dedicated pulse generator instrument. Just keep in mind that since this is a digital instrument, there are some limitations to the pulse design that evolve from the fact that the best resolution is one sample clock interval. Also, remember that the pulse is created digitally in the arbitrary memory and therefore, its smallest incremental step has a maximum value limitation as specified in Appendix A. Figures 4-7 through 4-9 show how the pulse commands affect the shape of the pulse when placed in Single, Delayed and Double pulse modes. The pulse commands are summarized in Table 4-9.

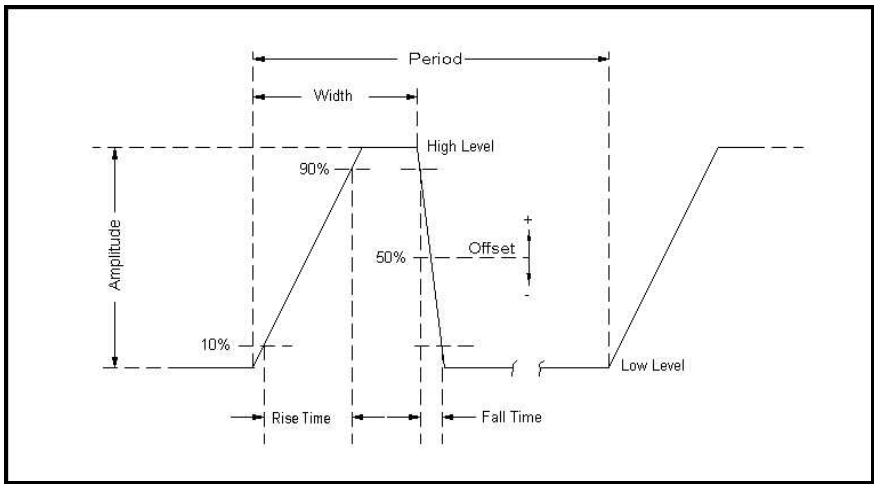

Figure 4-7, Single Pulse Parameters

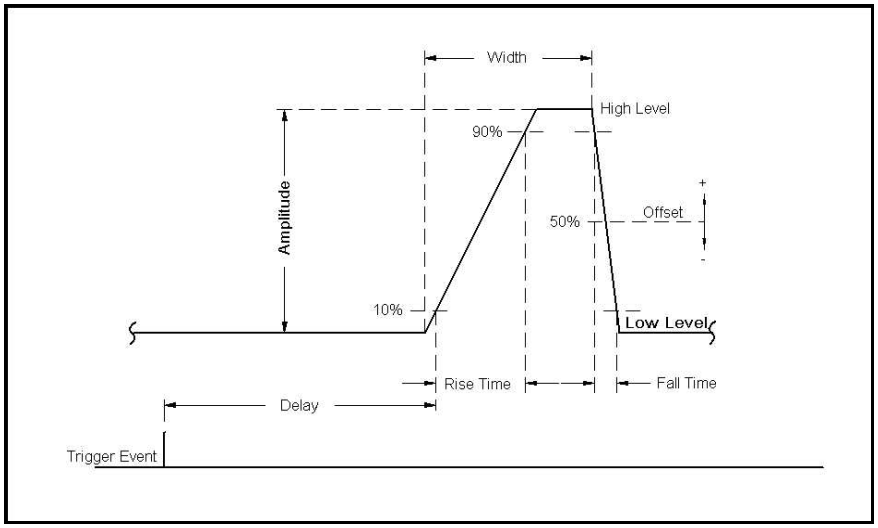

Figure 4-8, Delayed Pulse Parameters

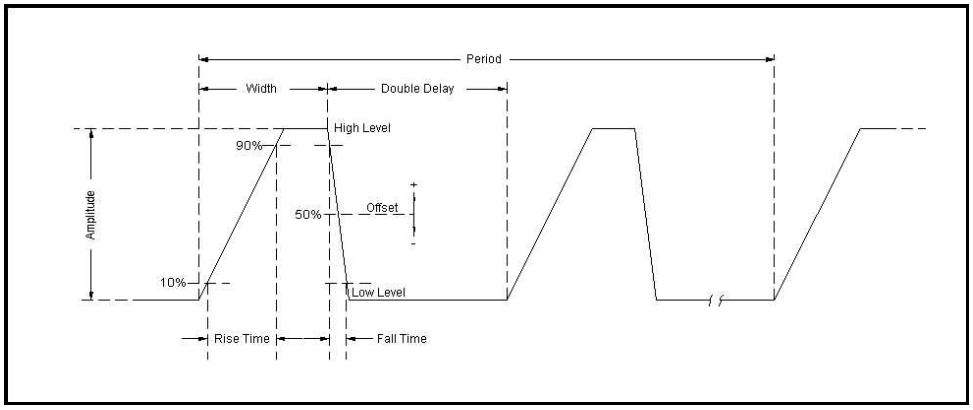

Figure 4-9, Double Pulse Parameters

Table 4-9, Pulse Waveform Commands Summary

Keyword	Parameter Form	Default	Notes
:PULse			
:CONFigure	TIME | PERCent	TIME	
:DELay	0 | 1e-9 to 1s	1e-3	Delay in sec
:PERCent	0 .01 to 99.99	10	Delay in %
:DOUBle			
:DELay	0 | 1e-9 to 1s	1e-3	Double del in sec
:PERCent	0 .01 to 99.99	10	Delay in %
:LEVel			
[:CONTrol]	HLOW | AOFFset | POSitive | NEGative	HLOW	
:HIGH	-2.25 to 2.25	1	
:LOW	-2.25 to 2.25	0	
:AMPLitude	50e-3 to 2 | MINimum | MAXimum	1	Amplitude in V
:OFFSet	-1.5 to 1.5 | MINimum | MAXimum	0.5	DC offset in volts
:MODE	SINGle | DELayed | DOUBle	SING	
:POLarity	NORMal | COMPlement | INVerted	NORM	
:PERiod	5e-9 to 1.6	10e-3	
:TRANsition			
[:STATe]	FAST | LINear | SYMMetrical	FAST	Transition type
[:LEADing]	1e-9 to 100e-3	1e-3	Rise time in sec
:PERCent	0 .01 to 99.99	10	Rise time in %
:TRAiling	1e-9 to 100e-3	1e-3	Fall time in sec
:PERCent	0 .01 to 99.99	10	Fall time in %
:WIDTh	2e-9 to 1s	2e-3	Width in sec
:PERCent	0 .01 to 99.99	20	Width in %

:PULSe:CONFigure{TIME|PERCent}(?)

Description

In applications where an absolute setting of a certain pulse parameter is required, it is recommended to select the time option. This means that the parameter can be programmed individually in units of time and will retain the programmed value, regardless of the pulse period setting. The percent option is useful for applications that require a certain relationship between the period and the individual parameter, such as width-to-period or rise-time-to-period. Use this command to configure the generator for one of these options.

Parameters

Name	Type	Default	Description
TIME	Discrete	TIME	Enables the programming of pulse parameters in units of time (seconds)
PERCent	Discrete		Enables the programming of certain pulse parameters in units of percent. The ratio is computed in reference to the period frequency. For example, if the period is set to 100 ms and the width is programmed to 10%, the width will remain 10% of the programmed period, (10 ms in this example) but will be automatically adjusted to 15 ms if the period is changed to 150 ms.

Response

The WS8352 will return TIME or PERC depending on the present pulse configuration setting.

:PULSe:DELay<delay>(?)

Description

This command programs the delayed interval of which the output idles on the low level, until the first transition to high level. The delay is measured from the trigger transition to the first pulse transition. Note that this delay does not include the system delay error that is specified in Appendix A. Also note that the only case where the delay can exceed the value of the period setting is in triggered mode, where the external trigger intervals determine the period of the pulse.

Parameters

Name	Range	Type	Default	Description
<delay>	0, 1e-9 to 1	Numeric	1e-3	Will set the delay time interval in units of seconds. As shown in Figure 4-8, the delay is measured from trigger transition to the first pulse transition. Puls:del 0 implies that delay is off.

Response

The WS8352 will return the pulse delay value in units of seconds.

:PULSe:DELay:PERCent<delay>(?)

Description

This command will program the delayed interval of which the output idles on the low level, until the first transition to high level. The delay is measured from the first external trigger transition to the first pulse transition. Note that this delay does not include the system delay error that is specified in Appendix A. Also note that the only case where the delay can exceed the value of the period setting is in triggered mode, where the external trigger intervals determine the period of the pulse.

Parameters

Name	Range	Type	Default	Description
<delay>	0.01 to 99.99	Numeric	10	Will set the delay time interval in units of percent. As shown in Figure 4-8, the delay is measured from trigger transition to the first pulse transition.

Response

The WS8352 will return the pulse delay value in units of %.

:PULSe:DOUBle:DELay<delay>(?)

Description

This command will program the delay between two adjacent pulses when the double mode is selected. Otherwise, the double pulse delay has no effect on the pulse structure. Note that the only case where the delay can exceed the value of the period setting is in triggered mode, where the trigger interval determines the period of the pulse. Double pulse building block parameters are shown in Figure 4-9.

Parameters

Name	Range	Type	Default	Description
<delay>	1e-9 to 1	Numeric	1e-3	Will set the delay between two adjacent pulses for the double pulse mode only. The delay is programmed in units of seconds and is measured from the last transition of the first pulse to the first transition of the second pulse.

Response

The WS8352 will return the present double pulse delay value in units of seconds.

:PULSe:DOUBle:DELay:PERCent<delay>(?)

Description

This command will program the delay between two adjacent pulses when the double mode is selected. Otherwise, the double pulse delay has no effect on the pulse structure. Note that the only case where the delay can exceed the value of the period setting is in triggered mode, where the trigger interval determines the period of the pulse. Double pulse building block parameters are shown in Figure 4-9.

Parameters

Name	Range	Type	Default	Description
<delay>	0.01 to 99.99	Numeric	10	Will set the delay between two adjacent pulses for the double pulse mode only. The delay is programmed in units of percent and is measured from the last transition of the first pulse to the first transition of the second pulse.

Response

The WS8352 will return the present double pulse delay value in units of percent.

:PULSe:LEVel{HLOW|AOFFset|POSitive|NEGative} (?)

Description

This command will determine how the pulse levels are programmed. Pulse level mode options are: High/Low, Amplitude/Offset, Positive and Negative.

Parameters

Name	Type	Default	Description
HLOW	Discrete	HLOW	Programs pulse level using high level and low level parameters.
AOFFset	Discrete		Programs pulse level using the amplitude and offset parameters. When the offset is left at 0 V settings (default), amplitude changes modifies the pulse level symmetrically about the 0 V level.
POSitive	Discrete		Programs pulse level using the high level parameters. The low level remains at 0 V at all times.
NEGative	Discrete		Programs pulse level using the low level parameters. The high level remains at 0 V at all times.

Response

The WS8352 will return HOLW, AOFF, POS or NEG depending on the present pulse level mode setting.

:PULSe:LEVel:HIGH<high_level>(?)

Description

This command programs the high level amplitude of the pulse waveform. The high level is calibrated when the load impedance is 50 Ω.

Parameters

Name	Range	Type	Default	Description

<high_level>	-2.250 to 2.250	Numeric	1	Will set the high level of the pulse waveform in units of volts.

Response

The WS8352 will return the present high-level value. The returned value will be in standard scientific format (for example: 100mV would be returned as 100e-3 – positive numbers are unsigned).

:PULSe:LEVel:LOW<low_level>(?)

Description

This command programs the low level amplitude of the pulse waveform. The low level is calibrated when the load impedance is 50 Ω.

Parameters

Name	Range	Type	Default	Description
<low_level>	-2.250 to 2.250	Numeric	0	Will set the low level of the pulse waveform in units of volts.

Response

The WS8352 will return the present low-level value. The returned value will be in standard scientific format (for example: 100mV would be returned as 100e-3 – positive numbers are unsigned).

:PULSe:LEVel:AMPLitude{<ampl>|MINumum|MAXimum}(?)

Description

This command programs the peak-to-peak amplitude of the pulse waveform. The amplitude is calibrated when the source impedance is 50 Ω. Note that this value is a duplication of the volt:ampl parameter and therefore, modifying this parameter in the pulse menu will automatically modify the amplitude setting for the other instrument functions.

Parameters

Name	Range	Type	Default	Description
<ampl>	50e-3 to 2	Numeric	1	Will set the amplitude of the pulse waveform in units of volts. Amplitude setting is always peak-to-peak. Offset and amplitude settings are independent, providing that the offset + amplitude do not exceed the amplitude window, as specified in Appendix A.
<MINimum>	Discrete			Will set the amplitude to the lowest possible amplitude (50e-3).
<MAXimum>	Discrete			Will set the amplitude to the highest possible amplitude level (2).

Response

The WS8352 will return the present pulse amplitude value. The returned value will be in standard scientific format (for example: 100mV would be returned as 100e-3 – positive numbers are unsigned).

:PULSe:LEVel:OFFset{<offs>|MINimum|MAXimum}(?)

Description

This command programs the offset amplitude of the pulse waveform. The offset is calibrated when the source impedance is 50Ω. Note that this value is a duplication of the volt:offs parameter and therefore, modifying this parameter in the pulse menu will automatically modify the offset setting for the other instrument functions.

Parameters

Name	Range	Type	Default	Description
<offs>	-1.5 to 1.5	Numeric	0.5	Will set the offset of the pulse waveform in units of volts. Offset and amplitude settings are independent providing that the offset + amplitude do not exceed the specified window.
<MINimum>	Discrete			Will set the amplitude to the lowest possible offset (-1.5).
<MAXimum>	Discrete			Will set the amplitude to the highest possible offset level (1.5).

Response

The WS8352 will return the present pulse offset value. The returned value will be in standard scientific format (for example: 100mV would be returned as 100e-3 – positive numbers are unsigned).

:PULSe:MODe{SINGle|DELayed|DOUBle}(?)

Description

This command will program the mode of the pulse. Pulse mode options are: Single pulse, Delayed pulse and Double pulse. These modes are depicted in Figures 4-7 through 4-9.

Parameters

Name	Type	Default	Description
SINGle	Discrete	SING	Programs single pulse output, which generates normal pulses
DELayed	Discrete		Programs a delayed pulse mode, which generates normal pulses that are delayed from the SYNC output
DOUBle	Discrete		Programs a double pulse mode, which generates a pair of single pulses that are displaced by a double delay period

Response

The WS8352 will return SING, DEL or DOUB depending on the present pulse mode setting.

:PULSe:POLarity{NORMal|COMPlement|INVerted}(?)

Description

This command will program the polarity of the pulse in reference to the baseline level. The polarity options are: Normal - where the pulse is generated exactly as programmed, Inverted - where the pulse is inverted about the 0 level base line and Complemented - where the pulse is inverted about its mid-amplitude axis.

Parameters

Name	Type	Default	Description
NORMal	Discrete	NORM	Programs normal pulse output
COMPlement	Discrete		Programs complemented pulse output
INVerted	Discrete		Programs an inverted pulse output

Response

The WS8352 will return NORM, COMP or INV depending on the present polarity setting.

:PULSe:PERiod<period>(?)

Description

This command will program the pulse repetition rate (period). Note that with the sum of all parameters, including the pulse width and fall time cannot exceed the programmed pulse period and therefore, it is recommended that the pulse period be programmed first, before all other pulse parameters. Note that by selecting the double pulse mode, the pulse period remains unchanged.

Parameters

Name	Range	Type	Default	Description
<period>	5e-9 to 1.6	Numeric	10e-3	Programs the period of the pulse waveform in units of seconds.

Response

The WS8352 will return the present pulse period value in units of seconds.

:PULSe:TRANsition:STATe{FAST|LINear|SYMMetrical} (?)

Description

This command will place the pulse output in one of three transition options: 1) Fast - the level transitions from high-to-low or low-to-high at the fastest rate that the generator can produce 2) Linear - the level transitions linearly at a programmed rate from low-to-high and from high-to-low and each transition can be programmed to a different rate and 3) Symmetrical - the leading and trailing edges transition exactly at the same rate.

Parameters

Name	Type	Default	Description
FAST	Discrete	FAST	Programs the fast transitions mode. In this mode, the leading and trailing edges will transition as fast as the instrument allows.
LINear	Discrete		Selects linear transitions. Note that unlike analog pulse generators, the WS8352 can be programmed freely within the specified boundaries, without the limitation of transition ranges commonly attributed to analog pulse generators.
SYMMertical	Discrete		Programs a special mode where the transitions are symmetrical for both the leading and trailing edges (lead time = trail time). In this case, the value of the lead-time is automatically attributed to the trail time and the value of the trail time has no effect on the pulse shape.

Response

The WS8352 will return FAST, LIN or SYMM depending on the present transition mode setting.

:PULSe:TRANsition<l_edge>(?)

Description

This command will program the interval it will take the leading edge of the pulse to transition from its low- to high-level settings. The parameter is programmed in units of seconds. Unlike analog pulse generators, the WS8352 can be programmed freely within the specified boundaries, without the limitation of transition ranges that are commonly attributed to analog pulse generators. Note that this parameter will affect the instrument only when the pulse transition mode is set to linear.

Parameters

Name	Range	Type	Default	Description
<l_edge>	1e-9 to 100e-3	Numeric	1e-3	Will set the leading-edge transition time parameter in units of seconds. Note that the sum of all parameters, including transition times, must not exceed the programmed pulse period.

Response

The WS8352 will return the present leading-edge transition time value in units of seconds.

:PULSe:TRANsition:PERCent<l_edge>(?)

Description

This command will program the interval it will take the leading edge of the pulse to transition from its low- to high-level settings. The parameter is programmed in units of percent of the pulse period. Note that this parameter will affect the instrument only when the pulse transition mode is set to linear and when the pulse configuration is programmed to percent.

Parameters

Name	Range	Type	Default	Description
<l_edge>	0.01 to 99.99	Numeric	10	Will set the leading-edge transition time parameter in units of %. Note that the sum of all parameters, including transition times must not exceed 100%.

Response

The WS8352 will return the present leading-edge transition time value in units of %.

:PULSe:TRANsition:TRAiling<t_edge>(?)

Description

This command will program the interval it will take the trailing edge of the pulse to transition from its high- to low-level settings. The parameter is programmed in units of seconds. Unlike analog pulse generators, the WS8352 can be programmed freely within the specified boundaries, without the limitation of transition ranges that are commonly attributed to analog pulse generators. Note that this parameter will affect the instrument only when the pulse transition mode is set to linear.

Parameters

Name	Range	Type	Default	Description
<T_edge>	1e-9 to 100e-3	Numeric	1e-3	Will set the trailing-edge transition time parameter in units of seconds. Note that the sum of all parameters, including transition times, must not exceed the programmed pulse period.

Response

The WS8352 will return the present trailing edge transition time value in units of seconds.

:PULSe:TRANsition:TRAiling:PERCent<t_edge>(?)

Description

This command will program the interval it will take the trailing edge of the pulse to transition from its high- to low-level settings. The parameter is programmed in units of percentages of the pulse period. Note that this parameter will affect the instrument only when the pulse transition mode is set to linear and when the pulse configuration is programmed to percent.

Parameters

Name	Range	Type	Default	Description
<l_edge>	0.01 to 99.99	Numeric	10	Will set the trailing-edge transition time parameter in units of %. Note that the sum of all parameters, including transition times, must not exceed 100%.

Response

The WS8352 will return the present leading edge transition time value in units of %.

:PULSe:WIDth<width>(?)

Description

This command will program the pulse width value. Figures 4-7 through 4-9 show how the pulse width affects the shape of the pulse. Note that the only case where the pulse width can exceed the value of the period setting is in triggered mode, where the trigger determines the period of the pulse.

Parameters

Name	Range	Type	Default	Description
<width>	2e-9 to 1	Numeric	2e-3	Will set the width of pulse in units of seconds. Note that the sum of all parameters, including the pulse width, must not exceed the programmed pulse period.

Response

The WS8352 will return the present pulse width value in units of seconds

:PULSe:WIDTh:PERCent<width>(?)

Description

This command will program the pulse width value. Figures 4-7 through 4-9 show how the pulse width affects the shape of the pulse. Note that this parameter will affect the instrument only when the pulse transition mode is set to linear and when the pulse configuration is programmed to percent.

Parameters

Name	Range	Type	Default	Description
<l_edge>	0.01 to 99.99	Numeric	20	Will set the pulse width parameter in units of %. Note that the sum of all parameters, including transition times, must not exceed 100%.

Response

The WS8352 will return the present leading edge transition time value in units of %.

Pulse Pattern Programming

Use the following commands for programming pulse pattern waveforms and their associated parameters. The patterns are created digitally. However, they closely simulate an analog pulse generator, so pulse pattern parameters are programmed just as they would be programmed on a dedicated pattern generator instrument. Just keep in mind that since this is a digital instrument, there are some limitations to the pattern design that evolve from the fact that the best resolution is one sample clock interval. Also, remember that the patterns are created digitally in the arbitrary memory and therefore, their smallest incremental step has a maximum value limitation, depending on the memory length, as specified in Appendix A.

Major consideration has been given to build in the capability to design special and complex pulse patterns, such as user-defined pulse patterns and Pseudo Random Bit Sequence.

The WS8352 pattern functionality is implemented as a stand alone Pattern Mode. In addition to RZ pulses, it allows the generation of pattern sequences that are using NRZ formatting with adjustable transition times. The pattern generation itself allows the definition of pattern sequences with 2, 3, 4 or 5 different level settings, which allows the emulation of electrical idle sequences as being required in several serial data protocols.

PRBS pattern is sequence of random patterns that can be used for testing and stressing bit receivers. PRBS is “pseudo” because it is deterministic and after N elements it starts to repeat itself, unlike real random sequences, such as sequences generated by radioactive decay or by white noise. PRBS's are used in telecommunication, encryption, simulation, correlation techniques and time-of-flight spectroscopy.

Figure 4-10 show an example of a digital pulse pattern that employs mixed fast and linear transitions. Figures 4-11 through 4-14 show the effect of level settings on the PRBS pattern. Commands and their associated definitions are given in the following. Note that the number of levels that are used during the pattern generation is being defined when creating a new pattern and cannot be changed afterwards.

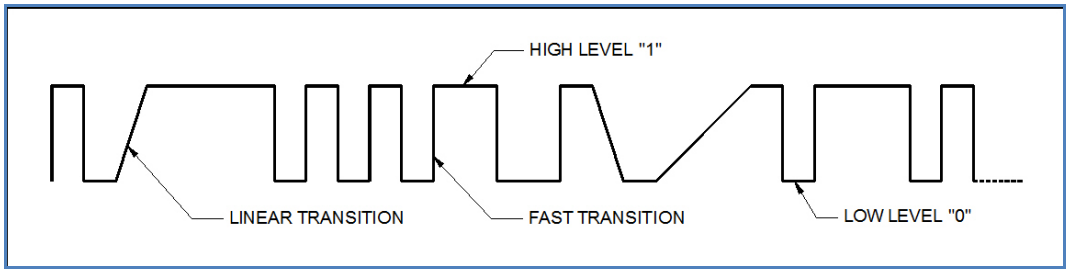

Figure 4-10, Composed Pulse Pattern with Mixed Fast and Linear transitions

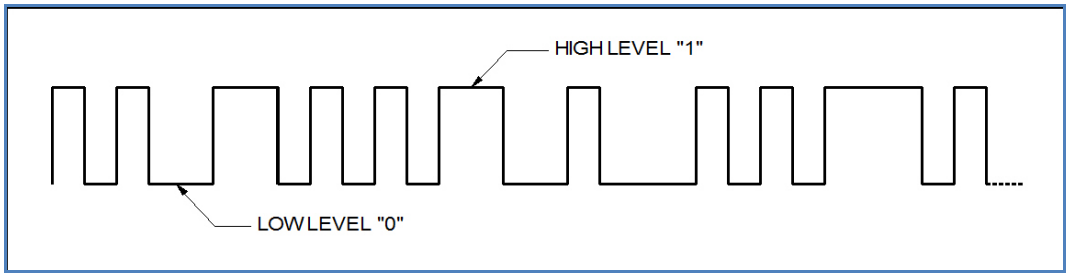

Figure 4-11, PRBS 2 Level Pattern Example

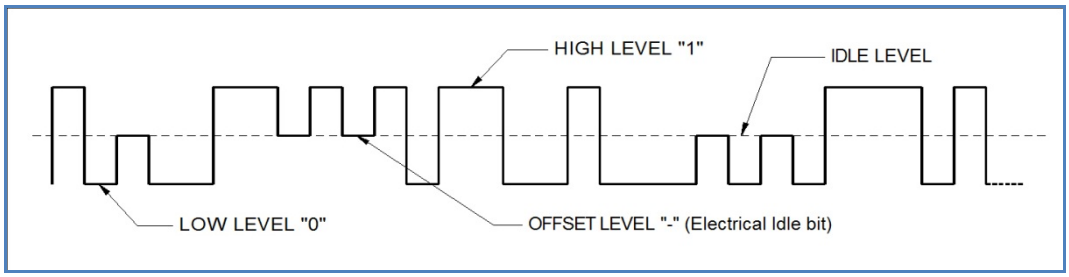

Figure 4-12, PRBS 3 Level Pattern Example

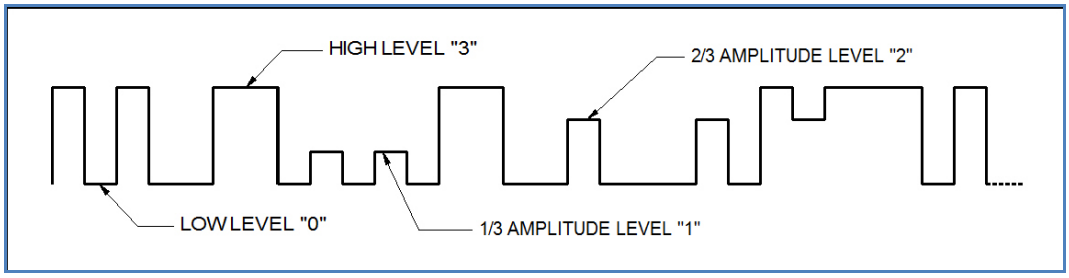

Figure 4-13, PRBS 4 Level Pattern Example

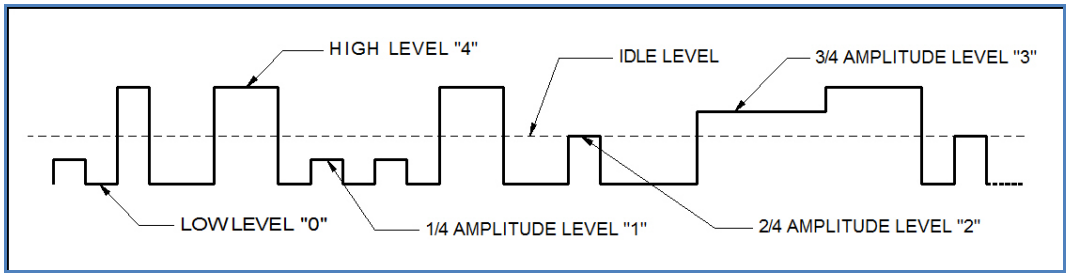

Figure 4-14, PRBS 5 Level Pattern Example

Table 4-9, Pulse Pattern Commands Summary

Keyword	Parameter Form	Default	Notes
:PATTern			
:MODE	PRBS | COMPosed	PRBS	
[: PRBS]			
:TYPE	PRBS7 | PRBS9 | PRBS11 | PRBS15 | PRBS23 | PRBS31 | USER	PRBS7	
:BAUD	10e-3 to 350e6	10e6	
:LEVel	2 | 3 | 4 | 5	2	
:HIGH	-2.5 to 2.5	1	
:LOW	-2.5 to 2.5	-1	
:LOOPs	1 to 1e6	1	
:PREamble	1 to 512e3	1	
:LENGth	1 to 512e3	32	
:DATA	#<header><data_array>		
:COMPosed			
:TRANsition			
:TYPe	FAST | LINear	FAST	Transition type
:FAST			
[:DATA]	#<header><data_array>		
:LINear			
:STARt	- 2 to +2	0.5	
[:DATA]	#<header><data_array>		
:RESolution	500e-12 to 100e-9	1e-9	
:TYPE	AUTO | USER	AUTO	

:PATTern:MODE{PRBS|COMPosed}(?)

Description

Use this command to set or query the type of pulse pattern that will be generated by the WS8352 output. There are 6 PRBS types and an additional user-defined PRBS type. The composed option provides access to special commands that lets you create any pattern and mix fast and linear transitions.

Parameters

Name	Type	Default	Description
PRBS	Discrete	PRBS	Selects one of 6 internal and one user-defined PRBS sequences. Patt:type selects the required PRBS type.
COMPoser	Discrete		Selects the free-programming pattern mode. Use this option if you intend to create complex digital patterns. These patterns can have fast or linear transitions, depending on the patt:comp:tran:type setting.

Response

The WS8352 will return PRBS or COMP depending on the present pattern mode setting.

:PATTern[:PRBS]:TYPE{ PRBS7 | PRBS9 | PRBS11 | PRBS15 | PRBS23 | PRBS31 | USER }(?)

Description

Use this command to set or query the type of PRBS sequence that will be generated by the WS8352 output. There are 6 PRBS types and an additional user-defined PRBS type. The sequence is generated by an internal PRBS generator. In continuous run mode, the sequence is repeated continuously but in triggered mode, the sequence is repeated until the patt:loop number has been reached.

Parameters

Name	Type	Default	Description
PRBS7	Discrete	PRBS7	Selects pseudo-random bit sequence that is generated internally from a polynomial series of 2e7 order.
PRBS9	Discrete		Selects pseudo-random bit sequence that is generated internally from a polynomial series of 2e9 order.
PRBS11	Discrete		Selects pseudo-random bit sequence that is generated internally from a polynomial series of 2e11 order.
PRBS15	Discrete		Selects pseudo-random bit sequence that is generated internally from a polynomial series of 2e15 order.
PRBS23	Discrete		Selects pseudo-random bit sequence that is generated internally from a polynomial series of 2e23 order.
PRBS31	Discrete		Selects pseudo-random bit sequence that is generated internally from a polynomial series of 2e31 order.
USER	Discrete		User programmable pseudo-random bit sequence that is generated from an external data file.

Response

The WS8352 will return PRBS7, PRBS9, PRBS11, PRBS15, PRBS23, PRBS31, or USER depending on the present pattern type setting.

:PATTern[:PRBS]:BAUD<baud >(?)

Description

Use this command to set or query the PRBS baud. PRBS baud is the rate of which each bit is sampled.

Parameters

Name	Range	Type	Default	Description
<baud>	10e-3 to 350e6	Numeric	10e6	Will set the PRBS baud in units of bits per second.

Response

The WS8352 will return the present baud value. The returned value will be in standard scientific format (for example: 100 ms would be returned as 100e-3 – positive numbers are unsigned).

:PATTern[:PRBS]:LEVel<level>(?)

Description

Use this command to set or query the PRBS voltage level setting. The effect of the level setting is demonstrated in Figures 4-10 to 4-14. The PRBS high and low levels determine the maximum amplitude swing while the PRBS levels parameter determine interim symbol levels.

Parameters

Name	Range	Type	Default	Description
<level>	2 to 5	Numeric (integer only)	2	Will set the symbol level, as demonstrated in Figures 4-10 to 4-14.

Response

The WS8352 will return the present PRBS symbol level value.

:PATTern[:PRBS]:LEVel:HIGH<high_level>(?)

Description

Use this command to set or query the high level voltage for the PRBS pattern. The pattern amplitude will swing from high to low level setting.

Parameters

Name	Range	Type	Default	Description
<high_level>	-2.50 to 2.50	Numeric	1	Will set the high level of the PRBS pattern in units of volts.

Response

The WS8352 will return the present PRBS high-level value. The returned value will be in standard scientific format (for example: 100 mV would be returned as 100e-3 – positive numbers are unsigned).

:PATTern[:PRBS]:LEVel:LOW<low _level>(?)

Description

Use this command to set or query the low level voltage for the PRBS pattern. The pattern amplitude will swing from high to low level setting.

Parameters

Name	Range	Type	Default	Description
<low_level>	-2.50 to 2.50	Numeric	-1	Will set the low level of the PRBS pattern in units of volts.

Response

The WS8352 will return the present PRBS low-level value. The returned value will be in standard scientific format (for example: 100 mV would be returned as 100e-3 – positive numbers are unsigned).

:PATTern[:PRBS]:LOOPs<cycle>(?)

Description

Use this command to set or query the number of PRBS patterns. Note that in continuous run mode, this parameter has no effect. In triggered run mode, the PRBS will start and repeat itself n times, depending on the loops value and then resume idle position.

Parameters

Name	Range	Type	Default	Description
<cycle>	1 to 1e6	Numeric (integer only)	1	Will set the number of cycles that the PRBS pattern will repeat following a trigger command.

Response

The WS8352 will return the present PRBS loops value.

:PATTern[:PRBS]:PREamble<count>(?)

Description

Use this command to set or query the number of PRBS patterns that will be used as preamble. This parameter is useful in triggered run mode where, after triggered, the PRBS preamble sequence will replay once only, followed by PRBS patterns that will repeat continuously or stopped by the count value. Normally, the preamble sequence is used for synchronization purpose and therefore, it must be created and controlled in a user-defined data file.

Parameters

Name	Range	Type	Default	Description
<count>	1 to 512e3	Numeric (integer only)	1	Will set the number of preamble patterns at the beginning of the PRBS sequence.

Response

The WS8352 will return the present PRBS preamble count value.

:PATTern[:PRBS]:LENGth<length>(?)

Description

Use this command to set or query the length of the PRBS patterns that will be allocated for downloading PRBS data using the patt:data command.

Parameters

Name	Range	Type	Default	Description
<length>	1 to 512e3	Numeric (integer only)	1	Will set the number of memory locations that will be allocated for the PRBS data.

Response

The WS8352 will return the present PRBS memory allocation value.

:PATTern[:PRBS]:DATA#<header><binary_block>

Description

This command will download an array of data for the user-defined PRBS pattern. The data is supplied to the generator in a form of binary characters, representing levels only. For example, 0,1,1,1,0,0,1,0 represents level 2 PRBS pattern; similarly, 1,2,0,3,3,-,1,-,2,-,4,0,0 contains all level which are associated with PRBS level 5 pattern. The data is provided as CHAR binary bytes that translate to ASCII levels 2, 3, 4 and 5. The translation to PRBS levels is done automatically by the generator so that users do not have to worry about setting levels as long as high and low levels are programmed prior to downloading the PRBS user data.

Parameters

Name	Type	Description
<header>	Discrete	Provides information on the size of the binary block that follows. Additional information on IEEE-488.2 arbitrary data downloads is available in earlier descriptions of data downloads. Contains PRBS pattern data strings.
<binary_block>	Binary	Block of binary data that contains PRBS pattern data strings. Each bit is represented by a single character (CHAR).

:PATTern:COMPosed:TRANsition:TYPE{FAST|LINear}(?)

Description

Use this command to set or query the type of transitions that the pulse composer will generate. You cannot mix fast and linear transitions if you select the fast mode however, if you select the linear mode, you can still generate pulses that have fast transitions. Note that this command has an effect on the pulse pattern only when the pattern mode option is COMP.

Parameters

Name	Type	Default	Description
FAST	Discrete	FAST	Using this option, the pulse composer can generate pulse patterns that have fast transitions only.
LINear	Discrete		Selects this option if you want ot mix fast and linear transitions in the pulse patter that you want ot compose.

Response

The WS8352 will return FAST or LIN depending on the present pattern transition setting.

:PATTern:COMPosed[:DATA]#<header><binary_block>

Description

This command will download an array of data for the built-in pulse composer. The composed data is made of 12 bytes. Figure 4-15 shows a pulse data parameter sequence that is acceptable for the WS8352.

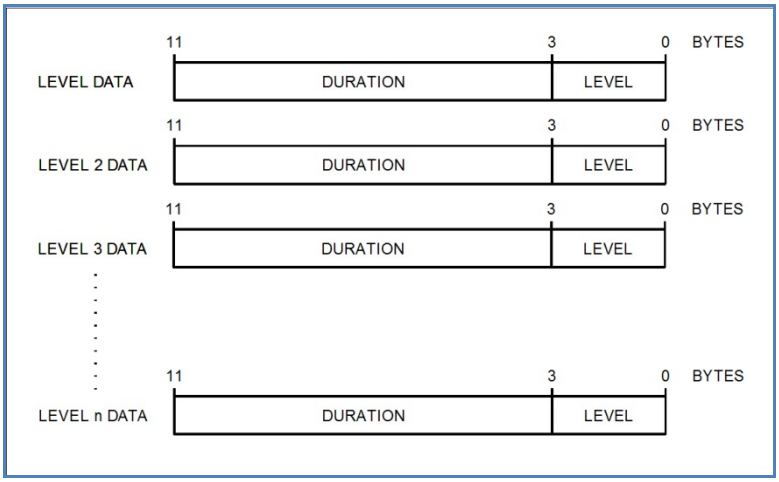

Figure 4-15: Composed "FAST" Pulse - Level Data Representation

Note in the above:

Pulse level data is provided in terms of level and duration only. The pulse will be built by defining the levels and the duration that the level dwells on itself.

Transitions between levels are FAST however, note the fastest transition that the output can generate is around 400 ps

Parameters

Name	Type	Description
<header>	Discrete	Provides information on the size of the binary block that contains pattern parameters data.
<binary_block>	Binary	Block of binary data that contains level and duration data, as explained and shown in Figure 4-15 above.

:PATTern:COMPosed:LINear:STARt<level>(?)

Description

Use this command to set or query the first level for the composed linear pulse. The first level is mandatory to place the first pulse level. Consequent data set the next pulse level and the duration that it will take for the level to transition from the first to the next level.

Parameters

Name	Range	Type	Default	Description
<level>	-2 to 2	Numeric	0	Will set the start level of the pulse waveform in units of volts.

Response

The WS8352 will return the present low-level value. The returned value will be in standard scientific format (for example: 100 mV would be returned as 100e-3 – positive numbers are unsigned).

:PATTern:COMPosed:LINear[:DATA]#<header><binary_block>

Description

This command will download an array of data for the built-in pulse composer. The composed data is made of 12 bytes. Figure 4-16 shows a pulse data parameter sequence that is acceptable for the WS8352. Figure 4-17 demonstrates how the pulse composer interprets the level and duration to generate linear transitions.

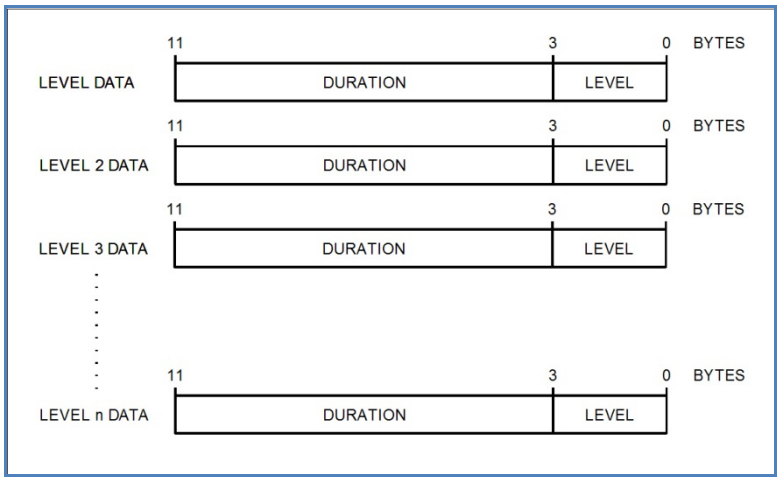

Figure 4-16, Composed Linear Pulse - Data Representation

Note in the above:

Pulse level data is provided in terms of level and duration only. The pulse will be built by defining the levels and the duration that the level transitions from last to next.

Note the fastest transition that the output can generate is around 400 ps

Note in Figure 4-17:

Initial level defines from what amplitude level the first transition will occur.

Final level 1 defines the slope of which the pulse will transition linearly and Duration 1 defines how long it will take for the amplitude to reach the end level.

The end level is automatically selected for the start level of the next transition.

Duration set to 0 generates fast transition. The fastest transition that the output can generate is around 400 ps

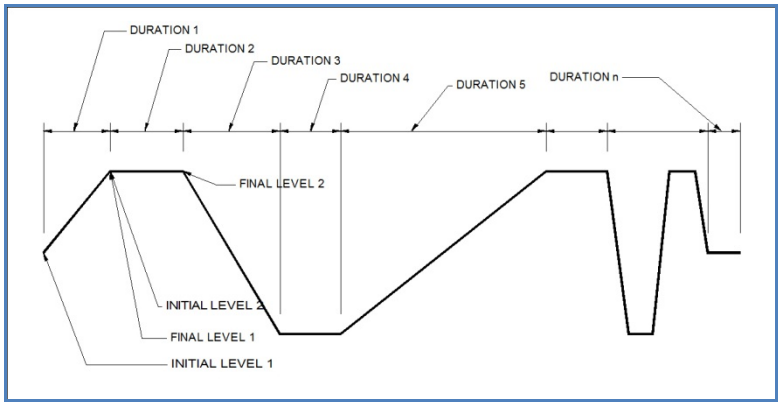

Figure 4-17, Composed Linear Pulse - Level Data Representation

Parameters

Name	Type	Description
<header>	Discrete	Provides information on the size of the binary block that contains pattern parameters data.
<binary_block>	Binary	Block of binary data that contains level and duration data, as explained and shown in Figure 4-16 above.

:PATTern:COMPosed:RESolution<resolution>(?)

Description

If patt:comp:res:type is set to user, you use this command to set or query the resolution that you prefer to build your linear waveform. Notice however, that fine resolution dictates many waveform data points and therefore, if you have slow transitions, make sure that your resolution allows for sufficient number of data points to build the waveform. When patt:comp:res:type is set to auto, the resolution will be set automatically by the machine and this command will not affect the output.

Parameters

Name	Range	Type	Default	Description
<resolution>	500e-12 to 100e-9	Numeric	1e-9	Will set the number of memory locations that will be allocated for the PRBS data.

Response

The WS8352 will return the present resolution value in units of seconds.

:PATTern:COMPosed:RESolution:TYPE{AUTO|USER}(?)

Description

Use this command to set or query the resolution type. If you do not want to bother with setting resolutions, select the auto option. Use the user option when you fully understand the implications of available waveform points and the amount of points that you require to build your linear transitions.

Parameters

Name	Type	Default	Description
AUTO	Discrete	AUTO	Using this option, the pulse composer will automatically select the best resolution to build the linear waveform.
USER	Discrete		Selects this option if you want to select the resolution that the linear transitions will increment when you build your required pulse.

Response

The WS8352 will return AUTO or USER depending on the present linear resolution type setting.

LAN System Configuration Commands

Use these commands to configure IP addresses and other LAN parameters. It is strongly recommended that this be done with a computer specialist, because incorrect programming may place the instrument in an unknown configuration which will not communicate as expected with the network. The LAN commands are summarized in Table 4-10.

Note

Last LAN configuration settings will remain as long as the instrument is turned on. New LAN configuration settings will take effect only after the instrument has been powered off and on.

Table 4-10, LAN Commands Summary

Keyword	Parameter Form	Default	Notes
:SYSTem			
:IP			
[:ADDRess]	<IP_address>		
:MASK	<mask>		
:GATeway	<gate_way>		
:BOOTp	OFF | ON | 0 | 1	0	
HOSTname:	<host_name>		
:KEEPalive			
:STATe	OFF | ON | 0 | 1	1	
:TIMEout	2 to 300	45	
:PROBes	2 to 10	2	

SYSTem:IP<ip_adrs>(?)

Description

This command programs the IP address for LAN operation. The same command is performed from the front panel Utility -> Remote Interface -> LAN menu. Note that after you use this command the power to the WS8352 must be recycled before the new address takes precedence.

Parameters

Name	Range	Type	Description
<ip_adrs>	0 to 255	String	Programs the IP address for LAN operation. The current IP address can be observed on the TCP/IP Network Properties display.

Response

The WS8352 will return the present IP address value similar to the following: 192.168.0.245

SYSTem:IP:MASK<mask_adrs>(?)

Description

This command programs the subnet mask address for LAN operation. The programming is performed from the front panel Utility -> Remote Interface -> LAN menu.

Parameters

Name	Range	Type	Description
<mask_adrs>	0 to 255	String	Programs the subnet mask address for LAN operation. Programming must be performed from the front panel. The current IP address can be observed on the TCP/IP Network Properties display.

Response

The WS8352 will return the present IP address value similar to the following: 255.255.255.0

SYSTem:IP:BOOTp{OFF|ON|0|1}(?)

Description

Use this command to toggle BOOTP mode on and off.

Parameters

Range	Type	Default	Description
0-1	Discrete	0	Toggles BOOTP mode on and off. When on, the IP address is administrated automatically by the system.

Response

The WS8352 will return 0 or 1, depending on the present BOOTP setting.

SYSTem:IP:GATeway<gate_adrs>(?)

Description

This command programs the gateway address for LAN operation. The programming is performed from the front panel Utility -> Remote Interface -> LAN menu.

Parameters

Name	Range	Type	Description
<gate_adrs>	0 to 255	String	Programs the gateway address for LAN operation. Programming must be performed from the front panel. The current IP address can be observed on the TCP/IP Network Properties display.

Response

The WS8352 will return the present IP address value similar to the following: 0.0.0.0

SYSTem:IP:HOSTname<name>(?)

Description

This command programs the host name address for LAN operation. The programming is performed in the factory and it is highly suggested that users do not change the host name without first consulting an Tabor customer service person.

Parameters

Name	Type	Description
<name>	String	Programs the host name for LAN operation.

Response

The WS8352 will return a string containing the host name. String length is 16 characters.

SYSTem:KEEPalive:STATe{OFF|ON|0|1}(?)

Description

Use this command to toggle the keep-alive mode on and off. The keep-alive mode assures that LAN connection remains uninterrupted throughout the duration of the LAN interfacing.

Parameters

Range	Type	Default	Description
0-1	Discrete	1	Toggles the keep-alive mode on and off. When on, the WS8352 constantly checks for smooth LAN connection at intervals programmed by the syst:keep:time command. The LAN will be probed as many times as programmed by syst:keep:prob parameter to check if there is an interruption in the LAN communication. When communication fails, the WS8352 reverts automatically to local (front panel) operation.

Response

The WS8352 will return 0 or 1, depending on the present keep-alive setting.

SYSTem:KEEPalive:TIMEout<time_out>(?)

Description

This command programs the keep-alive time-out. The keep-alive mode assures that LAN connection remains uninterrupted throughout the duration of the LAN interfacing.

Parameters

Name	Range	Type	Default	Description
<time_out>	2 to 300	Numeric	45	Programs the keep-alive time out in units of seconds. The time-out period is initiated when the LAN is idle for more than the time-out period. The LAN will be

probed as many times as programmed by syst:keep:prob parameter to check if there is an interruption in the LAN communication. When communication fails, the WS8352 reverts automatically to local (front panel) operation.

Response

The WS8352 will return the present keep-alive time-out value.

SYSTem:KEEPalive:PROBes<probes>(?)

Description

This command programs the number of probes that are used by the keep-alive sequence. The keep-alive mode assures that LAN connection remains uninterrupted throughout the duration of the LAN interfacing.

Parameters

Name	Range	Type	Default	Description
<probes>	2 to 10	Numeric	2	Programs the number of probes that are used by the keep-alive sequence. The time-out period is initiated when the LAN is idle for more than the time-out period and the LAN will be probed as many times as programmed by this parameter to check if there is an interruption in the LAN communication. When communication fails, the WS8352 reverts automatically to local (front panel) operation.

Response

The WS8352 will return the present keep-alive number of probes.

LXI Configuration Commands

LAN eXtensions for Instrumentation (LXI) allows for the user to control the instrument via a built in web interface. To use the web interface the user simply enters the ip address of the instrument into the web browser. Use these commands to configure the properties of the LXI functionality. The LXI configuration commands are summarized in Table 4-11.

Table 4- 11, LXI configuration commands

Keyword	Parameter Form	Default	Notes
:SYSTem			
:IP			
:MAC?			
:LXI			
:CLASs?			
:VERSion?			
:IDENtify			
[:STATE]	OFF | ON | 0 | 1		
:MDNS			
:ENABle	OFF | ON | 0 | 1		
:HNAMe			
[:RESolved]?			
:SNAMe			
:DESired	<Sname>		
[:RESolved]?			
:RESet			Reset the LAN settings
:RESTart			Restart the LAN interface

SYSTem:IP:MAC(?)

Description

Use this command to query the MAC address of the instrument

Response

The WS8352 will return the MAC address of the instrument.

SYSTem:LXI:CLASs?

Description

Use this command to query the instrument's LXI class

Response

The WS8352 will return the class value, in the case of model WS8352 the return value will be "C"

SYSTem:LXI:VERSion?

Description

Use this command to query the instrument's LXI version

Response

The WS8352 will return 1.2 with internal flash size of 16Mbyte or 1.4 with internal flash size of 32Mbyte.

SYSTem:LXI:IDENtify {OFF | ON | 0 | 1}(?)

Description

Use this command to turn the LXI Identify Indicator on the display on or off

Parameters

Range	Type	Default	Description
0-1	Discrete	0	Turns on or off the LXI indicator.

Response

The WS8352 will return 0 or 1 depending on the current LXI indicator state.

SYSTem: LXI:MDNS:ENABle{OFF | ON | 0 | 1}(?)

Description

Use this command to disable or enable the Multicast Domain Name System (mDNS)

Parameters

Range	Type	Default	Description
0-1	Discrete	0	Turn on or off the mDNS

Response

The WS8352 will return 0 or 1 depending on the current mDNS state.

SYSTem: LXI:MDNS:HNAMe?

Description

Use this command to query the resolved mDNS hostname

Response

The WS8352 will return the mDNS hostname.

SYSTem: LXI:MDNS:SNAMe:DESired<Sname>

Description

Use this command to set the desired mDNS service name

Parameters

Name	Type	Description
<Sname>	string	Sets the mDNS service name to the desired name

SYSTem: LXI:MDNS:SNAMe?

Description

Use this command to query the mDNS service name

Response

The WS8352 will return the mDNS service name.

SYSTem: LXI:RESet

Description

Us this command to reset the LAN settings to a known operating state, beginning with DHCP. If DHCP fails, it uses AutoIP. It also clears the WebUI password, if set.

SYSTem: LXI:RESTart

Description

Use this command to restart the LAN to the default settings as specified by the system LAN commands.

Store/Recall Commands

Use these commands to store instrument settings. The store command collects the current front panel setting and parameters and stores them in a dedicated memory cell. The store operation can include front panel settings and current waveforms but, due to memory limitations, you may select to keep settings only without waveforms or waveforms only without settings. The store/recall commands are summarized in Table 4-12.

Table 4-12, Store/Recall Commands Summary

Keyword	Parameter Form	Default	Notes
:SYSTem			
:STORe			
:CELL	1 to 9	1	
:CLEar			Clears memory cell
:CONFig	SETup | WAVE | ALL	ALL	
:TARGet	INTernal | USB	INT	
:UPDate			
:RECall			
:CELL	1 to 9	1	
:TARGet	INTernal | USB	INT	
:UPDate			

SYSTem:STORe:CELL<cell_number>(?)

Description

This command selects a memory cell. The selected memory cell will become the target for the store operation. You may select to store front panel settings, waveforms or both.

Parameters

Name	Range	Type	Description
<cell_number>	1 to 9	Numeric (integer only)	Selects an active memory cell number. Consequent store commands will affect this cell only.

Response

The WS8352 will return the active memory cell value.

SYSTem:STORe:CLEar

Description

Use this command to clear the content of a specific memory cell. This will prepare the memory cell to accept new setup and waveform data.

SYSTem:STORe:CONFig{SETup|WAVE|ALL}(?)

Description

Use this command to select what you intend to store in the active memory cell. The default setting is ALL. If you plan to save anything, make sure that the default setting is changed before you do a cell memory update.

Parameters

Name	Type	Default	Description
SETup	Discrete		Selects front-panel configuration to be stored in the active memory cell.
WAVE	Discrete		Selects the current arbitrary waveform to be stored in the active memory cell.
ALL	Discrete	ALL	Will store both front-panel configuration and waveform in the active memory cell.

Response

The WS8352 will return SET, WAVE, or ALL depending on the present configuration setting.

SYSTem:STORe:TARGet{INTernal|USB}(?)

Description

Use this command to select the target of your store operation. You may select between an internal flash memory that is limited in size and disk-on-key flash that you can attach to the front panel input. Selecting the internal option, you may store waveforms up to 100k long but external memory has no limitations except the physical size of the flash on the disk-on-key.

Parameters

Name	Type	Default	Description
INTernal	Discrete	INT	Selects the internal flash memory as the target for the store operation. Waveform size for this option is limited to 100k points.
USB	Discrete		Selects the front panel USB input as the target for the store operation. Waveform size for this option is limited only by the size of the disk-on-key flash.

Response

The WS8352 will return INT or USB, depending on the present store target setting.

SYSTem:STORe:UPDate

Description

Use this command to update the active memory cell with the front panel settings, waveforms, or both.

SYSTem:RECall:CELL<cell_number>(?)

Description

This command selects a memory cell. The selected memory cell will become the source for the recall operation. You may select to recall front panel settings, waveforms, or both.

Parameters

Name	Range	Type	Description
<cell_number>	1 to 9	Numeric (integer only)	Selects an active memory cell number. Consequent recall commands will affect this cell only.

Response

The WS8352 will return the active memory cell value.

SYSTem:RECall:TARGet{INTernal|USB}(?)

Description

Use this command to select the source of your recall operation. You may select between an internal flash memory that is limited in size and disk-on-key flash that you can attach to the front panel input. Selecting the internal option, you may recall waveforms up to 100k long, but external memory has no limitations except the physical size of the flash on the disk-on-key.

Parameters

Name	Type	Default	Description
INTernal	Discrete	INT	Selects the internal flash memory as the source for the recall operation. Waveform size for this option is limited to 100 k points.
USB	Discrete		Selects the front panel USB input as the source for the recall operation. Waveform size for this option is limited only by the size of the disk-on-key flash.

Response

The WS8352 will return INT or USB, depending on the present recall source setting.

SYSTem:RECall:UPDate

Description

Use this command to update the front panel and arbitrary memory with the information stored in the active memory cell.

The Store/Recall Folder Structure

Bear in mind that the flexibility of the embedded operating system within the WS8352 is not the same as the Windows OS and therefore, strict adherence to the folder and file structure are required for the store and recall operation. The following paragraphs explain how to create and maintain the correct folder and file images; this is done automatically when a USB stick is used and the store operation is done from the front panel.

The simplest option is of course to start with an empty stick. The folders must be placed in the root directory. Each setup is stored in a separate folder and each setup folder must have a unique name that associates itself with the cell number. The folder names are of the structure Setup'X' where X can be a number from 1 to 9. For example, folder name Setup1 is legal and corresponds to cell 1 but folder name Setup5_created_May_2011 is illegal. Figure 4-18 shows legal folder names for using the stored data on a USB stick.

In Figure 4-18, note that each setup is stored in a separate folder. Folders are named Setup1 through Setup2. Setup1 contains several files, some examples are Setup.txt, which includes instrument settings, w00001c1.wav through w00003c1 which contain waveforms coordinated in binary format for generating arbitrary waveforms, ahp_fix2, which contains the fixed amplitude hopping values list of channel 2. Instructions how to use setup file names is given in the following paragraphs.

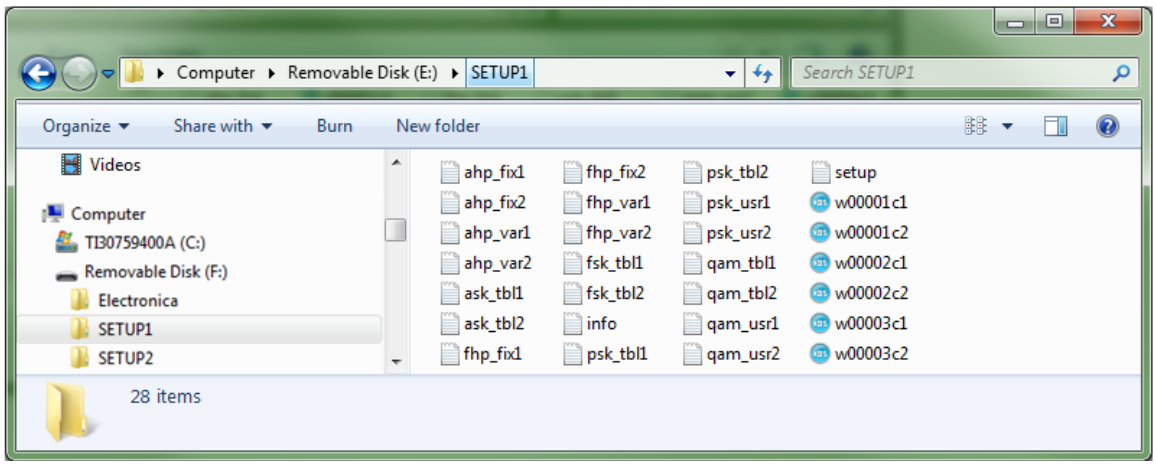

Figure 4-18, Store/Recall Folders Structure Example

The Store/Recall File Names

The setup folder contains files that are translated to instrument settings when downloaded to the WS8352. These files have specific and unique file names for the OS to be able to read them properly. Failure to name the files as requested and understood by the WS8352 will result in false expectations that the settings were loaded to the instrument. Therefore, use the names and extensions exactly as given below. Note that files containing parameter values contain the name of the parameter and the corresponding channel.

setup.txt - is the main image file name (case sensitive!). It contains the entire settings of the generator written as SCPI commands. The file can be written and edited using MS word or any other word processor but it must be saved as a text file without attributes and characters that are not recognized by the WS8352 OS. An example of this file can be seen in the following pages.

w0000Xc1.wav – is a binary file that contains arbitrary waveform coordinates in binary format. The "X" represents the segment number where this file is stored and "c1" corresponds to the instrument channel 1. Information how to create this file is given in this chapter. Another option to create this file easily is using the waveform composer in ArbConnection. Information how to use ArbConnection to generate an arbitrary waveform is given in a separate ArbConnection manual. Note in Figure 4-18 that three arbitrary waveform files are shown; each is downloaded to a different segment in channel 1.

info.txt - is a meta information text file. It contains information such as creation date, device model and device model id. Furthermore the file consists of the type of data to be restored, the 'Endianness' and 'Wave Data Format'. An example of this file can be seen below.

ahp_fix1.txt – is a text file that contains a list of amplitude hopping values for channel 1. Only one list is allowed per setup.

ahp_var1.txt – is a text file that contains a list of amplitude hopping values and their corresponding dwell time for channel 1. Only one list is allowed per setup.

ask_tbl1.txt – is a text file that contains a list of ASK values for channel 1. Only one list is allowed per setup.

fhp_fix1.txt – is a text file that contains a list of frequency hopping values for channel 1. Only one list is allowed per setup.

fhp_var1.txt – is a text file that contains a list of frequency hopping values and their corresponding dwell time for channel 1. Only one list is allowed per setup.

fsk_tbl1.txt – is a text file that contains a list of FSK values for channel 1. Only one list is allowed per setup.

psk_tbl1.txt – is a text file that contains a list of PSK values for channel 1. Only one list is allowed per setup.

psk_usr1.txt – is a text file that contains a list of user defined phase shift values for channel 1. Only one list is allowed per setup.

qam_tbl1.txt – is a text file that contains a list of QAM values for channel 1. Only one list is allowed per setup.

qam_usr1.txt – is a binary file that contains a list of random QAM values for channel 1. Only one list is allowed per setup.

Note that for channel 2 all parameter list files and waveform files names will be identical but will end with the channel number. For example seq_c2.

The Store/Recall File Structure

If you perform a store operation, the file shown below shows the entire configuration of the WS8352. Of course, the values may look differently but the contents of the file will be similar. You may use the file examples below to start exerting and compiling your external file. There are some guidelines that you can use, which will help you minimize the amount of work that you have to do; note the following:

1. The Setup file contains all of the commands that control the generator. The file below shows the parameters and configuration of the example setup. If you do not intend to change parameter values, reset the generator before the recall operation and then recall the stored cell. The instrument will change those parameters that are listed in the file and will not modify default values that need not be touched.
2. Colon (:) designates a command must follow. The pound signs designate remarks and are being ignored.
3. If the commands look familiar, this is because these are exactly the SCPI commands that are being used for remote programming. If you are familiar with the SCPI concept then it should be very easy for you to comprehend the usage of these commands.

4. Channel dependent commands are separated from commands that are common for both channels. It is recommended that the order of programming remain as in the Setup file but it is up to the user's discretion to rearrange the commands in an order more familiar or friendlier for his application.
5. Each arbitrary waveform is specified in the setup directory, bearing exactly the name format as specified above. The names of the file are defined so as to include the segment where they are to be located and the channel.
6. Following SCPI rules, commands can be used in short or long format.

Recall Setup3 Example

The Removable Disk folder structure is shown in Figure 4-19 and the setup, info, ahp_var2 files are given below. Note that there are three arbitrary waveform files w00001c1, w00002c1 and w00003c1.

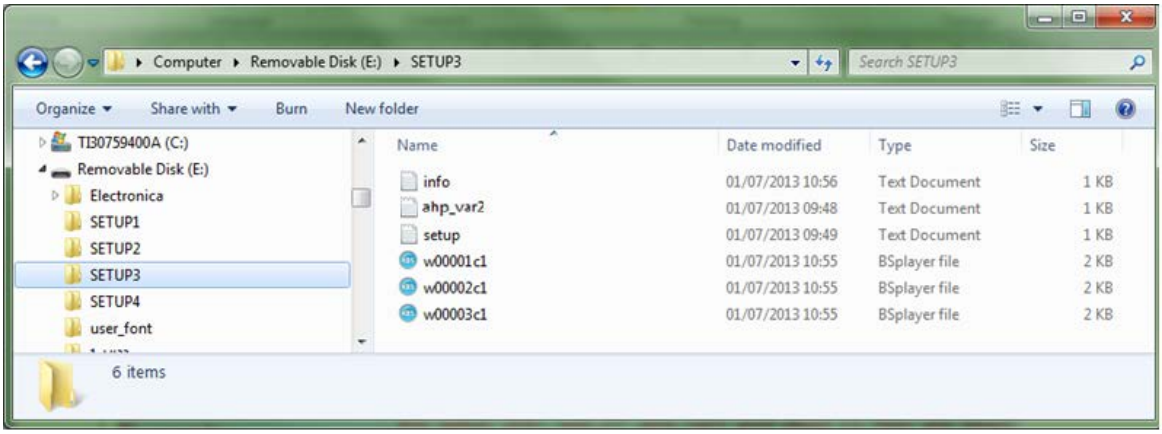

Figure 4-19, Setup3 Example Folder

Setup.txt

```
############ Configure Channel 2 ############
:INST:SEL 2 //Select channel 2

# Function Mode:
:SOUR:FUNC:MODE MOD  //Channel function mode is set to modulation

#MOdulation Config
:SOUR:MOD:TYPE AHOP  //Modulation type is set to amplitude hop
```

```
########### Configure Channel 1 ###########
:INST:SEL 1//Select channel 1

# Freq-Raster Config:

:SOUR:FREQ:RAST 1.2e+09 //Set SCLK to 1.2GS/s

# Function Mode:
:SOUR:FUNC:MODE USER //Set function mode to Arbitrary
:TRAC:SEL 3
```

Info.txt

```
DEVICE_VENDER: Tabor Electronics
DEVICE_MODEL: WS8352
DEVICE_MODEL_ID: 0x168C8352
DEVICE_SW_VER: 2.01
DATA_TYPE: All

ENDIANNESS: LITTLE_ENDIAN

WAVE_DATA_FORMAT: U14
```

ahp_var2.txt

```
# AHP hop-sections (with variable dwell-times)#
0.7 5e-06
1 7.5e-06
0.275 2.5e-06
```

The above Setup3 file when recalled from the front panel of the unit will do the following:

Channel1 – Will be set to Arbitrary mode with an SCLK of 1.2GS/s and segment 3 will be generated.

Channel2 – Will be set to modulation mode with an amplitude hop modulation type.

Please note that the comments written in the setup line after the SCPI command are for the benefit of the reader, and must not be written in the actual setup.txt file that is loaded to the unit.

Store Setup1 Example

The Removable Disk folder structure is shown in Figure 4-18 after the unit setup was stored on it. The setup, info and ahp_var1 files are given below. Note that there are six arbitrary waveform files and six digital arbitrary waveform files in this folder.

Model WS8352 Setup file format example

```
#################################################################
# Setup Config Script
# (each line is either comment line or SCPI command).
#
# Config parameters read from: TABOR WS8352 ver: 2.01
# Storing date: 2013/07/17 18:08:22
#################################################################


# Common Parameters:
:FORM:DATA SEP
:FORM:ARB:RES 1P
:SYST:POW DEF
:INST:COUP:OFFS 0
:INST:COUP:SKEW 0.000000e+00
:INST:COUP:STAT OFF
:OUTP:SYNC:SOUR CH1


########### Configure Channel 2 ###########

:INST:SEL 2

# ARM Config:
:ARM:SEQ:LEV 1.600000e+00
:ARM:SEQ:SLOP POS
:INIT:CONT:ENAB SELF
:INIT:CONT:ENAB:SOUR BUS
```

```
# TRIG Config:
:INIT:CONT:STAT ON
:INIT:GATE:STAT OFF
:TRIG:SEQ:COUN 1
:TRIG:SEQ:DEL 0
:TRIG:SEQ:FILT:HPAS:WIDT 1.000000e-01
:TRIG:SEQ:FILT:HPAS:STAT OFF
:TRIG:SEQ:FILT:LPAS:WIDT 1.000000e-03
:TRIG:SEQ:FILT:LPAS:STAT OFF
:TRIG:SEQ:HOLD 1.000000e-07
:TRIG:SEQ:HOLD:STAT OFF
:TRIG:SEQ:LEV 1.600e+00
:TRIG:SEQ:MODE NORM
:TRIG:SEQ:SLOP POS
:TRIG:SEQ:SOUR:ADV EXT
:TRIG:SEQ:TIM:MODE TIME
:TRIG:SEQ:TIM:DEL 76
:TRIG:SEQ:TIM:TIME 1.500000e-05

# Freq-Raster Config:
:SOUR:FREQ:RAST 1.200000000e+09
:SOUR:FREQ:RAST:SOUR INT
:SOUR:FREQ:RAST:DIV 1
:SOUR:ROSC:SOUR INT
:SOUR:ROSC:EXT:FREQ 1.000000000e+08

# Common Train Config:
:SOUR:VOLT:LEV:HV 5.000e-01
:TABL:LINE:READ:AMPL 5.000e-01
:SOUR:VOLT:LEV:OFFS 0.000e+00

# Standard-Wave Config:
:SOUR:FREQ:CW 1.000000000e+07
:SOUR:FUNC:SHAP SIN
:SOUR:SIN:PHAS 0.000
:SOUR:TRI:PHAS 0.000
:SOUR:SQU:DCYC 50.000
```

```
:SOUR:RAMP:DEL 10.000
:TABL:RAMP:TRAN:LEAD 60.000
:TABL:RAMP:TRAN:TRA 30.000
:TABL:SINC:NCYC 10
:SOUR:GAUS:EXP 10
:SOUR:EXP:EXP -10
:TABL:DC:OFFS 0.000

# Digital-Pulse Config:
:PULS:CONF TIME
:PULS:DEL 1.000000000e-03
:PULS:DEL:PERC 1.00e+01
:PULS:DOUB:DEL 1.000000000e-03
:PULS:DOUB:DEL:PERC 1.00e+01
:PULS:LEV:CONT HLOW
:PULS:LEV:HIGH 1.000
:PULS:LEV:LOW 0.000
:PULS:LEV:AMPL 1.000
:PULS:LEV:OFFS 0.500
:PULS:MOD SING
:PULS:POL NORM
:PULS:PER 1.000000000e-02
:PULS:TRAN:LEAD 1.000000000e-03
:PULS:TRAN:LEAD:PERC 1.00e+01
:PULS:TRAN:TRA 1.000000000e-03
:PULS:TRAN:TRA:PERC 1.00e+01
:PULS:TRAN:STAT FAST
:PULS:WIDT 2.000000000e-03
:PULS:WIDT:PERC 2.00e+01

# Pattern Generator Config:
:PATT:MODE COMP
:PATT:PRBS:TYPE USER
:PATT:PRBS:BAUD 1.00000000e+07
:PATT:PRBS:LEV 2
:PATT:PRBS:LEV:HIGH 1.000e+00
:PATT:PRBS:LEV:LOW -1.000e+00
```

```
:PATT:PRBS:LOOP 1
:PATT:PRBS:PRE 0
:PATT:PRBS:LENG 8
:PATT:COMP:TRAN:TYPE LIN
:PATT:COMP:LIN:STAR 5.000e-01
:PATT:COMP:RES 1.000000000e+09
:PATT:COMP:RES:TYP AUTO

# Arbitrary Modulations Config:
:SOUR:MOD:TYPE OFF
:TABL:MOD:CARR:FREQ 1.000000000e+06
:TABL:MOD:CARR:FUNC SIN
:TABL:AM:FUNC:SHAP SIN
:TABL:AM:INT:FREQ 1.000000000e+03
:TABL:AM:DEPT 50.000
:SOUR:FM:DEV 5.000000000e+05
:SOUR:FM:FUNC:SHAP SIN
:SOUR:FM:FREQ 1.000000000e+04
:SOUR:FM:MARK:FREQ 5.050000000e+05
:TABL:SWE:FREQ:STAR 4.000000000e+07
:TABL:SWE:FREQ:STOP 8.000000000e+07
:TABL:SWE:TIME 1.000000000e-05
:SOUR:SWE:DIR UP
:SOUR:SWE:SPAC LIN
:TABL:SWE:MARK:FREQ 6.000000000e+07
:TABL:CHIR:WIDT 1.000000000e-05
:TABL:CHIR:REP 2.500000000e-05
:SOUR:CHIR:FREQ:STAR 4.000000000e+07
:SOUR:CHIR:FREQ:STOP 8.000000000e+07
:TABL:CHIR:FREQ:DIR UP
:TABL:CHIR:FREQ:SPAC LIN
:TABL:CHIR:AMPL:DIR UP
:TABL:CHIR:AMPL:SPAC LIN
:SOUR:CHIR:AMPL:DEPT 5.000e+01
:TABL:CHIR:MARK:FREQ 6.000000000e+07
:SOUR:FSK:FREQ:SHIF 2.000000000e+06
:SOUR:FSK:BAUD 1.000000000e+04
```

```
:SOUR:FSK:MARK 1
:TABL:ASK:AMPL:STAR 0.500000
:SOUR:ASK:AMPL:SHIF 1.000000
:SOUR:ASK:BAUD 1.000000000e+04
:TABL:ASK:MARK 1
:SOUR:FHOP:DWEL:MODE VAR
:SOUR:FHOP:DWEL:TIME 5.000000000e-06
:TABL:FHOP:MARK 1
:TABL:AHOP:DWEL:MODE VAR
:SOUR:AHOP:DWEL:TIME 5.000000000e-06
:TABL:AHOP:MARK 1
:TABL:PSK:TYPE PSK
:SOUR:PSK:PHAS:STAR 0.00
:SOUR:PSK:PHAS:SHIF 180.00
:SOUR:PSK:MARK 1
:TABL:PSK:BAUD 1.000000000e+04
:TABL:PSK:CARR:STAT OFF
:SOUR:QAM:TYPE 16QAM
:TABL:QAM:CARR:STAT OFF
:TABL:QAM:BAUD 1.000000000e+04
:SOUR:QAM:MARK 1

# Active Segment:
:TRAC:SEL 3

# Sync Config:
:OUTP:SYNC:FUNC PULS
:OUTP:SYNC:POS:POIN 0
:OUTP:SYNC:WIDT 32

# Function Mode:
:SOUR:FUNC:MODE USER


########### Configure Channel 1 ###########

:INST:SEL 1
```

```
# ARM Config:
:ARM:SEQ:LEV 1.600000e+00
:ARM:SEQ:SLOP POS
:INIT:CONT:ENAB SELF
:INIT:CONT:ENAB:SOUR BUS

# TRIG Config:
:INIT:CONT:STAT ON
:INIT:GATE:STAT OFF
:TRIG:SEQ:COUN 1
:TRIG:SEQ:DEL 0
:TRIG:SEQ:FILT:HPAS:WIDT 1.000000e-01
:TRIG:SEQ:FILT:HPAS:STAT OFF
:TRIG:SEQ:FILT:LPAS:WIDT 1.000000e-03
:TRIG:SEQ:FILT:LPAS:STAT OFF
:TRIG:SEQ:HOLD 1.000000e-07
:TRIG:SEQ:HOLD:STAT OFF
:TRIG:SEQ:LEV 1.600e+00
:TRIG:SEQ:MODE NORM
:TRIG:SEQ:SLOP POS
:TRIG:SEQ:SOUR:ADV EXT
:TRIG:SEQ:TIM:MODE TIME
:TRIG:SEQ:TIM:DEL 76
:TRIG:SEQ:TIM:TIME 1.500000e-05

# Freq-Raster Config:
:SOUR:FREQ:RAST 1.000000000e+09
:SOUR:FREQ:RAST:SOUR INT
:SOUR:FREQ:RAST:DIV 1
:SOUR:ROSC:SOUR INT
:SOUR:ROSC:EXT:FREQ 1.000000000e+08

# Common Train Config:
:SOUR:VOLT:LEV:HV 5.000e-01
:TABL:LINE:READ:AMPL 5.000e-01
:SOUR:VOLT:LEV:OFFS 0.000e+00
```

```
# Standard-Wave Config:
:SOUR:FREQ:CW 1.000000000e+07
:SOUR:FUNC:SHAP SIN
:SOUR:SIN:PHAS 0.000
:SOUR:TRI:PHAS 0.000
:SOUR:SQU:DCYC 50.000
:SOUR:RAMP:DEL 10.000
:TABL:RAMP:TRAN:LEAD 60.000
:TABL:RAMP:TRAN:TRA 30.000
:TABL:SINC:NCYC 10
:SOUR:GAUS:EXP 10
:SOUR:EXP:EXP -10
:TABL:DC:OFFS 0.000

# Digital-Pulse Config:
:PULS:CONF TIME
:PULS:DEL 1.000000000e-03
:PULS:DEL:PERC 1.00e+01
:PULS:DOUB:DEL 1.000000000e-03
:PULS:DOUB:DEL:PERC 1.00e+01
:PULS:LEV:CONT HLOW
:PULS:LEV:HIGH 1.000
:PULS:LEV:LOW 0.000
:PULS:LEV:AMPL 1.000
:PULS:LEV:OFFS 0.500
:PULS:MOD SING
:PULS:POL NORM
:PULS:PER 1.000000000e-02
:PULS:TRAN:LEAD 1.000000000e-03
:PULS:TRAN:LEAD:PERC 1.00e+01
:PULS:TRAN:TRA 1.000000000e-03
:PULS:TRAN:TRA:PERC 1.00e+01
:PULS:TRAN:STAT FAST
:PULS:WIDT 2.000000000e-03
:PULS:WIDT:PERC 2.00e+01
```

```
# Pattern Generator Config:
:PATT:MODE COMP
:PATT:PRBS:TYPE USER
:PATT:PRBS:BAUD 1.00000000e+07
:PATT:PRBS:LEV 2
:PATT:PRBS:LEV:HIGH 1.000e+00
:PATT:PRBS:LEV:LOW -1.000e+00
:PATT:PRBS:LOOP 1
:PATT:PRBS:PRE 0
:PATT:PRBS:LENG 8
:PATT:COMP:TRAN:TYPE LIN
:PATT:COMP:LIN:STAR 5.000e-01
:PATT:COMP:RES 1.000000000e+09
:PATT:COMP:RES:TYP AUTO

# Arbitrary Modulations Config:
:SOUR:MOD:TYPE OFF
:TABL:MOD:CARR:FREQ 1.000000000e+06
:TABL:MOD:CARR:FUNC SIN
:TABL:AM:FUNC:SHAP SIN
:TABL:AM:INT:FREQ 1.000000000e+03
:TABL:AM:DEPT 50.000
:SOUR:FM:DEV 5.000000000e+05
:SOUR:FM:FUNC:SHAP SIN
:SOUR:FM:FREQ 1.000000000e+04
:SOUR:FM:MARK:FREQ 5.050000000e+05
:TABL:SWE:FREQ:STAR 4.000000000e+07
:TABL:SWE:FREQ:STOP 8.000000000e+07
:TABL:SWE:TIME 1.000000000e-05
:SOUR:SWE:DIR UP
:SOUR:SWE:SPAC LIN
:TABL:SWE:MARK:FREQ 6.000000000e+07
:TABL:CHIR:WIDT 1.000000000e-05
:TABL:CHIR:REP 2.500000000e-05
:SOUR:CHIR:FREQ:STAR 4.000000000e+07
:SOUR:CHIR:FREQ:STOP 8.000000000e+07
:TABL:CHIR:FREQ:DIR UP
```

```
:TABL:CHIR:FREQ:SPAC LIN
:TABL:CHIR:AMPL:DIR UP
:TABL:CHIR:AMPL:SPAC LIN
:SOUR:CHIR:AMPL:DEPT 5.000e+01
:TABL:CHIR:MARK:FREQ 6.000000000e+07
:SOUR:FSK:FREQ:SHIF 2.000000000e+06
:SOUR:FSK:BAUD 1.000000000e+04
:SOUR:FSK:MARK 1
:TABL:ASK:AMPL:STAR 0.500000
:SOUR:ASK:AMPL:SHIF 1.000000
:SOUR:ASK:BAUD 1.000000000e+04
:TABL:ASK:MARK 1
:SOUR:FHOP:DWEL:MODE VAR
:SOUR:FHOP:DWEL:TIME 5.000000000e-06
:TABL:FHOP:MARK 1
:TABL:AHOP:DWEL:MODE VAR
:SOUR:AHOP:DWEL:TIME 5.000000000e-06
:TABL:AHOP:MARK 1
:TABL:PSK:TYPE PSK
:SOUR:PSK:PHAS:STAR 0.00
:SOUR:PSK:PHAS:SHIF 180.00
:SOUR:PSK:MARK 1
:TABL:PSK:BAUD 1.000000000e+04
:TABL:PSK:CARR:STAT OFF
:SOUR:QAM:TYPE 16QAM
:TABL:QAM:CARR:STAT OFF
:TABL:QAM:BAUD 1.000000000e+04
:SOUR:QAM:MARK 1

# Active Segment:
:TRAC:SEL 3

# Sync Config:
:OUTP:SYNC:FUNC PULS
:OUTP:SYNC:POS:POIN 0
:OUTP:SYNC:WIDT 32
```

```
# Function Mode:
:SOUR:FUNC:MODE USER


########### Select Channel 2 ###########

:INST:SEL 2
```

Model WS8352 info file format example:

```
# SETUP1 meta information
# Creation date: 2013/07/17 18:08:22

DEVICE_VENDER: Tabor Electronics
DEVICE_MODEL: WS8352
DEVICE_MODEL_ID: 0x168C8352
DEVICE_SW_VER: 2.01

# The 'DATA_TYPE' is the type of data to restored.
# The choices are:
#  - 'Config' (configuration data).
#  - 'Wave'   (wave data).
#  - 'All'    (both config data and wave data).
#  - 'None'   (none).
# The default is: 'All'.
DATA_TYPE: All

# The 'ENDIANNESS' refers to the wave-data and digital-data.
# It can be either 'LITTLE_ENDIAN' ("Intel-format") or 'BIG_ENDIAN' ("Motorola-format").
# The default is: 'LITTLE_ENDIAN')
ENDIANNESS: LITTLE_ENDIAN

# The 'WAVE_DATA_FORMAT' is the format of wave-samples in the (binary) '.wav' files
# (those files consists of 16-bits-words, where each word contains single wave-sample).
# The choices are: 'U16', 'S16', 'U14', 'S14', 'U12', 'S12'
# Where U/S means Signed/Unsigned, and 12/14/16 is the number of bits (out of 16).
```

```
# For example, 'S14' means that the 14 less-significant bits of each
# 16-bits-word represents wave-sample's value as singed integer
# (the 14th bit is the sign-bit!).
# The default value is: 'U14'.
WAVE_DATA_FORMAT: U14
```

Model WS8352 ahp_var1 file format example:

```
#################################################################
# AHP hop-sections (with variable dwell-times)
# Storing Date: 2013/07/17 18:08:22
#################################################################
0.5 5e-06
1.25 7.5e-06
0.275 2.5e-06
```

System Commands

The system-related commands are not related directly to waveform generation but are an important part of operating the WS8352. Use these commands to reset the instrument and query its system settings.

Table 4-13, System Commands Summary

Keyword	Parameter Form	Default
:RESet (*RST)		
:SYSTem		
:ERRor?		
:LOCal		
:VERSion?		
:INFormation		
:CALibration?		
:MODel?		
:SERial?		
:HARDware?		
:POWerup	DEFault | SETup	DEF
*RST		
*TRG		
*OPC?		
*STB?		
*IDN?		
*OPT?		

RESet, or *RST

Description

This command will reset the WS8352 to its factory defaults.

SYSTem:ERRor?

Description

Query only. This query will interrogate the WS8352 for programming errors.

Response

The WS8352 will return error code. Error messages are listed below.

Error Messages

In general, whenever the WS8352 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.

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.

250,"Mass storage error". General error related to mass memory storage. Mass memory errors relate to the internal flash, working memory and external USB stick.

251,"Missing mass storage". This error will generate when attempting to store settings on an external USB stick but the media is not mounted.

252,"Write buffer overflow". This will occur when the writable buffer exceeds its limitation. Error relates to mass storage only.

253,"Cannot create a directory". Will be generated when the external media is incapable of creating a specific directory.

254,"Cannot delete file or directory". An attempt to delete a file or directory has failed.

255,"File extension not found". Store and recall files are expected to have certain extensions. Files that do not have the correct

extension will generate this error.

256,"File name not found". An attempt to read a file name that does not exist from an external media.

257,"File type not supported". Store and recall files are expected to have certain format. Files that do not have the correct format will generate this error.

258,"Invalid specified path". An unexpected file path encountered.

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.

301,”Digital Pulse-specific-error”. This is the generic device-dependent error for the instrument when it is attempting to construct a digital pulse but cannot detect more specific errors.

311,”Memory error”. Indicates that an error was detected in the instrument’s memory.

350,”Queue Overflow”. The error queue is full because more than 30 errors have occurred. No additional errors are stored until the errors from the queue are removed. The error queue is cleared when power has been shut off, or after a *CLS command has been executed.

410,”Query INTERRUPTED”. A command was received which sends data to the output buffer, but the output buffer contained data from a previous command (the previous data is not overwritten). The output buffer is cleared when power is shut off or after a device clear has been executed.

SYSTem:LOCal

Description

This command will deactivate the active interface and will restore the WS8352 to local (front panel) operation.

SYSTem:VERSion?

Description

Query only. This query will interrogate the WS8352 for its current firmware version. The firmware version is automatically programmed to a secure location in the flash memory and cannot be modified by the user except when performing firmware update.

Response

The WS8352 will return the current firmware version code in a format similar to the following: 1.15

SYSTem:INFormation:CALibration?

Description

Query only. This query will interrogate the instrument for its last calibration date.

Response

The generator will return the last calibration date in a format similar to the following: 24 Sep 2010 (10 characters maximum).

SYSTem:INFormation:MODel?

Description

Query only. This query will interrogate the instrument for its model number in a format similar to the following: WS8352-116. The model number is programmed to a secure location in the flash memory and cannot be modified by the user.

Response

The generator will return its model number WS8352-116, WS8352-132, WS8352-216, or WS8352-232.

SYSTem:INFormation:SERial?

Description

Query only. This query will interrogate the instrument for its serial number. The serial number is programmed to a secure location in the flash memory and cannot be modified by the user.

Response

The generator will return its serial number in a format similar to the following: 2xxxxx

SYSTem:INFormation:HARDware?

Description

Query only. This query will interrogate the instrument for its hardware revision level. The hardware revision includes: PCB revision, FPGA revision and FPLD revision. It is programmed to a secure location in the flash memory and cannot be modified by the user.

Response

The generator will return its hardware revisions in a format similar to the following: E, D, A

SYSTem:POWerup{DEFault|SETup}(?)

Description

Use this command to define how the WS8352 powers up. Normally, the instrument powers up with its parameters rest to factory default setting however, if one requires that the instrument powers up with its last setting, this could be changed using this command. Using the “SET” option is not recommended in conjunction with long waveform segments because the instrument powers down and then up only after the waveforms have been stored in its internal flash memory; an operation that may last very long.

Parameters

Name	Type	Default	Description
DEFault	Discrete	DEF	Selects the factory reset as the power up setting of the instrument.
SETup	Discrete		Selects the last setup before power down as the power up setting for the instrument.

Response

The WS8352 will return DEF or SET, depending on the present power up setting.

LAN, USB and GPIB Programming Considerations

The Model WS8352 can be programmed from one of three remote interfaces: LAN USB and GPIB. These interfaces not only differ by how they mechanically interface to the instrument but also they are very different in the way that the instrument reacts to their commands. For example, the generator does not require any LAN drivers to connect to a host computer but without a proper USB driver installed on the computer, the generator will not link and will not receive commands. There are also hardware issues that differ from interface to interface, for example, there is one standard in the market for the USB interface and driving hardware but, on the other hand, the GPIB standard being developed back in the early 80's of the last decade, triggered competition between vendors that lead to multiple and parallel development of GPIB interfaces and drivers and, by that, although there is one common standard (IEEE-488.2), each of the interfacing hardware reacts a bit different to commands and has its own peculiarities when it comes to timing, response and handshaking principals.

The model WS8352 is supplied with IVI.COM driver that has code examples and hence eliminates the need to deal with timing issues that are associated with the different interfaces and more specifically the driver examples already have the proper delays and pauses that are mandatory when using some of the GPIB cards so, if you are using the examples in the supplied driver, you'll probably have no problem whatsoever to control instrument parameters and download waveforms without getting into timing issues that will cause unpredictable behavior of the generator.

When the generator receives waveform coordinates or table data, the amount of data that is being transferred to the instrument is huge and can reach 128,000,000 words of data, if both channels are being written with waveform data. Waveform coordinates are being downloaded using special technique, which is described earlier in the manual so, it is important to remember that, compared to SCPI commands that may take a few milliseconds to program, downloading time of waveforms and table data is in the order of many seconds.

Some of the interfaces are not so forgiving when it comes to such differences in timing, especially when control commands are chained with waveforms and table data and therefore, one must install the proper control and suitable handshake that inhibits the flow of data till the generator is fully ready to accept the next command, query or waveform coordinates.

In general, the model WS8352 should always be ready to accept commands but bear in mind that commands are parsed, interpreted by the firmware and then distributed to various registers and internal

busses that control the instrument functions. Some of the commands trigger just one event but some commands have to access and set a huge bank of registers. For example, a *trg command flips one port but *rst has to access and reset hundreds of registers so, obviously, there will be timing issue if one expects that *trg and *rst take the same amount of time to execute.

The bottom line is that one must place proper delays and inhibits before and after each command or data download otherwise, the generator will miss data or generate errors that will interfere with its normal operation.

There is more than one way to delay commands; although undesired, one can place fixed delays in the program. For example, to make sure that the generator is ready to send a response to a query, it is simple to place a delay right after the query and interrogate the response right after the delay has lapsed. Simple but not efficient because, as was explained above, the response of the firmware differs from command to query so setting a general delay for example of 100 ms will be ok for one query but will slow the rest of the process unnecessarily.

A more efficient way to assure that the WS8352 is ready for the next command or query is to use the IEEE-488.2 status model. The status model is explained earlier in this manual but, in general, provides status registers that, if queried and dealt with correctly, eliminate unnecessary wait time entirely. In general, the status model is built around a status byte register (STB) that can be programmed to request service when a specific condition is true. For example, it can be programmed to tell you that the output queue is empty and ready for the next command or, it can be programmed to request service when an Operation Complete bit (OPC) has been set true.

The Status Model has been refined over the years and programmers may take advantage of this system when using the Instrument Class of GPIB, USB and LAN interfaces. This new class employs a ReadSTB function that reads the status byte register and is available for all message-based devices. Out of the above three interfaces, the GPIB interface chip is the only device that embeds the STB function as a hardware register so polling the status byte does not interrupt the firmware flow and hence the STB register can be queried continuously until a satisfying response is available. LAN and USB emulate the STB byte using a simulated register and hence, it is not recommended to continuously query the STB but wait till the status byte generates the expected status value.

There is also the problem of timeout. Different programs expect that certain operations do not exceed time limit that is set by the system. Often, programmers set this value vaguely without really investigating

what is the real timeout that is required to execute a command and, in some case, when an operation exceeds the programmed time out value, the instruments simply reports that it timed out and the reason is not always obvious to the programmer. Notice in the attached program that the timeout value is modified occasionally to match the require interval that is required to complete the operation safely.

The model WS8352 accepts four types of data from any remote interface:

Commands that set and program functions and parameters for the various inputs and outputs of the generator;

Commands that query current status or generator settings;

Data for generating arbitrary waveforms, and

Data for tables such as sequences and memory segmentation.

Commands that control instrument functions and parameters are programmed using Standard Commands for Programmable Instruments (SCPI commands). These are normally ASCII characters that are parsed and interpreted and converted by the firmware to control registers and serial trains. Generally, such commands are parsed in just a few milliseconds so command streams flow to the generator with practically no delays. This is true for command streams that do not exceed the input buffer size of 256 characters. However, commands chain that exceeds the size of 256 characters may chock the input buffer and therefore it is recommended that programs use short command strings. For example, one may use the following command string:

Inst:sel 1;:Func:mode user;:trac:def 1,10240;:trac:def 2, 20480;:trac:def 3, 348;:trac:sel 1;:volt 1.250;offs -0.350;:outp 1;:inst:sel 2;: Func:mode user;:trac:def 1,10240;:trac:def 2, 20480;:trac:def 3, 348;:trac:sel 1;:volt 1.250;offs -0.350;:outp 1

Depending on the speed of the computer and the interface that is being used, it is possible that the string will be executed properly however; one should not take the chance because it may cause timeouts and may not be executed properly. Better practice would be to send the commands one at a time or chain just short strings that will not overload the input buffer.

No delays between commands or status interrogation is required when using the following example:

```
Inst:sel 1
Func:mode user
trac:def 1,10240;def 2, 20480;def 3, 348; sel 1
volt 1.250;offs -0.350;:outp 1
Inst:sel 2
```

```
Func:mode user
trac:def 1,10240;def 2, 20480;def 3, 348; sel 1
volt 1.250;offs -0.350;:outp 1
```

So, the recommendation for sending SCPI commands is to keep them short as possible. Also, bear in mind that control commands should not be mixed with waveform data because data is transferred to the generator using special binary format that is routed directly to the arbitrary working memory and hence there is danger that, if interrupted unexpectedly, the transmission will either time out or, in extreme cases will lock out the interface and only power recycling will revive the generator.

An exception to the above recommendation is the *rst command. This command is usually sent at the beginning of a program to make sure that the instrument is programmed from its default setting. It is possible that a program modified just a few parameters but a hard reset does not care and has to access and process hundreds of settings and therefore the generator is not ready to accept any commands till all of its internal registers were reset. A fixed delay of around 1 to 2 seconds is sufficient to avoid hiccups but, if timing is crucial, it is also possible to use the STB register to discover when the generator has recovered all parameters and is ready for the next set of commands.

Queries which interrogate instrument settings and parameters delay certain interface activities when approaching registers that contain the required information. Depending on the current operation and the priority of certain processes of the generator, it is possible that the generator is inhibiting the response till it completes a critical and more important task so, in this case, it is recommended that the program does not intercept the output with a flow of queries and read cycles that are not critical to the operation of the instrument but wait for the generator to complete its more important tasks first.

The following example demonstrates bad practice when it comes to program and query instrument functions and parameters:

```
Inst:sel 1;:Func:mode fix;:func:shap squ;: squ:dcyc 30;:volt
1.250;:volt:offs -0.350;:outp 1
Inst:sel?;:Func:mode?;:func:shap?;:squ:dcyc?;:volt?;:volt:offs?;:outp?;
:syst:err?
```

Sending the string of commands in the above example should not be a problem and no delays are necessary between commands however, interrogating the generator continuously and without placing proper pauses may cause timeouts and therefore it is recommended that after each query, the STB register is read to assure that a response is

available and only then the response should be read. The following practice is recommended when using multiple queries:

*sre16 (enable service request on message available bit - MAV)
Query?
ReadSTB and wait till the response it 16
Read the response to the query

The above is recommended as general practice for all queries however, it is up to the programmer do decide if he wants to query parameters that he just programmed or eliminate all and just query the generator for errors only (syst:err?). It is also possible to place fixed delays after each query but this method is less efficient and may accumulate large and unnecessary delays in the program.

Programming the generator with waveform or table data is more of a challenge because there are two parts to this process: 1) the instrument is prepared with ASCII commands to a point where it is ready to receive waveform data and 2) download waveform data.

Sounds similar but, in fact, the two processes are completely different. The commands that prepare the generator for the download process are the same as any control commands; these are simple SCPI commands that select and define the segment number. An example of segment definition is shown below:

func:mode user
trac:sel 1
trac:def 1, 2048

The above simple example places the generator in arbitrary mode and selects and defines segment 1 to have a size of 2,048 words of waveform data.

The next command that starts the download process is trac#<data_array>. As explained earlier in this chapter, this command has two parts: 1) header, that tells the generator how many bytes are expected to be downloaded. The header part is delimited by the character “#” and 2) waveform data. The header is all ASCII but once the “#” is encountered, the generator reverts to binary mode and the CPU interface bus is rerouted to the arbitrary waveform memory so the interface has no control over bus activities till the entire waveform bytes have been transferred to the working memory and only then the CPU re-enables receipt of control commands over the interface.

It is important to understand that interrupting the binary download process while the firmware branched out to loop on the downloaded

data, and has no control over interface functions, will cause complete lockout of the interface and only recycling of the power will resume normal operation and therefore, it is recommended and shown in the C# example below how to prepare, control, download waveform data and wait for the generator to complete the processes in a way that will not cause timeouts or lockups.

One last recommendation is the use of CR (Carriage Return) and NL (New Line) in the program. As was mentioned before, LAN, USB and GPIB have different requirements, not only by definition of their relevant standard but also in the way that different interface vendors interpret the end or string. IEEE-488.2 standard has specific rules how to terminate a string of commands; the OEI (End or Identify) characters can be selected as hardware or software termination but this was true while the GPIB was used as the main interfacing options. Later arrivals in the interface arena were the USB and LAN of which behave differently than the GPIB interface. It is hard to define common rules for end termination that will uniformly satisfy all interfaces and therefore it is recommended that rules that were designed for the model WS8352 be observed while using one or another interfacing channel.

In general, CR character (\r) is not required and, in fact, removed from the IEEE-488.2 standard entirely however, it such character is programmed or received by the WS8352, it is ignored. GPIB is the only interface that can be set to accept hardware end of string but is not commonly used by programmers and therefore, the general recommendation for all USB, LAN and GPIB users is to terminate commands with NL character (\n) and expect that the end of response from the generator is the NL character (\n) as well.

C# Language - Example: Creating and downloading an Arbitrary Waveform

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;
using System.IO;
using System.Collections.ObjectModel;
using Ivi.Visa.Interop;
using IO488Extensions;
```

```
namespace downloadArbitraryWaveform
{
    public partial class Form1 : Form
    {
        ResourceManagerClass rm = new ResourceManagerClass();
        FormattedIO488Class fIO = new FormattedIO488Class();
        public Form1()
        {
            InitializeComponent();
            this.StartPosition = FormStartPosition.CenterScreen;
            textBox1.Text = "GPIB0::5::INSTR";
        }
        private void DownloadWaveformButton_Click(object sender, EventArgs e)
        {
            try
            {
                // Prepare the coordinates of an Arbitrary Waveform (sinewave)
                int iWaveLength = Convert.ToInt32(WaveLengthTextBox.Text);
                Collection<float> dataPoints = calculateSinusoidWaveform
                                    (iWaveLength, 1.5, 0);
                // Connect and identify the instrument
                string addressString = textBox1.Text;
                fIO.IO = (IMessage)rm.Open(addressString, AccessMode.NO_LOCK, 0,
                                    "Timeout = 10000");

                if (fIO.IO.HardwareInterfaceName == "GPIB" ||
                    fIO.IO.HardwareInterfaceName == "USB")
                {
                    // Enable the MAV bit in the Service Request Enable
                    // Register (SRE)
                    // of IEEE 488.2
                    fIO.WriteString("*CLS;*SRE16\n", true);
                }
                else if (fIO.IO.HardwareInterfaceName == "TCPIP")
                    fIO.IO.TerminationCharacterEnabled = true;
                // Reset the instrument
                fIO.WriteString("*RST\n", true);
                // Read the identification string of the discovered instrument
                // using the
                        // QueryString method. This method is extension method for
```

```
        // FormattedIO488Class
            // class and is implemented in the IO488QueryExtension class.
        string strDevID = fIO.QueryString("*IDN?\n", true);
        fIO.WriteString(":INST:SEL 1", true);
        // Set the ARBITRARY mode for channel 1
        fIO.WriteString(":FUNC:MODE USER", true);
        // Program instrument Parameters
        // Program the sample clock frequency
        fIO.WriteString(":FREQ:RAST 1.5E+08", true);
        // Program the amplitude
        fIO.WriteString(":VOLT 2", true);
        // Program the offset
        fIO.WriteString(":VOLT:OFFS 0", true);
        // Delete the segment table
        fIO.WriteString(":TRAC:DEL:ALL", true);
        // Download the Arbitrary Waveform as binary block
        SendDataToInstrument(dataPoints.ToArray(), 1);
        fIO.WriteString(":OUTP ON", true);
        fIO.IO.Close();
    }
    catch (Exception ex)
    {
        MessageBox.Show(ex.Message);
    }
}
private void SendDataToInstrument(float[] fDataPts, int segmentNumber)
{
    // Define a segment
    fIO.WriteString(":TRAC:DEF " + segmentNumber.ToString()
                + "," + fDataPts.Length.ToString(), true);
    // Select the pre-defined segment
    fIO.WriteString(":TRAC:SEL " + segmentNumber.ToString(), true);
    // DAC Values Conversion
    short[] dacValues = new short[fDataPts.Length];
    float fMin = fDataPts.Min();
    float fMax = fDataPts.Max();
    float fDiff = Math.Abs(fMax - fMin);
    byte[] bArray = new byte[fDataPts.Length * sizeof(short)];
    int cnt = 0;
    for (int i = 0; i < fDataPts.Length; i++)
    {
```

```
                if (i < fDataPts.Length)
                {
                    if (fDiff == 0)
                        fDataPts[i] = 0.0f;
                    else
                        fDataPts[i] = ((fDataPts[i] - fMin)/fDiff * (1 * 2))-1;
                    dacValues[i] = (short)Math.Floor((fDataPts[i]*2047)+2048.5);
                }
            else
                    dacValues[i] = 2048;
                // Convert DAC Values to Bytes
                byte[] temp = new byte[2];
                temp = BitConverter.GetBytes(dacValues[i]);
                // SWAPPING OF BYTES
                bArray[cnt++] = temp[0];
                bArray[cnt++] = temp[1];
            }
            // Download data (binary block) using the WriteIEEEBlock method.
              // This is an extension method for FormattedIO488Class class and
              // is implemented in the IO488WriteIEEEBlockExtension class
            fIO.WriteIEEEBlock(":TRACe:DATA ", bArray);
        }
        private Collection<float> calculateSinusoidWaveform(long lPoints,
        double dCycles, double dStartPhase)
        {
            double omega, phase, cycle;
            Collection<float> dataPoints = new Collection<float>();
            cycle = (double)(lPoints) / dCycles;
            // Calculate the start phase
            phase = (double)((double)(dStartPhase) * Math.PI / (double)180.0);
            // Calculate Omega
            omega = (double)(1.0 / lPoints * Math.PI * 2 * dCycles);
            for (long i = 0; i < lPoints; i++)
                dataPoints.Add((float)Math.Sin((omega * (double)i) + phase));
            return dataPoints;
        }
    }
}
using System;
using System.Collections.Generic;
```

```
using Ivi.Visa.Interop;
namespace IO488Extensions
{
   public static class IO488QueryExtension
   {
      private const short MAV = 0x10;
      private const long TIMEOUT = 8000; // 8s by default
      /*
       *  Query the MAV string
       */
       public static string QueryString(this FormattedIO488Class io,
       string format, bool flushAndEND)
      {
         io.WriteString(format, flushAndEND);
         return ReadString(io, true);
      }
      /*
       *  Read the MAV string
       */
      public static string ReadString(this FormattedIO488Class io,
      bool CheckMAVBit)
      {
         if (CheckMAVBit &&
            (io.IO.HardwareInterfaceName == "GPIB" ||
            io.IO.HardwareInterfaceName == "USB"))
         {
            short stb = 0;
            long endMilliseconds, startMilliseconds = DateTime.Now.Ticks /
            TimeSpan.TicksPerMillisecond;
            do
            {
               endMilliseconds = DateTime.Now.Ticks /
               TimeSpan.TicksPerMillisecond;
               if ((endMilliseconds - startMilliseconds) > TIMEOUT)
                  throw new Exception("IO488QueryExtension:
                  A timeout occurred");
               stb = io.IO.ReadSTB();
            } while ((stb & MAV) != MAV);
         }

         return io.ReadString();
```

```
    }
}
public static class IO488WriteIEEEBlockExtension
{
    private const int CHUNK_LENGTH = 32000;
    private const string OPERATION_COMPLETED = "1";
    /*
     *  WriteIEEEBlock
     */
    public static void WriteIEEEBlock(this FormattedIO488Class io,
    string Command,
                                object data)
    {
        if (io.IO.HardwareInterfaceName == "GPIB" ||
        io.IO.HardwareInterfaceName == "USB")
        {
            string answer = io.QueryString("*OPC?\n", true).TrimEnd('\n');
            if (answer.Equals(OPERATION_COMPLETED))
            {
                byte[] BinaryBlock = (byte[])data;
                // Make the binary block prefix
                string Digits = String.Format("{0}", BinaryBlock.Length);
                byte[] Header = ToByteArray(String.Format("{0} #{1}{2}",
                Command, Digits.Length, Digits));

                // Write a prefix of binary block to formatted I/O write
                // buffer.
                if (io.IO.Write(ref Header, Header.Length) == Header.Length)
                {
                    byte[] Chunk = new byte[CHUNK_LENGTH];
                    int Length;

                    for (int Start = 0; Start < BinaryBlock.Length;
                    Start += Chunk.Length)
                    {
                Length = Math.Min(Chunk.Length, BinaryBlock.Length - Start);

                        System.Buffer.BlockCopy(BinaryBlock,
                        Start, Chunk, 0, Length);
                        if (io.IO.Write(ref Chunk, Length) != Length)
```

```
                    {
                      throw new Exception("IO488WriteIEEEBlockExtension:
                      A buffer is not transmitted correctly");
                    }
                  }
                }
                else
                  throw new Exception("IO488WriteIEEEBlockExtension:
                  A buffer is not transmitted correctly");
              }
              else
                throw new Exception("IO488WriteIEEEBlockExtension:
                A device is not ready for the next command");
            }
            else if (io.IO.HardwareInterfaceName == "TCPIP")
            {
              io.WriteString("*OPC?\n", true);
              string answer = io.ReadString().TrimEnd('\n');

              if (answer.Equals(OPERATION_COMPLETED))
                io.WriteIEEEBlock(Command, data, true);
              else
                throw new Exception("IO488WriteIEEEBlockExtension:
                A device is not ready for the next command");
            }
            else
              io.WriteIEEEBlock(Command, data, true);
          }
          private static byte[] ToByteArray(string str)
          {
            System.Text.ASCIIEncoding enc = new System.Text.ASCIIEncoding();
            return enc.GetBytes(str);
          }
        }
      }
```

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 WS8352

***RST** - Resets the generator to its default state.

***TRG** - Triggers the generator from the remote interface. This command affects the generator if it is first placed in the Trigger or Burst mode of operation and the trigger source is set to "BUS".

***CLS** - Clear the Status Byte summary register and all event registers.

***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. 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.

***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.

***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.

***OPT?** - Returns the instrument option: 1 or 2.

Chapter 5
Performance Checks

Title **Page**

What's in This Chapter 5-3
Performance Checks 5-3
Environmental Conditions....5-3
Warm-up Period....5-3
Initial Instrument Setting 5-4
Recommended Test Equipment....5-4
Frequency Accuracy....5-4
Test Procedures 5-4
Frequency Accuracy, Internal Reference 5-5
Frequency Accuracy, External 100 MHz Reference....5-5
Frequency Accuracy, External Sample Clock 5-6
Amplitude Accuracy....5-7
Amplitude Accuracy 5-7
Offset Accuracy 5-8
Offset Accuracy....5-8
Square Wave Characteristics....5-9
Square Wave Checks 5-9
Sine Wave Characteristics 5-10
Sinewave Spectral Purity....5-10
Inter-Channel Propagation Characteristics 5-11
Offset Between Channels 5-11
Skew Between Channels....5-12
Run Mode Tests 5-13
Continuous Run Mode Test 5-13
Triggered Run Mode Test....5-14
Gated Run Mode Test....5-15
Trigger Inputs Tests....5-16
Front Panel Trigger Input Test....5-16
Rear Panel Event Input Test....5-17
Delayed Trigger Characteristics 5-18
Timed Internal Trigger Tests....5-19
Delayed Internal Trigger Tests 5-20
SYNC Output Operation....5-21

SYNC Output – Pulse 5-21
SYNC Output - WCOM 5-21
SYNC Source 5-22
SYNC Position Checks 5-22
SYNC Width Checks 5-23
Waveform Memory Operation 5-24
Waveform Memory 5-24
Internal Waveform 5-24
GPIB Control 5-25
USB Control 5-25
LAN Control 5-26

What's in This Chapter

This procedure provides performance tests necessary to validate the Model WS8352 Universal Waveform Generator.

WARNING

The procedures described in this section are for use only by qualified service personnel. Do not remove instrument covers as it may affect product characteristics and temperature.

CAUTION

ALWAYS PERFORM PERFORMANCE TESTS IN A STATIC SAFE WORKSTATION.

Performance Checks

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

1. As part of final validation;
2. As a part of the incoming inspection of the instrument specifications;
3. As part of the troubleshooting procedure;
4. 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 WS8352 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 WS8352 to factory defaults, use the Factory Rest option in the Utility menu.

Recommended Test Equipment

Recommended test equipment for troubleshooting, calibration and performance checking is listed in Table 5-1 below. Test instruments other than those listed may be used only if their specifications equal or exceed the required characteristics.

Table 5-1, Recommended Test Equipment

Equipment	Model No.	Manufacturer
Oscilloscope	DSA90604A	Agilent
Digital Multimeter	3458A	Agilent
Frequency Counter	53132A	Agilent
Spectrum Analyzer	N9010A	Agilent
Function Generator	33250A	Agilent
Signal Generator	N5181A	Agilent
Power Meter	N1913A	Agilent
Power Sensor	E9304A	Agilent

Frequency Accuracy

Frequency accuracy checks tests the accuracy of the generator using internal and external oscillator references. Both channels share the same reference oscillators and therefore, the accuracy is tested on channel 1 only.

Test Procedures

Use the following procedures to check the Model WS8352 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 5-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, Internal Reference

Equipment: Counter

Preparation:

1. Configure the counter as follows:
   Termination: 50Ω, DC coupled
2. Connect the WS8352 Channel 1 output to the counter input – channel 1
3. Configure the WS8352, channel 1 as follows:
   Waveform: Square wave
   Amplitude: 2V
   Output: On
   Frequency: As specified in Table 5-2

Test Procedure:

1. Perform frequency Accuracy tests using Table 5-2

Table 5-2, Frequency Accuracy

WS8352 Setting	Error Limits	Counter Reading	Pass	Fail
10 kHz	±10 mHz			
100 kHz	±100 mHz			
10 MHz	±10 Hz			
100 MHz	±100 Hz			
250 MHz	±250 Hz			

Frequency Accuracy, External 100 MHz Reference

Equipment: 100 MHz reference (at least 0.1ppm), Counter

Preparation:

1. Leave counter setting and WS8352 connections as in last test
2. Connect the 100 MHz reference oscillator to the WS8352 rear panel reference input
3. Configure the WS8352 channel 1 as follows:
   Ref Clock Source: External
   Waveform: Square wave
   Output: On
   Frequency: As specified in Table 5-3

Test Procedure

1. Perform frequency Accuracy tests using Table 5-3

NOTE

The external reference input accepts frequencies from 10 MHz to 100 MHz. This validation procedure recommends 100 MHz reference however, other reference frequencies may be used for this test but the external frequency value must be adjusted accordingly in the Clocks menu.

Table 5-3, Frequency Accuracy Using External 100 MHz Reference

WS8352 Setting	Error Limits	Counter Reading	Pass	Fail
10 MHz	±1 Hz			
100 MHz	±10 Hz			

Frequency Accuracy, External Sample Clock

Equipment: Signal Generator (at least 0.1ppm), Counter

Preparation:

1. Configure the counter as follows:
   Function: Frequency
   Gate Time: 1 ms
2. Connect the signal generator output to the rear-panel External SCLK input.
3. Configure the signal generator as follows:
   Amplitude: 0 dBm
   Frequency: As required by the test
4. Configure the WS8352 channel 1 as follows:
   Function: Arbitrary
   Waveform: Square wave, 1024 points, 256 cycles
   CH1 SCLK: EXT
   Ext SCLK Freq: As required by the test
   Divider: As required by the test
   CH1 Output: On

Test Procedure

1. Perform frequency Accuracy, external sample clock tests using Table 5-4.

NOTE

The external sample clock input accepts frequencies from 1 GHz to 4 GHz. Every time you change the external reference frequency, the EXT SCLK FREQ field in the Clocks menu must be set accordingly. Failure to set up the SCLK reference may result in output inaccuracies.

Table 5-4, Frequency Accuracy Using External Sample Clock

Signal Generator Setting	WS8352 Divider Setting	Counter Reading Limits	Counter Reading	Pass	Fail
1.8 GHz	1	225 MHz, ±22.5 Hz			
2.4 GHz	1	300 MHz, ±30 Hz			
4.0 GHz	1	500 MHz, ±50.0 Hz			
1.8 GHz	2	112.5 MHz, ±11.25 Hz			
3.2 GHz	16	25 MHz, ±2.5 Hz			
4.0 GHz	64	7.812500 MHz, ±0.78 Hz			
4.0 GHz	256	1.953125 MHz, ±0.19 Hz			

Amplitude Accuracy

Amplitude accuracy checks tests the accuracy of the output amplifier and attenuators in each channel separately.

Amplitude Accuracy

Equipment**:** DMM

Preparation:

1. Configure the DMM as follows:
   Function: ACV
   Range: As required by the test
2. Connect WS8352 Channel outputs to the DMM input
3. Configure the WS8352 as follows:
   Frequency: 10 kHz
   Outputs: On
   Amplitude: As specified in Table 5-5

Test Procedure

1. Perform amplitude Accuracy tests on both channels using Table 5-5

Table 5-5, Amplitude Accuracy

WS8352 Amplitude Setting	Error Limits	DMM Reading		Pass	Fail
		CH 1	CH 2		
4 V	1.414 mV, ±47 mV				

Offset Accuracy

Offset accuracy checks tests the accuracy of the offset generators. Each channel has its own set of offset generators and therefore, the accuracy is tested on each channel separately.

Offset Accuracy

Equipment**:** DMM

Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: As required by the test
2. Connect the WS8352 outputs to the DMM input
3. Configure the WS8352 as follows:
   Frequency: 1 MHz
   Amplitude: 100 mV
   Outputs: On
   Offset: As specified in Table 5-6

Test Procedure

1. Perform Offset Accuracy tests on both channels using Table 5-6.

Table 5-6, Offset Accuracy

WS8352 Offset Setting	Error Limits	DMM Reading		Pass	Fail
		CH 1	CH 2		
+1.5 V	1.5 V, ±80 mV				
+750 mV	750 mV, ±42.5 mV				
0 V	0 V, ±5 mV				
-750 mV	-750 mV, ±42.5 mV				
-1.5 V	-1.5 V, ±80 mV				

Square Wave Characteristics

This tests the characteristics of the square waveform. It includes transition times, aberrations and skew between channels. Each channel has its own set of amplifiers and attenuators and therefore, the characteristics are tested on each channel separately.

Square Wave Checks

Equipment: Oscilloscope

Preparation:

1. Configure the Oscilloscope follows:
   Setup: As required for the test
2. Connect WS8352 outputs to the oscilloscope input
   Configure the WS8352 as follows:
   Frequency: 1 MHz
   Waveform: Square wave
   Amplitude: 2 V
   Outputs: On

Test Procedure

1. Perform Square Wave Characteristics tests on both channels using Table 5-7.

Table 5-7, Square Wave Characteristics

Parameter Tested	Error Limits	Oscilloscope Reading		Pass	Fail
		CH 1	CH 2		
Rise/Fall Time	<1 ns				
Ringing	<10%				
Over/undershoot	<10%				

Sine Wave Characteristics

This tests the characteristics of the sine waveform. It includes distortions, spectral purity, spurs and flatness. Each channel has its own set of amplifiers and attenuators and therefore, the characteristics are tested on each channel separately.

Sinewave Spectral Purity

Equipment: Spectrum Analyzer, Balloon Adapter

Preparation:

1. Connect WS8352 outputs to the spectrum analyzer input.
2. Configure the WS8352 as follows:
   Amplitude: 3 V
   Function: Arbitrary
   Outputs: On
   Sample Clock: 2.0 GSa/s
   Waveform: Sine
   Frequency: 100 MHz (6,400 points, 320 cycles)

Test Procedure

1. Perform sinewave spectral purity tests using Tables 8 and 9. Note for testing sinewave harmonics, connect the Normal and inverted outputs through a balloon circuit (double input to single output).

Table 5-8, Sinewave Harmonics Test

WS8352 Freq Settings	Reading Limits	Spectrum Analyzer, Settings & Results				Pass	Fail
		Start	Stop	CH 1	CH 2		
100 MHz	-35 dBc	10 MHz	500 MHz				

Table 5-9, Sinewave Spurious Test

WS8352 Freq Settings	Reading Limits	Spectrum Analyzer, Settings & Results				Pass	Fail
		Start	Stop	CH 1	CH 2		
100 MHz	-75 dBc	10 MHz	1 GHz				

Inter-Channel Propagation Characteristics

This tests the offset and skew characteristics between the two channels.

Offset Between Channels

Equipment: Oscilloscope

Preparation:

1. Configure the Oscilloscope follows:
   Setup: As required for the test
2. Connect WS8352 outputs to the oscilloscope inputs
3. Configure the WS8352 as follows:
   Function: Arbitrary
   Waveform: Square, 1024 points, single cycle
   SCLK: 2 GSa/s
   SCLK Feed: Common
   Amplitude: 1 V
   Outputs: On
   Offset: 0 points

Test Procedure

1. Measure the initial Offset between the channels to be less than ±200 ps

Test Results	Pass		Fail	

2. Change CH2 -> offset to 64 points and verify offset reading on the oscilloscope is 32 ns ±200 ps
3. Restore CH2 -> Offset to 0 points
4. Change CH2 <- offset to 64 points and verify offset reading on the oscilloscope is 32 ns ±200 ps

Test Results	Pass		Fail	

Skew Between Channels

Equipment: Oscilloscope

Preparation:

1. Configure the Oscilloscope follows:
   Setup: As required for the test
2. Connect WS8352 outputs to the oscilloscope inputs
3. Configure the WS8352 as follows:
   Function: Arbitrary
   Waveform: Square, 1024 points, single cycle
   SCLK: 2.0 GSa/s
   SCLK Feed: Common
   Amplitude: 1 V
   Outputs: On
   Skew: 0 ns

Test Procedure

1. Measure the skew between the channels. Should be less than 200 ps. Record this value as reference for the next steps (T_0).

Test Results	Pass		Fail	

2. Change CH2 -> Skew to 1 ns and verify skew reading on the oscilloscope is 1 ns + T_0 ±120 ps.
3. Restore CH2 -> to 0 ns.
4. Change CH2 <- Skew to 1 ns and verify skew reading on the oscilloscope is 1 ns + T_0 ±120 ps.

Test Results	Pass		Fail	

Run Mode Tests

This tests the operation of the various run modes. There are three run modes: Continuous, Triggered and Gated. These tests do not challenge the individual inputs but only tests the operation of the standard functions in all three modes. Additional tests will be carried out on individual trigger inputs and on other instrument functions.

Continuous Run Mode Test

Equipment: Oscilloscope, Function Generator

Preparation:

1. Configure the oscilloscope follows:
   Setup: As required for the test
2. Configure the function generator as follows:
   Frequency: 1 MHz
   Amplitude: 2 V
   Offset: 1 V
   Run Mode: Triggered
3. Connect WS8352 outputs to the oscilloscope inputs
4. Configure the WS8352 as follows:
   Outputs: On
   Run Mode: Continuous
   Enable Mode: Armed
   Enable Source: TRIG

Test Procedure

1. Observe that there is no signals are generated at the WS8352 outputs.
2. Press MAN and observe that the WS8352 now generates 10 MHz sine waveforms.
3. Press the Abort soft key and observe that the signal is no longer generated.

Test Results	Pass		Fail	

4. Connect the function generator to the front panel trigger input.
5. Press the manual trigger button on the function generator and observe that the WS8352 generates 10 MHz sine waveforms.
6. Press the Abort soft key and observe that the signal is no longer generated.

Test Results	Pass		Fail	

7. Modify the WS8352 Enable Source to setting BUS and remove the function generator cable from the event input.
8. Generate *trg from remote and observe that the WS8352

generates 10 MHz sine waveforms.
9. Use a remote ABORt signal and observe that the signal is no longer generated.

Test Results	Pass		Fail	

Triggered Run Mode Test

Equipment: Oscilloscope, Function Generator, Counter

Preparation:
1. Configure the oscilloscope follows:
   Setup: As required for the test
2. Configure the function generator as follows:
   Frequency: 1 MHz
   Amplitude: 2 V
   Offset: 1 V
3. Connect WS8352 outputs to the oscilloscope inputs
4. Configure the WS8352 as follows:
   Outputs: On
   Run Mode: Triggered
   Trigger Source: EXT

Test Procedure
1. Observe that there is no signals are generated at the WS8352 outputs.
2. Press MAN and observe that the WS8352 generates a single 10 MHz sine waveform every time you press the button.
3. Connect the WS8352 channel 1 output to the counter input – channel 1.

Test Results	Pass		Fail	

4. Connect the function generator to the front panel trigger input.
5. Observe that the counter reading is 1 MHz (Accuracy is equal to the accuracy of the function generator output).

Test Results	Pass		Fail	

6. Modify the WS8352 Trigger Source to setting Event.
7. Connect the function generator to the rear panel event input.
8. Observe that the counter reading is 1 MHz (Accuracy is equal to the accuracy of the function generator output).

Test Results	Pass		Fail	

9. Modify the WS8352 Trigger Source to setting BUS and remove the function generator cable from the event input.
10. Program the counter to Totalize measurements.
11. Generate 10 events of *trg from remote and observe that the counter reading is 10.

Test Results	Pass		Fail	

Gated Run Mode Test

Equipment: Oscilloscope, Function Generator

Preparation:

1. Configure the oscilloscope follows:
   Setup: As required for the test
2. Configure the function generator as follows:
   Frequency: 100 kHz
   Amplitude: 2 V
   Offset: 1 V
3. Connect WS8352 outputs to the oscilloscope inputs
4. Configure the WS8352 as follows:
   Outputs: On
   Run Mode: Gated
   Frequency: 1 MHz

Test Procedure

1. Observe that there is no signals are generated at the WS8352 outputs.
2. Press MAN and observe that the WS8352 generates 10 MHz sine waveforms as long as you keep the MAN button depressed.

Test Results	Pass		Fail	

3. Connect the function generator to the front panel trigger input.
4. Observe that the WS8352 generates bursts of 10 MHz sine waveforms for roughly 5 μs and then DC.

Test Results	Pass		Fail	

Trigger Inputs Tests

This tests the operation of the individual trigger inputs. The WS8352 can accept trigger signals from a number of sources: Front panel trigger input, Rear panel event input, Internal trigger generator and remote trigger commands from a host computer. The characteristics of these inputs are checked using the following tests.

Front Panel Trigger Input Test

Equipment: Function Generator, Counter/Timer

Preparation:

1. Configure the counter to Period measurements.
2. Configure the function generator as follows:
   Frequency: 100 KHz
   Amplitude: 0.2 V
   Offset: -1 V
   Waveform: Square
3. Connect the function generator output to the WS8352 trigger input.
4. Connect the WS8352 outputs to the counter input – channel 1.
5. Configure the WS8352 as follows:
   Outputs: On
   Frequency: 1 MHz
   Run Mode: Triggered
   Trigger Level: As specified by the test
   Trigger Slope: As specified by the test

Test Procedure

1. Check the trigger level and slope operation using Table 5-10. Note that accuracy of the measurement is directly related to the accuracy of the function generator.

Table 5-10, Trigger Input Characteristics

WS8352 Trigger Level	81180 Trigger Slope	Counter Reading		Pass	Fail
		CH 1	CH 2		
-2 V	Positive	10 μs	10 μs		
-2 V	Negative	10 μs	10 μs		
-2 V	Either	5 μs	5 μs		

2. Modify the function generator offset setting to 1 V.
3. Continue with the trigger level and trigger slope tests using Table 5-11.

Table 5-11, Trigger Input Characteristics Checks, Continued

WS8352 Trigger Level	81180 Trigger Slope	Counter Reading		Pass	Fail
		CH 1	CH 2		
2 V	Positive	10 μs	10 μs		
2 V	Negative	10 μs	10 μs		
2 V	Either	5 μs	5 μs		

4. Modify the function generator frequency setting to 1Hz.
5. Configure the counter to Totalize measurements.
6. Modify the Count field as shown in Table 5-12 and continue with the counted burst tests using Table 5-12.

Table 5-12, Trigger Input Counted Burst Checks

WS8352 Trigger Count	Counter/Timer Reading		Pass	Fail
	CH 1	CH 2		
2	Counts multiples of 2	Counts multiples of 2		
10,000	Counts multiples of 10,000	Counts multiples of 10,000		
1,000,000	Counts multiples of 1,000,000	Counts multiples of 1,000,000		

Rear Panel Event Input Test

Equipment: Counter, Function Generator

Preparation:

1. Configure the counter to Period measurements.
2. Configure the function generator as follows:
   - Frequency: 100 KHz
   - Amplitude: 0.2 V
   - Offset: -1 V
   - Waveform: Square
3. Connect the function generator output to the WS8352 event input.
4. Connect WS8352 outputs to the counter input – channel 1.
5. Configure the WS8352 as follows:
   - Outputs: On
   - Frequency: 1 MHz
   - Run Mode: Triggered
   - Trigger Source: Event Input
   - Event Level: As specified by the test
   - Event Slope: As specified by the test

Test Procedure

1. Check the event level and slope operation using Table 5-13.

Table 5-13, Event Input Characteristics

WS8352 Event Level	81180 Event Slope	Counter Reading		Pass	Fail
		CH 1	CH 2		
-2 V	Positive	10 μs	10 μs		
-2 V	Negative	10 μs	10 μs		
-2 V	Either	5 μs	5 μs		

2. Modify the function generator offset setting to 1 V.
3. Continue with the event level and event slope tests using Table 5-14.

Table 5-14, Event Input Characteristics Checks, Continued

WS8352 Event Level	81180 Event Slope	Counter Reading		Pass	Fail
		CH 1	CH 2		
2 V	Positive	10 μs	10 μs		
2 V	Negative	10 μs	10 μs		
2 V	Either	5 μs	5 μs		

Delayed Trigger Characteristics

Equipment: Function generator, Oscilloscope

Preparation:

1. Configure the Function generator as follows:
   Frequency: 1 MHz
   Amplitude: 2 V
   Offset: 1 V
   Waveform: Square
2. Place a “T” BNC connector on the front panel trigger input connector. Connect one side of the “T” to the output connector of the function generator and the other side of the “T” to the oscilloscope input – channel 1
3. Connect the WS8352 outputs to channel 2 input of the oscilloscope.
4. Configure the counter to TI A to B measurements
5. Configure the WS8352 as follows:
   Function: Arbitrary
   SCLK: 2 GSa/s
   Waveform: Square, 1024 points, 1 cycle
   Run Mode: Triggered
   Delay: As required for the test
   CH1 Output: On
   SYNC: On

Test Procedure

1. Note and record the system delay with the WS8352 delay set

to 0 points. Always add the system delay value to the actual result.

2. Perform trigger delay tests using Tables 15. The delay is measured in reference to the SYNC output pulse.

Table 5-15, Trigger Delay Tests

WS8352 Delay Setting	Error Limits	Oscilloscope Reading		Pass	Fail
		CH1	CH2		
0	Reference, <150 ns				
1,024	Ref +512 ns, ±4 ns				
102,400	Ref +51200 ns, ±4 ns				
1,024,000	Ref +512000 ns, ±4 ns				

Timed Internal Trigger Tests

Equipment: Counter

Preparation:

1. Connect the WS8352 outputs to channel A input of the counter.
2. Configure the counter to Period measurements
3. Configure the WS8352 as follows:
   Frequency: 100 MHz
   Run Mode: Triggered
   Trigger Source: INT
   Trigger Mode: Timer
   Timer: As required for the tests
   Outputs: On

Test Procedure

1. Perform timed internal trigger tests using Table 5-16.

Table 5-16, Trigger Delay Tests

WS8352 Delay Setting	Error Limits	Counter Reading		Pass	Fail
		CH1	CH2		
200 ns	200 ns, ±0.02 ns				
100 μs	100 μs, ±10 ns				
100 ms	100 ms, ±10 μs				

Delayed Internal Trigger Tests

Equipment: Counter

Preparation:

1. Connect the WS8352 outputs to channel 1 input of the counter.
2. Configure the counter to pulse width. Set channel 1 slope to negative.
3. Configure the WS8352 as follows:

   Function: Arbitrary
   SCLK: 2 GSa/s
   Waveform: Square, 1024 points, 1 cycle
   Run Mode: Triggered
   Trigger Source: INT
   Trigger Mode: Delay
   Delay: As required for the tests
   Outputs: On

Test Procedure

1. Perform delayed internal trigger tests using Tables 17.

Table 5-17, Trigger Delay Tests

WS8352 Delay Setting	Error Limits	Counter Reading		Pass	Fail
		CH1	CH2		
1,024	768 ns, ±5 ns				
10,240	5376 ns, ±5 ns				
102,400	51456 ns, ±5 ns				

SYNC Output Operation

This tests the operation of the SYNC output. There are four parameters being tested: Type, Source, Position and Width. The sync output has fixed TTL level amplitude into an open circuit. Perform the SYNC Output Operation tests if you suspect that the SYNC output does not perform as expected.

SYNC Output – Pulse

Equipment: Oscilloscope

Preparation:

1. Configure the oscilloscope as follows:
   Setup: As required by the test
   Trigger Source: Channel 2
2. Connect WS8352 channel 1 output to the oscilloscope input
3. Connect WS8352 SYNC output to the oscilloscope channel 2 input
4. Configure model WS8352 as follows:
   CH1 Output: On
   SYNC: On

Test Procedure:

1. Verify trace on the oscilloscope shows sine waveforms and synchronization pulses at 100 ns intervals and pulse width is roughly 14 ns.

Test Results	Pass		Fail	

SYNC Output - WCOM

Equipment: Oscilloscope

Preparation:

1. Configure the oscilloscope as follows:
   Setup: As required by the test
   Trigger Source: Channel 2
2. Connect WS8352 channel 1 output to the oscilloscope input
3. Connect WS8352 SYNC output to the oscilloscope channel 2 input
4. Configure model WS8352 as follows:
   CH1 Output: On
   SYNC: On
   Run Mode: Triggered
   Trigger Source: Internal
   Trigger Count: 5

Test Procedure:

1. Verify trace on the oscilloscope shows sine waveforms and synchronization pulses. Verify that the SYNC pulse transitions to high level at the start address and transitions to low level at the end of the waveform.

Test Results	Pass		Fail	

SYNC Source

Equipment: Oscilloscope

Preparation:

1. Configure the oscilloscope as follows:
   Setup: As required by the test
   Trigger Source: Channel 1
2. Connect WS8352 SYNC output to the oscilloscope input, channel 1
3. Connect WS8352 channel 1 output to the oscilloscope input, channel 2
4. Connect WS8352 channel 2 output to the oscilloscope input, channel 3
5. Configure model WS8352 channel 1 and 2 controls as follows:
   Function: Arbitrary
   Waveform CH1: Sine, 384 points, 1 cycle
   Waveform CH2: Sine, 1024 points, 1 cycle
   Output: On
   SYNC: On

Test Procedure:

1. Verify that the trace on the oscilloscope is synchronized with the WS8352 channel 1 waveform

Test Results	Pass		Fail	

2. Modify the WS8352 SYNC Source from channel 1 to channel 2
3. Verify that the trace on the oscilloscope is synchronized with the WS8352 channel 2 waveform

Test Results	Pass		Fail	

SYNC Position Checks

Equipment: Oscilloscope

Preparation:

1. Configure the oscilloscope as required by the test.
2. Connect WS8352 main output to the oscilloscope – channel 1.
3. Connect WS8352 SYNC output to the oscilloscope – channel 2.
4. Configure the WS8352 as follows:
   Function: Arbitrary
   SCLK: 2.0 GSa/s

Waveform: Square, 512,000 points, 1 cycle
CH1 Output: On
SYNC: On
SYNC Position:: As required by the tests

Test Procedure

1. Check the SYNC position using Table 5-18. The position is referenced to the channel output. Note that there is a constant delay between the outputs and the SYNC that must be considered as part of the accuracy limits. The position in reference to the output waveform is programmed in units of sample clock periods (or waveform points).
2. Note and record the SYNC position with the WS8352 SYNC position set to 0 points. Always add the initial delay value to the actual result. Typically, the initial SYNC position delay is less than 3.5 ns.

Table 5-18, SYNC Position Tests

SYNC Position Setting	Error Limits	Oscilloscope Reading	Pass	Fail
0	Reference, <12 ns			
512	Ref + 256 ns, ±4 ns			
5,120	Ref + 2560 ns, ±4 ns			
51,200	Ref + 25600 ns, ±4 ns			

SYNC Width Checks

Equipment: Oscilloscope

Preparation:

1. Configure the oscilloscope as required by the test.
2. Connect WS8352 SYNC output to the oscilloscope input.
3. Configure the WS8352 as follows:

Function: Arbitrary
SCLK: 2.0 GSa/s
Waveform: Square, 512,000 points, 1 cycle
CH1 Output: On
SYNC: On
SYNC Width: As required by the tests

Test Procedure

1. Check the SYNC width using Table 5-19. The width is programmed in units of sample clock periods (or waveform points).

Table 5-19, SYNC Width Tests

SYNC Width Setting	Error Limits	Oscilloscope Reading	Pass	Fail
32	16 ns, ±2 ns			
512	256 ns, ±4 ns			
5,120	2560 ns, ±4 ns			
51,200	25600 ns, ±4 ns			

Waveform Memory Operation

This tests the integrity of the waveform memory and the control of the individual memory segments. The waveform memory stores the waveforms that are being generated at the output connector and therefore, flaws in the memory can cause distortions and impurity of the output waveforms. Each channel has its own working memory and therefore each channel is tested separately. Perform the waveform memory operation tests if you suspect that there are problems with the arbitrary waveform memory.

Waveform Memory

Equipment: Oscilloscope

Preparation:

1. Connect WS8352 outputs to the oscilloscope inputs. Configure the WS8352 as follows:
   Function: Arbitrary
   SCLK: 2.0 GSa/s
   Waveform: Sine, 512,000 points, 1 cycle
   Outputs: On
2. Using ArbConnection, build and download four segments to the WS8352, each 128 K long:
   Segment 1: Sine waveform, 128 K points, 1 cycle
   Segment 2: Triangle waveform, 128 K points, 1 cycle
   Segment 3: Square waveform, 128 K points, 1 cycle
   Segment 4: Sinc waveform, 128 K points, 1 cycle

Test Procedure

1. Set the oscilloscope to “Glitch Detect” and vary oscilloscope delay and offset to check flaws in the waveform shape. Do this on each of the four waveform segments.

Test Results	Pass		Fail	

Internal Waveform

Equipment: Oscilloscope

Preparation:

1. Connect WS8352 outputs to the oscilloscope inputs. Configure the WS8352 as follows:
   Function: Arbitrary
   SCLK: 2.0 GSa/s
   Segment 1: Sine, 1,024 points, 1 cycle
   Segment 2: Square, 1,024 points, 1 cycle
   Segment 3: Triangle, 1,024 points, 1 cycle
   Segment 4: Ramp, 1,024 points, 1 cycle
   Segment 5: SINC, 1,024 points, 1 cycle
   Outputs: On

Test Procedure

1. Select segments 1 through 5 and observe that the shape changes on the oscilloscope as programmed for each segment.

Test Results	Pass		Fail	

GPIB Control

Equipment: Spectrum Analyzer, ArbConnection

Preparation:

1. Set up the WS8352 for GPIB operation and connect the instrument to a host controller
2. Connect WS8352 Normal output to the distortion analyzer input.
3. Configure the WS8352 as follows:
   SCLK: 1,024 GSa/s
   Waveform: Arbitrary
   Output: On
4. Using ArbConnection prepare and download the following waveform:
   Waveform: 1,024 points, Sine wave, 1 cycle

Test Procedure

1. Check the resulting trace on the oscilloscope
2. Perform Sine wave distortion. It should be less than -55 dBc

Test Results	Pass		Fail	

USB Control

Equipment: Spectrum Analyzer, ArbConnection

Preparation:

1. Set up the WS8352 for USB operation and connect the instrument to a host controller
2. Connect WS8352 Normal output to the distortion analyzer input.
3. Configure the WS8352 as follows:
   SCLK: 1,024 GSa/s
   Waveform: Arbitrary
   Output: On
4. Using ArbConnection prepare and download the following waveform:
   Waveform: 1,024 points, Sine wave, 1 cycle

Test Procedure

1. Check the resulting trace on the oscilloscope
2. Perform Sine wave distortion. It should be less than -55 dBc

Test Results	Pass		Fail	

LAN Control

Equipment: Spectrum Analyzer, ArbConnection

Preparation:

1. Set up the WS8352 for LAN operation and connect the instrument to a host controller
2. Connect WS8352 Normal output to the distortion analyzer input.
3. Configure the WS8352 as follows:
   SCLK: 1,024 GSa/s
   Waveform: Arbitrary
   Output: On
4. Using ArbConnection prepare and download the following waveform:
   Waveform: 1,024 points, Sine wave, 1 cycle

Test Procedure

1. Check the resulting trace on the oscilloscope
2. Perform Sine wave distortion. It should be less than -55 dBc

Test Results	Pass		Fail	

Chapter 6
Programming Reference

Title **Page**

What's in This Chapter....6-2
Performance Checks....6-2
Environmental Conditions....6-2
  Warm-up Period....6-2
Recommended Test Equipment....6-3
Adjustment Procedures....6-3
Reference Oscillators Adjustments....6-6
  Baseline Offset Adjustments....6-7
  Amplitude Adjustments....6-8
  Offset Adjustments....6-8
  Pulse Response Adjustments....6-12
  High Frequency Delay Chain Adjustments....6-13
  Baseline Offset Adjustments....6-14
  Amplitude Adjustments....6-15
  Offset Adjustments....6-15
  Pulse Response Adjustments....6-19
  High Frequency Delay Chain Adjustments....6-20
  Channel 1 to Channel 2 Skew Balance....6-21
  Channel 1 to Channel 2 Skew Adjustment....6-24
  Inter channels Jitter Adjustment....6-24
Updating WS8352 Firmware....6-26

What's in This Chapter

This chapter provides adjustment information for the WS8352 Dual Channel Waveform Generator. The same procedures are used for the WS8352 except all references to the second channel should be ignored.

WARNING

The procedures described in this section are for use only by qualified service personnel. Some 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.

Performance Checks

Do not attempt to calibrate the instrument before you verify that there is no problem with the functionality of the product. A complete set of specifications is listed in Appendix A. If the instrument fails to perform within the specified limits, the instrument must be tested to find the source of the problem.

In case of a reasonable suspicion of an existing electrical problem within the WS8352, perform a complete performance check as described in Chapter 5, to verify proper operation of the instrument.

Environmental Conditions

The WS8352 can operate from 0°C to 50°C. Adjustments should be performed under laboratory conditions with an ambient temperature of 25°C, ±5°C and relative humidity of less than 80%. Turn on the power to the WS8352 and allow it to warm up for at least 30 minutes before beginning the adjustment procedure. If the instrument has been subjected to conditions outside these ranges, allow at least one additional hour for the instrument to stabilize before beginning the adjustment procedure.

Warm-up Period

Most equipment is subject to a small amount of drift when it is first turned on. To ensure accuracy, turn on the power to the Model WS8352 and allow it to warm-up for at least 30 minutes before beginning the performance test procedure.

Recommended Test Equipment

Recommended equipment for adjustments is listed in Table 6-1. Instruments other than those listed may be used only if their specifications equal or exceed the required minimal characteristics. Also listed below are accessories required for calibration.

Table 6-1: Recommended Calibration for Adjustments

Equipment	**Model No.**	**Manufacturer**
Oscilloscope	DSA90604A	Agilent
Digital Multimeter	3458A	Agilent
Frequency Counter	53132A	Agilent
Power Meter	N1913A	Agilent
Power Sensor	E9304A	Agilent
Accessories	SMA to BNC cables	
	SMB to BNC cables	
	BNC to BNC cables	
	50Ω Feedthrough termination	
	Dual banana to BNC adapter	

Adjustment Procedures

Use the following procedures to calibrate the WS8352. The following paragraphs show how to set up the instrument for calibration and what the acceptable calibration limits are.

Calibration is done with the covers closed and the WS8352 connected through an interface to a host computer. Any interface can be used from the following: USB, LAN, or GPIB. Calibration requires that external calibration utility be installed and interfaced to the instrument.

Calibration is performed from the Calibration Panel in **ArbConnection**. To invoke this panel, you need a password that is available to service centers only. Contact your nearest Tabor service center for information and permit to obtain your calibration password. Use the following procedure to calibrate the generator:

1. Invoke the calibration utility.
2. Click on the UTIL icon on the Panels bar.
3. On the Utility Panel click on Calibration and expect to be prompted with the following dialog box.

Figure 6-1: Calibration Password

4. Type your User Name Password and click on OK. The Calibration Panel as shown in Figure 2 will appear.

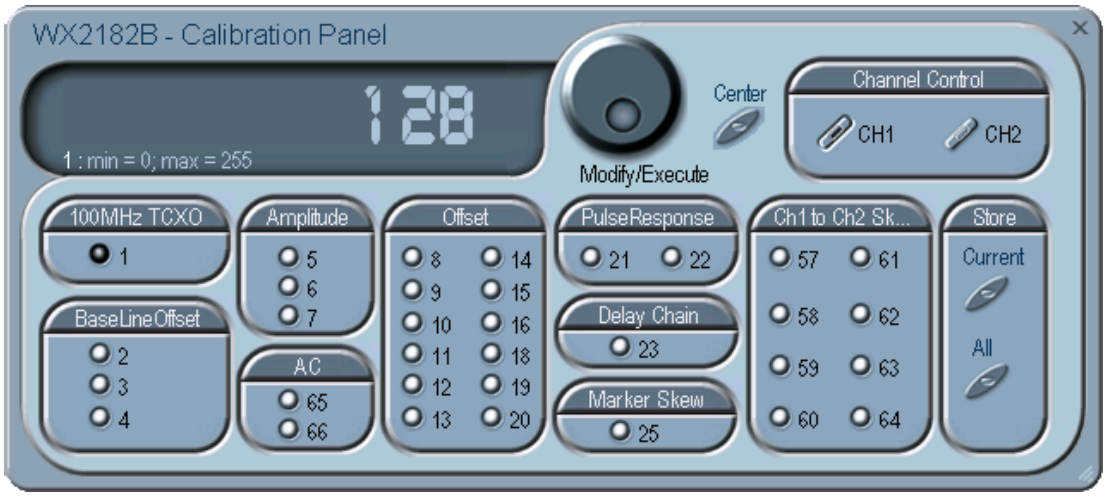

Figure 6-2: Calibration Panel Example

NOTE

Initial factory adjustments require that the covers be removed from the instrument. Field calibration does not require readjustments of these factory settings, unless the unit was repaired in an authorized service center. Factory adjustments are enclosed in parentheses to differentiate from normal field calibration setups. Bypass these adjustments when performing field calibration.

Calibrations are marked with numbers from 1 to 24 and should be carried out exactly in the order as numbered on the panel. There are separate adjustments for Channel 1 and Channel 2, so make sure that the output cables are connected to the appropriate channel during the adjustments.

The numbers that are associated with each adjustment are identified as Setup Number at the title of each of the adjustments in the following procedure.

Remote adjustments have the range of 1 through 256 with the center alignment set to 128. Therefore, if you are not sure of the direction, set the adjustment to 128 and add or subtract from this value. If you have reached 1 or 256 and were not able to calibrate the range, there is either a problem with the way you measured the parameter or possibly there is a problem with the instrument. In either case, do not leave any adjustment in its extreme setting, but center the adjustment and contact your nearest service center for clarifications and support.

NOTE

Software rest is mandatory before every adjustment.

Reference Oscillators Adjustments

Use this procedure to adjust the reference oscillators. The reference oscillators determine the accuracy of the output frequency, so if you suspect that there is an accuracy issue, proceed with the calibration of the reference oscillators.

Setup 1

100 MHz TCXO Frequency

Equipment: Counter

Preparation:

1. Configure the counter as follows:
   Function: Frequency
2. Connect the WS8352 Channel 1 output to the counter input.
3. Configure the WS8352 as follows:
   Frequency: 100 MHz
   CH1 Output: On

Adjustment:

1. Adjust CAL:SETUP1 for counter reading of 100 MHz, ±20 Hz

Channel 1 Adjustments

The following procedures pertain to the channel 1 output only. Therefore, make sure that your connections are made to the channel 1 connectors.

Baseline Offset Adjustments

The baseline offset adjustments assure that the AC signal is symmetrical around the 0V line. Use this procedure if you suspect that there is a baseline accuracy issue.

Setup 2

Output Amplifier Offset and DC Paths

Equipment: DMM

Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 100 mV
2. Connect the WS8352 Channel 1 normal output center pin to the "+" input of the DMM and connect the channel 1 inverted output center pin to the "-" input of the DMM.
3. Configure the WS8352 as follows:
   CH1 Output: ON
   Run Mode: Triggered
   Amplitude: 100 mV

Adjustment:

1. Adjust RV5 for DMM reading of 0 V, ±2 mV, measured differentially between the normal and inverted outputs.
2. Remove the DMM wires and reconnect only channel 1 output to the DMM. Use banana adapter to connect the DMM. Adjust CAL:SETUP2 for a DMM reading of 0 V, ±2 mV.
3. Remove the DMM wires and reconnect as in step 1. Readjust RV5 for DMM reading of 0 V, ±2 mV.

Setup 3

Pre-Amplifier Offset

Equipment: DMM

Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 100 mV
2. Connect the WS8352 Channel 1 normal output center pin to the "+" input of the DMM and connect the channel 1 inverted output center pin to the "-" input of the DMM.
3. Configure the WS8352 as follows:
   CH1 Output: ON
   Run Mode: Triggered
   Amplitude: 4V

Adjustment

1. Adjust CAL:SETUP3 for DMM reading of 0 V, ±10 mV (measured differentially between the normal and inverted outputs).
2. Remove the connections from the DMM and connect the channel 1 normal output with a BNC to banana cable to the DMM input. Adjust RV1 for a DMM reading of 0 V, ±10 mV.

Amplitude Adjustments

The amplitude adjustments assure that the AC levels are within the specified range. Use this procedure if you suspect that the amplitude accuracy is an issue.

Setup 5

Amplitude

Equipment: DMM

Preparation:

1. Configure the DMM as follows:
   Function: ACV
   Range: 2 mV
2. Connect the WS8352 Channel 1 output to the DMM input.
3. Configure the WS8352 as follows:
   CH1 Output: ON
   Frequency: 10 kHz
   Amplitude: 4V

Adjustment

1. Adjust CAL:SETUP5 for DMM reading of 1.414V ±20 mV

Offset Adjustments

The offset adjustments assure that the DC offsets are within the specified range. Use this procedure if you suspect that the offset accuracy is an issue.

Setup 8

+500 mV Offset

Equipment: DMM
Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +500 mV
   CH1 Output: On

Adjustment:
1. Adjust CAL:SETUP8 for DMM reading of +500 mV, ±10 mV.

Setup 9 +600 mV Offset

Equipment: DMM
Preparation:
1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +600 mV
   Output: On

Adjustment:
1. Adjust CAL:SETUP9 for DMM reading of +600 mV, ±10 mV.

Setup 10 +700 mV Offset

Equipment: DMM
Preparation:
1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +700 mV
   Output: On

Adjustment:
1. Adjust CAL:SETUP10 for DMM reading of +700 mV, ±10 mV.

Setup 11 +800 mV Offset

Equipment: DMM
Preparation:
1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +800 mV
   Output: On

Adjustment:
1. Adjust CAL:SETUP11 for DMM reading of +800 mV, ±10 mV.

Setup 12 — +900 mV Offset

Equipment: DMM
Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 50mV
   Offset +900mV
   CH1 Output: On

Adjustment:

1. Adjust CAL:SETUP12 for DMM reading of +900 mV, ±10 mV.

Setup 13 — +1 V Offset

Equipment: DMM
Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +1 V
   CH1 Output: On

Adjustment:

1. Adjust CAL:SETUP13 for DMM reading of +1 V, ±10 mV.

Setup 14 — +1.2 V Offset

Equipment: DMM
Preparation:

4. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
5. Connect the WS8352 output to the DMM input.
6. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +1.2 V
   CH1 Output: On

Adjustment:

2. Adjust CAL:SETUP14 for DMM reading of +1.2 V, ±10 mV.

Setup 15

+1.4 V Offset

Equipment: DMM
Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +1.4 V
   CH1 Output: On

Adjustment:

1. Adjust CAL:SETUP15 for DMM reading of +1.4 V, ±10 mV.

Setup 16

+1.5 V Offset

Equipment: DMM
Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +1.5 V
   CH1 Output: On

Adjustment:

1. Adjust CAL:SETUP16 for DMM reading of +1.5 V, ±10 mV.

Setup 18

-500 mV Offset

Equipment: DMM
Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset -500 mV
   CH1 Output: On

Adjustment:

1. Adjust CAL:SETUP18 for DMM reading of -500 mV, ± 10 mV.

Setup 19

-1 V Offset

Equipment: DMM
Preparation:
1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset -1 V
   CH1 Output: On

Adjustment:
1. Adjust CAL:SETUP19 for DMM reading of -1 V, ± 10 mV.

Setup 20

-1.5 V Offset

Equipment: DMM
Preparation:
1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset -1.5 V
   CH1 Output: On

Adjustment:
1. Adjust CAL:SETUP20 for DMM reading of -1.5 V, ± 10 mV.

Pulse Response Adjustments

The pulse response adjustments assure that the rise and fall times, as well as the aberrations, are within the specified range. Use this procedure if you suspect that the pulse response is an issue.

Setup 21

Pulse Response

Equipment: Oscilloscope

Preparation:
1. Configure the WS8352 as follows:
   Output: ON
   Function: Square
   Amplitude: 3V
2. Connect the WS8352 Channel 1 output to the oscilloscope input.

Adjustment:

1. Program CAL:SETUP21 and adjust the vertical trace to 6 divisions
2. Adjust C636 for best pulse response

High Frequency Delay Chain Adjustments

The delay chain adjustment assures that the waveforms at high frequencies do not generate inconsistencies. Use this procedure if you suspect that the waveform at high sample clock rates generate erroneous spikes.

Setup 23

Delay Chain

Equipment: Oscilloscope

Preparation:

1. Configure the WS8352 as follows:
   Output: ON
   Function: Arbitrary
   Sample Clock: 2.0 GSa/s
   Waveform: Sine, 1024 point, 1 cycle
2. Connect the WS8352 Channel 1 output to the oscilloscope input.

Adjustment:

1. Step with CAL:SETUP23 backwards (numbers below 127) till the sine waveform becomes distorted. Record this number as low limit. Step from this point forward till the sine waveform completes and becomes distorted again. Record the point as high limit.
2. Set CAL:SETUP23 with the median value.

Channel 2 Adjustments

The following procedures pertain to the channel 2 output only. Therefore, make sure that your connections are made to the channel 2 connectors.

Baseline Offset Adjustments

The baseline offset adjustments assure that the AC signal is symmetrical around the 0V line. Use this procedure if you suspect that there is a baseline accuracy issue.

Setup 30

Output Amplifier Offset and DC Paths

Equipment: DMM

Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 100 mV
2. Connect the WS8352 Channel 2 normal output center pin to the "+" input of the DMM and connect the channel 1 inverted output center pin to the "-" input of the DMM.
3. Configure the WS8352 as follows:
   CH2 Output: ON
   Run Mode: Triggered
   Amplitude: 100 mV

Adjustment:

1. Adjust RV6 for DMM reading of 0 V, ±2 mV, measured differentially between the normal and inverted outputs.
2. Remove the DMM wires and reconnect only channel 2 output to the DMM. Use banana adapter to connect the DMM. Adjust CAL:SETUP2 for a DMM reading of 0 V, ±2 mV.
3. Remove the DMM wires and reconnect as in step 1. Readjust RV6 for DMM reading of 0 V, ±2 mV.

Setup 31

Pre-Amplifier Offset

Equipment: DMM

Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 100 mV
2. Connect the WS8352 Channel 2 normal output center pin to the "+" input of the DMM and connect the channel 2 inverted output center pin to the "-" input of the DMM.
3. Configure the WS8352 as follows:
   CH2 Output: ON
   Run Mode: Triggered
   Amplitude: 4V

Adjustment

1. Adjust CAL:SETUP31 for DMM reading of 0 V, ±10 mV (measured differentially between the normal and inverted outputs).
2. Remove the connections from the DMM and connect the channel 2 normal output with a BNC to banana cable to the DMM input. Adjust RV2 for a DMM reading of 0 V, ±10 mV.

Amplitude Adjustments

The amplitude adjustments assure that the AC levels are within the specified range. Use this procedure if you suspect that the amplitude accuracy is an issue.

Setup 33

Amplitude

Equipment: DMM

Preparation:

1. Configure the DMM as follows:
   Function: ACV
   Range: 2 mV
2. Connect the WS8352 Channel 2 output to the DMM input.
3. Configure the WS8352 as follows:
   CH2 Output: ON
   Frequency: 1 kHz
   Amplitude: 4V

Adjustment

1. Adjust CAL:SETUP33 for DMM reading of 1.414V, ±20 mV

Offset Adjustments

The offset adjustments assure that the DC offsets are within the specified range. Use this procedure if you suspect that the offset accuracy is an issue.

Setup 36

+500 mV Offset

Equipment: DMM

Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 channel 2 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +500 mV
   CH2 Output: On

Adjustment:
1. Adjust CAL:SETUP36 for DMM reading of +500 mV, ±10 mV.

Setup 37 +600 mV Offset

Equipment: DMM
Preparation:
1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 channel 2 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +600 mV
   CH2 Output: On

Adjustment:
1. Adjust CAL:SETUP37 for DMM reading of +600 mV, ±10 mV.

Setup 38 +700 mV Offset

Equipment: DMM
Preparation:
1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 channel 2 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +700 mV
   CH2 Output: On

Adjustment:
1. Adjust CAL:SETUP38 for DMM reading of +700 mV, ±10 mV.

Setup 39 +800 mV Offset

Equipment: DMM
Preparation:
1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 channel 2 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +800 mV
   Ch2 Output: On

Adjustment:
1. Adjust CAL:SETUP39 for DMM reading of +800 mV, ±10 mV.

Setup 40 +900 mV Offset

Equipment: DMM
Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 channel 2 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 50mV
   Offset +900mV
   CH2 Output: On

Adjustment:

1. Adjust CAL:SETUP40 for DMM reading of +900 mV, ±10 mV.

Setup 41 +1 V Offset

Equipment: DMM
Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 channel 2 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +1 V
   CH2 Output: On

Adjustment:

1. Adjust CAL:SETUP41 for DMM reading of +1 V, ±10 mV.

Setup 42 +1.2 V Offset

Equipment: DMM
Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 channel 2 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +1.2 V
   CH2 Output: On

Adjustment:

1. Adjust CAL:SETUP42 for DMM reading of +1.2 V, ±10 mV.

Setup 43 — +1.4 V Offset

Equipment: DMM
Preparation:
1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 channel 2 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +1.4 V
   CH2 Output: On

Adjustment:
1. Adjust CAL:SETUP43 for DMM reading of +1.4 V, ±10 mV.

Setup 44 — +1.5 V Offset

Equipment: DMM
Preparation:
1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 channel 2 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset +1.5 V
   CH2 Output: On

Adjustment:
1. Adjust CAL:SETUP44 for DMM reading of +1.5 V, ±10 mV.

Setup 45 — -500 mV Offset

Equipment: DMM
Preparation:
1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 channel 2 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset -500 mV
   CH2 Output: On

Adjustment:
1. Adjust CAL:SETUP45 for DMM reading of -500 mV, ± 10 mV.

Setup 46

-1 V Offset

Equipment: DMM
Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 channel 2 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset -1 V
   CH2 Output: On

Adjustment:

1. Adjust CAL:SETUP46 for DMM reading of -1 V, ± 10 mV.

Setup 47

-1.5 V Offset

Equipment: DMM
Preparation:

1. Configure the DMM as follows:
   Function: DCV
   Range: 2 V
2. Connect the WS8352 channel 2 output to the DMM input.
3. Configure the WS8352 as follows:
   Amplitude: 100 mV
   Offset -1.5 V
   CH2 Output: On

Adjustment:

1. Adjust CAL:SETUP47 for DMM reading of -1.5 V, ± 10 mV.

Pulse Response Adjustments

The pulse response adjustments assure that the rise and fall times, as well as the aberrations, are within the specified range. Use this procedure if you suspect that the pulse response is an issue.

Setup 50

Pulse Response

Equipment: Oscilloscope

Preparation:

1. Configure the WS8352 as follows:
   CH2 Output: ON
   Function: Square
   Amplitude: 3V
2. Connect the WS8352 Channel 2 output to the oscilloscope input.

Adjustment:

1. Program CAL:SETUP50 and adjust the vertical trace to 6 divisions
2. Adjust C656 for best pulse response

High Frequency Delay Chain Adjustments

The delay chain adjustment assures that the waveforms at high frequencies do not generate inconsistencies. Use this procedure if you suspect that the waveform at high sample clock rates generate erroneous spikes.

Setup 55

Delay Chain

Equipment: Oscilloscope

Preparation:

1. Configure the WS8352 as follows:
   CH2 Output: ON
   Function: Arbitrary
   Sample Clock: 2.0 GSa/s
   Waveform: Sine, 1024 point, 1 cycle
2. Connect the WS8352 Channel 2 output to the oscilloscope input.

Adjustment:

1. Step with CAL:SETUP55 backwards (numbers below 127) till the sine waveform becomes distorted. Record this number as low limit. Step from this point forward till the sine waveform completes and becomes distorted again. Record the point as high limit.
2. Set CAL:SETUP55 with the median value.

Channel 1 to Channel 2 Skew Balance

The channel 1 to channel 2 skew balance adjustments assure that the channels are balanced for the skew adjustment values at different frequency settings. Always start with this procedure if you suspect that the outputs generate skews that appear to be out of the specified range.

Setup 57

Synchronization Detector 2 GSa/s – Step 1

Equipment: Oscilloscope

Preparation:

1. Configure the WS8352 as follows:
   CH1 Output: ON
   CH2 Output: ON
   Function 1/2: Arbitrary
   Sample Clock: 2 GSa/s
   Waveforms:Square, 1024 points, 1 cycle
2. Connect the WS8352 outputs to the oscilloscope inputs. Sync the oscilloscope on channel 1 signal.

Adjustment:

1. Program CAL:SETUP57
2. Adjust the oscilloscope time base setting to 0.5 ns/div. Note and record the oscilloscope reading.

- If CH2 leading edge is lagging CH1 by 1 ns to 2 ns, continue with setup 60.
- If CH2 leading edge is lagging CH1 by more than 2 ns, proceed with setup 58.
- If CH1 leading edge is lagging CH2, proceed with setup 59.

Setup 58

Synchronization Detector 2 GSa/s – Step 2

Equipment: Oscilloscope

Preparation:

1. Leave WS8352 and oscilloscope configuration as in setup 57.

Adjustment:

1. Program CAL:SETUP58
2. Note and record the oscilloscope reading.

- If CH2 leading edge is lagging CH1 by 1 ns to 2 ns, continue with setup 60.
- If CH2 leading edge is lagging CH1 by more than 2 ns, repeat setup 58.
- If CH1 leading edge is lagging CH2, proceed with setup 59.

Setup 59

Synchronization Detector 2 GSa/s – Step 3

Equipment: Oscilloscope

Preparation:

1. Leave WS8352 and oscilloscope configuration as in setup 57.

Adjustment:

1. Program CAL:SETUP59
2. Note and record the oscilloscope reading.

- If CH2 leading edge is lagging CH1 by 1 ns to 2 ns, continue with setup 60.
- If CH1 leading edge is lagging CH2, repeat setup 59.

Setup 60

Synchronization Detector 2 GSa/s – Step 4

Equipment: Oscilloscope

Preparation:

1. Leave WS8352 and oscilloscope configuration as was left from the last calibration step.

Adjustment:

1. Attach an oscilloscope probe (1:10) to R1073
2. Program CAL:SETUP60 for duty cycle of 50%, ±5%.

Setup 61

Channel Skew Balance 1GSa/s - Observation

Equipment: Oscilloscope

Preparation:

3. Configure the WS8352 as follows:
   CH1 Output: ON
   CH2 Output: ON
   Function 1/2: Arbitrary
   Sample Clock: 1 GSa/s
   SCLK Feed: Common
   Waveform: Square, 1024 points, 1 cycle
4. Connect the WS8352 outputs to the oscilloscope inputs. Sync the oscilloscope on channel 1 signal.

Adjustment:

3. Note and record the skew value between the channels, including which channel is lagging.

Setup 62

Channel Skew Balance 2GSa/s

Equipment: Oscilloscope

Preparation:

1. Configure the WS8352 as follows:
   CH1 Output: ON
   CH2 Output: ON
   Function 1/2: Arbitrary
   Sample Clock: 2 GSa/s
   SCLK Feed: Common
   Waveform: Square, 1024 points, 1 cycle
2. Connect the WS8352 outputs to the oscilloscope inputs. Sync the oscilloscope on channel 1 signal.

Adjustment:

1. Adjust CAL:SETUP62 till the skew appears to be the same as was recorded in step 61, ±20 ps.

Setup 63

Channel Skew Balance 1GSa/s

Equipment: Oscilloscope

Preparation:

1. Configure the WS8352 as follows:
   CH1 Output: ON
   CH2 Output: ON
   Function 1/2: Arbitrary
   Sample Clock: 1 GSa/s
   SCLK Feed: Common
   Waveform: Square, 1024 points, 1 cycle
2. Connect the WS8352 outputs to the oscilloscope inputs. Sync the oscilloscope on channel 1 signal.

Adjustment:

1. Adjust CAL:SETUP63 till the skew appears to be the same as was recorded in step 61, ±20 ps.
2. Repeat steps 58 and 59 until you observe no difference between the skew under the two frequency settings

Channel 1 to Channel 2 Skew Adjustment

The channel 1 to channel 2 skew adjustment assures that the skew between the channels is adjusted properly. Use this procedure if you suspect that the outputs generate skews that appear to be out of the specified range. Always use the channel 1 to channel 2 balance adjustments before you proceed with the skew adjustment.

Setup 64

Channel 2 to 1 Skew

Equipment: Oscilloscope

Preparation:

1. Configure the WS8352 as follows:
   CH1 Output: ON
   CH2 Output: ON
   Function 1/2: Arbitrary
   Sample Clock: 2 GSa/s
   SCLK Feed: Common
   Waveform: Square, 1024 points, 1 cycle
2. Connect the WS8352 outputs to the oscilloscope inputs. Sync the oscilloscope on channel 1 signal.

Adjustment:

1. Adjust CAL:SETUP64 for a skew reading between the channels of 0 ps, ±20 ps.

Inter channels Jitter Adjustment

The Inter Channels Jitter adjustment assures that channel 1 and 2 output signals will not jitter while working in couple mode with internal or external triggers. Use this procedure if you observe a jitter between the channels while working with coupled channels in triggered mode.

Setup 75

Low Clock Trigger Jitter

Equipment: Oscilloscope

Preparation:

1. Configure the 81180B as follows:
   CH1 Output: ON
   CH2 Output: ON
   Function 1/2: Arbitrary
   Run Mode: Triggered
   Trigger Source: Internal
   Trigger Delay: 15 µs
   SCLK Feed: Common
   Waveform: Square, 1024 points, 1 cycle
2. Connect the 81180B outputs to the oscilloscope inputs. Sync the oscilloscope on channel 1 signal.

Adjustment:

1. Adjust CAL:SETUP75 up from 1 till you observe a jitter between the channels. Record the value and keep adjusting the setup up till the jitter disappears. Calculate and enter the mid-point value between these two values.

Setup 76

High Clock Trigger Jitter

Equipment: Oscilloscope

Preparation:

1. Leave 81180B and oscilloscope configuration as in setup 75

Adjustment:

1. Set the setup value, to the same value that made the jitter disappeared in setup 75
2. Adjust CAL:SETUP76 up till you observe a jitter between the channels. Record the value and keep adjusting the setup up till the jitter disappears. Calculate and enter the mid-point value between these two values.

Updating WS8352 Firmware

WARNING

Only qualified persons may perform Firmware updates. DO NOT even attempt to perform this operation unless you were trained and certified by Tabor, as you may inflict damage on the instrument. Always verify with the factory that you have the latest firmware file before you start with your update.

Before you update the firmware of your WS8352, 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 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 6-3. To access this screen, select the TOP menu, then select the Utility soft key and scroll down to the System option. Press Enter and the screen will show the system information. Check both the Software Version and the Version Date as both should match with the latest release.

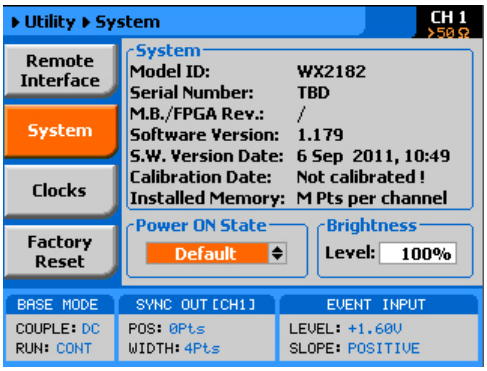

Figure 6-3: Software Version Screen

NOTE

Firmware updates are performed with the LAN set as the active interface and the WS8352 communicating with the PC through the network.

To update the WS8352 firmware, you will have to run the **NETConfig** utility. If you do not have this utility installed on your computer, run the installation procedure from the enclosed CD. You will not be able to update firmware without the NETConfig utility. To invoke this utility, complete the following steps:

1. Turn power **OFF** on your WS8352.
2. Click on NETConfig shortcut on the desktop or select Start »Programs» Tabor Electronics» NETConfig» NETConfig 1.0

The NETConfig window lists **Tabor** devices found on your subnet. Figure 6-4 shows an example of this display.

3. Click on the "Use wait message" to select this option as shown in Figure 6-4.

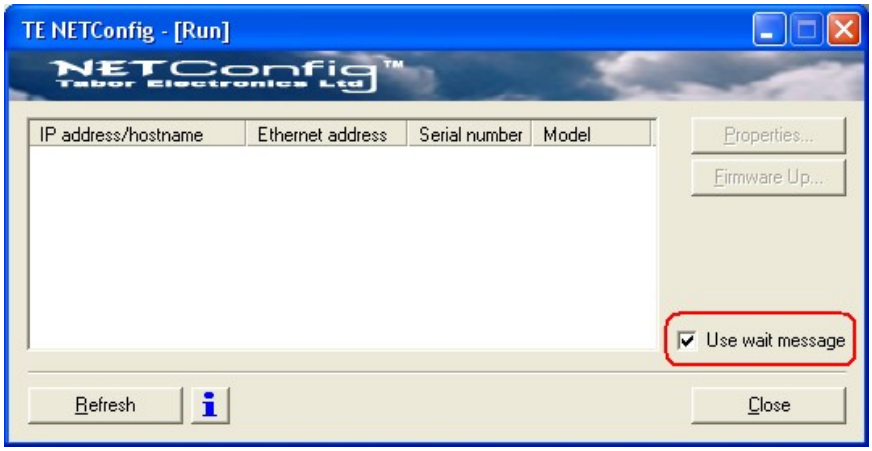

Figure 6-4: The NETConfig Utility

4. Turn power **ON** on your WS8352 and observe that the progress bar, as shown in Figure 6-5, is advancing from left to right. Do not do anything on the WS8352 until the progress bar completes its travel to the right end.

Tips

If the progress bar is not moving, check the following for possible problems:

1. If you are connecting to a LAN network, make sure your device is connected with standard LAN wire to your wall plug.

2. If you use a direct connection from your PC to the WS8352, your cable should be cross-wired. You can buy this type of cable from any computer store in your area.

3. If your network is using a managed switch, it is possible that it is configured to break the package with a broadcast address and therefore, the only way to use NetConfig is to connect the instrument directly to the PC with a cross- wired cable.

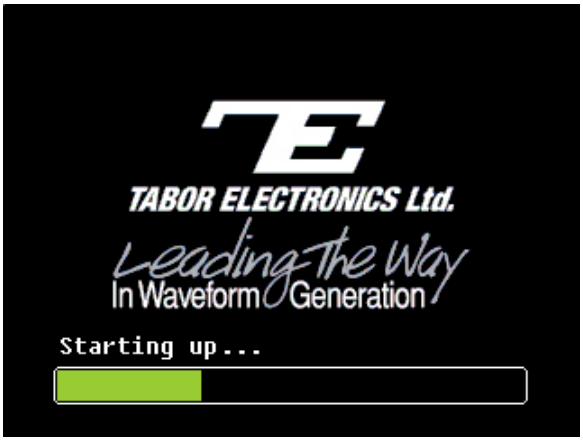

Figure 6-5: Check for Progress Bar Movement

5. As soon as the progress bar reaches the far right-hand side of the bar, click on the Refresh button. If your device was connected and booted correctly, the device address will appear in the device list, as shown in Figure 6-6.

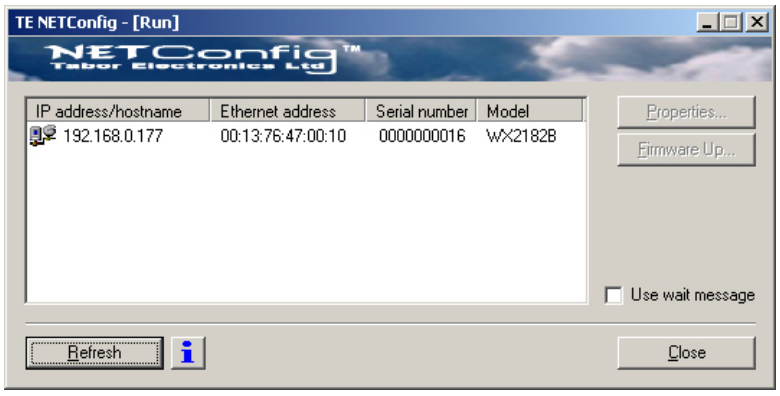

Figure 6-6: WS8352 has been Detected on the LAN Network

NOTES

Click Refresh again if you do not see your device in the list of Ethernet devices. If you cannot detect your device after a few attempts, check that you have not lost the connection as described in previous paragraphs.

You can only update instrument(s) that appear in the NETConfig window.

Point and click on the device you want to update. The selected device will now have a blue background. Click on the Firmware Up... button. The firmware Update dialog box as shown in Figure 6-7 appears.

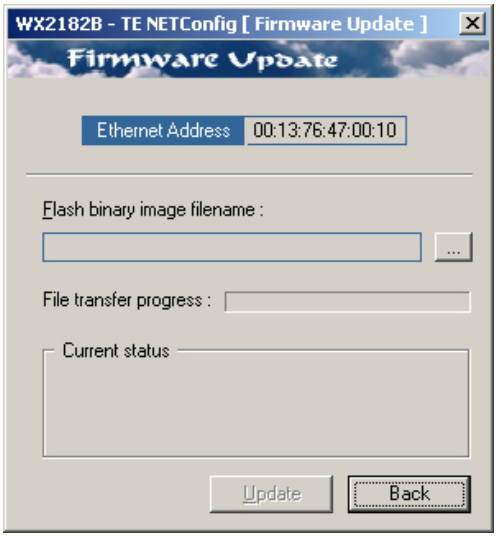

Figure 6-7: The Firmware Update Dialog Box

In the TE NETConfig [Firmware Update] dialog box click on the button to browse and locate the upgrade file. After you select the fil,e its complete path will be displayed in the Flash binary image filename field as shown in Figure 6-8. Make sure the file in the path agrees with that specified by your supervisor. To complete the update process, click on Update and observe the File Transfer Progress bar. The update will complete with a Firmware Update d Successfully message, as shown in Figure 6-9.

Click on Back to close NETConfig Firmware Update dialog box and turn off the power to the WS8352. The next time you power-up the instrument, the device automatically reboots with the new firmware in effect.

Figure 6-8: Firmware Update Path

Figure 6-9: Firmware Update Completed

Appendices

Appendix	Title	Page
A	Specifications	A-1

Appendix A
Specifications

Instrument configuration

Characteristics	Description
WS8351	Single channel 350MHz Arbitrary Function Pulse Generator with 512,000 waveform points
WS8352	Dual channel 350MHz Arbitrary Function Pulse Generator with 512,000 waveform points

Inter-channel offset control (Course tuning – Dual-channel versions only)

Characteristics		Description
Initial skew		<200 ps
Control		
	Range	0 to n – 128 points; 0 to 80 points with external segment control
	Resolution	4 points
Accuracy		Same as sample clock accuracy

Inter-channel skew control (Fine Tuning – Dual-channel versions only)

Characteristics		Description
Initial skew		<200 ps
Control		
	Range	-3 ns to +3 ns
	Resolution	10 ps
Accuracy		±(10% of setting + 20 ps)

Waveform type

Characteristics	Description
Standard	A waveform is selected from a built in library. The standard waveform parameters are programmable
Arbitrary	Arbitrary waveform coordinates are downloaded and stored in memory segments. The arbitrary waveform parameters are programmable
Modulated	A modulated waveform is calculated from a built in library of modulation schemes
Pulse	A pulse waveform is calculated and downloaded to the arbitrary waveform memory.

Run mode

Characteristics	Description
Continuous	A selected output function shape is output continuously
Self armed	No start commands are required to generate waveforms
Armed	The output dwells on a dc level and waits for an enable command and then the output waveform is output continuously; An abort command turns off the wave
Triggered	A trigger signal activates a single-shot or counted burst of output waveforms and then the instrument waits for the next trigger signal
Normal mode	The first trigger signal activates the output; consecutive triggers are ignored for the duration of the output waveform
Override mode	The first trigger signal activates the output; consecutive triggers restart the output waveform regardless if the current waveform has been completed or not
Gated	A waveform is output when a gate signal is asserted. The waveform is repeated until the gate signal is de-asserted. Last period is always completed

Standard Waveforms

Characteristics	Description
General	Waveforms are computed and generated every time a standard waveform is selected.
Standard waveform library	Built-in, auto computed waveforms: sine, triangle, square, ramp, pulse, sinc, exponential rise, exponential decay, gaussian, noise and dc.
Standard waveform control	The standard waveform parameters can be adjusted to specific requirements. The waveform is re-computed with each parameter change.

Standard waveforms frequency Control

Characteristics	Description
Range	
Sine, Pulse	10 kHz to 350 GHz
Square	10 kHz to 250 MHz
All others	10 kHz to 125 MHz
Resolution	8 digits
Accuracy	
Internal reference	≤1 ppm from 19°C to 29°C; 1ppm/°C below 19°C or above 29°C; ≤1 ppm/year aging rate
External reference	Same as accuracy and stability of the external reference. Reference is applied to the reference input

Arbitrary Waveforms

Characteristics	Description
General	Arbitrary Waveforms are created on a remote computer and downloaded to the arbitrary waveform memory through one of the available remote interfaces. The frequency of the waveform is calculated from its programmed SCLK value and the number of waveform points that were used for creating the waveform
Waveform length	192 to 512,000 points in multiples of 16 points

Number of waveforms	1 to 16,000
DAC resolution	14 bits
Waveform creation utilities	Waveform Editor creates complex arbitrary and sequenced waveforms.

Arbitrary waveforms Sample Clock Control

Characteristics	**Description**
Range	10 MSa/s to 2.0 GSa/s common or separate for each channel
Resolution	8 digits
Accuracy	
Internal reference	≤1 ppm from 19°C to 29°C; 1ppm/°C below 19°C or above 29°C; 1 ppm/year aging rate
External reference	Same as accuracy and stability of the external reference. Reference is applied to the reference input or sample clock input

Pulse Composer

Characteristics	**Description**
Pulse Type	Multi-Levels or Linear Points
Transition Type	Fast or Linear
Number of Levels	1 to 1000
Dwell Time	500ps to 10s
Memory	100k
Amplitude Resolution	4 digits
Time Resolution	500ps to 100ns (Auto or User)

Pattern

Characteristics	**Description**
PRBS Type	PRBS7, PRBS9, PRBS11, PRBS15, PRBS23, PRBS31, User-defined
Data Rate	10mbps to 350Mbps
Number of Levels	2, 3, 4, 5
High/Low Levels	±2.5V
Resolution	4 digits
Loops	1 to 1e6
Preamble	1 to 512e3
Length	1 to 512e3

Modulation Common Characteristics

Characteristics	**Description**
Carrier Waveform	Sine, square, triangle
Carrier Frequency	10 kHz to 350 MHz
Modulation Source	Internal

FM

Characteristics	Description
Modulation Shape	Sine, square, triangle, ramp
Modulation Frequency	100 Hz to 35 MHz (CW/6) > (M.F) > (30e-6xCW)
Deviation Range	10 mHz to 175 MHz (CW/2)

FSK / Frequency Hopping

Characteristics	Description
FSK Baud Rate	10 mbps to 350 Mbps
Hop Table Size	2 to 256 (<CWx10.24e-3)
Hop Type	Fast or Linear
Dwell Time Mode	Fixed or programmable per step
Dwell Time	2 ns to 10 s
Resolution	2 ns

Sweep / Chirp

Characteristics	Description
Sweep Type	Linear or log
Sweep Direction	Up or down
Sweep Time	1.4 µs to 10 ms (9/High Freq.) > (S.T) > (50e3/High Freq.)
Modulation Shape	Pulse
Pulse Repetition	
Range	200 ns to 20 s
Resolution	3 digits
Accuracy	100 ppm

AM

Characteristics	Description
Modulation Shape	Sine, square, triangle, ramp
Modulation Frequency	100Hz to 1MHz (CW/9) > (M.F) > (CW/50e3)
Modulation Depth	0.1 to 200%

ASK / Amplitude Hopping

Characteristics	Description
ASK Baud Rate	10 mbps to 350 Mbps
Hop Table Size	2 to 256 (<CWx10.24e-3)
Hop Type	Fast or Linear
Dwell Time Mode	Fixed or programmable per step
Dwell Time	2 ns to 10 s
Resolution	2 ns

(n)PSK and (n)QAM

Characteristics	Description
Modulation Type	PSK, BPSK, QPSK, OQPSK, PI/4 DQPSK, 8PSK, 16PSK, 16QAM, 64QAM, 256QAM and User Defined
Symbol Rate Range	10 mbps to 350 Mbps
Table Size	2 to 256

Analog outputs

Characteristics	Description
Connector type	SMA
ON/OFF control	Output is turned On or OFF for each channel independently
Type of output	Single-ended (1) or differential
Impedance	50 Ω, typical
Amplitude control	Specified into 50 Ω, levels double into high impedance
Range, single-ended	50 mV to 4 Vp-p
Range, differential	100 mV to 8 Vp-p
Resolution	3 digits
Accuracy, offset = 0V	±(3% +5 mV)
Offset control	Common mode, specified into 50 Ω, levels double into high impedance
Range	-1.5 V to + 1.5 V
Resolution	3 digits
Accuracy	±(5% +5 mV)
Rise/fall time (10% to 90%)	1 ns, typical
Bandwidth	350 MHz, typical (calculated)
Overshoot	10%, typical
Harmonic distortion (2)	-35 dBc, 3 Vp-p
Non harmonic distortion (2)	-75 dBc, 3 Vp-p
Phase Noise (2)	-110 dBc/Hz, 0.5 Vp-p, 10 kHz offset

(1) The unused output must be terminated with 50 Ω to ground
(2) offset=0 V, SCLK=2.3 GSa/s, 23 points sine waveform (100 MHz output frequency)
(3) Amplitude/2 + |Offset| < 2.25

Internal Trigger Generator

Characteristics	Description
Source	Common or separate for each channel
Mode	Timer (waveform start to waveform start); Delayed (waveform stop to waveform start)
Timer	
Range	200 ns to 2 s
Resolution	3 digits
Accuracy	100 ppm

Delayed	
Range	152 to 8,000,000 sample clock periods
Resolution	Integer numbers, divisible by 4

SYNC output

Characteristics	**Description**
Connector type	SMA
Type of output	Single ended
Source	Channel 1 or channel 2
Waveform	
Pulse	16 points
WCOM	Waveform duration pulse
Impedance	50 Ω, typical
Amplitude	1.2 V, typical; doubles into high impedance
Variable position control	
Range	0 to segment length
Resolution	16 points
Rise/fall time	2 ns, typical
Variable Width control	
Range	16 points to segment length
Resolution	16 points

Trigger input

Characteristics	**Description**
Connector type	SMA
Drive	Channel 1, channel 2, or both
Input impedance	10 kΩ, typical
Polarity	Positive, negative, or both, selectable
Damage level	± 20 Vdc
Frequency range	0 to 15 MHz
Trigger level control	
Range	-5 V to 5 V
Resolution	12 bit (2.5 mV)
Accuracy	± (5% of setting + 2.5 mV)
Sensitivity	200 mVp-p
Pulse width, minimum	10 ns
System delay [(4)]	200 sample clock periods + 50 ns, typical
Trigger delay	Separate for each channel
Range	0 to 8,000,000 sample clock periods
Resolution	4 points
Accuracy	Same as sample clock accuracy

Smart Trigger	Detects a unique pulse width range
Conditioned trigger	<pulse width, >pulse width, <>pulse width
Pulse width range	50 ns to 2 s
Resolution	2 ns
Accuracy	±(5% of setting +20 ns)
Trigger Holdoff	Ignores triggers for a holdoff duration
Holdoff range	100 ns to 2 s
Resolution	2 ns
Accuracy	±(5% of setting +20 ns)
Trigger jitter	4 sampling periods

[4] Trigger input to analog output

Event input

Characteristics	**Description**
General	Used for branching in or out from a sequence loop. Also used for enabling or disabling the output in armed mode.
Connector type	Rear panel BNC
Input impedance	10 kΩ, typical
Polarity	Positive, negative or either, selectable
Damage level	± 20 Vdc
Frequency range	0 to 15 MHz
Trigger level control	
Range	-5 V to 5 V
Resolution	12 bit (2.5 mV)
Accuracy	± (5% of setting + 2.5 mV)
Sensitivity	200 mVp-p
Pulse width, minimum	10 ns

External reference clock input

Characteristics	**Description**
Connector type	Rear panel BNC
Input frequency	10 MHz to 100 MHz, programmable
Input impedance	50 Ω, typical
Input voltage swing	-5 dBm to 5 dBm
Damage Level	10 dBm

External sample clock input

Characteristics	**Description**
General	External signal is fed to a frequency splitter. Same frequency is applied to both channel
Connector type	Rear panel SMA
Input impedance	50 Ω, typical

Input voltage swing	0 dBm to 10 dBm
Input frequency range	2.0 GHz to 4.0 GHz
Clock divider	1/1, 1/2, 1/4, … 1/256, separate for each channel
Damage Level	15 dBm

Mechanical, Environmental and Maintenance Specifications

Display

Characteristics	Description
Type	TFT LCD, back-lit
Size	4 “
Resolution	320 x 240 pixels

Peripheral devices

Characteristics	Description
USB port	1 x front, USB host, standard A; 1 x rear, USB device, standard B
LAN port	1000/100/10 BASE-T
GPIB port	IEEE 488.2 standard interface, 24 pin

Power supply

Characteristics	Description
Source voltage and frequency	
Rating range	100 VAC to 240 VAC
Frequency range	50 Hz to 60 Hz
Power consumption	100 VA

Mechanical

Characteristics	Description
Dimensions	
With feet	315 x 102 x 395 mm (W x H x D)
Without feet	315 x 88 x 395 mm (W x H x D)
Weight	
Without package	4.5 kg
Shipping weight	6 kg

Environmental

Characteristics	Description
Operating temperature	0°C to 40°C
Storage temperature	-40°C to 70°C
Humidity	85% RH, non condensing

Certifications and compliances

Characteristics	Description
Safety	IEC61010-1
EMC	IEC 61326-1:2006

Maintenance

Characteristics	Description
General	Periodical recalibration is required to maintain accuracy of output characteristics
Recalibration Period	2 years

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