AIM & THURLBY THANDAR INSTRUMENTS

TGP3151/TGP3121 & TGP3152/TGP3122

Pulse and Universal Generators

INSTRUCTION MANUAL

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1 Table of Contents

1 Table of Contents 1

2 Introduction 4

2.1 The TGP3100 Series of Pulse and Universal Generators 4

2.2 Using this Manual 4

3 Safety 5

4 Installation 6

5 Connections 7

5.1 Front Panel Connections 7

5.2 Rear Panel Connections 7

6 Getting Started 9

6.1 Initial Operation 9

6.2 Front Panel Layout 9

7 Control Principles 12

7.1 Control Menus 12

7.2 Editing Parameters 13

8 Output Menu 16

8.1 Setting Output Parameters 16

9 Pulse Generator Operation 19

9.1 Capabilities 19

9.2 Pulse Functions 19

9.3 Setting Parameters for Pulse 20

9.4 Setting Parameters for Square 23

9.5 Setting Parameters for Double Pulse 23

9.6 Setting Parameters for Pattern/PRBS 24

9.7 Pattern Editing 25

9.8 Pulse Modulation 27

9.9 Swept Pulse Operation 27

9.10 Pulse Burst Operation (Triggered or Gated) 27

9.11 Asynchronous Pulse Generation, Delay and Reconstruction 27

9.12 Pulse Output Conditions 28

10 Noise Generator Operation 29

10.1 Capabilities 29

10.2 Setting Parameters for Noise 29

10.3 Noise Modulation 31

10.4 Noise Burst Operation (Triggered or Gated) 31

10.5 Noise Output Conditions 31

11 ARB/Function Generator Operation 32

11.1 Capabilities 32

11.2 Function and Arbitrary Waveform Menu 32

11.3 Function Generator Waveforms 33
11.4 Arbitrary Generator Waveforms 34
11.5 Waveform Modulation 37
11.6 Sweep Operation 37
11.7 Burst Operation (Triggered or Gated) 37
11.8 ARB/Function Output Conditions 37
12 Two Channel Operation 38
12.1 Capabilities 38
12.2 Channel Selection 38
12.3 Link Menu 38
13 Waveform Modulation 41
13.1 The Modulation Menu 41
13.2 Modulations 42
14 Sweep Operation 44
14.1 The Sweep Menu 44
15 Burst Operation 47
15.2 The Burst Menu 47
15.3 Internal Trigger Generator 48
16 Trigger and Sync Menu 49
16.2 Trigger Setup 49
16.3 Sync Output(s) Setup 49
17 Stores Menu 51
17.1 Stores Menu Functions 51
17.2 Instrument Set-ups 51
17.3 Transferring Pulse Patterns and Arbitrary/Noise Waveforms 53
18 Utility Menu 58
18.1 System Settings 58
18.2 Instrument Settings 59
18.3 I/O (Remote Control) Settings 60
18.4 Calibration 60
18.5 Help 60
18.6 Status 61
19 Help Screens 62
20 Phase Control and Synchronisation 64
20.1 Waveform Phase and Delay Control 64
20.2 Synchronising Two Generators 65
21 Remote Interface Operation 67
21.1 Address Selection 67
21.2 Remote/Local Operation 67
21.3 USB Interface 68
21.4 LAN Interface 68

21.5 GPIB Interface 70
21.6 Status Reporting 71
22 Remote Commands 74
22.1 Command List 74
23 Maintenance 85
24 Specification 86
24.1 Waveforms 86
24.2 Standard Waveforms 86
24.3 Modulation 90
24.4 Gated Burst 92
24.5 Triggered Burst 92
24.6 Sweep 92
24.7 Dual-channel Operations (applies only to TGP31x2) 93
24.8 Outputs 94
24.9 Inputs 95
24.10 Interfaces 96
24.11 General 96
25 Editing Arbitrary Waveforms 97
25.1 General 97
25.2 Waveform Manager Plus 97
26 Appendix 1. Information, Warning and Error Messages 98
27 Appendix 2. Factory Default Settings 105
28 Appendix 3. Calibration Procedure 108
28.1 Equipment Required 108
28.2 Calibration Procedure 108
28.3 Calibration Routine 109
28.4 Remote Calibration 110

2 Introduction

2.1 The TGP3100 Series of Pulse and Universal Generators

2.1.1 General Description

The TGP3100 Series are true pulse generators using all digital techniques. They can replicate the capabilities of traditional pulse generators whilst adding many additional facilities such as pulse modulations.

Unlike DDS based function generators the TGP3100 Series can generate pulses with very high resolution of width and delay (100ps), and can operate in an asynchronously triggered mode with low jitter.

A high drive capability output stage enables up to 20 volts pk-pk to be driven into a 50 Ohm load.

As well as operating as pulse generators, the instruments can act as high performance noise generators and as function/arbitrary generators - making them truly universal waveform generators.

Single and dual channel models are available with a maximum frequency of either 50MHz or 25MHz

2.1.2 Important Features

Pulse waveforms from 1mHz to 50MHz [25MHz], minimum rise time 5ns [8ns]

Pulse, double pulse, pulse pattern and PRBS waveforms

Pulse period, width and delay resolutions of 100ps or 11 digits

Independently variable rise and fall times from 5ns [8ns] to 800 seconds

Low jitter asynchronous operation, externally triggered pulses or pulse reconstruction

High drive capability output can provide 20V pk-pk into 50Ω (unmatched)

Wide range of pulse modulations including AM.FM, PM, FSK, BPSK, SUM, PWM, PDM using internal or external modulation sources.

Triggered (burst count) or gated operation using internal or external trigger sources

Full Noise generator to 25MHz [12.5MHz] with selectable crest factor and user defined distribution

Full Arbitrary/Function generator with 16 waveform types

Sine waves up to 50MHz [25MHz]

Arbitrary waveforms at 800MS/s sampling rate and 16-bit vertical resolution

Extensive internal/external modulation of all waveform types

Linear and logarithmic sweeps of all waveform types

Front panel mounted USB Flash drive interface

GPIB, USB and LXI compliant LAN interfaces

2.2 Using this Manual

This manual is for the TGP3151 and TGP3121 single channel generators and the TGP3152 and TGP3122 dual channel generators. Wherever there are differences in the specification, the limits for the TGP312x are shown in square brackets [ ] after the TGP315x limits.

In this manual front panel keys and sockets are shown in capitals, e.g. SWEEP, SYNC OUT. Soft–key labels on the LCD are shown in a different type–font, e.g. **`Width`**, **`Offset`**.

The manual is available in printed form and as an electronic document in PDF format. The manual includes cross references which are underlined within the text. These are hyperlinks within the PDF document. The Table of Contents is also fully hyperlinked.

Hyperlinks enable the user to jump rapidly to the section referred to and then jump back to continue reading the original section. (N.B. for hyperlink navigation within Acrobat Reader, enable “show all page navigation tools” or use the keyboard shortcuts Alt+Left_Arrow and Alt+Right_Arrow).

3 Safety

This generator is a Safety Class I instrument according to IEC classification and has been designed to meet the requirements of EN61010–1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use). It is an Installation Category II instrument intended for operation from a normal single phase supply.

This instrument has been tested in accordance with EN61010–1 and has been supplied in a safe condition. This instruction manual contains some information and warnings which have to be followed by the user to ensure safe operation and to retain the instrument in a safe condition.

This instrument has been designed for indoor use in a Pollution Degree 2 environment in the temperature range 5°C to 40°C, 20% – 80% RH (non–condensing). It may occasionally be subjected to temperatures between +5° and –10°C without degradation of its safety. Do not operate while condensation is present.

Use of this instrument in a manner not specified by these instructions may impair the safety protection provided. Do not operate the instrument outside its rated supply voltages or environmental range.

WARNING! THIS INSTRUMENT MUST BE EARTHED

Any interruption of the mains earth conductor inside or outside the instrument will make the instrument dangerous. Intentional interruption is prohibited. The protective action must not be negated by the use of an extension cord without a protective conductor.

When the instrument is connected to its supply, terminals may be live and opening the covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts. The apparatus shall be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair.

Any adjustment, maintenance and repair of the opened instrument under voltage shall be avoided as far as possible and, if inevitable, shall be carried out only by a skilled person who is aware of the hazard involved.

If the instrument is clearly defective, has been subject to mechanical damage, excessive moisture or chemical corrosion the safety protection may be impaired and the apparatus should be withdrawn from use and returned for checking and repair.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short–circuiting of fuse holders is prohibited.

This instrument uses a Lithium button cell for non–volatile memory battery back–up; typical life is 5 years. In the event of replacement becoming necessary, replace only with a cell of the correct type, i.e. 3V Li/Mn0_2 20mm button cell type 2032. Exhausted cells must be disposed of carefully in accordance with local regulations; do not cut open, incinerate, expose to temperatures above 60°C or attempt to recharge.

Do not wet the instrument when cleaning it and in particular use only a soft dry cloth to clean the LCD window. The following symbols are used on the instrument and in this manual:–

⚠ **Caution** –refer to the accompanying documentation, incorrect operation may damage the instrument.

⏚ terminal connected to chassis ground.

○ mains supply OFF.

I mains supply ON.

∿ alternating current.

4.1.1 Mains Operating Voltage

This instrument has a universal input range and will operate from a nominal 115V or 230V AC supply without adjustment. Check that the local supply meets the AC input requirement given in the Specification.

4.1.2 Mains Lead

Connect the instrument to the AC supply using the mains lead provided. Should a power plug be required for a different power outlet socket, a suitably rated and approved mains lead set should be used which is fitted with the required wall plug and an IEC60320 C13 connector for the instrument end. To determine the minimum current rating of the lead-set for the intended AC supply, refer to the power rating information on the equipment or in the Specification.

WARNING! THIS INSTRUMENT MUST BE EARTHED.

Any interruption of the power earth conductor inside or outside the instrument will make the instrument dangerous. Intentional interruption is prohibited.

4.1.3 Mounting

This instrument is suitable both for bench use and rack mounting. It is delivered with soft protective front and rear bezels which have integral moulded feet; this is the most suitable configuration for bench use.

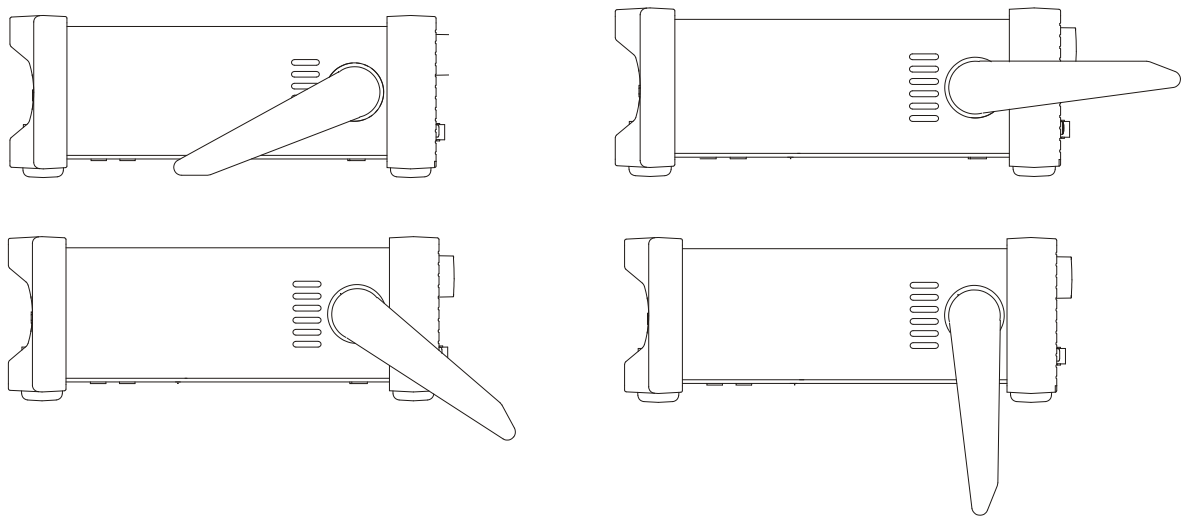
For rack mounting the protective bezels and handle/stand can be removed such that the instrument can be fitted beside any other standard 2U half-rack instrument in a 19” rack. A suitable 2U 19” rack kit is available from the Manufacturers or their overseas agents; full details of how to remove the handle and bezels are included with the kit.

4.1.4 Ventilation

The generator uses a small fan fitted to the rear panel. Take care not to restrict the rear air exit or the inlet vents at the front (sides and underneath). In rack-mounted situations allow adequate space around the instrument and/or use a fan tray for forced cooling.

4.1.5 Handle/stand

The instrument is fitted with a 4-position handle/stand. Pull out both sides of the handle at the case pivot points, to free the position locking pegs, and rotate the handle from the stowed position to the required stand or handle position. Release the sides of the handle to lock it in the new position.



5 Connections

5.1 Front Panel Connections

5.1.1 **MAIN OUT** (one for each channel on dual channel instruments)

This is the variable amplitude output from main generator. It can provide up to 22V peak–to–peak e.m.f. from a 50Ω or 5Ω source impedance. The output has both over-voltage and over-current protection and will turn off in the event of an output short circuit.

See section 7 Output Menu for more details.

⚠ Do not apply an external voltage to this output.

5.1.2 **SYNC OUT** (one for each channel, rear mounted on dual channel instruments)

Logic level output which can generate a synchronisation signal related to the main (carrier) waveform, modulation waveform, trigger or gate signal, or sweep marker.

See section 15 Trigger and Sync Menu for more details.

⚠ Do not apply an external voltage to this output.

5.1.3 **FLASH DRIVE**

This is a USB Host port for the connection of most types of flash drive which conform to the Mass Storage Class specification. The instrument will accept drives formatted with the FAT16 or FAT32 filing systems. This port does not support any other class of device.

5.2 Rear Panel Connections

5.2.1 **SYNC OUT** (Rear mounted on TGP31x2 only. One for each channel)

See Front Panel section for description.

5.2.2 **MOD IN**

This is the external modulation input socket for AM, FM, PM, SUM, BPSK PWM, PDM, SPDM, or external pattern. Full-scale input is ±2.5V, frequency DC to 5MHz.

⚠ Do not apply an external voltage exceeding ±5V.

5.2.3 **10MHz REF IN**

Input for an external 10MHz reference clock. Input range 1Vpp – 5Vpp.

⚠ Do not apply external voltages exceeding + 5V or –1V to this signal connection.

5.2.4 **10MHz REF OUT**

Buffered version of the 10MHz clock currently in use (internal or external). Output level nominally 3V logic from 50Ω.

⚠ Do not apply external voltages to this output.

5.2.5 **TRIG IN**

This is the external input for Trigger, Gate and Sweep operations. It is also the input used to synchronise the generator (as a slave) to another (which is the master).

⚠ Do not apply an external voltage exceeding ±10V.

5.2.6 LAN (Ethernet)

The LAN interface is designed to meet 1.4 LXI (Lan eXtensions for Instrumentation) Core 2011. Remote control using the LAN interface is possible using the TCP/IP Socket protocol. The instrument also contains a basic Web server which provides information on the unit and allows it to be configured.

Further details are given in section 20 Remote Interface Operation.

5.2.7 USB

The USB port is connected to instrument ground. It accepts a standard USB cable. If the USB driver has been installed from the CD, the Windows plug-and-play function should automatically recognise that the instrument has been connected. See the USB folder on the CD for information on installing the driver on a PC.

Further details are given in section 20 Remote Interface Operation.

5.2.8 GPIB (IEEE–488)

The GPIB interface is not isolated; the GPIB signal grounds are connected to the instrument ground. The implemented subsets are:

SH1 AH1 T6 TE0 L4 LE0 SR1 RL1 PP1 DC1 DT1 C0 E2. The default GPIB address is 5.

Further details are given in section 20 Remote Interface Operation.

6 Getting Started

6.1 Initial Operation

This section is a general introduction to the organisation of the instrument and is intended to be read before using the generator for the first time. Detailed operation is covered in later sections of this manual.

6.1.1 Switching On

The power switch is located at the bottom left of the front panel. To fully disconnect from the AC supply unplug the mains cord from the back of the instrument or switch off at the AC supply outlet; make sure that the means of disconnection is readily accessible. Disconnect from the AC supply when not in use.

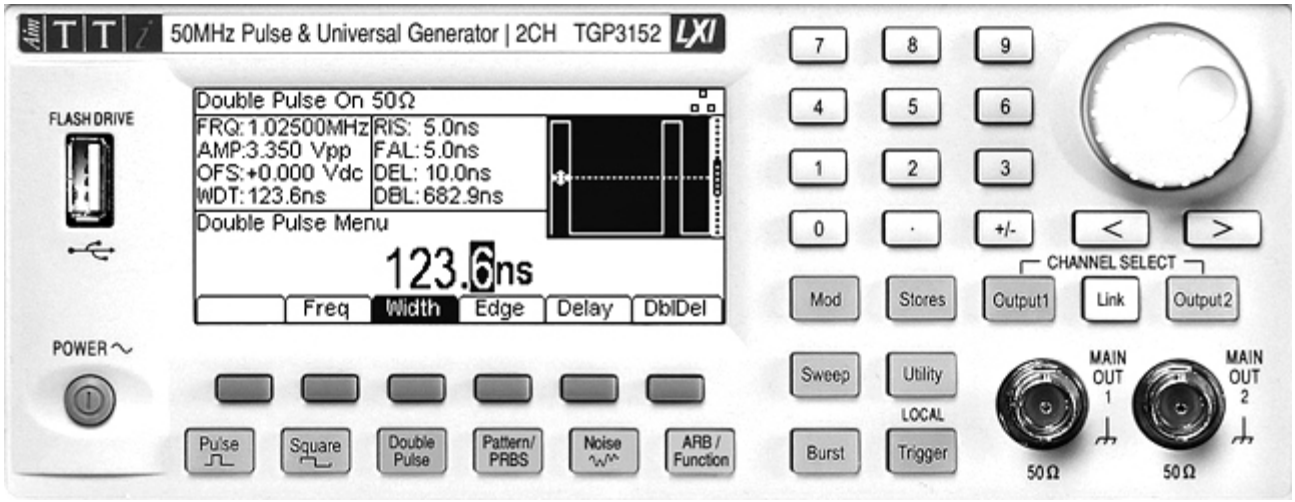
At power up the generator displays a start-up message whilst initialising the application. Loading takes a few seconds, after which the pulse waveform set-up screen is displayed, showing the generator parameters set to their default values, with the MAIN OUT output(s) set off.

This is the Factory Defaults state which will appear whenever the instrument is powered on.. Alternatively the instrument can be set so that it returns to its settings at power down.
See section 17.1.1 Power-On Settings for how to change the power up settings to either those at power down (latest settings) or to the defaults.

In the event that an error is encountered while the instrument is initialising, an error message will be displayed, see the Warnings and Error Messages section for an explanation.

6.2 Front Panel Layout

The front panel contains the liquid crystal display (LCD) and the keyboard which are used together to control all instrument functions.



(Dual channel instrument shown, single channel instrument differs only around output sockets)

6.2.1 Keyboard

The keys are grouped as follows:

Six soft-keys under the display. The function of these keys change as the instrument is operated. The current function is shown on the LCD soft-key label above each key. An empty label means that the key currently has no function.

Numeric keys permit direct entry of a value for the parameter currently selected.

Six keys under the soft-keys select the carrier waveform from PULSE, SQUARE, DOUBLE PULSE, PATTERN/PRBS and ARB/FUNCTION.

The key representing the currently selected waveform glows green. Pressing another waveform key brings up the parameter screen for the new waveform but does not change the waveform until the **`Apply`** key is pressed.

Three keys to select the waveform modification mode from MOD (modulation), SWEEP and BURST. The selected key glows yellow. If all keys are unlit the mode will be continuous carrier wave.

The OUTPUT key(s) open the Output Settings menu which allows the parameters for the selected channel to be edited.
On a dual channel instrument the keys also select the current channel as displayed on the left hand side of the status line.
Note that the OUTPUT key(s) do not turn the outputs on or off directly, this is done via a soft-key in the Output Menu screen.

TRIGGER/LOCAL key. Used to enter the Trigger menu where the instrument trigger parameters may be specified. This key is also used on a dual channel instrument to return to local from remote mode.

UTILITY key gives access to menus for a variety of functions such as SYNC OUT set–up, power–up parameters and error message settings.

STORES key allows access to the built in storage for waveforms and set-ups and to a connected flash drive.

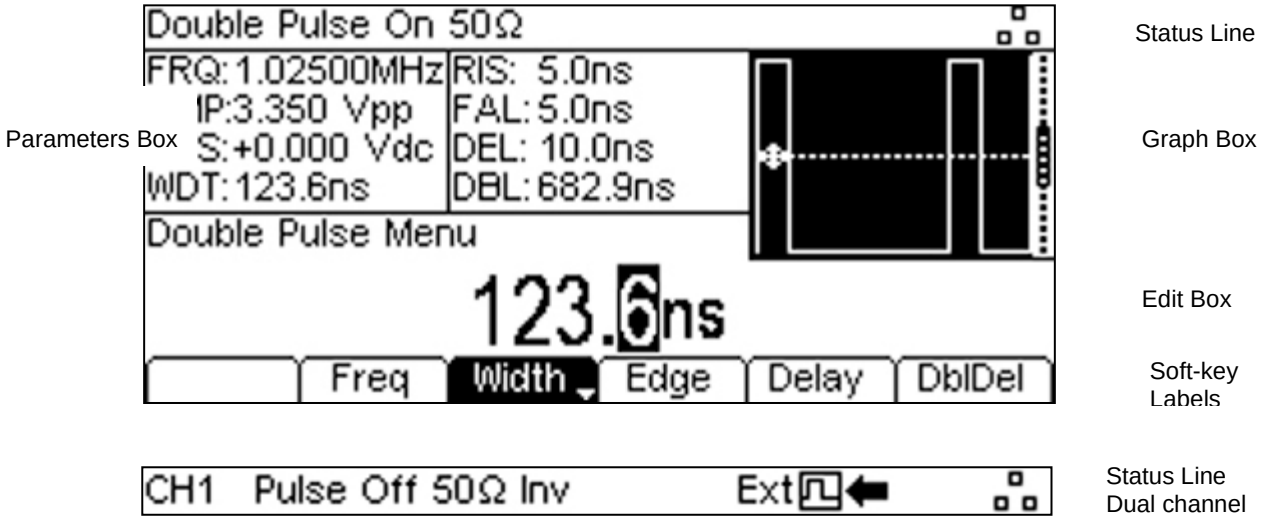
SPIN WHEEL and left and right cursor keys. Used during numeric entry. The left and right keys move the edit position left or right and the spin wheel increments or decrements the value of the selected digit.

The HELP/ LOCAL key, available on a single channel instrument, gives direct access to the complete help system. On a dual channel instrument the help system is accessed from the Utility menu. However, context sensitive help can be obtained for any key, including soft-keys, by holding the key down for 2 seconds. The HELP/ LOCAL key is also used on a single channel instrument to return to local from remote mode.

Further explanations will be found in the detailed descriptions of the generator's operation.

6.2.2 Display

All parameter settings are displayed on the backlit liquid crystal display (LCD). The most common type of display layout is shown below:



The Status Line indicates the status of the instrument as follows(from left to right):

The Channel field is blank on a single channel instrument. On a dual channel instrument it indicates which channel is currently selected for editing (**CH1** or **CH2**). If the channels are Tracking the field will change to **Track** . If the channels are Tracking with inversion the field will show **InvTk** .

The Waveform field shows the currently selected pulse mode, waveform or pattern (e.g. **PULSE**).

The Output signal status for the channel is displayed as **On** or **Off**.

The selected load impedance is shown in Ohms.

If the output is set to be inverted **Inv** will be displayed

The next field indicates the external clock status. If the internal clock is being used, nothing is displayed. If an external clock is being applied or is being used, the Ext symbol appears. If the clock is in use the symbol is followed by an arrow. If a valid clock signal is detected (but not used), the symbol is followed by **DET** . If the clock source is set to external and a valid external clock signal is not detected, the symbol is followed by **ERR** .

When the instrument is under remote control via any interface **REM** will be displayed.

The field indicates the status of the Local Area Network interface. As shown, there is no LAN connection. When connected the field will change to LAN . While a connection is being established the indicator will flash. If the LAN is connected but not enabled the field will show as LAN . See section 20 Remote Interface Operation for more detailed information.

The Parameters Box on the left shows the waveform parameter settings for the selected channel. These always include **FRQ** (frequency), **AMP** (amplitude) and **OFS** (offset). Additional parameters shown will depend upon the waveform type. When a waveform modifier (Modulation, Sweep or Burst) is enabled, the right hand section will show parameters of the modifier.

The Graph Box on the right shows a representation of the waveform which the instrument is generating on the selected channel. The parameter currently being edited is indicated by arrows.

The lower part of the display contains the Edit Box which shows the value of the parameter currently being edited on the selected channel. This will be a numeric value or a parameter string.

Under the Edit Box are the current Soft-key Labels which change as editing proceeds.

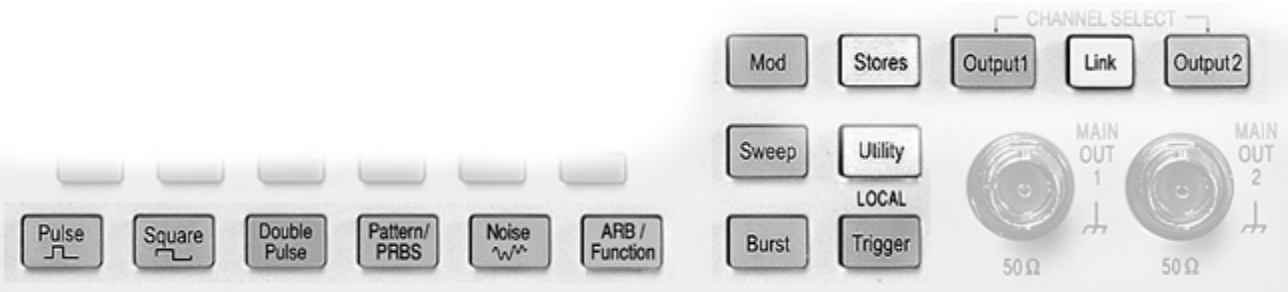
The Status Line and the Soft-key Labels are always shown on the LCD. The section between these areas will sometimes change in appearance, for example when displaying help.

A Pop-up Box may also appear to provide error or warning messages or to give other information to the user. See Appendix 1. Information, Warning and Error Messages for a full list of messages.

7 Control Principles

7.1 Control Menus

Menus are selected using the keys shown below:



7.1.1 Main Menus

There are four types of Main Menu:

Waveform Menus (Pulse, Square, Double Pulse, Pattern/PRBS, Noise, ARB/Function)
These are selected using the six illuminated keys below the display. Parameters can be set for any waveform without making that waveform active. Separate waveform parameters are retained for each.

Modification Menus (Modulation, Sweep, Burst)
These are selected using the three illuminated keys to the bottom right of the display. The three waveform modification modes are mutually exclusive.

Output Menu(s)
This is selected using the illuminated Output key(s). On dual channel instruments this is also used to change the channel for subsequent editing.

Link Menu (dual channel instruments only)
This is selected with the Link key between the two output keys. It enables coupled or tracking operation of the two channels to be set up.

Note that a menu is re-selected by pressing the appropriate menu key again. For example, having set up Burst parameters for a Pulse waveform, press the Pulse key to close the Burst menu and return to the Pulse menu.

Sub Menus

Each main menu may have a number of sub menus which are selected using the soft-keys. These sub menus will include a key marked **Done** and may contain a key marked ⮥.

The ⮥ key is known as BACK and will move up one level in the menu hierarchy. The **Done** key will move directly to the top level in the hierarchy.

Additional options within any menu are accessed using the ➡ key.

7.1.2 Channel Selection (dual channel instruments only)

On a dual channel instrument, the OUTPUT 1 and OUTPUT 2 keys are used to change the channel currently being edited. For example if Channel 1 is being edited, and a change is required to the main waveform parameters of Channel 2, press the OUTPUT 2 key, followed by the currently selected Waveform key.

7.1.3 Additional Menus

Four additional menus are available:

Stores
Provides access to internal or external storage of Set-ups, Arbitrary Waveforms, Noise Distribution or Patterns.

Utility
Provides access to system settings, instrument operational settings, interface settings, and calibrations.

Trigger
Provides access to the set-up for the external trigger input and the set-up for the Sync output signal(s). Note that the TRIGGER menu key can also act as the manual trigger.

Help
Offers explanation for specific topics of the instrument's operation. Note that context sensitive help is also available from holding down the relevant key. Note that, on dual channel instruments there is no HELP key and the Help menu is selected from within the Utility menu.

7.2 Editing Parameters

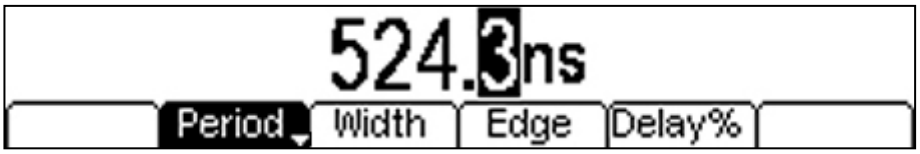
The instrument parameters are edited using the keyboard in conjunction with the Soft-key Labels and the Edit Box.

7.2.1 Soft-key Types

Within any menu, the parameter to be edited is selected with a soft-key. There are three types of soft-keys:

Numeric parameter keys (single function)
These keys select a single numeric parameter for editing. When pressed, the key changes to white text on a black background and the current value of the parameter appears in the edit box.

Numeric parameter keys (multiple function)
These keys have more than one function that changes with multiple presses of the key. When first pressed the key changes to white text on a black background with a small arrow on the right hand side. Subsequent presses change the soft-key text between two or more parameter options (e.g. Frequency or Period).



Option selection keys (single option)
These keys select a single option of a parameter. An example is the waveform selection keys within the Wave sub-menu of the Arb/Function waveform menu.

These keys do not change background colour when pressed and remain as black text on a white background.

Option selection keys (multiple options)
These keys select between multiple options of a parameter.. When first pressed the key changes to white text on a black background with a small arrow on the right hand side. The current option appears in the Edit Box.

Subsequent presses change the option as shown in the edit box (e.g. Coupled or Independent).

7.2.2 Numeric Editing

Any numeric parameter may be changed in one of the following ways:

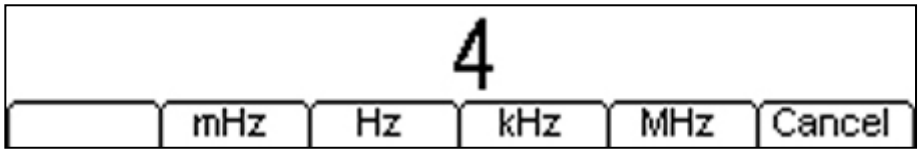
Enter a new value from the numeric key pad.

Use the left and right cursor keys to select a digit position then use the spin wheel to increment/decrement the value at that position.

Examples of each method are shown below.

7.2.3 Using the Numeric Key Pad

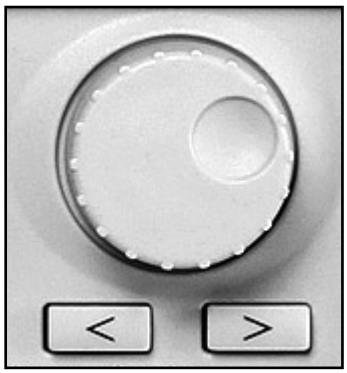
Pressing a number key will erase the current parameter value in the Edit Box and replace it with the current entry. The Soft-key Labels will also change to a list of units applicable to the parameter being edited. The examples below show frequency units and period (time) units respectively.



During the numeric data entry a decimal point and, if appropriate, a sign may be entered. The **+/-** key is used to alternately change the sign between + and –. The left cursor key may be used to erase the last digit entered. The entry may be cancelled by pressing the **Cancel** key

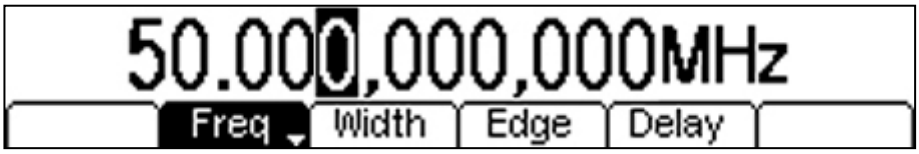
Once the entry is complete it may be terminated by pressing the soft-key below the required units. The value will be checked and accepted as the new value for the relevant parameter.

7.2.4 Using the Spin wheel and Cursor Keys



A numeric parameter will be displayed with an inverse edit cursor over one of the digits. The left and right cursor keys may be used to move the edit cursor to any digit in the value. Values are always shown with enough digits to the right of the decimal point to show the best resolution for the parameter. For example the right-most digit in a frequency value will be mHz.

Depending on the actual value one or more digits to the left of the most significant digit displayed may be zero and will not be shown. It is possible to move the edit cursor into these digit positions and the suppressed zeros will be shown as in the example below.



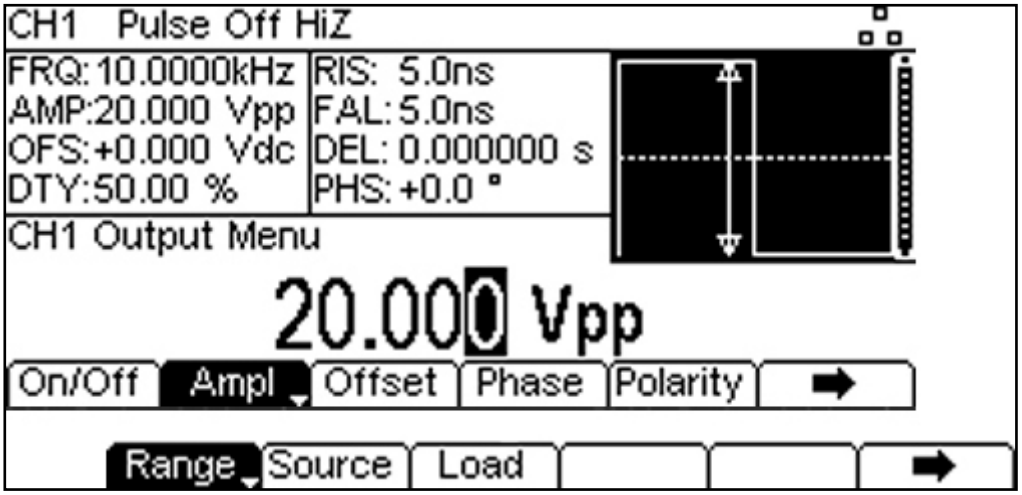
With the edit cursor positioned at the required digit the spin wheel may be rotated left or right to decrement or increment the digit. As the value passes between 9 and 0 the digits to the left will also change. In this way it is possible to set any legal value for the parameter.

Changes made by turning the spin wheel are applied immediately to the parameter as long as the value remains legal.

8.1 Setting Output Parameters

The output menu sets the output condition for each channel independently of the waveform type.
It is selected by pressing the OUTPUT key (single channel instruments) or the OUTPUT1 or OUTPUT2 key (dual channel instruments).

Note that, on a dual channel instrument the OUTPUT keys are also used to select the channel for editing.



To return from the output menu to a waveform menu or other menu, press the appropriate menu key.

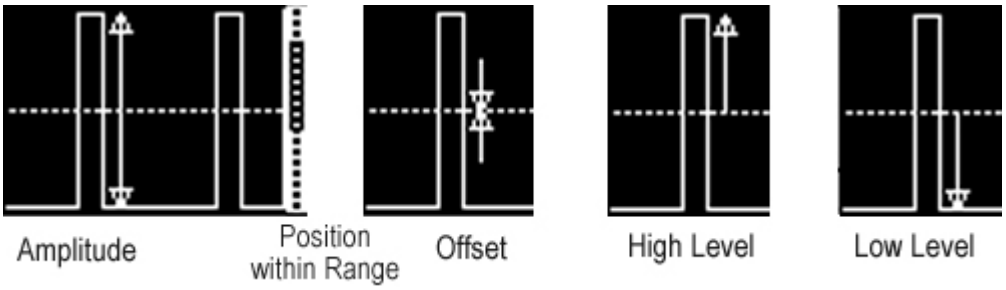
8.1.1 Output On/Off

Pressing the **`On/Off`** soft-key toggles the output On or Off. The OUTPUT key is illuminated when the output is On.

8.1.2 Output Amplitude and Offset (High and Low Levels)

The output can be set either in terms of a peak to peak amplitude and a DC offset, or as a high level and a low level. Multiple presses of these soft-keys toggles between these two modes with the key names changing accordingly (**`Ampl`** <> **`HiLvl`** and **`Offset`** <> **`LoLvl`**).

Pressing either soft-key displays the parameter in the Edit Box and the Graph Box changes to show the parameter that is being edited.



The maximum and minimum voltage levels depend upon the source and load impedances. The maximum and minimum EMF amplitudes (high impedance load) are 22V pk-pk and 200mV pk-pk respectively. The maximum and minimum high and low EMF levels are +11V and -11V.

8.1.3 Output Phase

Pressing the **Phase** soft-key creates a set of further soft-keys from which the output phase can be adjusted.

Phase

The output phase defines the position of the output waveform relative to the synchronisation signal. It can be set between 0 and 360 degrees to a resolution of 0.001 degrees.

For continuous waveforms, the phase relates to the carrier sync signal. For triggered waveforms the phase relates to the trigger signal. Either signal is available at the SYNC output socket.

Pressing the **Phase** soft-key displays the phase in the Edit Box and the Graph Box changes to show the phase graphically.

Reset

Pressing the **Reset** soft-key returns the phase to zero (0.0 degrees).

Align

In a 2 channel generator, or a generator phase locked to another generator, changes to frequency or other parameters can cause a loss of phase alignment.

Pressing the **Align** soft-key realigns the phase between the channels or generators.

8.1.4 Output Polarity

Pressing the **Polarity** soft-key alternates between Normal and Inverted. When inverted, positive voltage levels become negative and vice versa.

8.1.5 Output Range (Glitch Free Level Changing)

In order to achieve a wide output voltage range whilst retaining high vertical resolution, the output circuitry incorporates multiple attenuators. When a new level is set, the attenuators are automatically selected to gives the highest possible vertical resolution.

A consequence of changing the attenuator settings is small glitches on the output while this takes place. Some applications require glitch-free changes in level. To achieve this the attenuator position needs to be fixed based upon the highest level required (amplitude plus offset), with lower levels achieved only through attenuation via the DAC.

Successive presses of the **Range** soft-key alternate between Range: Auto and Range: Hold.

8.1.6 Output Source Impedance

Pressing the **Source** soft-key toggles the output impedance between 50 Ohms and 5 Ohms.

When driving a 50Ω load from 50Ω source impedance the maximum EMF of 22V pk-pk is reduced to 11V pk-pk. By changing the source impedance to 5Ω, the voltage into a 50Ω load can be increased to 20V pk-pk.

Note that, depending upon cable length and edge speeds, the impedance mismatch will degrade the pulse shape.

WARNING

When the source impedance is set to 5Ω a short circuit, or very low load impedance, may cause the over-current trip to operate turning the output off. It is advisable to make connection to the load with the output set to off.

8.1.7 Load Impedance

Pressing the **Load** soft-key enables the intended load impedance to be set. The displayed output amplitudes are calculated based upon the source and load impedances.

Successive presses of the **Load** soft-key toggles between a numeric value and High-Z (high impedance). The numeric value can be set between 50Ω and 10kΩ.

9 Pulse Generator Operation

9.1 Capabilities

The instrument can produce a wide range of pulses with adjustable period, width, delay and edge speed. It may also be set in Gated or Triggered mode, Swept Frequency mode, or be modulated using a wide variety of internal or external modulators. For more information see the sections on Burst, Sweep and Modulation.

Each channel of a two channel instrument has an independent pulse generator. These may be set to any combination of period, width, delay and modulation or burst. However, when the channels are linked by one of the dual-channel functions there are some restrictions between the parameters of the two channels; see the Dual-Channel Operations section of the Specification for details.

9.2 Pulse Functions

When operating as a pulse generator, the instrument has four functional types of operation as selected by the illuminated keys below the display - Pulse, Square, Double Pulse and Pattern/PRBS.

9.2.1 Changing Functions

The function is selected by pressing one of the illuminated keys below the display. However, the function is not changed until the **Apply** soft-key is pressed. This allows the parameters of the new function to be reviewed or altered prior to the change of function.

The function key for the currently active function will remain illuminated and the key for the new function will flash until the **Apply** key is pressed. Alternatively a second press of the flashing key will perform the Apply function.

9.2.2 Pulse

This function provides the maximum flexibility as to how pulses are defined.

The pulse period (i.e. how often free running pulses are repeated) can be set as a repetition rate (Freq.) or as a time (Period).

The pulse width can be set as an absolute time (Width) or as a percentage of the repetition period (Duty).

The rise and fall times can be set independently or together (Edge) and the delay time from the trigger/sync point set as an absolute time (Delay) or a percentage of the period (Delay%).

9.2.3 Square

This is a simplified version of the Pulse function in which rise and fall times are always minimum, and the pulse always commences at the start of the period (delay = zero).

The pulse width is always defined by duty cycle percentage (DtyCyc) and has a default value of 50%.

9.2.4 Double Pulse

This is an extended version of Pulse function in which two identical pulses are generated during each period.

The delay between the two pulse can be set as an absolute time (DblDel) or a percentage of the period (DblDl%). The delay is defined as from the start of pulse one to the start of pulse two, and therefore includes the width and edge times of one pulse.

9.2.5 Pattern/PRBS

This enables patterns of pulses to be produced either from user defined patterns or from a PRBS (Pseudo-Random Bit Sequence) algorithm. Patterns can be defined externally with the generator acting as a pulse reconstruction engine.

9.2.6 Retained Settings

The instrument retains independent settings for the four pulse functions.

9.2.7 Invalid Settings

In order for the settings to be valid, they must conform to rules which ensure that the period is equal to or greater than pulse width plus delay plus 0.625 x (rise plus fall times) plus 3.75ns.

The minimum period is 20ns [40ns], minimum pulse width 10ns [20ns], minimum delay 0ns, minimum rise/fall times 5ns each [8ns]. For Double Pulse mode, the double pulse delay must be added (minimum 20ns).

Attempting to make an invalid setting will bring up an error message on the display. No change to settings will be made.

9.2.8 Changing Channels (dual channel models only)

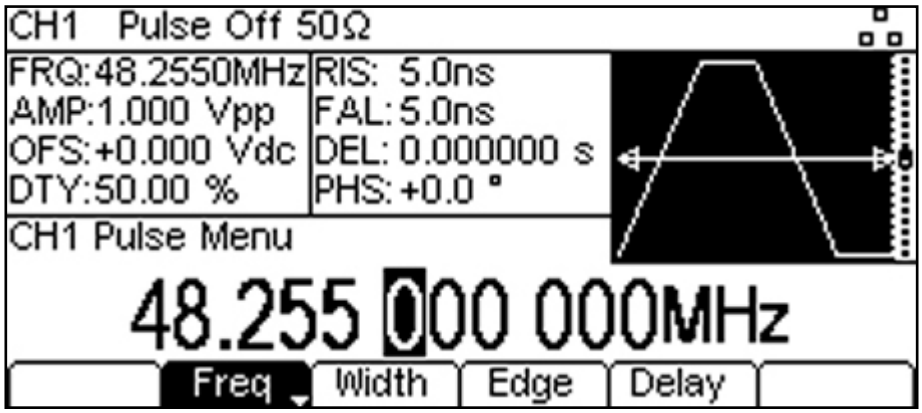
The current channel being edited is shown at the top left of the display (CH1 or CH2). Pressing either of the two keys marked OUTPUT 1 or OUTPUT 2 opens the Output Menu for Channel 1 or Channel 2, and sets the current editing channel accordingly.

Thus, to move from editing waveform parameters CH1 to editing CH2, press the OUTPUT 2 key followed by the appropriate waveform key below the display. Illumination of the OUTPUT 1 and OUTPUT 2 keys indicates that the output is turned On.

9.3 Setting Parameters for Pulse

9.3.1 Frequency/Period

The frequency or period may be changed in either of the ways detailed in section 6.2.2 Numeric Editing. Pressing the **`Freq`** soft-key while it is highlighted will change the label to **`Period`** and vice versa. The parameter units will change between frequency and time as appropriate. Note that the upper frequency limits are lower for the TGP312x than for the TGP315x.

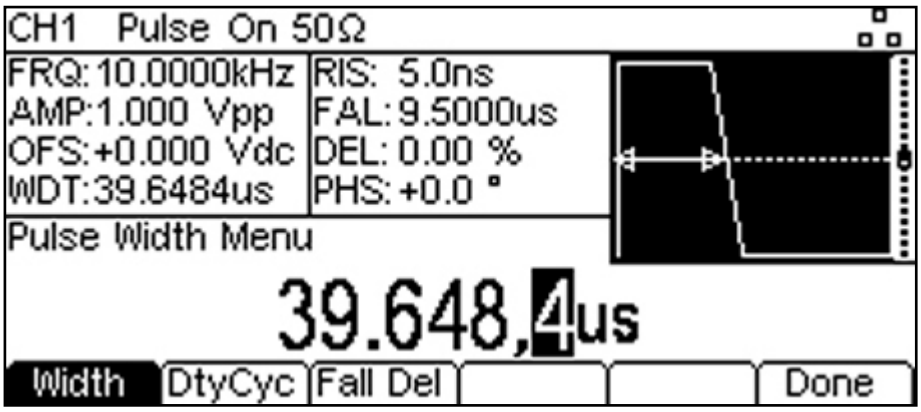


9.3.2 Pulse Width

Pressing the **`Width`** soft-key opens the Width Sub-menu, along with the width parameter in the Edit Box The Graph Box changes to show that width is being edited. The value of the Width may be changed as detailed in section 6.2.2 Numeric Editing. The sub-menu enables the width of the pulse to be set in any of three different ways

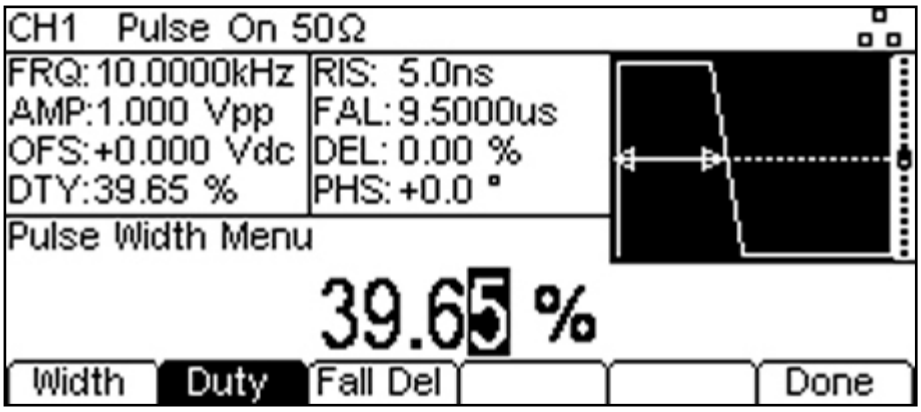
Width

Pressing **`Width`** shows the width of the pulse in terms of time (ns, us, ms or s). The value represents the time from the mid point of the rising edge to the mid-point of the falling edge.



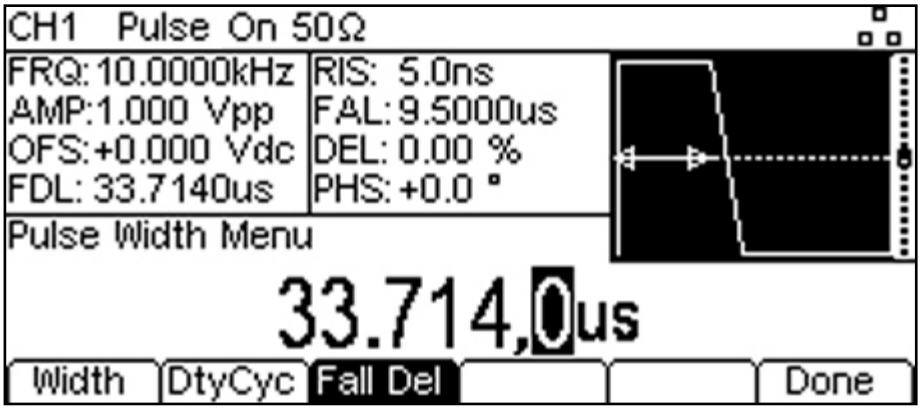
Duty Cycle

Pressing **`Duty`** shows the width of the pulse as a percentage of the period to a maximum resolution of 0.01%.



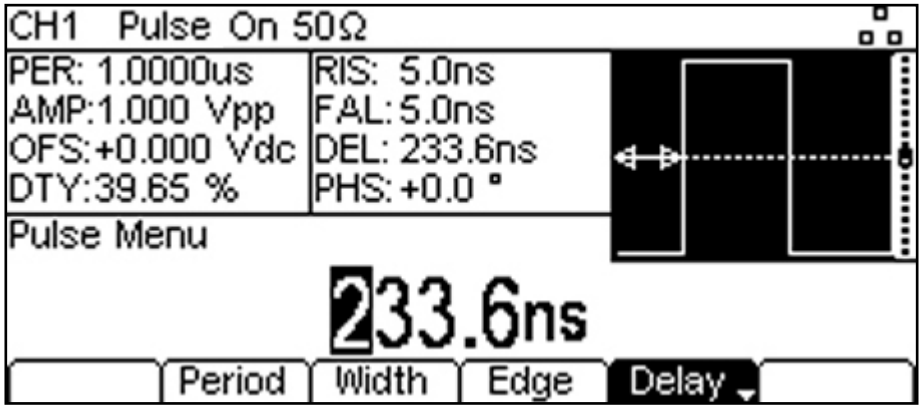
Fall Delay

Pressing **`Fall Del`** shows the width of the pulse in terms of time (ns, us, ms or s). The value represents the time from the mid point of the rising edge to the start of the falling edge.



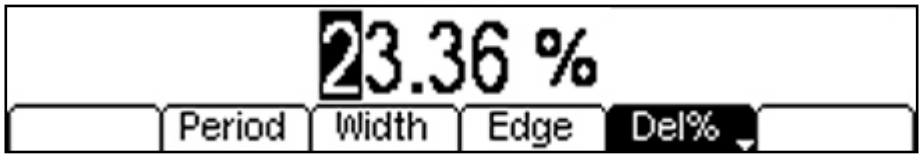
9.3.3 Pulse Delay

Pressing the **Delay** soft-key shows the delay parameter in the Edit Box and the Graph Box changes to show that delay is being edited.



The Graph box shows the delay parameter between the arrows.

Delay can be specified in terms of time (ns, us, ms or s), or as a percentage of the period. Pressing the key alternates between **Delay** and **Del%.**



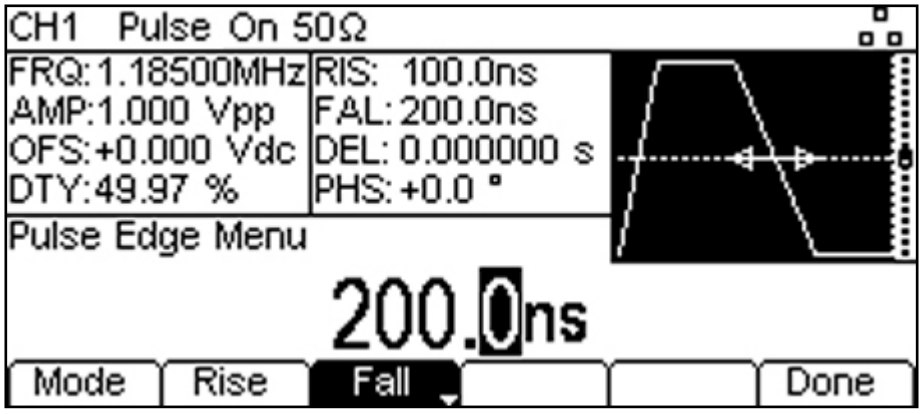
Changing the delay causes the start of the pulse to be delayed with respect to the sync pulse available at the SYNC OUT connector.

The delay also adds a delay between the trigger signal and the pulse output during burst modes. See section 14 Burst Operation for more details of Burst and Gate modes. The delay also changes the relative timings of the pulses in dual channel modes.

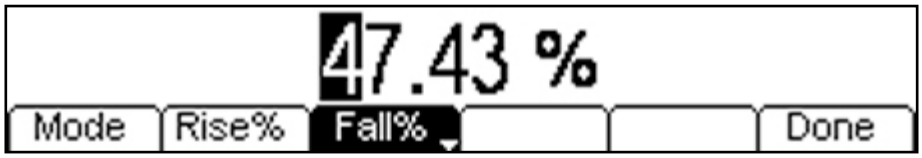
9.3.4 Edge Time

Pressing the **Edge** soft-key opens the Edge sub-menu. The edge time represents the time between the 10% and 90% points on the pulse edges. Rise time and fall time can be adjusted independently or together (Coupled).

The **Mode** soft-key toggles between Independent or Coupled mode. For Independent mode, two soft-keys (**Rise** and **Fall**) are provided. For Coupled mode there is a single soft-key of **Edge**.



Alternatively the edge time can be entered as a percentage of the pulse width.



The selected edge time may be changed in either of the ways detailed in 6.2.2 Numeric Editing.

9.4 Setting Parameters for Square

9.4.1 General

Square is a simplified version of Pulse in which the edge speed is always maximum, and the delay is always zero. The on time is always specified in terms of duty cycle.

9.4.2 Frequency/Period

The frequency or period may be changed in either of the ways detailed in section 6.2.2 Numeric Editing.

Pressing the **Freq** soft-key while it is highlighted will change the label to **Period** and vice versa. The parameter units will change between frequency and time as appropriate.

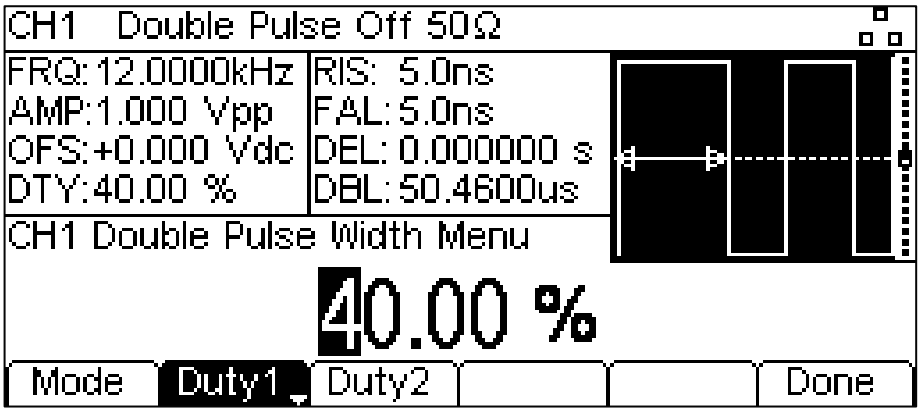
Note that the upper frequency limits are lower for the TGP312x than for the TGP315x.

9.5 Setting Parameters for Double Pulse

9.5.1 General

The Double Pulse function generates two identical pulses or two pulses with different widths with a selectable delay between them.

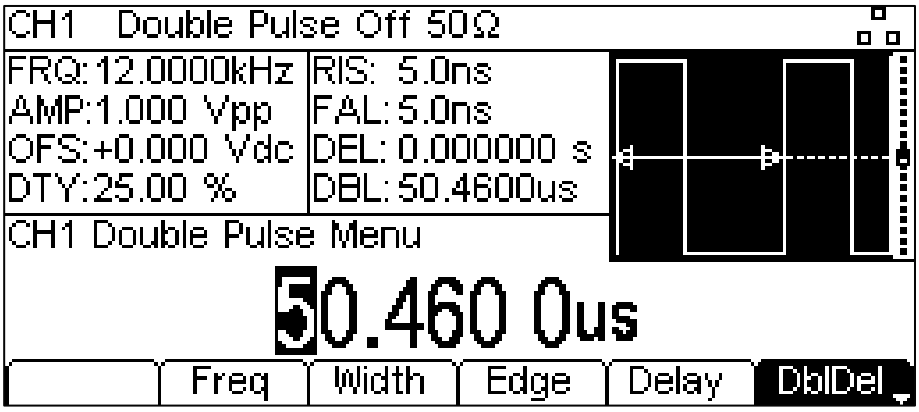
The **Mode** soft-key in the width sub-menu toggles between Independent or Coupled mode. When the mode is coupled, the two pulses are of identical widths. When the mode is independent, the widths of the mode can be set independently.



Setting up of Double Pulse is identical to setting Pulse parameters (as described earlier), but with the additional parameter of delay between the pulses.

9.5.2 Double Pulse Delay

This parameter specifies the delay between the start of the first pulse and the start of the second pulse. Pressing the **DblDel** soft-key shows the delay parameter in the Edit Box and the Graph Box changes to show that delay is being edited.



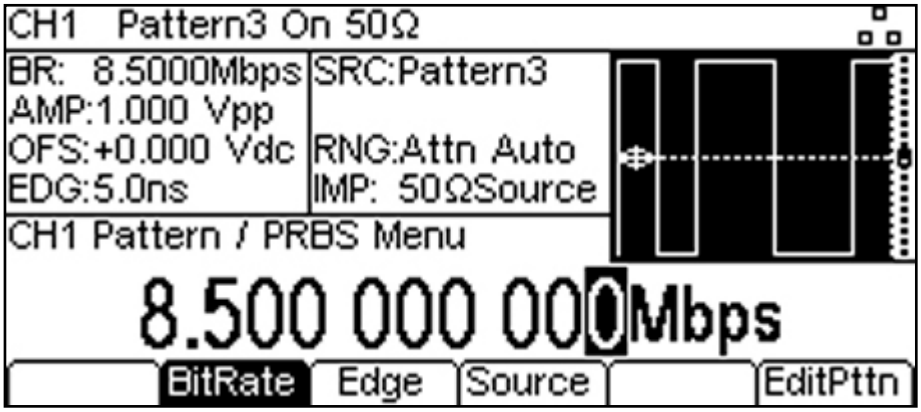
Alternatively the delay can be set in terms of a percentage of the period.

9.6 Setting Parameters for Pattern/PRBS

9.6.1 General

Patterns of pulses can be produced either from user defined patterns or from a PRBS (Pseudo-Random Bit Sequence) algorithm. Bit rates from 1mbps up to 50Mbps [25Mbps] can be used and internally stored patterns can have up to 65536 bits. PRBS sequence lengths are between 127 to 8,388,607 bits.

Patterns can also be defined externally with the generator acting as a pulse reconstruction engine.



9.6.2 Bit Rate

The bit rate is set in terms of bps (bits per second) in a similar way to setting frequency. The pattern repetition rate is a function of the bit rate and the pattern length.

Pressing the **`BitRate`** soft-key shows the bit rate parameter in the Edit Box and the value can be changed as detailed in section 6.2.2 Numeric Editing.

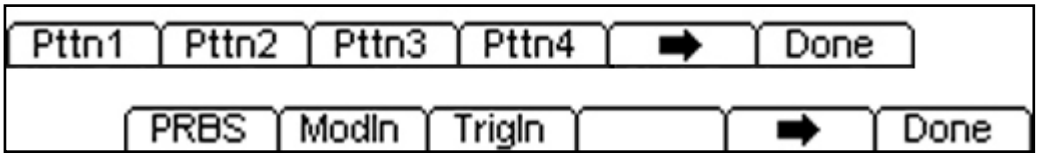
9.6.3 Edge Time

The pulse edge transition time is variable in a similar way to other pulse modes; however, the rise and fall times are always set equal.

Pressing the **`Edge`** soft-key shows the edge time parameter in the Edit Box and the Graph Box changes to show that edge time is being edited.

9.6.4 Pattern Source

Pressing the **`Source`** soft-key creates a set of further soft-keys from which the source of the pulse pattern can be selected.



Internal Patterns

The soft-keys **`Pttn1`** through **`Pttn4`** select one of four patterns stored within the instrument. Each pattern can have up to 65536 bits and can be loaded from a flash drive or from the digital interfaces. Patterns can be created externally or created/edited internally, see section 8.7 Pattern Editing.

External Patterns

Patterns can be generated externally whereby the generator acts as a pulse shaper and amplifier. Two methods are available.

Pressing the **ModIn** soft-key selects the modulation input (MOD IN socket on the rear panel) as the external pattern source. In this mode external patterns at up to 5Mbps can be applied and these are synchronised to the generator's internal clock using a 50Mbps sampling clock.

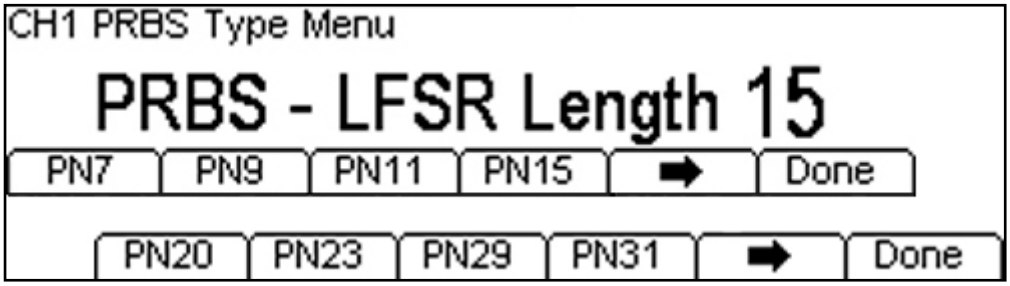
Pressing the **TrigIn** soft-key selects the trigger input (TRIG IN socket on the rear panel) as the external pattern source. In this mode external patterns at up to 50Mbps can be applied which are regenerated at the output asynchronously relative to the generator's system clock. This enables the generator to act as a low jitter asynchronous pulse shaper and amplifier.

PRBS

Pressing the **PRBS** soft-key selects the source as an internally generated PRBS (Pseudo-Random Bit Sequence).

Pressing the **Done** soft-key returns to the main Pattern/PRBS menu which will then include an extra soft-key of **Type** .

Pressing the **Type** soft-key creates a set of further soft-keys from which the PRBS type can be selected from eight different types.



For information about PRBS types see Specifications section 22.2.4 Pattern/PRBS.

9.7 Pattern Editing

Patterns can be created or edited externally to the instrument using the Aim-TTi Windows application Waveform Manager Plus (v4.1 or later). These can be transferred using a USB Flash drive or loaded via the digital interfaces.

Alternatively patterns can be created and edited within the instrument. Pressing the **EditPttn** soft-key from the Pattern/PRBS main menu opens the Pattern Edit Select sub-menu

The soft-keys **Pttn1** through **Pttn4** select one of four patterns stored within the instrument. Each pattern can have up to 65536 bits and can be loaded from a flash drive or from the digital interfaces.

The soft-keys **Pttn1** through **Pttn4** select one of the four patterns and pressing the **Edit** soft-key creates the Pattern Edit menu.

Each pattern has a default name of PATTERN1 thro PATTERN4 and has a default length of 4 bits arranged as Low, High, Low, High.

9.7.1 Pattern Length

Pressing the **Length** soft-key enables the length of the pattern to be defined. Additional bits created are always as alternating high/low states. Minimum pattern length is 1 bit and maximum is 65536 bits.

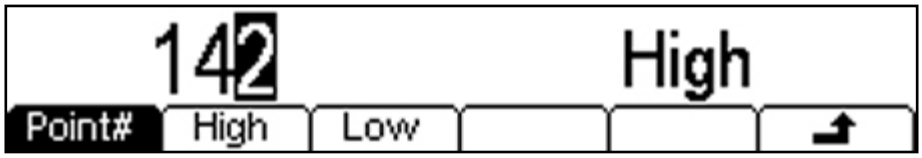
9.7.2 Pattern Preamble

When the pattern is used as a triggered burst (where the pattern is replayed more than once in response to a trigger signal), it is possible to define a section at the start of the pattern which is only replayed once. This is called the preamble.

Pressing the **Preamb** soft-key enables the length of the preamble section to be defined. Note that the preamble remains part of the pattern length.

9.7.3 Setting Point Levels

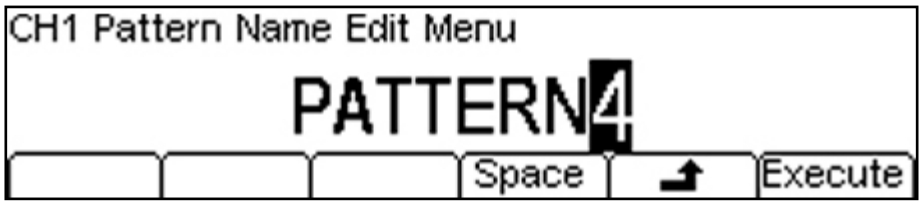
Pressing the **Point** soft-key creates an additional set of soft-keys from which the level of each point in the pattern can be set.



The **Point#** soft-key allows the point number to be selected and its current level shown within the edit box. The level for each point can be changed by pressing the **High** or **Low** soft-keys.

9.7.4 Pattern Renaming

Pressing the **Name** soft-key creates a further sub-menu from which the name can be changed.



A name of up to 8 characters can be used. The cursor keys < > are used to select the character and the spin wheel used to change the character. When the wheel is turned clockwise the characters change in the following order: 0 to 9, A to Z, ^ _ ' { } ~ (space) ! # $ % & ' ( ) -

Spaces can be introduced or characters deleted using the **Space** soft-key. The name is changed when the **Execute** soft-key is pressed.

9.7.5 Pattern Reset

Pressing the **Reset** soft-key opens a further sub-menu from which the pattern can be reset to either Default (alternating Highs and Lows) or All Highs or All Lows. The pattern length is not changed.

9.8 Pulse Modulation

All pulse types can be modulated in a wide variety of ways using an internal or external source.
See section 12 Waveform Modulation.

Note that FM modulation of pulses will retain a fixed pulse width even when the width has been set as a duty cycle percentage.

9.9 Swept Pulse Operation

All pulse types can have their frequency swept over a wide range at a variable rate.
See section 13 Sweep Operation.

Note that swept pulses will retain a fixed pulse width even when the width has been set as a duty cycle percentage.

9.10 Pulse Burst Operation (Triggered or Gated)

All pulse types can be triggered or gated. See section 14 Burst Operation.

9.11 Asynchronous Pulse Generation, Delay and Reconstruction

Conventional digital waveform generators align all waveform points to a system clock.
In consequence, pulses generated in response to an asynchronous external trigger signal will be subject to jitter.

TGP3100 Series generators incorporate circuitry that measures the interval between the external trigger event and the system clock, and adds a compensating amount of time so as to provide a fixed delay between trigger and output.

9.11.1 Pulse Delay Generator Operation

The instrument can be used to generate a variable pulse delay with minimal jitter. The fixed (minimum) delay between trigger input and pulse output is approximately 448ns with a typical jitter of 60ps RMS. Additional delay can be added to a resolution of 100ps. Maximum delay is 800 seconds. Maximum trigger repetition rate is 50MHz [25MHz].

Operation is set using a Pulse waveform and Triggered Burst mode, see section 14 Burst Operation for more details. The pulse width and edge speeds are as defined within the pulse waveform menu.

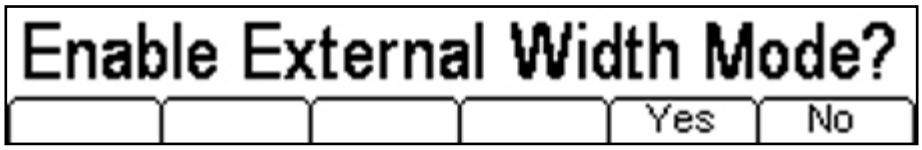
9.11.2 Pulse Reconstruction (External Width mode)

In the mode described above, the pulse width is defined within the generator in response to a trigger edge. An alternative requirement is to generate pulse waveforms that directly replicate the signal applied to the trigger input. In this mode the pulse width as well as the pulse repetition rate is defined by the external signal.

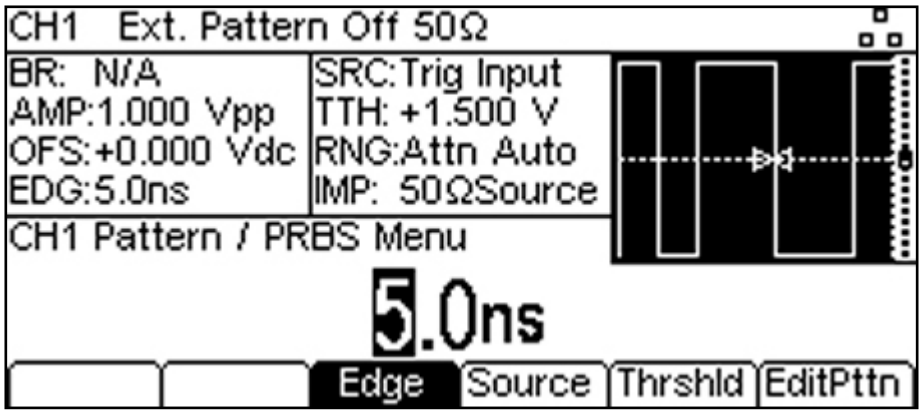
The pulse edge speed can be set over a wide range, but rise time and fall time are always set equal. Typical trigger input to pulse output delay is 448ns with a typical jitter of 60ps RMS.

Asynchronous External Width mode is a variant of a Pulse Pattern waveform that can be selected from the Pattern/PRBS menu by setting the Source to External Trigger Input. Alternatively it can be directly selected from the TRIGGER menu by pressing the **ExtWdt** soft-key.

A confirmation message appears:



Pressing the **Yes** soft-key opens the Pattern/PRBS waveform menu with the source set to External Trigger Input.



9.11.3 Synchronous Pulse Reconstruction

Pulse patterns can also be reconstructed in a synchronous mode using a 50Mbps sampling clock. This has the effect of reconstructing the pulses synchronously with the internal system clock which will create an uncertainty of 20ns relative to input. Maximum input pattern bit rate is 5Mbps.

Synchronous External Width mode is a variant of a Pulse Pattern waveform that can be selected from the Pattern/PRBS menu by setting the Source to External Modulation Input.

9.11.4 Modulations for External Width modes

Both of the modes described above can be modulated using AM, AM-SC or SUM. No other types of modulation are possible.

9.12 Pulse Output Conditions

Setting levels, turning the output on or off, and other matters relating to the output are done from the output menu. See section 7 Output Menu

10 Noise Generator Operation

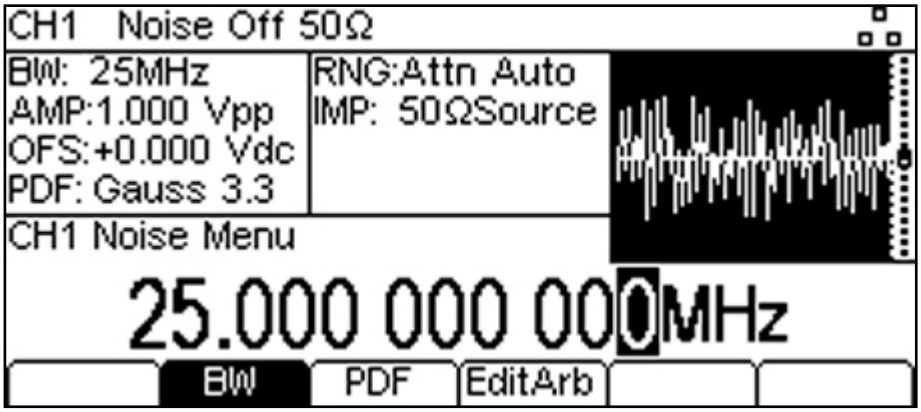
10.1 Capabilities

The instrument contains a full variable bandwidth noise generator with user definable PDF (probability density function). Maximum noise bandwidth is 25MHz [12.5MHz].

Noise can be used as a primary waveform (carrier waveform) or as a modulator for other waveform types.

In dual channel mode there are some restrictions on Noise; see the Dual-Channel Operations section of the Specification for details.

10.2 Setting Parameters for Noise



10.2.1 Noise Bandwidth

Pressing the **BW** soft-key displays the current noise bandwidth in the Edit Box. The bandwidth can be set anywhere between 1mHz and 25MHz [12.5MHz].

10.2.2 Noise Probability Density Function (PDF)

Pressing the **PDF** soft-key creates a further set of soft-keys from which the PDF can be selected.

Four standard Gaussian PDFs are provided with crest factors between 3.3 and 7.0, accessed by the soft-keys **G3.3** thro **G7.0**. Alternatively pressing the **Arb** soft-key selects an arbitrary waveform as a user-defined probability density function.

10.2.3 User Defined PDF

Pressing the **EditArb** soft-key creates the Arb Edit sub-menu from which the arbitrary waveform based distribution can be edited.

The user can create an arbitrary waveform that will define the PDF based upon the density of occurrence of levels within the waveform.

For example, a ramp waveform with levels between -32767 and +32767 would contain every level at equal density. However, a rectangular waveform with an 80% duty cycle would result in noise which, although still random in occurrence, would include only two levels, with the high level occurring four times more often than the low level.

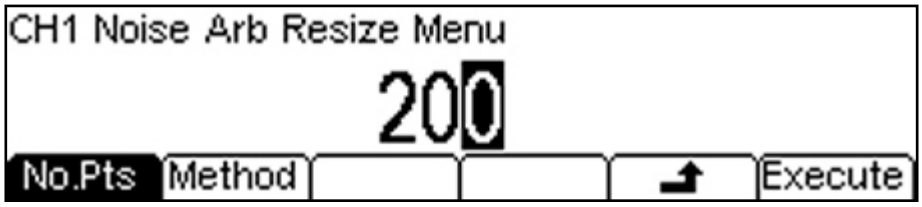
The arbitrary waveform has the default name ARB_DIST and can be created outside of the instrument and loaded from the Flash Drive or bus interfaces, or it can be created and/or edited within the instrument.

Creating or Editing the Arbitrary Noise Distribution Waveform

Pressing the **EditArb** soft-key on the main noise menu opens the Arb Edit menu.

Pressing the **Interp** soft-key alternates between Interpolator Off and Interpolator On. Whatever the waveform length it will be increased to 4096 points internally when it is used. The interpolator setting defines whether this is done by repeating points or by straight line interpolation.

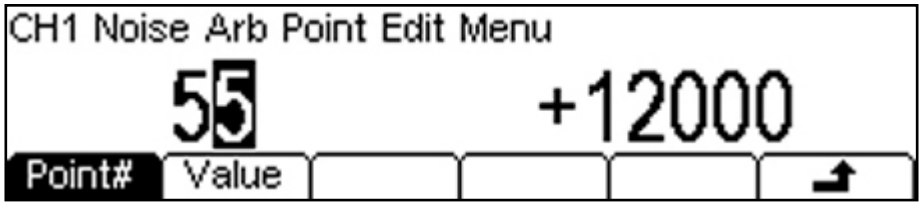
Pressing the **Resize** soft-key opens the Waveform Resize sub-menu.



The number of points in a waveform can be within the range 1 to 2048. Default waveforms have only four points. The waveform size should be set prior to further editing because points cannot be added or removed other than by resize.

Pressing the **Method** soft-key alternates between Interpolate and Repeat Points as the resizing method. The resize is performed when the **Execute** soft-key is pressed.

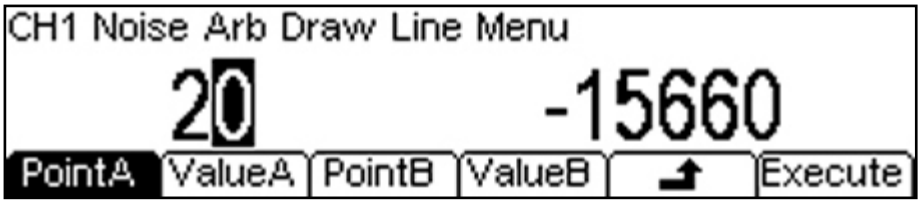
Pressing the **Point** soft-key opens the Point Edit sub-menu.



Points are selected with the **Point#** soft-key and the value changed with the **Value** soft-key.

Only points within the current size can be edited. Additional points cannot be added.

Pressing the **Line** soft-key opens the Draw Line sub-menu.



Points for the start and end of the line are selected with the **PointA** and **PointB** soft-keys and the values changed with the **ValueA** and **ValueB** soft-keys. The line is created when the **Execute** soft-key is pressed.

Pressing the **Name** soft-key opens the Name Edit sub-menu.

The name can be changed if required. A name of up to 8 characters can be used.
The cursor keys < > are used to select the character and the spin wheel used to change the character. When the wheel is turned clockwise the characters change in the following order:
0 to 9, A to Z, ^ _ ' { } ~ (space) ! # $ % & ' ( ) -

Characters can be deleted or spaces created using the **Space** soft-key. The name is changed when the **Execute** soft-key is pressed.

10.3 Noise Modulation

Noise can be modulated in a wide variety of ways using an internal or external source. See section 12 Waveform Modulation.

10.4 Noise Burst Operation (Triggered or Gated)

Noise can be triggered or gated.

In the case of triggering, the burst number represents the number of noise sample points generated following the trigger. The relationship between noise bandwidth and sample points is approximately: points = 3.2 x bandwidth in Hz.

See section 14 Burst Operation.

10.5 Noise Output Conditions

Setting levels, turning the output on or off, and other matters relating to the output are done from the output menu. See section 7 Output Menu

11 ARB/Function Generator Operation

11.1 Capabilities

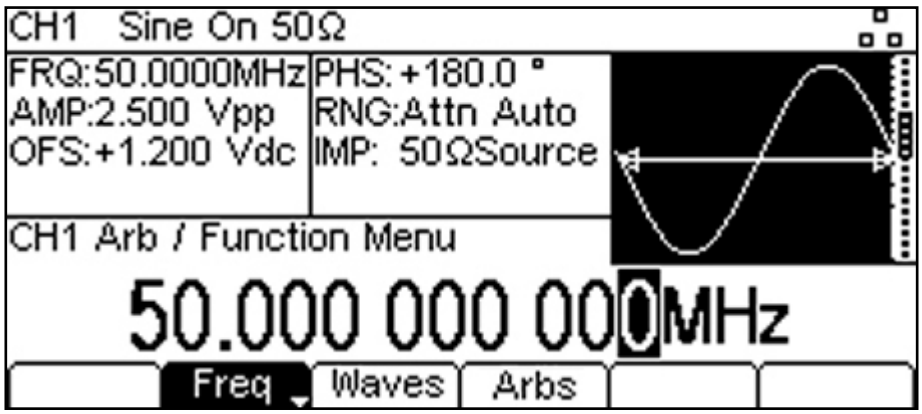
The instrument can operate as a conventional function and arbitrary generator using DDS (direct digital synthesis) techniques. Maximum sine/square frequency is 50MHz [25MHz].

Built-in waveforms are Sine, Square, Triangle, Ramp Down, Ramp Up, Sinex/x, Haversine, Cardiac, Exponential Rise, Exponential Fall, Logarithmic Rise, Logarithmic Fall, Lorentz, D-Lorentz and DC.

Four arbitrary waveforms of up to 4096 points each can be held within the instrument. Any number of waveforms can be stored and transferred via the Flash Drive interface, or the bus interfaces. Maximum waveform frequency is 50MHz [25MHz] and sampling rate is 800MS/s.

11.2 Function and Arbitrary Waveform Menu

Standard waveforms (function generator waveforms) and arbitrary waveforms are controlled in a similar way.



Parameters are set in terms of a Frequency (or Period) and a Waveform type. A further soft-key appears for certain waveform types including Square and Sinc.

11.2.1 Frequency/Period

The frequency or period may be changed in either of the ways detailed in section 6.2.2 Numeric Editing.

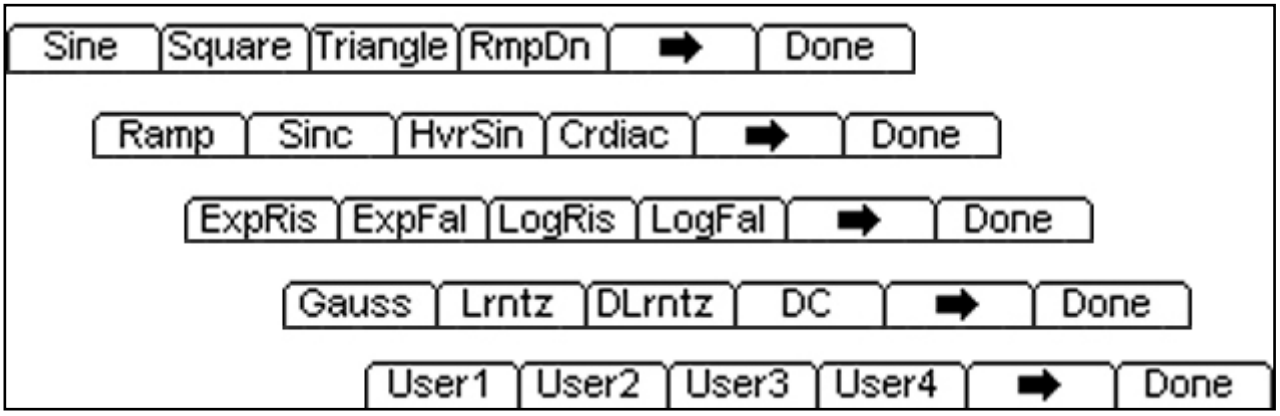
Pressing the **Freq** soft-key while it is highlighted will change the label to **Period** and vice versa. The parameter units will change between frequency and time as appropriate.

The lower frequency limit is 1mHz. The upper frequency limits is 50MHz [25MHz].

Sine waves and square waves are available up to the maximum frequency (square wave shape limited by output amplifier bandwidth). For other waveform types, the limited number of waveform points with increasing frequency will reduce the waveform quality. No restrictions are placed on the maximum frequency for any waveform.

11.2.2 Waveform Type

Pressing the **Waves** soft-key creates a further set of keys from which the waveform type can be selected.



Pressing the **Done** soft-key selects the waveform and returns to the main waveform menu.
A graphical representation of the waveform appears in the Graph Box.

11.3 Function Generator Waveforms

11.3.1 Sine or Haversine

Pressing the **Sine** soft-key selects the sinusoidal waveform type which is available at high quality up to the maximum generator frequency.

Pressing the **HvrSin** soft-key selects a haversine waveform which is a sine waveform that does not cross zero but has only positive values.

There are no additional options for these waveforms.

11.3.2 Square

Pressing the **Square** soft-key selects the rectangular waveform type which is available at high quality up to the maximum generator frequency subject to bandwidth limitations.

Pressing the **Duty** soft-key shows the existing duty cycle percentage and allows it to be set within the range 1.00% to 99.00%. This range reduces with increasing frequency subject to the minimum high or low period of 20ns [40ns].

11.3.3 Triangle

Pressing the **Triangle** soft-key selects a triangular waveform in which the waveform rises linearly for half the period and falls linearly for the other half period..

There are no additional options for this waveform.

11.3.4 Ramp Down

Pressing the **RmpDn** soft-key selects a waveform that falls linearly for almost of the whole of the period and then returns at the maximum possible edge speed.

There are no additional options for this waveform.

11.3.5 Ramp

Pressing the **Ramp** soft-key selects a triangular waveform with a fully variable ratio between the ramp up and ramp down times (symmetry).

Pressing the **Symm** soft-key shows the existing symmetry percentage and allows it to be set within the range 0.00% to 100.00%..

11.3.6 Sine(x)/x

Pressing the **Sinc** soft-key selects waveform created using a Sine(x)/x formula and which has a damped sinusoidal shape..

Pressing the **ZerCrs** soft-key shows the existing number of zero crossings within a cycle and allows it to be edited within the range 4 to 50.

11.3.7 Cardiac

Pressing the **Crdiac** soft-key selects a waveform characteristic of the electrical signal associated with a human heart beat.

There are no additional options for this waveform.

11.3.8 Exponential / Logarithmic Rise and Fall

Pressing the soft-keys **ExpRis** , **ExpFal** , **LogRis** , **LogFal** select waveforms that follow an exponential or logarithmic rise or fall.

Pressing the **TimCnst** soft-key shows the time constant used to calculate the function and allows it to be edited within the range 1.00% and 100.00%. The percentage multiplied by the waveform period represents the time constant.

11.3.9 Gaussian, Lorentz, D-Lorentz

Pressing the soft-keys **Gauss** , **Lrntz** , **DLrntz** select waveforms that follow a Gaussian. Lorentz or D- Lorentz shape.

Pressing the **Width%** soft-key shows the standard deviation used to calculate the function and allows it to be edited within the range 1.00% and 100.00%. The percentage represents the proportion of the waveform period required for one standard deviation.

This adjustment is not available for D- Lorentz.

11.3.10 DC (No Waveform)

Pressing the **DC** soft-key removes any waveforms from the output. This is a convenience function that allows the DC Offset control (set within the Output menu) to be used to generate DC voltages within the +/-22V range of the generator.

11.4 Arbitrary Generator Waveforms

11.4.1 Arbitrary Waveform Principles

The instrument generates arbitrary waveforms using a DDS technique. User defined waveforms of between 2 and 4096 points are stored in high speed memory. Vertical resolution is 16 bits and the DDS clock rate is 800MHz. The DDS system replays the complete waveform at a rate defined by the chosen waveform frequency or period.

Up to four waveforms can be stored within the instrument. Additional waveforms can be stored on a Flash Drive and transferred into the instrument as required. Alternatively waveforms can be transferred using the bus interfaces. Each waveform can be given a user defined name of up to 8 characters.

Waveforms can be created and edited within the instrument. However, complex waveforms are more conveniently created outside of the instrument. Waveform Manager Plus is a Windows based waveform creation and editing program intended for this purpose.

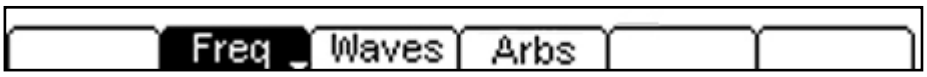
11.4.2 Waveform Frequency/Period

The frequency or period relates to the whole waveform, rather than each point within the waveform. The value may be changed in either of the ways detailed in section 6.2.2 Numeric Editing.

Pressing the **Freq** soft-key while it is highlighted will change the label to **Period** and vice versa. The parameter units will change between frequency and time as appropriate.

The lower frequency limit is 1mHz. The upper frequency limits is 50MHz [25MHz].

11.4.3 Loading or Editing an Arbitrary Waveform

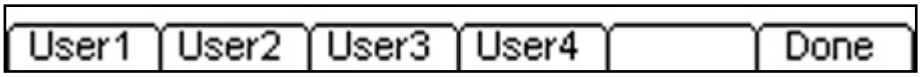


Pressing the **Arbs** soft-key within the Arb/Function waveform menu opens the Arbitrary Waveform loading or editing menu.

d

Waveform Load

Pressing the **Load** soft-key opens the Arb Load sub-menu.



The four keys User1 thro User4 represent the four arbitrary waveform stored within the instrument. These have default names of ARB1 thro ARB4, but these names can be changed by the user.

Press one of the four soft-keys **User1** thro **User4** to select it, followed by the **Load** soft-key to load it as the current waveform. Note that it is also possible to load an arbitrary waveform from the **Waves** key in a similar way to a standard waveform.

By default each waveform has 4 points.

Waveform Edit

Pressing the **Edit** soft-key opens the Arb Edit Select sub-menu.

The four keys User1 thro User4 represent the four arbitrary waveforms stored within the instrument. These have default names of ARB1 thro ARB4, but these names can be changed by the user. By default each waveform is a full amplitude square wave of 4 points.

Press one of the four soft-keys **User1** thro **User4** to select it, followed by the **Edit** soft-key to commence the editing process.

11.4.4 Arbitrary Waveform Creation and Editing

Arbitrary waveforms can be created externally on a PC (see section 23.2 Waveform Manager Plus) and transferred into the instrument using a USB flash drive or the digital interfaces, or created internally via the built-in editor.

Arbitrary waveform are defined by a point number (between 1 and 4096) and an associated vertical level between +32767 (positive full scale) and -32767 (negative full scale).

Pressing the **Edit** soft-key within the Arb Edit Select menu opens the Arbitrary Waveform editing menu.

Interpolator

Pressing the **Interp** soft-key alternates between Interpolator Off and Interpolator On. Whatever the waveform length it will be increased to 4096 points internally when it is used. The interpolator setting defines whether this is done by repeating points or by straight line interpolation between points.

Resize

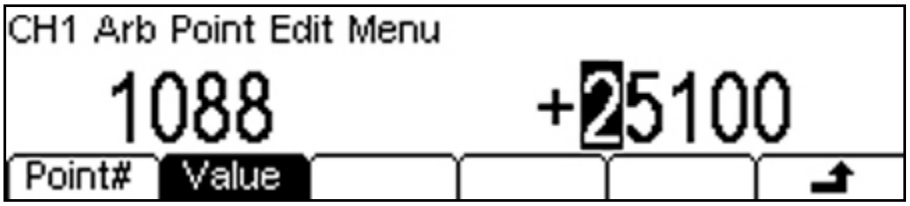
Pressing the **Resize** soft-key opens the Waveform Resize sub-menu.

The number of points in a waveform can be within the range 1 to 4096. Resize is the only method by which points can be added or deleted. When creating a new waveform it is helpful to decide the total number of points required before commencing. Default waveforms contain only four points.

Pressing the **Method** soft-key alternates between Interpolate and Repeat Points as the resizing method. The resize is performed when the **Execute** soft-key is pressed.

Point

Pressing the **Point** soft-key opens the Point Edit sub-menu.

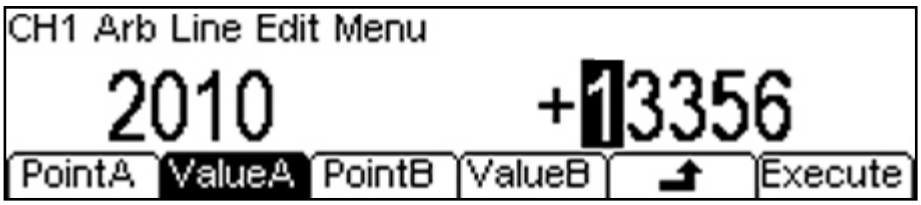


Points are selected with the **Point#** soft-key and the value changed with the **Value** soft-key.

Only points within the current size can be edited. Additional points cannot be added.

Line

Pressing the **Line** soft-key opens the Draw Line sub-menu.



Points for the start and end of the line are selected with the **PointA** and **PointB** soft-keys and the values changed with the **ValueA** and **ValueB** soft-keys. The line is created when the **Execute** soft-key is pressed.

Name

Pressing the **Name** soft-key opens the Name Edit sub-menu.

The name can be changed if required. A name of up to 8 characters can be used.
The cursor keys < > are used to select the character and the spin wheel used to change the character. When the wheel is turned clockwise the characters change in the following order:
0 to 9, A to Z, ^ _ ' { } ~ (space) ! # $ % & ' ( ) -

Characters can be deleted or spaces created using the **Space** soft-key. The name is changed when the **Execute** soft-key is pressed.

11.5 Waveform Modulation

All standard and arbitrary waveforms can be modulated in a wide variety of ways using an internal or external source. See section 12 Waveform Modulation.

11.6 Sweep Operation

All standard and arbitrary waveforms can have their frequency swept over a wide range at a variable rate. See section 13 Sweep Operation.

11.7 Burst Operation (Triggered or Gated)

All standard and arbitrary waveforms can be triggered or gated. See section 14 Burst Operation.

11.8 ARB/Function Output Conditions

Setting levels, turning the output on or off, and other matters relating to the output are done from the output menu. See section 7 Output Menu

12 Two Channel Operation

12.1 Capabilities

This section is specific to the TGP3122 and TGP3152 two channel generators.

The instruments incorporate two separate generators in which all parameters can be set independently of each other. However, the two generators use the same system clock and share a single Trigger Input and Modulation Input on the rear panel.

The two channels can be linked in a variety of ways using the Link menu. Additionally the output of one channel can be used as the modulation source for the other channel.

12.2 Channel Selection

The two output keys OUTPUT1 and OUTPUT2 have a dual function. Firstly they select an output menu from which output conditions can be changed. Secondly they select the channel to which future editing will apply.

Example: The user has finished setting pulse parameters for Channel 1 and now wants to set pulse parameters for Channel 2. They press the OUTPUT2 key to change the channel, followed by the PULSE key to open the Pulse menu for Channel 2.

12.3 Link Menu

Pressing the LINK key opens the Link Menu.

Track	Freq	Ampl	Output		Status

Two modes of channel linking are provided: Tracking, in which all of the parameters of channel 2 are set equal to those of channel 1 (apart from output inversion), and Coupled in which only specific parameters (e.g. Frequency) are set equal.

12.3.1 Link Status

Pressing the **Status** soft-key brings up a screen which shows the current Coupling or Tracking status.

Channel Coupling / Tracking Parameters
Frequencies Not Coupled
Amplitudes and Offsets Not Coupled
Outputs Not Coupled

or

Channel Coupling / Tracking Parameters
Channel tracking enabled. Both channel parameters are identical. The two channels behave as one channel.

12.3.2 Tracking Mode

Pressing the **Track** soft-key brings up the Channel Tracking sub-menu.

Three option are provided: Off, Equal or Inverse.

When set to **Equal** all parameters for Channel 2 are set identically to those of Channel 1. Channel selection is disabled, and the word Track appears in place or CH1 or CH2 at the top left of the screen.
Track Pulse Off 50Ω

When set to **Inverse** all parameters for Channel 2 are set identically to those of Channel 1 apart from the output polarity which is inverted, and the word InvTk appears in place or CH1 or CH2 at the top left of the screen.
InvTk Pulse Off 50Ω

Inverse Tracking creates a differential output between the two output sockets.

12.3.3 Coupled Modes

Coupled modes enable specific parameters of one channel to be set equal to those on the other channel. Neither acts as the master with changes being accepted on either channel.

Three parameters can be coupled in any combination.

Frequency Coupling

Frequency coupling sets both the frequency for both channels either equal, or related by a formula. A change on either channel is automatically made on the other channel.

Pressing the **Freq** soft-key brings up the Frequency Coupling sub-menu.

Pressing the **On/Off** soft-key alternates between Frequencies Not Coupled and Frequencies Coupled.

Two types of frequency coupling can be selected, Ratio (CH2/CH1) or Offset (CH2-CH1).
If the ratio is set to 1.000 or the offset is set to 0Hz then the frequencies will be equal.

Pressing the **Type** soft-key alternates between Ratio CH2 Freq / Ch1 Freq and Offset CH2 Freq - CH1 Freq.

Pressing the **Ratio** soft-key enables the Ratio (CH2/CH1) to be set between 0.001 and 1000.

Pressing the **Offset** soft-key enables the Offset (CH2-CH1) to be set between 1mHz and 50MHz [25MHz].

Amplitude Coupling

Amplitude coupling sets both the output amplitude and offset for both channels equal. A change on either channel is automatically made on the other channel.

Pressing the **`Ampl`** soft-key alternates between Amplitude and Offsets Not Coupled and Amplitude and Offsets Coupled.

Output On/Off Coupling

Output coupling sets both the output on/off states equal. A change on either channel is automatically made on the other channel.

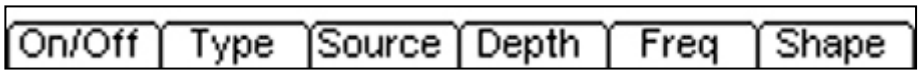
Pressing the **`Output`** soft-key alternates between Outputs Not Coupled and Outputs Coupled.

13 Waveform Modulation

13.1 The Modulation Menu

All carrier waveforms (pulses, patterns, noise, arbitrary waveforms and function waveforms) can be modulated in a wide variety of ways using an internal or external source.

Pressing the MOD key opens the Modulation Menu.



Note that the three soft-keys on the right hand side will change depending upon the modulation type and modulation source selected.

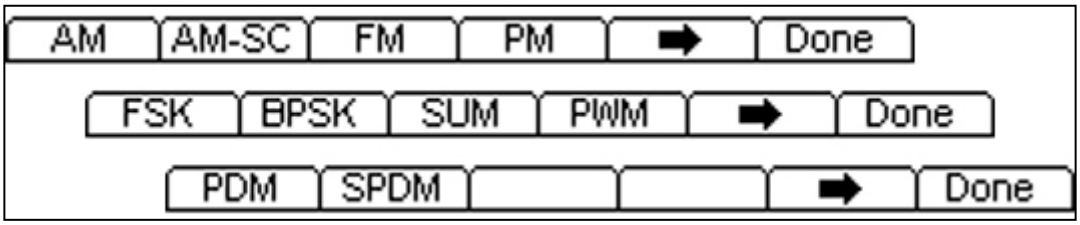
To close the Modulation menu, press the currently illuminated main waveform menu key (or any other waveform key).

13.1.1 Modulation On/Off

The **On/Off** soft-key turns modulation On or Off. The MOD key illuminates when modulation is On.

13.1.2 Modulation Type

Pressing the **Type** soft-key creates a set of further soft-keys from which the modulation type can be selected. There are 10 modulation type options spread across three sets of soft-keys. Pressing the ➡ key reveals the next set of options.



When selected, the modulation type appears in the edit box. Press the **Done** soft-key to return to the Modulation Menu.

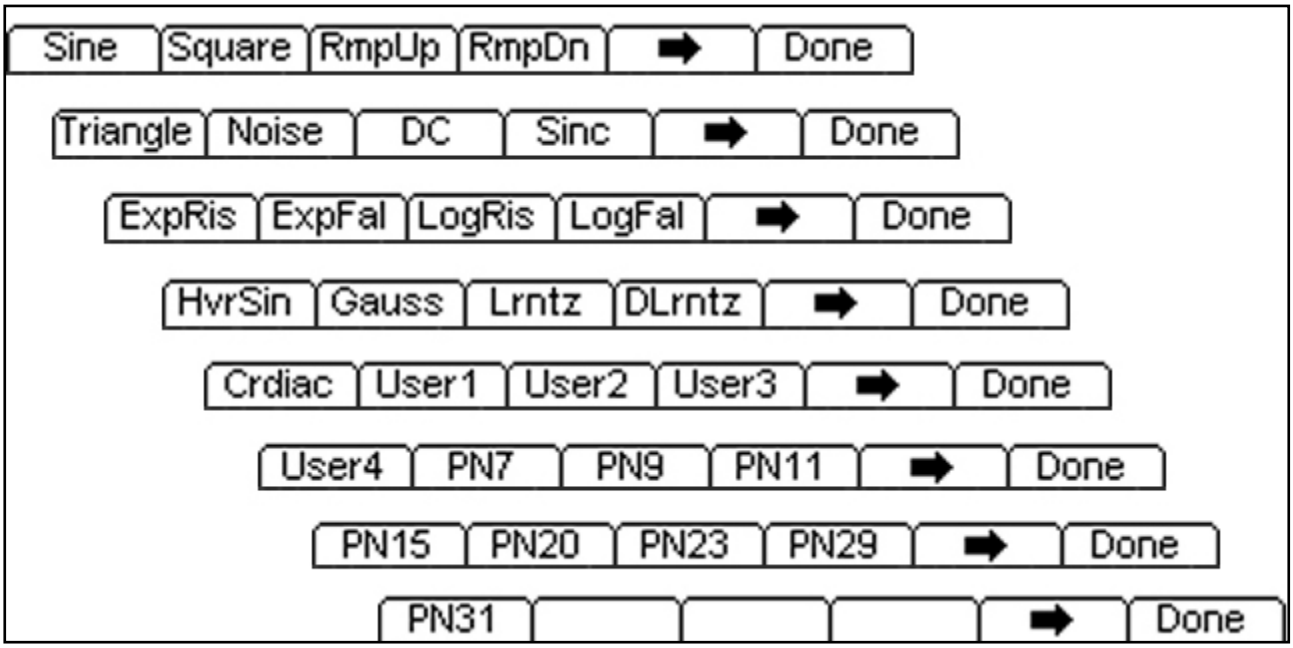
13.1.3 Modulation Source

Pressing the **Source** soft-key creates further soft-keys from which the modulation source can be selected as Internal or External. On two channel generators an additional option of using the other channel as the modulation source is provided.

When the source is Internal, the two soft-keys on the right hand side of the modulation menu provide control of the internal modulation source.

13.1.4 **Internal Modulation Wave Shape** (AM, AM-SC, FM, PM, SUM, PWM, PDM, SPDM)

With the modulation source set to Internal, pressing the **Shape** soft-key creates a set of further set soft-keys from which the modulating waveform shape can be selected. There are 29 waveform shape type options spread across eight sets of soft-keys. Pressing the ➡ key reveals the next set of options. Note that PWM, PDM and SPDM are relevant to pulse waveforms only.



The large number of waveform shapes available include Arbitrary Waveforms and PRBS. See the sections describing Function/Arbitrary and Pattern/PRBS generator for details.

13.1.5 **Internal Modulation Frequency (AM, AM-SC, FM, PM, SUM, PWM, PDM, SPDM)**

With the modulation source set to Internal, pressing the **Freq** soft-key allows the modulating frequency to be set within the range 1mHz to 10MHz.

13.1.6 **Closing the Modulation Menu**

To close the Modulation menu, press the currently illuminated main waveform menu key (or any other menu key).

13.2 Modulations

13.2.1 **Amplitude Modulation (AM and AM-SC)**

Both standard Amplitude Modulation and Suppressed Carrier Amplitude Modulation are available.

Modulation Depth
Pressing the **Depth** soft-key allows the modulation depth to be set between 0.00% and 100.00%.

13.2.2 **Frequency and Phase Modulation (FM and PM)**

Both Frequency and Phase Modulation are available.

Frequency/Phase Deviation
Pressing the **Deviatn** soft-key allows the frequency deviation to be set in Hz, or phase deviation set in degrees.

13.2.3 Frequency Shift Keying (FSK)

In FSK modulation the output frequency is shifted between two preset frequencies in response to an internal or external signal. The main frequency is called the Carrier frequency, and the alternative frequency is called the Hop frequency.

Setting the Hop Frequency
Pressing the **`HopFrq`** soft-key allows the alternative frequency to be set in Hz.

Setting the Keying Rate (only with Internal Source)
Pressing the Rate soft-key allows the keying rate to be set in Hz. The internal generator has a 50/50 duty cycle.

Setting the Hop Control Polarity
Pressing the **`HopPol`** soft-key allows the frequency change to occur when the controlling signal is positive or negative..

13.2.4 Binary Phase Shift Keying (BPSK)

In BPSK modulation the phase of the output frequency is shifted between two preset values in response to an internal or external signal. The main phase is called the Carrier phase, and the alternative phase is called the Hop phase.

Setting the Hop Phase
Pressing the **`HopPhs`** soft-key allows the alternative phase to be set in degrees.

Setting the Keying Rate (only with Internal Source)
Pressing the Rate soft-key allows the keying rate to be set in Hz. The internal generator has a 50/50 duty cycle.

Setting the Hop Control Polarity
Pressing the **`HopPol`** soft-key allows the phase change to occur when the controlling signal is positive or negative..

13.2.5 Waveform Sum Modulation (SUM)

In Sum modulation the modulating signal is added to the main waveform as a percentage of the main waveform amplitude.

Summation Level
Pressing the **`Level`** soft-key allows the amount of the modulation waveform added to be set between 0% and 100% of the carrier waveform amplitude,

13.2.6 Pulse Width Modulation (PWM)

Available only for Pulse waveforms. In PWM modulation the width of pulses is varied in response to the modulating waveform.

Width Deviation
Pressing the **`Deviatn`** soft-key allows the pulse period deviation to be set in terms of period time.

13.2.7 Pulse Delay Modulation (PDM)

Available only for Pulse waveforms. In PDM modulation the position of pulses is varied in response to the modulating waveform.

Delay Deviation
Pressing the **`Deviatn`** soft-key allows the pulse delay deviation to be set in terms of delay time.

13.2.8 Second Pulse Delay Modulation (SPDM)

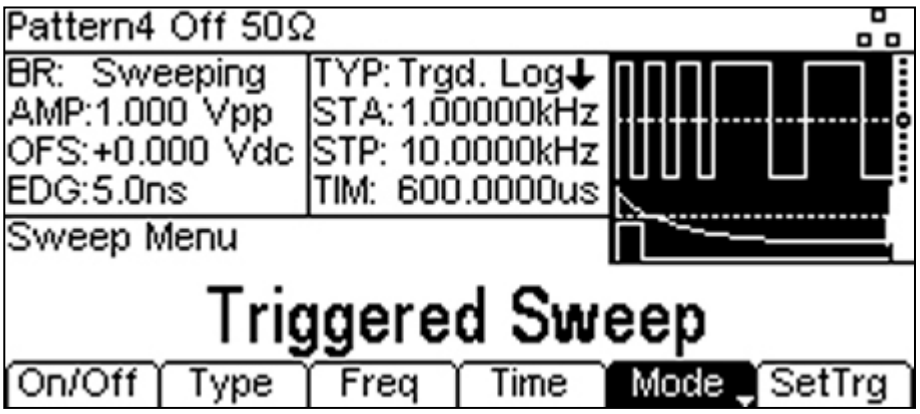
Available only for Pulse waveforms. In SPDM modulation operates only when the pulse type is set to Double Pulse. SPDM modulates the position of second pulse relative to the first pulse in response to the modulating waveform.

Second Pulse Delay Deviation
Pressing the **`Deviatn`** soft-key allows the second pulse delay deviation to be set in terms of delay time.

14 Sweep Operation

14.1 The Sweep Menu

The waveform frequency can be swept over a wide range at a variable rate. The sweep can have individual sweep, hold and return times and use a linear or logarithmic shape. Sweep can be continuous or triggered using an internal or external source. A marker point can be added which creates an output from the SYNC socket.



14.1.1 Sweep On/Off

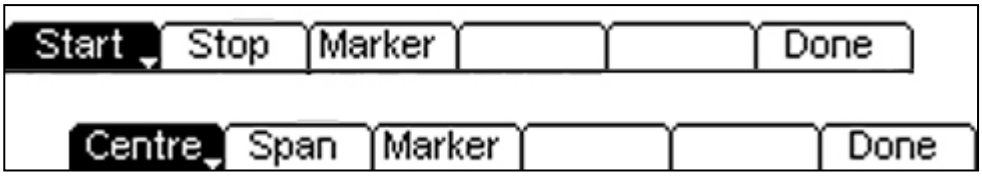
The **On/Off** soft-key turns sweep On or Off. The SWEEP key illuminates when sweep is On.

14.1.2 Sweep Type

Pressing the **Type** soft-key creates a set of further soft-keys from which the sweep type can be selected. Options are Linear Up, Linear Down, Logarithmic Up and Logarithmic Down.

14.1.3 Setting the Sweep Frequencies

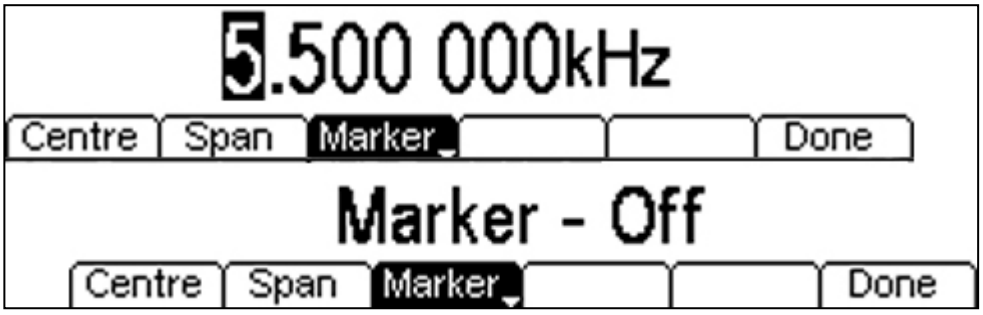
Pressing the **Freq** soft-key creates a set of further soft-keys from which the sweep frequencies can be set. Note that sweep can only be set in terms of frequency and not period.



The sweep can be set in terms of **Start** and **Stop** or **Centre** and **Span**. Alternate presses of any of the keys will change the setting mode.

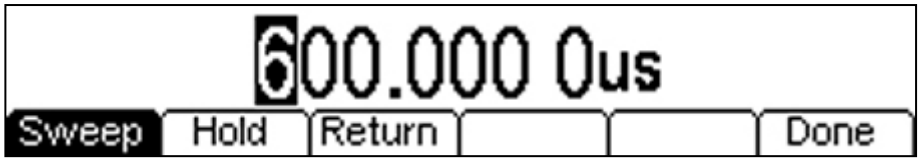
The stop frequency cannot be lower than the start frequency. Reversal of the sweep is done by selecting Down within sweep type.

The Marker frequency can be set anywhere within the frequency span. Alternate presses of the **Marker** soft-key turn it On or Off



14.1.4 Setting the Sweep Times

Pressing the **Time** soft-key creates a set of further soft-keys from which the sweep times can be selected.



The **Sweep** time defines the time taken to go from the start frequency to the stop frequency.

The **Hold** time defines the length of time that stop frequency dwells at the stop, and the **Return** time defines the time taken to go from the stop frequency back to the start frequency.

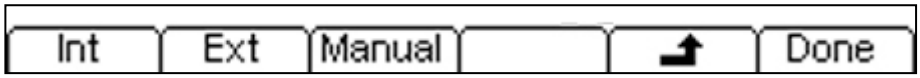
14.1.5 Setting the Sweep Mode – Continuous or Triggered

Pressing the **Mode** soft-key alternates between continuous sweep and triggered sweep.

14.1.6 Sweep Trigger Sub-menu (only for Triggered Sweep)

Set Trigger
The **SetTrg** soft-key opens the Sweep Trigger sub-menu.

Trigger Source
The **Source** soft-key creates three further soft-keys.



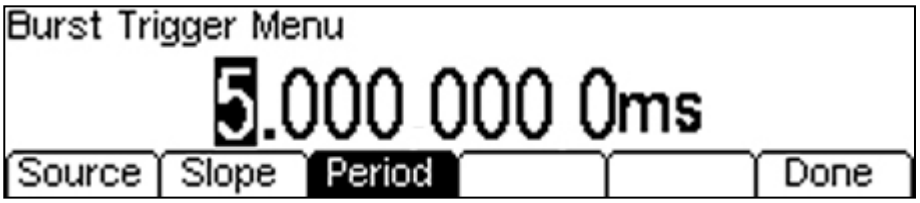
The **Int** soft-key selects an internal square wave generator to provide the trigger source.

The **Ext** soft-key selects the rear panel TRIG IN socket as the trigger source. The trigger threshold can be set from the Trigger menu - which is selected using the TRIGGER key.

The **Manual** soft-key selects manual triggering using the TRIGGER key.

Trigger Slope Polarity
The **Slope** soft-key alternates between the Positive or Negative slope of the trigger signal as the start point of the trigger signal.

Trigger Generator Period (only for Internal Trigger)
The **`Period`** soft-key only appears if the Source is set to Internal.



The period can be set between 20ns and 500s.

14.1.7 Closing the Sweep Menu

To close the Sweep menu, press the currently illuminated main waveform menu key (or any other menu key).

15.1.1 General

Pulses can be triggered or gated using an internal trigger generator, the external trigger input, or the manual trigger key.

For a triggered burst, the number of pulse cycles generated following the trigger can be set between 1 and 4,294,967,295 or infinite.

For a gated burst, pulses are generated during the period when the gate signal is true.

15.2 The Burst Menu

Pressing the BURST key selects the burst menu.

On/Off

The **`On/Off`** soft-key turns burst operation On or Off. The BURST key is illuminated when the burst operation is turned on.

Note that selecting Modulation or Sweep will automatically turn Burst to Off. (Modulation, Sweep and Burst are mutually exclusive.

Burst Type

The **`Type`** soft-key selects between Triggered Burst or Gated Burst.

Burst Count (only for Triggered Burst)

The **`Count`** soft-key enables the number of pulse cycles to be set. Alternate presses of the key change between a numeric value and Infinite. The numeric value can be set within limits of 1 and 4,294,967,295.

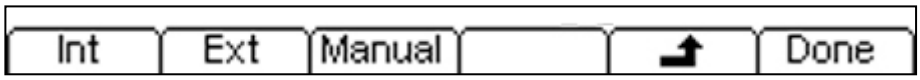
15.2.1 Burst Trigger Sub-menu

Set Trigger

The **`SetTrg`** soft-key opens the Burst Trigger sub-menu.

Trigger Source

The **`Source`** soft-key creates three further soft-keys.



The **`Int`** soft-key selects an internal square wave generator to provide the trigger source.

The **`Ext`** soft-key selects the rear panel TRIG IN socket as the trigger source. The trigger threshold can be set from the Trigger menu - which is selected using the TRIGGER key.

The **`Manual`** soft-key selects manual triggering using the TRIGGER key.

Trigger Slope Polarity (only for Triggered Burst)

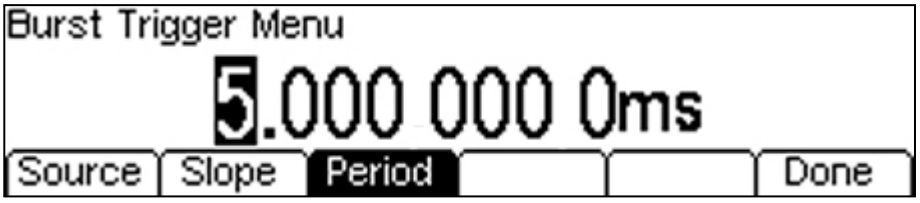
The **`Slope`** soft-key alternates between the Positive or Negative slope of the trigger signal as the start point of the trigger signal.

Trigger Gate Polarity (only for Gated Burst)

The **`Gate`** soft-key alternates between Positive true or Negative true for the gating signal.

Trigger Generator Period (only for Internal Trigger)

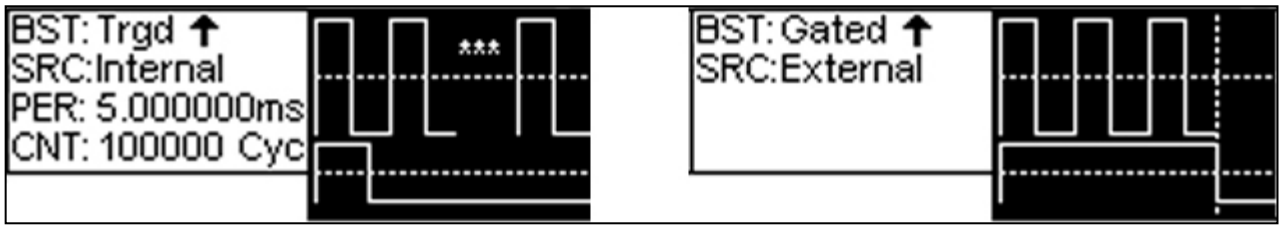
The **`Period`** soft-key only appears if the Source is set to Internal.



The period can be set between 20ns and 500s.

15.2.2 Parameters Box and Graph Box

With Burst turned On, burst parameters are shown in the right hand column of the parameters box and a visual representation shown in the graph box.



The left hand example shows a Triggered Burst of 100,000 cycles using the internal trigger generator set to a 5ms period. Trigger slope is positive as indicated by the upwards arrow.

The right hand example shows a Gated Burst using an external trigger source. Gating true is set to positive as indicated by the upwards arrow.

15.2.3 Closing the Burst Menu

To close the Burst menu, press the currently illuminated main waveform menu key (or any other menu key).

15.3 Internal Trigger Generator

The internal trigger generator is a square wave generator (50% duty cycle) that can be set to any frequency between 2mHz and 50MHz..

It can be used as the source for sweep or burst mode operation, and can be outputted to SYNC OUT socket - see section 15.3 Sync Output(s) Setup.

16.1.1 General

Pressing the TRIGGER key opens the Trigger Menu that provides options for the External Trigger input (rear panel TRIG IN socket) and the Sync Output signal (SYNC OUT socket or sockets).

16.2 Trigger Setup

On dual channel instruments, there are separate trigger menus for each channel. However, because there is only a single trigger input socket and a single manual trigger key, some settings apply to both menus.

The **ManTr** soft-key appears only on dual channel instruments.

16.2.1 Trigger Threshold

Pressing the **Thrshld** soft-key displays the current external trigger threshold and enables it to be set within the range +3.0 volts to -3.0 volts.

16.2.2 Manual Trigger Key

The front panel key marked TRIGGER acts as manual trigger. If Burst mode has been set to use a manual trigger and is set to on, the key will illuminate to indicate that it is active.

16.2.3 Manual Trigger Select (dual channel generators only)

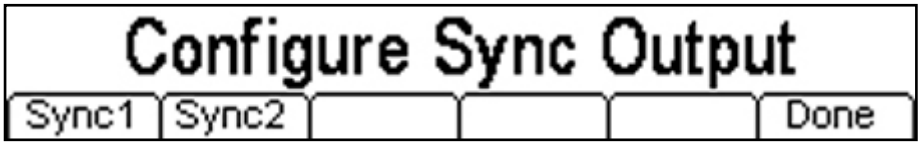
The manual trigger key can be set to send a trigger signal to just the current channel (single) or to both channels simultaneously (dual).

Pressing the **ManTr** soft-key alternates between Manual Trigger Setup: Single and Manual Trigger Setup: Dual.

16.3 Sync Output(s) Setup

Pressing the **Sync** soft-key displays the Sync sub-menu.

Sync Select (dual channel generators only)



On dual channel instruments, an intermediate screen appears that allows either of the two Sync outputs to be selected.

Sync Out Menu

The output from the SYNC OUT socket can be set to one of four modes, Normal, Carrier, Trigger or Off which are selected by the soft-keys. The current selection appears within the Edit Box.

Sync Out: Normal

With Sync Out set to Normal, the output is set automatically depending upon the waveform type and waveform modification settings (modulation, sweep, burst).

A full list of the automatic settings is given within the Specifications section 22.8.2 Sync Outs.

Sync Out: Carrier

With Sync Out set to Carrier, the output is a square wave at the repetition frequency of the main output waveform (the carrier) and with a phase angle of zero.

Sync Out: Trigger

With Sync Out set to Trigger, the output follows the trigger signal. This can be the internal trigger generator, the external trigger input, or the manual trigger key.

Burst mode does not have to be turned On in order to generate a trigger signal at the Sync output. For example, if Burst is Off but the trigger source has been set to internal, the internal trigger generator can be outputted from the Sync output socket as an independent square wave generator.

See section 14.3 Internal Trigger Generator.

16.3.1 Closing the Trigger Menu

To close the trigger menu, press the currently illuminated main waveform menu key (or any other menu key).

17 Stores Menu

17.1 Stores Menu Functions

The stores menu gives access to both the instrument's local storage of patterns, arbitrary waveforms and parameter set-ups, and to the external storage of a connected USB flash drive.

There are facilities for saving and recalling set-ups to and from local stores, deleting set-ups, patterns and arbitrary waveforms and copying pattern, waveform and set-up files to and from a USB flash drive. It is possible to save a file from a PC to a USB flash drive and then copy the file into the instrument for use.

17.1.1 Flash Drive Files and Folders

The instrument uses the folder called \TGP31XX for all file storage. This folder contains up to three more folders used as follows:

\TGP31XX\WAVES. This folder is used to store arbitrary waveforms and noise distributions. It is the only place where the instrument will look for arbitrary waveform and noise files. A waveform or noise file has a file extension of .WFM. Files with any other extension will be ignored.

\TGP31XX\PATTERNS. This folder is used to store pulse patterns. It is the only place where the instrument will look for pulse pattern files. A pattern file has a file extension of .PTN. Files with any other extension will be ignored

\TGP31XX\SETUPS. This folder is used to store set-ups. It is the only place where the instrument will look for set-up files. A set-up file has a file extension of .SU. Files with any other extension will be ignored.

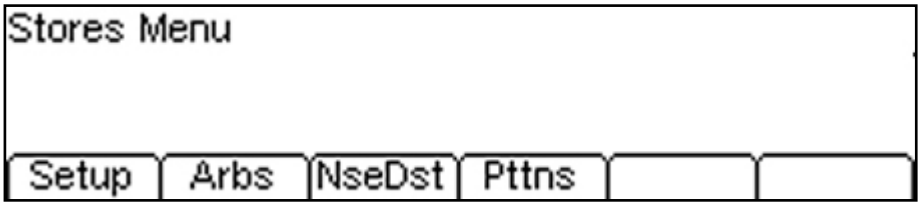
When a new flash drive is attached to the instrument the required folders will be created automatically.

The instrument is able to read and write flash drives formatted FAT16 or FAT32. The instrument does not generate or use long filenames. A filename can only be up to eight characters in length.

17.1.2 The Stores Menu

The Stores Menu is used for both saving and recalling instrument set-ups, and for transferring pulse patterns, arbitrary waveform and set-up files to and from an external USB Flash drive (disk).

Pressing the STORES key opens the Stores Menu.



17.2 Instrument Set-ups

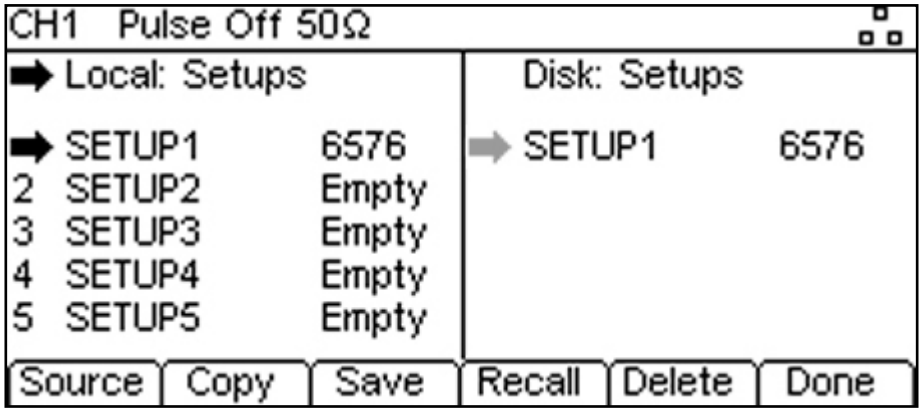
17.2.1 General

The complete settings of the instrument can be saved to non-volatile memory. Up to nine instrument set-ups can be stored internally as files under default or user-defined names.

Set-up files can be copied to and from a USB Flash drive.

17.2.2 The Set-up Menu

Pressing the **Setup** soft-key displays the Set-up sub-menu.



File Source Location

When a USB flash drive is plugged in, Pressing the **Source** soft-key toggles between the local memory and the USB disk as the active file source. The active source (Local or Disk) is indicated by a black arrow. The most recently selected file within the non-active source is shown in grey.

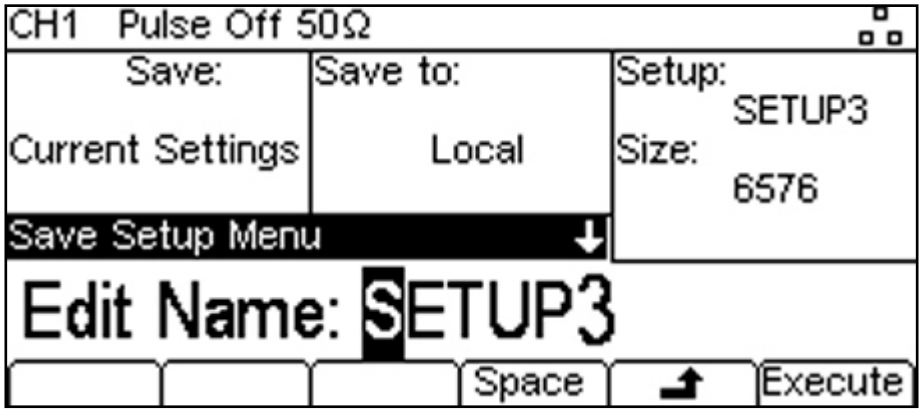
Local Set-up Files

There can be up to nine set-up files stored locally. The file locations are numbered 1 to 9 and have default file names of SETUP1 thro SETUP9. The selected file position is indicated by a black arrow which can be moved using the spin wheel.

The file position must be selected before any further action is performed.

Save Set-up

The Save key only appears when the active source is set to Local. Pressing the **Save** soft-key displays the Save Set-up screen.



The current name can be changed if required. A name of up to 8 characters can be used. The cursor keys < > are used to select the character and the spin wheel used to change the character. When the wheel is turned clockwise the characters change in the following order:

0 to 9, A to Z, ^ _ ' { } ~ (space) ! # $ % & ' ( ) -

Characters can be deleted or spaces created using the **Space** soft-key.

Pressing the **Execute** soft-key causes the settings to be stored using the chosen file source location and name.

Recall Set-up

The Recall key only appears when the source is set to Local. Pressing the **Recall** soft-key causes the instrument to be restored from the settings saved at the selected file location.

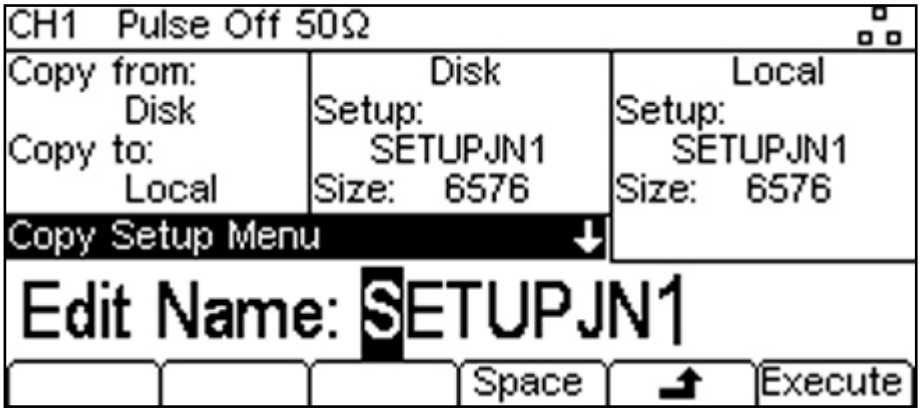
Delete Set-up

The Delete key only appears when the source is set to Local. Pressing the **Delete** soft-key causes the set-up file at the selected file location to be deleted.

Copy Set-up

The Copy key appears for either source location and operates as copy from the source. It can be used to copy files to or from the USB flash disk.

When copying from the disk, a local file location (1 to 9) must be selected first. The source must then be set to Disk and the file to be copied selected. Pressing the **Copy** soft-key displays the Copy Set-up screen.



The current file name for the selected file appears in the edit box and can be changed if required. A name of up to 8 characters can be used.

The cursor keys < > are used to select the character and the spin wheel used to change the character. When the wheel is turned clockwise the characters change in the following order:

0 to 9, A to Z, ^ _ ' { } ~ (space) ! # $ % & ' ( ) -

Characters can be deleted or spaces created using the **Space** soft-key.

Pressing the **Execute** soft-key causes the selected disk file to be copied to the selected local file location using the chosen name. An overwrite confirmation warning will appear.

When copying from local to the disk, only the local file location need be selected in advance. The copying procedure is otherwise similar to copying from the disk.

17.3 Transferring Pulse Patterns and Arbitrary/Noise Waveforms

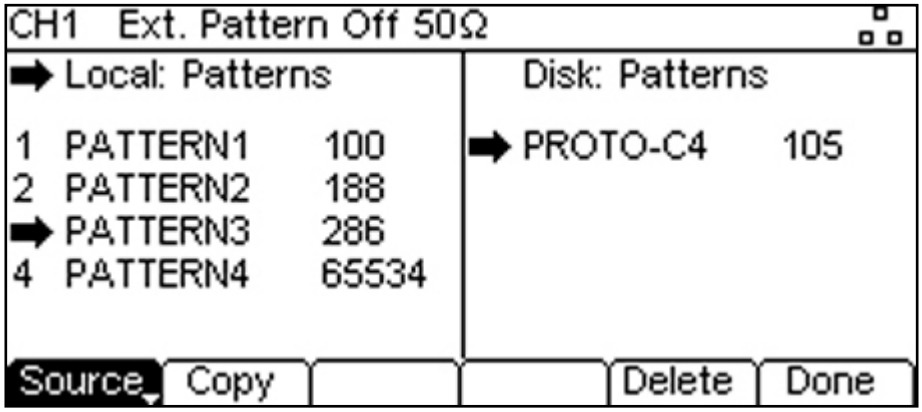
17.3.1 General

Four pulse patterns, four arbitrary waveforms and one noise distribution can be stored as files within the instrument. However any number of pattern and waveform files can be stored using a USB Flash drive (disk). Files can be copied to and from the USB disk.

Patterns and waveforms can be created on a PC using the Aim-TTi software application Waveform Manager Plus. Files created on the PC can be copied to the instrument using the USB disk.

17.3.2 The Pulse Patterns Transfer Menu

Pressing the **Pttns** soft-key displays the Pulse Patterns Transfer sub-menu.



File Source Location

When a USB flash drive is plugged in, Pressing the **Source** soft-key toggles between the local memory and the USB disk as the active file source. The active source (Local or Disk) is indicated by a black arrow. The most recently selected file within the non-active source is shown in grey.

Local Patterns

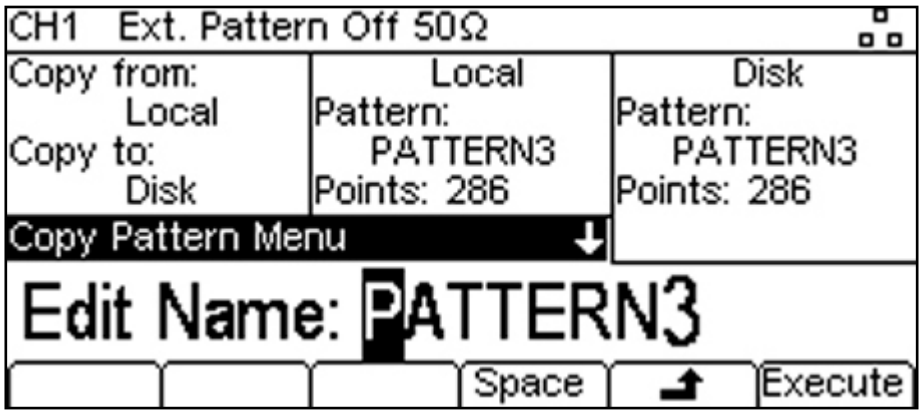
There are four pulse patterns stored locally. The file locations are numbered 1 to 4 and have default file names of PATTERN1 thro PATTERN4. The selected file position is indicated by a black arrow which can be moved using the spin wheel.

The file position must be selected before any further action is performed.

Copy Pattern

The Copy key appears for either source location and operates as copy from the source location.
It can be used to copy files to or from the USB flash disk.

When copying from the disk, a local file location (1 to 4) must be selected first. The source must then be set to Disk and the file to be copied selected. Pressing the **Copy** soft-key displays the Copy Pattern screen.



The current file name for the selected file appears in the edit box and can be changed if required. A name of up to 8 characters can be used.

The cursor keys < > are used to select the character and the spin wheel used to change the character. When the wheel is turned clockwise the characters change in the following order:

0 to 9, A to Z, ^ _ ' { } ~ (space) ! # $ % & ' ( ) -

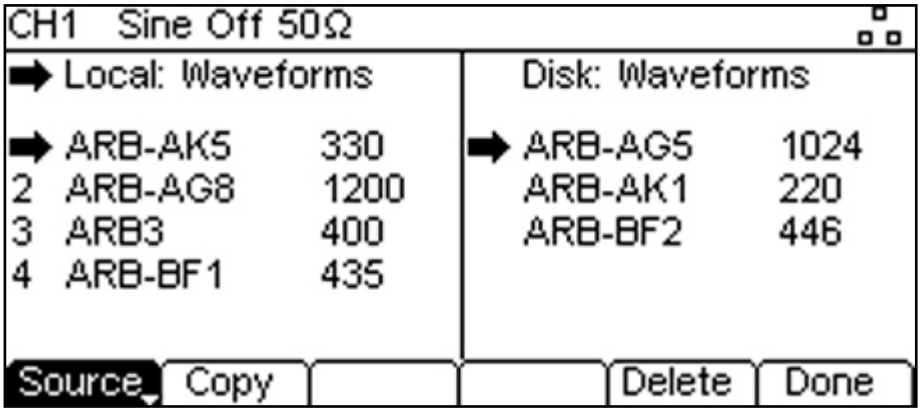
Characters can be deleted or spaces created using the **Space** soft-key.

Pressing the **Execute** soft-key causes the selected disk file to be copied to the selected local file location using the chosen name. An overwrite confirmation warning will appear.

When copying from local to the disk, only the local file location need be selected in advance. The copying procedure is otherwise similar to copying from the disk.

17.3.3 The Arbitrary Waveforms Transfer Menu

Pressing the **Arbs** soft-key displays the Arbitrary Waveforms Transfer sub-menu.



File Source Location

When a USB flash drive is plugged in, Pressing the **Source** soft-key toggles between the local memory and the USB disk as the active file source. The active source (Local or Disk) is indicated by a black arrow. The most recently selected file within the non-active source is shown in grey.

Local ARBs

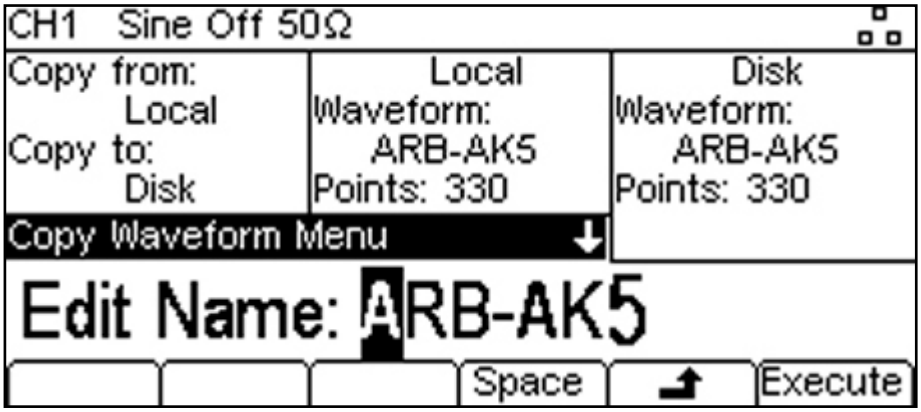
There are four arbitrary waveforms stored locally. The file locations are numbered 1 to 4 and have default file names of ARB1 thro ARB4. The selected file position is indicated by a black arrow which can be moved using the spin wheel.

The file position must be selected before any further action is performed.

Copy ARB

The Copy key appears for either source location and operates as copy <u>from</u> the active location.
It can be used to copy files to or from the USB flash disk.

When copying from the disk, a local file location (1 to 4) must be selected first. The source must then be set to Disk and the file to be copied selected. Pressing the **Copy** soft-key displays the Copy Pattern screen.



The current file name for the selected file appears in the edit box and can be changed if required. A name of up to 8 characters can be used.

The cursor keys < > are used to select the character and the spin wheel used to change the character. When the wheel is turned clockwise the characters change in the following order:

0 to 9, A to Z, ^ _ ' { } ~ (space) ! # $ % & ' ( ) -

Characters can be deleted or spaces created using the **Space** soft-key.

Pressing the **Execute** soft-key causes the selected disk file to be copied to the selected local file location using the chosen name. An overwrite confirmation warning will appear.

When copying from local to the disk, only the local file location need be selected in advance. The copying procedure is otherwise similar to copying from the disk.

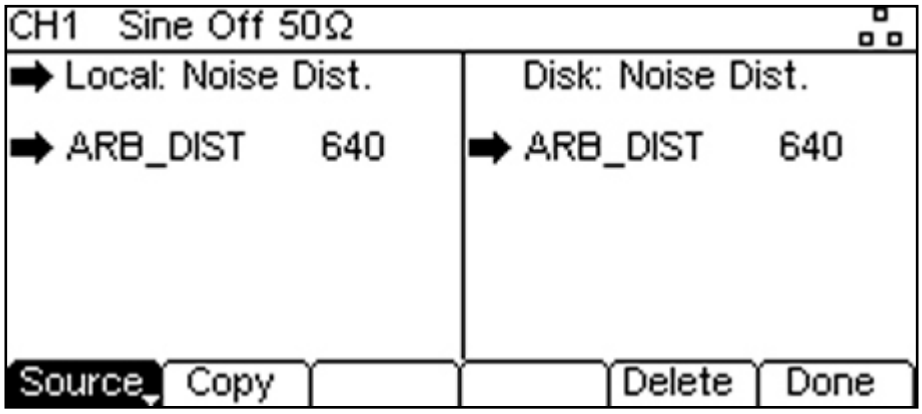
NOTE

Because noise distributions are created as an arbitrary waveform, the two types of file share the same directory on the USB disk and both can appear within the disk source for arbitrary waveform listings and noise distribution listings.

17.3.4 The Noise Distributions Menu

When used as a noise generator, a user-defined PDF (probability density function) can be created via a noise distribution waveform file.

Pressing the **NseDst** soft-key displays the Noise Distributions Transfer sub-menu.



File Source Location

When a USB flash drive is plugged in, Pressing the **Source** soft-key toggles between the local memory and the USB disk as the active file source. The active source (Local or Disk) is indicated by a black arrow. The most recently selected file within the non-active source is shown in grey.

Local Noise Distribution

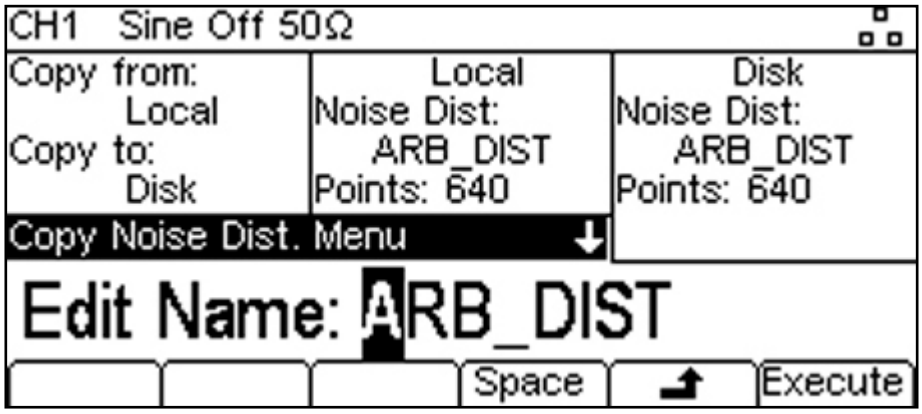
There is only one noise distribution waveform file stored locally. It has a default name of ARB_DIST.

Copy Noise Distribution

The Copy key appears for either source location and operates as copy <u>from</u> the source location.
It can be used to copy files to or from the USB flash disk.

When copying from the disk the source location must then be set to Disk and the file to be copied selected. When copying to the disk the source must be set to Local.

Pressing the **Copy** soft-key displays the Copy Noise Distribution screen.



The current file name for the selected file appears in the edit box and can be changed if required. A name of up to 8 characters can be used.

The cursor keys < > are used to select the character and the spin wheel used to change the character. When the wheel is turned clockwise the characters change in the following order:

0 to 9, A to Z, ^ _ ' { } ~ (space) ! # $ % & ' ( ) -

Characters can be deleted or spaces created using the **Space** soft-key.

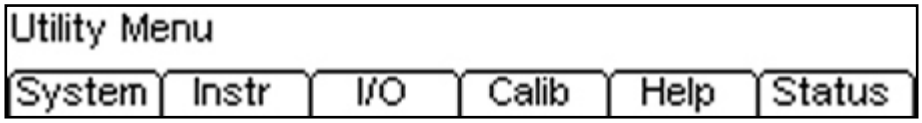
Pressing the **Execute** soft-key causes the selected disk file to be copied to the selected local file location using the chosen name. An overwrite confirmation warning will appear.

NOTE

Because noise distributions are created as an arbitrary waveform, the two types of file share the same directory on the USB disk and both can appear within the disk source for arbitrary waveform listings and noise distribution listings.

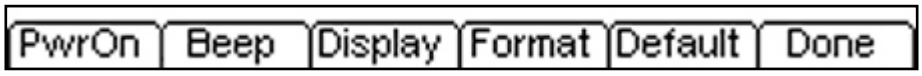
18 Utility Menu

Pressing the UTILITY key opens the Utility Menu, from which a series of sub-menus are available:



18.1 System Settings

Pressing the **System** soft-key opens the Utility System sub-menu.



18.1.1 Power-On Settings

Pressing the **PwrOn** soft-key changes the behaviour of the instrument when it is powered to On from Off. Successive presses of the key alternate between Default and Latest.

When set to Default, all parameters are set to the factory default values as set out in Appendix 2. Factory Default Settings. When set to Latest, all parameters are restored to their values when the instrument was turned off.

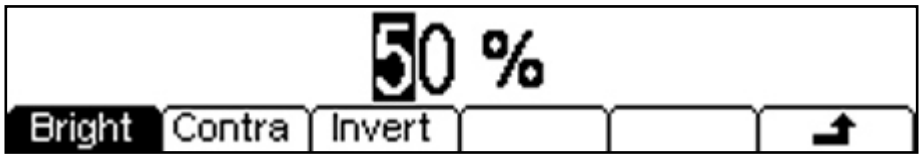
18.1.2 Beep Sound

Pressing the **Beep** soft-key alternates between Beep On and Beep Off.

With Beep set to On, the error and warning messages will be accompanied by a sound. These sounds are suppressed with Beep off.

18.1.3 Display Settings

Pressing the **Display** soft-key creates a further set of keys from which changes to the LCD can be made. The clarity of the display may vary a little with changes of ambient temperature or viewing angle but can be optimised for a particular environment by using the contrast and brightness controls.



Brightness

The **Bright** soft-key enables the LCD brightness to be set within the range 1% to 99%.

Contrast

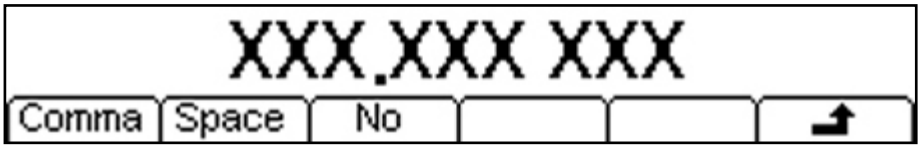
The **Contra** soft-key enables the LCD contrasts to be set within the range 1% to 99%.

Inverted Display

Alternate presses of the **`Invert`** soft-key changes the display from black-on-white to white-on-black.

18.1.4 Number Format

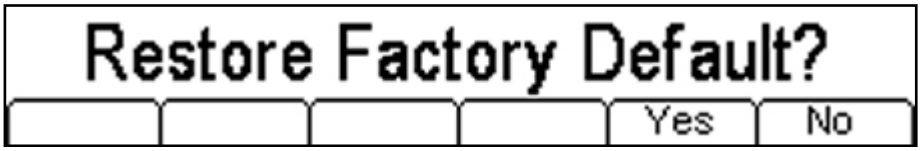
Pressing the **`Format`** soft-key creates a further set of keys from which changes to the format of numbers within the Edit Box can be made. Because numbers can be displayed with up to 11 digits of resolution, it can be helpful to break the digits into blocks of three.



Three options are provided, separate with commas (**`Comma`**), separate with spaces (**`Space`**) or no separation (**`No`**).

18.1.5 Restore Factory Defaults

Pressing the **`Restore`** soft-key allows all parameters instrument can be restored to their ex-factory settings as detailed in Appendix 2. Factory Default Settings.



18.2 Instrument Settings

Pressing the **`Instr`** soft-key opens the Utility Instrument sub-menu.

18.2.1 Clock Source

Alternate presses of the **`ClkSrc`** soft-key change between using the Internal Clock and the External Clock. An external clock must have a frequency of 10MHz (+/-50kHz) and is applied to the rear panel socket 10MHz REF IN.

When a valid external clock is in use (clock source = external), Ext is shown on the top line of the display

If a valid external clock is present but not in use (clock source = internal), Ext **Det** is shown on the top line of the display.

If the clock source is set to external but the external clock signal is not valid, Ext **Err** is shown on the top line of the display

18.2.2 Master-Slave Modes

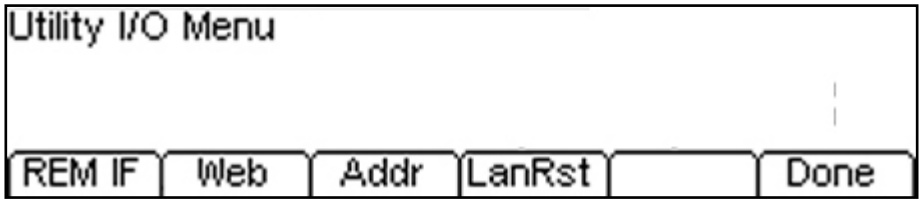
Pressing the **`Mode`** soft-key creates a further set of keys

The normal mode of operation is Independent, but the generator can be combined with a second similar instrument in order to add channels.

See section 19.2 Synchronising Two Generators for details.

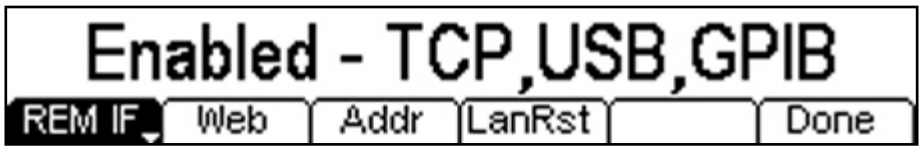
18.3 I/O (Remote Control) Settings

Pressing the **`I/O`** soft-key opens the Utility I/O (remote interfaces) sub-menu.



18.3.1 Remote Interface Selection

Pressing the **`REM IF`** soft-key repeatedly selects which remote interfaces are enabled.



Available options are TCP (LAN) only, USB only, GPIB only, and TCP, USB and GPIB simultaneously.

18.3.2 Web Page Enable

The instrument incorporates a web page.

Pressing the **`Web`** soft-key toggles the web page on or off..

18.3.3 GPIB Address

The default GPIB address is 5.

Pressing the **`Addr`** soft-key shows the current address setting in the edit box and allows it to be set within the range 0 to 30 using the numeric keypad or spin wheel.

18.3.4 LAN Reset

Under certain circumstances it can be necessary to reset the LAN interface.

Pressing the **`LanRst`** soft-key twice causes the reset to be performed.

18.4 Calibration

Pressing the **`Calib`** soft-key opens the Calibration menu.

See Appendix 3. Calibration Procedure.

18.5 Help

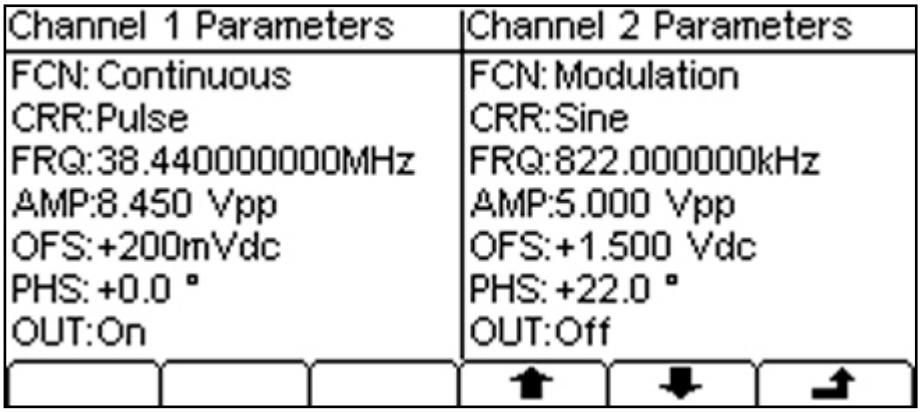
Pressing the **`Help`** soft-key opens the Help menu.

See section 18 Help Screens for a full explanation of the help screen system.

18.6 Status

Pressing the **Status** soft-key opens the Status Display pages.

This provides detailed information on the current set-up of the instrument covering several pages. The up and down arrows access further pages.



On two channel instruments parameters for both channels are displayed simultaneously.

19.1.1 Overview

The instrument has a comprehensive help system which allows easy access to any Help page. It is possible to get help in two ways:

Help Screens

There are two types of help screen.

The Help menu. This is the screen that gives a list of general help topics.

The Help topic screen. This is the screen that displays actual help texts.

Opening the Help Menu - one channel instruments

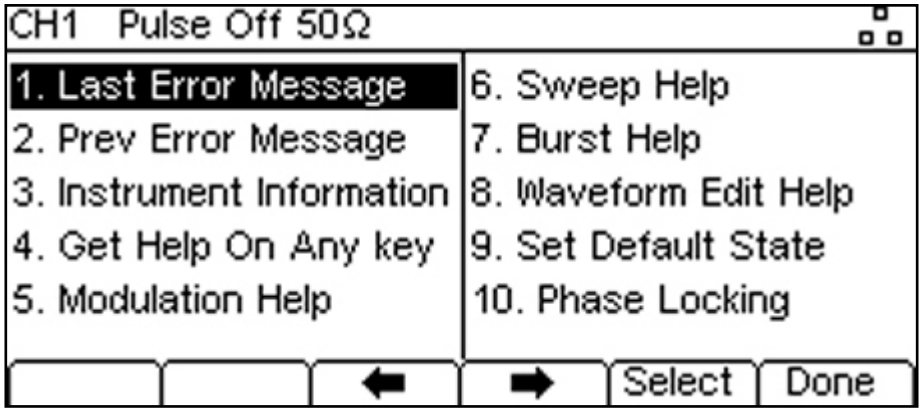
Press the HELP key to access a list of help topics which give general information about instrument operations.

Opening the Help Menu - two channel instruments

Two channel instruments do not have a HELP key so Help is accessed from a soft-key in the Utility menu.

19.1.2 Help menu

The Help menu uses all the screen space between the Status Line and the Soft-key Labels and contains a list of help topics.



To show a topic use the ⬅ and ➡ soft-keys to move the highlight back or forward through the list to select the required topic, then press the **Select** soft-key to show the topic screen.
Press the **Done** soft-key to exit from the Help menu.

19.1.3 Context Sensitive Help.

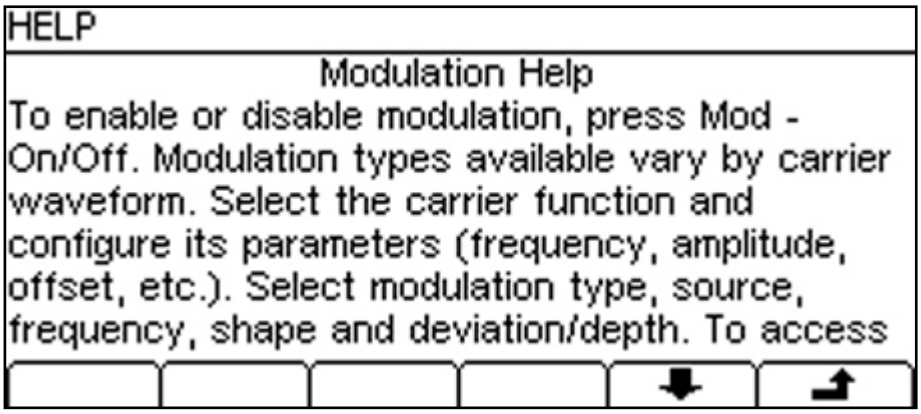
Press and hold down any key, including soft-keys, for two seconds to access the Help page for that key.

On a single channel instrument the HELP key glows yellow while any Help screen is shown. Pressing the HELP key while it is glowing yellow will exit from the Help menu or topic and return to the screen from which help was initiated.

Press the ⬆ soft-key to exit from context sensitive Help on a two channel instrument.

19.1.4 **Help Topics**

Selecting a Help topic from the Help menu or initiating context sensitive help will show a Help topic screen similar to that shown below.



Below the topic heading is the topic text. If there is more text than will fit on the screen press the ⬇ soft-key to scroll the text up one line. Continue scrolling until there is no more text indicated by the ⬇ soft-key label disappearing.

Once the text has been scrolled the ⬆ soft-key may be used to scroll the text up one line. Pressing the ⮥ soft-key will return to the previous screen.

20 Phase Control and Synchronisation

20.1 Waveform Phase and Delay Control

A common requirement is to generate waveforms with a defined phase relationship to another signal. This may be an external signal or, in the case of a two channel generator, the signal from the other channel.

20.1.1 Phase versus Delay

The phase of a waveform is the position of the waveform start point relative to the total waveform period described in degrees. The total period is described as 360 degrees.

Phase is defined relative to a datum point. The proportion of the period from the datum point to the start of the waveform is described as the phase (or phase angle) varying from 0 degrees to 360 degrees. The datum point may be a trigger or synchronisation signal, or a point on another waveform.

For both continuous and triggered waveforms phase can be positive or negative. Negative values cause the waveform to be delayed relative to the synchronisation or trigger output. Positive values cause the synchronisation or trigger output to be delayed relative to the waveform.

Phase is independent of waveform period. It can be converted into an equivalent delay by multiplying by the period. Thus for a 10kHz waveform repetition rate (100us period) a -90 degree phase would represent a waveform delay of 25us.

20.1.2 Phase control on the TGP3100 Series

Phase control for all waveform types is set within the Output menu, see section 7.1.3 Output Phase. However, for Pattern/PRBS and Noise waveforms the phase value is ignored.

Phase resolution is 0.001 degrees. For continuous waveforms, the phase relates to the carrier sync signal. For triggered waveforms the phase relates to the trigger signal. Either signal is available at the SYNC output socket.

The current phase value is retained when the waveform type is changed. The **Reset** soft-key returns the phase to zero (0.0 degrees).

20.1.3 Phase Alignment

In a 2 channel generator, or a generator phase locked to another generator, changes to frequency or other parameters can cause a loss of phase alignment. Pressing the **Align** soft-key realigns the phase between the channels or generators.

However, triggered waveforms using Burst mode are automatically aligned by the trigger signal.

20.1.4 Phase Control from an External Trigger

Where the user wishes to create a phase relationship to an external signal, the waveform will need to be generated from a triggered burst using the external trigger input.

Triggered waveforms can only have a negative phase because the waveform cannot precede an trigger input signal. If a positive delay is set, the generator calculates a negative value by subtracting 360 degrees from it.

The external trigger input is subject to a fixed delay of 448ns (typical), and this must be taken into account when calculating resultant phase angle. The fixed delay is also added to the Sync output signal, so the phase relationship between the waveform and sync outputs remains correct.

If the user wishes to define a phase relationship to the trigger input (rather than the sync output) the phase angle must be converted to time and the fixed delay deducted. Thus for a 100kHz period and a desired phase angle of -90 degrees, the required delay is 2.5us. Because 0.448us is being created by the trigger delay, the phase setting would need to be reduced to -73.872 degrees.

For a 1kHz waveform period, the fixed delay represents approximately 0.16 degrees of phase. Consequently for sub-kHz periods, trigger delay can effectively be ignored.

20.1.5 Delay Control (Pulse waveforms only)

Pulse and Double Pulse waveforms include the ability to set a pulse delay time. This time can be set with very high resolution (100ps) over the full delay range.

Delay differs from phase control in representing a fixed time rather than a proportion of the period. For a fixed waveform period, delay and negative phase can be used interchangeably. However, the maximum resolution for phase is limited to the period divided by 360000, whereas pulse delay can be defined to 100ps for any period.

20.1.6 Pulse Delay Control from External Trigger

Because the TGP3100 can generate asynchronously triggered pulses with low jitter, it can be used as a precision delay generator. For precision delay generation the phase should be set to zero.

The external trigger input is subject to a fixed delay of 448ns (typical), and this must be taken into account when calculating total input to output delay. The fixed delay is also added to the Sync output signal, so the timing relationship between the waveform and sync outputs remains correct.

Where both channels of a dual channel generator are being used to generate different delays from the single external trigger there will be some skew between the pulses. This is typically less than 1ns.

20.2 Synchronising Two Generators

Two generators can be synchronised together following the procedure outlined below. It is possible to link more than two generators in this way but results are not guaranteed.

20.2.1 Synchronising Principles

Frequency locking is achieved by using the clock output from the master generator to drive the clock input of a slave. The additional connection of an initialising SYNC signal permits the slave to be synchronised such that the phase relationship between master and slave outputs may be specified.

The most practical use of synchronisation will be to provide outputs at the same frequency, or maybe harmonics, but with phase differences. Using dual channel generators allows up to four synchronised channels.

20.2.2 Connections for Synchronisation

The clock connection arrangement is for the rear panel 10MHz REF OUT of the master (which will be set to **`master`**) to be connected directly to the 10MHz REF IN socket of the slave (which will be set to **`slave`**).

Similarly the synchronising connection is from the SYNC OUT of the master to the TRIG IN input of the slave.

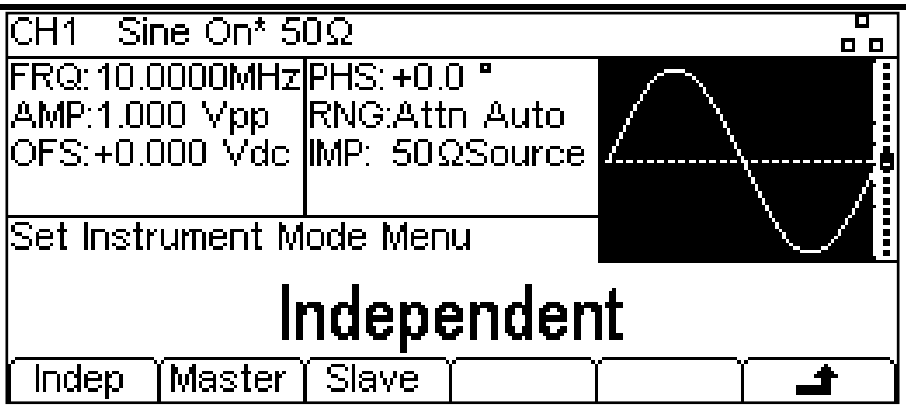
It is also possible for the master instrument to have its 10MHz REF IN driven from a frequency reference during synchronisation.

20.2.3 Generator Set-ups

Each generator can have its main parameters set to any value and each generator can be set to any waveform, except Noise and Pattern / PRBS.

The master is set as follows.

Press the UTILITY key to open the Utility menu. Press the **`Inst`** soft-key followed by the **`Mode`** soft-key



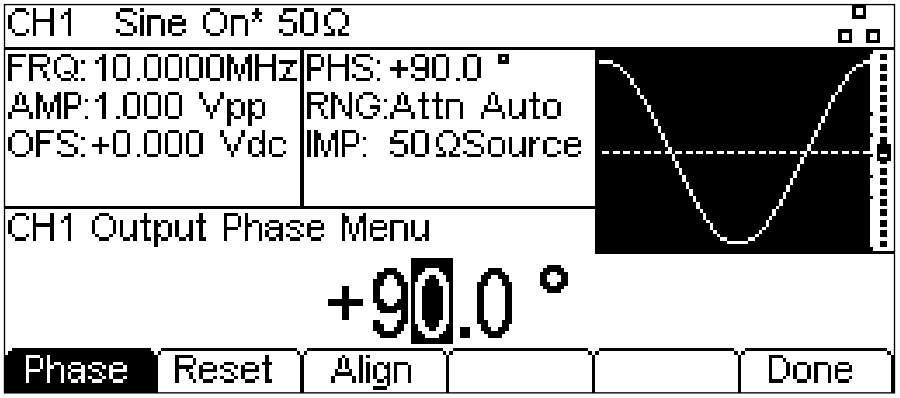
Press the **Master** soft-key to set the instrument as master. The signal at the MAIN OUT from the generator will stop at the dc offset level. Press Done.

To set the instrument as slave press **Slave** soft-key. The slave instrument will switch to using the external clock from the master. The signal at the MAIN OUT from the generator will stop at the dc offset level. Press Done.

Note. On dual channel instruments Tracking, Coupling, Master and Slave modes are mutually exclusive.

Press the **Reset** soft-key on the slave followed by the **Lock** soft-key on the master. The generators will now both output their waveforms, which will be synchronised at the selected phases.

The phase relationship between the slave and the master is set independently for each channel from the Output Phase menus.



The convention adopted for the phase relationship between generators is that a positive phase setting advances the slave generator with respect to the master and a negative setting delays the slave generator. Phase changes on either generator will not cause a loss of synchronisation.

Hardware delays become increasingly significant as the frequency increases, causing additional phase delay between the master and slave. However, these delays can be largely nulled–out by ‘backing–off’ the phase settings of the slave.

20.2.4 Resynchronising

If the frequency value of either the master or the slave is changed it will be necessary to resynchronise the generators. This may be done by pressing the **Align** soft-key in the Output Phase menu on either channel of the Slave generator followed by pressing the **Align** soft-key on either channel of the Master generator.

20.2.5 Triggered Burst

Because the external trigger input is used for synchronisation, triggered bursts can only use the internal trigger generator or manual trigger.

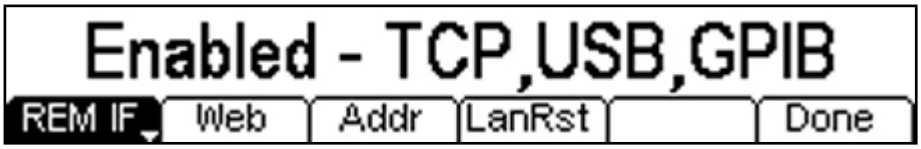
21 Remote Interface Operation

The instrument can be remotely controlled via its USB, LAN or GPIB interfaces.

USB remote control operates in a similar way to an RS232 interface but via the USB connector. Software supplied with the instrument sets up the controlling computer to treat the USB connection as a virtual COM port. Application software on the computer can then access the instrument via that COM port.

The LAN interface is designed to meet 1.4 LXI (LAN eXtensions for Instrumentation) Core 2011. Remote control using the LAN interface is possible using the TCP/IP Sockets protocol. The instrument also contains a basic Web server which provides information on the instrument and allows it to be configured from a web browser. Simple command line control from the browser is also possible.

The instrument is supplied with GPIB, USB and LAN interfaces as standard. All interfaces are live at initial power up but access to individual interfaces may be restricted using the menus on the front panel or the configuration options on the web pages. To control the restriction of interfaces from the front panel select Utility-**I/O** to show the screen below.



The default is for all available interfaces to be enabled as shown. The **REM IF** soft-key may be used to select the interfaces required. Pressing the **REM IF** key will cycle round the possibilities, in this case **Enabled – TCP,USB,GPIB**, **Enabled – TCP only**, **Enabled – USB Only** and **Enabled – GPIB Only**. TCP is used instead of LAN because the LAN itself is not disabled and could still be used to access the instrument web server, Disabling TCP does, however, disable the web page command line control of the instrument.

The web page access may also be disabled independently by pressing the Web soft-key. Alternate presses will produce **Enabled – WEBPAGE** and **Disabled – WEBPAGE**.

21.1 Address Selection

The instrument address capability is strictly required only by the GPIB interface. However, use can be made of the ADDRESS? command over any of the interfaces to easily identify which instrument is being controlled by a particular COM port (for USB) or TCP socket (for LAN). Note that the LAN interface also has a separate 'Identify' function, accessible from the instrument's web pages, that flashes the instrument's display until the function is cancelled.

The address is set from the instrument's front panel or web pages. To set the address from the front panel press the **Addr** soft-key on the Utility-**I/O** menu which will show the following.

The address may be changed in either of the ways detailed in Numeric Editing Principles.

21.2 Remote/Local Operation

At power-on the instrument will be in the local state so the REM indicator is not displayed on the Status Line. In this state all front panel operations are possible. When the instrument receives a command from an interface the remote state will be entered and the REM indicator is displayed on Status Line. In this state the front panel is locked out and remote commands only will be processed. The instrument may be returned to the local state by pressing the LOCAL key; however, the effect of this action will only remain until the instrument receives another character from the interface, when the remote state will once again be entered. Returning to Local by this action will keep the settings at their last remotely set values.

21.3 USB Interface

Using the USB interface for remote control requires a Communications Device Class driver on the PC to provide a virtual COM port instance. In Windows a suitable driver is provided by Microsoft, but it is not installed by default. The data (.INF) file to control the installation is provided on the Product Documentation CD delivered with the unit; however the same driver is also used by many other instruments from this manufacturer and may already be known to the PC.

To install the driver for the first time, first switch the unit on, and then connect the USB port to the PC. The Windows plug and play functions should automatically recognise the attachment of new hardware to the USB interface and (possibly after searching the internet for some time) prompt for the location of a suitable driver. Follow the Windows prompts and point to the CD, then the sub-directory for this product, and then to the USB Driver sub-directory below that. The file is named USB_ARM_VCP_xxx**.**INF, where xxx is a version number. (A readme.pdf file will also be found in that directory if further assistance is needed.)

In some cases Windows will not complete this procedure (especially recent versions which search the internet first, looking for the unique Vendor ID and Product ID), in which case the instrument will show in Device Manager as “not working properly”. If this happens, select this device, right click and choose “update driver software...” and then “browse this computer for driver software...” and then locate the .INF file on the CD as described above.

Once Windows has installed the device driver it will assign a COM port number to this particular unit. This number will depend on previous COM port assignments on this PC, and it may be necessary to use Device Manager to discover it. Each instrument has a unique USB identifier which is remembered by the system, so it will receive the same COM port number whenever it is attached to the same PC (regardless of the physical interface socket used), even though the COM port will disappear while the instrument is disconnected or switched off. Other instruments will receive different COM port numbers.

Note that a different PC will not necessarily assign the same COM port number to a particular instrument (it depends on the history of installations), however Device Manager can be used to change the assignments given.

This virtual COM port can be driven by Windows applications (including a terminal emulator) in exactly the same way as any standard COM port, except that the Baud rate and other settings are unnecessary and are ignored. Some old applications might not function with COM port numbers 3 or 4, or above 9. In this case, use Device Manager to change the allocation given. Once it is installed, the driver will be maintained by Windows Update in the usual way..

21.4 LAN Interface

The LAN interface is designed to comply with the 1.4 LXI Core 2011 and contains the interfaces and protocols described below. Since it is possible to misconfigure the LAN interface, making it impossible to communicate with the instrument over LAN, a LAN Configuration Initialise (LCI) mechanism is provided via the menus from the front panel to reset the instrument's interfaces to the factory default. The default setting is for the instrument to attempt to obtain settings via DHCP if available or, if DHCP times out (30 seconds), via Auto-IP. In the very unlikely event that an Auto-IP address cannot be found a static IP address of 192.168.0.100 is assigned. Resetting the LAN removes any password protection which has been set on the wab page.

To reset the LAN interface press the **`LanRst`** soft-key on the Utility-**`I/O`** menu.

For more information on LXI standards refer to www.lxistandard.org

21.4.1 LAN Connection

To use the LAN interface, the IP address of the unit must be known. On the supplied CD-ROM is a guide to the LXI Discovery Tool which provides links to the latest version of the tool and associated downloads. The tool is a Windows PC application which can be used to display the IP addresses or host names of all connected devices that comply with the VXI-11 protocol or support multicast Domain Name System (mDNS) records.

Connecting via a router is recommended as this is significantly quicker to assign an IP address; connecting directly to the PC will begin to assign an IP address only after a 30 second DHCP time-out.

Double clicking on any entry in the list of devices discovered will open the PC's web browser and display the Home page of that device.

There are also tools for LAN discovery included as part of the National Instruments Measurement and Automation Explorer package and the Agilent Vee application.

It is also possible to discover the assigned IP address from the Help menu. On single channel instruments, press the Help key, select option 3 and scroll down to the IP address. For dual channel instruments, press the Utility key followed by the Help soft-key, then select option 3 and scroll down to the IP address.

21.4.2 Web Server; Configuration Password Protection

The unit contains a basic web server. This provides information on the instrument and allows it to be configured. The Configure page can be password protected to deter unauthorised changes to the remote operation configuration; the default configuration is 'no password'.

The Configure page itself explains how to set the password. The password can be up to 15 characters long. The password will, however, be reset to the default (no password) if the front panel is used to reset all the LAN parameters to their factory default.

The web pages also have an 'Identify' function which allows the user to send an identifying command to the instrument which causes its display to flash until the command is cancelled.

21.4.3 ICMP Ping Server

The unit contains an ICMP server allowing the instrument to be 'pinged' via either its host name or IP address.

21.4.4 VXI-11 Discovery Protocol

The instrument has very limited support of VXI-11 which is sufficient for the discovery protocol and no more.

The instrument implements a Sun RPC Port-mapper on TCP port 111 and UDP port 111 as defined in RPC1183. The calls supported are: NULL, GET PORT and DUMP.

On TCP port 1024 a very simple VXI-11 protocol is implemented sufficient only for instrument discovery. This implements the following calls: CREATE LINK, DEVICE_WRITE, DEVICE_READ and DESTROY_LINK.

Once a link has been created anything written to the device is ignored and any read from the device returns the identification string as would be expected from a "*IDN?" of the form

'Manufacturer, Model, Serial No., XX.xx – YY.yy' – ZZ.zz

where 'XX.xx' is the revision of the main firmware and 'YY.yy' is the revision of the remote interface firmware and 'ZZ.zz' is the revision of the USB flash drive firmware.

21.4.5 mDNS and DNS-SD Support

Multicast DNS provides DNS services even on networks without a central DNS server (or DHCP server). This simplifies the setting up of a simple LAN using meaningful hostnames instead of a raw IP address. With service discovery it becomes straightforward for the device to be discovered and the services it provides.

The services provided by the instrument are http (_http._tcp) and lxi (_lxi._tcp).

21.4.6 VISA Resource Name

Because of the limited support for VXI-11(Discovery Protocol only), the instrument must be referred to by its raw socket information when used in software packages which communicate via a VISA resource name. For example, an instrument at IP address 192.168.1.100 would normally have a VISA resource name of "TCPIP0::192.168.1.100::inst0::INSTR" but for this instrument the name must be modified to read "TCPIP0::192.168.1.100::9221::SOCKET" where 9221 is the TCP port used by this instrument for control and monitoring, see below.

21.4.7 XML Identification Document URL

As required by the LXI Standard, the instrument provides an XML identification document that can be queried via a GET at “http://<hostname>:80/lxi/identification” that conforms to the LXI XSD Schema (available at http://www.lxistandard.org/InstrumentIdentification/1.0) and the W3C XML Schema Standards (http://www.w3.org/XML/Schema). This document describes the instrument.

21.4.8 TCP Sockets

The instrument uses 1 socket on TCP port 9221 for instrument control and monitoring. Text commands are sent to this port as defined in ‘Remote Commands’ and any replies are returned via the same port. Commands may be separated with either semicolons “;” or line feeds.

21.4.9 LAN Status indication

The **LAN** field in the Status Line can show multiple status indications. When there is no LAN connection, for example no cable connected, the field will show LAN. While the system is attempting to connect the icon will flash. When successfully connected with remote control enabled the field will show LAN. If connected but remote control is disabled it will show LAN. Finally an unsuccessful attempt to connect will show LAN.

21.5 GPIB Interface

The GPIB interface 24-way connector is located on the instrument rear panel. The pin connections are as specified in IEEE Std. 488.1-1987 and the instrument complies with IEEE Std. 488.1-1987 and IEEE Std. 488.2-1987.

21.5.1 GPIB Subsets

This instrument contains the following IEEE 488.1 subsets:

Source Handshake	SH1
Acceptor Handshake	AH1
Talker	T6
Listener	L4
Service Request	SR1
Remote Local	RL2
Parallel Poll	PP1
Device Clear	DC1
Device Trigger	DT0
Controller	C0
Electrical Interface	E2

21.5.2 GPIB IEEE Std. 488.2 Error Handling – Query Error Register

The IEEE 488.2 UNTERMINATED error (addressed to talk with nothing to say) is handled as follows. If the instrument is addressed to talk and the response formatter is inactive and the input queue is empty then the UNTERMINATED error is generated. This will cause the Query Error bit to be set in the Standard Event Status Register, a value of 3 to be placed in the Query Error Register and the parser to be reset. See the Status Reporting section for further information.

The IEEE 488.2 INTERRUPTED error is handled as follows. If the response formatter is waiting to send a response message and a <PROGRAM MESSAGE TERMINATOR> has been read by the parser or the input queue contains more than one END message then the instrument has been INTERRUPTED and an error is generated. This will cause the Query Error bit to be set in the Standard Event Status Register, a value of 1 to be placed in the Query Error Register and the response formatter to be reset thus clearing the output queue. The parser will then start parsing the next <PROGRAM MESSAGE UNIT> from the input queue. See the Status Reporting section for further information.

The IEEE 488.2 DEADLOCK error is handled as follows. If the response formatter is waiting to send a response message and the input queue becomes full then the instrument enters the DEADLOCK state and an error is generated. This will cause the Query Error bit to be set in the Standard Event Status Register, a value of 2 to be placed in the Query Error Register and the response formatter to be reset thus clearing the output queue. The parser will then start parsing the next <PROGRAM MESSAGE UNIT> from the input queue. See the Status Reporting section for further information.

21.5.3 GPIB Parallel Poll

Complete parallel poll capabilities are offered on this instrument. The Parallel Poll Enable Register is set to specify which bits in the Status Byte Register are to be used to form the ist local message The Parallel Poll Enable Register is set by the *PRE <NRF> command and read by the *PRE? command. The value in the Parallel Poll Enable Register is ANDed with the Status Byte Register; if the result is zero then the value of ist is 0 otherwise the value of ist is 1.

The instrument must also be configured so that the value of ist can be returned to the controller during a parallel poll operation. The instrument is configured by the controller sending a Parallel Poll Configure command (PPC) followed by a Parallel Poll Enable command (PPE). The bits in the PPE command are shown below:

bit 7 =	X	don't care
bit 6 =	1	Parallel poll enable
bit 5 =	1	
bit 4 =	0	
bit 3 =	Sense	sense of the response bit; 0 = low, 1 = high
bit 2 =	?	bit position of the response
bit 1 =	?	
bit 0 =	?	

Example. To return the RQS bit (bit 6 of the Status Byte Register) as a 1 when true and a 0 when false in bit position 1 in response to a parallel poll operation send the following commands

*PRE 64<pmt>, then PPC followed by 69H (PPE)

The parallel poll response from the instrument will then be 00H if RQS is 0 and 01H if RQSis 1.

During parallel poll response the DIO interface lines are resistively terminated (passive termination). This allows multiple devices to share the same response bit position in either wired-AND or wired-OR configuration, see IEEE 488.1 for more information.

21.6 Status Reporting

A separate error and status model is maintained for each interface instance; an interface instance is defined as a potential connection. USB and GPIB are inherently single connections so represent one interface instance each. LAN, however, allows for multiple simultaneous connections and therefore represents multiple interface instances. One interface instance is allocated to the TCP socket interface and one more is allocated to the Web page interface. Having a separate model for each interface instance ensures that data does not get lost as many commands e.g. '*ESR?' clear the contents on read. Error status is maintained using a set of registers; these are described in the following paragraphs and shown on the Status Model at the end of this section.

21.6.1 Standard Event Status and Standard Event Status Enable Registers

These two registers are implemented as required by the IEEE Std. 488.2.
Any bits set in the Standard Event Status Register which correspond to bits set in the Standard Event Status Enable Register will cause the ESB bit to be set in the Status Byte Register.

The Standard Event Status Register is read and cleared by the *ESR? command. The Standard Event Status Enable register is set by the *ESE <NRF> command and read by the *ESE? command.

It is a bit field where each bit has the following significance.

Bit 7: Power On. Set when power is first applied to the instrument.

Bit 6: User Request (Not used).

Bit 5: Command Error. Set when a syntax type error is detected in a command from the bus. The parser is reset and parsing continues at the next byte in the input stream

Bit 4: Execution Error. Set when an error is encountered while attempting to execute a completely parsed command. The appropriate error number will be reported in the Execution Error Register, see Error Messages section

Bit 3: Not used.

Bit 2: Query Error. Set when a query occurs. The appropriate error number will be reported in the Query Error Register, see Query Error Register section.

Bit 1: Not used.

Bit 0: Operation Complete: Set in response to the '*OPC' command.

21.6.2 Execution Error Register

This register contains a number representing the last error encountered over the current interface. The Execution Error Register is read and cleared using the 'EER?' command. On power up this register is set to 0 for all interface instances.

21.6.3 Status Byte Register and Service Request Enable Register

These two registers are implemented as required by the IEEE STD. 488.2.
Any bits set in the Status Byte Register which correspond to bits set in the Service Request Enable Register will cause the RQS/MSS bit to be set in the Status Byte Register, thus generating a Service Request on the bus.

The Status Byte Register is read either by the *STB? command, which will return MSS in bit 6, or by a Serial Poll which will return RQS in bit 6. The Service Request Enable register is set by the *SRE <NRF> command and read by the *SRE? command.

Bit 7 - Not used.

Bit 6 - RQS/MSS. This bit, as defined by IEEE Std. 488.2, contains both the Requesting Service message and the Master Status Summary message. RQS is returned in response to a Serial Poll and MSS is returned in response to the *STB? command.

Bit 5 - ESB. The Event Status Bit. This bit is set if any bits set in the Standard Event Status Register correspond to bits set in the Standard Event Status Enable Register.

Bit 4 - MAV. The Message Available Bit. This will be set when the instrument has a response message formatted and ready to send to the controller. The bit will be cleared after the Response Message Terminator has been sent.

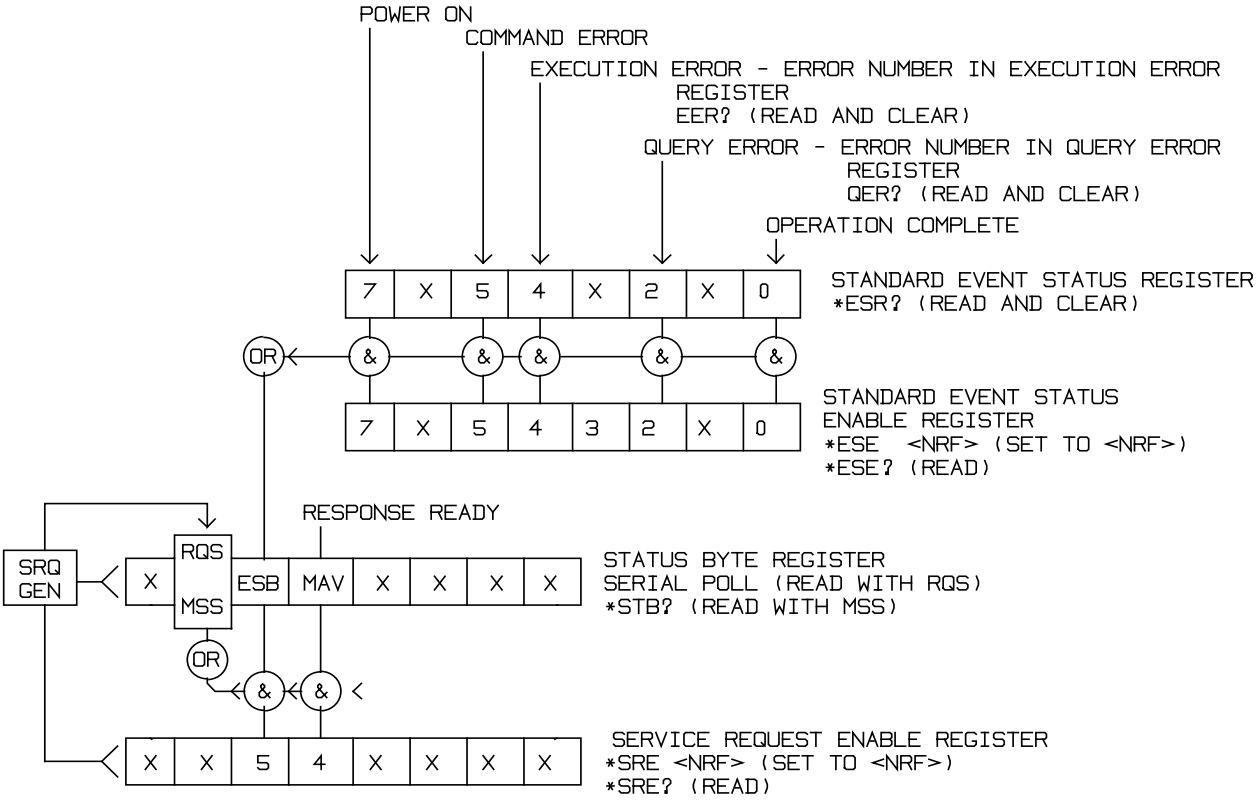
Bit 3 - Not used.

Bit 2 - Not used.

Bit 1 - Not used

Bit 0 - Not used

21.6.4 Status Model



21.6.5 Power-on and Remote Operation Default Settings

The following instrument status values are set at power on:

Status Byte Register	=	0
Service Request Enable Register †	=	0
Standard Event Status Register	=	128 (pon bit set)
Standard Event Status Enable Register †	=	0
Execution Error Register	=	0
Query Error Register	=	0
Parallel Poll Enable Register †	=	0

† Registers marked thus are specific to the GPIB section of the instrument and are of limited use via other interfaces.

The instrument will be in local state with the front panel controls active.

The instrument parameters at power-on are, by default, set to the factory default values as set out in Appendix 2. Factory Default Settings but the user may change this from the front panel to be the same at power on as it was at switch off, see Power On State paragraph in the Utility Menus - System section.

The *RST (reset) interface command resets the instrument parameters to the factory default settings. Remote interface settings are unchanged by *RST.

22 Remote Commands

22.1 Command List

This section lists all commands and queries implemented in this instrument.

Note that there are no dependent parameters, coupled parameters, overlapping commands, expression program data elements or compound command program headers; each command is completely executed before the next command is started. All commands are sequential and the operation complete message is generated immediately after execution in all cases.

The following nomenclature is used:

<RMT>	<RESPONSE MESSAGE TERMINATOR>
<CPD>	<CHARACTER PROGRAM DATA>, i.e. a short mnemonic or string such as ON or OFF. Multiple CPDs in a command are shown as <CPD1>, <CPD2>, <CPD3>, etc.
<NRF>	A number in any format. e.g. 12, 12·00, 1·2 e1 and 120 e-1 are all accepted as the number 12. Any number, when received, is converted to the required precision consistent with the use then rounded to obtain the value of the command.
<NR1>	A number with no fractional part, i.e. an integer.
<CRD>	<CHARACTER RESPONSE DATA> .
<BIN>	Binary data as detailed for the particular command.
[..]	Any item(s) enclosed in these brackets are optional parameters. If more than one item is enclosed then all or none of the items are required.

The commands which begin with a ***** are implemented as specified by IEEE Std 488.2 as Common commands. All will function when used on the other interfaces but some may be of little use.

The Operation Complete bit (bit 0) in the Standard Event Status Register is only ever set by the *OPC command. The *OPC (or the *OPC?) command can be used for device synchronisation due to the sequential nature of remote operations.

22.1.1 Channel Selection

Most commands act on a particular channel of the generator. The following command is used to select the required channel. Subsequent commands will change only the specified parameter on the selected channel.

CHN	<NRF>	Set channel <NRF> as the destination for subsequent commands. <NRF> can be 1 or 2. For a single channel instrument this is always 1.
CHN?		Returns currently selected channel number

22.1.2 Continuous Carrier Wave Commands

WAVE	<CPD>	Set the output waveform type to <PULSE>, <SQUARE>, <DOUBLEPULSE>, <PATTERN>, <PRBSPN7>, <PRBSPN9>, <PRBSPN11>, <PRBSPN15>, <PRBSPN20>, <PRBSPN23>, <PRBSPN29>, <PRBSPN31>, <NOISE>, <ARB>, <SINE>, <RAMP> or <TRIANG>.
FREQ	<NRF>	Set the current waveform frequency to <NRF> Hz
PER	<NRF>	Set the current waveform period to <NRF> Sec
AMPLRNG	<CPD>	Set the amplitude range to <AUTO> or <HOLD>
AMPL	<NRF>	Set the amplitude to <NRF> Volts peak to peak
HILVL	<NRF>	Set the amplitude-high-level to <NRF> Volts
LOLVL	<NRF>	Set the amplitude-low-level to <NRF> Volts

DCOFFS	<NRF>	Set the dc offset to <NRF> Volts
OUTPUT	<CPD>	Set the output to <ON>, <OFF>, <NORMAL> or <INVERT>
CHN2OUTPUT	<CPD>	Set the channel 2 output to <ON> or <OFF>. Useful to control channel 2 output status when the instrument is in tracking mode.
ZLOAD	<CPD>	Set the output load, which the generator is to assume for amplitude and dc offset entries, from <50> to <10,000>Ohms or <OPEN>.
ZSRC	<CPD>	Set the output source impedance to <5> or <50> Ohms.
SYNCOUT	<CPD>	Set the sync output to <ON>, <OFF>
SYNCTYPE	<CPD>	Set the sync type to <AUTO>, <NORMAL>, <CARRIER>, <TRIGGER> or <OFF>
PHASE	<NRF>	Set the waveform phase offset to <NRF> Degree.
ALIGN		Sends signal to align zero phase reference of both channels.

22.1.3 Pulse Generator Commands

PULSFREQ	<NRF>	Set the pulse waveform frequency to <NRF> Hz
PULSPER	<NRF>	Set the pulse waveform period to <NRF> Sec
PULSWID	<NRF>	Set the pulse waveform width to <NRF> Sec
PULSSYMM	<NRF>	Set the pulse waveform symmetry to <NRF> %
PULSFALLDEL	<NRF>	Set the pulse fall time delay to <NRF> Sec
PULSEDGE	<NRF>	Set the pulse waveform edges (positive and negative edge) to <NRF> Sec.
PULSEDGESYMM	<NRF>	Set the pulse waveform edges (positive and negative edge) as a percentage of pulse width to <NRF> %
PULSRISE	<NRF>	Set the pulse waveform positive edge to <NRF> Sec
PULSRISESYMM	<NRF>	Set the pulse waveform positive edge as a percentage of pulse width to <NRF> %
PULSFALL	<NRF>	Set the pulse waveform negative edge to <NRF> Sec
PULSFALLSYMM	<NRF>	Set the pulse waveform negative edge as a percentage of pulse width to <NRF> %
PULSDLY	<NRF>	Set the pulse waveform delay to <NRF> Sec
PULSDLYSYMM	<NRF>	Set the pulse waveform delay as a percentage of pulse period to <NRF> %

22.1.4 Square Generator Commands

SQRFREQ	<NRF>	Set the square waveform frequency to <NRF> Hz
SQRPER	<NRF>	Set the square waveform period to <NRF> Sec
SQRSYMM	<NRF>	Set the square waveform symmetry to <NRF> %

22.1.5 Double Pulse Generator Commands

DBLFREQ	<NRF>	Set the double pulse waveform frequency to <NRF> Hz
DBLPER	<NRF>	Set the double pulse waveform period to <NRF> Sec
DBLWID	<NRF>	Set the double pulse waveform width to <NRF> Sec

DBLSYMM	<NRF>	Set the double pulse waveform symmetry to <NRF> %
DBLEDGE	<NRF>	Set the double pulse waveform edges (positive and negative edge) to <NRF> Sec
DBLEDGESYMM	<NRF>	Set the double pulse waveform edges (positive and negative edge) as a percentage of double pulse width to <NRF> %.
DBLRISE	<NRF>	Set the double pulse waveform positive edge to <NRF> Sec
DBLRISESYMM	<NRF>	Set the double pulse waveform positive edge as a percentage of double pulse width to <NRF> %
DBLFALL	<NRF>	Set the double pulse waveform negative edge to <NRF> Sec
DBLFALLSYMM	<NRF>	Set the double pulse waveform negative edge as a percentage of double pulse width to <NRF> %
DBLDLY	<NRF>	Set the double pulse waveform delay to <NRF> Sec
DBLDLYSYMM	<NRF>	Set the double pulse waveform delay as a percentage of double pulse period to <NRF> %
DBLDBLDLY	<NRF>	Set the double pulse waveform double delay (delay between the two pulse) to <NRF> Sec
DBLDBLDLYSYMM	<NRF>	Set the double pulse waveform double delay as a percentage of double pulse period to <NRF> %

22.1.6 Pattern Generator Commands

PTTNBITRATE	<NRF>	Set the Pattern / PRBS waveform bit rate to <NRF> Bits Per Second.
PRBSBITRATE	<NRF>	Set the Pattern / PRBS waveform bit rate to <NRF> Bits Per Second.
PTTNEDGE	<NRF>	Set the Pattern / PRBS waveform edges to <NRF> Sec.
PRBSEDGE	<NRF>	Set the Pattern / PRBS waveform edges to <NRF> Sec.
PTTNSRC	<CPD>	Set the pattern source to <PATTERN1>, <PATTERN2>, <PATTERN3>, <PATTERN4>, <PRBS>, <EXTTRIG> or <EXTMOD>. The user specified name of the patterns stored in PATTERN1, PATTERN2, PATTERN3 or PATTERN4 are also accepted as valid entries to change the source to PATTERN1, PATTERN2, PATTERN3 or PATTERN4 respectively.
PRBSTYPE	<CPD>	Set the PRBS waveform type to <PRBSPN7>, <PRBSPN9>, <PRBSPN11>, <PRBSPN15>, <PRBSPN20>, <PRBSPN23>, <PRBSPN29> or <PRBSPN31>
PTTNLEN	<CPD>, <NR1>	Change the length of pattern waveform <PATTERN1>, <PATTERN2>, <PATTERN3> or <PATTERN4> to <NR1>
PTTNOFFSET	<CPD>, <NR1>	Change the offset (preamble length) of pattern waveform <PATTERN1>, <PATTERN2>, <PATTERN3> or <PATTERN4> to <NR1>
PTTNRESET	<CPD1>, <CPD2>	Reset pattern waveform <PATTERN1>, <PATTERN2>, <PATTERN3> or <PATTERN4> to <DEFAULT>, <HIGH> or <LOW>
PTTNDEF	<CPD1>, <CPD2>	Define a pattern waveform with user specified waveform name. <CPD1> PATTERN1, PATTERN2, PATTERN3 or PATTERN4 <CPD2> “user specified waveform name”

PTTN1	<BIN>	Load data to an existing pattern waveform memory location PATTERN1. The data consists of two bytes per point with no characters between bytes or points. The point data is sent high byte first. If the data is greater than zero than pattern point is set as high, else the pattern point is set as low. The data block has a header which consists of the # character followed by several ascii coded numeric characters. The first of these defines the number of ascii characters to follow and the following characters define the length of the binary data in bytes. The instrument will wait for data indefinitely If less data is sent. If more data is sent the extra is processed by the command parser which results in a command error.
PTTN2	<BIN>	See PTTN1 description.
PTTN3	<BIN>	See PTTN1 description.
PTTN4	<BIN>	See PTTN1 description.
PTTN1DEF?		Returns user specified pattern name, length and offset for the pattern stored in location PATTERN1.
PTTN2DEF?		See PTTN1DEF? description.
PTTN3DEF?		See PTTN1DEF? description.
PTTN4DEF?		See PTTN1DEF? description.
PTTN1?		Returns the data from an existing pattern waveform location PATTERN1. The data consists of two bytes per point with no characters between bytes or points. The point data is sent high byte first. If the pattern bit is high, data value is 0x7FFF. If the pattern bit is low, data value is 0x8000. The data block has a header which consists of the # character followed by several ascii coded numeric characters. The first of these defines the number of ascii characters to follow and the following characters define the length of the binary data in bytes.
PTTN2?		See PTTN1? description.
PTTN3?		See PTTN1? description.
PTTN4?		See PTTN1? description.

22.1.7 Noise Generator Commands

NSEBANDWID	< NRF >	Set the noise bandwidth to <NRF> Hz
NSESRC	<CPD>	Set the noise distribution to <GAUSSIAN33>, <GAUSSIAN48>, <GAUSSIAN60>, <GAUSSIAN70> or <USERARB>. The user specified name of the arbitrary noise distribution is also accepted as a valid entry to select arbitrary noise distribution.
NSEARBRESIZE	<NR1>	Change the size of arbitrary noise distribution waveform to <NR1>.
NSEARBDEF	<CPD1>, <CPD2>	Define an arbitrary noise distribution waveform with user specified waveform name and waveform point interpolation state. <CPD1> “user specified waveform name” <CPD2> waveform point interpolation <ON> or <OFF>

NSEARB	<BIN>	Load data to the arbitrary noise distribution waveform memory location. The data consists of two bytes per point with no characters between bytes or points. The point data is sent high byte first. The data block has a header which consists of the # character followed by several ascii coded numeric characters. The first of these defines the number of ascii characters to follow and the following characters define the length of the binary data in bytes. The instrument will wait for data indefinitely If less data is sent. If more data is sent the extra is processed by the command parser which results in a command error.
NSEARBDEF?		Returns user specified waveform name, waveform point interpolation state and waveform length of arbitrary noise distribution waveform.
NSEARB?		Returns the data from the arbitrary noise distribution waveform memory location. The data consists of two bytes per point with no characters between bytes or points. The point data is sent high byte first. The data block has a header which consists of the # character followed by several ascii coded numeric characters. The first of these defines the number of ascii characters to follow and the following characters define the length of the binary data in bytes.

22.1.8 Function / Arbitrary Waveform Commands

ARBFREQ	<NRF>	Set the function / arbitrary waveform frequency to <NRF> Hz
ARBPER	<NRF>	Set the function / arbitrary waveform period to <NRF> Sec
RMPSYMM	<NRF>	Set the ramp waveform symmetry to <NRF> %
ARBSQRSYMM	<NRF>	Set the arb square waveform symmetry to <NRF> %
ARBSNCZERO	<NR1>	Set the number of zero crossings of sinc waveform to <NR1>.
ARBEXPLOGTC	<NRF>	Set the time constant of exponential / logarithmic waveform as a percentage of waveform period to <NRF> %.
ARBGAUSLRTC	<NRF>	Set the width of gaussian / lorentz waveform as a percentage of waveform period to <NRF> %.
ARBDCOFFS	<NRF>	Set the arbitrary dc waveform offset to <NRF> Volts
ARBLOAD	<CPD>	Set the function / arbitrary waveform to <SINE>, <SQUARE>, <RAMP>, <TRIANG>, <RAMPUP>, <RAMPDN>, <SINC>, <HAVERSINE>, <CARDIAC>, <EXPRISE>, <LOGRISE>, <EXPFALL>, <LOGFALL>, <GAUSSIAN>, <LORERNTZ>, <DLORENTZ>, <DC>, <ARB1>, <ARB2>, <ARB3> or <ARB4>. The user specified name of the arbs stored in ARB1, ARB2, ARB3 or ARB4 are also accepted as valid entries to change the waveform to ARB1, ARB2, ARB3 or ARB4 respectively.
ARBRESIZE	<CPD>, <NR1>	Change the size of arbitrary waveform <CPD> to <NR1>.
ARBDEF	<CPD1>, <CPD2>, <CPD3>	Define an arbitrary waveform with user specified waveform name and waveform point interpolation state. <CPD1> ARB1, ARB2, ARB3 or ARB4 <CPD2> “user specified waveform name” <CPD3> waveform point interpolation ON or OFF

ARB1	<BIN>	Load data to an existing arbitrary waveform memory location ARB1. The data consists of two bytes per point with no characters between bytes or points. The point data is sent high byte first. The data block has a header which consists of the # character followed by several ascii coded numeric characters. The first of these defines the number of ascii characters to follow and the following characters define the length of the binary data in bytes. The instrument will wait for data indefinitely If less data is sent. If more data is sent the extra is processed by the command parser which results in a command error.
ARB2	<BIN>	See ARB1 description.
ARB3	<BIN>	See ARB1 description.
ARB4	<BIN>	See ARB1 description.
ARB1DEF?		Returns user specified waveform name, waveform point interpolation state and waveform length of ARB1.
ARB2DEF?		See ARB1DEF? description.
ARB3DEF?		See ARB1DEF? description.
ARB4DEF?		See ARB1DEF? description.
ARB1?		Returns the data from an existing arbitrary waveform location ARB1. The data consists of two bytes per point with no characters between bytes or points. The point data is sent high byte first. The data block has a header which consists of the # character followed by several ascii coded numeric characters. The first of these defines the number of ascii characters to follow and the following characters define the length of the binary data in bytes.
ARB2?		See ARB1? description.
ARB3?		See ARB1? description.
ARB4?		See ARB1? description.

22.1.9 Modulation Commands

MOD	<CPD>	Set modulation to <OFF>, <AM>, <AMSC>, <FM>, <PM>, <FSK>, <SUM>, <BPSK>, <PWM>, <PDM> or <SPDM>.
MODAMSHAPE	<CPD>	Set AM waveform shape to <SINE>, <SQUARE>, <RAMPUP>, <RAMPDN>, <TRIANG>, <NOISE>, <DC>, <SINC>, <EXPRISE>, <LOGRISE>, <EXPFALL>, <LOGFALL>, <HAVERSINE>, <CARDIAC>, <GAUSSIAN>, <LORENTZ>, <DLORENTZ>, <ARB1>, <ARB2>, <ARB3>, <ARB4>, <PRBSPN7>, <PRBSPN9>, <PRBSPN11>, <PRBSPN15>, <PRBSPN20>, <PRBSPN23>, <PRBSPN29> or <PRBSPN31>
MODFMSHAPE	<CPD>	Set FM waveform shape to <SINE>, <SQUARE>, <RAMPUP>, <RAMPDN>, <TRIANG>, <NOISE>, <DC>, <SINC>, <EXPRISE>, <LOGRISE>, <EXPFALL>, <LOGFALL>, <HAVERSINE>, <CARDIAC>, <GAUSSIAN>, <LORENTZ>, <DLORENTZ>, <ARB1>, <ARB2>, <ARB3>, <ARB4>, <PRBSPN7>, <PRBSPN9>, <PRBSPN11>, <PRBSPN15>, <PRBSPN20>, <PRBSPN23>, <PRBSPN29> or <PRBSPN31>

MODPMSHAPE	<CPD>	Set PM waveform shape to <SINE>, <SQUARE>, <RAMPUP>, <RAMPDN>, <TRIANG>, <NOISE>, <DC>, <SINC>, <EXPRISE>, <LOGRISE>, <EXPFALL>, <LOGFALL>, <HAVERSINE>, <CARDIAC>, <GAUSSIAN>, <LORENTZ>, <DLORENTZ>, <ARB1>, <ARB2>, <ARB3>, <ARB4>, <PRBSPN7>, <PRBSPN9>, <PRBSPN11>, <PRBSPN15>, <PRBSPN20>, <PRBSPN23>, <PRBSPN29> or <PRBSPN31>
MODPWMSHAPE	<CPD>	Set PWM waveform shape to <SINE>, <SQUARE>, <RAMPUP>, <RAMPDN>, <TRIANG>, <NOISE>, <DC>, <SINC>, <EXPRISE>, <LOGRISE>, <EXPFALL>, <LOGFALL>, <HAVERSINE>, <CARDIAC>, <GAUSSIAN>, <LORENTZ>, <DLORENTZ>, <ARB1>, <ARB2>, <ARB3>, <ARB4>, <PRBSPN7>, <PRBSPN9>, <PRBSPN11>, <PRBSPN15>, <PRBSPN20>, <PRBSPN23>, <PRBSPN29> or < PRBSPN31>
MODSUMSHAPE	<CPD>	Set SUM waveform shape to <SINE>, <SQUARE>, <RAMPUP>, <RAMPDN>, <TRIANG>, <NOISE>, <DC>, <SINC>, <EXPRISE>, <LOGRISE>, <EXPFALL>, <LOGFALL>, <HAVERSINE>, <CARDIAC>, <GAUSSIAN>, <LORENTZ>, <DLORENTZ>, <ARB1>, <ARB2>, <ARB3>, <ARB4>, <PRBSPN7>, <PRBSPN9>, <PRBSPN11>, <PRBSPN15>, <PRBSPN20>, <PRBSPN23>, < PRBSPN29> or < PRBSPN31>
MODPDMSHAPE	<CPD>	Set PDM waveform shape to <SINE>, <SQUARE>, <RAMPUP>, <RAMPDN>, <TRIANG>, <NOISE>, <DC>, <SINC>, <EXPRISE>, <LOGRISE>, <EXPFALL>, <LOGFALL>, <HAVERSINE>, <CARDIAC>, <GAUSSIAN>, <LORENTZ>, <DLORENTZ>, <ARB1>, <ARB2>, <ARB3>, <ARB4>, <PRBSPN7>, <PRBSPN9>, <PRBSPN11>, <PRBSPN15>, <PRBSPN20>, <PRBSPN23>, <PRBSPN29> or < PRBSPN31>
MODSPDMSHAPE	<CPD>	Set SPDM waveform shape to <SINE>, <SQUARE>, <RAMPUP>, <RAMPDN>, <TRIANG>, <NOISE>, <DC>, <SINC>, <EXPRISE>, <LOGRISE>, <EXPFALL>, <LOGFALL>, <HAVERSINE>, <CARDIAC>, <GAUSSIAN>, <LORENTZ>, <DLORENTZ>, <ARB1>, <ARB2>, <ARB3>, <ARB4>, <PRBSPN7>, <PRBSPN9>, <PRBSPN11>, <PRBSPN15>, <PRBSPN20>, <PRBSPN23>, <PRBSPN29> or < PRBSPN31>
MODAMSRC	<CPD>	Set AM waveform source to <INT>, <EXT> or <CRC>
MODFMSRC	<CPD>	Set FM waveform source to <INT>, <EXT> or <CRC>
MODPMSRC	<CPD>	Set PM waveform source to <INT>, <EXT> or <CRC>
MODPWMSRC	<CPD>	Set PWM waveform source to <INT>, <EXT> or <CRC>
MODSUMSRC	<CPD>	Set SUM waveform source to <INT>, <EXT> or <CRC>
MODPDMSRC	<CPD>	Set PDM waveform source to <INT>, <EXT> or <CRC>
MODSPDMSRC	<CPD>	Set SPDM waveform source to <INT>, <EXT> or <CRC>
MODAMFREQ	<NRF>	Set AM waveform frequency to <NRF> Hz
MODFMFREQ	<NRF>	Set FM waveform frequency to <NRF> Hz
MODPMFREQ	<NRF>	Set PM waveform frequency to <NRF> Hz
MODPWMFREQ	<NRF>	Set PWM waveform frequency to <NRF> Hz
MODSUMFREQ	<NRF>	Set SUM waveform frequency to <NRF> Hz
MODPDMFREQ	<NRF>	Set PDM waveform frequency to <NRF> Hz

MODSPDMFREQ	<NRF>	Set SPDM waveform frequency to <NRF> Hz
MODAMDEPTH	<NRF>	Set AM depth to <NRF> %
MODFMDEV	<NRF>	Set FM deviation to <NRF> Hz
MODPMDEV	<NRF>	Set PM deviation to <NRF> Degree
MODPWMDEV	<NRF>	Set PWM width deviation to <NRF> sec
MODSUMLEVEL	<NRF>	Set SUM level to <NRF> %
MODPDMDEV	<NRF>	Set PDM delay deviation to <NRF> sec
MODSPDMDEV	<NRF>	Set SPDM second pulse delay deviation to <NRF> sec
MODFSKSRC	<CPD>	Set FSK waveform source to <INT> or <EXT>
MODHOPFREQ	<NRF>	Set HOP frequency to <NRF> Hz
MODFSKRATE	<NRF>	Set FSK rate to <NRF> Hz
MODPOLFSK	<CPD>	Set FSK slope to <POS> or <NEG>
MODBPSKSRC	<CPD>	Set BPSK waveform source to <INT> or <EXT>
MODBPSKPHASE	<NRF>	Set BPSK phase offset to <NRF> Degree
MODBPSKRATE	<NRF>	Set BPSK rate to <NRF> Hz
MODPOLBPSK	<CPD>	Set BPSK slope to <POS> or <NEG>

22.1.10 Sweep Commands

SWPTYPE	<CPD>	Set the sweep type to <LINUP>, <LINDN>, <LOGUP> or <LOGDN>.
SWPMODE	<CPD>	Set the sweep mode to <CONT> or <TRIG>.
SWPTRGSRC	<CPD>	Set the sweep trigger source to <INT>, <EXT> or <MAN>.
SWPTRGPER	<NRF>	Set the sweep trigger period to <NRF> Sec.
SWPTRGPOL	<CPD>	Set the sweep trigger slope to <POS> or <NEG>.
SWPBEGFREQ	<NRF>	Set the sweep start frequency to <NRF> Hz.
SWPENDFREQ	<NRF>	Set the sweep stop frequency to <NRF> Hz.
SWPCNTFREQ	<NRF>	Set the sweep centre frequency to <NRF> Hz.
SWPSPNFREQ	<NRF>	Set the sweep frequency span to <NRF> Hz.
SWPMKR	<CPD>	Set the sweep marker to <ON> or <OFF>.
SWPMKRFREQ	<NRF>	Set the sweep marker to <NRF> Hz.
SWPTIME	<NRF>	Set the sweep time to <NRF> Sec.
SWPHOLDTIME	<NRF>	Set the sweep hold time to <NRF> Sec.
SWPRTNTIME	<NRF>	Set the sweep return time to <NRF> Sec.
SWP	<CPD>	Set the sweep to <ON> or <OFF>.

22.1.11 Burst Commands

BSTTRGSRC	<CPD>	Set the burst trigger source to <INT>, <EXT> or <MAN>.
BSTPER	<NRF>	Set the burst trigger period to <NRF> Sec.
BSTTRGPOL	<CPD>	Set the burst trigger slope to <POS> or <NEG>.
BSTCOUNT	<NR1>	Set the burst count to <NR1> Cycles.
BSTPHASE	<NRF>	Set the burst phase to <NRF> Degree.

BSTPTTNMODE	<CPD>	Set the pattern burst mode to <BIT> or <BLOCK>.
BST	<CPD>	Set the burst to <OFF>, <NCYC>, <GATED> or <INFINITE>.

22.1.12 Clock and Synchronising Commands

CLKSRC	<CPD>	Set the clock source to <INT> or <EXT>.
CLKSRC?		Returns the clock source <INT> or <EXT>.
LOCKMODE	<CPD>	Set the synchronising mode to <MASTER>, <SLAVE> or <INDEP>.
SLVRST		Set the SLAVE generator ready to be synchronised.
MSTLOCK		Send signal to SLAVE generator to get synchronoised.
MSTRELOCK		Resynchronise the two generators in Master-SLAVE mode.

22.1.13 Inter-channel Function Commands

AMPLCPLNG	<CPD>	Set amplitude coupling to <ON> or <OFF>.
OUTPUTCPLNG	<CPD>	Set output coupling to <ON> or <OFF>.
FRQCPLSWT	<CPD>	Set waveform frequency coupling to <ON> or <OFF>.
FRQCPLTYP	<CPD>	Set waveform frequency coupling type to <RATIO> or <OFFSET>.
FRQCPLRAT	<NRF>	Set waveform frequency coupling ratio to <NRF>.
FRQCPLOFS	<NRF>	Set waveform frequency coupling offset to <NRF> Hz.
PLSFRQCPLSWT	<CPD>	Set waveform frequency coupling to <ON> or <OFF>.
PLSFRQCPLTYP	<CPD>	Set waveform frequency coupling type to <RATIO> or <OFFSET>.
PLSFRQCPLRAT	<NRF>	Set waveform frequency coupling ratio to <NRF>.
PLSFRQCPLOFS	<NRF>	Set waveform frequency coupling offset to <NRF> Hz.
TRACKING	<CPD>	Set channel tracking to <OFF>, <EQUAL> or <INVERT>.

22.1.14 Miscellaneous Commands

EXTRGTHRSHLD	<NRF>	Set external trigger input threshold to <NRF> Volts.
EXMODTHRSHLD	<NRF>	Set external modulation input threshold to <NRF> Volts. Applies only to external pattern waveform where external source is MOD IN.
CHNTRG	<CPD>	Sends manual trigger to channel <ONE> or <TWO>. This command is the same as pressing the manual trigger soft-key in the Trigger Menu. Its effect will depend on the context in which it is asserted. If the trigger source is manual and the generator is set to perform triggered burst or triggered sweep operation, this command sends a trigger pulse to the generator. If the trigger source is manual and the generator is set to perform gated burst operation, this command simply inverts the level of the manual trigger to high or low.

22.1.15 System and Status Commands

*CLS	Clear Status. Clears the Status structure. This indirectly clears the Status Byte Register.
*ESE	Set the Standard Event Status Enable Register to the value of <NRF>
*ESE?	Returns the value in the Standard Event Status Enable Register in <NR1> numeric format. The syntax of the response is <NR1><RMT>

*ESR?	Returns the value in the Standard Event Status Register in <NR1> numeric format. The register is then cleared. The response is <NR1><RMT>. See Status Reporting section for details.
*IST?	Returns **ist** local message as defined by IEEE Std. 488.2. The syntax of the response is 0<RMT>, if the local message is false, or 1<RMT>, if the local message is true.
*OPC	Sets the Operation Complete bit (bit 0) in the Standard Event Status Register. This will happen immediately the command is executed because of the sequential nature of all operations.
*OPC?	Query Operation Complete status. The response is always 1<RMT> and will be available immediately the command is executed because all commands are sequential.
*PRE	Set the Parallel Poll Enable Register to the value <NRF>.
*PRE?	Returns the value in the Parallel Poll Enable Register in <NR1> numeric format. The syntax of the response is <NR1><RMT>
*SRE	Set the Service Request Enable Register to <NRF>.
*SRE?	Returns the value of the Service Request Enable Register in <NR1> numeric format. The syntax of the response is<NR1><RMT>
*STB?	Returns the value of the Status Byte Register in <NR1> numeric format. The syntax of the response is<NR1><RMT>
*WAI	Wait for Operation Complete true. As all commands are completely executed before the next is started this command takes no additional action.
*TST?	The PSU has no self test capability and the response is always 0 <RMT>
EER?	Query and clear Execution Error Register. The response format is NR1<RMT>.
QER?	Query and clear Query Error Register. The response format is NR1<RMT>
*LRN?	Returns the complete setup of the instrument as a binary data block. To re-install the setup the block should be returned to the instrument exactly as it is received. The syntax of the response is LRN <BIN>. The settings in the instrument are not affected by execution of the *LRN? Command.
LRN	Install data from a previous *LRN? command.
*RST	Resets the instrument parameters to their default values.
*RCL	Recalls a previously stored instrument set-up file from the specified non-volatile memory location.
*SAV	Saves the complete instrument set-up file to the specified non-volatile memory location.

*TRG	This command is the same as pressing the manual trigger soft-key in the Trigger Menu. Its effect will depend on the context in which it is asserted. If the trigger source is manual and the generator is set to perform triggered burst or triggered sweep operation, this command sends a trigger pulse to the generator. If the trigger source is manual and the generator is set to perform gated burst operation, this command simply inverts the level of the manual trigger to high or low.
*IDN?	Returns the instrument identification. The exact response is determined by the instrument configuration and is of the form of <Manufacturer, Model, Serial No., XX.xx – YY.yy' – ZZ.zz> where 'XX.xx' is the revision of the main firmware and 'YY.yy' is the revision of the remote interface firmware and 'ZZ.zz' is the revision of the USB flash drive firmware
BEEPMODE	Set beep mode to <ON>, <OFF>, <WARN>, or <ERROR>.
BEEP	Sound one beep.

22.1.16 Interface Management Commands

LOCAL	Go to local. This does not release any active interface lock so that the lock remains with the selected interface when the next remote command is received.
ADDRESS?	Returns the bus address of the instrument; This is the address used by GPIB, if fitted, or may be used as a general identifier over the other interfaces.
IPADDR?	Returns the present IP address of the LAN interface, provided it is connected. If it is not connected, the response will be the static IP if configured to always use that static IP, otherwise it will be 0.0.0.0 if waiting for DHCP or Auto-IP. The response is nnn.nnn.nnn.nnn<RMT>, where each nnn is 0 to 255.
NETMASK?	Returns the present netmask of the LAN interface, provided it is connected. The response is nnn.nnn.nnn.nnn<RMT>, where each nnn is 0 to 255.
NETCONFIG?	Returns the first means by which an IP address will be sought. The response is <CRD><RMT> where <CRD> is DHCP, AUTO or STATIC.

The following commands specify the parameters to be used by the LAN interface. **Note:** a power cycle is required after these commands are sent before the new settings are used (or returned in response to the queries listed above). The instrument does not attempt to check the validity of the IP address or netmask in any way other than checking that each part fits in 8 bits. The rear panel LAN RESET switch will override these commands and restore the defaults as described earlier.

NETCONFIG	<CPD>	Specifies the means by which an IP address will be sought. <CPD> must be one of DHCP, AUTO or STATIC.
IPADDR	<quad>	Sets the potential static IP address of the LAN interface (as on the webpage). The parameter must be strictly a dotted quad for the IP address, with eachaddress part an <NR1> in the range 0 to 255, (e.g. 192.168.1.101).
NETMASK	<quad>	Sets the netmask to accompany the static IP address of the LAN interface. The parameter must be strictly a dotted quad for the netmask, with each part an <NR1> in the range 0 to 255, (e.g. 255.255.255.0).

22.1.17 Calibration Specific Commands

See the calibration section for details of calibration specific commands.

22.1.18 Error Messages

Each error message has a number; only this number is reported via the remote control interfaces. Error message numbers are placed in the Execution Error Register where they can be read via the remote interfaces.

23 Maintenance

The Manufacturers or their agents overseas will provide a repair service for any unit developing a fault. Where owners wish to undertake their own maintenance work, this should only be done by skilled personnel in conjunction with the service guide which may be obtained directly from the Manufacturers or their agents overseas.

23.1.1 Cleaning

If the instrument requires cleaning use a cloth that is only lightly dampened with water or a mild detergent.

WARNING! TO AVOID ELECTRIC SHOCK, OR DAMAGE TO THE INSTRUMENT, NEVER ALLOW WATER TO GET INSIDE THE CASE. TO AVOID DAMAGE TO THE CASE NEVER CLEAN WITH SOLVENTS.

23.1.2 Web link

For the latest version of this instruction manual, IVI driver and any applicable firmware updates go to http://www.aimtti.com/support

24 Specification

Applicable Products

TGP3151 – 1 channel, 50MHz
TGP3152 – 2 channel, 50MHz
TGP3121 – 1 channel, 25MHz
TGP3122 – 2 channel, 25MHz

General specifications apply for the temperature range 5°C to 40°C. Accuracy specifications apply for the temperature range 18°C to 28°C after 30 minutes warm–up, at maximum output 50Ω source impedance into 50Ω load impedance. Typical specifications are determined by design and are not guaranteed.

TGP312x limits, where different, are shown in square brackets [ ] after the TGP315x limits. Options shown in curly brackets { } are only applicable for TGP31x2.

24.1 Waveforms

24.2 Standard Waveforms

Pulse, Square, Double Pulse, Pattern, PRBS (Pseudo Random Binary Sequence), Noise, Pre Defined Function Waveforms (Sine, Square (User Defined Duty Cycle), Triangle, Ramp (User Defined Symmetry), Negative Ramp, DC, Sin(x)/x (User Defined Zero Crossings), Exponential Rise (User Defined Time Constant), Exponential Fall (User Defined Time Constant), Logarithmic Rise (User Defined Time Constant), Logarithmic Fall (User Defined Time Constant), Haversine, Gaussian (User Defined Width), Lorentz (User Defined Width), D-Lorentz and Cardiac) and 4 User Defined Arbitrary Waveforms.

24.2.1 Pulse

Frequency Range:		1mHz to 50MHz [1mHz to 25MHz]
Frequency Resolution:		1mHz, 11 digits
Jitter RMS:		<30ps (cycle to cycle)
Aberrations (Typical):		±5% of amplitude (for transition time 5ns)
		±3% of amplitude (for transition time 10ns)
		<±2% of amplitude (for transition time > 20ns)
Period		Period can also be entered as frequency
	Range:	20ns to 1000s [40ns to 1000s]
	Resolution:	100ps
Width		Width can be entered as absolute width, duty cycle or fall time delay
	Range:	10ns to 999.99999999s [20ns to 999.99999998s]
	Resolution:	100ps
	Accuracy:	±200ps ±0.01% of period
Delay		Delay can be entered as absolute delay, phase or % of period
	Range:	0ns to 999.99999998s [0ns to 999.99999996s]
	Resolution:	100ps
	Accuracy:	±200ps ±0.01% of period

Transition (Rise/Fall) Time		Rise and Fall times can be independently varied or can be varied together simultaneously and can be entered as absolute rise/fall time or as a % of width
	Range:	5ns to 799.999999989s (10% to 90%) [8ns to 799.999999984s]
	Resolution:	100ps
	Accuracy:	±500ps ±0.01% of period

24.2.2 Double Pulse

Frequency Range:		1mHz to 25MHz [1mHz to 12.5MHz]
Frequency Resolution:		1mHz, 11 digits
Jitter RMS:		<30ps (cycle to cycle)
Aberrations (Typical):		±5% of amplitude (for transition time 5ns)
		±3% of amplitude (for transition time 10ns)
		<±2% of amplitude (for transition time > 20ns)
Period		Period can also be entered as frequency
	Range:	40ns to 1000s [80ns to 1000s]
	Resolution:	100ps
Width		Width can be entered as absolute width, duty cycle or fall time delay
	Range:	10ns to 499.99999999s [20ns to 499.99999998s]
	Resolution:	100ps
	Accuracy:	±200ps ±0.01% of period
Delay		Delay can be entered as absolute delay, phase or % of period
	Range:	0ns to 999.99999996s [0ns to 999.99999992s]
	Resolution:	100ps
	Accuracy:	±200ps ±0.01% of period
Transition (Rise/Fall) Time		Rise and Fall times can be independently varied or can be varied together simultaneously and can be entered as absolute rise/fall time or as a % of width
	Range	5ns to 399.999999989s (10% to 90%) [8ns to 399.999999984s]
	Resolution	100ps
	Accuracy:	±500ps ±0.01% of period
Double Delay		Double delay is the delay from the start of the first pulse to the start of the second pulse.
	Range:	20ns to 999.99999998ns [40ns to 999.99999996ns]
	Resolution	100ps
	Accuracy:	±200ps ±0.01% of period

24.2.3 Square

Frequency Range:	1mHz to 50MHz [1mHz to 25MHz]
Frequency Resolution:	1mHz, 11 digits
Jitter RMS:	<30ps (cycle to cycle)
Aberrations (Typical):	±5% of amplitude ±3% of amplitude]

Period	Period can also be entered as frequency
Range:	20ns to 1000s [40ns to 1000s]
Resolution:	100ps
Duty Cycle	
Range:	0.1% to 99.9%
Resolution:	0.1%
Transition (Rise/Fall) Time	5ns Fixed [10ns Fixed]

24.2.4 Pattern/PRBS

Bit Rate:	1mbps to 50Mbps [1mbps to 25Mbps]
Bit Rate Resolution:	1mbps, 11 digits
Pattern Source:	Internal from memory (memory size of 65536 bits with 1 bit resolution, user-defined). Up to 4 user-defined patterns may be stored in non-volatile memory. Patterns can be defined by downloading of pattern data via remote interfaces or from instrument's front panel.
	Internal PRBS: Sequence Length 2^m – 1, where m = 7, 9, 11, 15, 20, 23, 29, 31
	External 1: Pattern is applied at External Modulation Input. Indefinite pattern length. Upto 5Mbps. Pattern is sampled at 50Mbps with user defined pattern threshold level.
	External 2 (External Width): Pattern is applied at External TRIG IN. Indefinite Pattern Length. Upto 50Mbps [25Mbps]. Fixed latency.
Transition (Rise/Fall) Time	Rise and Fall times are varied together simultaneously and can only be entered as absolute time
Range:	5ns to 799.999999989s (10% to 90%) [8ns to 799.999999984s]
Resolution:	100ps

24.2.5 Noise

Bandwidth	Defines the bandwidth in which the energy of the noise signal is concentrated
Range:	1mHz to 25MHz [1mHz to 12.5MHz]
	Noise sampling rate is 3.2 times the specified bandwidth. DAC sampling rate is fixed at 800MSa/s. Intermediate points are calculated by interpolation. Frequency response follows Sin(x) / x (or Sinc) characteristic. Stopband attenuation of first aliasing / image band is 30dB, Typical.
Resolution:	1mHz, 11 digits
Amplitude Distribution:	Gaussian or user-defined (user-defined waveform defines how often a level will occur relative to all others). Waveform memory size is 2048 points. Waveform is stored in non-volatile memory. Waveform can be defined by downloading of waveform data via remote interfaces or from instrument's front panel.
Crest Factor (Gaussian):	3.3, 4.8, 6.0, 7.0, Typical
Repetition Time:	> 10 years

24.2.6 Function

Waveforms	Sine, Square (User Defined Duty Cycle 1.0 % - 99.0%), Triangle, Ramp (User Defined Symmetry 0.0% - 100.0%), Negative Ramp, DC, Sin(x)/x (User Defined Zero Crossings 4 - 50), Exponential Rise (User Defined Time Constant 1.0% - 100.0%), Exponential Fall (User Defined Time Constant 1.0% - 100.0%), Logarithmic Rise (User Defined Time Constant 1.0% - 100.0%), Logarithmic Fall (User Defined Time Constant 1.0% - 100.0%), Haversine, Gaussian (User Defined Width 1.0% - 100.0%), Lorentz (User Defined Width 1.0% - 100.0%), D-Lorentz and Cardiac
Waveform Memory Size	4096 points
Vertical Resolution:	16 bits
Frequency Range:	1mHz to 50MHz [1mHz to 25MHz]
Frequency Resolution:	1mHz, 11 digits
Sampling Rate:	800MSa/s
Point to Point Jitter:	1.25ns Typical
Sine Amplitude Flatness (Relative to 1kHz):	<100kHz 0.1dB <5MHz 0.5dB <25MHz 1.25dB <50MHz 1.75dB

Sine Harmonic Distortion:		<1 Vp-p	≥ 1Vp-p
	DC to 10MHz	-60dBc	-60dBc
	10MHz to 50MHz	-50dBc	-40dBc

Sine Non–Harmonic Spurii:	<–65dBc
Sine Phase Noise (10kHz offset):	-113dBc/Hz, typical
Ramp Linearity Error:	<0.1% to 200 kHz

24.2.7 Arbitrary

Waveforms	Up to 4 user-defined waveforms may be stored in non-volatile memory. Waveforms can be defined by downloading of waveform data via remote interfaces or from instrument’s front panel.
Waveform Memory Size	4096 points
Vertical Resolution:	16 bits
Frequency Range:	1mHz to 50MHz [1mHz to 25MHz]
Frequency Resolution:	1mHz, 11 digits
Sampling Rate:	800MSa/s
Point to Point Jitter:	1.25ns Typical

24.2.8 Internal Frequency Reference

Internal Setting Error:	< ± 2ppm
Oscillator Ageing Rate:	< ± 1ppm first year
Temperature Stability:	< 1ppm over the specified temperature range

24.3 Modulation

Carrier waveform ‘Function’ could be selected from one of the following waveforms: Sine, Square, Triange, Ramp, Negative Ramp, DC, Sin(x)/x, Exponential Rise, Exponential Fall, Logarithmic Rise, Logarithmic Fall, Haversine, Gaussian, Lorentz, D-Lorentz and Cardiac.

24.3.1 AM (Amplitude Modulation) Normal & Suppressed Carrier

Carrier Waveforms:	Pulse, Double Pulse, Square, Pattern/PRBS, Noise, Function, Arb
Modulation Source:	Internal / External / {Other Channel}
Internal Modulating Waveforms:	Sine, Square, Positive Ramp, Negative Ramp, Triangle, Gaussian Noise, DC, Sinc, Exponential Rise, Exponential Fall, Logarithmic Rise, Logarithmic Fall, Haversine, Gaussian, Lorentz, D-Lorentz, Cardiac, PRBS-PN7, PN9, PN11, PN15, PN20, PN23, PN29, PN31 and User Defined Arbs
Internal Modulating Frequency:	1mHz to 10MHz, 1mHz resolution
Amplitude Depth:	0.0% to 100%, 0.1% resolution

24.3.2 FM (Frequency Modulation)

Carrier Waveforms:	Pulse (width, delay and edges are fixed when modulated), Double Pulse (width, delay, double delay and edges are fixed when modulated), Square (width is fixed when modulated), Pattern/PRBS (edges are fixed when modulated), Function (square duty cycle is fixed when modulated), Arb
Modulation Source:	Internal / External / {Other Channel}
Internal Modulating Waveforms:	Sine, Square, Positive Ramp, Negative Ramp, Triangle, Gaussian Noise, DC, Sinc, Exponential Rise, Exponential Fall, Logarithmic Rise, Logarithmic Fall, Haversine, Gaussian, Lorentz, D-Lorentz, Cardiac, PRBS-PN7, PN9, PN11, PN15, PN20, PN23, PN29, PN31 and User Defined Arbs
Internal Modulating Frequency:	1mHz to 10MHz, 1mHz resolution
Frequency Deviation:	DC to Fmax/2, 1 mHz resolution

24.3.3 PM (Phase Modulation)

Carrier Waveforms:	Pulse, Double Pulse, Square, Function, Arb
Modulation Source:	Internal / External / {Other Channel}
Internal Modulating Waveforms:	Sine, Square, Positive Ramp, Negative Ramp, Triangle, Gaussian Noise, DC, Sinc, Exponential Rise, Exponential Fall, Logarithmic Rise, Logarithmic Fall, Haversine, Gaussian, Lorentz, D-Lorentz, Cardiac, PRBS-PN7, PN9, PN11, PN15, PN20, PN23, PN29, PN31 and User Defined Arbs
Internal Modulating Frequency:	1mHz to 10MHz, 1mHz resolution
Phase Deviation:	-360.0 to +360.0 degrees, 0.001 degree resolution

24.3.4 FSK (Frequency Shift Keying)

Carrier Waveforms:	Pulse (width, delay and edges are fixed when modulated), Double Pulse (width, delay, double delay and edges are fixed when modulated), Square (width is fixed when modulated), Pattern/PRBS (edges are fixed when modulated), Function (square duty cycle is fixed when modulated), Arb

Source:	Internal / External (via TRIG IN)
Internal Modulation:	2mHz to 10MHz, 1mHz resolution (50% duty cycle square)

24.3.5 BPSK (Binary Phase Shift Keying)

Carrier Waveforms:	Pulse, Double Pulse, Square, Function, Arb
Source:	Internal / External (via TRIG IN)
Internal Modulation:	2mHz to 10MHz, 1mHz resolution (50% duty cycle square)

24.3.6 SUM (Additive Modulation)

Carrier Waveforms:	Pulse, Double Pulse, Square, Pattern/PRBS, Noise, Function, Arb
Modulation Source:	Internal / External / {Other Channel}
Internal Modulating Waveforms:	Sine, Square, Positive Ramp, Negative Ramp, Triangle, Gaussian Noise, DC, Sinc, Exponential Rise, Exponential Fall, Logarithmic Rise, Logarithmic Fall, Haversine, Gaussian, Lorentz, D-Lorentz, Cardiac, PRBS-PN7, PN9, PN11, PN15, PN20, PN23, PN29, PN31 and User Defined Arbs
Internal Modulating Frequency:	1mHz to 10MHz, 1mHz resolution
Amplitude Depth:	0.0% to 100.0%, 0.1% resolution

24.3.7 PWM (Pulse Width Modulation)

Carrier Waveforms:	Pulse, Double Pulse
Modulation Source:	Internal / External / {Other Channel}
Internal Modulating Waveforms:	Sine, Square, Positive Ramp, Negative Ramp, Triangle, Gaussian Noise, DC, Sinc, Exponential Rise, Exponential Fall, Logarithmic Rise, Logarithmic Fall, Haversine, Gaussian, Lorentz, D-Lorentz, Cardiac, PRBS-PN7, PN9, PN11, PN15, PN20, PN23, PN29, PN31 and User Defined Arbs
Internal Modulating Frequency:	1mHz to 10MHz, 1mHz resolution
Pulse Width Deviation:	0% to 100% of pulse width (subject to pulse width limits), resolution same as of pulse width

24.3.8 PDM (Pulse Delay Modulation)

Carrier Waveforms:	Pulse, Double Pulse
Modulation Source:	Internal / External / {Other Channel}
Internal Modulating Waveforms:	Sine, Square, Positive Ramp, Negative Ramp, Triangle, Gaussian Noise, DC, Sinc, Exponential Rise, Exponential Fall, Logarithmic Rise, Logarithmic Fall, Haversine, Gaussian, Lorentz, D-Lorentz, Cardiac, PRBS-PN7, PN9, PN11, PN15, PN20, PN23, PN29, PN31 and User Defined Arbs
Internal Modulating Frequency:	1mHz to 10MHz, 1mHz resolution
Pulse Delay Deviation:	0% to 100% of pulse delay (subject to pulse delay limits), resolution same as of pulse delay

24.3.9 SPDM (Second Pulse Delay Modulation)

Carrier Waveforms:	Double Pulse
Modulation Source:	Internal / External / {Other Channel}

Internal Modulating Waveforms:	Sine, Square, Positive Ramp, Negative Ramp, Triangle, Gaussian Noise, DC, Sinc, Exponential Rise, Exponential Fall, Logarithmic Rise, Logarithmic Fall, Haversine, Gaussian, Lorentz, D-Lorentz, Cardiac, PRBS-PN7, PN9, PN11, PN15, PN20, PN23, PN29, PN31 and User Defined Arbs
Internal Modulating Frequency:	1mHz to 10MHz, 1mHz resolution
Pulse Delay Deviation:	0% to 100% of double delay (subject to double delay limits), resolution same as of double delay

24.4 Gated Burst

Waveform will run while the Gate signal is true and stop while false. Starts synchronously with the input edge.

Carrier Waveforms:	Pulse, Double Pulse, Square, Pattern/PRBS, Noise, Function, Arb
Trigger Repetition Rate:	2mHz to 50MHz [25MHz] internal (10ns period resolution)
	DC to 50MHz [25MHz] external.
Gate Signal Source:	Internal from keyboard, trigger generator.
	External from TRIG IN or remote interface.
Gate Start/Stop Phase:	-360.0 to +360.0 degrees, 0.001 degree resolution (Phase offset cannot be set for Noise and Pattern / PRBS waveforms)

24.5 Triggered Burst

Selected active edge will produce one burst of the waveform

Carrier Waveforms:	Pulse, Double Pulse, Square, Function, Arb
	Pattern/PRBS: Selectable ‘Bit’ or ‘Block’ mode. In bit mode a fixed number of bits (specified as number of cycles) are generated at every trigger event. In block mode the whole pattern is generated at every trigger event.
	Noise is reset to its start condition at every trigger event. Allows generating same random noise sequence.
Number of Cycles:	1 to 4294967295 and infinite
Trigger Repetition Rate:	2mHz to 50MHz [25MHz] internal (10ns period resolution)
	DC to 50MHz [25MHz] external.
Gate Signal Source:	Internal from keyboard, trigger generator.
	External from TRIG IN or remote interface.
Gate Start/Stop Phase:	-360.0 to +360.0 degrees, 0.001 degree resolution (Phase offset cannot be set for Noise and Pattern / PRBS waveforms)

24.6 Sweep

Frequency sweep capability is provided for all standard (except noise) and arbitrary waveforms.

Carrier Waveforms:	Pulse (width, delay and edges are fixed when modulated), Double Pulse (width, delay, double delay and edges are fixed when modulated), Square (width is fixed when modulated), Pattern/PRBS (edges are fixed when modulated), Function (square duty cycle is fixed when modulated), Arb
Sweep Mode:	Linear or logarithmic, triggered or continuous.
Sweep Direction:	Up or Down

Sweep Range:	From 1mHz to 50MHz [25MHz]. Phase continuous. Independent setting of the start and stop frequency.
Sweep Time:	100µs to 500s
Hold Time:	100µs to 500s
Return Time:	100µs to 500s
Sweep Trigger Source:	The sweep may be free run or triggered from the following sources: Internal from keyboard or trigger generator. Externally from TRIG IN input or remote interface.

24.6.1 Trigger Generator

Internal source 2mHz to 50MHz [25MHz] square wave adjustable in 10ns steps, 11 digit resolution. Available for external use from the SYNC OUT socket.

24.7 Dual-channel Operations (applies only to TGP31x2)

24.7.1 Tracking

Independent (Off):	The channels are independent of each other.
Equal:	The two channels are identical and behave identically.
Inverse:	The two channels are identical except that the output of channel 2 is inverted. In this mode the two channels can be used together as a differential signal source.

24.7.2 Coupling

Frequency coupling:	The frequencies of the two channels can be coupled. Changing the frequency of one channel changes the frequency of the other channel, either by a fixed ratio or fixed offset.		
	Waveforms	Pulse, Double Pulse, Square, Function, Arb. Noise and Pattern / PRBS cannot be frequency coupled.	
	Type	Ratio	1 to 1000, resolution 0.001
		Offset	+/- 50MHz [+/- 25MHz] -1mHz, resolution 1mHz
Amplitude (and DC Offset) coupling:	Amplitude (and DC offset) of the two channels can be coupled. Changing the amplitude and offset on one channel changes the amplitude and offset of both channels.		
Output coupling:	Output On/Off can be coupled. Switching the output On/Off on one channel switches the output On/Off of both channels.		

24.7.3 Digital Channel Addition

Channel 2 can be added to Channel1 (using SUM modulation (modulation source: other channel) and vice versa. The maximum output voltage of the combined output remains unchanged. The uncombined channel still outputs the unchanged waveform.

24.7.4 Characteristics

Relative phase:	-360 to 360 degrees, 0.001 degree resolution (Phase offset cannot be set for Noise and Pattern / PRBS waveforms)
Channel to channel skew (typical):	<1ns (when performing identical operations)
Crosstalk (typical):	<-80db

24.8 Outputs

24.8.1 Main Output

Amplitude:	100mVpp to 10Vpp 50Ω into 50Ω 200mVpp to 20Vpp 5Ω into 50Ω or 50Ω into open circuit
Amplitude Accuracy:	1.5% ±5mV at 1kHz 50Ω into 50Ω
DC Offset Range:	±5V. DC offset plus signal peak limited to ±5V from 50Ω into 50Ω
	±10V. DC offset plus signal peak limited to ±5V from 5Ω into 50Ω or 50Ω into open circuit
DC Offset Accuracy:	Typically 1% ±50mV.
Resolution:	3 digits or 1mV for both Amplitude and DC Offset.
Source Impedance	5Ω or 50Ω selectable

Amplitude can be specified open circuit (hi Z) or into an assumed load of 50Ω to 10kΩ in Vpp.

24.8.2 Sync Outs

Multifunction output automatically selected to be any of the following. User can choose Sync to always be carrier referenced, to output the currently used trigger signal or turn it off.

Carrier Waveform Sync:	Pulse / Square / Double Pulse / Function / Arbs	A square wave with 50% duty cycle at the waveform frequency.	
	Pattern / PRBS	Internal Source	A positive pulse which is 1 bit rate wide at the beginning of the sequence
		External Source	A square wave with same duty cycle and frequency as the external source.
	Noise	No sync associated with noise.	
Modulation Sync:	AM/FM/PM/SUM/ PWM/PDM/SPDM	A square wave with 50% duty cycle referenced to the internal modulation waveform when modulation source is internal, or a square wave referenced to the carrier waveform when modulation source is external. No sync is associated with noise as the modulation source.	
	FSK	A square wave referenced to the trigger rate. The sync is a TTL high when hop frequency is the output frequency and TTL low when carrier frequency is the output frequency for positive slope and vice versa for negative slope.	
	BPSK	A square wave referenced to the trigger rate. The sync is a TTL high when the hop phase is the output phase and TTL low when carrier phase is the output phase for positive slope and vice versa for negative slope.	
Sweep Sync:	Marker Off	A square wave that is a TTL high from the beginning of the sweep and a TTL low from the midpoint of the sweep	
	Marker On	A square wave that is a TTL high from the beginning of the sweep and a TTL low from the marker frequency	

Burst Sync:	Internal Trigger	A square wave with 50% duty cycle at the trigger frequency.
	External Trigger	A square wave with same duty cycle and frequency as the external source.
	Manual Trigger	A positive pulse which is approximately 18us wide at the beginning of the event.
Trigger:	Selects the current trigger signal.	
Sync to Output Delay	0.0ns typical	
Output Signal Level:	Logic level nominally 3V	
Output Impedance:	50Ω	

24.8.3 Ref Clock Output

Buffered version of the 10MHz clock currently in use (internal or external)

Output Level:	Nominally 3V logic level from 50Ω

24.9 Inputs

24.9.1 Trig In

For FSK, BPSK, triggered sweep, gated burst, triggered burst, external pattern (external width)

Threshold:	±3V
Maximum Input:	±10V
Minimum Pulse Width:	10ns [20ns]
Frequency Range:	DC to 50MHz [DC to 25MHz]
Polarity:	Selectable as high/rising edge or low/falling edge.
Input Impedance:	10kΩ
Trigger to Output Delay (Fixed)	448ns (Typical)
Trigger to Output Jitter	60ps RMS (Typical)
	Valid for externally triggered pulse, square, double pulse, internal pattern / PRBS, arb / function, external pattern (external width). Measured with 50Ω source impedance at main output. Trigger amplitude >500mV, transition time <10ns. Externally triggered noise, sweep, FSK and BPSK has peak to peak jitter of 5ns.

24.9.2 External Modulation Input

For AM, FM, PM, SUM, PWM, PDM, SPDM, external pattern

Voltage Range:	± 2.5V full scale
Input Impedance:	5kΩ typical
Bandwidth:	DC to 5MHz

24.9.3 Ref Clock Input

Input for an external 10MHz reference clock

Voltage Range:	1Vp-p – 5Vp-p
Maximum Voltage:	+5V
Minimum Volatge:	-1V

24.10 Interfaces

Full digital remote control facilities are available through LAN, USB and optional GPIB interfaces.

LAN Interface	Ethernet 100/10base – T hardware connection. 1.4 LXI Core 2011.
USB Interface	Standard USB 2.0 hardware connection. Implemented as virtual-COM port.
USB Flash Drive	For waveform and set-up storage/recall.
GPIB	Conforming with IEEE488.1 and IEEE488.2

24.11 General

Display:	256 x 112 pixel monochrome graphics display. White LED backlight with adjustable brightness and contrast. Black-on-white or inverse modes.
Data Entry:	Keyboard selection of mode, waveform etc.; value entry direct by numeric keys or by rotary control.
Stored Settings:	Up to 9 complete instrument set–ups may be stored and recalled from non-volatile memory.
Size:	Bench Top: 97mm height; 250mm width; 295mm long
	Rack mount: 86.5mm (2U) height; 213.5mm (½–rack) width; 269mm long
Weight:	3.2kg
Power:	100-240VAC ±10% 50/60Hz; 100-120VAC ±10% 400Hz; 60VA max. Installation Category II.
Operating Range:	+5°C to 40°C, 20–80% RH.
Storage Range:	–20°C to + 60°C.
Environmental:	Indoor use at altitudes up to 2000m, Pollution Degree 2.
Options:	19 inch rack mounting kit.
Safety & EMC:	Complies with EN61010-1 & EN61326-1. For details, request the EU Declaration of Conformity for this instrument via http://www.aimtti.com/support (serial no. needed).

25 Editing Arbitrary Waveforms

25.1 General

The instrument contains some basic creation and editing capabilities for arbitrary waveforms. The built-in editor is described in section 10.4 Arbitrary Generator Waveforms .

Complex arbitrary waveform are likely to be created outside of the instrument using a dedicated waveform editor, or from captured real-world waveforms.

The supplied Waveform Manager Plus Version 4.10 for Windows application may be used when more comprehensive capabilities for creation and editing are required.

25.2 Waveform Manager Plus

The Waveform Manager Plus Version 4.10 program allows construction, editing, exchange, translation and storage of many types of waveform data. It is compatible with all Aim-TTi waveform generation products and some popular DSOs.

Waveform Manager Plus is compatible with all versions of Windows from Windows 2000 onwards.

Operation was the TGP3100 Series requires version 4.10 or above. This provides the capability to create and edit pulse patterns as well as arbitrary waveforms.

Waveforms created in Waveform Manager Plus may be downloaded to the instrument via a remote control interface or they may be transferred using a USB flash drive.

26 Appendix 1. Information, Warning and Error Messages

In the following list where [VALUE] appears a numeric value will be inserted in the message which is appropriate to the parameter currently being edited. Message numbers that are omitted are reserved and not currently used. Some numbers can produce two different messages depending on the current instrument editing mode; these are indicated by ‘or’ in the list. Other information messages do not have a message number associated with them.

26.1.1 Error Messages

-1 Firmware Update / Battery Fail. Initialised to factory default state.

-2 Frequency / Period invalid. Frequency lower limit [VALUE]. Period upper limit [VALUE].

-3 Frequency / Period invalid. Frequency upper limit [VALUE]. Period lower limit [VALUE].

-4 Pulse width invalid. Limited by pulse period.

-5 Pulse width invalid. Lower limit [VALUE].

-6 Pulse delay invalid. Limited by pulse period.

-7 Pulse delay invalid. Lower limit [VALUE].

-8 Pulse rise / edge invalid. Limited by pulse width.

-9 Pulse rise / edge invalid. Lower limit [VALUE].

-10 Pulse fall time invalid. Limited by pulse width.

-11 Pulse fall time invalid. Lower limit [VALUE].

-12 Invalid entry. Width cannot be less than (0.675*Rise + 0.675*Fall + 3.75ns).

-13 Invalid entry. Period cannot be less than (Delay + 0.675*Rise + Width + 0.675*Fall + 3.75ns).

-14 Frequency deviation invalid for current pulse parameter settings.

-15 Hop frequency invalid for current pulse parameter settings.

-16 Pulse width deviation invalid for current pulse parameter settings.

-17 Pulse delay deviation invalid for current pulse parameter settings.

-18 Sweep frequency invalid for current pulse parameter settings.

-19 Frequency / Period invalid. Frequency lower limit [VALUE]. Period upper limit [VALUE].

-20 Frequency / Period invalid. Frequency upper limit [VALUE}. Period lower limit [VALUE].

-21 Square width invalid. Limited by square period.

-22 Square width invalid. Lower limit [VALUE].

-23 Invalid entry. Period cannot be less than (Width + 10.0ns).

-24 Frequency deviation invalid for current square parameter settings.

-25 Hop frequency invalid for current square parameter settings.

-26 Sweep frequency invalid for current square parameter settings.

-27 Frequency / Period invalid. Frequency lower limit 1mHz. Period upper limit 1000s.

-28 Frequency / Period invalid. Frequency upper limit [VALUE]. Period lower limit [VALUE].

-29 Double pulse width invalid. Limited by double pulse period.

-30 Double pulse width invalid. Lower limit [VALUE].

-31 Double pulse delay invalid. Limited by double pulse period.

-32 Double pulse delay invalid. Lower limit [VALUE].

-33 Double pulse double delay invalid. Limited by double pulse period.

-34 Double pulse double delay invalid. Lower limit [VALUE].

-35 Double pulse rise / edge invalid. Limited by double pulse width.

-36 Double pulse rise / edge invalid. Lower limit [VALUE].

-37 Double pulse fall invalid. Limited by double pulse width.

-38 Double pulse fall invalid. Lower limit [VALUE].

-39 Invalid entry. Width cannot be less than (0.675*Rise + 0.675*Fall + 3.75ns).

-40 Invalid entry. Double delay cannot be less than (0.675*Rise + Width + 0.675*Fall + 3.75ns).

-41 Invalid entry. Period cannot be less than (Delay + Double Delay + 0.675*Rise + Width + 0.675*Fall + 3.75ns).

-42 Frequency deviation invalid for current double pulse parameter settings.

-43 Hop frequency invalid for current double pulse parameter settings.

-44 Pulse width deviation invalid for current double pulse parameter settings.

-45 Pulse delay deviation invalid for current double pulse parameter settings.

-46 Second pulse delay deviation invalid for current double pulse parameter settings.

-47 Sweep frequency invalid for current double pulse parameter settings.

-48 Bitrate invalid. Lower limit 1mbps.

-49 Bitrate invalid. Upper limit [VALUE].

-50 Edge time invalid. Upper limit 1000s.

-51 Edge time invalid. Lower limit [VALUE].

-52 Invalid entry. Bitrate cannot be less than (1.25*Edge + 3.75ns).

-53 Modulation threshold invalid. Upper limit 2.5V.

-54 Modulation threshold invalid. Lower limit -2.5V.

-55 Pattern length invalid. Lower limit 1.

-56 Pattern length invalid. Upper limit 65536.

-57 Pattern offset invalid. Lower limit 0.

-58 Pattern offset invalid. Cannot exceed pattern length.

-59 Point number invalid. First defined point 1.

-60 Point number invalid. Last defined point [VALUE].

-61 Frequency deviation invalid for current pattern / prbs parameter settings.

-62 Hop frequency invalid for current pattern / prbs parameter settings.

-63 Sweep frequency invalid for current pattern / prbs parameter settings.

-64 Noise bandwidth invalid. Upper limit [VALUE].

-65 Noise bandwidth invalid. Lower limit 1mHz.

-66 Frequency / Period invalid. Frequency lower limit 1mHz. Period upper limit 1000s.

-67 Frequency / Period invalid. Frequency upper limit [VALUE]. Period lower limit [VALUE].

-68 Ramp symmetry invalid. Upper limit 100%.

-69 Ramp symmetry invalid. Lower limit 0%.

-70 Number of zero crossings of sinc waveform invalid. Upper limit 50.

-71 Number of zero crossings of sinc waveform invalid. Lower limit 4.

-72 Arb waveform time constant invalid. Upper limit 100%.

-73 Arb waveform time constant invalid. Lower limit 1%.

-74 Arb waveform width percent invalid. Upper limit 100%.

-75 Arb waveform width percent invalid. Lower limit 1%.

-76	Arb square duty cycle invalid. Upper limit 99%.
-77	Arb square duty cycle invalid. Lower limit 1%.
-78	Frequency deviation invalid for current arbitrary waveform parameter settings.
-79	Hop frequency invalid for current arbitrary waveform parameter settings.
-80	Sweep frequency invalid for current arbitrary waveform parameter settings.
-81	Amplitude value invalid. Upper limit +32767.
-82	Amplitude value invalid. Lower limit -32768.
-83	Point number invalid. Last defined point [VALUE].
-84	Point number invalid. First defined point 1.
-85	Number of points invalid. Upper limit 4096.
-86	Number of points invalid. Lower limit 1.
-87	Please specify a filename in Short File Name (SFN) format.
-88	AM frequency invalid. Upper limit 10MHz.
-89	AM frequency invalid. Lower limit 1mHz.
-90	Amplitude depth invalid. Upper limit 100%.
-91	Amplitude depth invalid. Lower limit 0%.
-92	FM frequency invalid. Upper limit 10MHz.
-93	FM frequency invalid. Lower limit 1mHz.
-94	Frequency deviation invalid. Cannot exceed carrier frequency. Max upper limit [VALUE].
-95	Frequency deviation invalid. Lower limit 0Hz.
-96	PM frequency invalid. Upper limit 10MHz.
-97	PM frequency invalid. Lower limit 1mHz.
-98	Phase deviation invalid. Upper limit +360°.
-99	Phase deviation invalid. Lower limit -360°.
-100	FSK rate invalid. Upper limit 10MHz.
-101	FSK rate invalid. Lower limit 2mHz.
-102	Hop frequency invalid. Upper limit [VALUE].
-103	Hop frequency invalid. Lower limit 1mHz.
-104	BPSK rate invalid. Upper limit 10MHz.
-105	BPSK rate invalid. Lower limit 2mHz.
-106	Hop phase invalid. Upper limit +360°.
-107	Hop phase invalid. Lower limit -360°.
-108	SUM frequency invalid. Upper limit 10MHz.
-109	SUM frequency invalid. Lower limit 1mHz.
-110	SUM modulation level invalid. Upper limit 100%.
-111	SUM modulation level invalid. Lower limit 0%.
-112	PWM frequency invalid. Upper limit 10MHz.
-113	PWM frequency invalid. Lower limit 1mHz.
-114	PWM deviation invalid. Maximum deviation limited by carrier width setting.
-115	PWM deviation invalid. Lower limit 0ns.
-116	PDM frequency invalid. Upper limit 10MHz.
-117	PDM frequency invalid. Lower limit 1mHz.
-118	PDM deviation invalid. Maximum deviation limited by carrier delay setting.
-119	PDM deviation invalid. Lower limit 0ns.

-120 SPDM frequency invalid. Upper limit 10MHz.

-121 SPDM frequency invalid. Lower limit 1mHz.

-122 SPDM deviation invalid. Maximum deviation limited by carrier double delay setting.

-123 SPDM deviation invalid. Lower limit 0ns.

-124 SPDM invalid for Pulse.

-125 Modulation cannot be enabled when Pattern is set as main output and pattern source is external.

-126 Arb DC cannot be selected when modulation is enabled and vice versa.

-127 FM invalid for Noise.

-128 PM invalid for Noise.

-129 FSK invalid for Noise.

-130 BPSK invalid for Noise.

-131 PWM invalid for Noise.

-132 PDM invalid for Noise.

-133 SPDM invalid for Noise.

-134 PWM invalid for Square.

-135 PDM invalid for Square.

-136 SPDM invalid for Square.

-137 PWM invalid for Arb.

-138 PDM invalid for Arb.

-139 SPDM invalid for Arb.

-140 PWM invalid for Pattern / PRBS.

-141 PDM invalid for Pattern / PRBS.

-142 SPDM invalid for Pattern / PRBS.

-143 FM cannot be enabled when generator is set as Master / Slave.

-144 FSK cannot be enabled when generator is set as Master / Slave.

-145 Start frequency invalid. Lower limit 1mHz.

-146 Start frequency invalid. Cannot be greater than stop frequency.

-147 Stop frequency invalid. Cannot be less than start frequency.

-148 Stop frequency invalid. Upper limit [VALUE].

-149 Marker frequency invalid. Cannot be less than start frequency.

-150 Marker frequency invalid. Cannot be greater than stop frequency.

-151 Sweep time invalid. Lower limit 1us.

-152 Hold time invalid. Lower limit 0us.

-153 Return time invalid. Lower limit 0us.

-154 Invalid time entry. (Sweep + Hold + Return) cannot exceed 500s.

-155 Trigger period invalid. Lower limit [VALUE].

-156 Trigger period invalid. Upper limit 500s.

-157 Arb DC cannot be selected when frequency sweep is enabled and vice versa.

-158 Frequency sweep cannot be enabled when generator is set as Master / Slave.

-159 Frequency sweep cannot be enabled when external pattern is set as main output.

-160 Frequency sweep cannot be enabled when Noise is set as main output.

-161 Burst count invalid. Upper limit 4294967296.

-162 Burst count invalid. Lower limit 1.

-163 Trigger period invalid. Upper limit 500s.

-164 Trigger period invalid. Lower limit [VALUE].

-165 Unable to perform Burst when generator is set as Master / Slave.

-166 Unable to perform Burst when Pattern is set as main output and pattern source is external.

-167 Arb DC cannot be selected when burst is enabled and vice versa.

-168 Trigger threshold invalid. Upper limit 3.000V.

-169 Trigger threshold invalid. Lower limit -3.000V.

-170 Clock source cannot be changed. when generator is set as Slave.

-171 OUTPUT VOLTAGE OVERLOAD. Output turned off for safety.

-172 OUTPUT CURRENT OVERLOAD. Output turned off for safety.

-173 Invalid entry. High level upper limit [VALUE].

-174 Invalid entry. Low level lower limit [VALUE].

-175 Invalid entry. Amplitude upper limit [VALUE].

-176 Invalid entry. Amplitude lower limit [VALUE].

-177 Invalid entry. Offset upper limit [VALUE].

-178 Invalid entry. Offset lower limit [VALUE].

-179 Invalid entry. High level upper limit [VALUE].

-180 Invalid entry. Low level lower limit [VALUE].

-181 Invalid entry. Amplitude upper limit [VALUE].

-182 Invalid entry. Amplitude lower limit [VALUE].

-183 Invalid entry. Offset upper limit [VALUE].

-184 Invalid entry. Offset lower limit [VALUE].

-185 Phase invalid. Upper limit +360°.

-186 Phase invalid. Lower limit -360°.

-187 Output load invalid. Upper limit 10kΩ.

-188 Output load invalid. Lower limit 50Ω.

-189 Frequency coupling cannot be turned on when modulation is enabled.

-190 Frequency coupling cannot be turned on when frequency sweep is enabled.

-191 Frequency coupling cannot be turned on when generator is set as Master / Slave.

-192 Frequency coupling cannot be turned on when carrier waveforms are not the same in both channels.

-193 Frequency coupling cannot be turned on when Pattern / PRBS is set as main output.

-194 Frequency coupling cannot be turned on when Noise is set as main output.

-195 Frequency coupling cannot be turned on when DC is set as main output.

-196 Outputs cannot be coupled when Tracking is selected.

-197 Amplitudes cannot be coupled when Tracking is selected.

-198 Frequencies cannot be coupled when Tracking is selected.

-199 Frequency ratio invalid. Upper limit 1000.0.

-200 Frequency ratio invalid. Lower limit 0.001.

-201 Frequency offset invalid. Upper limit [VALUE].

-202 Frequency offset invalid. Lower limit 0Hz.

-203 Generator cannot be Master / Slave when Tracking is selected.

-204 Tracking cannot be selected when outputs are coupled.

-205	Tracking cannot be selected when amplitudes are coupled.
-206	Tracking cannot be selected when frequencies are coupled.
-207	Tracking cannot be selected when generator is set as Master / Slave.
-208	Channel 2 parameters not available when Tracking is selected.
-209	Generator cannot be Master / Slave when DC is set as main output.
-210	Generator cannot be Master / Slave when Noise is set as main output.
-211	Generator cannot be Master / Slave when Pattern / PRBS is set as main output.
-212	Generator cannot be Master / Slave when FM / FSK / Sweep / Burst is on.
-214	Invalid entry. Upper limit 99%.
-215	Invalid entry. Lower limit 1%.
-216	GPIB address invalid. Upper limit 30.
-217	GPIB address invalid. Lower limit 0.
-218	Incorrect password. Please try again.
-219	Password did not match. Please try again.
-220	Unsupported USB device. Device current limit to 500mA.
-221	Unsupported USB device. Please insert USB-Flash disk only.
-222	Unsupported remote command.
-223	Unsupported remote command parameter.
-225	The specified ARB location is not available.
-227	Please insert USB-Flash disk and try again.
-228	USB-Flash disk files limit to 1260.
-229	Please edit different file name as the current file already exist.
-230	FATAL ERROR: Invalid waveform location.
-231	FATAL ERROR: Invalid setup location.
-232	Unsupported waveform file or the file may be corrupted. Please wait.
-233	Unsupported setup file or the file may be corrupted Please wait.
-234	Unsupported command on the Webpage.
-235	Unable to recall instrument setup. The specified location is empty.
-236	Test FAILED at address [VALUE]. Data written [VALUE]. Data read back [VALUE].
-237	Pulse edge cannot be set as % of width when width is specified as fall time delay.
-238	Pulse width cannot be set as fall time delay when edge is specified as % of width.
-239	Sync cannot be changed when generator is set as Master.
-240	PM invalid for Pattern / PRBS.
-241	BPSK invalid for Pattern / PRBS.

26.1.2 Warning Messages

1	Arb square waveform duty cycle set to default 50%.
2	Marker frequency changed to fall between start and stop frequencies.
8	External trigger threshold set to default 1.5V.
10	Amplitude and or offset changed to fall within limits for the current impedance setting.
11	DC Offset set to default 0V.
12	Frequency coupling turned off.
13	Generator set as Master.
14	Generator set as Slave.

15 Wrong key pressed. Press keys as instructed.
16 Instrument is not calibrated.
17 Calibration values cleared. Please power-cycle the instrument.
18 USB-Flash disk waveform files limited to 1260.
19 USB-Flash disk setup files limited to 1260.
20 Please press again to overwrite.
21 File was created from 1-CHN-Model. Please press again to copy.
22 File was created from 25MHz-Model. Please press again to copy.
23 File was created from different firmware. Please press again to copy.
24 Pattern length changed. Pattern offset set to default.

26.1.3 Information Messages

513 Key test successful.
514 New password stored.
515 Select a unit to enter value or press Cancel.
516 Please reduce the files on USB-Flash disk and try again.
517 Test data has been written to RAM.
518 RAM test successful.
519 Press Trigger key to send a manual trigger pulse.
520 Press Trigger key to invert the manual trigger level. Current level High [or Low].
521 To send a manual trigger pulse, press Trigger key again.
522 To invert manual trigger level, press Trigger key again.
523 Manual trigger pulse sent
524 Manual trigger level inverted. Current level High [or Low].

26.1.4 Other Information Messages

Please wait.
Please wait. The file is being read from USB-Flash disk.
Please wait. The file is being written to USB-Flash disk.
Please wait. The current settings are being saved.
Please wait. The local setup file is being recalled.
Please wait. The local setup file is being deleted.
Please wait. The local waveform file is being deleted.
Please wait. The local noise file is being deleted.
Please wait. The local pattern file is being deleted.
Please wait. Writing test data to RAM.
Please wait. Reading test data from RAM.

27 Appendix 2. Factory Default Settings

Output Configuration	**Factory Setting**
Function	Pulse Wave
Frequency (Period)	10kHz (100us)
Amplitude / Offset	1 Vpp / 0.000 Vdc
Output Units	Vpp
Output Source Impedance	50Ω
Output Termination	50Ω
Autorange	On
Output Polarity	Normal
Output Phase	0°
Output State	Off
Sync Out State	On, 10kHz Carrier Sync
Pulse Configuration	**Factory Setting**
Width (Duty Cycle)	50us (50%)
Leading / Trailing Edge	5ns [10ns]
Delay	0s
Square Configuration	**Factory Setting**
Frequency (Period)	10kHz (100us)
Duty Cycle	50%
Double Pulse Configuration	**Factory Setting**
Frequency (Period)	10kHz (100us)
Width (Duty Cycle)	25us (25%)
Leading / Trailing Edge	5ns [10ns]
Delay	0s
Double Delay	50us
Pattern / PRBS Configuration	**Factory Setting**
Pattern Source	Internal PRBS
PRBS Type	PRBS – LFSR Length 7
Bit Rate	10kbps
Edge	5ns [10ns]
Noise	**Factory Setting**
Bandwidth	10kHz
PDF	Gaussian with Crest Factor 3.3
Function / Arb Configuration	**Factory Setting**
Frequency (Period)	10kHz (100us)

Waveform	Sine
Square Wave Duty Cycle	50%
Ramp Wave Symmetry	100%
Sinc Wave Number of Zero Crossings	25
Exponential / Logarithmic Wave Time Constant	10%
Gaussian / Lorentz Wave Width	10%
Modulation	**Factory Setting**
Carrier AM, AM-SC, FM, PM, FSK, BPSK, SUM, PWM, PDM	10 kHz Pulse Wave
Carrier SPDM	10 kHz Double Pulse Wave
Mod. Waveform AM, AM-SC, FM, PM, SUM, PWM, PDM, SPDM	1 kHz Sine wave
Mod. Waveform AM, AM-SC, FM, PM, SUM, PWM, PDM, SPDM, FSK, BPSK	Internal
AM, AM-SC Depth	50%
FM Deviation	2 kHz
PM Deviation	180°
FSK Hop Frequency	5 kHz
FSK Rate	1 kHz
FSK Polarity	Positive
SUM Modulation Level	50%
BPSK Hop Phase	180°
BPSK Rate	1 kHz
BPSK Polarity	Positive
PWM Width Deviation	5us
PDM Delay Deviation	0s
SPDM Double Delay Deviation	5us
Modulation State	Off
Sweep	**Factory Setting**
Start / Stop Frequency	1 kHz / 10 kHz
Sweep Time / Hold Time / Return Time	500us
Sweep Type / Mode	Linear Up / Continuous
Sweep Trigger Source	Internal
Sweep Trigger Polarity	Positive (Rising Edge)
Sweep Trigger Period	5ms
Sweep State / Frequency Marker	Off
Burst	**Factory Setting**
Burst Type	Triggered, N-Cycle
Burst Count	1 Cycle

Burst Trigger Source	Internal
Burst Trigger Polarity	Positive (Rising Edge / High Level)
Burst Trigger Period	5ms
Burst Start Phase	0°
Pattern Burst Mode	Bit Mode
Burst State	Off
Input Configuration	**Factory Setting**
Trigger Input (TRIG IN) Threshold Voltage	1.5V
Modulation Input (MOD IN) Threshold Voltage	0V (for External Pattern only)
System-Related Operations	**Factory Setting**
Power-Down Recall	Disabled
Display Mode	On
Error Queue	Errors are Cleared
Stored States, Stored Arbs	No Change
Remote Interface Configuration	**Factory Setting**
GPIB Address	5
DHCP	On
Auto IP	On
IP Address	192.168.1.100
Subnet Mask	255.255.255.0
Default Gateway	0.0.0.0
DNS Server	0.0.0.0
Host Name	*none*
Domain Name	*none*
Calibration	**Factory Setting**
Calibration State	Not protected

28 Appendix 3. Calibration Procedure

All parameters can be calibrated without opening the case, i.e. the generator offers ‘closed–box’ calibration. All adjustments are made digitally with calibration constants stored in flash memory. The calibration routine requires only a DVM, oscilloscope and a frequency counter and takes no more than a few minutes.

Calibration should be carried out only after the generator has been operating for at least 30 minutes in normal ambient conditions.

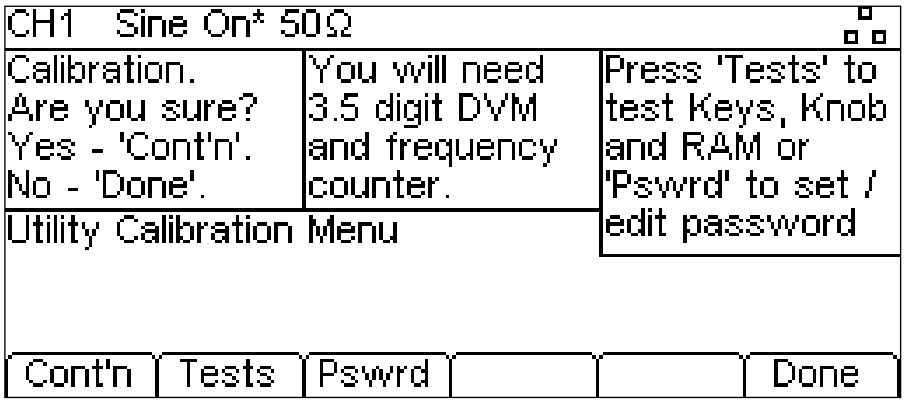
28.1 Equipment Required

3½ digit DVM with 0·25% DC accuracy and 0·5% AC accuracy at 1kHz.

Universal counter capable of measuring 10·00000MHz with an accuracy of ±0.1ppm.

28.2 Calibration Procedure

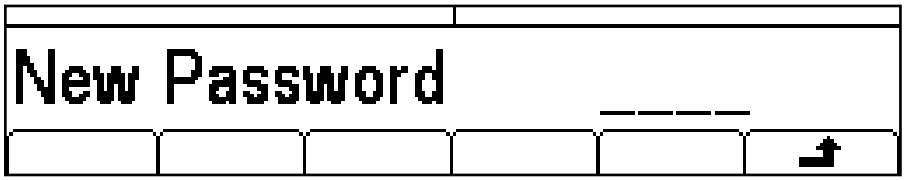
Pressing the UTILITY key followed by the **`Calib`** soft-key shows the opening screen for instrument calibration.



The software provides for a 4–digit password in the range 0000 to 9999 to be used to access the calibration procedure. If the password is left at the factory default of 0000 no messages are shown and calibration can proceed as described in the Calibration Routine section; only if a non–zero password has been set will the user be prompted to enter the password.

28.2.1 Setting the Password

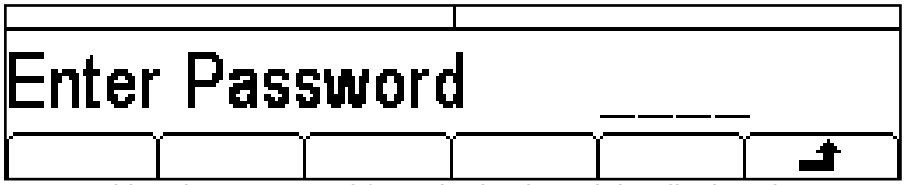
On opening the Calibration screen press the **`Pswrd`** soft-key to show the password screen:



Enter a 4–digit password from the keyboard; the Edit Box will show the message Confirm. Re-enter the password and the message **`NEW PASSWORD STORED`** will pop up for two seconds before returning to the top level calibration menu.

28.2.2 Using the Password to Access Calibration or Change the Password

With the password set, pressing **`calib`** on the utility screen will now show:



When the correct password has been entered from the keyboard the display changes to the opening screen of the calibration routine and calibration can proceed as described in the Calibration Routine

section. If an incorrect password is entered the message **Incorrect Password Please Try Again** will pop up for two seconds before the display reverts to the Utility menu.

With the opening screen of the calibration routine displayed after correctly entering the password, the password can be changed by pressing **Pswrd** soft-key and following the procedure described in Setting the Password. If the password is set to 0000 again, password protection is removed.

The password is held in flash memory and will not be lost when the memory battery back–up is lost. In the event of the password being forgotten, contact the manufacturer for help in resetting the instrument.

28.3 Calibration Routine

The calibration procedure proper is entered by pressing **Cont'n** on the top level Calibration menu; pressing **Done** returns the display to the Utilty menu. Pressing **Tests** calls a menu of basic hardware checks used at production test; these are largely self–explanatory but details can be found in the Service Manual if required.

At each calibration step the display changes to prompt the user to adjust the KNOB or cursor keys, until the reading on the specified instrument is at the value given. The cursor keys provide coarse adjustment, and the KNOB fine adjustment. Pressing ➡ increments the procedure to the next step; pressing ⬅ decrements back to the previous step. Alternatively, pressing **Cancel** returns the display to the final calibration screen at which the user can choose to either **Save , Recall** or **Restart .**

Each calibration step allows a calibration value to be calibrated. The screen messages specify the instrument to use for measurement, the connector to connect it to, the value to adjust for and the method of adjustment

The full procedure is as follows:

STEP 1	CH1 DC offset zero.	Adjust for 0V ± 5mV
STEP 2	CH1 DC offset at +full scale.	Adjust for + 10V ± 10mV
STEP 3	CH1 DC offset at –full scale.	Check for –10V ± 50mV
STEP 4	CH1 Output level at full scale.	Adjust for 10V ± 10mV
STEP 5	CH1 6dB attenuation	Adjust for 5V ± 5mV
STEP 6	CH1 12dB attenuation	Adjust for 2.5V ± 3mV
STEP 7	CH1 18dB attenuation	Adjust for 1.25V ± 3mV
STEP 8	CH1 24dB attenuation	Adjust for 0.625V ± 3mV
STEP 9	CH1 30dB attenuation	Adjust for 0.3125V ± 3mV

The following steps (10 to 18) only apply to TGP31x2.

STEP 10	CH2 DC offset zero.	Adjust for 0V ± 5mV
STEP 11	CH2 DC offset at +full scale.	Adjust for + 10V ± 10mV
STEP 12	CH2 DC offset at –full scale.	Check for –10V ± 50mV
STEP 13	CH2 Output level at full scale.	Adjust for 10V ± 10mV
STEP 14	CH2 6dB attenuation	Adjust for 5V ± 5mV
STEP 15	CH2 12dB attenuation	Adjust for 2.5V ± 3mV
STEP 16	CH2 18dB attenuation	Adjust for 1.25V ± 3mV
STEP 17	CH2 24dB attenuation	Adjust for 0.625V ± 3mV
STEP 18	CH2 30dB attenuation	Adjust for 0.3125V ± 3mV

Step numbers for the following calibration steps are different for TGP31x1 and TGP31x2. TGP31x2 step numbers are shown in [ ].

STEP 10 [19]	MOD offset	Adjust for 5V ± 50mV
STEP 11 [20]	MOD full scale	Adjust for 8V ± 50mV
STEP 12 [21]	Ref clock calibration	Adjust for 10·00000 MHz ± 1ppm

STEP 13 [22]	Sync Jitter Calibration (Offset)	Adjust for minimum reading on display
STEP 14 [23]	Sync Jitter Calibration (Mulitplier 1)	Adjust for minimum reading on display
STEP 15 [24]	Sync Jitter Calibration (Multiplier 2)	Adjust for minimum reading on display

28.4 Remote Calibration

Calibration of the instrument may be performed over the LAN, USB or GPIB interface. To completely automate the process the multimeter and universal counter will also need to be remote controlled and the controller will need to run a calibration program unique to this instrument.

The remote calibration commands allow a simplified version of manual calibration to be performed by issuing commands from the controller. The controller must send the CALADJ command repeatedly and read the dmm or frequency meter until the required result for the selected calibration step is achieved. The CALSTEP command is then issued to accept the new value and move to the next step.

While in remote calibration mode very little error checking is performed and it is the controllers responsibility to ensure that everything progresses in an orderly way. Only the following commands should be used during calibration.

WARNING: Using any other commands while in calibration mode may give unpredictable results and could cause the instrument to lock up, requiring the power to be cycled to regain control.

CALIBRATION <CPD>, [NR1]	The calibration control command. <CPD> can be one of three sub–commands:–
	START - Enter calibration mode; this command must be issued before any other calibration commands will be recognised.
	SAVE - Finish calibration, save the new values and exit calibration mode.
	ABORT - Finish calibration, do not save the new values and exit calibration mode.
	[NR1] represents the 4-digit calibration password. The password is only required with CALIBRATION START and then only if a non–zero password has been set from the instrument's keyboard. The password will be ignored, and will give no errors, at all other times.
	It is not possible to set or change the password using remote commands.
CALADJ <NR1>	Adjust the selected calibration value by <NR1>. The value must be in the range –100 to +100. Once an adjustment has been completed and the new value is as required the CALSTEP command must be issued for the new value to be accepted.
CALSTEP	Step to the next calibration point.
CALVAL?	Returns the value from sync jitter calibration. Valid for steps 13 to 15 for TGP31x1 or steps 22 to 24 for TGP31x2 only, otherwise returns -1

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