



GPS-2000HD series

12-Bit Digital Storage Oscilloscope

GPS-2104HD · GPS-2202HD · GPS-2204HD

Operating Manual

Issue 1

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1 Safety

Read this chapter before connecting anything to the instrument. Every item in it is here because ignoring it can injure you or damage what you are working on.

This oscilloscope must not be used for measurements on mains circuits, or on voltages beyond the ranges in this manual. The maximum additional transient voltage must not exceed 1300 V.

Power and earth

- Use only the supplied power cord, or one approved for your country, and make sure the instrument is earthed. It earths through the protective conductor of the cord, and the earth must be connected before anything is connected to the inputs or outputs.
- Interrupting the protective conductor, inside or outside the instrument, or disconnecting the safety earth, is dangerous and prohibited.
- The outer shells of the four channel BNCs are connected to the chassis and so to earth, and so is the ground lead of every probe. Never connect a ground lead to anything that is not at earth potential, and do not connect a signal lead to a high voltage.
- Keep the plug where you can reach it. The power key puts the instrument into standby and does not disconnect it from the mains. To isolate it completely, unplug the power cord, and unplug it if it will not be used for a long time.

Connections

- Do not exceed 400 V peak on any input. Check the ratings of every terminal before connecting to it.
- Use only probe assemblies that meet the safety requirements for use with this instrument. Do not alter or replace any part of the instrument or its accessories except as authorised by GPS.
- Do not touch exposed contacts or components while the instrument is powered.

Where and how to use it

- Use the instrument indoors, in a clean, dry place. Do not operate it in wet, damp, dusty or explosive surroundings, and keep its surface clean and dry.
- It is cooled by forced air, through ventilation openings at each side. Leave at least 15 cm clear at each side, do not block the openings, and do not let anything enter them.
- Do not use the instrument if it is visibly damaged or has been through severe transport stress. If you suspect its protection has been impaired, disconnect the power cord and make sure it cannot be used by accident.
- Do not connect the instrument directly to a person, and do not use it for patient monitoring.
- Protect it from surges on the mains, such as lightning, and from electrostatic discharge.

Service

- There are no operator-serviceable parts inside. Capacitors, the power supply and transformers hold energy, and the internal parts are sensitive to static. Do not open the instrument: return it to GPS, or to a service organisation GPS has named, and always unplug it first.
- A normal start-up shows no alarm or error message, and the trace sweeps freely from left to right. If a pop-up, alarm or error appears, read the message and restart the instrument. If the fault remains, do not use it for measurements; contact GPS.

Working environment

The instrument is designed for indoor use, in pollution degree 2 (a dry environment where only non-conductive pollution occurs, with occasional temporary conductivity from condensation) and to IP20. The mains supply it connects

to is installation (overvoltage) category II, which is the local power distribution level for equipment connected to the AC line. The permitted temperature, humidity and altitude are in chapter 30.

Symbols and terms

These may appear on the instrument or in this manual:

- Caution: refer to the accompanying information or documents.
- Risk of electric shock.
- Measurement ground, and safety ground connections.
- On/standby switch. It does not disconnect the instrument from the mains.
- Alternating current.

CAUTION marks a procedure, practice or condition that may be dangerous if not followed. WARNING marks one that could cause injury or death. Do not go on until the conditions are understood and met.

If the instrument is used in a way that is not specified in this manual, the protection it provides may be impaired.

2 Introduction

The GPS-2000HD series are digital storage oscilloscopes with 12-bit analogue-to-digital converters. They sample at up to 2 GSa/s into a record of up to 100 Mpts, and the front end holds a noise floor of 70 μ V rms at 200 MHz bandwidth, so a small signal riding on a large one, such as ripple on a supply rail, is resolved rather than lost to quantisation.

The display is a seven inch capacitive touch screen, and every function can be reached by touch, by a USB mouse, or from the front panel. The instrument triggers on fourteen conditions, decodes five serial buses as standard, and offers history, sequence acquisition, hardware mask test, a hardware frequency counter, an automatic Bode plot, and, as options, power analysis, 16 digital channels and a 25 MHz waveform generator.

Model	Analogue channels	Bandwidth	Largest memory per channel
GPS-2104HD	4	100 MHz	50 Mpts
GPS-2202HD	2	200 MHz	100 Mpts
GPS-2204HD	4	200 MHz	100 Mpts

The complete specification is in the technical datasheet; chapter 30 summarises it.

How to read this manual

Operations that take several steps are written as a path. Utility > Menu > System Settings > Language means: touch Utility in the menu bar, touch Menu, touch System Settings, and then Language. Front-panel keys are named as they appear on the panel, and screen items as they appear on the screen. Knobs turn and also press, and a press recalls the function printed beside the knob.

The SCPI command reference for programming the instrument is a separate document, available from GPS on request. Chapter 28 covers the connections.

3 Unpacking and setting up

Unpacking

Check the packaging for damage, and keep it until the instrument has been checked. Check the contents against the list below. If anything is missing or damaged, contact GPS at once.

- GPS-2000HD oscilloscope (GPS-2104HD, GPS-2202HD or GPS-2204HD)
- One passive probe for each channel

- Power cord
- USB cable
- Quick start guide and certificate of calibration

The options (the logic probe, the waveform generator module and power analysis) are supplied separately. Each needs a software licence, described below.

Position

Place the instrument on a firm, level surface, with 15 cm clear at each side for the ventilation openings. The supporting legs fold out under the front to tilt the instrument back, which makes the display easier to see and the controls easier to reach.

Power

The instrument runs from a single-phase supply of 100 to 240 V at 50 or 60 Hz, and adapts automatically over 90 to 264 V and 47 to 63 Hz: there is no voltage selector. With options and accessories fitted it can draw up to 80 W. Use the supplied cord, which has a moulded three-terminal plug and a standard IEC C13 connector, and plug it into an outlet with a safety earth contact.

Switching on and off

Press the power key at the bottom left of the front panel. The instrument starts and shows its main screen when the start-up checks are done.

There are two ways to start it. By default the power key is the only control of the power state. With Auto Power On enabled, under Utility > Menu > System Settings, the instrument starts as soon as the power cord is connected, which suits an automated rack or an instrument that is hard to reach.

To switch off, press the power key, or choose Utility > Shutdown. In both cases the instrument goes to standby. It is fully off only when the power cord is unplugged.

System information

Utility > Menu > System Info shows the software and hardware versions and the serial number.

Installing an option

A software licence unlocks each option. Choose Utility > Menu > Software Options, select the option, enter the licence key with the on-screen keyboard and touch Install. A key held on a USB flash drive can be installed automatically if it is stored in the root directory of the drive.

An option that is not yet installed shows a temporary licence, which can be tried up to 30 times.

Checking the instrument

- Press Default to return the instrument to its default configuration.
- Connect a probe to channel 1, clip its ground lead to the ground terminal beneath the probe compensation output, and connect its tip to the output.
- Press Auto Setup. A steady square wave should appear.
- Repeat on channels 2, 3 and 4. If a square wave is not flat-topped, compensate that probe as described in chapter 4.

4 Probes and connections

Probes

The instrument works with passive and active probes. Probe documents are available from GPS.

The probe and the channel must agree

The channel dialog sets the probe attenuation factor, 1X, 10X, 100X or a custom value, and the instrument rescales the vertical scale to match. If the setting does not match the probe, every voltage is wrong by the difference and the display still looks reasonable. With a standard 10X probe that has a readout terminal, the instrument sets 10X by itself.

If a probe has a 1X setting, use 10X for general work. At 1X its bandwidth is far below the instrument's, and fast signals appear smaller and slower than they are.

There is no internal 50 Ω

Every input is 1 M Ω . For a measurement that needs 50 Ω , use an external feed-through terminator. The bandwidth, rise time, flatness and isolation figures are specified with one fitted.

Compensating a passive probe

A probe used for the first time, or moved to another channel, should be compensated to that channel. A probe that is not compensated, or is poorly compensated, increases measurement error.

- Connect the probe to any channel.
- Connect the probe tip to the probe compensation output on the front panel, and its ground clip to the ground terminal beneath it.
- Press Auto Setup, and compare the square wave with the drawings below.
- Use a non-metallic tool to adjust the low-frequency compensation hole in the probe until the waveform matches the correct one.

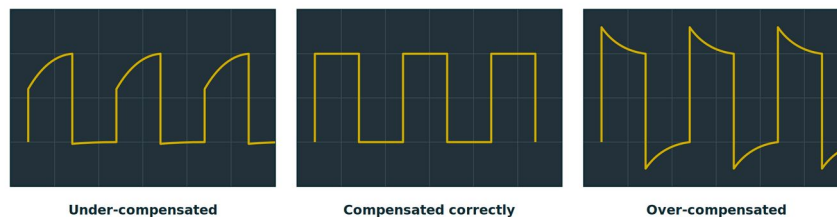


Figure 1 Probe compensation: under-compensated, correct, and over-compensated

Probe > Probe Check in the channel dialog guides you through the same check. Active probes do not need compensating.

USB peripherals

Connect a USB flash drive to either USB host port to save and recall files. FAT32 is recommended. The drive must be a flash storage type; the instrument does not support other types of USB storage. A USB mouse and keyboard can be connected to either port and control the instrument as touch would.

LAN

Connect the LAN port to the network with an RJ45 cable for remote control. The address is set under Utility > Menu > I/O > LAN Config; see chapter 27.

Auxiliary output

The BNC on the rear panel outputs a trigger indicator, which can be used to measure the waveform capture rate. When mask test is on it outputs the pass/fail signal instead (chapter 20).

Waveform generator module

The optional module connects to any USB host port, and the oscilloscope controls it. Chapter 25 describes it.

Logic probe

The optional logic probe plugs into the SBUS socket and adds 16 digital channels (chapter 10). It is made up of the probe itself, an interface cable, a flat cable, flying leads and probe clips.

- Connect one end of the interface cable to the SBUS socket on the instrument and the other to the probe.
- Connect the flat cable and the flying leads to the probe, in the direction their connectors allow.
- Connect the short flying lead to the ground of the circuit under test, and the long one to the circuit through a probe clip.

To remove the probe, first touch Remove Device in the digital menu and wait for the message Digital Device Disconnected. Two lights on the side of the probe show its state. The red one is on while its power is normal, and flashing or off means a power fault. The green one comes on, goes out, flashes slowly at one-second intervals and then stays on once the probe is connected, and flashes quickly while data is transferred.

The SBUS socket looks like an HDMI connector but is not one. Connect only the optional logic probe to it. Connecting anything else may damage the instrument.

5 The front panel

The front panel lets you work the basic functions without opening a software menu. Most of its controls duplicate the touch screen, and are quicker. Every knob turns and presses, and pressing recalls a specific function, named by the printing beside the knob.

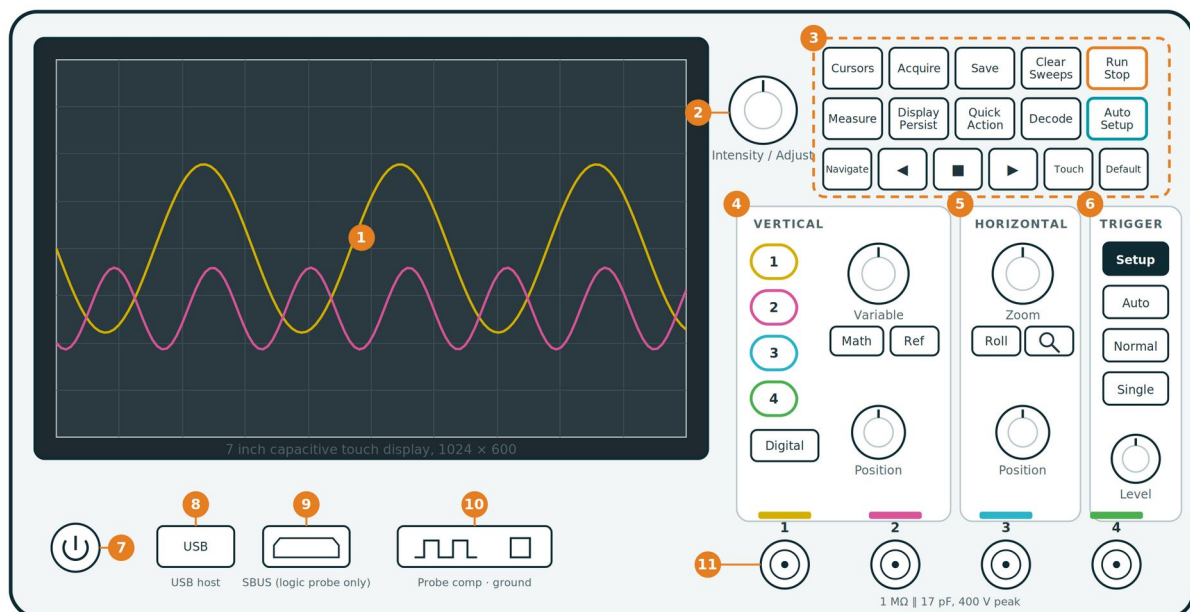


Figure 2 The front panel, schematic. Callout 3 marks the whole group of function keys

No.	Control	What it does
1	Touch display	7 inch capacitive touch screen, 1024 × 600. Touch, drag, pinch and spread; a USB mouse works the same way
2	Universal knob	Adjusts the highlighted parameter, and selects an option from a list when pressed. By default it adjusts the intensity of the traces
3	Cursors	Opens the cursors dialog. Turn the knob to move the selected cursor; press it to select another
3	Measure	Turns measurements on and off, and opens the measure dialog
3	Acquire	Opens the acquire dialog

No.	Control	What it does
3	Save	Quick save: a screenshot, or the currently selected file type, to the chosen path
3	Clear Sweeps	Clears persistence, measurement statistics, average sweeps and pass/fail statistics
3	Display / Persist	Opens the display dialog. A second press turns persistence on and lights the key; a third turns it off
3	Quick Action	Calls a preset function, set up in the Utility menu
3	Run/Stop	Starts and stops acquisition. Lit green while running and red when stopped
3	Auto Setup	Sets the vertical scale, horizontal scale and trigger level to suit the input
3	Decode	Turns bus operation on and opens the decode dialog; press again to turn it off
3	Navigate	Opens the navigate dialog
3	Play keys	Play backward, stop, and play forward through the record
3	Touch	Switches the touch screen on and off. Its light shows that the touch screen is working
3	Default	Returns the instrument to its default configuration
4	Channel keys 1 to 4	Press an off channel to turn it on; press an on channel that is not active to activate it; press an active channel to turn it off
4	Digital	Turns the digital channels on and opens the digital dialog; press again to turn them off
4	Math	Turns math on and opens the math dialog; press again to turn it off
4	Ref	Turns reference waveforms on and opens the reference dialog; press again to turn them off
4	Vertical scale knob	Sets volts per division for the active trace, whether channel, digital, zoom, math or reference. Press to switch between coarse and fine
4	Vertical position knob	Sets the offset or vertical position of the active trace. Press to set it to zero. With a digital channel active, it moves the selected digital channel
5	Horizontal scale knob	Sets the timebase. Press to enable Zoom, and press again to switch between the main window and the zoom window
5	Roll	Enables roll mode; press again to leave it
5	Zoom key	Enables Zoom; press again to leave it
5	Delay knob	Sets the trigger delay. Press to set it to zero
6	Setup	Opens the trigger setup dialog
6	Auto, Normal, Single	Set the trigger mode
6	Level knob	Sets the trigger level. Press to set it to 50% of the waveform
7	Power	Switches the instrument between operation and standby
8	USB host	For a USB storage device, a mouse or a keyboard
9	SBUS	For the optional logic probe only

No.	Control	What it does
10	Probe compensation	A 1 kHz square wave of 0 to 3 V, with a ground terminal beneath it, for compensating probes
11	Channel inputs	Four BNC inputs, colour-coded to match the traces. 1 M Ω , 400 V peak maximum

Three ways to reach a function

The same dialogs can be opened three ways. From the menu bar, for example Trigger > Menu opens the trigger dialog. By touching a descriptor box: touching the trigger box opens the same dialog, and the channel and timebase boxes work likewise. Or with a front-panel key: Setup in the trigger block opens it directly. The menu bar reaches everything, and a few functions can be reached only there: Utility > Help, Utility > Save/Recall, Utility > Reboot and Display.

6 The rear panel

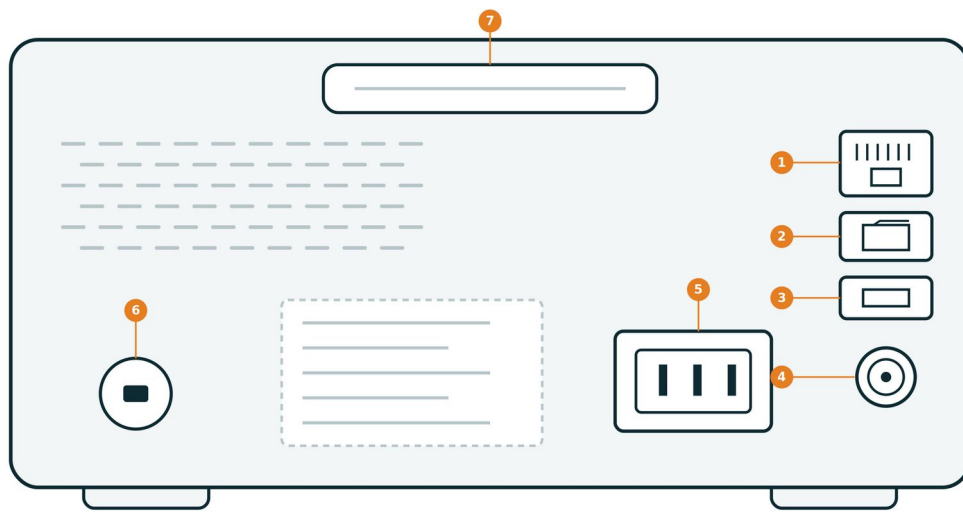


Figure 3 The rear panel, schematic

No.	Connection	What it is for
1	LAN	10/100 Mbit/s network connection, for remote control
2	USB device	Connection to a PC, for remote control
3	USB host	For a USB storage device, a mouse or a keyboard
4	Auxiliary output	A trigger indicator, which can be used to measure the waveform capture rate. With mask test on, it outputs the pass/fail signal instead
5	AC power input	100 to 240 V, 50/60 Hz, through a standard IEC C13 connector
6	Keyhole	For a security lock
7	Handle	For carrying the instrument

The rating label is also on the rear panel. The ventilation openings are at the sides of the case; keep them clear.

7 The touch screen

The whole display is a capacitive touch screen. Touch, drag, pinch, spread or draw a selection box with your fingers. Many controls that show information are also buttons that open other functions. With a USB mouse connected you can click anywhere you could touch, and you can alternate between the two.

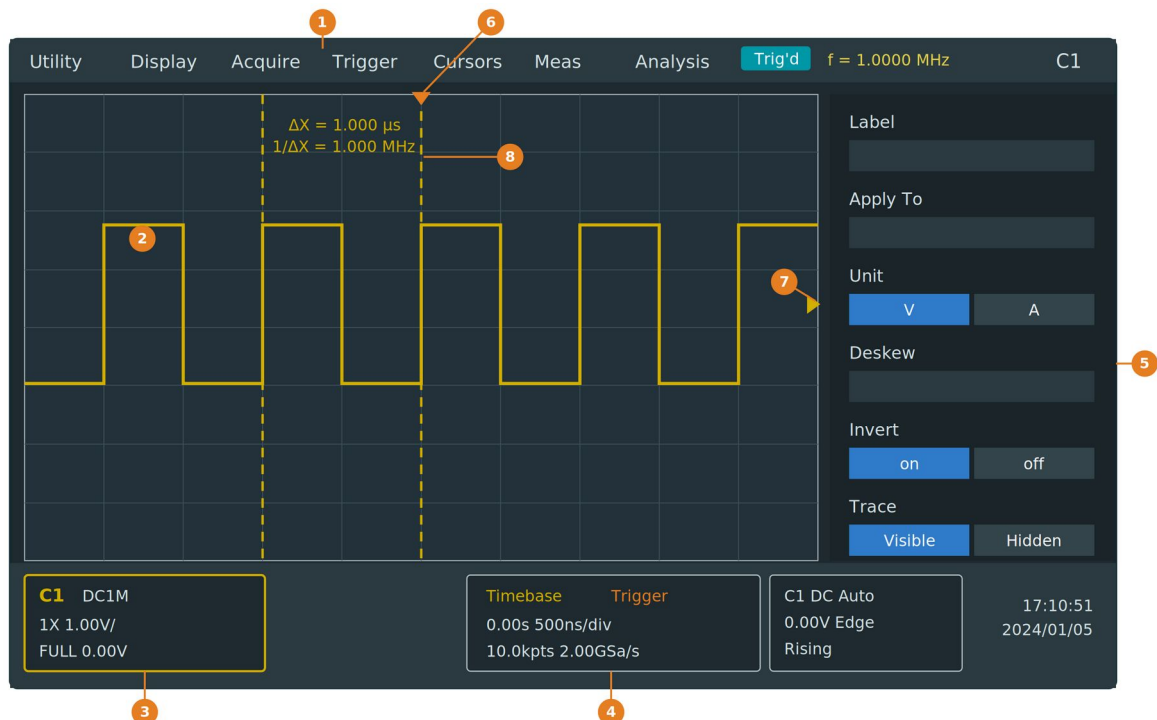


Figure 4 The touch screen, schematic

No.	Area	What it shows
1	Menu bar	Drop-down menus along the top. Every function can be reached from here
2	Grid area	The traces, on an 8 × 10 grid. Drag a trace to move it; pinch or spread to rescale it
3	Channel descriptor boxes	Under the grid, one for each trace that is on. Touch one to open its dialog
4	Timebase and trigger descriptor boxes	The timebase and trigger settings. Touch either to open its dialog
5	Dialog box	At the right: where the settings of the selected function are made
6	Trigger delay indicator	A marker along the top of the grid showing where the trigger is in time. When the trigger is off the screen, the marker points towards it
7	Trigger level indicator	A marker at the side of the grid showing the trigger level
8	Cursors	Dashed lines marking where measurement points are set. Move them to reposition the measurement

Channel descriptor boxes

These sit under the grid. Each is for one trace: an analogue channel (C1 to C4), the digital channels (D), a zoom trace (Z1 to Z4), a math trace (F1 to F4) or a reference (Ref). Touching a box opens its dialog. A box for an analogue channel shows:

- The channel index.
- The coupling and input impedance: DC with 1 MΩ, AC with 1 MΩ, or ground.

- The vertical scale, which is the size of one grid division. At 1.00 V/div the full scale is 8 divisions, so 8 V.
- The vertical offset. At zero, the channel offset indicator is in the middle of the vertical axis.
- The bandwidth information: an icon for the 20 MHz limit or for full bandwidth.
- The probe attenuation factor, 1:1, 10:1, 100:1 or custom. Changing it rescales the vertical scale to match: 100 mV/div at 1X becomes 1 V/div at 10X.

An invert indicator also appears when the channel is inverted.

Timebase and trigger descriptor boxes

The timebase box shows the trigger delay, which is the time offset of the trigger position (at zero the delay indicator is at the centre of the horizontal axis); the timebase, which is the time of one grid division (500 μ s/div means a screen of 5 ms); the number of samples on the current screen; and the sample rate.

The trigger box shows the source (C1 to C4, AC Line, or D0 to D15), the coupling, the mode, the level, the type and the slope. Levels set in volts normally stay put when the vertical gain or offset changes.

Near the top of the screen, a status tag shows the trigger state (Arm, Ready, Trig'd, Stop or Auto), and the hardware counter's reading appears beside it.

Indicators on the grid

- The trigger level indicator shows the level on the vertical axis.
- The trigger delay indicator shows where the trigger is on the horizontal axis. If the trigger is outside the screen, the marker points that way.
- A channel offset indicator, with the channel number, shows the offset of that channel.
- Axis labels can be shown or hidden under Display > Menu > Axis Label Setting.

Dialog boxes and entering values

The dialog box on the right of the screen is where the parameters of the selected function are set. Its title bar hides it when touched and shows it again when touched again. When the dialog is longer than the display, a scroll bar appears, and you scroll by sliding the dialog or by turning the mouse wheel. Parameters are entered in three ways:

- A switch has two states, such as on and off. Touch it to change from one to the other.
- A list has more than two options, such as the coupling of a channel. Touch the parameter, then choose from the list.
- A value is entered by touching the parameter, which then responds to the Universal knob or the mouse wheel. Touch it again to open a virtual keypad. Type the number and choose the unit, for example 65 and n for a deskew of 65 ns. Max, Min and Default on the keypad set the largest, smallest and default values at once.

Menu style and hiding the dialog

The menu style, set under Display > Menu, is either Embedded or Floating. Embedded compresses the grid horizontally so the whole waveform stays visible beside the dialog. Floating lets the dialog cover part of the grid. In either case, touch the title bar to hide the dialog when you want a clear view. Display > Menu > Hide Menu hides it automatically after a time of no operation.

Gestures

Waveforms, cursors and trigger levels can be adjusted by touch.

Gesture	What it does
Drag a trace left or right	Moves it along the time axis
Pinch or spread horizontally	Rescales the timebase
Drag a trace up or down	Moves it on the vertical axis
Pinch or spread vertically	Rescales the vertical gain
Touch and drag a cursor	Moves it
Touch and drag the cursor readout	Moves the pair of cursors together

Mouse, keyboard, brightness and language

A USB mouse clicks wherever you could touch, and a USB keyboard enters characters in place of the on-screen keyboard. Display > Menu > LCD Brightness sets the backlight. The language is set under Utility > Menu > System Settings > Language; the instrument offers ten.

8 Capturing a signal quickly

This example assumes the signal is connected to channel 1 and that channel 1 is off.

- Press the channel 1 key. Its light comes on and its descriptor box appears at the bottom of the screen.
- Press Auto Setup. The instrument adjusts the vertical scale, the horizontal scale and the trigger level to the signal, and sets the trigger type to edge. Acquire > Auto Setup does the same.

Auto Setup will not work on every signal, especially time-varying bursts and slow signals below 100 Hz. When it cannot give the display you want, set the vertical, horizontal and trigger systems by hand: chapters 9, 11 and 13.

9 Vertical system

Turning a channel on and off

From the front panel, press the channel key. With the channel off, a press turns it on. With it on but not active, a press makes it active. With it on and active, a press turns it off. From the touch screen, touch the + button and choose the channel; its descriptor box and dialog appear. To turn it off, touch its descriptor box and then Off.

The quick dialog

Touching a channel descriptor box opens a quick dialog. It sets the vertical scale and offset, and has shortcuts:

- Vertical scale: touch the value to set it with the Universal knob or the virtual keypad, or use the up and down arrows.
- A check box switches the scale between coarse and fine adjustment. Fine mode brings the trace as close to full scale as possible, which gives the best vertical measurement accuracy. The instrument switches to fine mode by itself when you scale by touch gestures.
- Offset: set it the same way, or set it to zero with one touch.
- Copy: copies the settings of this channel to another channel.
- Apply to: makes this channel the source of a chosen operation (trigger, FFT, simple measure, cursors, search or counter).
- Off disables the channel, and Hide hides its trace.

The channel dialog

Activating a channel opens the full dialog. It holds the channel on/off, coupling, bandwidth limit, probe, label, apply to, unit, deskew, invert and trace.

Coupling

- DC passes every frequency component of the signal.
- AC couples the signal through a capacitor and rejects the DC component. Use it for an AC signal sitting on an offset, such as power supply ripple. The cut-off frequency is in the technical datasheet.
- GND grounds the channel through an internal switch. Use it to see the zero-offset error of a channel, or to find whether noise comes from the signal or from the instrument.

Bandwidth limit

Full bandwidth passes signals with high-frequency content, and also the noise that goes with it. When the signal itself is low in frequency, a bandwidth limit gives a better signal-to-noise ratio. The instrument has two hardware settings: full bandwidth, or a limit of 20 MHz.

Probe

The attenuation factor can be 1X, 10X, 100X or a custom value from 10^{-6} to 10^6 . The instrument converts the vertical scale to match, and sets the factor itself when a standard probe with a readout terminal is connected. Probe Check guides you through checking the probe's compensation: connect the probe as described in chapter 4 and follow the prompts.

Label

A channel can carry a label of up to 20 characters; anything longer is not displayed. Open the label dialog, choose the source (C1 to C4, math, or references A to D), type the text and switch the display on. The label then appears beside the channel's offset indicator.

Apply to

This gives the channel to a common function in one step: trigger, FFT, simple measure, cursors, search, mask test, counter or waveform generator. The instrument opens that function's menu and sets the channel as its source.

Unit

The channel is shown in volts or in amps. Set amps when using a current probe.

Deskew

Signals take different times through different channels, cables and probes. Two coaxial cables that differ in length by one inch can introduce a skew of more than 100 ps. When it matters, for example when measuring setup and hold time between a clock and data, compensate for it.

Probe the same signal on two channels, using the cables and probes you intend to measure with, and adjust the deskew of one channel until the two waveforms coincide horizontally. When the channel being deskewed is the trigger source, the trigger delay indicator does not move as the deskew value changes.

Invert

Invert rotates the waveform 180 degrees about 0 V.

Trace

A hidden trace is no longer displayed, but its acquisition carries on in the background.

10 Digital channels (option)

The optional logic probe monitors up to 16 digital signals at once. The channels are in two groups, D0 to D7 and D8 to D15, and each group has its own threshold, so signals from different logic families can be seen together. A software licence is needed as well as the probe (chapter 3).

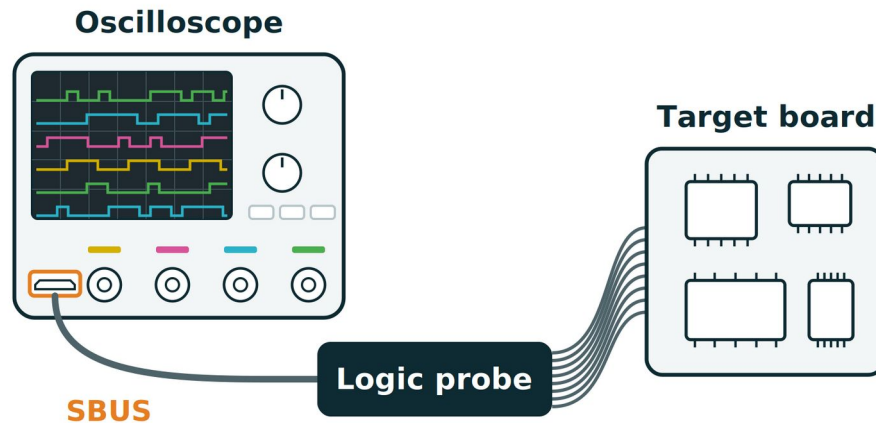


Figure 5 The logic probe on the SBUS socket, with its leads to a target board. Schematic

With the option, the instrument can acquire and analyse the digital signals, including waveform display, saving and parameter measurement; trigger on a digital channel; and use a digital channel as a source for serial decode.

Turning the digital channels on and off

Press Digital on the front panel to turn them on and show the waveforms; press it again to turn them off. From the touch screen, touch + at the bottom of the display and choose Digital, and touch the digital descriptor box and then Off to turn them off. Each channel can also be turned on or off individually. Digital data can be saved as waveform files, and horizontal cursors and most horizontal measurements apply to digital waveforms.

The digital waveforms share the grid with the analogue channels. A digital descriptor box and the channel indicators show the two groups, D15 to D8 and D7 to D0. Labels can be set to data, address or custom characters, and a digital bus can be displayed.

The quick menu

Touching the digital descriptor box opens a quick menu with the upper limit of the display area for the digital channels, which is the position, and its height in divisions. Reducing the height gives more room to adjust the position. If the height covers every division there is no room left to move it. Each has an arrow pair and a reset, and one touch turns the digital channels off or opens the full dialog.

The digital dialog

- On and off for the digital channels, and the label type.
- The logic threshold for D7 to D0 and for D15 to D8. Input below the threshold is read as 0 and above it as 1. Choose a logic family and the instrument sets the threshold: TTL, CMOS, LVCMOS 3.3 V or LVCMOS 2.5 V. Or choose Custom and set any value from -8.0 V to +8.0 V.
- Which channels to display, and deskew, set as for analogue channels.
- Bus settings, system information and firmware upgrade, and Remove Device.

Digital buses

Press Digital, or touch the digital descriptor box, then Bus. Choose Bus 1 or Bus 2, the data format (binary, decimal, unsigned decimal or hexadecimal) and the bit width, and switch the display on, and set the vertical position of the bus.

Touch Data to assign channels to bits. The dialog shows each bit as Bit.x[Dy]: Bit.0[D15] means that bit 0 of the bus is D15. Touch one to assign any of D0 to D15 to that bit. A reset returns the bus to its default.

System information and upgrade

System Info shows the software version, the operating system and FPGA versions, the serial number and the hardware version of the logic probe. The probe's own firmware can be upgraded from a USB flash drive:

- Copy the upgrade file to the flash drive and insert it in a USB host port.
- Touch Browse to select the file, then Upgrade. A progress bar shows the percentage done.
- When it finishes, the probe is removed from the system and the instrument prompts you to reconnect it. Open System Info again and check that the hardware version is the one intended.

Do not cut the power during an upgrade.

11 Horizontal system and acquisition

Timebase

The timebase sets the scale and offset of the horizontal axis, for all analogue and digital channels and all math traces except FFT. Touch the timebase descriptor box for a quick menu: the horizontal scale, set from the keypad or with arrows; the trigger delay, set the same way; a touch to set the delay to zero, or to the left or right part of the screen; and a button that opens the acquire dialog. While the instrument is running, changing the timebase changes the sample rate. When it is stopped, it zooms into the record already captured.

The acquire dialog

Open it from the timebase quick menu, with the Acquire key, or with Acquire > Menu. It holds the interpolation mode, the acquisition speed, the acquisition mode, memory management, the maximum memory depth, the sequence menu and XY mode.

Interpolation

At small timebases the screen may hold fewer original samples than the grid has pixels, so the instrument interpolates to draw a continuous waveform. At 1 ns/div and 2 GSa/s there are 20 original points across a grid of 1000 pixels, so it interpolates by 50.

- X is linear interpolation: a straight line between two points.
- Sinc is $\sin(x)/x$ interpolation, which reconstructs a sine well. On steps and fast edges it introduces false overshoot, because of the Gibbs phenomenon.

Acquisition speed

Fast is the default, and gives a very high waveform update rate. Slow reduces the update rate on purpose.

Acquisition mode

- Normal samples at equal intervals and gives the best display for most waveforms.
- Peak Detect keeps the largest and smallest values in each sample interval. It shows occasional narrow pulses or spurs at a low sample rate, at the cost of a noisier display, and displays every pulse wider than 2 ns. A 16.3 ns pulse train at 200 Hz, sampled at 5 MSa/s, is easily missed in Normal mode, because the sample interval is 200 ns, but Peak Detect captures every pulse.

Memory management

- Auto is the default. Once the maximum memory is set, the instrument adjusts the sample rate and the memory depth to the timebase. The sample rate is the number of samples divided by the time of acquisition, which is the full ten divisions of the display. The maximum is an upper limit: the actual number of samples depends on the timebase, and is shown in the timebase box.

- Fixed Sample Rate holds the rate you set, and the instrument adjusts the depth to the timebase. Check that the rate is at least twice the highest frequency in the signal, or it will alias and the display will be distorted.

Memory depth

Acquisition time equals the number of points multiplied by the sample interval, so a larger memory depth gives a higher sample rate at a given timebase. More points take more processing, which lowers the update rate. The best update rate comes with a depth of 1 kpts. At full depth the instrument still samples at full speed at timebases faster than 5 ms/div on the 200 MHz models, which gives high-resolution captures of long events.

XY

XY mode uses a frame from channel 1 as the horizontal axis and a frame from channel 2 as the vertical axis, to show how two signals relate. It is usually used for Lissajous figures and for the volt-ampere characteristic of a component.

Sample rate and memory depend on the channels in use

The sample rate and the memory per channel both depend on how many channels are on, and the headline figures hold with one channel only.

Channels on	Sample rate	Memory, GPS-2104HD	Memory, GPS-2202HD and GPS-2204HD
One channel on	2 GSa/s	50 Mpts	100 Mpts
Two channels on	1 GSa/s	25 Mpts	50 Mpts
Four channels on	500 MSa/s	10 Mpts	25 Mpts (GPS-2204HD)

Switch off any channel you are not using. At slow timebases the instrument lowers the sample rate to cover the time on screen. At full depth the full rate holds to 5 ms/div on the 200 MHz models. On the GPS-2104HD it holds to 2.5 ms/div with one or two channels on, and to 2 ms/div with four.

Roll mode

Press Roll to enter roll mode. The waveform moves across the screen from right to left, like a strip chart. It works at timebases of 50 ms/div and slower, and at those settings Roll is recommended so the waveform is shown in real time. The horizontal delay control is disabled while it is active, and there is no trigger. Press Run/Stop to stop the display, and press it again to clear the display and restart. Zoom works in roll mode only after Stop.

Sequence mode

Sequence mode divides the memory into up to 80,000 segments, each holding one triggered shot. The instrument only acquires and stores until the chosen number of segments is full, without processing or displaying, so the dead time between triggers is as short as 2 μ s, which is a waveform update rate of 500,000 wfms/s. While it runs the display does not update, and a counter shows how many segments have been acquired. Afterwards all the segments are mapped to the screen together.

Sequence mode can also capture rare events over a long period. It records every event that meets the trigger condition and ignores the quiet time between them, so the memory is used only for what matters, and you keep the full accuracy of the timebase to measure selected segments.

Open it with Acquire > Sequence, switch it on and set the number of segments. For example, with a 20 ms pulse train, a single trigger, a timebase of 100 ns/div and the segments set to maximum, one such test allowed 45,976 segments; the figure can be up to 80,000, depending on the number of samples at the current timebase. Use history to look at each segment separately.

History

The instrument stores the frames it acquires automatically, up to 80,000, though the number depends on the memory depth and the timebase. Open Analysis > History and turn history on to recall and measure them.

- Specify a frame by touching the frame number area twice and typing the number on the keypad.

- Turn the list on to see each frame's index and time label. The time label is either Acq Time, the absolute time of the frame, synchronised with the instrument's clock, or Delta T, the interval between adjacent frames. The resolution is microseconds.
- Play backward, pause and play forward replay the frames automatically, from the current frame to the first, or to the last. The interval time sets the speed.

When a measurement is on in history mode, and the interval time is very small, such as microseconds, playback may run slower than set, because each frame takes time to measure.

12 Zoom

The instrument zooms the waveform horizontally and vertically. Press the horizontal knob, or the Zoom key, to turn Zoom on.

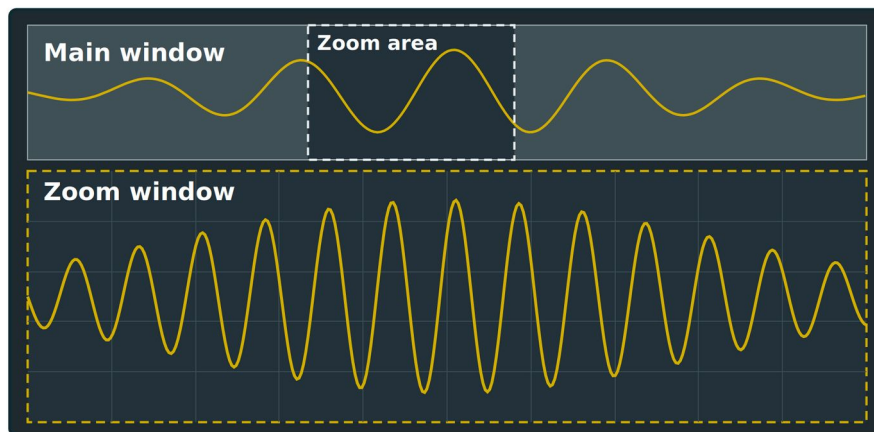


Figure 6 The zoom layout: the main window above, the zoom window below

With Zoom on, the waveform area is split. About the top third is the main window, and the rest is the zoom window. The part of the main window that is not greyed is the zoom area. Touch a window to make it active; a dashed line shows which is. Touching the zoom vertical or horizontal parameter regions opens quick dialogs for the zoom window.

With the zoom window active

- Turning the horizontal and vertical scale knobs expands or compresses the zoom area, and turning the position knobs moves it.
- Drag left and right, or up and down, in the zoom area of the main window, or on the waveform in the zoom window, to move the zoom area.
- Pinch or spread horizontally or vertically in the zoom area or the zoom window to change its scale.
- Double-click a point in the main window to centre the zoom area on it.

With the main window active

- The scale and position knobs change the scale and the delay or offset of the main window.
- Drag in the grey area to move the waveform, and pinch or spread there to rescale the main window.

Zoom traces, Z1 to Z4, can be used as the source of measurements, math and mask tests.

13 Trigger

The instrument only acquires waveforms that meet the trigger condition, and aligns every trigger event at the trigger position to give a stable display. A signal can be analysed only if it can be triggered reliably, so the trigger is one of the

most important parts of an oscilloscope. Trigger settings should follow from what you know about the signal: a repeating sine can be triggered on its rising edge, and a pulse trigger can catch hazards in combinational logic.

How the memory fills

The acquisition memory is divided into a pre-trigger buffer and a post-trigger buffer, and the trigger position is the boundary between them. Before the trigger event, the instrument fills the pre-trigger buffer, then keeps updating it first in, first out until the event arrives. After the event, data fills the post-trigger buffer. When that is full, the acquisition is complete.

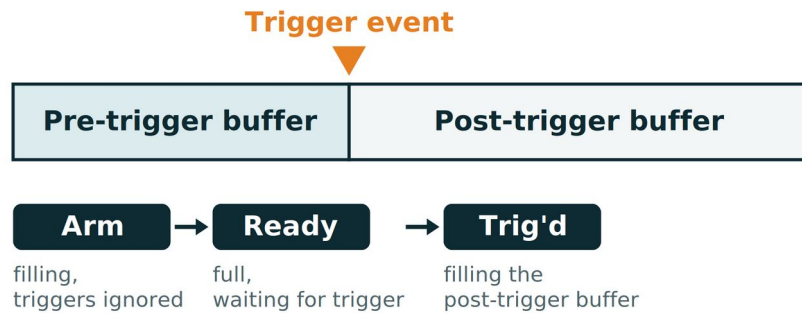


Figure 7 The acquisition memory and the three trigger states

- Arm: the pre-trigger buffer is not full, and the instrument does not respond to trigger events.
- Ready: the pre-trigger buffer is full, and the instrument is waiting for the trigger event.
- Trig'd: a trigger event has been detected and the instrument is filling the post-trigger buffer.

Trigger setup

Touch the trigger descriptor box to open a quick menu, and the trigger dialog appears on the right of the screen. Pressing Setup opens the dialog directly.

The quick menu

- The trigger level: touch the level region and turn the Level knob, or touch it again for the keypad. Arrows raise and lower it, and one touch sets it to the vertical centre of the waveform.
- The trigger mode: Auto, Single and Normal, equivalent to the three keys on the front panel, and Force, which has no key (see below).

The dialog

- The trigger type and the trigger source.
- The slope, for edge, slope and other types that use one.
- Holdoff, which is None or a time.
- Trigger coupling: DC, AC, LF reject or HF reject.
- Noise reject, which adds hysteresis so noise upsets the trigger less, at the cost of sensitivity.

Trigger level

Analogue and digital triggers both need a correct level. The instrument decides whether a waveform meets the condition when it crosses the level, and the crossing time is the trigger position. With a rising edge selected, a signal with a positive slope that crosses the level satisfies the condition. Some triggers set the level themselves, for example when the source is the AC line.

Trigger mode

- **Auto:** an internal timer triggers the sweep after a timeout if no trigger has been found, so the display refreshes whether a trigger occurs or not. It suits unknown signals and DC. If a signal meets the condition but will not trigger steadily, the gap between trigger events may be longer than the timeout; try Normal.
- **Normal:** acquisition happens only when the condition is met; otherwise the last waveform stays on the display and the instrument waits for the next trigger. It suits events specified by the trigger settings, and rare events.
- **Single:** captures and displays one frame that meets the condition, then stops. Later events are ignored until Single is restarted. It suits one-shot events and periodic signals such as power-on and power-off waveforms on a rail, and rare events.
- **Force:** forces one frame to trigger whether or not the signal meets the condition. In Auto it forces one frame and returns to Auto; in Normal it forces one and returns to Normal; in Single it forces one and returns to Stop. There is no front-panel key, so the shortcut is in the trigger drop-down menu at the top of the screen and the trigger information pull-up menu at the bottom.

Trigger types

The triggers are digital, which improves trigger precision and jitter compared with analogue circuits, and allows many types and complex conditions. Pressing Auto Setup sets the type to Edge. The sources each type accepts are in the table at the end of this section.

Edge

Triggers on a rising edge, a falling edge, or both (Alternating), at the trigger level. Set the source and the slope in the dialog. Holdoff, coupling and noise reject are available.

Slope

Triggers when an edge takes a time within or outside a chosen range to move from one level to another. The positive slope time is the interval between the two crossings of trigger levels A and B by a rising edge. Choose rising or falling.

A slope trigger needs an upper and a lower level. Touch Level Upper or Level Lower in the quick menu and set the value, or use the Level knob: press it to switch between the two, and turn it to set the value. The lower level must not be above the upper, and the trigger box shows the lower.

Limit Range sets the time condition and the time value or values: less than, greater than, within a range, or outside a range. Holdoff, coupling and noise reject are available.

Pulse

Triggers on a positive or negative pulse of a given width. Set the source, the polarity, the limit range and the time value. The limit range works as for the slope trigger. For example, a positive pulse width of less than 100 ns, or greater than 100 ns, or between 100 ns and 300 ns. Holdoff, coupling and noise reject are available.

Video

Captures the complicated waveforms of standard analogue video. The trigger circuit detects the vertical and horizontal intervals of the waveform and triggers from the settings. Any analogue channel can be the source, and the synchronisation amplitude must be more than half a grid division. Set the source, the standard and the synchronisation mode.

Standard	Scan type	Sync pulse
NTSC	Interlaced	Bi-level
PAL	Interlaced	Bi-level
HDTV 720P/50	Progressive	Tri-level
HDTV 720P/60	Progressive	Tri-level
HDTV 1080P/50	Progressive	Tri-level
HDTV 1080P/60	Progressive	Tri-level
HDTV 1080i/50	Interlaced	Tri-level
HDTV 1080i/60	Interlaced	Tri-level
Custom	—	—

Sync has two modes. In Any, the signal triggers on any line that meets the condition. In Select, it triggers on a chosen field and line. Progressive signals (720p and 1080p) have only a line to choose. Interlaced signals (NTSC, PAL, 1080i and custom) have a line and a field.

Standard	Field 1 lines	Field 2 lines
NTSC	1 to 263	1 to 262
PAL	1 to 313	1 to 312
HDTV 720P/50, 720P/60	1 to 750	—
HDTV 1080P/50, 1080P/60	1 to 1125	—
HDTV 1080i/50, 1080i/60	1 to 563	1 to 562

To trigger on field 1, line 22 of an NTSC signal: press Setup, set the type to Video, the source to C1 and the standard to NTSC, set Sync to Select, then set Field to 1 and Line to 22 with the Universal knob or the keypad.

For a custom signal, set the standard to Custom and open Custom Setting. Choose the interlace ratio, the frame rate, the number of lines and the number of fields, then the sync mode and, in Select, the field and line.

Custom parameter	Range
Frame rate	25 Hz, 30 Hz, 50 Hz, 60 Hz
Number of lines	300 to 2000
Number of fields	1, 2, 4, 8
Interlace	1:1, 2:1, 4:1, 8:1

The number of fields you can choose depends on the interlace ratio, and so does the number of lines per field. With 800 lines:

Interlace	Number of fields	Lines per field	Trigger field
1:1	1	800	1
2:1	1, 2, 4 or 8	400	1 to the number of fields
4:1	1, 2, 4 or 8	200	1 to the number of fields
8:1	1, 2, 4 or 8	100	1 to the number of fields

Window

Like an edge trigger with two levels: it triggers when the signal passes through the upper or the lower level. If both levels are within the amplitude of the waveform, it triggers on both rising and falling edges. If only the upper level is within it, it triggers on the rising edge only, and if only the lower level is, on the falling edge only.

There are two window types. Absolute lets you set the upper and lower levels separately, as for the slope trigger. Relative has a Level Center for the middle of the window and a Level +/-Delta for its half-width, and the two levels always move together. Delta is half the window: 200 mV means a range of ± 200 mV, a window of 400 mV. Set them in the quick menu, or with the Level knob, pressing it to switch between the two.

Interval

Triggers when the time between neighbouring rising edges, or neighbouring falling edges, meets a limit. For example, when two rising edges are closer than a set time. Set the source, the slope, the limit range and the time.

Dropout

Triggers when a signal disappears for longer than a set time. There are two types.

- Edge: the time from a rising (or falling) edge crossing the level to the neighbouring rising (or falling) edge crossing it is greater than the set time.
- State: the time from a rising (or falling) edge crossing the level to the neighbouring falling (or rising) edge crossing it is greater than the set time.

Set the source, the slope, the dropout type and the time.

Runt

Looks for pulses that cross one threshold but not the other, and then re-cross the first. A positive runt crosses the low level but not the high; a negative runt crosses the high level but not the low.

Pattern

Identifies a condition by a pattern of states across channels. The logic is AND, OR, NAND or NOR of the channels, and each channel is set to Low, High or Don't Care. If every channel is Don't Care, the instrument does not trigger. All inputs are DC coupled. Set the logic, the sources, the limit range and the time.

Touch Source Setting to set each channel separately; the level value sets each threshold. With the digital channels on, their logic states can be set there as well. The limit range is particularly useful for filtering out hazards in combinational logic. Holdoff is available.

Qualified

An edge trigger that works only after a qualifying condition is met, so it has two sources: the edge trigger source, and the qualified source. There are four types.

- State: triggers on the first edge while the qualified source is in the chosen state, high or low.
- State with Delay: the same, with a time limit condition as well.
- Edge: triggers at the first edge after the chosen edge, rising or falling, of the qualified source.
- Edge with Delay: the same, with a time limit condition as well.

Touch Qualify Setting to set the qualified source and its threshold, and Edge Setting to set the edge trigger source, threshold and slope.

Nth Edge

An edge trigger with conditions. It triggers on the Nth edge of a burst, after the signal has been idle for at least a set time. For example, when the idle time between pulse trains is longer than the one set, it can trigger on the third falling edge of the train. Set the source, the slope, the idle time and the edge number.

Delay

True when an edge of source B occurs after source A has met its conditions and a delay time has passed. Source A is set up like the pattern trigger, and can be an AND of several channels. Touch Source B Setting to set the edge source, threshold and slope, and Limit Range with the upper and lower value to set the delay condition.

Setup/Hold

Needs a clock and a data source. The setup time begins when the data signal crosses the trigger level and ends when the chosen clock edge arrives. The hold time begins at the clock edge and ends when the data signal crosses the level again. The instrument triggers when the setup or hold time meets the limit condition. Touch Clk Setting for the clock source, threshold and slope, and Data Setting for the data source, threshold and state.

Serial

See chapter 14.

Trigger sources

Each trigger type accepts different sources.

Trigger type	Sources
Edge	C1 to C4, AC Line, D0 to D15
Slope	C1 to C4
Pulse	C1 to C4, D0 to D15
Video	C1 to C4
Window	C1 to C4
Interval	C1 to C4, D0 to D15
Dropout	C1 to C4, D0 to D15
Runt	C1 to C4
Pattern	C1 to C4, D0 to D15
Serial	C1 to C4, D0 to D15
Qualified	C1 to C4
Nth Edge	C1 to C4
Delay	C1 to C4
Setup/Hold	C1 to C4

Holdoff

Holdoff is an additional condition that stabilises triggering on complex waveforms such as pulse trains. It is a time: the instrument waits that long before re-arming the trigger circuit, and will not trigger until it has passed. It lets you trigger on repetitive waveforms with several edges between repetitions, or on the first edge of a burst when you know the minimum time between bursts. For example, a pulse train that repeats with extra pulses between repetitions triggers

steadily when the holdoff is longer than the spacing of the extra pulses and shorter than the repetition interval. Holdoff can be set from 8 ns to 30 s.

Trigger coupling

Trigger coupling applies only when the source is C1 to C4.

- DC: every frequency component reaches the trigger circuit, for high-frequency bursts or where AC coupling would shift the effective level.
- AC: capacitively coupled; DC levels are rejected.
- HFR (HF reject): DC coupled, with a low-pass network that attenuates high frequencies, for triggering on low frequencies.
- LFR (LF reject): coupled through a high-pass network; DC is rejected and low frequencies attenuated, for steady triggering on medium and high frequencies.

The cut-off frequencies are in the technical datasheet.

Noise reject

Noise reject adds hysteresis to the trigger circuit. The more hysteresis, the better the noise immunity and the worse the trigger sensitivity.

14 Serial trigger and decode

The instrument triggers on and decodes five serial protocols: I²C, SPI, UART, CAN and LIN. Decoding is standard.

Setting up

To trigger, press Setup or touch the trigger descriptor box, set the type to Serial, choose the protocol, set the signals (which channel carries which bus signal, and the thresholds) and then the trigger condition.

To decode, touch Analysis > Decode, or press Decode. In the decode dialog, choose Bus 1 or Bus 2, switch the bus on, choose the protocol and set the signals in the same way, then configure the protocol. Two buses can be decoded at once. Bus Display chooses how the result is shown (binary, decimal, hexadecimal or ASCII) and where the bus sits on the screen, and Result List sets the list.

The signal settings for the trigger and for the decode are independent. To synchronise them, use Protocol Copy in the decode dialog: copy the decode settings to the trigger, or the trigger settings to the decode. The copy is not automatic, so it has to be repeated whenever one of them changes.

The waveform display shows the original waveforms of the bus signals, the bus display shows the decoded result, and the list shows the results of several frames, each row with a time label. A red point at the end of a segment on the bus means there is not enough room to show the whole frame. Time in the list is the offset of the start of the frame from the trigger position.

I²C

Signals

Connect the serial clock (SCL) and serial data (SDA) lines, assign them to channels and set the threshold of each.

Trigger

Open Trigger Setting in the I²C dialog and choose the condition.

- Start: SDA goes from high to low while SCL is high.
- Stop: SDA goes from low to high while SCL is high.
- Restart: another start occurs before a stop.

- No Ack: SDA is high during an acknowledge bit of SCL.
- EEPROM: looks for the EEPROM control byte 1010xxx on the bus, followed by a read bit and an acknowledge bit. Set the data value and the compare type in Data1 and Limit Range; if the EEPROM data is greater than, less than or equal to Data1, it triggers on the edge of the acknowledge bit after the data byte. The data byte need not follow the EEPROM.
- 7 Address & Data: triggers on a read or write frame in 7-bit addressing. A frame is start, 7-bit address, read/write, acknowledge, and optionally data, acknowledge and a second data byte.
- 10 Address & Data: the same for 10-bit addressing, where the first byte carries part of the address.
- Data Length: triggers when the length of the data in bytes equals the value and the address length matches.

For the address conditions, the address can be set from 0x00 to 0x7F (7-bit) or 0x3FF (10-bit); 0xXX or 0xFFFF ignores the address. Data1 and Data2 can be 0x00 to 0xFF, and 0xXX ignores the data. The read/write bit can be Write, Read or Don't Care. The data length is 1 to 12 bytes, and the address length is 7 or 10 bits.

Decode

The address is shown at the start of a frame, write addresses in green and read addresses in yellow. The read/write bit follows as (W) or (R). A mark after a byte shows acknowledged or not acknowledged. Data is shown in white. The list has the columns Time, Address, R/W and Data. The one configuration option, Include R/W Bit, decides whether the address is shown with the read/write bit as part of it or separately: address 0x4E with write and acknowledge is shown as 0x4E (W) when it is not included, and as 0x9C when it is.

SPI

Signals

Connect CLK, MOSI, MISO and CS, assign them to channels and set the thresholds. For CLK, set the edge that latches data: Rising when the falling edge of the clock is aligned with the data, Falling when the rising edge is.

Set the CS type. Active High needs a complete rising edge of CS on the screen to be active, and Active Low needs a complete falling edge. Clock Timeout needs no source or threshold for CS: its only parameter is the time the clock must be idle before the instrument accepts valid data. It suits an unconnected CS, or an instrument with too few channels.

To choose a timeout, measure with the cursors. Suppose the clock is idle for 505 μ s between frames and clock pulses are 0.5 μ s apart: any timeout between those works, such as 4.5 μ s. If the data width is more than 8 bits, the idle time between 8-bit packets sets the lower limit. With 5.05 μ s between packets, a value between 5.05 and 500 μ s works.

Trigger

The condition is about the data. Choose MISO or MOSI, and a position type: Any triggers on the specified data wherever it is, and Value triggers on the data from the start bit. Set the start bit, the data length (4 to 96 bits when the start bit is 0), the value, and the bit order, MSB or LSB. The data value is set on the keypad, or All Same sets every bit to 0, 1 or ignored (X).

Decode

Similar to I²C. In the protocol configuration, set the data length (4 to 32 bits) and the bit order.

UART

Signals

Connect RX and TX, assign them to channels and set thresholds. In the bus configuration set the baud rate (600, 1200, 2400, 4800, 9600, 19200, 38400, 57600 or 115200 b/s, or Custom), the data length (5 to 8 bits), the parity (None, Odd, Even, Mark or Space; with 9 data bits the ninth is treated as mark or space parity), the number of stop bits, the idle level and the bit order.

Trigger

Choose RX or TX, and the condition.

- Start: the start bit appears on RX or TX.

- Stop: the stop bits appear. It always triggers on the first stop bit.
- Data: choose =, > or < and set the value, 0x00 to 0xFF.
- Error: the instrument checks the parity of the data against the type you set, and triggers if it is wrong.

Decode

Configured like I²C.

CAN

Signals

Connect CAN_H and CAN_L, assign them to channels and set thresholds. The baud rate can be 5, 10, 20, 50, 100, 125, 250, 500 or 800 kb/s, 1 Mb/s or Custom.

Trigger

- Start: the start of a frame.
- Remote: a remote frame with the ID you set. Set the ID, the ID bits (11 or 29) and the current ID byte (1st to 4th), which is the byte the Universal knob adjusts.
- ID: a data frame with the ID you set.
- ID + Data: a data frame with the ID and data you set, using Data1 and Data2 as well.
- Error: an error frame.

Decode

On the bus, the ID is green, the data length yellow, the data white and the CRC blue. The list has the columns Time, Type (D for a data frame, R for a remote frame), ID (11 or 29 bits, detected automatically), Length, Data, CRC and Ack.

LIN

Signals

Connect the LIN signal and set its threshold. The baud rate can be 600, 1200, 2400, 4800, 9600 or 19200 b/s, or Custom.

Trigger

- Break: the beginning of a frame.
- ID: a frame with the ID you set, 0x00 to 0x3F.
- ID & Data: a frame with the ID and data you set, using Data1 and Data2.
- Data Error: when a data error occurs.

Decode

On the bus, the ID is green, the length and checksum blue and the data white. The list has the columns Time, ID, Data length, ID Parity, Data and Checksum.

15 Cursors

Cursors give fast measurements in both directions. The types are X1, X2 and X1-X2, which mark time (or frequency) on the horizontal axis, and Y1, Y2 and Y1-Y2, which mark amplitude on the vertical axis, on a chosen waveform: channels 1 to 4, math traces F1 to F4, or a reference. Press Cursors, or choose Cursors > Menu, to open the dialog.

The dialog

- Turns the cursors on and off, and selects the cursor mode.
- Selects which cursor is active and sets its position, by gesture, Universal knob or keypad.

- Selects the cursor type (horizontal, vertical, or both), in Manual mode only, and the source.
- Sets the display style of the cursor text, and the reference for the X cursors (Delay or Position) and for the Y cursors (Offset or Position; Manual mode only).

Cursor mode

- Manual: you set the cursor positions, and the type can be horizontal, vertical, or both.
- Track: the type is set to horizontal plus vertical. Only the horizontal cursors are adjustable; the vertical cursors attach themselves to the point where the cursor crosses the source waveform.
- Measure: the cursors mark the item being measured automatically.

Cursor type

- X: vertical dotted lines that measure time. With an FFT waveform as the source, X cursors measure frequency. X1 is the left line by default and X2 the right, and each can be moved anywhere. X1-X2 is the difference, and turning the Universal knob with it selected moves both together.
- Y: horizontal dotted lines that measure voltage or current, depending on the unit of the channel, or the unit of the math function. Y1 is the upper line by default and Y2 the lower. Y1-Y2 is the difference, and it moves both together in the same way.
- X+Y: both sets are on.

Display mode

Following attaches each cursor's position to the cursor, and shows the difference between the two with arrows, which is more intuitive. Fixed shows the positions and the difference in one region of the screen, which you can drag out of the way of the waveform, and is more concise.

Cursor reference

The reference decides what stays fixed when the scale changes.

- X cursors, Fixed Delay: the cursors keep their values when the timebase changes. Fixed Position: they keep their place on the grid.
- Y cursors, Fixed Offset: the cursors keep their values when the vertical scale changes. Fixed Position: they keep their place on the grid.

For example, with a timebase of 50 ns/div, X1 at -50 ns (-1 division) and X2 at 100 ns (2 divisions), changing to 100 ns/div gives different results. With Fixed Position, the cursors stay at -1 and 2 divisions, and read -100 ns and 200 ns. With Fixed Delay, they stay at -50 ns and 100 ns, and move to -0.5 and 1 division.

Selecting and moving cursors

You can select and move a cursor by gesture, with the Universal knob, or in the dialog.

- Gestures: touch the cursor and drag it. In Following mode, touching and dragging the ΔX or ΔY area moves both cursors at once, as the X1-X2 or Y1-Y2 type does.
- Universal knob: turn it to move the cursor and press it to select a different line. With X1 selected, pressing selects X2, and pressing again selects X1-X2.
- Dialog: touch the cursor value, then turn the Universal knob.

Gestures move a cursor quickly but not precisely, and the knob moves it precisely but not quickly. Make the rough adjustment by gesture and the fine adjustment with the knob.

16 Measurements

The automatic measurement list needs no cursors, and includes common measurements such as rise time, fall time, peak-to-peak and period. The instrument can measure several channels at the same time and show up to five parameters with statistics. For more parameters on one channel, use Simple mode. To measure a part of the waveform, use the Gate.

Some parameters, such as the mean, are generated from all the data in a frame. Others, such as the period, accumulate every measurement in a frame, but the value displayed is always the first. To see how a parameter is distributed across a frame, use statistics.

The measure dialog

Press Measure, or choose Measure > Menu. The dialog holds:

- Measure on and off.
- The mode, Simple or Advanced. Simple shows the chosen basic parameters of the selected channel. In Advanced you add parameters one at a time.
- Config: the gate, the amplitude strategy and the threshold.
- Type, to select parameters, and Clear, to remove all of them.
- Tools: trend, track and measure cursors.
- Statistics on and off, and the statistics settings: count limit, AIM limit, reset and histogram.
- The result style: embedded or floating.

Adding parameters

Touch Type in the dialog, or touch the measurement area, to open the parameter window. Choose the source first, then a tab (Favorite, Vertical, Horizontal, Miscellaneous or CH Delay), then the parameter. A highlighted parameter is active, and touching it again closes it. To measure Pk-Pk on C1 and Period on C2: Source > C1 > Vertical > Pk-Pk, then Source > C2 > Horizontal > Period.

A delay measurement has more than one source, so the steps differ. Choose the channel for Source A, then the channel for Source B, then the parameter. For the skew between C1 and C2: Source A > C1 > Source B > C2 > Skew.

Each parameter then appears below the grid. Touch + in the empty area to add one, – in a parameter's corner to close it, × in the area's corner to close measurement, or Clear in the dialog to close all.

The Favorite tab keeps up to 20 frequently used items. Long-press an item to add it or remove it. For example, Advanced > Type > Vertical > Pk-Pk > Add to favorite, and Advanced > Type > Favorite > Period > Delete from favorite.

Vertical parameters

Nineteen parameters.

Parameter	What it measures
Max	The highest value in the waveform
Min	The lowest value
Pk-Pk	The difference between the maximum and the minimum
Top	The most probable higher state in a bimodal waveform
Base	The most probable lower state in a bimodal waveform
Amplitude	Top minus base in a bimodal waveform; otherwise maximum minus minimum

Parameter	What it measures
Mean	The average of the data values
Cycle Mean	The average over the first cycle
Stdev	The standard deviation of the data
Cycle Stdev	The standard deviation over the first cycle
RMS	The root mean square of the data
Cycle RMS	The root mean square over the first cycle
Median	The value with half the data above it and half below
Cycle Median	The median of the first cycle
Overshoot (FOV)	Overshoot after a falling edge: $100\% \times (\text{base} - \text{min}) / \text{amplitude}$
Overshoot (ROV)	Overshoot after a rising edge: $100\% \times (\text{max} - \text{top}) / \text{amplitude}$
Preshoot (FPRE)	Preshoot before a falling edge: $100\% \times (\text{max} - \text{top}) / \text{amplitude}$
Preshoot (RPRE)	Preshoot before a rising edge: $100\% \times (\text{base} - \text{min}) / \text{amplitude}$
L@T	The level at the trigger position

Horizontal parameters

Seventeen parameters.

Parameter	What it measures
Period	The time between the middle threshold points of two consecutive like-polarity edges
Freq	The reciprocal of the period
Time@max	The first time of the maximum value
Time@min	The first time of the minimum value
+Width	From the middle threshold of a rising edge to that of the next falling edge
-Width	From the middle threshold of a falling edge to that of the next rising edge
+Duty	Positive duty cycle: the positive width divided by the period
-Duty	Negative duty cycle: the negative width divided by the period
+BWidth	From the first rising edge to the last falling edge, at the middle threshold
-BWidth	From the first falling edge to the last rising edge, at the middle threshold
Delay	From the trigger to the first transition at the middle threshold
T@M	From the trigger to each rising edge at the middle threshold
Rise Time	The duration of a rising edge from the lower threshold to the upper threshold
Fall Time	The duration of a falling edge from the upper threshold to the lower threshold
10-90% Rise	The duration of a rising edge from 10% to 90%
90-10% Fall	The duration of a falling edge from 90% to 10%

Parameter	What it measures
CCJ	The difference between two continuous periods

Miscellaneous parameters

Sixteen parameters.

Parameter	What it measures
+Area@DC	The area of the waveform above zero
-Area@DC	The area below zero
Area@DC	The area of the waveform
AbsArea@DC	The absolute area of the waveform
+Area@AC	The area above the average
-Area@AC	The area below the average
Area@AC	The area above the average minus the area below it
AbsArea@AC	The area above the average plus the area below it
Cycles	The number of cycles in a periodic waveform
Rising Edges	The number of rising edges
Falling Edges	The number of falling edges
Edges	The number of edges
Ppulses	The number of positive pulses
Npulses	The number of negative pulses
PSlope	The slope of the rising edge
NSlope	The slope of the falling edge

Delay parameters

Fourteen parameters, for the time difference between two channels.

Parameter	What it measures
Phase	The phase difference between two edges
Skew	The time of a source A edge minus the time of the nearest source B edge
FRFR	First rising edge of A to the following first rising edge of B, at the middle threshold
FRFF	First rising edge of A to the following first falling edge of B
FFFR	First falling edge of A to the following first rising edge of B
FFFF	First falling edge of A to the following first falling edge of B
FRLR	First rising edge of A to the last rising edge of B
FRLF	First rising edge of A to the last falling edge of B
FFLR	First falling edge of A to the last rising edge of B
FFLF	First falling edge of A to the last falling edge of B

Parameter	What it measures
Tsu@R	Data setup time before the clock rising edge
Tsu@F	Data setup time before the clock falling edge
Th@R	Data hold time after the clock rising edge
Th@F	Data hold time after the clock falling edge

Trend

After adding a parameter, a trend plot shows how its value changes over time. The plot has the current, maximum, minimum, average and count values, a control to reduce the time range, and a reset. Pressing Clear Sweeps, touching Reset Statistics in the measure dialog, or touching the reset symbol in the statistics area clears and restarts it.

Track

With Track on, the value of a horizontal parameter, such as frequency or rise time, is plotted against time within one frame. The upper limit of the number of values in a frame is set in Statistics Setting > AIM Limit; values over the limit are not shown in the plot.

Statistics

Statistics are based on the total number of captured waveforms. In roll mode they increase with time. Touch Statistics Setting in the dialog to open the configuration:

- Count limit: the maximum number of samples, from 0 to 1024, or unlimited. With a limit, once the maximum N is reached only the latest N measurements are counted, and only the first period value of each frame is counted. Without one, the count accumulates.
- AIM limit: the upper limit of the number of values counted in a frame, 1 to 25,000. It applies only when the count limit is unlimited.
- Reset, which is the same as Clear Sweeps, and the histogram on and off.

For each selected parameter the statistics show Value (the current measurement), Mean, Min, Max and Stdev (of all historical measurements), and Count. When a trace under test is clipped, an overflow indicator appears after the value, showing whether it is clipped at the top, at the bottom, or both.

Statistics histogram

With statistics on, a histogram can be added at the bottom of the statistics area, to show the probability distribution of the parameter. Its colour follows the measurement source: channel 1 is yellow, and so on. Touch a parameter's histogram to enlarge it. You can drag the enlarged window around the display, and touch another histogram to switch to it. The horizontal axis is the measured value and the vertical axis is the probability, with the current value in red, and the window shows the count, the current value, and the bin that holds the maximum, with its probability.

Simple measurements

Simple mode shows all the selected parameters of one channel at once. The text colour follows the source: yellow for channel 1, purple for channel 2, and so on.

Gate

To measure only part of the signal in time, turn on the Gate. Two cursors, A and B, appear in the grid and the gate dialog opens. The instrument measures only the data between A and B and ignores the rest. The gate cursors are set like ordinary cursors (chapter 15). A gate can, for example, isolate the trough of an amplitude-modulated waveform for a Pk-Pk measurement.

Amplitude strategy

Choose how the amplitude is calculated to suit the signal, for more accurate top and base values. Open it with Config > Amplitude Strategy.

- Amplitude: Auto selects the strategy from the signal.
- Top: Histogram counts the values in the upper half of the waveform and takes the most probable as the top. Max takes the maximum.
- Base: Histogram counts the lower half and takes the most probable as the base. Min takes the minimum.

Threshold

Measurement thresholds can be set to suit the signal, which is more flexible than fixed ones: for example a pulse width at a chosen level rather than 50%, or a rise time between chosen lower and upper levels rather than 10% and 90%. Changing them can change Period, Frequency, widths, duty cycles, delay, T@M, rise and fall times, CCJ, the counts of cycles, edges and pulses, and the delay measurements. Open it with Config > Threshold, choose the source, the type, and the upper, middle and lower values.

- Percent: set as a percentage of the waveform, 1% to 99%, with the lower not above the middle and the upper.
- Absolute: set against the vertical range, which depends on the vertical scale, offset and probe attenuation, so set those first. The values are limited to the range of the screen, and a threshold above or below the waveform may make the measurement invalid.

Hardware frequency counter

The hardware counter is separate from the Frequency parameter. The Frequency parameter is measured in software, and its accuracy depends on the sample rate: the lower the rate, the worse it is, and below twice the input frequency the result is wrong. The hardware counter takes the trigger signal directly into a hardware counter, which gives seven-digit accuracy without that limit. Its result is always shown at the top right of the display. Chapter 21 describes the counter analysis tool, which is separate again.

17 Math and FFT

The instrument has four math traces, labelled F1 to F4, which can be measured with cursors and used as the source of automatic measurements. The operators are:

- Arithmetic: addition, subtraction, multiplication, division, average, ERES, identity, negation, max-hold and min-hold.
- Algebra: differential (d/dt), integral ($\int dt$), square root, absolute, sign, exp, ln, lg and interpolate.
- FFT, a filter, and a formula editor.

Press Math, or touch + in the descriptor box region and choose F1 to F4, to open the math dialog. It has the trace, on and off, the function (touch it to choose the source and operator), the vertical scale and position, the label, visible or hidden, and invert.

Units

The unit of the scale depends on the operation.

Operation	Unit
Addition or subtraction	V, A, or U when the two sources have different units
Multiplication	V^2 , A^2 or W
Division	None, Ω or S (siemens)
FFT	dBVrms, Vrms, dBArms, Arms or dBm
Identity or negation	V, A
d/dt	V/s or A/s
$\int dt$	V·s or A·s
Square root	$V^{0.5}$ or $A^{0.5}$
Absolute, sign, exp, exp10, ln, lg, interpolate	V, A

Arithmetic

- Addition, subtraction, multiplication and division work on any two analogue channels, point by point (for example $F1 = C1 + C2$).
- Identity and negation work point by point on one source (for example $F1 = -C1$).
- Average averages the waveform over several acquisitions to reduce random noise: the higher the count, the less noise.
- ERES filters the sample points to reduce random noise in the bandwidth and improve the signal-to-noise ratio.
- Max-hold and min-hold keep the largest or smallest value over multiple frames.

Algebra

- Differential gives the derivative of a source, and is used to find the instantaneous slope of a waveform, such as the slew rate of an amplifier. It is calculated from the values a set interval apart, and the interval can be set from 4 to the number of sample points.
- Integral integrates the waveform on the screen or within a gate. An Offset setting corrects a small DC offset in the source or the instrument, which would otherwise make the integral ramp up or down. To integrate within a gate, touch Gate in the math dialog, switch it on and set Gate A and Gate B.
- Square root: a negative waveform value is shown as zero.
- Absolute, and sign, which is -1 for a negative value, 0 for zero and 1 for a positive value.
- Exp gives e to the power of the value, or 10 to the power of it (exp10). Ln and lg are the logarithms to base e and base 10, and a negative value is shown as zero.
- Interpolate fills in between adjacent samples by the interpolation method set under Acquire > Menu > Interpolation. The coefficient can be 2, 5, 10 or 20.

Filter

The filter is a FIR filter with up to 200 taps and a roll-off as fast as 0.01 times the sample rate. The types are low pass, high pass, band pass and band reject. Set the type and the corner frequency, or the lower and upper frequencies for band pass and band reject, and the instrument calculates the coefficients. The attenuation at a corner frequency is about 3 dB.

A real filter rolls off gradually, and the limited number of taps limits where a corner can be set for a given sample rate. For a low pass filter the corner frequency f_c must be at least $0.01 \times$ the sample rate f_s , and the roll-off must not pass the first Nyquist zone: $(f_s/2) - f_c \geq 0.01 f_s$. At 5 GSa/s the legal range is 50 MHz to 2450 MHz. If the corner you want is outside the range at the current rate, change the rate: at 1 GSa/s a corner of 5 MHz is illegal, and the rate must be lowered to 500 MSa/s.

Adapt Sample Rate lets the instrument set the rate itself. It forces the memory management to Fixed Sample Rate and adjusts the rate to suit the corner. It is recommended unless you know FIR filters. Keep the rate sensible: with a very low corner it may fall below twice the highest input frequency.

FFT

The FFT shows the frequency spectrum of the source. The horizontal axis is in hertz, and the vertical axis can be logarithmic (dBVrms, dBArms or dBm). Choose FFT as the function in the math dialog.

The parameters shown

- S_a , the FFT sample rate. The result is the first Nyquist zone, DC to $S_a/2$. It may not equal the time-domain rate. With the maximum points set to 2 Mpts and fewer points than that in the time domain, the FFT uses the nearest power of 2 and the rates are equal. With more, it first decimates by D and takes the first 2 Mpts, and S_a is the time-domain rate divided by D . For example, 10 Mpts at 2 GSa/s is decimated by 4 to 2.5 Mpts, and the first 2 Mpts are used, so S_a is 500 MSa/s.
- Curr, the current FFT points, a power of 2, up to 2,097,152.
- Δf , the frequency interval between adjacent points, which sets the resolution.
- Avg, the completed average count, shown in Average mode.
- RBW, the resolution bandwidth: the 3 dB bandwidth of the window's response, which depends on the record length and the window.

Configuration

Touch Config. Set the maximum points (2 to the power n , with n from 10 to 21); the window; whether to set the horizontal axis to the full span, 0 to $f_s/2$, and the centre frequency to the largest component of the previous frame; the display mode (Split, Full Screen or Exclusive); the FFT mode (Normal, Average or Max-Hold); and, for Average, the count and a reset.

Windows

A window reduces spectral leakage. For two tones very close in frequency, use Rectangle, which has the best frequency resolution. When amplitude accuracy matters most, use Flattop, which has the best amplitude resolution.

Window	Main lobe	Side lobe	Max error	Characteristics
Rectangle	$4\pi/N$	-13 dB	3.9 dB	The best frequency resolution and the worst amplitude resolution; the same as no window
Hanning	$8\pi/N$	-32 dB	1.4 dB	Better frequency resolution, poor amplitude resolution
Hamming	$8\pi/N$	-43 dB	1.8 dB	Better frequency resolution, poor amplitude resolution
Blackman	$12\pi/N$	-58 dB	1.1 dB	Poor frequency resolution, better amplitude resolution
Flattop	$23\pi/N$	-93 dB	< 0.1 dB	The worst frequency resolution and the best amplitude resolution

Display mode

- Split: the time-domain waveform is in the upper half and the spectrum in the lower. With Zoom on, the zoomed waveform and the spectrum share the lower half.

- Full Screen: both are shown together.
- Exclusive: only the spectrum is shown.

FFT mode

- Normal shows the FFT of each frame directly.
- Max-Hold holds the maximum value over earlier frames until cleared. It suits sporadic pulses and frequency hopping. Clear Sweeps clears it.
- Average reduces random noise on the signal. The count is 4 to 1024. Clear Sweeps, or Reset in the dialog, restarts the count.

Vertical and horizontal settings

Touch Vertical for the scale, the reference level and the unit (dBVrms, Vrms or dBm). dBVrms is recommended for a large dynamic range, and Vrms is linear. dBm is a power unit, and gives the correct result only when Ext Load matches the load impedance of the signal. Scale and reference level can also be set with the vertical knobs shared by decode, digital, math and reference, and scaling is about the reference level.

Touch Horizontal for the sweep mode (Linear or Decade) and the frequency settings. Center and Span, or Start and End, are related: $\text{Center} = (\text{Start} + \text{End}) / 2$ and $\text{Span} = \text{End} - \text{Start}$.

Peaks and markers

Touch Tools. Peaks searches for qualifying peaks and marks them on the spectrum, up to 10. Set the search threshold, so only peaks above it are shown, and the search excursion, the difference between a peak and the minimum on both sides, which must be exceeded. The table can be turned on, with or without frequency, and sorted by amplitude or frequency.

Markers, based on the same search, can mark peaks or mark each harmonic automatically, up to 8, and you control each marker's position. The table, the frequency display and the delta display can be switched on and off. The FFT dialog is longer than the display, so slide it up and down.

Measuring the spectrum

Press Cursors and set the source to Math: X1 and X2 then measure frequency. Only the maximum parameter of the FFT is available in automatic measurement. A DC component can show a large amplitude near 0 Hz; if you do not need it, set the source channel to AC coupling.

Formula editor

Touch Formula Editor on the operation page. The editor has a formula text box, controls to clear and edit it, special operators, the sources (Cx for an analogue trace, Zx for a zoom trace, Fx for a math trace), the basic operators (+, -, *, /) and a confirm button, which applies the formula. An example is $F1 = (3 * C1) + 1V$.

Operations can be nested. $F1 = d(C1)/dt$ and $F2 = \text{FFT}(d(C1)/dt)$ are equivalent to $F2 = \text{FFT}(F1)$, which is an FFT of the differential of channel 1.

18 Reference waveforms

Data from an analogue channel or a math trace can be saved to a reference location, REFA, REFB, REFC or REFD, in the built-in non-volatile memory, and recalled to compare with the current waveform. Press Ref, or touch + in the descriptor box region and choose Ref, to open the dialog.

- Select the location, REFA to REFD, and the source (C1 to C4 and math).
- Turn the display of the reference on and off, set its label, and show or hide the trace.
- Save stores the chosen source in the chosen location.

A reference has its own descriptor box. Set its vertical position with the offset knob and its vertical scale with the scale knob.

19 Search and navigate

Search

The instrument can search a frame for events you specify, and shows each with a white triangle. In YT mode, or in roll mode with acquisition stopped, up to 1000 events are supported; in roll mode with acquisition running, the number is unlimited. The waveform can be zoomed while search is on. A figure shows the total number of events; when stopped, the figure shows the index of the current event over the total, and the current event is the one in the centre of the display.

Choose Analysis > Search to open the dialog and turn it on. Choose the search type in Setup. There are five.

Type	Setup
Edge	Slope: rising, falling or either
Slope	Slope: rising or falling. Limit range is available
Pulse	Polarity: positive or negative. Limit range is available
Interval	Slope: rising or falling. Limit range is available
Runt	Polarity: positive or negative. Limit range is available

The setup is like the matching trigger type (edge, slope, pulse, interval and runt; chapter 13).

Copy

- Copy from Trigger makes the search settings the same as the trigger settings.
- Copy to Trigger makes the trigger settings the same as the search settings.
- Cancel Copy undoes the last copy.

Copy from Trigger has no effect if the trigger type is one that search does not support.

Navigate

Choose Analysis > Navigate. There are three types.

- Time: the instrument adjusts the trigger delay in the direction you set. Set the time with the Universal knob or the keypad, or use the play backward, stop and play forward keys. Pressing backward or forward more than once speeds up playing, with three speeds: low, medium and high.
- Search Event: with search on and acquisition stopped, navigate steps through the search events. Set the event number, or press the backward and forward keys to go to the previous or next event, and set the playing mode and the interval time. The event list, when on, gives a time label for each event, and touching a row jumps to it.
- History Frame: with history on, navigate plays the history frames. Set the frame number, use the backward, stop and forward keys, and set the list time type, playing mode and interval time.

Example: finding an occasional runt

A 5 V square wave has, every 20 ms, a pulse one third of the normal height. Set the trigger type to Runt to trigger on it. Turn on Search and use Copy from Trigger so the instrument searches by the same settings. At 10 ms/div, five markers about 20 ms apart show that five such pulses are in the 100 ms screen. Turn on Zoom to see the full frame and the detail of the third pulse together. Press Run/Stop to stop, then choose Navigate > Type > Search Event to step through them, with the list on to show their time labels.

20 Mask test

Mask test lets you create a mask and define the rule that decides pass or fail. An event that breaks the rule is a failure, and a pulse can be sent from the auxiliary output on the rear panel, which is useful for finding and counting anomalies

in production tests and similar batch measurements. The test is done in hardware, at up to 80,000 frames a second. When pass/fail is on, the auxiliary output automatically switches to the pass/fail pulse.

On the screen the mask is green and any point that breaks the rule is drawn in red instead of the normal waveform colour. An information area shows the number of frames that passed, the number that failed, the total, and the fail rate.

The mask test dialog

Choose Analysis > Mask Test.

- Test on and off, and the source (C1 to C4; zoom traces can also be used).
- The rule: All In, All Out, Any In or Any Out.
- Mask Setup, and Operation, which starts and stops the pass/fail test. Stopping a test in progress stops the counters at once. Starting it again clears them all. Clear Sweeps does the same.
- The information display on and off.
- Stop on Fail: the instrument stops acquiring when it detects a failure.
- Capture on Fail: when a failure is detected, a screenshot of the failing frame is saved to the external USB flash drive.
- A sound prompt on a failure, on or off.

The pass/fail rule

- All In: every data point must be inside the mask to pass. One point outside is a failure.
- All Out: every data point must be outside the mask to pass. One point inside is a failure.
- Any In: any data point inside the mask is a pass. Every point outside the mask is a failure.
- Any Out: any data point outside the mask is a pass. Every point inside the mask is a failure.

Setting up the mask

Touch Mask Setup. There are two ways to make a mask: by setting horizontal and vertical values, or by drawing a polygon. You can also load a mask you saved earlier.

Create Mask

This builds a mask around the trace currently displayed. Set the horizontal spacing (Mask X) and the vertical spacing (Mask Y) around the trace, as fractions of a division, from 0.04 to 4.00 division, then touch Create Mask. A mask with X and Y of 0.2 division is a tight band round the trace, and a mask of 1 division is a wide one. Save it to keep it. Mask files are saved and recalled like setup files (chapter 26).

Mask Editor

The Mask Editor draws custom masks. It has a menu bar with File and Edit menus, the coordinates of the last point touched, the mask edit area (equivalent to the grid), a toolbar, and an area to enter X and Y coordinates, which you apply with Set Point. Buttons show or hide the coordinates of the polygon vertices and exit the tool.

- File menu: New, Open, Save, Save As and Exit. The Edit menu holds the same functions as the toolbar.
- Toolbar: Draw, to make the vertices of a polygon by touching the display or entering values; Create Polygon, to make a polygon from the vertices; Undo; Redo; Insert Point, to add a vertex on a selected side; Edit Polygon; and Delete Polygon.

To edit a vertex, side or polygon, select it, and then drag it or enter a value. For a side, the value is for its midpoint. For a polygon, it is for its geometric centre.

A mask made with Create Mask cannot be recalled by the Mask Editor.

21 Counter

The counter measures the frequency or period of a signal, or counts the events in it. It runs asynchronously to the acquisition system, so it keeps working when acquisition is stopped, which is shown by a red Run/Stop key. Choose Analysis > Counter to open the dialog.

- Counter on and off, and the mode: frequency, period or totalizer.
- The source, C1 to C4, and the counter level.
- Statistics on and off, and a reset. Clear Sweeps does the same.

Modes

- Frequency: the average frequency over a set period.
- Period: the reciprocal of the average frequency over a set period.
- Totalizer: a cumulative count. Set the edge of the counting source. With the gate on, the counter counts only while the gate source meets the conditions.

The counter resolves frequency to seven digits.

Statistics

With statistics on, each count adds to the data and the results appear on the screen: Value (the latest count), Mean, Min, Max, Stdv (the standard deviation, which shows how the counts are distributed), Count and Level.

Gate

Touch Gate Setting in totalizer mode. Switch the gate on and choose the gate type, Level or After Edge. The gate sources are paired: C1 and C2 are gate sources for each other, and so are C3 and C4. With a level gate, set the polarity of the gate source, positive or negative; with an edge gate, set the slope, rising or falling. Set the gate level.

22 Power analysis (option)

Power analysis helps with the design and debugging of switching power supplies. It calculates power quality, current harmonics, inrush current, switching loss, slew rate, modulation, output ripple, turn on and turn off, transient response, PSRR, power efficiency and the safe operating area (SOA). It is an option, enabled by a software licence (chapter 3).

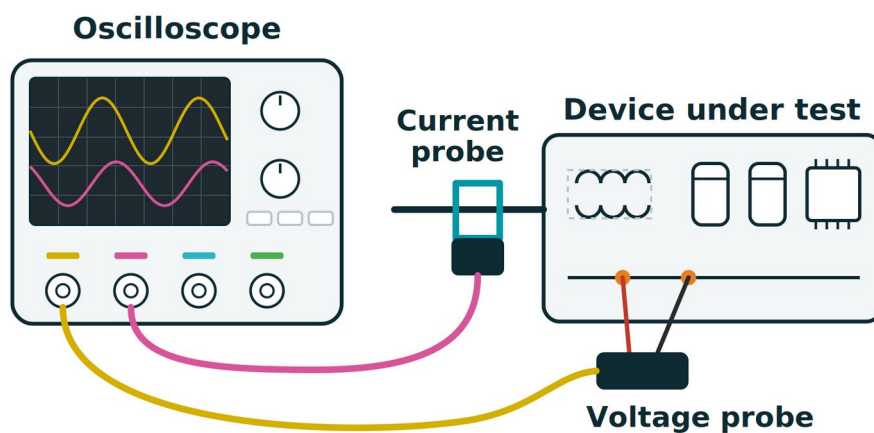


Figure 8 Power analysis: a voltage probe across the circuit and a current probe on a conductor. Schematic

Choose Analysis > Power Analysis. The dialog turns the test on and off, selects the analysis item, turns the item's state on and off, sets the input source, and selects the analysis type. For most items, Input Setup holds the source settings

and a Connection Guide, a diagram on the screen that shows how to connect the probes. Follow it, and close it with the icon at its top right.

Power quality

Measures the power input of a switching supply: active power, apparent power, reactive power, power factor, power phase angle, voltage and current r.m.s. values, and voltage and current crest factors.

- Power: active power P , apparent power $S = V_{rms} \times I_{rms}$, reactive power $Q = \sqrt{S^2 - P^2}$, the phase angle between voltage and current, and the power factor, which is the ratio of active to apparent power.
- Voltage Crest: the voltage crest, the r.m.s. value, and the crest factor, which is the peak divided by the r.m.s.
- Current Crest: the same for current.

In Input Setup set the voltage source, the current source and the periods displayed, and view the connection guide.

Current harmonics

Analyses the harmonics of the input current by an FFT of the selected channel. The signal settings and connection guide are as for power quality. Touch Config to set the line frequency (Auto, 50 Hz, 60 Hz or 400 Hz), the standard (IEC 61000-3-2 class A, B, C or D) and the display (Off, Bar Chart or Table).

The standard limits harmonic currents from the second to the fortieth. Class A is balanced three-phase equipment, household appliances not in class D, tools other than portable ones, dimmers for incandescent lamps, audio equipment, and anything not in another class. Class B is portable tools and non-professional arc welding equipment. Class C is lighting. Class D is PCs, PC monitors, and radio or TV receivers, with input power up to 600 W.

For each of the first 40 harmonics the instrument shows the measured value, the limit value, and the margin, which is $(\text{standard value} - \text{measured value}) / \text{standard value} \times 100\%$. Rows or bars are coloured by pass or fail, and a value between 85% and 100% of the limit is critical. The total harmonic distortion is also shown: $100\% \times \sqrt{(X_2^2 + X_3^2 + \dots + X_n^2) / X_1^2}$, where X_n is the n th harmonic and X_1 the fundamental.

Inrush current

A current far larger than the steady value can flow at the instant a supply is switched on. In Input Setup set the voltage and current sources, the expected current (100 mA to 500 A) and the maximum input voltage (1 V to 1 kV, r.m.s.). The instrument sets the trigger level to the expected current divided by 20 and the vertical scale of the current channel to the expected current divided by 3, and sets the vertical scale of the voltage channel to the maximum voltage divided by 6.

Switching loss

Calculates the power dissipated in the switching period.

Deskew

A small skew can cause a large error in switching loss, especially in the on phase, when the voltage is near zero, and when the current is near zero in the non-on phase. This is a typical dynamic-range limit of an oscilloscope measuring a weak voltage or current in the presence of a large switching voltage or current. Do the deskew once at the start, and again whenever any part of the hardware setup changes, such as a probe or a channel, or the ambient temperature changes. It uses a deskew fixture, and you should use current and voltage probes that suit it. Ask GPS which suit your setup.

- Demagnetise and zero-adjust the current probe.
- Connect the high-voltage differential probe to the fixture's signal and earth terminals.
- Connect the current probe to the loop, with the arrow showing the direction of current flow, and set the fixture's switch to the small loop or large loop to suit it.
- Connect the fixture to a USB port on the instrument or a PC. The port supplies its power.
- Connect the voltage and current probes to the instrument's input channels.

- Touch Input Setup, select the input channels, and touch Auto Deskew. A message says whether it succeeded.

Configuration

Touch Config to set the voltage reference and the current reference, the switching levels at the edge of the input switch, as percentages of the maximum switching voltage and current. Adjusting them ignores background noise or an offset that is hard to remove in the current probe. Set the conduction type.

- Waveform: uses the original data, with $P = V \times I$ and $E = P \times T$.
- Rds(on): in the on region, where the voltage is below the voltage reference, $P = I^2 \times R_{ds(on)}$; in the off region, where the current is below the current reference, $P = 0$. Set the Rds(on) resistance.
- Vce(sat): in the on region, $P = V_{ce(sat)} \times I$; in the off region, $P = 0$. Set the Vce voltage.

Slew rate

Measures the rate of change of voltage or current during switching. See the connection guide in Input Setup.

Modulation

Measures the control pulse signal of the switching device, and shows how its pulse width, duty, period, frequency and other values trend in response to different events.

Output ripple

Ripple is an important measure of the quality of a DC supply. The analysis measures the current, average, minimum and maximum values, the standard deviation and the count of the output ripple.

Turn on and turn off

Turn-on analysis finds the time for the supply to reach 90% of its steady-state output. Turn-off analysis finds the time for the output to fall to 10% of its maximum. In Input Setup set the input and output voltage sources, the input type (AC or DC), the duration (5 ns to 20 s, from which the instrument sets the timebase as the duration divided by 10), the maximum input voltage (1 V to 1 kV r.m.s.; the voltage channel is set to that divided by 7 and the trigger level to that divided by 10), and the stable output voltage (–30 V to 30 V; the output channel scale is that divided by 6).

Turn on is the time from T1, when the input voltage first rises to a percentage (usually 10%) of its maximum, to T2, when the output rises to a percentage (usually 90%) of its maximum. Turn off is the time from T1, when the input finally falls to a percentage (usually 10%) of its maximum, to T2, when the output finally falls to a percentage (usually 10%) of its maximum.

Transient response

Finds how quickly the output voltage responds to a change in load: from the first time the output leaves the stable band to the last time it enters it. In Input Setup set the output voltage and current sources, the duration, the stable output voltage and the output overshoot percentage, which sets the stable band. In Config set the low and high current values, the expected values before and after the load changes. They set the trigger level and the vertical scale, and the instrument triggers when the current changes from low to high or high to low.

PSRR

The power supply rejection ratio test shows how a regulator suppresses ripple at different frequencies. The oscilloscope controls a waveform generator to output a sweep, which introduces ripple into the DC voltage supplied to the regulator, measures the r.m.s. ratio of input to output, and plots the ratio against frequency. The oscilloscope has a higher noise floor and lower sensitivity than a network analyser, so a PSRR measured with it is difficult to take beyond –60 dB. It suits sampling the overall behaviour of the supply. The configuration is the same as the Bode plot (chapter 23).

Power efficiency

Measures the overall efficiency of the supply from the output power and the input power. It needs the input voltage, input current, output voltage and output current, so it is supported on four-channel models only.

SOA

The safe operating area of a MOSFET is the voltage, current and power conditions in which it can be expected to run without damage. The instrument generates the SOA from the Voltage Limit, Current Limit and Power Limit you set in Config, and judges whether the stress on the MOSFET is outside it, which helps find problems and latent risks. Do a deskew between the voltage and current channels first.

- In Input Setup, assign the correct channels to Input Voltage and Input Current.
- Set Duration to the time you want to observe, and the instrument sets the timebase.
- In Config set the voltage, current and power limits from the datasheet of the device under test. The instrument generates the SOA and sets the vertical scales.
- Turn on Test State. The instrument acquires the voltage and current, and shows the SOA result, which is Pass when all the stresses are inside the mask. You can adjust the horizontal, vertical and trigger settings during the test.

23 Bode plot

The instrument can plot the frequency response of a device under test automatically. It sets the output frequency and amplitude of a generator, compares the input signal with the output of the device, measures gain and phase at each frequency, and plots them. When the sweep is done you can move markers on the chart to read the gain and phase at each point, and adjust the scale and offset of the amplitude and phase plots.

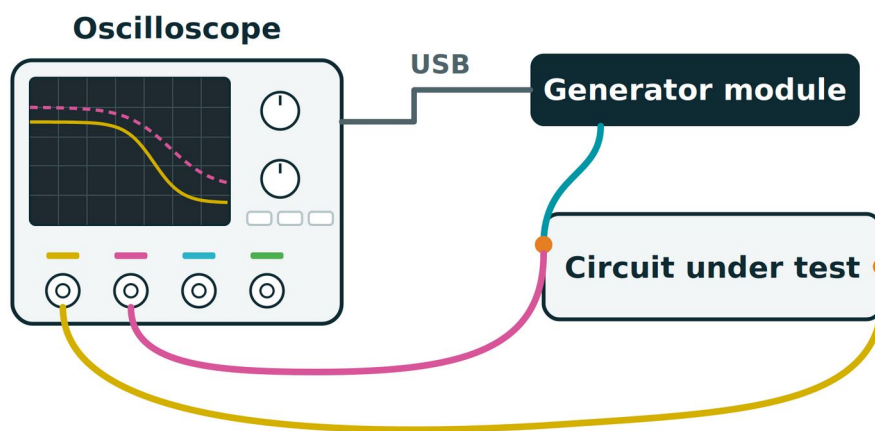


Figure 9 The Bode plot: a generator module drives the circuit, and two channels read its input and output. Schematic

Choose Analysis > Bode Plot. The dialog turns the plot on and off, configures it (the device, the generator connection and the sweep), starts the operation, sets the display, opens the data list, sets the measurement parameters, and prints the plot area to the storage.

Configuration

Connection

- The input and output channels of the device under test.
- Channel gain: Auto adapts the vertical scale to the signal amplitude, and Hold keeps the scale from before the test.
- The generator connection. Touch Interface to choose the connection. For LAN, set the IP address and save it. Touch Test to confirm the generator is connected.

Sweep

Choose the sweep type, Simple or Vari-Level.

- Continue or Single, to repeat the sweep or run it once.
- The frequency mode, Linear or Decade. For Linear set the centre frequency and span. For Decade set the start and stop frequencies.
- The number of points: more points give a finer sweep resolution.
- The amplitude and the offset of the sweep signal, and the amplitude unit. When it is dB, set the reference level and the load, and set the load.

A Vari-Level sweep varies the signal amplitude with frequency. Up to four profiles can be edited. Touch Edit to open the profile editor, set the number of nodes, and touch a cell in the table to set the frequency and amplitude of that node.

Display

- Amplitude: set the reference position (centre or top), the scale and the reference level, and the mode. Vout shows the output signal's amplitude, in Vpp, Vrms, dBV, dBu, dBm or arbitrary dB; Vout/Vin shows the ratio of output to input, on a linear or logarithmic axis. Auto-Set sets the scale and reference level from the curve.
- Phase: the reference position, scale and reference level, the unit (degree or radian) and Auto-Set.
- Cursors: on or off, the type (X or Y), the cursor (X1, X2 or X2-X1), its position and the two sources. They work like the ordinary cursors (chapter 15).
- Trace Visibility: when several outputs are connected, the plot shows the amplitude and phase curves of all of them at once, and you can turn others off to see one in detail.

Data analysis

- The data list gives the information for each point of the sweep. Turn it on, select a row with the Universal knob or by touching it, and set the data source. The data can be saved as a CSV file, and recalled from a USB flash drive (chapter 26).
- Cursors measure the curve at any position.
- Automatic measurement gives five parameters: upper cut-off frequency (UF), lower cut-off frequency (LF), bandwidth (BW), gain margin (GM) and phase margin (PM). Choose the position and the source, up to five items. For example, UF for C2 and GM for C3: Measure > Position > Source > UF, then Measure > Position > Source > GM.

24 Display

Display settings cover the waveform display type, colour, persistence, grid, trace and graticule brightness, and more. Choose Display > Menu.

Display type

There is no difference between vectors and dots when a frame has more than 1000 samples. With fewer, there is. Vectors joins the samples with lines, interpolated linearly or by $\sin(x)/x$ (see chapter 11). Dots shows the raw samples directly.

While the instrument is running, the high update rate means that what you see is the superposition of many frames. Dots then looks like equivalent sampling rather than discrete points. Stop the acquisition to see the original samples of each frame.

Colour grade

Colour grade uses colour temperature to show how probable a waveform is at each pixel. The more often the waveform falls on a pixel, the warmer its colour, and the less often, the colder.

Persistence

With persistence, the display is updated with new acquisitions but does not erase earlier ones for a period. Earlier acquisitions are shown at reduced intensity and new ones in normal colour and intensity. With the high update rate, an anomaly can often be found in a short time with infinite persistence and no complex trigger. If the display dialog and persist are off, Display > Persist turns persist on quickly, and so does a second press of the Display/Persist key.

- Off turns persistence off.
- 1 s, 5 s, 10 s or 30 s keep earlier acquisitions for that time, then clear them.
- Infinite never erases them until Clear Display or Clear Sweeps.

Grid

- Full Grid: the 8×10 grid.
- Light Grid: a 2×2 grid.
- No Grid.

Brightness

Trace intensity, LCD brightness and graticule brightness are each set from 0% to 100%.

Axis labels

With axis labels on, the horizontal labels appear at the foot of the grid and the vertical ones at its left. In Moving mode, the axes move with the waveform when you move it and the coordinates stay fixed. In Fixed mode, the axes stay put and the coordinates update as the waveform moves.

Menu style, auto-hide and font

Menu style is Embedded or Floating (chapter 7), and the menu auto-hide time hides the dialog after a period without operation. The system font is Large, for use on the instrument itself, or Small, a finer display for large-screen uses such as remote viewing. Clear Display clears all the waveforms on the screen and the persistence.

25 Waveform generator module (option)

The instrument can generate arbitrary waveforms and functions through an external USB waveform generator module, with a software licence for the option (chapter 3). The functions are:

- Six basic waveforms: sine, square, ramp, pulse, noise and DC.
- 45 built-in arbitrary waveforms.
- Output frequency up to 25 MHz, and an output amplitude from -3 V to $+3\text{ V}$.
- Output terminals isolated from the ground of the oscilloscope, with $\pm 42\text{ Vpk}$ insulation voltage.

Connect the module to any USB host port with a standard USB cable. When the connection is made, the instrument shows the message AWG device detected. Choose Utility > Wave Gen to open the dialog. The specification of the generator is in the technical datasheet.

The dialog

- Output on and off, the waveform type, and the frequency, amplitude and offset.
- Other settings: the output load, over-voltage protection and so on.
- System information and firmware upgrade.

Waveform types

Waveform	Parameters
Sine	Frequency, amplitude, offset
Square	Frequency, amplitude, offset, duty
Ramp	Frequency, amplitude, offset, symmetry
Pulse	Frequency, amplitude, offset, duty
Noise	Standard deviation, mean
DC	Offset
Arb	Frequency, amplitude, offset, arbitrary type

Arbitrary waveforms are either built-in or stored. Touch Arb Type and choose from the window, which has six tabs: the built-in waveforms are under Common, Math, Engine, Window and Trigo, and the stored ones under Stored. Stored waveforms are sent to the instrument through the remote interface, or imported from a USB flash drive.

Other settings

- Output load: it must match the load impedance, or the amplitude and offset of the output are wrong.
- OVP: with over-voltage protection on, the output switches off automatically when the absolute value at the output port exceeds $4\text{ V} \pm 0.5\text{ V}$, and a warning appears.
- Sync output: the module's auxiliary port outputs a CMOS signal at the frequency of the basic or arbitrary waveform, except noise and DC, up to 10 MHz.
- Zero adjust and default.

Zero adjust

This calibrates the output zero error, so that when the generator outputs 0 V DC, the mean value measured on the channel is within $\pm 1\text{ mV}$. There are two ways.

- Auto: connect the output of the generator to channel 1 (it works only with channel 1), and press Auto. The generator adjusts itself, and the message Zero adjust completed! appears.
- Manual: use any channel. For channel 2, connect the generator output to it, open it, set DC coupling, turn on the bandwidth limit and set the probe attenuation to 1X. Set the vertical scale to a small value such as 1 mV/div, turn on Measure and set the parameter to the mean of channel 2. Press Manual and turn the Universal knob to adjust the compensation until the mean is within $\pm 1\text{ mV}$, then press Save.

System

Device Info shows the model, serial number, firmware version and hardware version of the module. Its firmware can be upgraded from a USB flash drive:

- Copy the upgrade file to the flash drive and insert it in a USB host port.
- Touch Browse to choose the file, then Upgrade. A progress bar shows the percentage done.
- When it finishes, the module is removed from the system and the instrument prompts you to reconnect it. Open System again and check the hardware version.

Do not cut the power during an upgrade.

26 Saving and recalling

The instrument saves setups, reference waveforms, screenshots and waveform data to its internal storage, an external USB flash drive, or an SMB file share (chapter 27). Saved setups and references can be recalled.

Save types

- Setup: the default type. It records the instrument's settings.
- Reference: the reference waveform data, with its setup information such as the vertical scale, vertical position and timebase.
- Image: a screenshot, as BMP, JPG or PNG.
- Binary data: the waveform data in a binary file.
- CSV data: the waveform data as a CSV file. Para Switch decides whether to include the instrument's configuration, such as the timebase and vertical scale. Save All Channel saves every displayed waveform, or you choose a Source: C1 to C4, Z1 to Z4 or F1 to F4.
- Matlab data: waveform data that can be imported by Matlab directly, from the same sources except FFT.
- To Default Key: saves the current setup as the default setting.
- FileConverter Tool: see below.

The Default key

The Default key restores one of two settings, chosen with the Default Type. Set to the first, it restores the instrument's original defaults. Set to Current, it restores the last setting you saved with To Default Key, so a shared bench can start from your setup every time.

FileConverter

This small tool converts binary waveform files to CSV, for viewing in a spreadsheet. It is ideal for large data sets. A frame with deep memory, such as 100 Mpts, takes a long time and a lot of memory on the flash drive if saved directly as CSV, so save it as a binary file and convert it on a computer.

The file manager

The file manager works like the Windows file manager. It has an address bar, a navigation panel, a file list, a toolbar and a file type selector. The toolbar icons are: back, forward, up one level, root directory, save, recall, save as, new directory, new file, paste, copy, rename, delete and move.

Example: saving a screenshot

- Insert the USB flash drive.
- Set Mode to Save and Type to BMP. Choose the Image Style: Normal saves the colours of the display, and Inverted saves a white background, to save ink. Choose Include Menu: No saves the grid area and the descriptor boxes, and Yes saves the whole display. Choose Path Tips: Hold keeps the prompt on screen, Fade makes it disappear after a time, and None shows no prompt.
- Touch File Manager and choose the folder on the drive.
- Touch Save As, touch the text box to bring up the keyboard, type a file name and touch OK. If you touch Save instead, the instrument names the file itself with a number that increases each time, and uses the default path.

A saved picture can be viewed on the instrument by opening it in the file manager. Utility > Print saves a screenshot at once to the place where the last one was saved.

Example: recalling a setup

- Insert the flash drive with the setup file in its folder.
- Set Mode to Recall and Type to Setup, and touch File Manager.
- Choose the folder and the file, touch the Recall icon, and wait for the instrument to finish recalling the setup.

27 Utility and system settings

Most of these settings are set once and left. Choose Utility > Menu.

System information

Utility > Menu > System Info shows the system status, including the software and hardware versions.

System settings

Language

The instrument offers ten interface languages. Choose Utility > Menu > System Settings > Language and select one from the list.

Screen saver

After a period without operation, the backlight is cut off to save power. Choose Utility > Menu > System Settings > Screen Saver to set the period, or Off. Any action from the mouse, the touch screen or the front panel ends it.

Beeper

Utility > Menu > System Settings > Beeper turns the audible buzzer on and off.

Auto power-on

Utility > Menu > System Settings > Auto Power On. See chapter 3.

Date and time

The instrument has no real-time clock, so the time can be set by hand or synchronised by NTP. Open Utility > Menu > System Setting > Date/Time.

- Manual: touch the Day, Month, Year, Hour, Minute and Second fields and enter values on the keyboard, then touch the button to apply them.
- NTP: enter the server IP address and touch Sync. Choose the time zone and touch Modify Time Zone.
- Choose whether to display the date and time at the lower right of the screen, and the time format, 12 or 24 hours.

Reference position

This sets the strategy for scaling on the horizontal and vertical axes. Open Utility > Menu > System Setting > Reference Pos.

- Horizontal Ref, Fixed Delay: when the timebase changes, the horizontal delay value stays fixed, and the waveform expands or contracts about the centre of the display. Fixed Position: the delay stays fixed to its place on the grid.
- Vertical Ref, Fixed Offset: when the vertical scale changes, the offset value stays fixed, and the waveform expands or contracts about the main X axis. Fixed Position: the offset stays fixed to its place on the grid, and the waveform expands or contracts about the vertical ground position.

At 10 ns/div with a delay of –20 ns (–2 divisions), changing to 5 ns/div gives a delay of –10 ns with Fixed Position, and the delay stays –20 ns, now 4 divisions, with Fixed Delay.

Save button

Pressing Save does the specified save action. By default it saves a screenshot as a picture. Utility > Save Button sets the type, Screenshot or Save to, and the path. With Save to, the save types are those in chapter 26.

Quick Action

Pressing Quick Action does a specified action. Utility > Quick Action opens the menu where you assign it, for example to change the trigger source, or to turn colour grading on. By default Quick Action is disabled, and the first press opens its menu. It has an enable switch, a category and an action: Analysis presets the key as an analysis function switch,

Edge trigger lets it change trigger parameters such as source and slope, and Display lets it change display parameters such as colour grade and persistence.

LAN settings

Utility > Menu > I/O > LAN Config opens the dialog.

- Automatic: a dynamic IP address. The instrument must be on a network with a DHCP server. Ask your network administrator.
- Without Automatic, the instrument uses a static IP address: set the address, subnet mask and gateway.
- If the network provides dynamic DNS, the instrument can register its host name and use a DNS server. Otherwise set the DNS address by hand.
- To control several instruments through a web browser, give each a different VNC port number, from 5900 to 5999.

Software options

Utility > Menu > Software Options installs options (see chapter 3). An option that is not activated shows a licence type of Temporary, which can be tried up to 30 times. Enter the key in the key field and touch Install, or put the licence in the root directory of a USB flash drive to install it automatically.

Maintenance

Upgrade

The firmware can be upgraded from a USB flash drive that holds the correct upgrade file. Open Utility > Menu > Maintenance > Upgrade, touch Browse, select the file and touch the Recall icon, then touch Upgrade. The instrument copies the file to its memory and parses it. If that succeeds, you can Cancel, or Reboot to continue at once; otherwise it restarts by itself to finish. After the reboot, check the version number in System Info.

Do not turn the power off during an upgrade. The instrument may not start again.

Self-test

The self-tests check the screen, the keys and the key lights, to find an electrical or mechanical problem in the user interface, such as colour distortion or a key that is not sensitive. Choose Utility > Menu > Maintenance > Self Test.

- Screen Test: the screen shows red. Press Single to move to green and then blue. Look for colour distortion, bad pixels or scratches. Press Run/Stop to exit.
- Keyboard Test: turn each knob both ways and press it, and watch that its value on the screen counts up and down and that the knob lights when pressed. Press each key and check that its icon lights. Press Run/Stop three times to exit.
- LED Test: press Single and the first light on the front panel comes on, with the matching key on the screen changing colour. Keep pressing Single to test the next. Press Run/Stop to exit.

Self-calibration

Self-calibration brings the instrument to its best working state for the most precise measurement. Do it if the ambient temperature has changed by more than 5 °C, and only after the instrument has been on for more than 30 minutes. Disconnect everything from all inputs, choose Utility > Menu > Maintenance > Self Calibration and select Continue. The instrument does not respond to anything until it is finished. When it is, touch the screen or press any key to exit.

Quick Cal

With Quick Cal enabled, the instrument runs an ADC calibration when the ADC temperature changes by more than 3 °C, to avoid drift. It is quick, but it interrupts the acquisition, so turn it off when capturing long waveforms or watching for rare events without a break. It is disabled by default. Changing the vertical scale or the channel interleaving mode starts the same calibration in the background whatever the setting. Set it under Utility > Menu > Maintenance > Quick Cal.

Service

SMB file share

Utility > Menu > Service > SMB File Share > Client opens the dialog. Choose the drive letter, tick the box to connect to the network directory at every power-on, enter the directory, and tick Remember to keep it. Enter the username and password, and tick Remember to save them, or tick Anonymous for guest access, which needs the server to allow it. Connect or disconnect by hand with the button.

Web server

The web server lets you control the instrument from a browser (chapter 28). Utility > Menu > Service > Web sets the password to control it, up to 20 characters.

LXI

The instrument provides LXI status and identification (LXI version 1.5), to help build automated test systems. Touch LXI to open the status box. LAN Reset restores the LAN defaults: automatic IP, the ICMP ping responder and multicast DNS are enabled, and the web server password is reset. After setting the LAN, the LXI welcome page can be loaded in a browser. When instrument identification is started in the web server, the LXI image at the top right flashes.

28 Remote control

The instrument has a LAN port and a USB device port for remote control.

Web browser

A built-in web server lets you control the instrument from a browser, with nothing to install on the computer. Set the LAN port (chapter 27), type the instrument's IP address in the browser's address bar, and the instrument information page appears, with a link to the control interface.

The control interface shows a copy of the instrument display, and using the mouse in it is the same as using the touch screen. It also has controls to take a screenshot, to save the waveform data as a binary or CSV file and download it to the computer, to download the converter for binary files, and to upgrade the firmware.

Other connections

SCPI commands can be sent over the LAN or the USB device port, using VISA, Telnet or a socket. The SCPI command reference is a separate document, available from GPS on request.

29 Troubleshooting

These are the failures most often met. If a problem remains after the steps, contact GPS.

The screen stays dark after switching on

- Check that the power is connected correctly, and that the power switch is on.
- Check whether the fuse has failed. If it has to be changed, contact GPS.
- Restart the instrument after these checks.

The signal is connected but no waveform appears

- Check that the probe is correctly connected to the signal lead, and the lead to the BNC of the channel, and the probe to the item under test.
- Check that the item under test is producing a signal, then sample the signal again.

Voltages read too high or too low

This usually happens with a probe.

- Check that the attenuation setting of the channel agrees with the attenuation of the probe.
- Disconnect the instrument from the external signal and run a self-calibration.

The waveform will not hold still

- Check the trigger source: that it is the channel carrying the signal.
- Check for a false waveform. When the signal frequency is more than half the sample rate, it can show as a false wave. Set a faster timebase so the sample rate is more than twice the signal frequency.
- Check the trigger type: ordinary signals need Edge and video signals need Video. Only the right type gives a stable display.
- Change the holdoff.

Nothing appears after pressing Run/Stop

Check whether the trigger mode is Normal or Single, and whether the trigger level is outside the waveform. If so, set the level to the middle, or set the mode to Auto. Pressing Auto Setup does this automatically.

The touch screen does not respond

- Check that the light on the Touch key is on. If not, the touch screen is off; press the key.
- Restart the instrument.

A USB drive is not recognised

- Check that the drive works, and that the USB port works.
- Use a flash storage type of drive; the instrument does not support other types of USB storage.
- Restart the instrument and insert the drive again.

30 Specification

This is a summary. The complete specification, with every trigger type and its ranges, the full measurement list, the options in detail and the environmental and electromagnetic figures, is in the technical datasheet.

Item	Specification
Channels	4 (GPS-2104HD, GPS-2204HD) or 2 (GPS-2202HD)
Bandwidth	100 MHz (GPS-2104HD) • 200 MHz (GPS-2202HD, GPS-2204HD) • 20 MHz bandwidth limit
Resolution	12-bit • noise floor 70 μ V rms typical at 1 mV/div
Sampling	2 GSa/s on one channel, 1 GSa/s on two, 500 MSa/s on four
Memory per channel	GPS-2104HD: 50, 25 and 10 Mpts • GPS-2202HD and GPS-2204HD: 100, 50 and 25 Mpts, for one, two and four channels on
Vertical scale	0.5 mV/div to 10 V/div at probe 1X • DC gain accuracy $\pm$ 0.5% typical from 5 mV/div
Input	1 M Ω $\pm$ 2% in parallel with 17 pF $\pm$ 2 pF • 400 V peak maximum • DC, AC, GND • no internal 50 Ω
Timebase	2 ns/div (100 MHz) or 1 ns/div (200 MHz) to 1000 s/div • $\pm$ 25 ppm

Item	Specification
Capture rate	Up to 80,000 wfm/s (100 MHz) or 120,000 wfm/s (200 MHz) • 500,000 wfm/s in sequence mode
Trigger	Fourteen types • holdoff 8 ns to 30 s • I ² C, SPI, UART, CAN and LIN trigger and decode, two decoders, standard
Analysis	Search, navigate, history (80,000 frames), sequence (80,000 segments), mask test, counter, Bode plot, power analysis (option)
Measurement	50+ parameters with statistics, histogram, trend and track • four math traces with a 2 Mpts FFT
Display and interfaces	7 inch capacitive touch screen, 1024 × 600 • USB host × 2, USB device (USBTMC), LAN, auxiliary output (trigger out, pass/fail) • SCPI • web server
Options	16-channel logic probe • isolated 25 MHz waveform generator module • power analysis, each with a licence
Power	100 to 240 V, 50/60 Hz • 80 W maximum • 4 W in standby
Environment	0 °C to 40 °C operating • -30 °C to 70 °C storage • up to 3000 m • indoor use, IP20
Size and mass	312 × 132.6 × 151 mm (l × w × h) • 2.6 kg

31 Care and maintenance

- Unplug the instrument before cleaning it. Clean the outside only, with a soft damp cloth. Do not use chemicals or abrasive cleaners, and do not let moisture enter.
- Keep the ventilation openings at both sides clear, with 15 cm free, and do not let anything enter them.
- Use the instrument indoors in a clean, dry place, and keep its surface clean and dry. Direct sunlight, radiators and other heat sources count towards the ambient temperature.
- Run a self-calibration when the ambient temperature has changed by more than 5 °C (chapter 27).
- There are no operator-serviceable parts inside. Calibration and repair are available from GPS. Contact us with the model and serial number.

32 Warranty

One year from the date of purchase, subject to product registration with GPS at www.gpslimited.com/register-product. The warranty covers defects in materials and workmanship. It does not cover damage caused by repair or installation by anyone other than GPS, connection to incompatible devices or incorrect connection, operation outside the rated conditions, or modification.

For service, calibration or technical support contact GPS at sales@gpslimited.com or +44 (0) 203 093 0914. Please quote the model and the serial number.