

# Functional comparison of the R&S RTB2000, Siglent SDS2000X Plus and Keysight InfiniiVision DSOX 1000 Oscilloscope series

Made by Rudi's Electronics Lab. Video episodes of this comparison are at:

<https://www.youtube.com/channel/UCSTHQUENuAc2UwmrlHkvGKw>

Document Version 0.79. This is a document under construction.  
Comments, corrections, additions etc. are welcome, please share here:  
<https://www.eevblog.com/forum/testgear/functional-comparison-of-rs-rtb2000-siglent-sds2000x-and-keysight-dsox1000/>

<b>INTRODUCTION</b>	<b>2</b>
General .....	2
Main discussion forum threads on EEVBlog .....	2
Physical construction .....	3
I/O connectors .....	4
Documentation .....	5
<b>USER INTERFACE</b>	<b>6</b>
Screen and graphical UI .....	6
Trace display .....	7
Labels and annotations .....	7
Grid customizability .....	9
Other customizability .....	9
<b>ACQUISITION SYSTEM &amp; MEMORY</b>	<b>10</b>
Acquisition system .....	10
Sample memory .....	11
<b>CHANNELS</b>	<b>12</b>
Analogue channels .....	12
Digital channels .....	13
Reference waveforms .....	13
Math channels (excl. FFT). Includes Picoscope 3405D SW 7.1.34 .....	14
<b>HORIZONTAL SYSTEM &amp; TRIGGER</b>	<b>17</b>
Horizontal mode XT .....	17
Horizontal mode XY .....	18
Zoom .....	18
Trigger system .....	19
<b>TOOLS</b>	<b>20</b>
Cursor .....	20
Measure .....	21
Digital Voltmeter (DVM) .....	24
Serial bus decoding .....	27
Parallel bus decode .....	36
<b>ANALYSES</b>	<b>36</b>
Mask (TBA) .....	36
Bode plots (Frequency Response Analysis) .....	38
FFT .....	40
Power Analysis (TBA) .....	43
<b>SIGNAL GENERATORS</b>	<b>43</b>
Function generator (except ARB) .....	43
Function generator – arbitrary waves (ARB) .....	44
Pattern generator .....	46
Training signals, demo modes .....	47
<b>MEMORY, HISTORY, SEARCH</b>	<b>47</b>
Segmented memory and history (TBA) .....	47
Search (events) (TBA) .....	47
<b>COMPUTER ACCESS AND AUTOMATIZATION</b>	<b>48</b>
Web-based remote access .....	48
Computer software, automation interfaces .....	49
<b>SYSTEM</b>	<b>51</b>
File system .....	51
Save and recall .....	52
Other system features (TBA) .....	54
<b>FIRMWARE AND MANUAL IMPROVEMENTS WISH LIST (TBA)</b>	<b>56</b>
Firmware improvements wish list (TBA) .....	56
Manual and specs improvements wish list (TBA) .....	57

## LEGEND

**Keyboard:** feature not mentioned in manual but present on the instrument

**Blue:** significant advantage, not present in other instruments

**RED:** significant disadvantage

**Orange:** something to note but not a significant disadvantage

**Courier font:** the precise naming as used on the instrument

**FW02.400:** reference to the FW version that first introduced the feature.

**DISPLAY > Persistence.** M86, S12. Reference to where this can be found on the instrument. **SETUP** refers to a physical knob or rotary dial. Lower key refers to menu item or soft button (DSOCX). For information sources,

M refers to a page in User Manual<sup>1</sup>,

S refers to a page in Specification Sheet,

B refers to a page in the product brochure,

OHF refers to onscreen help function.

[statement] something assumed or observed, but not explicitly documented

Aspect 1	Advantage over other two
Aspect 2	Very significant advantage over other two
Aspect 3	Disadvantage over other two
Aspect 4	Very significant disadvantage over other two

## Acknowledgements

This document has benefitted from feedback by:

EEV-Blog user 2N3055, Kcbrown, HJ, Calvin, tautech, bdunham7, mawyatt, Domitronic, Martin72, Pope, Normi, PeDre and others.

## INTRODUCTION

### General

Series	R&S RTB2000	Siglent SDS2000X Plus	Keysight InfiniiVision 1000 X
<b>Model/version reviewed</b>	<b>RTB2K-COM4</b>	<b>SDS2104X Plus, 16LA, AWG</b>	<b>DSOX1204G</b>
<b>Market introduction</b>	March 2017	January 2020	March 2017 (4ch. version January 2019) <sup>2</sup>
<b>Market position</b>	Low mid-range	Low mid-range	Low range
<b>FW version reviewed</b>	FW 2.4 (Released 06 December 2021)	FW 1.3.9R6 (Released 25 October 2021)	FW 2.12 (Released 10 September 2021)
<i>Note: Document later updated to V1.3.9R12 (Released 23 May 2022)</i>			
<b>FW updates</b>	10 updates in 56 months	6 updates in 22 months	~ 5 + 3 updates in 56 months

### Main discussion forum threats on EEVBlog

Series	R&S RTB2000	Siglent SDS2000X Plus	Keysight InfiniiVision 1000 X
<b>Main threats (pages as of July 2022)</b>	<a href="#">General threat</a> (126)	<a href="#">General threat</a> (140)	<a href="#">General threat on 4 ch. model</a> (4) <a href="#">Other</a> (3)

<sup>1</sup> RTB: Version 11 (for 2.4 FW); SDS: version EN01C (undated and no reference to which FW version); DSOX: Fourth edition, September 2021 (for FW 2.12).

<sup>2</sup> Some report that the 2019 models, recognizable by their black case, run on Linux OS whereas earlier models run on Windows CE. ([Source](#))

## Physical construction

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Physical design</b>	Very solid	OK, but not top notch <sup>3</sup>	Very solid
<b>Front panel color</b>	Grey	Beige	Black
<b>Power switch (front panel)</b>	Hard (back panel) Soft (front panel) Auto power-on	Soft (front panel) <b>Auto power-on selectable</b> Utility > Menu > Power On Line M29 Turn off, Reboot Utility > Shutdown / Reboot	Hard (front panel)
<b>Start-up time</b>	8-10 sec	55 sec	44 sec (was longer before FW2.01)
<b>Settings on power-on</b>	From last session M34	From last session (Not discussed in manual)	From last session (Not discussed in manual)
<b>Button/control layout</b>	Very logical	I do not find it always logical <sup>4</sup> , but opinions differ across users	Not always logical
<b>Rotary dials</b>	6, all have clicks  Shared V scale, V position H scale, H position Trigger Multifunction	6, two have clicks  Shared V scale, V position H scale, H position Trigger Multifunction	9, three have clicks  Shared V scale, V position M/FFT scale, M/FFT position (not very useful, and not used for FFT) H scale, H position Trigger Cursor Multifunction
<b>Recessed buttons</b>		Default, Auto-setup	Auto Scale, Default Setup
<b>Channel indicators for shared vertical controls<sup>5</sup></b>	Active Ch: lighted button, screen Selected Ch.: matching colour LEDs in both vertical dials <sup>6</sup>	Active Ch.: screen only Selected Ch.: lighted button	Active Ch.: lighted button, screen Selected Ch.: matching colour LED <sup>7</sup> indicator next to vertical dials
<b>Channel indicators for shared vertical controls</b>	Matching colour LED in Trigger button	Screen only	Screen only
<b>Painted front panel colour indicators for channels</b>	None	Around BNC <sup>8</sup>	Around BNC
<b>Fan noise</b>	Silent to very low	Very loud	Notable
<b>Energy use<sup>9</sup></b>	45 Watt (on, measured) 0.5 Watt (standby, measured) Manual: "max. 60 W" M33	55 Watt (on measured) <b>4 Watt</b> (standby, measured) <b>Manual: "Up to 100 Watt"</b> M14	
<b>Weight</b>	2.6 kg	3.5 kg	3.2 kg
<b>Transport accessories</b>	<a href="#">Plastic front cover</a> , Soft carry bag, Hard transit case	Soft carry bag	Soft carry bag

<sup>3</sup> Rotary dials wobble a bit. Rubber feet come off regularly. Overall, a more 'plastic' feel.

<sup>4</sup> Examples: "Start/Stop" button is away from "Single" button, whereas on most other oscilloscopes these are together. Yet, in the [EVVBlog Forum](#), some users express they find the SDS button layout intuitive.

<sup>5</sup> Across digital oscilloscopes, the implementation to have channel button lights indicate active channels (like the RTB and SDOX) seems to be the dominant one. We see it in various LeCroy models (WavePro HD, WaveRunner 8000HD, HDO6000B, WaveSurfer 4000HD), on Tektronix models (3 series, 4 series, 5 series), on R&S models (RTM3000, RTA4000, RTE1000, RTO2000 and RTP RTP), and Keysight models (2000X, 3000X, 4000X), to name a few. While it is my own preference too, others may prefer the Siglent choice to show on selected channels.

<sup>6</sup> In some versions (recent years?) the colors around the rotary dials do not look constant.

<sup>7</sup> Severe color mismatch for Channel 1 (dark yellow on button, bright yellow on the screen).

<sup>8</sup> On pictures on the internet, all the SDS2000X Plus scopes I see also have colors printed around the channel selection buttons. But on my unit, these colors are gone. Perhaps when FR1.3.7R5 introduced the selectable color for analogue traces (and changed the LED colours in the buttons accordingly with the chosen user color), Siglent decided to remove the paint on the front panel. But why they remove it only for one of the two places ?!

<sup>9</sup> Measured with GW-INSTEK GPM-8310 Power Meter. Here, 'on' means turned on, showing one channel, no special processing, no USB devices connected, etc.

## I/O connectors

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
BNC connectors	Goldplated (all)	Not goldplated. automatic x10 probe sense for supported probes; but cannot be overridden, creating creates problems with incompatible probes <sup>10</sup>	Not goldplated
USB (Flash, Mouse, Keyboard, Power)	1x host (FMKP) 1x device	2x host (FMKP) 1x device	1x host (FPK) <sup>11</sup> (keyboard since FW2.10) 1x device
Provides error information for connected USB devices?	Yes, detailed error information is provided for unsupported devices/file systems or when multiple devices in same device class are connected.	No messages shown	An error is shown when unsupported USB devices are connected.
Allows USB hub	Manual says a hub is not supported <sup>12</sup> M77 but in practice, a hub works just fine.	Manual is silent on this; experiences with hubs seem to differ across connected devices. <sup>13</sup>	Manual is silent on this but in practice, a hub works just fine.
Network	Ethernet (1Gbps)	Ethernet (100Mbps)	Ethernet (100Mbps) Recessed socket, gives problem with some plugs <sup>14</sup>
Ext. trigger in	Front panel (dedicated) Sensitivity 300mV, level -5/5V, max. 300 V (RMS), max. 400 V (Vp)	Back panel (dedicated) Max. 1.5Vrms; max. 7.5Vrms with EXT/5 attenuator	Back panel (dedicated) Max 30 Vrms, 40 Vpk
Trigger out	Front panel (shared conn.) Polarity: positive or negative pulse Level: 4.8V (2.4@50Ω)  Pulse width (250ns to 1s) and polarity (pos or neg pulse) can be set via remote command <sup>15</sup> , default 250ns (measured) <sup>16</sup> Trigger > Action on Trigger: M77, 86, 461, 462; remote command 461, 462, 87.	Back panel (shared conn.) Polarity: negative pulse Level: 2.6Vpp (900mVpp @ 50Ω) (measured)  Pulse width varies with horizontal scale (measured): 600ms @ 100ms/div 860μs @ 100μs/div 90μs @ 100ns/div (but duty cycle at 99%)	Front panel (shared conn.) Polarity: positive pulse Level: 5.3Vpp (2.7Vpp @ 50Ω) (measured) Trigger out disabled if training signals on (even if these appear at the probe comp connector... <sup>17</sup> )  Pulse width varies with horizontal scale (measured): 500ms @ 100ms/div 520μs @ 100μs/div 20μs @ 100ns/div (but duty cycle at 85%)
Mask test out	Pass, fail Front (shared conn.)	Pass, fail Back (shared conn.)	Fail (5V) Front (shared conn.)
Generator out	Front (shared conn.)	Front (dedicated)	Front (shared conn.)
10MHz reference in/out	-/+ (shared conn.)	-/-	-/-
Combined in multifunction out connector	Labelled Aux Out (front panel)  Supports Trigger Out, 10MHz ref, Mask, Function Generator Can be manually selected Setup > Aux out: M27, 177/178  Via SCPI commands, more flexible routing options are possible <sup>18</sup>	Labelled Pass/Fail out / Trig out (back panel)  Trigger Out, Mask Automatic selection: is set to Trigger, and switches to Mask Pass/Fail pulse when the Mask Analysis is activated <sup>19</sup>	labelled GEN OUT  Trigger Out, Mask, Function Generator() Can be manually selected  UTILITY > Options > Auxiliary. M242-243
Probe compensation	1kHz, 2.5V (measured)	1 kHz (meas.), 2.5Vpp (measured)	1 kHz (meas.), 2.5Vpp (measured)
Other IO	4 pin pattern generator		

<sup>10</sup> As there are differences across manufacturers of scopes and probes in terms of which attenuation modes are implemented and what their coding resistor value is, incompatibilities can arise. Not being able to override the autosense means that probes whose sensing is not picked up well become useless.

<sup>11</sup> Mouse does not make sense because the device does not have a graphic UI.

<sup>12</sup> Maybe they wrote this in the manual because connecting two storage devices may cause problems.

<sup>13</sup> In my own tests, the SDS did not work with an Anker type A7516 (a fairly straightforward, recent 4 port hub) and a HP H3C52AA keyboard (a fairly standard PC keyboard) or an Apple A1243 keyboard (both keyboards did work with the same hub on the RTB and DSOX. Yet, the SDS with hub did accept 'original' Raspberry Pi keyboard and the Logitech wireless K270 keyboard with its supplied proprietary (not 'unity') Logitech dongle.

<sup>14</sup> The socket is recessed by about 5 mm in the case. This makes it difficult to read the latch clip to remove the plug again, and connectors that have plastic/rubber covers over the latch clip (which is increasingly common) may have problems fitting in this instrument.

<sup>15</sup> For instance, with the SCPI command TRIGger:OUT:PLENghT 1E-3 the pulse width becomes 100ms. See manual page 461, 462.

<sup>16</sup> A 50% duty cycle square with 260ns positive pulse has a period of 520ns and a frequency of 1.9MHz. So, with trigger actions above this frequency one will want to shorten the pulse width.

<sup>17</sup> If you have an active training signal, and then change the GEN OUT to trigger, then you need to turn that GEN OUT back to WaveGen and then manually activate the output of the training signal again.

<sup>18</sup> For instance, with the SCPI command :WGENerator:OUTPUT:DESTination BNC | P3 you can also switch the output from the Function Generator to the Pattern Generator P3. Such documents are not documented in the user manual, though.

<sup>19</sup> Not being able to chose this manually, it means that it is not possible to check the actual (re)triggering behavior of the scope in Mask Analysis mode. Given the not very predictable (re)trigger behaviour of the SDS this is an issue.

## Documentation

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>User manual</b>	<p>Available <a href="#">here</a> (609 pages). Well written and informative Updated with each new FW versions (now FW2.4)</p> <p>Also: interactive online web version with very good search function, available <a href="#">here</a>.<sup>20</sup></p>	<p>Available <a href="#">here</a> (352 pages). Less informative, (specified) functions often poorly explained and some are missing altogether. Often, figures are not readable.<sup>21</sup></p> <p>Manual is not dated and not (systematically?) updated with new firmware versions.</p>	<p>Available <a href="#">here</a> (332 pages) Well written and informative Updated with each new FW versions (now FW2.12)</p>
<b>Programming guide (SCPI)</b>	<p>Part of User Manual List if commands is <a href="#">here</a> in the interactive online web version (adapted to online environment)<sup>22</sup></p>	<p>Separate document, available <a href="#">here</a> (585 pages)</p> <p>Also: <a href="#">SDS2000X Plus IVI-C Programming Guide</a></p>	<p>Separate, available <a href="#">here</a> (952 pages). Offers some information not available in the user manual<sup>23</sup></p> <p>There is also a Windows HTML Help (*.chm) format file, available <a href="#">here</a><sup>24</sup></p>
<b>Service Guide</b>		<p>Functional test, interface test, performance test, disassembly procedure, troubleshooting Available <a href="#">here</a>. (70 pages).</p>	<p>Verification, calibration etc. Available <a href="#">here</a> (57 pages)</p>
<b>Educator's Training Kit</b>			<p>For physics/EE students, the Educator's Training Kit is quite informative and specifically highlights functions in this instrument. Available <a href="#">here</a> (96 pages)</p>
<b>Other</b>	Lots of white papers, application notes, etc.		Lots of white papers, application notes, etc.
<b>Datasheet / specifications document</b>	Available <a href="#">here</a>	Available <a href="#">here</a>	Available <a href="#">here</a>
<b>Product brochure</b>	Available <a href="#">here</a> (Version 06.00)		Available <a href="#">here</a>

<sup>20</sup> [https://www.rohde-schwarz.com/webhelp/RTB\\_HTML\\_UserManual\\_en/Content/welcome.htm](https://www.rohde-schwarz.com/webhelp/RTB_HTML_UserManual_en/Content/welcome.htm)

<sup>21</sup> See for instance the pictures on page 68, 84, 97

<sup>22</sup> [https://www.rohde-schwarz.com/webhelp/RTB\\_HTML\\_UserManual\\_en/Content/welcome.htm](https://www.rohde-schwarz.com/webhelp/RTB_HTML_UserManual_en/Content/welcome.htm)

<sup>23</sup> Example: detailed description of all training signals on p.232 of Programming Guide.

<sup>24</sup> <https://www.keysight.com/nl/en/assets/9018-17471/help-files/9018-17471.chm>

## User interface

### Screen and graphical UI

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Screen</b>	10.1" (1280 x 800 pixel) 1.0 Mpixel <b>Glossy<sup>25</sup></b> Viewing angle good in all directions	10.1" (1024x600) 0.611 Mpixel <b>Matte</b> <b>Limited vertical viewing angle</b> <b>Backlight adjustable</b> Display > Backlight... M305	7" (800x480) 0.32 Mpixel <b>Almost glossy<sup>26</sup></b> <b>Limited vertical viewing angle</b>
<b>Touch screen</b>	Capacitive touch Gestures: Touch/select, Swipe, Drag, Pinch, <b>Two finger swipe<sup>27</sup></b>	Capacitive touch Gestures: Touch/select, Swipe, Drag, Pinch, <b>Draw</b>	
<b>Languages</b>	13 languages (FW1.203) Setup > Language... M198	10 languages Utility > Menu > System Setting > Languages... M33... 330	15 languages
<b>Trigger indicator LEDs</b>	Triggered	<b>Ready</b> , Triggered	
<b>Screen/ control UI</b>	Highly functional and consistent (but some misses)	Usable but with some misses. <b>Many 'small' submenus, and apart from some selected module such as measure or math, the device does not take real advantage from having a touch screen and seems a migration from a soft-button UI like the Keysight.<sup>28</sup></b> <b>Sometimes rather ambiguous terminology.<sup>29</sup></b>	No touch screen, a bit cumbersome menu structure
<b>Toolbar</b>	User-definable with 8 out of 24 icons selectable		
<b>Undo, Redo</b>	Undo: Reverses last actions step by step Redo: Recovers the undone steps in reverse order		
<b>Menu History</b>	Displays all menus used during the current session		
<b>Other</b>	QuickAccess: up to 10 parameters can be changed any moment in their own movable window (FW02.101)		
<b>Help mode</b>	Extensive context-based help Screen shortcut	Book style help pages Utility > Help	Extensive context-based help 3 second button push
<b>UI responsiveness (buttons, controls and screen)</b>	High. Responsiveness seems totally unrelated to system load.	Medium, somewhat sluggish. <b>Under significant load, the instrument can become unresponsive to front panel controls<sup>30</sup></b>	High. Generally, responsiveness seems totally unrelated to system load. sometimes temporary hickups after entering slow USB flash drive
<b>Experienced hangs/glitches</b>	Extremely rare, none experienced since FW02.300	Infrequent hangs in UI when doing more advanced settings	None experienced.

<sup>25</sup> Those that do not like a glossy display, can consider adding a matte screen protector (the other way round is not possible).

<sup>26</sup> Those that do not like a glossy display, can consider adding a matte screen protector (the other way round is not possible).

<sup>27</sup> In history segments.

<sup>28</sup> To see all the parameters to serial decode and trigger a SPI signal, no less than seven menu pages need to be looked at (plus a couple of others to gain access to these). On the RTB, in contrast, the user is presented one single screen in which all the relevant serial decode and serial trigger can be seen and changed.

<sup>29</sup> One example of this is provided in footnote 70.

<sup>30</sup> Confirmed by others, see [here](#).

## Trace display

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
Colour maps for intensity level <a href="#">(Analog, Math, Ref)</a>	Yes, individual per channel Colour set: Temperature, Fire, Rainbow. Levels set via intensity control For A, R, M Vertical > Channel... M62	Yes, only global Colour set: Rainbow No level setting For A Display > Color Grade... M306	No. Instead: "Signal detail is displayed using 256 levels of intensity." M35
Colour maps for intensity level (works on)	XT, XY, FFT	XT, XY (Colours lost in persistence mode)	
Trace intensity	{0-100%} INTENSITY Display > Intensities M194	{0-100%} Default for front-panel dial UNIVERSAL Display > Intensity M303	{0-100%} INTENSITY
Inverse Brightness	Supported Display M194		
Persistence	Fully variable {50ms to 12.8s, ∞} XT, XY, FFT For A, M Display M193	Four values <sup>31</sup> {1, 5, 10, 30s, ∞} XT, XY, not FFT For A (not M) Display > Persistence M306	Fully variable {100ms to 60s, ∞} XT, XY, FFT For A, M DISPLAY > Persistence M85
Display types	{Vectors, dots} Display M194	{Vectors, dots} Display > Type M304	
Custom trace colour <a href="#">(Analog, Math, Ref)</a>	R, M (not A) Individual colour per channel, also for math (FW02.300) and ref Individual colour per math channel Ref... M106, 62	A (1,3,7R5), R, M Individual colour per channel, also for math and ref For A, LED buttons change colour accordingly Display > Color setting M306	

## Labels and annotations

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
Analogue channel labels	Full text (8char) 39 presets <sup>32</sup> Vertical > Label... M63-64	Full text (20char) No presets	Full text (10 char) 75 presents
Digital channel labels	Full text (8char) 38 presets ("Clock", "MOSI", etc.) Logic > Label... M275	Full text (8char) (input is truncated <sup>33</sup> ) Preset "ADR[0-15]" Preset "DATA[0-15]"	
Reference channel labels	Full text (8char) 7 presets Ref > Label... M106	Full text (20char) No presets	Full text (10 char) 75 presents
Math channel labels		Full text (20char) No presets	
Serial bus labels	Full text (8char) 15 presents (specific for busses) Decode > Label... M217		Fixed label (according to chosen serial protocol)
Parallel bus labels	Full text (8char) 15 presents (specific for busses) Decode > Label... M217		Full text (10 char) 75 presents "AnalogBus"
Label readability	Labels small but well readable	Analogue labels poorly readable Digital labels almost unreadable (no shadow)	
Screen annotation	Text (50+ characters), pencil drawings, colours Screen shortcut M182		Text, 10 lines of 30 characters each, 10 colours, inverted
Keyboard options for label or annotations entry	Onscreen keyboard USB keyboard PC keyboard in web interface	Onscreen keyboard USB keyboard PC keyboard in web interface	Rotary dial USB keyboard (FW2.10) Not via PC keyboard in web interface
Character sets <sup>34</sup>	Full	Full	Labels: no lower case Annotations: Full
Other	In edit window, the input field shows last entered label (for any)		

<sup>31</sup> The limited number of available preset values may be limiting when looking at signals (problems) that may repeat, for instance, more than once a second.

<sup>32</sup> Preset set for analogue channels is different from that for digital channels.

<sup>33</sup> The input field does not have a character limit. But after hitting enter, it becomes clear that all character beyond position 8 are discarded.

<sup>34</sup> Here, 'full' refers to a set of upper case, lower case, numerical, and symbols.

	channel), not current label of selected channel		
--	--	--	--

## Grid customizability

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Grid divisions shown</b>	<b>12 horizontal, 10 vertical</b>	10 horizontal, 8 vertical	10 horizontal, 8 vertical
<b>Grid area occupied by menus</b>	<p>Pop-up icon bar takes 5% (% div horizontal) of screen surface</p> <p>Pop-up settings menu takes 22% (2.5 div. horizontal) of screen surface</p> <p>Menu auto-hide: 8 seconds (for multi-option menus)</p>	<p>Pop-up settings menu takes 14% (2.5 div. horizontal) of screen surface. <b>With Embedded mode activated, the waveform screen is compressed and no div are lost.</b> (13.7RS)</p> <p>Display &gt; Menu Style... M303</p> <p><b>Menu auto-hide - Variable (Off, 3, 5, 10, 30, 60s)</b></p> <p>Display &gt; Hide Menu... M303</p>	<p>16% of the screen is always occupied by the menus. Does not cost horizontal divisions but makes the waveform area small on the already small screen.</p> <p>There is a <b>Menu auto-hide (0-60s)</b> but that brings the default menu in view so still taking space</p> <p>Utility &gt; Options &gt; Menu Timeout</p>
<b>Grid display</b>	<p><b>Grid types:</b></p> <ul style="list-style-type: none"> <li><b>Lines:</b> full line grid; H&amp;V centre lines have tick marks</li> <li><b>Recticle:</b> grid crosshairs plus H&amp;V centre lines with tick marks</li> <li><b>Off</b></li> </ul> <p>Display &gt; Grid... M195</p> <p><b>Grid intensity (0-100%)</b></p> <p>Display &gt; Intensities &gt; Grid... M194</p>	<p><b>Grid types:</b></p> <ul style="list-style-type: none"> <li><b>Full:</b> dashed line grid; H&amp;V centre lines with tick marks; 25% and 75% dashed horizontal lines</li> <li><b>Light:</b> H&amp;V centre lines with tick marks; 25% and 75% dashed horizontal lines (<b>no horizontal divisions visible</b>)</li> <li><b>No grid</b></li> </ul> <p>Display &gt; Grid... M303</p> <p><b>Grid Intensity (0-100%)</b></p> <p>Display &gt; Graticule... M42</p>	<p><b>Grid intensity (0-100%)</b></p> <p>DISPLAY &gt; Grid &gt; Intensity... M87</p> <p><b>Fixed grid type:</b> full line grid; H&amp;V centre lines have tick marks</p> <p><b>Specific grid type for analogue video (Institute of Radio Engineers)</b></p> <p>DISPLAY &gt; Grid &gt; Intensity... M86</p> <p>ANALYZE &gt; Features &gt; Video &gt; Grid</p>
<b>Grid track</b>	When activated, grid moves horizontally and vertically with waveform repositioning		
<b>Grid axis values</b>	<p>Horizontal and vertical values on the grid axis {On, Off}</p> <p>Values and units ("e.g., 40mV" or "-400 µs") switch automatically with selected channel.</p> <p>Display &gt; Grid &gt; Annotation... M195</p>	<p>Horizontal and vertical values on the grid axis {On, Off} (FW 13.9R4)</p> <p>Display &gt; Axis Label settings (missing in manual)</p> <p>Values and units ("e.g., 40mV" or "-400 µs") switch automatically with selected channel.</p> <p><b>With four digits after the period the axis values clutter the screen and are not very readable. Solved in FW 13.9R12</b></p> <p><b>Modes {moving, fixed}</b></p> <p>Display &gt; Axis Label settings (missing in manual)</p>	<b>No axis values shown</b>

## Other customizability

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Device name</b>	Can be changed (for screen prints and device information fields) (FW02.400)		

<b>LED lights/buttons brightness</b>	Brightness (20-100%) Front panel button <b>[INTENS]</b> Display > Intensities M194	Brightness (0-100%) Display > LED light... M303	
<b>Screen saver</b>		Screen goes black after set time (Off, 1, 5, 10, 30, 60 min.) <i>(not really off...)</i> Utility > System Setting > Screen saver. M332	
<b>Date/time clock</b>	Supported. <b>Time display on screen can be disabled (FW02.300)</b> Screen shortcut Setup. M28	Supported Screen shortcut Utility > Menu > System Setting > Date/Time. M334 Has time zone setting (FR 1.5.2R1) <b>but this feature does not work, and many others report this as well)</b>	Supported <b>UTILITY &gt; Options &gt; Clock.</b> Settings as 0-23hr but main screen display always 12 hrs clock (am and pm) Has time zone in UTC + and -
<b>Sound</b>	Can be set at trigger event Trigger. M86 Can be set at violation of mask Mask > Actions. M164 General control events, e.g. changing the measurement type in the "Measure" menu. Via SCPI command. M465	Can be set at violation of mask Analyze > Mask test. M267 <b>General buzzer sound {On, Off}</b> Utility > Menu > System Setting > Sound. M330	

## Acquisition system & memory

### Acquisition system

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Analogue channel sample resolution (ADC)</b>	<b>10-bit ADC</b> 16-bit high-res decimation "mode", Does not require repetitive signals. [limited in bandwidth <sup>35</sup> ] S. 4, 68	8-bit ADC <sup>36</sup> 10-bit "mode" using oversampling <sup>37</sup> Maximum bandwidth approx. 100MHz. [Its workings are comparable to what other scopes call a 'High-Res' acquisition mode. ] [Does not require repetitive signals.] Acquisition > Menu. M82. ENOB enhancement at lower bandwidth (see ERES at Math section) M222	8-bit ADC High Resolution Acquisition "Mode", claimed to be equivalent to up to 12 bits at 20 µs/div time base setting. Does not require repetitive signals. M140
<b>Analogue channel sample rate (ADC)</b>	<b>2.5GSa/s (interleaved 2ch mode)</b> 1.25 GSa/s (normal)	2 GSa/s (interleaved 2ch mode) 1 GSa/s (normal)	2 GSa/s interleaved 2ch mode) 1 GSa/s (normal)
<b>Available bandwidth in series</b>	70, 100, 200, 300 MHz (All possible via software upgrades)	100, 200, 350 MHz 500MHz (two channels only) (All possible via software upgrades)	70, 100, 200 MHz (All possible via software upgrades)
<b>Digital channel sample rate</b>	<b>1.25 GSa/s every channel</b>	Up to 500 MSa/s	
<b>Waveform update rate</b>	Up to 50,000 wfm/s S.6 In fast-segmented memory mode (acquisitions into memory, no screen updates, Nx>1) up to 300,000 wfm/s <sup>38</sup> S.17	Up to 120,000 wfm/s. In practice, the screen update experience is order of magnitude below that of the RTB or SDOX (also when most favourable sequence mode selected)  In 'sequence mode' up to 500,000 wfm/s in S.1, S.4 Reduce waveform update rate [Fast, Slow] Acquire > Menu. M82.  <i>Some terminology ambiguity<sup>39</sup></i>	200,000 wfm/s, some ambiguity <sup>40</sup> (FW2.10) S.10

<sup>35</sup> Precise specs not provided, but the manual mentions this mode works "if the waveform sample rate is less than the ADC sample rate". M68.

<sup>36</sup> See

[https://www.eevblog.com/forum/testgear/high-resolution-adc-converters-in-oscilloscopes-\(8-bit-10-bit-12-bit-14-bit\)/](https://www.eevblog.com/forum/testgear/high-resolution-adc-converters-in-oscilloscopes-(8-bit-10-bit-12-bit-14-bit)/)

<sup>37</sup> <https://www.eevblog.com/forum/testgear/siglent-sds2000x-plus-coming/>

<sup>38</sup> Specification, p. 17: "continuous recording of waveforms in acquisition memory without interruption due to visualization; blind time between consecutive acquisitions less than 2.5 µs". (up to 300 000 waveforms/s)

<sup>39</sup> In the specifications (S1, S2, S4, S5, S11) the terms "waveform update rate" and "waveform capture rate". Are used interchangeably.

<sup>40</sup> Specifications are inconsistent. "≥ 200,000 waveforms/sec" (p.12), "Up to 200,000 waveforms/sec update rate" (p. 5)

<b>Visually observed glitches in 50kHz signal with one glitch per second present<sup>41</sup></b>	36	2	38
---	----	---	----

## Sample memory

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Analogue channel memory depth (per channel)</b>	10 Msample 20 Msample (interleaved 2ch mode)	100 Msample 200 Msample (interleaved 2ch mode) (Both half for 10-bit mode)	1 Msample 2 Msample (interleaved 2ch mode) (FW2,10)
<b>Segmented memory depth (per channel)</b>	160Msample 320Msample (interleaved 2ch mode) <small>S17</small>	Not specified ?!?	Not specified (?!?)
<b>Digital channel memory depth (per channel)</b>	10 MSa every channel	"Up to" 50 MSa every channel	
<b>Total instrument sample memory</b>	Total 840Msample <sup>42</sup>	Total 400Msample	Total 4MSa

<sup>41</sup> In this test, a 50 kHz clock is input to the instrument with an infrequent glitch (1 glitch per 50,000 clocks, so one per second). Using the most favorable setting on the instrument, I closely watched the displayed waveform and counted how often I could see a glitch in a one-minute observation time. All scopes 10us/div. RTB: Record Length 10 kSa/s. SDS: Record length 20k (= smallest value available); Seq. Acq Mode off (with that mode on I observe no glitches at all in one minute). DSOX in default length (cannot be selected)

<sup>42</sup> In 4 channel operation, the RTB has 10Msample per analogue channel plus 160Msample deep memory per analogue channel, plus 10Msample per digital channel, totaling 840Msample. In interleave (2 channel) mode, the RTB has 20Msample per analogue channel plus 320Msample deep memory per analogue channel, , plus 10Msample per digital channel, totaling (again) 840Msample. S17.

## Channels

### Analogue channels

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Input impedance</b>	1 MΩ, 9pF S4	1 MΩ, 17pF; 50 Ω note <sup>43</sup> S10	1 MΩ, 16pF S12
<b>Max voltage at channel input (Vpp)</b>	400Vpp S4	400Vpp S10	200 Vpk S12
<b>Channel overload warning</b>	Yes, always visible <sup>44</sup> (red arrows for positive and negative overload)	Possible via a trick <sup>45</sup>	
<b>Probe Attenuation</b>	4 presents; Fully variable (100μ to 10M) (equals 10 <sup>-4</sup> ~ 10 <sup>7</sup> ) (V02.3)  Vertical > Channel > Probe Channel shortcut menu. M66	3 presents; Fully variable (0.000001 to 1000000) (equals 10 <sup>-6</sup> ~10 <sup>6</sup> ) automatic x10 probe sense for supported probes  Channel shortcut menu. M67	16 presets (0.1X to 10,000X) (100m to 10M) in 1-2-5 sequence (equals 10 <sup>-1</sup> ~10 <sup>7</sup> )
<b>Channel BW limit modes</b>	20 MHz (also any value via math LPF)  Vertical > Channel Channel shortcut menu. M60	20 MHz, 200 MHz 	20 MHz (also any value via math LPF)
<b>Coupling</b>	DC, AC, GND AC: 2Hz HPF S4 Channel shortcut menu. M60	DC, AC, GND AC : 5Hz HPF S10 	DC, AC
<b>Vertical scale / Sensitivity (@ 1MΩ)</b>	1 mV/div to 5 V/div  Front-panel dial VERTICAL SCALE Vertical > Channel. M61	500 μV/div – 10 V/div (50 Ω: 500 μV/div – 1 V/div)  Front-panel dial VERTICAL V=1 Screen channel shortcut	1 mV/div to 10 V/div (500 μV/div mode is digital zoom <sup>46</sup> )
<b>Auto scale</b>	For all channels: Autoset See manual, page 51 for what Autoset exactly does. 	For all channels: Auto Setup “The oscilloscope will automatically set the vertical scale, horizontal scale, and trigger level according to the input signal to get the optimum waveform display” (p. 63).  “Press the Auto Setup button, and the oscilloscope will set the trigger type to Edge.” (p. 101)  Is also used for probe compensation (p. 32)  Error in manual. <sup>47</sup>  Acquire > Auto Setup. M68, 63	For all channels: Autoscale. “to automatically configure the oscilloscope to best display the input signals.”  For displayed channels: Autoscale  Fast Debug option <sup>48</sup> Preserve acquisition mode option Undo option
<b>Vertical position</b>	Front-panel dial VERTICAL ▲  Vertical > Channel. M61	Front-panel dial Vertical ▲ Screen channel shortcut	Front-panel dial VERTICAL ▲
<b>Vertical position setting<sup>49</sup></b>	Position and Offset are simultaneously available in as menu items. The vertical rotary dial behaviour can be switched between the above modes (FW02.202) Note <sup>50</sup>  Vertical. M57	{Position, Offset} Utility > Menu > Reference position. M337 is placed in a bit odd position in the menu system (not a menu related to the vertical system)	Offset (in Volt)
<b>(De)skew (time compensation)</b>	-500 to 500ns  Vertical > Channel Channel shortcut menu. M61-62	-100 to 100ns 	-100 to 100ns
<b>Invert</b>	Yes	Yes	Yes

<sup>43</sup> Generally, this should be regarded as a plus, a facility that is usually limited to higher class scopes. But I don't use it myself. Why? If I get across older scopes, if they are broken, it's quite often because people used the 50Ω setting and accidentally connect, say, 10V or more to that channel. Then you make very serious damage to the scope with high repair costs. I always use 50Ω termination true adapters (R&S HZ22, Rigol ADP0150BNC). If I ever blow one, I do not have to send the oscilloscope back into repair.

<sup>44</sup> Present as red arrows up or down in the bottom of the screen input channels are shown.

<sup>45</sup> Set up a Pk-Pk measurement for each of the four input channels in the ‘advanced’ measurement mode. If you look well. Results are in the bottom of the screen (do take up some space) In case of channel overload, there is an “>” symbol before the value shown, and a double arrow behind it. But it has to be set up every time and is still hard to see (compared to the RTB where there are always clear red arrows visible when overload occurs).

<sup>46</sup> Instrument has 500 μV/div mode but the specifications (p.12) mention “500 μV/div is a 2X digital magnification of 1 mV/div setting.”

<sup>47</sup> Here, the manual, page 58, indicates “Trigger >Auto Setup” but that is likely a mistake.

<sup>48</sup> Manual: “When fast debug is enabled, autoscale lets you make quick visual comparisons to determine whether the signal being probed is a DC voltage, ground, or an active AC signal.”

<sup>49</sup> For ‘Position’ (in div) the entire wave goes up or down on the screen. For ‘Offset’ (in Volt): When AC wave is superimposed on, say, 8V DC, then this allows to put 8V at centre line and zoom in or out while the wave stays in position.

<sup>50</sup> While this is by no means a hidden menu, it is one not many people will ever visit at all because all of us will use the channel buttons [1-4], which are handy shortcuts but don't bring you to the top-level hierarchy in this menu.

<sup>51</sup> Is in the top-level vertical menu (so tap the ‘vertical’ icon at right hand size of screen).

	Vertical > Channel, M61	Vertical > Channel	
Channel hide	No (but inactive channel can be used for trigger, math, etc.)	Yes (hidden channel can trigger but inactive channel cannot trigger)  (FW1.3.5R5) Screen channel shortcut 	No (but inactive channel can be used for trigger, math, etc.)
Copy settings to another channel		Yes ("Fast apply to") Screen channel shortcut	
Vertical scale units displayed on screen	V, A (attenuation adjusts)  Vertical > Channel > Probe, M68 	V, A (attenuation adjusts)  Vertical > Channel > Probe, M68 	V, A (attenuation adjusts)
Turning analogue channel into digital (for Boolean logic)	Yes  Threshold, hysteresis  Vertical > Channel > Threshold, M64 		
Zero adjust (compensate for different ground levels of DUT)	Yes  Vertical > Channel, M61-62 		

## Digital channels

	RTB2000	SIGLENT SDS 2000X+	KEYSIGHT TECHNOLOGIES DSOX 1200
Digital channels	16 channels	16 channels	
Predefined logic levels	TTL, CMOS 5.0 V, CMOS 3.3 V, CMOS 2.5 V, ECL, Custom Logic, M274	TTL, CMOS, LVCMS3.3, LVCMS2.5, Custom Screen (digital) channel shortcut	
Custom level	-2 V to +8 V in 10 mV steps Logic, M274	-10V to +10V in 1mV steps	
Hysteresis	{Low, Medium, High} Logic, M276, 80		
Display modes digital channels	Individual per channel, show 8 ch. as small block or large block, move as block	Fixed block; position and height of block can be set via menu (not vertical position rotary!)	

## Reference waveforms

	RTB2000	SIGLENT SDS 2000X+	KEYSIGHT TECHNOLOGIES DSOX 1200
	References		Far not as flexible as in other devices
Number	4	4	2
Copy source (Analog, Math, Ref)	4A, 5M, R(4-1) <sup>32</sup> , FFT spectrum (specs: also D, R)	4A, 16D, 2M (incl. FFT spectrum)	4A, 1M
Disk load/save	Load, Save From internal or external (See section Save and Recall below for details)	Save, Recall Only to external (See section Save and Recall below for details)	Save, Recall Only to external (See section Save and Recall below for details)
Other			Skew (takes hundreds of turns to cover the range)
			Scale and offset only via menu (unlike math that can use rotary button for that)

<sup>32</sup> Can select another reference waveform as source. Since there are four references, you can select the three other.

## Math channels (excl. FFT). Includes Picoscope 3405D SW 7.1.34

	 RTB2000	 SDS 2000X+	 DSOX 1200	Picoscope 3405D SW 7.1.34
	 Math > Menu	 Math > Menu	 Math > Menu	Math icon
<b>Math channels</b>	<b>5 channels (FW02.302)</b>	2 channels	1 channel Function G(t) allows a low-pass filter or FFT on the result of arithmetic operation (e.g. subtract); you could call that two math channels.	Unlimited (up to 8 shown in one window, can show multiple windows of each 8 traces) <b>Does experience crashes with many math functions</b>
Source (Analog, Digital, Math, Ref)	4A, (5-1)M <sup>53</sup> , constant <sup>54</sup> No D	4A, (2-1)M <sup>53</sup> , (Zoom), No D (constant <sup>54</sup> only when using formula editor)	4A	4A + xR + time, constant <sup>54</sup> No M
Total functions (excl. FFT)	19 (see below)	23 (see below)	6 (see below)	62 (see below)
Filters	LPF (0-300MHz) (FW02.300) HPF (0-300MHz) (FW02.300)		LPF (0-70MHz)	LPF, HPF, Band Pass, Band Stop (all at any frequency)
Tracking	Period, Freq, PW, Duty cycle (FW02.400)			Freq
Formulae editor	No	Yes. Supports: • 16 math functions as indicated in the below table with FE • the four analogue channels, the four zoom channels, the Math functions F1 and F2 • Pi, e, and own constants • Parenthesis • FFT <sup>55</sup> <i>Almost no information in manual, actual working not so clear.<sup>56</sup> (Formulae length limited to 25 char.)</i>		Yes (all math is via formulae editor)
Units / scales of result	Library of 75 units (V, A, Ω, etc.)	21 units that adapt to function (e.g.: V.A=W)	9 units that adapt to input channels (e.g.: V.A=W)	Units that adapt to function Manually override by free text. SI prefixes can be activated.
Math trace colour selection	11 trace colours	Any trace colour Display > Color setting, M308		Any trace colour
Math channel labels		Full text (20char)		Full text
Save math functions	Save & load math sets with up to 5 formularies (see section Save and Recall below for details).			Saves math channels by default
Other functions		Tooltips (but not for in formulae editor)		

## Overview of all Math Functions

	Series	Symbol	Units	Input ch.	RTB2000	SDS 2000X+		DSOX 1200	Picoscope 3405D SW 7.1.34	All math is in formulae editor
						As regular function	In formulae editor <sup>57</sup>			
<b>Basic operators</b>	Addition	+	V, A <sup>58</sup>	2	Y	Y	Y	Y	Y	Y
	Subtraction	-	V, A <sup>58</sup>	2	Y	Y	Y	Y	Y	Y
	Multiplication	x	V <sup>2</sup> , A <sup>2</sup> , W <sup>58</sup>	2	Y	Y	Y	Y	Y	Y
	Division	/	None, Ω, Siemens	2	Y (special treatment to prevent infinity)	Y	Y	Y (divide by zero shown as zero result)	Y	Y
<b>Value</b>	Identity ("Output of the trace itself")	Y				Y				
	Absolute value	y			Y	Y	Y			Y
	Inverse	-Y			Y	Y (Negation)				
	Signum (sign)					Y (1.3.5R3) (FE)	Y			Y
	Reciprocal	1/x			Y (special treatment of second input is small to prevent infinity)					
	Normalize									Y <sup>59</sup>
	Amplitude (peak-peak)									Y
	Top (positive peak)									Y
	Base (negative peak)									Y
	Ceiling									Y. Seems to hold signal in 4 levels?
	Floor									Y. Seems to hold signal in 4 levels?
	+ Overshoot (%)									Y

<sup>53</sup> All math channels except itself.

<sup>54</sup> Here we mean a user-entered constant value, entered via keyboard (for a like Pi or e, see further on).

<sup>55</sup> Basically starts FFT view like in the 'regular' FFT function, but can be used to do FFT on, say, "C1+6" or "C3/C1". The RTB can do the same thing as you can select a math channel (made with own calculation) as input to FFT.

<sup>56</sup> Experimenting with it is a bit of a mixed experience. It seems to light up red if a formula is not allowed but at the same time, "F1=F1/2" or "F1=C1+C2/F1" is allowed, while these are recursive formulae.

<sup>57</sup> Some functions are not there ready-made but can be created via math functions (like "Identity" or 'Inverse'. But we do not discuss these here.

<sup>58</sup> Siglent shows Unit "U" when the units of two sources are not consistent. Same for the Keysight: "A scale unit of U (undefined) will be displayed for math functions when two source

channels are used and they are set to dissimilar units and the combination of units cannot be resolved. A scale unit of U (undefined) will be displayed for math functions when two source channels are used and they are set to dissimilar units and the combination of units cannot be resolved."

<sup>59</sup> "PicoScope calculates the maximum and minimum values of the argument over the capture period, and then scales and offsets the argument so that it exactly fits the range [0, +1] unit". Manual of v6. <https://www.picotech.com/download/manuals/picoscope-6-users-guide.pdf>

	- Overshoot (%)								
Powers	Square	$y^2$		$y^2, A^2$	$y$				$y$
	X*Y	$x^y$							$y$ (via X*Y)
	Square root	$\sqrt{y}$		$y^{0.5}$ or $A^{0.5}$	$y$	$y$	$y$		$y$
Log & Exp	Natural logarithm	In / Log[e]			$y$	$y$	$y$		$y$
	10-base logarithm	$\log_{10}$			$y$ ('Common Log')	$y$	$y$		$y$
	Natural exponent	$e^x$				$y$	$y$		$y$
	10-base exponent	$10^x$				$y$	$y$		
Integral & Differential	Dervative (differential)	$r$ or $d/dt$		$V/s$ or $A/s^{60}$	$y$ (const.) (FW02.202)	$y$ (called $d/dx$ )	$y$ (called $d/dt$ )		$y$ (not further settings) <sup>61</sup>
	Integral	$\int dt$		$VS$ or $AS^{62}$	$y$ (time range via V-marker cursor) (FW02.203)	$y$ (DC Offset, time range via Gate values) (FE)	$y$		$y$ (not further settings) <sup>63</sup>
Filters	Lowpass Filter	LPF			BW 0Hz to 300 MHz 2 <sup>nd</sup> order infinite impulse response filter (IIR)			BW 0Hz to 70 MHz 4th order Bessel-Thompson filter	$y$
	Highpass Filter	HPF			BW 0Hz to 300 MHz 1 <sup>st</sup> order infinite impulse response filter (IIR)				$y$
	Bandpass Filter	BPF							$y$ . Parameters: "-3dB low cutoff (Hz)", "-3dB high cutoff (Hz)"
	Bandstop Filter								$y$ . Parameters: "-3dB low cutoff (Hz)", "-3dB high cutoff (Hz)"
Tracking	Track Period				Upper Level (UL) Hyst, Edge (FW02.400)	[No track functions in Math, but track is available in measurements]			
	Track Frequency								$y$
	Track Pulse Width								
	Track Duty Cycle			2		$y$ (Count 4-1024, reset). Requires periodical signal. Parameters show in later screen. <sup>64</sup>			
Process multiple traces	Average ("Averages multiple traces [in time] and displays the resulting trace")					$y$ (enhanced bits 0.5 to 3) (FE)	$y$ (enhanced bits 0.5 to 3) (FE) Parameters show in later screen. <sup>64</sup>		
Sample processing	ERES ("Average adjacent data into a point and rebuilds the trace") (removes HF noise)					$y$ (Upsample Coef.) (1.3.7R5)	$y$ (called 'Intrp'). (Upsample Coef.) Parameters show in later screen. <sup>64</sup> (1.3.7R5)		
Duty cycle	+Duty								$y^{\text{65}}$
	-Duty								$y^{\text{65}}$
Between channels	Phase (between channels)		2						$y$
	Delay (between channels)			2					$y$ (had some issues with restricted time settings)
Power	True Power	W	2 (V, A)						$y$
	Apparent Power	VA	2 (V, A)						$y$
	Reactive Power	Var	2 (V, A)						$y$
	Power Factor	-	2 (V, A)						$y$
Area	Area AC	Vs							$y$
	+Area AC	Vs							$y$
	- Area AC	Vs							$y$
	abs area AC	Vs							$y$
	Area DC	Vs							$y$
	+Area DC	Vs							$y$
	- Area DC	Vs							$y$
	abs area DC	Vs							$y$
Constants	Pi	$\pi$				$y$			$y$
	e (base of the natural logarithm)	e				$y$			
Trigonometric	Sin	Sin							$y$
	Cos	Cos							$y$
	Tan	Tan							$y$
	Arcsine <sup>66</sup>	Asin							$y$
	Arccosine <sup>66</sup>	Acos							$y$
	Arctangent <sup>66</sup>	Atan							$y$
	Hyperbolic sine	Sinh							$y$
	Hyperbolic cosine	Cosh							$y$
	Hyperbolic tangent	Tanh							$y$
Functions over longer time	Min				$y$ (MinHold hold the minimal value in multiple sweeps)	$y$ (MinHold hold the minimal value in multiple sweeps)			$y$ (Negative peak detect of all previous waveforms since capturing <sup>67</sup> )
	Max				$y$ (MaxHold hold the maximal value in multiple sweeps)	$y$ (MaxHold hold the maximal value in multiple sweeps)			$y$ (Positive peak detect of all previous waveforms since capturing <sup>67</sup> )

<sup>60</sup> Unit = V/s (Volt/second) or A/s (A/second).

<sup>61</sup> "Calculated with respect to the x-axis". "Note: the derivative of a sampled signal contains a large amount of noise, so it is advisable to apply digital lowpass filtering to all channels used as inputs to this function". [Manual of v6](#).

<sup>62</sup> Unit = VS (Volt\*second) or AS (A\*second)

<sup>63</sup> "Along the x-axis." [Manual of v6](#). <https://www.picotech.com/download/manuals/picoscope-6-users-guide.pdf>

<sup>64</sup> When you create the formula, there is no option to set the parameters. But once the function is performed, in the math menu, you can set the parameters for all the functions that do have parameters.

<sup>65</sup> Picoscope6 only had a duty function, expressed as %. Picoscope7 replaced that by +Duty and -Duty/

<sup>66</sup> Also known as inverse sine, inverse cosine, inverse tangent.

<sup>67</sup> "When the scope is running, these functions operate continuously on all waveforms since the scope started capturing. If a math channel containing these functions is enabled when the scope is stopped, it operates on the contents of the waveform buffer instead." [Manual of v6](#).

	Average							Y (Arithmetic mean of all previous waveforms since capturing <sup>a)</sup> )
	Peak							Y (Maximum-to-minimum range of all previous waveforms since capturing <sup>a)</sup> )
Coupler	RG58 cable							Y. Parameter distance between the master and slave probing points, in metres
	Cat5 cable							Y. Parameter distance between the master and slave probing points, in metres
Other	Moving							Y. Parameter "resolution (power of 2)". Not sure what this does.
	Deskew							Y. Parameter "time offset (s)". To add deskew time (i.e. time offset) (i.e. advance or delay channels). For instance to compensate for differences in cable lengths or skew in trace lengths.
	Total functions (excl. FFT)			19	23		6	61

## Horizontal system & trigger

### Horizontal mode XT

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Acquire mode</b>  * decimation mode: sample rate > ADC rate ** arithmetic mode: consecutive acquisitions	<p>Sample, Peak Detect * High Resolution * Average (2-100k) ** Envelope ** Envelope+ Peak Detect</p> <p>Nx (samples per acq) selectable {1-13k} Screen shortcut Acquisition M68</p>	<p>Sample ("normal") Peak Acquire, Manu. M33</p> <p>Has 10-bit acquisition mode, whose workings are comparable to what other scopes call a 'High-Res' acquisition mode. It uses oversampling<sup>68</sup> and maximum bandwidth is approx. 100MHz. Acquisition &gt; Menu, M82.</p> <p>Also, averages are an available function in the math channel.</p>	<p>Sample ("normal") Peak Detect High Resolution Average (2-64k)</p> <p>ACQUIRE &gt; Time Mode &gt; Acq Mode</p>
<b>Horizontal Time scale X(t) (time base range)</b>	1ns /div to 500s/div Front-panel dial HORIZONTAL SCALE Screen shortcut Horizontal > Time Scale M68	1 ns/div – 1000 s/div (0.5 ns/div – 1000 s/div if 500 MHz bandwidth option installed) Only in 1-2-5 steps, no fine control <sup>69</sup>	5 ns/div to 50 s/div Front-panel dial HORIZONTAL SCALE
<b>Roll</b>	Roll (default 500ms/div, selectable 50ms/div to 500s/div) (FW02.000) Start position left Math available (except HPF, LPF and tracking) Acquisition M69	Roll (50 ms/div and slower) Start position right Math disabled Acquire, Roll	Roll (50 ms/div and slower) Start position right Math disabled ACQUIRE > Time Mode > Roll M41
<b>Interpolation modes (when there are less ADC sample points than screen values needed)</b>	Sin(x)/x, Linear, S&H Acquisition M70	Sin(x)/x (Sinc), Linear (x) Acquire > Menu, M82	Not specified
<b>Offset positions</b>	 Check PS. Activate grid axis to see what you are doing!	Offset mode selectable in Utility > Menu > Reference position. M337 PS. Activate grid axis (default off) to see what you are doing!	
<b>Horizontal reference point position (so the horizontal zoom is centered from this point)</b>	Left (~10%), Centre (50%), Right (~90%) Horizontal M54	From 0% to 100%. Ambiguous terminology <sup>70</sup> Is placed in a bit odd position in the menu system Utility > Menu > Reference position. M337	Left (~10%), Centre (~50%), Right (90%) ACQUIRE > Rfme Ref Center M36

<sup>68</sup> <https://www.eevblog.com/forum/testgear/siglent-sds2000x-plus-coming/>

<sup>69</sup> Cannot be set to in-between values (say, 12ms/div), also not when entering manual values via screen 'calculator' input. Can be an issue to get exactly a wave into view, or a specific sequence in a serial bus decode.

<sup>70</sup> I find the terminology used here rather confusing, especially because both for the "Fixed Delay" and "Fixed position" mode, the word 'delay' is left away on the instrument's screen. With just 'position' left on the screen, you think you can change a position, but in fact you cannot do so. But in Fixed Delay, the position can be changed.

, 'position' vs. 'delay', quite confusing. Calling this "Centre Position" and "Adjustable" Position", or simply a single parameter that is default at 50% (like in other devices) would be much more intuitive. Just my two cents.

## Horizontal mode XY

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
	App > XY, M163	Acquire, XY Mode	ACQUIRE > Time Mode > XY, M43
<b>Number of simultaneous Y channels shown</b>	2	1	1
Sources (Analog)	4A (any analogue channel) No M, no R	Input hardwired Ch1-Ch2 <sup>71</sup> No M, no R	Input hardwired C1-Ch2 No M, no R
Simultaneous time domain (XT) traces shown	Yes, in two separate grids		
Trigger and time base functions	Present <sup>72</sup>		Horizontal scale adjusts sample rate OHF check
Trace intensity control ('Z-axis'; 'blanking')	[not specified or documented in manual, but possible via SCPI remote commands, with limitations <sup>73</sup> ]		Yes, via ext. trigger input. If above threshold of 1.4V, trace is blanked
Allows use of cursors measurements	Two horizontal and two vertical cursors	Two horizontal and two vertical cursors	Two horizontal and two vertical cursors

## Zoom

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
Type of zoom	Horizontal, Vertical (FW02.202)  Screen shortcut	Horizontal, Vertical  Front-panel dial Zoom (click) Acquire, Zoom M92	Horizontal  Front-panel dial HORIZONTAL SCALE
Select horizontal zoom area	Draw zoom area Pinch zoom trace Timebase dial (position & scale) Menu with numerical values	Pinch zoom trace Timebase dial (position & scale) Menu with numerical values 	Timebase dial (position & scale)
Select vertical zoom area	Draw zoom area Pinch zoom trace Vertical dial (position & scale) Menu with numerical value	Pinch zoom trace Vertical dial (position & scale) Menu with numerical values 	
Split screen	Selectable windows size	Fixed windows (½ and ¾)	Fixed windows (about ¼ and ¾)

<sup>71</sup> Hence, the front panel has "X" and "y" printed under the BNC for channels 1 and 2...

<sup>72</sup> This means that if the timebase is set such that only a part of a waveform is shown in the time domain graphs, then the XY graph will only show those parts of the traces.

<sup>73</sup> The RTB responds to the same Z-mode commands (DISPlay:XY:ZSource, DISPlay:XY:ZMode, DISPlay:XY:ZTHreshold) as the RTM and HMO series (see the R&S [RTM2000 manual](#), page 464). These commands allow to turn the Z mode on, select the blanking input channel, and choose analog or digital control (the latter with a selectable threshold). There are some observed limitations. In analogue mode, it seems from min to max channel values there are four equal 'zones' in which brightness goes from low to high. In digital mode, the threshold can be set from -100 to +100 (different from the RTM) but value 0 puts the threshold at the minimum channel value (next to negative overload) and other values don't change this behavior. Having this said, this is not a claimed or documented feature, so we should not complain. After some experimentation it's useful for those that need it.

## Trigger system

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
Source	4A, 16D, Ext., AC Line, 2 Serial Dedicated source button with colour code	4A, 16D, Ext., AC Line, 2 serial (varies by trigger type)	4A, Ext., AC Line, Wavegen, Wavegen Modulation
Ext. trigger in	Front (dedicated) Sensitivity 300mV, level -5/5V, max. 300 V (RMS), max. 400 V (Vp)	Back (dedicated) Max. 1.5Vrms; max. 7.5Vrms with EXT/5 attenuator	Back (dedicated) Max 30 Vrms, 40 Vpk
Channel selection	Always (on, off) <sup>74</sup>	When active or hidden (not off)	Always (on, off) <sup>75</sup>
Trigger mode	Auto, Normal  Trigger > Trigger type... M76	Auto, Normal  Trigger > Auto Trigger > Normal	Auto, Normal
Trigger start and stop	Run, Stop, Single <b>Force trigger</b>    Screen shortcut	Run, Stop, Single   Trigger > Single	Run, Stop, Single <b>Force trigger</b>   
Trigger types	6 (see below)	10 (see below)	7 (see below)
Type: Edge	{Rise, fall, alternate} Trigger > Trigger type... M76	{Rise, fall, alternate} Trigger > Menu... M101	{Rise, fall, alternate, either} M101
Type: Pulse width	Polarity {> < ≠ inside outside} Delta Δ Threshold Hysteresis Trigger > Trigger type... M78	Polarity {> < inside outside} Trigger > Menu... M105	Polarity {> < inside}
Type: Video	Polarity, SSD 3HD video standards, 3 interlace modes, line select Trigger > Trigger type... M80	Polarity, 4SD 4HD video standards, <b>custom standard</b> , 2 interlace modes, line select Trigger > Menu... M106	Polarity, 4 SD video standards, 3 interlace modes, line select  >Features >Video > Standard  Supports auto setup  >Features >Video > Auto Setup
Type: Pattern (Analog, Digital, Math, Ref)	Up to 20 bits (4A 16D) {AND, OR} State: {H, L, don't care} {True, False, Goes True, Goes False} Analogue channels thresholds Time limitation {> < ≠ inside outside} with Δ Trigger > Trigger type... M82	{AND, OR, NAND, NOR} State: {H, L, don't care}  Goes True for OR and NAND, To False for AND and NOR  Time limit range (AND and NOR only)  <b>Check in practice</b>	"State"
Type: Serial	Supported Trigger > Trigger type... M342	Supported Trigger > Menu	Supported
Type: Timeout	Supported (FW1.203) Trigger > Trigger type... M86		
Type: Edge within vertical window		"Window" Trigger > Menu... M111	
Type: Runt		Polarity, {> < inside outside}, upper time value Trigger > Menu... M116	
Type: Interval		Supported Trigger > Menu... M114	
Type: Dropout		Supported Trigger > Menu... M114	
Type: Setup and hold			Supported
Type: Slope (Rise/fall time)		Supported Trigger > Menu... M102	Supported
Trigger Zone		Trigger zone Trigger > Zone #124-120	
Hold-off	For all trigger types (FW02.000) Time. Trigger > Trigger type... M76	For all trigger types <b>except video and serial.</b> By Time [8ns to 30s; 8ns step] By # of events (1 to 10 <sup>8</sup> ) Trigger > Menu... M120-121	Time
Trigger coupling	AC, DC Trigger > Coupling... M77	DC, AC (AC: 20Hz HPF, Ext. trig: 8 Hz HPF) Trigger > Menu... M122	AC, DC (AC: 10Hz HPF) (DC ext. trigger: 50Hz)

<sup>74</sup> Digital channels available while logic probe connected

<sup>75</sup> Digital channels available while logic probe connected

			TRIGGER > Coupling... M124
LF Reject	15kHz HPF <sup>76</sup> Trigger > Coupling... M77	1.2MHz HPF (EXT trig: 33kHz HPF) Trigger > Menu (part of Coupling menu)) M122, S11	50kHz HPF (ext, 50Hz) TRIGGER > Coupling > M124
HF Reject	5kHz LPF <sup>77</sup> Trigger... M77	600kHz LPF (EXT trig: 967kHz LPF) Trigger > Menu (part of Coupling menu)) M122, S11	50kHz LPF TRIGGER > Coupling > Reject... M124
Noise reject	Yes (extends the hysteresis to avoid unwanted trigger events) <sup>78</sup> Trigger... M77, 334	Yes (increases the trigger hysteresis) Trigger > Menu... M122	Yes (adds additional hysteresis to the trigger circuitry) TRIGGER > Coupling > Reject... M124
BNC pulse out (For pulse amplitude and see IO/connections, above)	BNC pulse out ("AUX", front side) Shared connector, settings via: Trigger... M86	BNC pulse out ("Auxiliary Out", front side) (Output of Auxiliary Out connector is Trigger, except when Mask analysis is activated)	BNC pulse out ("GEN OUT"), front side) Shared connector, settings via: UTILITY > Options > Auxiliary... M242-243
Actions on mask (other than BNC Pulse out)	Sound Screenshot Save waveform Save all channels to references Trigger... M86 (FW02.300)	BNC pulse out ("Auxiliary Out") see (Output of Auxiliary Out connector is Trigger, except when Mask analysis is activated)	

## Tools

### CURSOR

	 RTB2000	 SDS 2000X+	 DSOX 1200
Location on instrument	All settings in Cursor CURSOR	All settings in Cursor > Menu CURSOR	All settings CURSOR
Mode	<ul style="list-style-type: none"> <li>Manual (H, V, H+V)</li> <li>Track (H+V) ("V-Marker"<sup>79</sup>)</li> </ul>	<ul style="list-style-type: none"> <li>Manual (H, V, H+V)</li> <li>Track (H+V)</li> <li>Measure (linked to a selected position in measure mode) (FW 1.3.9R4)</li> </ul>	<ul style="list-style-type: none"> <li>Manual (H+V)</li> <li>Track (H+V)</li> <li>Binary<sup>80</sup></li> <li>Hex<sup>81</sup></li> </ul>
Source (Analog, Digital, Math, Ref)	4A, 16D, 5M, 4R	4A, <b>16D</b> , 2M, 4R	4A, M, FFT, 2R
Different source for X1 and X2	Yes (FW02.400)	Yes	Yes
Cursor control rotary dial	Multifunctional dial	Multifunctional dial	Dedicated dial
Track scaling (when time base or vertical scale is changed)	Selectable ("Track Scaling")	Selectable separately for X and Y CursorX Ref CursorY Ref	
Coupling of cursor lines	Via "Coupling" {Off, On}	Via "X2-X1" or "Y2-Y1"	Via "X1-X2 Linked" or "Y1-Y2" Linked"
Measurement results in cursor mode	7 measurements: t1, t2, Δt, V1, V2, ΔV and ΔY/ΔX (in kV/s) (FW02.000)	7 measurements: t1, t2, Δt, V1, V2, ΔV and 1/ΔX (in MHz)	6 measurements: t1, t2, Δt, V1, V2, ΔV
Position of measurement results	Overlay of waveform	Overlay of waveform or movable table	Table (bottom)
Unit definition			X units {Sec., Hz., Phase <sup>82</sup> , Ratio <sup>83</sup> } Y units {Base, Ratio <sup>84</sup> }

<sup>76</sup> Inconsistent with Specifications (p.5): "LF reject (attenuates < 50 kHz (meas.)"

<sup>77</sup> Inconsistent with Specifications (p.5): "HF reject (attenuates > 50 kHz (meas.)"

<sup>78</sup> Manual page 334 also mentions additional 100 MHz LPF.

<sup>79</sup> V-Marker is in Type menu.

<sup>80</sup> Logic levels of displayed waveforms at the current X1 and X2 cursor positions are displayed in binary. The display is color coded to match the color of the related channel's waveform. Meaning: 1 is higher than trigger level, 0 is lower than trigger level.

<sup>81</sup> Logic levels of displayed waveforms at the current X1 and X2 cursor positions are displayed in hexadecimal. Meaning: 0x8 is higher than trigger level, 0x0 is lower than trigger level.

<sup>82</sup> With phase, X cursor = 360°.

<sup>83</sup> With ratio, X cursor is 100%.

<sup>84</sup> With ratio, Y cursor is 100%.

## Measure

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT DSOX 1200
<b>Location on instrument</b>	All settings in Measure 	All settings in Measure > Menu 	All settings 
<b>Regular measure positions</b>	6 positions (FW02.400) Shown in columns (6 horizontal) Shown in rows (6 vertical) when statistics on 	5 positions in M1 mode Shown in columns (5 horizontal) Shown in rows (5 vertical) when statistics on  > Mode > Advanced p/us Config > Display Mode M1  12 positions in M2 mode Shown in 4:3 matrix Shown in rows (up to 12 vertical, variable) when statistics on  > Mode > Advanced p/us Config > Display Mode M2	4 positions Shown in columns (4 horizontal)  Statistics display comes in addition to regular measurements, in rows (4 vertical)
<b>Quick measurement</b>	9 measurement overlay with live trace 	Table with 12 measurements  > Mode > Simple	Table with 26 measurements  > Type > Snapshot All, M169 Can be assigned to "Quick Action" button via  > Quick Action > Quick Measure All, M169, 249
<b>Turn on/off measurements display (without deleting settings)</b>	Turn on: individual measurements not global Turn off: individual or global <sup>85</sup>		Not at all
<b>Adding measurements to show</b>	First choose measurement position in menu, then select type, bit cumbersome	By "+" shortcut in measurement table	Via selection rotary in FIFO queue <sup>86</sup> , very cumbersome
<b>Source (Analog, Digital, Math, Ref) (Zoom)</b>	4A, 16D, 5M, 4R	4A, 16D, 2M, 4R, 4Z, 4ZA, 16ZD History S13	4A, M, (FFT: 6 only)
<b>Measurement types</b>	33 types (see table below)	51 types (see table below)	32 types (see table below)
<b>Measurements update rate for 1kHz / 10MHz wave<sup>87</sup></b>	16 meas/sec 260 meas/sec	3 meas/sec 20 meas/sec	36 meas/sec 667 meas/sec
<b>On-screen explanation of measurements</b>	Detailed icons	Small icons, and a one-line text which cannot be seen when you need it. <sup>88</sup>	Small icon; with soft key is pressed, extensive explanation with pictures is shown.
<b>Display of dimensions (V, A)</b>	Types are described dimensionless but in results view, some measurements show voltage as fixed dimension, where it may actually also be current <sup>89</sup>	All dimensionless	All dimensionless
<b>Histogram</b>		Small histogram for each measurement position, one histogram can be zoomed  > Statistics Settings (menu name confusion <sup>90</sup> )	
<b>Trend display</b>		Track display can be selected for one active measurements. Shown in floating window that can be set to two sizes.  > Tools = Track, M207	
<b>Track display</b>		Track display (FW 1.3.9R4) Not documented. Track display can be selected for [up to three] active measurements. Shown in floating window. Auto or manual scales  > Tools > Track	
<b>Gate (to measure specific time period)</b>		"Gate mode". Gate open and gate close moment are visible alike cursors.  > Config > Gate, M213	By via changing measurement window between the main screen and the zoom screen.  > Settings > Meas Window, M168
<b>Show relevant measurement data points in the waveform display</b>		In Cursor Measure Mode (FW 1.3.9R4) not documented, H and V cursors show relevant data points (horizontal, vertical)	H and V cursors show relevant data points (horizontal, vertical)

<sup>85</sup> By activating Statistics, and in the "Measure" tap click the tab close "X" icon.

<sup>86</sup> The first selected goes into measurement position #1, second in #2, etc. When the four positions are full, the first is deleted, the others move one place, and the new one comes in #4.

<sup>87</sup> Tested as follows: an RMS type full screen measurement on a 1kHz or 10MHz sine wave on channel 1; statistics on, everything else deactivated.

<sup>88</sup> To see the on-line text you need to select the measurement in question. But by selecting it, the instrument automatically closes the window and the text disappears. So you have to re-open the menu again to see what text appeared there. Very cumbersome if you need to figure out what measurement type you need for a certain job.

<sup>89</sup> For instance, when channel is set to current, the screen shows units such as  $V_{pp}$ ,  $V_{top}$ ,  $V_{base}$ ,  $V_{amp}$ ,  $V_p$ ,  $V_{P}$ , which should be  $A_{pp}$ ,  $A_{top}$ , etc. Having that said, after the value there is the right dimensions. So: ' $V_a = 0.5A$ '. So the confusion is limited but this could be improved.

<sup>90</sup> Once selected, this menu is called "Statistics Config" instead of "Statistics Settings".

		vertical) for almost any measurement <sup>91</sup> . Also shows selected wave parts for First Cycle measurements. <b>MEASURE</b> > Tools > Measure cursor (which actually brings you to the cursor menu with Measure Cursor mode activated)	for almost any measurement . <b>CURSORS</b> > Mode > Track Waveform
Threshold settings for relevant measurements (middle for pulse width etc., lower and upper for rise time etc.)	Lower, Middle and /or Upper Level can be set manually (e.g., 10%, 50% 90%). <sup>@@@</sup>	Lower, Middle and /or Upper Level can be set manually (e.g., 10%, 50%, 90%), or in voltages. <b>(1.3.7R5)</b> M216	Lower, Middle and /or Upper Level can be set manually (e.g., 10%, 50%, 90%), or in voltages. <b>ANALYZE</b> > Feature > Measure thresholds. M176
Statistics	5 (Value, Min, Max, Mean, SD) + count (from FW02.400)  @@@	6 (Value, Min, Max, Mean, PP, SD) + count  Count limit: 1-1024, $\infty$ <b>MEASURE</b> > Statistics Settings (menu name confusion <sup>92</sup> )	5 (Value, Min, Max, Mean, SD) + count (from FW02.12) <b>MEASURE</b> > Statistics  Count limit: 1-2000, $\infty$ (from FW02.12) <b>MEASURE</b> > Statistics > Max Count  Option to show standard deviation/mean ("Relative σ") (which is a dimensionless value) <b>MEASURE</b> > Statistics > Relative - Q
Reset statistics	<b>CLEAR SCREEN</b> M45 Via icon shown right of statistics table, or touch any setting or button that affects measurements	<b>CLEAR SWEEPS</b> M208 Via 'reset statistics' icon	<b>MEASURE</b> > Statistics > Reset Statistics
Increment statistics			Incremental statistics add the currently measured waveform to the collected statistical data (only when acquisition is stopped and segments are off) <b>MEASURE</b> > Statistics > Increment Statistics
Save measurements and statistics	Save measurements and statistics set to file (CSV) (See below at Save and Recall section)		

<sup>91</sup> After changing a measurement, you need to go to item **CURSORS**, and change value from "NULL" to the new measurement.

<sup>92</sup> Once selected, this menu is called "Statistics Config" instead of "Statistics Settings".

## Overview of all measurement types

			 RTB2000	 SIGLENT SDS 2000X+	 Keysight DSOX 1200
	Measurement types <sup>93</sup>	Dimension	33 types	51 types <sup>94</sup> 55 types (FR 1.5.2R1)	32 types
Horizontal (time)	Frequency	Hz	Frequency	Freq	Frequency
	Period	s	Period	Period	Period
	Duty Cycle +	%	Duty Cycle +	+Duty	+ Duty Cycle
	Duty Cycle -	%	Duty Cycle -	-Duty	- Duty Cycle
	Pulse Width +	s	Pulse Width +	+Width	+ Width
	Pulse Width -	s	Pulse Width -	-Width	-Width
	Burst Width	s	Burst Width		
	Rise Time	s	Rise Time	Rise Time; 10-90%Rise <sup>95</sup>	Rise Time
	Fall Time	s	Fall Time	Fall Time; 90-10%Fall	Fall Time
	Slew rate+	MV/s	Slew rate+ (FW02.000)	PSlope (FW 1.3.9R4)	
	Slew rate-	MV/s	Slew rate- + (FW02.000)	NSlope (FW 1.3.9R4)	
	Delay to Trigger	s	Delay to Trigger (FW02.400)	Delay (same?)	
	Time from trigger to each rising edge <sup>96</sup>	s		T@M	
	Time of max value	s		Time@max	
	Time of min value	s		Time@min	
	Difference between two consecutive periods	s		CCJ <sup>97</sup>	
Horizontal delay between two channels	X at Min Y	s			X at Min Y
	X at Max Y	s			X at Max Y
	Delay	s	"Delay" Settings on either channel: (Rising, Falling) (**) (4 combinations) <sup>98</sup>	"FRFR", "FRFF", etc. Settings on either channel: (Rising, Falling) {First, Last } (8 combinations)	"Delay" Settings on either channel: (Rising, Falling) (4 combinations)
	Phase	°deg	Phase (**)	Phase	Phase
	Skew	s		Skew	
	Data setup time before the clock rising edge	s		tsu@R (FR 1.5.2R1)	
Vertical (amplitude)	Data setup time before the clock falling edge	s		tsu@F (FR 1.5.2R1)	
	Data hold time after the clock rising edge	s		th@R (FR 1.5.2R1)	
	Data hold time after the clock falling edge	s		th@F (FR 1.5.2R1)	
	Peak to Peak	V	Peak Peak	Pk-Pk	Peak-Peak
	Peak +	V	Peak +	Max	Maximum
	Peak -	V	Peak -	Min	Minimum
	Amplitude (top to base)	V	Amplitude	Amplitude <sup>99</sup>	Amplitude
	Top Level	V	Top Level	Top <sup>99</sup>	Top
	Base Level	V	Base Level	Base <sup>99</sup>	Base
	Mean Value	V	Mean Value	Mean	Average Full Screen
	<i>Idem, First Cycle</i>	V	Mean Cycle	Cycle Mean	Average - Cyc
	<i>Idem, integral cycles only<sup>100</sup></i>	V			
	Median (50% above 50% below)	V		Median	
	Median First Cycle	V		Cycle Median	
Vertical (power)	RMS Value	V	RMS Value	RMS <sup>101</sup>	DC RMS Full Screen
	<i>Idem, First Cycle</i>	V	RMS Cycle	Cycle RMS	DC RMS - N Cycles
	<i>Idem, integral cycles only<sup>100</sup></i>	V			
	FrPos/neg pulses, Rising/falling edges,	V	σ-Std. Deviation	Stdef	AC RMS Full Screen (Std. Deviation)
	<i>Idem, First Cycle</i>	V	σ-Std. Dev. Cycle	Cycle Stdef	AC RMS - N Cycles
	<i>Idem, integral cycles only<sup>100</sup></i>	V			
	Crest	check		Crest (option <sup>102</sup> )	
	Crest Factor	ratio	Crest Factor	Crest factor (option <sup>103</sup> )	
	Power factor	Check		Power factor(option <sup>103</sup> )	
	Real Power (active power)	Check		Real power (option <sup>103</sup> )	
Vertical (phase)	Apparent Power	Check		Apparent Power option <sup>103</sup> )	
	Reactive Power	check		Reactive Power (option <sup>103</sup> )	
	Phase Angle	check		Phase Angle (option <sup>103</sup> )	

<sup>93</sup> Not counting multiple variants possible in the delay section.

<sup>94</sup> Not considering "10-90%Rise" and "90-10%Fall" because these functionally overlap with "Rise Time" and "Fall Time".

<sup>95</sup> The first variant measures between low threshold and high threshold (which can be manually set, like the other scopes, see above). The second variant is between 10% and 90%, which overlaps with the first variant.

<sup>96</sup> Creates multiple values in a single trace. So, if there are three edges after the trigger on the screen, the values may be 1µs, 2µs and 3µs. The histogram function can show these clearly. The shown "Value" is the last one (3µs) and the average would be 1.5 µs.

<sup>97</sup> Not sure what this exactly means and no information is offered in the manual. Screen says: 'Time difference between two continuous periods'. Somewhat different but not any clearer.

<sup>98</sup> Older FW02.300 had 36 combinations.

<sup>99</sup> A menu item MEASURE > Config > Amplitude Strategy allows different strategies how to calculate top and bottom. M215.

<sup>100</sup> Looks for at least three full waveforms on the display and then takes only these three waveforms. With less than three detected edges, an error is shown.

<sup>101</sup> When used in the Power Analysis Option, this is written as "Rms" (lower case letters) but it seems to be the same as the RMS measurement.

<sup>102</sup> Only when SDS-2000XP-PA Power Analysis Option is installed, and in the relevant PA Analysis menu's (cannot be chosen from regular measurement menu)

	Level at trigger	V	L <small>GT</small>	
	Pos. Overshoot	%	Pos. Overshoot	ROV
	Neg. Overshoot	%	Neg. Overshoot	FOV
	Overshoot before a falling edge	%	Preshoot(FPRE)	Overshoot <sup>103</sup>
Counting	Overshoot before a rising edge	%	Preshoot(RPRE)	Preshoot <sup>104</sup>
	# of positive pulses on display	Cnt.	Positive Pulse	Positive Pulse Count
	# of negative pulses on display	Cnt.	Negative Pulse	Negative Pulse Count
	# of rising edges on display	Cnt.	Positive Slope	Rising Edges
	# of falling edges on display	Cnt.	Negative Slope	Falling Edges
	# of edges in a waveform	Cnt.		Edges
	# of cycles in a periodic waveform	Cnt.		Cycles
	Bit Rate	Mbps		Bit Rate
	Counter trigger level crossings during gate time	Hz		Counter some specifics <sup>105</sup>
Area	.. waveform above zero	Wb <sup>106</sup>	+Area@DC	
	.. waveform below zero	Wb	-Area@DC	
	.. waveform	Wb	Area@DC	
	Absolute area of the waveform	Wb	AbsArea@DC	
	.. waveform above average	Wb	+Area@AC (1.3.7R5)	
	.. waveform below average	Wb	-Area@AC (1.3.7R5)	
	.. above average minus area of the waveform below average	Wb	Area@AC (1.3.7R5)	
	.. above average add area of the waveform below average	Wb	AbsArea@AC (1.3.7R5)	

## Digital Voltmeter (DVM)

	RTB2000	SIGLENT SDS 2000X+	KEYSIGHT TECHNOLOGIES DSOX 1200
	aapje		
Location on instrument	App > Meter Quick Toolbar > Meter M168: ST		ANALYZE > Feature > DMM M196: ST, 717 DVM standard since FW2.10
Source (Analog, Digital, Math, Ref)	4A  (does not work for channels turned off)		4A  (works for channels turned off)
Positions (shown simultaneous)	4 positions		2 (one selected voltage plus frequency but only if channel is selected for trigger)
Resolution	3 digits		3 digits
Scale	Via analogue channel settings		<ul style="list-style-type: none"> <li>Via analogue channel settings<sup>107</sup></li> <li>Auto range mode, is especially useful for inactive channels. Overwrites the channel gain and position setting for active channels.<sup>108</sup> Not available for channels selected for trigger</li> </ul>
Source (Analog)	4A, active or inactive		4A, active or inactive
Measurements	DC, AC, ACrms, DC+ACrms  (shown DC measurements are wrong when channel itself is set to AC coupling, no warning <sup>109</sup> )		DC, DCrms, ACrms  (DC only when channel set to DC, otherwise automatic switches to AC)
Bandwidth (for AC signals)	1MHz		20 Hz to 100 kHz (for RMS), warning when outside range
Display	Display colour adapts to channel.  Show in overlay window (screen position can be dragged)		Seven-segment readout style. Display colour adapts to channel. <ul style="list-style-type: none"> <li>While DVM menu is selected: results shown in large font in overlay window (transparency selectable).<sup>110</sup> (Frequency shown simultaneously but only if channel is selected for trigger).</li> </ul>

<sup>103</sup> The edge that is closest to the trigger is measured (which can be seen by the shown X cursor). To switch between positive and negative overshoot, change the trigger.

<sup>104</sup> The edge that is closest to the trigger is measured (which can be seen by the shown X cursor). To switch between rising edge and falling edge, change the trigger.

<sup>105</sup> This counter is hardware implemented, only for the channel selected for trigger and edge or pulse width trigger is selected, and uses trigger threshold. See Frequency Counter section below. See M168 as well as some additional information on on-screen help (press "Type" softbutton for 3 seconds).

<sup>106</sup> See discussion at <https://electronics.stackexchange.com/questions/562058/siglent-sds1104x-e-integrate-function-units-of-measure>

<sup>107</sup> But asynchronous from oscilloscope's acquisition system.

<sup>108</sup> This is important to be aware of when auto-range is activated and DVM menu is left. After than, any moment you attempt change the channel gain, a second later, that change is undone (as auto-range overrides the new selected setting)...

<sup>109</sup> This suggests the DVM is located after the AC coupling capacitor of the channels. While this is apparently also the case for the DSOX, that device takes a better approach: it disables the DVM DC mode when the channel is coupled AC (and if the DVM was already on DC before the channel was put into AC, it switches the DVM back to AC).

<sup>110</sup> When switching from Analysis to Measurement menu, there is weird interference with measurement window.

			<p>Small analogue scale showing measurement extrema over last 3 seconds. The scale's blue triangle pointer shows the most recent measurement. If measurement statistics is also on, the display jumps erratically between both. But disappears when leaving DVM menu.</p> <ul style="list-style-type: none"><li>• Always: results shown in small font at left bottom. Only voltage or frequency (not both). No scale.</li></ul>
--	--	--	---

## Frequency counter

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Location on instrument</b>	App > Counter, M167, S7	Analysis > Counter, M264, S14	ANALYZE > Feature > DVM, M195, S7, 17
<b>Implementation</b>	Separate from DMM  Show in overlay window (screen position can be dragged)  (Separate freq. counter in Measurements) (Separate freq. track in Math)	Show in overlay window (screen position can be dragged)  (Trigger frequency is shown on the screen independent of the counter)  (Separate freq. counter in Measurements)	Part of DMM (results shown simultaneously with voltage), hardware implemented  (Same freq. counter shown in Measurements) (Separate event counter with gate in Measurements)
<b>Modes</b>	Frequency, Period (shown simultaneous)	Freq, Period, Totalizer	Frequency
<b>Inputs (Analog, Digital, Math, Ref)</b>	4A, trigger, ext. trigger (Independent of DMM) (Independent of channel selected for trigger <sup>111</sup> )	4A (Independent of channel selected for trigger but only works if trigger (level) for that channel is properly set <sup>112</sup> ) Also works for serial trigger (1.3.7R5) Add regular trigger?	4A (Same channel as DMM) (Only works when channel is also selected for trigger <sup>113</sup> , but independent of proper trigger level)
<b>Digits</b>	6 digits	7 digits	5 digits
<b>Measurement rate</b>	[Not specified]	100 times/second	[Not specified]
<b>Totalizer gate / trigger modes</b>		Totalizer can count rising or falling edges  Gate mode: Voltage level, Polarity  Trigger "After Edge" mode: Rising or falling edges (on gate channel); Level	
<b>Statistics</b>		Statistics for Freq. and Period (Value, Mean, Min, Max, Stdev, Count <sup>114</sup> ). Update rate ~0.5 meas/sec	

<sup>111</sup> In the FW02.400 manual (p. 167) it is called the "Trigger Counter" and the screenshot also shows this at the icon, suggesting its use is limited for the channel serving as trigger. But on the instrument, the text at the icon is different (just 'counter') and when used, it can just measure the frequency of any channel, whether selected for trigger or not.

<sup>112</sup> Alternatively, a "Level" setting can be used in the counter menu which is linked to the trigger level setting for that channel (if moved, trigger level moves, if trigger level moved, this level moves).

<sup>113</sup> If user selects other channel for trigger, the frequency counter automatically changes to voltmeter for the selected channel.

<sup>114</sup> Here, count represents is how many frequency data points have been gathered for the statistical analysis.

## Serial bus decoding<sup>115</sup>

(Table below is for general aspects; for specific protocols see below)

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT DSOX 1200
<b>Location on instrument</b>	All settings in Protocol <b>PROTOCOL</b>	All settings in Analysis > Decode <b>DECODE</b>	<b>ANALYZE</b> > Features > Serial
<b>'Bundle' protocols<sup>116</sup></b>	SPI, I <sup>2</sup> C, UART, CAN, LIN	SPI, I <sup>2</sup> C, UART, CAN, LIN	SPI, I <sup>2</sup> C, UART, CAN, LIN
<b>Optional</b>		FlexRay, MIL-STD-1553B, I <sup>2</sup> S, CAN FD, Manchester <sup>117</sup> , SENT (since 1.3.7R5)	
<b>Simultaneous decode buses</b>	1 bidirectional <sup>118</sup> , 2 unidirectional	2 bidirectional	1 bidirectional
<b>Signal sources (Analog, Digital, Math, Ref)</b>	4A, 16D (not M <sup>119</sup> or R)	4A, 16D (not M <sup>92</sup> or R)	4A (not M <sup>92</sup> or R)
<b>Decoder works with channels turned off</b>	Yes	No, but does work from hidden channels	Yes
<b>Logic bit level display</b>	Yes, shown just above telegram (various useful purposes <sup>120</sup> )		
<b>Relation decode module to trigger module</b>	Relevant decode settings automatically shared with trigger. <b>Serial trigger settings shown on same screen as decode settings</b>	Protocol settings can be copied to and from trigger <sup>121</sup> Analysis > Decode > Protocol copy	Relevant decode settings automatically shared with trigger
<b>Color-coding for message elements telegram display</b>	Yes	Yes	Yes
<b>Refresh rate telegram display</b>	Very fast	Very fast	Very fast
<b>Event table ('tabular view', 'table', 'lister'): Number of lines shown simultaneous</b>	Variable, up to 20 lines shown (scroll option) Special pointer shows selected	Variable, up to 7 lines shown S12 (scroll option)	(Lister since FW2.10) Fixed 9 lines shown (scroll option) Table disappears each time you leave the specific lister menu.
<b>Track frame option<sup>122</sup></b>	Available. Also shows purple flag at selected frame (regardless of track frame activated)		Available
<b>Refresh event table</b>	Low (observed as approximately 2 times per second)	Medium (observed as approximately 6 times per second)	Very fast (observed as more than 25 times a second)
<b>Export event table</b>	Yes, to CSV file icon next to table	Yes [to CSV file] Analysis > Decode > Save icon	Yes, to CSV file <b>SAVE/RECALL</b> Format > Lister data
<b>Base display format</b>	{Bin, Hex, Dec, Oct, ASCII <sup>123</sup> } (non-valid ASCII values shown as HEX)	{Bin, Hex, Dec, ASCII} <b>(Problem with 'non-valid' ASCII character values<sup>124</sup>)</b>	UART: {Hex, Bin, ASCII} Other protocols: only {Hex}
<b>Label Lists ('symbolic ID')</b>	Label list (Protocol Translation Table) for I <sup>2</sup> C, CAN and LIN can be loaded from file. Examples provided. (FW1.203)		
<b>Other</b>		For SPI, I <sup>2</sup> C, CAN, LIN, no errors are shown in telegram or table. This is especially problematic because in identified cases, the instrument shows garbage data as if it were correct decoded data <sup>125</sup>	

<sup>115</sup> Descriptions in this table are based on the 'Bundle' protocols' (i.e., SPI, I<sup>2</sup>C, UART, CAN, LIN) and do not consider the optional protocols.

<sup>116</sup> Protocols that are either included with any device version, or bundled together with specific device offers.

<sup>117</sup> Implemented without serial trigger function.

<sup>118</sup> If a bidirectional bus is used (e.g. UART RX/TX or SPI MOSI/MISO), two bus decoders are occupied. S9.

<sup>119</sup> Not being able to decode from a math channel is a pity. Busses such as CAN or RS485 are differential, and the ability to use a math function to create a proper differential signal from two channels (allowing floating measurements) can prevent the purchase of a differential probe.

<sup>120</sup> This shows the actual logic levels that are input to the decoder and are useful for various reasons: (1) they tell whether the thresholds are well set, (2) they inform whether the sample rate is sufficient for the decode at stake, (3) they tell there are enough horizontal sample points (as some scope use decimation and thus use only 1 out of every N samples as input to the decoder), (4) they show you the bit levels also when you decide to turn the channel off to save screen estate (in the RTB, the serial decode can also work from a channel turned off).

<sup>121</sup> At first, it sounds nice that protocols settings (serial protocol type, channel selection, thresholds) can be copied to and from the trigger section. At second thought: why? In the other scopes, these settings are already automatically shared with the trigger section, and there is no need to go into this copy action at all. Having the possibility to have different settings in the decode section and in the trigger section can only lead to confusion.

<sup>122</sup> A track frame function makes the trace and telegram jump to the selected frame in the table. Note that this only works when acquisition is stopped.

<sup>123</sup> If a value is observed that does not correspond to a valid ASCII character, then the instrument shows the HEX value instead.

<sup>124</sup> ASCII characters other than regular characters are shown as, for instance, ☐ or □, effectively meaningless for decoding purposes.

<sup>125</sup> See <https://www.eevblog.com/forum/testgear/siglent-sds2000x-plus-coming/3125/>

## UART protocol decoding

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
	a16	a12	a16
<b>Bus speed (baud rate)</b>	Manual from 300b/s to 3Mb/s; 10 presets	Manual from 300b/s to 20Mb/s; 9 presets	100 bps to 8 Mbps 27 presets
<b>Polarity</b>	{Active High, Active Low} for Rx and Tx	Idle High, Idle Low	Idle High, Idle Low
<b>Threshold</b>	Auto determine, manual <sup>126</sup>	Manual	Manual
<b>Hysteresis for serial decode<sup>127</sup></b>	Yes, for all analogue and digital channels, in channel menu. <sup>128</sup> Vertical > Channel > Threshold > Hysteresis M54 Logic > Hysteresis M274		Perhaps <sup>129</sup>
<b>Data symbol size</b>	{5 to 9 bit} Supports 9 <sup>th</sup> bit for addressing in RS485 and other schemes. <sup>130</sup>	{5 to 8 bit} Does not supports 9 <sup>th</sup> bit for addressing in RS485 and other schemes. <sup>131</sup>	{5 to 9 bit} Supports 9 <sup>th</sup> bit for addressing in RS485 and other schemes. <sup>132</sup>
<b>Parity</b>	{none, even, odd}	{none, even, odd, mark, space}	{none, even, odd}
<b>Stop bits</b>	{1, 1.5 or 2}	{1, 1.5 or 2}	
<b>Idle time for end-of-frame</b>	78us to 53ms		
<b>Bit order</b>	[Always LSB first]	{LSB, MSB}	{LSB, MSB}
<b>Max decoded frames</b>	[not specified]	15,000	[not specified]
<b>Columns shown in Bus Table / Bus Display / Lister</b>	Frame, Start time, Source (RX, TX), Data, Status <sup>131</sup> Several time settings <sup>132</sup>	Time, Rx, Rx error, Tx, Tx error	Time, Rx [data], Tx [data], Errors. Several time settings <sup>133</sup>
<b>Error states, warnings or status shown in Bus Table / Bus Display / Lister</b>	<ul style="list-style-type: none"> <li>Start error (no start bit found)</li> <li>Stop error (no stop condition found)</li> <li>Parity error (transmission error)</li> <li>INSufficient<sup>134</sup> (warning)</li> <li>Break condition found (warning)</li> <li>(a)</li> </ul> <p>(Column is rather small<sup>135</sup>) Additional options for observing UART errors available in SCPI for both frames (M497) and words (M497)</p>	"Stop error" "Parity Error" "Over Length" (a)	"Parity error" "Unknown error" (a)  M324
<b>Content shown in Bus Table / Bus Display / Lister</b>	Shows entire frame in a line (e.g., a full text string)	New line for every value /character in a frame	New line for every value /character in a frame
<b>UART Trigger: Timing event</b>	<ul style="list-style-type: none"> <li>Start bit</li> <li>Start of frame</li> <li>Break<sup>136</sup></li> </ul>	<ul style="list-style-type: none"> <li>Start bit</li> <li>Stop</li> <li>.. Tx, Rx</li> </ul>	<ul style="list-style-type: none"> <li>Start</li> <li>Stop</li> <li>.. Tx, Rx</li> </ul>
<b>UART Trigger: Symbol position</b>	'Symbol <n>', where n is the signal position (offset) from 0 to 4k		
<b>UART Trigger: Specific symbol</b>	'Any symbol': A specific word content (where the word is 5 to 9 bits depending on protocol setting). Supports wildcards ('don't care') for individual bits and for HEX digits	'Data' .. specific word between 00 and FF .. =, <, > .. Tx, Rx	'Data' .. specific word in HEX (00 and FF) or ASCII (scrolls through all ASCII values) .. =, ≠, <, > .. Tx, Rx
<b>UART Trigger: Specific symbol and position</b>	'Pattern': .. symbol offset position from 0 to 4k .. specific pattern of up to 32 bits. Supports wildcards ('don't care') for individual bits and for HEX digits		
<b>UART Trigger: Errors</b>	<ul style="list-style-type: none"> <li>Stop bit error</li> <li>Parity error (not available if protocol parity is set to 'none')</li> </ul>	<ul style="list-style-type: none"> <li>[Parity] error M149, S12</li> </ul>	<ul style="list-style-type: none"> <li>Parity error (not available if protocol parity is set to 'none')</li> </ul>
<b>Hold off</b>	Can be used in combination with any of the above trigger functions		Can be used in combination with any of the above trigger functions
<b>UART searching</b>			
<b>Other</b>			UART bus statistics (Real-time totalizer) shows bus quality and efficiency. Shows frame count and error rates M323

<sup>126</sup> For both analogue and digital channels, thresholds can be manually set and the threshold can be automatically determined.

<sup>127</sup> This is relevant if noise or imperfect digital signals cause oscillation across the threshold value and as a result hinder the decoder doing its work properly.

<sup>128</sup> While this setting is not in the digital decoder menu itself, tests have confirmed it indeed works for the serial decoder.

<sup>129</sup> Not entirely clear. But since noise reject is available during serial decode trigger, and that function is described in the manual as as "increases the trigger hysteresis", it might be.

Trigger > Menu. M122

<sup>130</sup> The '9th bit' can be used in RS485 and other UART schemes to implement an addressing system. This 9th bit indicates whether the preceding 8-bits should be interpreted as 'address' or as 'data'. If the 9th bit is a '1', the preceding 8-bits should be interpreted as an 'address' byte. If the 9th bit is a '0', then the preceding 8-bits should be interpreted as a 'data' byte. See [here](#) and [here](#).

<sup>131</sup> The status table can show errors (see next row) but also it can also show values [OK, Break].

<sup>132</sup> Time can be selected to be relative to trigger or relative to previous frame. In the latter case, the column name changes to "time difference".

<sup>133</sup> Time can be selected to be relative to trigger or relative to previous row in table.

<sup>134</sup> INSufficient: the frame is not completely contained in the acquisition; but the acquired part of the frame is valid.

<sup>135</sup> The width of the column showing errors can be small, especially for showing multiple errors (they are still shown but in shorted form (e.g., 'NACK+Fo' for NACK plus Form error). Occasionally, after you come back from a menu, making a small switch in time base (and back) makes the column somewhat wider.

<sup>136</sup> Triggers if a start bit is not followed by a stop bit, the data line remains at logic 0 for longer than a UART word.

(a) These error values are not documented but have been observed in practice. There might be others

## I<sup>2</sup>C protocol decoding

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
		s12	ANALYZE >Features >Serial mode I <sup>2</sup> C, Addr Size, M287, S16
<b>Supported I<sup>2</sup>C protocol speeds</b>	High-speed, fast mode plus, fast mode, and standard mode. M229	[not specified]	[not specified]
<b>Bus speed</b>	up to 10 Mbps	[not specified]	Up to 3.4 Mbps S18
<b>Threshold</b>	Auto determine, manual <sup>137</sup>	Manual	Manual
<b>Hysteresis for serial decode<sup>138</sup></b>	Yes, for all analogue and digital channels, in channel menu. <sup>139</sup> Vertical > Channel > Threshold > Hysteresis M84; Logic > Hysteresis M274		
<b>Treatment of R/W bit</b>		Consider R/W bit as the 8 <sup>th</sup> bit in the address (instead of showing the 7 bit address value) M141	Consider R/W bit as the 8 <sup>th</sup> bit in the address (instead of showing the 7 bit address value) M292
<b>Max decoded frames</b>	[not specified]	2,000	[not specified]
<b>Columns shown in Bus Table / Bus Display / Lister</b>	Frame, Start time, Type, ID, Length, Data, State <small>Additional options for I<sup>2</sup>C errors available in SCPI (M484)</small>	Time, Address, R/W, Data	Time, Restart flag, Address (including R/W flag), Data, Missing Ack
<b>Error states, warnings or status shown in Bus Table / Bus Display / Lister</b>	<ul style="list-style-type: none"> <li>Address Error</li> <li>Data error</li> <li>Stop error</li> <li>INSufficient<sup>140</sup> (warning)</li> <li>Restart (status)</li> <li>OK (status)</li> </ul> <small>(Acknowledgement bits after each data and address byte are shown in the telegram, not in the table<sup>141</sup>) (column rather small<sup>142</sup>) (a)</small>	No errors shown. <sup>143</sup>	Missing Ack. No other errors shown. M294
<b>Other</b>		Bus table has long data mode (can show long strings of texts) <sup>144</sup> Analysis > Decode > Results List > Long Data	
<b>I<sup>2</sup>C Trigger: Timing event</b>	<ul style="list-style-type: none"> <li>Start</li> <li>Stop</li> <li>Restart (Repeated start condition)</li> </ul>	<ul style="list-style-type: none"> <li>Start</li> <li>Stop</li> <li>Restart (Repeated start condition)</li> </ul>	<ul style="list-style-type: none"> <li>Start</li> <li>Stop</li> <li>Restart ("triggers when another start condition occurs before a stop condition.")</li> </ul>
<b>I<sup>2</sup>C Trigger: No Ack.</b>	<ul style="list-style-type: none"> <li>No Ack (bytes with missing acknowledgement bit)</li> </ul>	<ul style="list-style-type: none"> <li>No Ack (bytes with missing acknowledgement bit)</li> </ul>	<ul style="list-style-type: none"> <li>Missing Acknowledge</li> <li><b>Address with no Ack</b></li> </ul>
<b>I<sup>2</sup>C Trigger: Address and data</b>	.. Slave address (7 bit, 10 bit) .. (Read, Write) .. Address (7 bits/HEX 00-7F or 10 bits/HEX 000-3FF) or "Any Address" .. Specified bit pattern, 1 to 3 bytes or 24 bits, supports wildcards ('don't care') for individual bits and for HEX digits .. A user Symbolic ID <sup>145</sup> .. up to 4k offset	.. Slave address (7 bit, 10 bit) .. (Read, Write, Ether) .. Address (7 bits/HEX 00-7F or 10 bits/HEX 000-3FF). <b>No wildcard</b> .. Two specified data bytes in HEX (00-FF). <b>Does not support other lengths than exactly two bytes, BIN or wildcards</b>	For 7-bit address: .. (Read, Write) .. Address (7 bits/HEX 00-7F or 10 bits/HEX 000-3FF) or "Any Address" .. One or two specified data bytes in HEX (00-FF), or "any byte" <b>Does not wildcards or BIN</b> For 10-bit address .. {Write} <b>no read</b> .. Address (10 bits HEX 000-3FF) or "Any Address" .. One data bytes in HEX (00-FF), or "any byte" <b>Does not wildcards or BIN</b>
<b>I<sup>2</sup>C Trigger: Data length</b>		.. Slave address (7 bit, 10 bit) .. SDA Data length 1-12	
<b>I<sup>2</sup>C Trigger: EEPROM</b>		The trigger searches for EEPROM control byte value 1010xxx on the SDA bus. And there is a Read bit and an ACK bit behind EEPROM. See M136	The trigger looks for EEPROM control byte value 1010xxx on the SDA line, followed by a Read bit and an Ack bit. See M289
<b>Hold off</b>	Can be used in combination with any of the above trigger functions		Can be used in combination with any of the above trigger functions
<b>I<sup>2</sup>C searching</b>			

(a) These error values are not documented but have been observed in practice. There might be others

<sup>137</sup> For both analogue and digital channels, thresholds can be manually set and the threshold can be automatically determined.

<sup>138</sup> This is relevant if noise or imperfect digital signals cause oscillation across the threshold value and as a result hinder the decoder doing its work properly.

<sup>139</sup> While this setting is not in the digital decoder menu itself, tests have confirmed it indeed works for the serial decoder.

<sup>140</sup> INSufficient: the frame is not completely contained in the acquisition; but the acquired part of the frame is valid.

<sup>141</sup> Unlike the DSOX, the RTB shows full lines of data values instead of just a single value per line in the table; therefore it would be difficult to show acknowledgement data for each of the bytes in a table row.

<sup>142</sup> The width of the column showing errors can be small, especially for showing multiple errors (they are still shown but in shorted form (e.g., 'NACK+Fo' for NACK plus Form error). Occasionally, after you come back from a menu, making a small switch in time base (and back) makes the column somewhat wider.

<sup>143</sup> There is no column to show errors, and also when there are known errors in the signal, none are shown.

<sup>144</sup> SPI, UART, CAN and LIN do not have such a function.

<sup>145</sup> If the user loaded a 'Label List' (see above), then the trigger menu allows to select the names in that list, like "Ignition" or "Valve".

## SPI protocol decoding

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
	M222	s12, M142	M303, s15
<b>Bus speed</b>	up to 25 Mbps	[Not specified] <sup>146</sup>	Up to 25 Mbps
<b>Polarity for MOSI, MISO</b>	Independent for MOSI, MISO	[ <sup>148</sup> ]	No adjustable
<b>Clock</b>	{Rise, Fall}	{Rise, Fall}	{Rise, Fall}
<b>Threshold</b>	Auto determine, manual <sup>147</sup>	Manual	Manual
<b>Hysteresis for serial decode<sup>148</sup></b>	Yes, for all analogue and digital channels, in channel menu. <sup>149</sup> Vertical > Channel > Threshold > Hysteresis M64; Logic > Hysteresis M274		
<b>Word size</b>	1 to 32 bit	1 to 32 bit	4 to 16 bit
<b>Bit order</b>	{MSB, LSB}	{MSB, LSB}	{MSB, LSB}
<b>Chip Select (CS)</b>	<ul style="list-style-type: none"> <li>• CS high</li> <li>• CS low</li> <li>• Idle time: 25.6ns to 53ms See also M277</li> </ul>	<ul style="list-style-type: none"> <li>• CS Active High</li> <li>• CS Active Low</li> <li>• CLK timeout: 100ns to 5ms</li> </ul>	<ul style="list-style-type: none"> <li>• CS</li> <li>• Not CS</li> <li>• Clock timeout: 100ns to 10s</li> </ul>
<b>Max decoded frames</b>	[not specified]	15,000	[not specified]
<b>Columns shown in Bus Table / Bus Display / Lister</b>	Frame, Start time, Source (MISO, MOSI), Length, Data, Status Several time settings <sup>150</sup>	Frame, Time, MISO [data], MOSI [data]	Time, MOSI [data], MISO [data]
<b>Error states, warnings or status shown in Bus Table / Bus Display / Lister</b>	<ul style="list-style-type: none"> <li>• Data error</li> <li>• INSufficient<sup>151</sup> (warning)</li> <li>(a)</li> </ul> <p>Additional options for observing SPI errors available in SCPI (M476)</p>	No errors shown. <sup>152</sup>	Aliased data is shown in pink colour.
<b>SPI Trigger: Timing event</b>	.. selectable MISO or MOSI <sup>153</sup> <ul style="list-style-type: none"> <li>• Frame Start See also M27</li> <li>• Frame End See also M27</li> </ul>		[Possible to trigger on frame start by using bit pattern triggering and set all bits to don't care]
<b>SPI Trigger: Specific bit position within frame</b>	.. selectable MISO or MOSI Offset 0-32k		
<b>SPI Trigger: Bit pattern</b>	.. selectable MISO or MOSI .. Specified bit pattern, max 8 nibbles (each 4 bits) or 32 bits supports wildcards ('don't care') for individual bits and for HEX digits .. up to 32k offset	.. selectable MISO or MOSI .. selectable ANY (at any position) or VALUE (offset position 0 to 64) Then.. (A) Specified bit pattern, between 4 bits and 96 bits. Value can be entered as bits or HEX, no wild cards OR (B) all bits zero (e.g., 0000), all bits one (e.g., 1111), or all bits don't care (e.g., xxxx)	.. selectable MISO or MOSI .. Specified bit pattern, between 4 bits and 64 bits. Supports wild cards. No HEX input.
<b>SPI searching</b>			

(a) These error values are not documented but have been observed in practice. There might be others

<sup>146</sup> The decode module has no polarity option, but the user can change invert the associated channel to achieve a polarity switch.

<sup>147</sup> For both analogue and digital channels, thresholds can be manually set and the threshold can be automatically determined.

<sup>148</sup> This is relevant if noise or imperfect digital signals cause oscillation across the threshold value and as a result hinder the decoder doing its work properly.

<sup>149</sup> While this setting is not in the digital decoder menu itself, tests have confirmed it indeed works for the serial decoder.

<sup>150</sup> Time can be selected to be relative to trigger or relative to previous frame. In the latter case, the column name changes to "time difference".

<sup>151</sup> INSufficient: the frame is not completely contained in the acquisition; but the acquired part of the frame is valid.

<sup>152</sup> There is no column to show errors, and also when there are known errors in the signal, none are shown.

<sup>153</sup> Via trigger > type > source.

## CAN protocol decoding

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
	M244-257	M151-154 (3.5 pages)	ANALYZE >Features >Serial mode CAN M277-285
<b>Supported CAN protocols</b>	CAN version 2.0A and 2.0B M245	[unspecified] <sup>154</sup>	CAN version 2.0A and 2.0B M279
<b>Bus speed (baud rate)</b>	manual from 100b/s to 2Mb/s; 10 presets	manual from 5kb/s to 1Mb/s <sup>155</sup> ; 10 presets	Manual form 10 kb/s to 5Mb/s <sup>156</sup> ; 15 presets
<b>Polarity</b>	{Active High, Active Low}	[ <sup>157</sup> ]	{CAN_H, CAN_L, Differential L-H, Differential H-L, Rx,Tx} M278-279
<b>Threshold</b>	Auto determine, manual <sup>158</sup>	Manual	Manual
<b>Hysteresis for serial decode<sup>159</sup></b>	Yes, for all analogue and digital channels, in channel menu. <sup>150</sup> Vertical > Channel > Threshold > Hysteresis M64; Logic > Hysteresis M274		
<b>Sample point<sup>161</sup></b>	25 to 90%		7 presets (from 60% to 87.5%)
<b>Max decoded frames</b>	[not specified]	2,000	[not specified]
<b>Columns shown in Bus Table / Bus Display / Lister</b>	Frame, Start time, Frame type, ID, Data length (DLC), Data, CRC, State Several time settings <sup>162</sup>	CAN [Frame], time, Frame type, ID, Data length, CRC, Ack.	Time, ID, Type, Data length (DLC), Data, CRC, Errors Several time settings <sup>163</sup>
<b>Errors, warnings or status shown in Bus Table / Bus Display / Lister</b>	<ul style="list-style-type: none"> <li>• NACK (Acknowledge is missing)</li> <li>• OVL (Overload frame)</li> <li>• Stuff (bit stuffing error)</li> <li>• CRC (Cyclic redundancy check failed)</li> <li>• Data error</li> <li>• Error-frame</li> <li>• Form error</li> </ul> <p>(a) Can show multiple errors per packet (column rather small)<sup>164</sup> Additional options for observing CAN errors available in CAN searching (see below) and via SCPI (M506).</p>	<p>Acknowledgement is confirmed (when they are lacking, sometimes there is a 'no' in the column, sometimes simply no value). But otherwise no errors shown.<sup>165</sup> CRC values are shown without indicating they are erroneous.</p>	<p>Acknowledge [missing] (Ack, A), Form [error] (Fo) Frame [error] (Fr)</p> <p>Can show multiple errors per packet.</p> <p>Telegram (but not lister) can also show THM<sup>166</sup> error.</p> <p>M284</p>
<b>CAN Trigger: Timing event</b>	Start of frame End of frame	Start (of frame)	SOF - Start of Frame
<b>CAN Trigger: frame type</b>	combination of .. FRAME TYPE ('Data', 'Remote', 'Data or Remote', 'Error', 'Overload') .. ID TYPE ('11bit', '29bit', 'any')		[Could be created by CAN Trigger Identifier and wildcards for full address]
<b>CAN Trigger: Identifier</b>	combination of .. FRAME TYPE ('Data', 'Remote', 'Either') .. ID TYPE ('11bit', '29bit') .. Specific identifier for the 11 or 29 bits ID in HEX or in BIN, supports wildcards ('don't care') for individual bits and for HEX digits .. Compare ID (>= ≠) ... A user Symbolic ID <sup>167</sup>	combination of <sup>168</sup> .. FRAME TYPE ('Data', 'Remote', 'Either'), not either .. ID TYPE ('11bit', '29bit') .. Specific identifier for the 11 or 29 bits in HEX or BIN, does not support wildcards	combination of .. FRAME TYPE ('Data', 'Remote', 'Either') .. ID TYPE ('11bit', '29bit') .. Specific identifier for the 11 or 29 bits in HEX or BIN, supports wildcards ('don't care') for individual bits and for HEX digits
<b>CAN Trigger: ID &amp; Data pattern</b>	Options as for ID above, combined with a data pattern up to 8 bytes / 32 bits, supports wildcards ('don't care') for individual bits and for HEX digits Must know data length <sup>169</sup> .. Compare data (= ≠)	Options as for ID above, combined with a data pattern of up to 16 bits, does not support wildcards. Cannot specify frame type (data or remote).	Options as for Remote Frame ID above, a data pattern up to 32 bits, supports wildcards ('don't care') for individual bits and for HEX digits. Cannot use data filter for remote frames

<sup>154</sup> From testing I infer that both CAN version 2.0A and 2.0B are supported.

<sup>155</sup> Specifications (p12...) are somewhat confusing: "Nominal Baud Rate: 10 kbps, 25 kbps, 50 kbps, 100 kbps, 250 kbps, 1 Mbps, custom" and "Data baud rate: 500 kbps, 1 Mbps, 2 Mbps, 5 Mbps, 8 Mbps, 10 Mbps, custom". But on the device, the maximum selectable speed is 1Mb/s so I used this value in the table.

<sup>156</sup> Fractional user-defined baud rates between 4 Mb/s and 5 Mb/s are not allowed.

<sup>157</sup> The CAN bus setting have no polarity option, but the user can change invert the associated channel to achieve a polarity switch.

<sup>158</sup> For both analogue and digital channels, thresholds can be manually set and the threshold can be automatically determined.

<sup>159</sup> This is relevant if noise or imperfect digital signals cause oscillation across the threshold value and as a result hinder the decoder doing its work properly.

<sup>160</sup> While this setting is not in the digital decoder menu itself, tests have confirmed it indeed works for the serial decoder.

<sup>161</sup> Position of the sample point within the bit, in percent of the horizontal bit time.

<sup>162</sup> Time can be selected to be relative to trigger or relative to previous frame. In the latter case, the column name changes to "time difference".

<sup>163</sup> Time can be selected to be relative to trigger or relative to previous row in table.

<sup>164</sup> The width of the column showing errors can be small, especially for showing multiple errors (they are still shown but in shorted form (e.g., 'NACK+Fo' for NACK plus Form error). Occasionally, after you come back from a menu, making a small switch in time base (and back) makes the column somewhat wider.

<sup>165</sup> There is no column to show errors, and also when there are known errors in the signal, none are shown.

<sup>166</sup> THM: If the header exceeds the length specified in the standard.

<sup>167</sup> If the user loaded a 'Label List' (see above), then the trigger menu allows to select the names in that list, like "Ignition" or "Valve".

<sup>168</sup> There is also a "Curr ID Byte" setting but this is not additional selection criteria but determines the byte changed by the rotary control (if you do not want the direct entry mode).

<sup>169</sup> While the wildcards are very flexible, there is one thing to be aware: you do need to set the number of bytes to the actual message length. So, finding any message where the first byte is "0xAF" is not possible. You need to know that message is, say, 1, 2 or 5 bytes and set that; even if you can set the other bytes to wildcards ('0XX') and can set even the full message ID to wildcards, you do need to know the number of bytes. A quick workaround is to set up the data pattern you look for, select the data [length] field, and then turn that slowly up from 1 to 8 bytes. While doing so, watch the trigger light on the front panel, the moment it goes on, you found the data length for which such a message exists. A workaround, but not perfect.

CAN Trigger: Message length	Possible by 'ID & Data pattern', set both message ID and all data to wildcard (XX) and select the message length in bytes.	check	check
CAN Trigger: Error	Selectable error type: <ul style="list-style-type: none"><li>• 'Stuff bit',</li><li>• 'Form',</li><li>• 'Acknowledge',</li><li>• 'CRC'</li></ul> <p>Any combination of these errors can be selected. (See also the two error frame types above)</p>	Yes, [but error type not specified or selectable] <sup>170</sup>	Selectable error type: <ul style="list-style-type: none"><li>• 'Error Frame',</li><li>• 'All Errors',</li><li>• 'Acknowledge Error',</li><li>• 'Overload Frame'</li></ul> <p>No combination of errors possible</p>
CAN searching	(continued on next page)		
CAN searching <sup>171</sup>	<ul style="list-style-type: none"><li>▪ Search Frame Start of frame End of frame Overload Error (frame) Data ID 11 bit Data ID 29 bit Remote ID 11 bit</li><li>▪ Search Identifier Same settings as Identifier at trigger section</li><li>▪ Search ID &amp; data Same settings as Identifier &amp; data at trigger section <small>Also here must know data length<sup>172</sup></small></li><li>▪ Search Error { Stuffbit, Form, Acknowledge, CRC } Any combination of these errors can be selected. In a bus table, each error is then identified by type.</li><li>▪ Search ID &amp; error Combines the settings as Identifier at trigger section with the settings at Error, above.</li></ul>		
Other			CAN bus statistics (Real-time totalizer) shows bus quality and efficiency. Shows total CAN frames, flagged error frames, overload frames, and bus utilization

<sup>170</sup> Manual only notes "Error—The oscilloscope triggers on the error frame." M152. It's surprising that in LIN mode several error types can be selected but in CAN mode this is not the case.

<sup>171</sup> In contrast to trigger, search can identify/show all events that meet the set criteria.

<sup>172</sup> While the wildcards are very flexible, there is one thing to be aware: you do need to set the number of bytes to the actual message length. So, finding any message where the first byte is "0xAF" is not possible. You need to know that message is, say, 1, 2 or 5 bytes and set that; even if you can set the other bytes to wildcards ('0XX') and can set even the full message ID to wildcards, you do need to know the number of bytes. A quick workaround is to set up the data pattern you look for, select the data [length] field, and then turn that slowly up from 1 to 8 bytes. While doing so, watch the trigger light on the front panel, the moment it goes on, you found the data length for which such a message exists. A workaround, but not perfect.

## LIN protocol decoding

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
Supported LIN protocol versions	v1.3, v2.0, V2.1, SAE J602 Manual selection or auto recognition (allows mixed traffic) <small>s16 s269</small>	v1.3, v2.0 <sup>s13</sup> Auto recognition (allows mixed traffic)	v1.3, v2.x Only manual setting. Mixed traffic not supported.
Bus speed (baud rate)	6 presets <sup>173</sup> ; User defined from 1 kbps to 2.5 Mbps <sup>s16</sup>	6 presents; User defined from 300 bps to 20 Mbps <sup>s16</sup>	6 presents; User defined from 2.4 kbps to 625kb/s
Polarity [in protocol menu]	Active high, Active low	No setting, device expects idle <i>low</i> . [if required change polarity in channel menu]  <b>When polarity is wrong, the SDS shows a completely wrong decoded signal as if it's a correct decode!</b>	No setting, device expects idle <i>high</i> . [if required change polarity in channel menu]
Threshold	Auto determine, manual <sup>174</sup>	Manual	Manual
Hysteresis for serial decode <sup>175</sup>	Yes, for all analogue and digital channels, in channel menu. <sup>176</sup> Vertical > Channel > Threshold > Hysteresis M64: Logic > Hysteresis M274		
Sample point <sup>177</sup>			7 presents from 60% to 87.5%
Sync break lengths			Sync break {>=11, >=12, >=13 clocks} ANALYZE >Features >Serial... mode LIN > Signals... M286
Max decoded frames	[not specified]	3,000	[not specified]
Columns shown in Bus Table / Bus Display / Lister	Frame, Start time, ID, Length, Data, Checksum, State  Several time settings <sup>178</sup>	Frame, Time, ID, Data length, ID Parity, Data, Checksum	Time, ID (problem <sup>179</sup> ), Data, Checksum, Error <sup>180</sup>  Several time settings <sup>181</sup>
Error states shown in Bus Table / Bus Display / Lister	<ul style="list-style-type: none"> <li>Sync</li> <li>Parity error</li> <li>Data error</li> <li>Checksum error</li> <li>Wakeup frame (status)</li> </ul> <p>Can show multiple errors per packet (column rather small<sup>182</sup>)</p> <p>Additional options for observing LIN errors available in LIN searching (see below) and via SCPI (M521)</p>	No errors shown. <sup>183</sup> Checksum values are shown without indicating they are erroneous.	Parity [error] Checksum [error] (a)  Can show multiple errors per packet
LIN Trigger: Timing event	Start of frame (sync break) Wakeup frame	Start of frame (break)	Start of frame (sync break)
LIN Trigger: Identifier	.. Specific identifier for the ID in HEX (00-3F) or in BIN (000000 to 111111), supports wildcards ('don't care') for individual bits and for HEX digits .. Compare (> < = ≠) <sup>184</sup> .. A user Symbolic ID <sup>185</sup>	Specific identifier for the ID in HEX (00-3F), does not support BIN or wildcards	Specific identifier for the ID in HEX (00-3F), does not support BIN or wildcards
LIN Trigger: ID & Data pattern	.. Options as for ID above, combined with a data pattern up to 8 bytes / 32 bits, supports wildcards ('don't care') for individual bits and for HEX digits .. Compare (> < = ≠) <sup>186</sup>	.. Options as for ID above, combined with two specified data bytes in HEX (00-FF). Does not support other lengths than exactly two bytes, BIN or wildcards	Options as for ID above, combined with a data pattern up to 8 bytes / 32 bits, supports wildcards ('don't care') for individual bits and for HEX digits
LIN Trigger: Error	Selectable error types: <ul style="list-style-type: none"> <li>Checksum</li> <li>Parity</li> <li>Synchronisation</li> </ul> Any combination of these errors can be selected.	Selectable error types: <ul style="list-style-type: none"> <li>Checksum</li> <li>Parity ('Header Parity')</li> <li>Synchronisation ('Sync Byte')</li> </ul> Any combination of these errors can be selected.  Checksum error option only available if one also specifies specific message ID, LIN version, and first data byte.	Selectable error types: <ul style="list-style-type: none"> <li>Checksum</li> <li>Parity</li> </ul> No combination of errors possible

<sup>173</sup> Presets including 10.417 bps, the maximum SAE J602 speed.

<sup>174</sup> For both analogue and digital channels, thresholds can be manually set and the threshold can be automatically determined.

<sup>175</sup> This is relevant if noise or imperfect digital signals cause oscillation across the threshold value and as a result hinder the decoder doing its work properly.

<sup>176</sup> While this setting is not in the digital decoder menu itself, tests have confirmed it indeed works for the serial decoder.

<sup>177</sup> Position of the sample point within the bit, in percent of the horizontal bit time.

<sup>178</sup> Time can be selected to be relative to trigger or relative to previous frame. In the latter case, the column name changes to "time difference".

<sup>179</sup> Then protocol option 'show parity' is selected, the ID value is made to include the parity but the column still simply says 'ID' which is very confusing.

<sup>180</sup> Table based on the actual device screen. Manual says "Frame ID, Data, Checksum, Errors" and also notes that LIN1.3 and 2.0 slightly different table formats. M302

<sup>181</sup> Time can be selected to be relative to trigger or relative to previous row in table.

<sup>182</sup> The width of the column showing errors can be small, especially for showing multiple errors (they are still shown but in shorted form (e.g., 'NACK+Fo' for NACK plus Form error). Occasionally, after you come back from a menu, making a small switch in time base (and back) makes the column somewhat wider.

<sup>183</sup> There is no column to show errors, and also when there are known errors in the signal, none are shown.

<sup>184</sup> If a wildcard is used, only (= ≠) – which is of course logical...

<sup>185</sup> If the user loaded a 'Label List' (see above), then the trigger menu allows to select the names in that list, like "Ignition" or "Valve".

<sup>186</sup> If a wildcard is used, only (= ≠) – which is of course logical...

LIN searching	<ul style="list-style-type: none"> <li>● Search Frame           <ul style="list-style-type: none"> <li>Start of frame</li> <li>Wakeup</li> </ul> </li> <li>● Search Error           <ul style="list-style-type: none"> <li>{'Checksum', 'Parity', 'Synchronisation'}. Any combination of these errors can be selected. In a bus table, each error is then identified by type.</li> </ul> </li> <li>● Search ID           <ul style="list-style-type: none"> <li>.. Specific identifier for the ID in HEX (00-3F) or in BIN (000000 to 111111), supports wildcards ('don't care') for individual bits and for HEX digits</li> <li>.. Compare (<math>&gt; &lt; = \neq</math>)<sup>187</sup></li> <li>.. A user Symbolic ID<sup>188</sup></li> </ul> </li> <li>● Search ID and data           <ul style="list-style-type: none"> <li>.. Options as for Search ID above, combined with a data pattern up to 8 bytes / 32 bits, supports wildcards ('don't care') for individual bits and for HEX digits</li> <li>.. Compare (<math>&gt; &lt; = \neq</math>)<sup>189</sup></li> </ul> </li> <li>● Search ID and data           <ul style="list-style-type: none"> <li>.. Options as for Search ID above combined with Search Error above.</li> </ul> </li> </ul>		
---------------	---	--	--

(a) These error values are not documented but have been observed in practice. There might be others

<sup>187</sup> If a wildcard is used, only {=} – which is of course logical...

<sup>188</sup> If the user loaded a 'Label List' (see above), then the trigger menu allows to select the names in that list, like "Ignition" or "Valve".

<sup>189</sup> If a wildcard is used, only {=} – which is of course logical...

## Parallel bus decode

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Location on instrument</b>	All settings in Protocol <b>PROTOCOL</b>	All settings: select digital channels, then Bus	Analysis > Features > Analog Bus ('ABUS') <i>Uses the analogue channels, with individual threshold</i>
<b>Busses, word size</b>	2 bus, 1-16 bit	2 bus, 1-16 bit	1 bus, 1-4 bit
<b>Base display format</b>	{Bin, Dec, Oct, Hex, ASCII}	{Bin, Dec, Unsigned Dec, Hex}	{Hex, Bin}
<b>Screen position</b>	Flex position & height	Flex position	Fixed
<b>Support for clocked busses</b>	Yes. Bus word size up to 15 bit (leaving 1 bit for CLK) or up to 14 bit (leaving 2 bits for CLK and CS <sup>190</sup> )		
<b>Routing support for busses</b>	Allows flexible routing of each of the 16 digital channels	Allows flexible routing of each of the 16 digital channels	
<b>Height of bus display</b>	Flexible (from 1 to 13 characters vertically)	Fixed (1 character vertically)	
<b>Maximum number of values than can be shown horizontally<sup>191</sup></b>	48 for 2 char HEX (0 thru FF) 48 for 3 char DEC (0 thru 255) 48 for 5 char DEC (0 thru 65,535) 14 for 16 char BIN (0 thru .....)	19 for 2 char HEX (0 thru FF) 19 for 3 char DEC (0 thru 255) 19 for 5 char DEC (0 thru 65,535) 5 for 16 char BIN (0 thru .....	
<b>Number of lines shown simultaneous in tabular form ('table', 'lister')</b>	20 lines shown (scroll option to see more) Lines show frame#, timing (abs or rel), and up to 16 char value		
<b>Bus labels (repeated from above)</b>	Yes		

## Analyses

### Mask (TBA)

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Location on instrument</b>	All settings in <b>APC</b> > Mask App > Mask	All settings in Analysis > Mask	TBA
<b>Mask</b>	See page 8 secs	Yes (80,000 Pass / Fail decisions each second.) on BNC	TBA
<b>BNC pulse out</b> (For pulse amplitude and width see I/O/connections, above)	BNC pulse out ("AUX", front side) Pulse on <b>check</b> Mask > Actions... M154  Output settings AUX connector: Setup > Aux out M27,177/178 Mask > Actions... M154	BNC pulse out ("Auxiliary Out") Pulse on {Pass, Fail} see above (Output of Auxiliary Out connector is Trigger, except when Mask analysis is activated)	TBA
<b>Actions on mask (other than BNC Pulse out)</b>	<ul style="list-style-type: none"> <li>Sound</li> <li>Stop acquisition</li> <li>Screenshot</li> <li><b>Save waveform</b> Mask &gt; Actions... M154</li> </ul>	<ul style="list-style-type: none"> <li>Sound ('beep')</li> <li>Stop acquisition ('Stop on Fail')</li> <li>Screenshot ('Capture on fail')</li> <li>Failure to history (The above are not mutually exclusive operations, i.e., you can combine them.)</li> </ul> TBA	TBA
		Advanced polymorphic graphic mask editor	
<b>1 minute mask test with 50kHz signal with one glitch per second present<sup>192</sup></b>	9 mask fails	1 mask fail (one occurred at 2:29 minutes) <i>This result is probably not valid because trigger was not running well -</i>	41 mask fails

<sup>190</sup> CS = Chip Select.

<sup>191</sup> For this test an 8 bit bus is configured, so values can vary from 0 to 127 (3 three digits). For a 16 bit bus (values 0 thru 65,535) the results are the same.

<sup>192</sup> Same as previous footnote. For SDS Seq. Acq Mode off (that mode cannot be activated in mask mode).

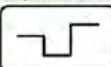
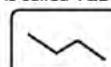
In this test, a 50 kHz clock is input to the instrument with an infrequent glitch (1 glitch per 50,000 clocks, so one per second). Using the most favorable setting on the instrument, I closely watched the displayed waveform and counted how often I could see a glitch in a one-minute observation time. All scopes 10us/div. RTB: Record Length 10 kSa/s. SDS: Record length 20k (= smallest value available); Seq. Acq Mode off (with that mode on I observe no glitches at all in one minute). DSOX in default length (cannot be selected)

10 minutes mask test run, 50kHz signal with one glitch per second present <sup>193</sup>	257k evaluated 34 failed Failure rate 0.013%	73k evaluated 8 failed Failure rate 0.011%	3.9 million evaluated 390 failures Failure rate 0.010%

<sup>193</sup> Same as in previous footnote. For SDS Seq. Acq Mode off (that mode cannot be activated in mask mode).

In this test, a 50 kHz clock is input to the instrument with an infrequent glitch (1 glitch per 50,000 clocks, so one per second). Using the most favorable setting on the instrument, I closely watched the displayed waveform and counted how often I could see a glitch in a one-minute observation time. All scopes 10us/div. RTB: Record Length 10 kSa/s. SDS: Record length 20k (= smallest value available); Seq. Acq Mode off (with that mode on I observe no glitches at all in one minute). DSOX in default length (cannot be selected)

## Bode plots (Frequency Response Analysis)

		 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT ISOX 1200 TECHNOLOGIES
General	Location on instrument	All settings in APP > Bode App > Bode Available since FW02.202	All settings in Analysis > Bode	ANALYZE > Features > Frequency Response Analysis
	Bode measurements	Gain & phase	Gain & phase	Gain & phase
	Simultaneous DUT outputs measured	One	Three	One
	Selectable channels for DUT in and out (Analog)	4A	4A	4A
Sweep	Signal source	Internal wave generator	Internal wave generator or an external (compatible) Siglent SDG series signal generator via LAN or USB	Internal wave generator
	Frequency range	10 Hz to 25 MHz <sup>S17</sup>	Specs: 10 Hz to 120 MHz <sup>S14</sup> But in my unit, it never works >50MHz However, when connected to an external WG I can confirm sweeps up to 120MHz	10 Hz to 20 MHz <sup>S17</sup> 'Fine', 'Normal' or 'Decade', allowing for convenient changes
	Sweep modes	Single or repeated	Singe (FW 1.3.9R4) or repeated ('continuous')	Single only
	Max. measurement points for a sweep	2500 Pts. (e.g., 5 decades, 500 Pts/dec)	500 Pts. <sup>194</sup>	1000 Pts.
	Time required for 100-point sweep from 100 to 999Hz	16 sec	1 DUT outputs: 3 min 22 dec. 2 DUT outputs: 4 min 37 sec 3 DUT outputs: 5 min 56 sec	57 sec
	Time required for 100-point sweep from 10MHz to 20MHz	17 sec	1 DUT outputs: 19 sec 2 DUT outputs: 26 sec 3 DUT outputs: 51 sec	8 sec
	Insert measurement delay between points <sup>195</sup>	10ms to 10s		
DUT in	DUT input amplitude levels	20 mV to 5 V into high Z 10 mV to 2.5 V into 50 Ω <sup>S17</sup>	Not specified in data sheet or manual. On device, the maximum setting is 24Vpp, but this seems to conflict with function gen specs, see above. Measuring at this maximum setting with a separate scope I see 6Vpp.	1 mVpp to 9 Vpp into 50-Ω <sup>S17</sup>
	Input load of DUT <sup>196</sup>	50Ω or Hi-Z	Fully variable in 1Ω steps from 50Ω to infinity (Hi-Z)	50Ω or Hi-Z
	Amplitude zones profile (e.g., for testing sensitive circuits and/or high dynamic range)	Up to 16 zones with individual amplitude level 	Up to 10 points with individual amplitude level, interpolation in between. Four curves can be stored. Feature is called vari-level. 	
DUT OUT	Vertical channel gain (of analogue input channel)	Automatic	Automatic or Hold <sup>197</sup>	[Automatic <sup>198</sup> ]
Scales	Horizontal scale (frequency) mode	Logarithmic (only)	Logarithmic mode ('Decade'): frequencies entered as start and stop Linear mode: frequencies entered as centre and span	Logarithmic (only)
	Horizontal scale (frequency) plot area	Range of plot can be changed without performing new measurement both using horizontal pos/scale rotaries and pinch	Range of plot tied to original sweep settings	Range of plot can be changed without performing new measurement (via menu)

<sup>194</sup> 500 points in linear mode. When it logarithmic (decade) mode, the points are distributed over de decades. For instance for a 10Hz to 20MHz swite, covering 6 decades, there are maximum 79 points per decade (so

<sup>195</sup> A measurement delay is useful for DUTs that need time to adapt to a new frequency, for instance filters with considerable time group delays.

<sup>196</sup> The output of the scope's waveform generators is always 50Ω. Yet, this function allows the Bode function to properly predict the actual input voltage of the DUT and therefore properly determine the gain.

<sup>197</sup> "Channel gain. When it is set to Auto, the oscilloscope will automatically adapt the vertical scale according to the signal amplitude. When it is set to Hold, it will always keep the currently selected vertical scale. If signals overload the selected range in Hold mode, the data may not accurately represent the physical test." M293

<sup>198</sup> Not specified, and even though I cannot see channel settings reflected on the screen when bode plots are performed, the device initially shows clipped waveforms which suggests it is adapting the channel gains to find the optimum points.

	<b>Vertical scale (gain/amplitude)</b>	<p>Gain, value shown in dB, logarithmic scale only</p> <p>Scale can be set in 0.11 dB steps (&lt;1dB) or 1dB steps. Offset can be set in 0.1 DIV.</p> <p>Scale and offset via regular channel rotary controls</p>	<p>Gain mode ('Vout/vin mode') : supports both logarithmic display (value shown in dB) and linear display (value shown as ratio). M296</p> <p>Amplitude mode ('Vout mode'<sup>199</sup>) : value shown as (Vpp, Vrms, dBV, dBU, dBm, Arbitrary dB) M296</p> <p>Scale can only be set in 1-2-5 steps, so a 3dB or 6dB scale is impossible.</p> <p>Offset (reference level) can be set in 0.04dB (!!) steps</p>	<p>Gain, value shown in dB, logarithmic scale only</p> <p>Scale can be set in 1 dB steps</p> <p>Offset can be set in 1 dB steps</p>
	<b>Vertical scale (phase)</b>	<p>Phase shown in degrees</p> <p>Scale can be set in 1° steps</p> <p>Offset can be set in 0.1 DIV.</p>	<p>Phase shown in degrees or rad M297</p> <p>Scale can be set to 1-2-5-10-15-20-25-30-45-50-60-90 degrees (or 8 specified steps in RAD)</p> <p>Offset can be set in 1° steps (but often unresponsive)</p>	<p>Phase shown in degrees</p> <p>Scale can be set in 1° steps</p> <p>Offset can be set in 1°steps</p>
	<b>Auto or manual scale</b>	Auto-scale and manual scaling and positioning	Autoset available for gain, phase and both. M296 Does not always work well. <sup>200</sup>	Auto-scaled during test with user-defined scaling after test
Display / other	Individual on/off for gain, phase	Yes	Yes (for each of the individual channels) Trace Visibility M298	Yes
	Display measurement points	Yes		
	Waveform view	Yes		Yes
	Table view	Yes	Yes	
	Screenshot -wave area		Yes (limited resolution <sup>201</sup> ) (only in non-operation mode <sup>202</sup> )	
	Measurement results		5 measure modes (Upper cutoff frequency, Lower cutoff frequency, Bandwidth, Gain margin, Phase margin) Work best after single shot is finished	
	Cursors/markers	X-type dual pair of cursors that track gain and phase, including Δ between the pair.	X-type dual pair of cursors that track gain and phase, including Δ between the pair. In the graph, there is no indication which marker is which <sup>203</sup> . Y-type pair of non-tracking cursor (basically movable lines)	X-type single cursor that track gain and phase. S17
	Graph formatting	Clear but less suitable to copy into documentation	Good looking, suitable to be copied into documentation. Trace colour for DUT1 is almost impossible to see on screenshots <sup>204</sup> (better to use DUT2 instead)	Very good looking, suitable to be copied into documentation
	Graph formatting for use in documentation	Graph export only via screenshot. <sup>205</sup> Inverted mode (graph on white background) available, can increase readability/usability. Colors (blue for gain, orange for phase) cannot be changed but can be well read from screenshot.	Graph export only via screenshot. <sup>211</sup> Inverted mode unavailable <sup>206</sup> . Colours cannot be changed; colours for DUT1 very hard to see in screenshot; when using only one DUT its better to use DUT2 instead,	Graph export only via screenshot. <sup>211</sup>
	Save and recall	Save (CSV)	Save (CSV) as well as recall M300	Save (CSV)

<sup>199</sup> Here, Vout is from the perspective of the DUT, not the scope! SO it's the signal at the output of the DUT.

<sup>200</sup> Several times, the autoset feature pushed the trace out of the viewable picture.

<sup>201</sup> Unfortunately, the resolution of the resulting graph (695 x 425 pixels) is not any higher than you would get when taking a regular screenshot of the instrument's screen and crop it.

<sup>202</sup> 'Operation' must be turned off to see this option. In continuous mode, the option is never available.

<sup>203</sup> Both markers have vertical lines. The one being actively edited is like a almost continuous line, the ones not being edited are dashed lines. But there is no indication in the graph itself which marker (line) is for X1 and which is for X2. You can try to find out looking at the measurement values associated with these markers, though.

<sup>204</sup> The screenshot options such as reverse color etc. are not available when the device is in Bode Analysis mode.

<sup>205</sup> Measurement data can be saved as CVS so one can also make a graph from that on a PC, but that is much more work.

<sup>206</sup> This mode is available in normal scope modes but not when in Bode Analysis mode.

## FFT

	RTB2000	SIGLENT SDS 2000X+	KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Location on instrument</b>	APP > FFT or App > FFT	Analysis > Mask	FFT or MATH > Source > FRA
<b>Implementation</b>	Separate to math (so comes in addition to 5 math channels). Own front panel button	As a math channels (takes one of the two math channels)	A bit in-between a math channel and a separate functionality. <sup>207</sup> Own FFT front panel but operation inconsistent with Math route. <sup>208</sup>
<b>Simultaneous FFT analyses</b>	1	$2^{209}$	1
<b>Source (Analog, Math, Ref)</b>	4A, 5M, 4R <sup>210</sup>	4A, (2-1)M <sup>211</sup>	4A, M <sup>207</sup>
<b>Number of FFT points</b>	128k (B, p.3) points, not selectable. <sup>212</sup>	2M points, selectable <a href="#">see this</a>	64k points, not selectable
<b>FFT modes</b>	Amplitude	Amplitude	Amplitude, phase
Windows	<ul style="list-style-type: none"> <li>• Rectangle (=uniform)</li> <li>• Hanning</li> <li>• Hamming</li> <li>• Blackman (Harris)</li> <li>• Flattop</li> </ul>	<ul style="list-style-type: none"> <li>• Rectangle (=uniform)</li> <li>• Hanning</li> <li>• Hamming</li> <li>• Blackman (Harris)</li> <li>• Flattop</li> </ul>	<ul style="list-style-type: none"> <li>• Rectangle (=uniform)</li> <li>• Hanning</li> <li>• Blackman-Harris</li> <li>• Flattop</li> </ul>
Waveform arithmetic	<ul style="list-style-type: none"> <li>• Spectrum (=normal)</li> <li>• Min. Hold (+reset)</li> <li>• Max. Hold (+reset)</li> <li>• Average (2 to 1024) (+reset)</li> </ul> <p>All the above can be shown at the same time.</p>	<ul style="list-style-type: none"> <li>• Normal</li> <li>• Max-Hold (+reset<sup>213</sup>)</li> <li>• Average (4 to 1024) (+reset<sup>213</sup>)</li> </ul> <p>Only one can be selected at any time</p>	<ul style="list-style-type: none"> <li>• Normal</li> </ul> <p>No average No Max Hold<sup>214</sup></p>
Display persistence works on FFT	Yes	No <sup>215</sup>	Yes
Vertical scales	<b>Logarithmic</b> dBm (50Ω <sup>216</sup> ) dBV [rms] FW02.30 (no A <sup>217</sup> ) dBµV [rms] FW02.30 (no A <sup>217</sup> )	dBm (1Ω to 1MΩ, not int. <sup>218</sup> ) dBVRms / dbArms	dBV (no A <sup>217</sup> ) [dBm scale missing <sup>219</sup> ]
	<b>Linear</b> Veff (RMS) (no A <sup>217</sup> )	Vrms / Arms	V RMS (linear) (no A <sup>217</sup> ) Degrees/Rad (for phase FFT)
Screen organisation for time and frequency domain graphs	Exclusive Split (shows also gate time)	Exclusive Split Overlay (full screen)	Exclusive <sup>220</sup> Overlay (full screen)
Resolution information	Shown on the screen as resolution bandwidth (RBW). Note <sup>221</sup> RBW can be set: <ul style="list-style-type: none"> <li>• Automatically (allows manual control of time gate)</li> <li>• Manual (time gate is automatically set)</li> </ul> Not via dial <sup>222</sup>	Shown on the screen as "Frequency interval ( $\Delta f$ )" which is the same as the FFT frequency spacing (a.k.a. the "bin-width").  Cannot be directly set but is the result of other settings	Shown on the screen as "FFT resolution" which is the same as the FFT frequency spacing (a.k.a. the "bin-width").  Cannot be directly set but is the result of other settings
Display of other parameters relevant to FFT engine <sup>223</sup>	Actual FFT points (shown in acquisition menu) <sup>224</sup> The actual	Small info display shows:	

<sup>207</sup> The FFT function can be selected as if it were a regular math channel. But then, there is an option to select arithmetic operation g(t) as a source, effectively create a second math channel (the DSOX normally only has one). See [M67](#), [M70](#). The procedure is not intuitive though and only works if FFT is done via the math module (not the FFT button on the front panel). (1) Push MATH, push FUNCTION soft button until you see g(t). Then set the operator, sources, etc. (2), push FUNCTION soft button until you see f(t). Operator should be set to FFT. Then select 'More' and set the FFT parameters.

<sup>208</sup> When FFT is initiated with its own front panel button, the functions seem to be similar to when initiated via a math channel, but the menu structure is different.

<sup>209</sup> Each of the two math channels can run FFT at the same time (and can have two different analogue channels as sources, for instance). Basically, the FFT menu settings are individual for each FFT (but settings such as the time base are common, of course).

<sup>210</sup> Allows a user to save an FFT waveform and open/analyze it later with the FFT function.

<sup>211</sup> In the SDS, FFT is implemented as one of the Math functions. There are two math functions, and if one of them is FFT, only the other (hence 2-1) math function can be selected.

<sup>212</sup> "If you are trying to look at low frequency signals the RTB insists on filling the entire 128K FFT memory before computing it, which takes an awful long time." [Source](#). For FW 2.40, R&S reported "Increased FFT waveform update rate for low start frequencies and activated 'Automatic RBW'."

<sup>213</sup> To reset either max hold or average, press the 'Clear Sweeps' button on the front panel to clear the max- hold waveform. For average (bit not max hold) reset is also possible via the dialogue box on the screen.

<sup>214</sup> But Waveform Persistence can be used if the results of a sweep need to be captured in a single graph.

<sup>215</sup> But Max Hold can be used instead if the results of a sweep need to be captured in a single graph.

<sup>216</sup> The dBm measurement assumes that there is an (external) 50Ω termination.

<sup>217</sup> Even if channel is set to current (A), the scale indication in FFT mode does not switch to dBA.

<sup>218</sup> The dBm measurement assumes an external load, which can be set to any value other value between 1Ω and 1MΩ. If the internal 50Ω channel impedance is selected, the FFT function does not adapt to that load.

<sup>219</sup> The manual states "dBV (when channel is set to 1MΩ)" and "dBm (when channel is set to 50Ω)" But the DSOX does not support 50Ω for channel impedance and indeed it seems impossible to select dBm at all.

<sup>220</sup> By turning the analogue channel off.

<sup>221</sup> The RBW is proportional to the FFT frequency spacing (a.k.a. the "bin-width"), with a factor depending on the chosen window. For the Flat Top window, for instance that factor is about 3.5 (e.g., RBW of 270Hz then equals FFT frequency spacing of 77Hz).

<sup>222</sup> This is one of the very few RTB parameters than can only be set via the numerical keypad and not via a physical dial.

<sup>223</sup> To understand how RBW can be calculated from the (decimated) number of time domain samples, the number of FFT points,

<sup>224</sup> When in FFT mode, there are not the regular items in the acquisition menu to be set (this all changed to automatic). Instead, it shows the record length, which equals the number of FFT points used. It is shown in SI style rather than 'binary' style, so showing 131kSa equaling 128k FFT points (128x1024).

		<b>FFT sample rate</b> <sup>225</sup> is not shown, making the overall FFT engine settings a black box	<ul style="list-style-type: none"> <li>- FFT sample rate (in addition to the time domain sample rate, which may be different) as well as time base<sup>226</sup>)</li> <li>- Actual FFT points<sup>227</sup></li> <li>- Frequency interval (<math>\Delta f</math>) (aka FFT frequency spacing, a.k.a. the "bin-width").</li> </ul>	
FFT horizontal controls	H center	<b>PHYSICAL</b> via horizontal position rotary dial or via screen shortcut <sup>228</sup> Drag and pinch on touchscreen	Via submenu (Center) Drag and pinch on touchscreen	<b>PHYSICAL:</b> horizontal scale rotary dial changes both span and center frequency for optimum viewing of the full spectrum <sup>M71</sup> (but only in when no overlay time trace shown) Center and span separately via submenu, span steps are very coarse <sup>229</sup> With many other changes (e.g., choosing different source), centre and span settings are lost Turning direction not intuitive <sup>230</sup>
	H span	<b>PHYSICAL</b> via horizontal scale rotary dial via screen shortcut <sup>228</sup>	Via submenu (Span) Drag and pinch on touchscreen	
	Start / stop frequency <sup>231</sup>	Via screen shortcut <sup>228</sup>	Via submenu	
FFT vertical controls	V position (=offset = ref. level)	<b>PHYSICAL</b> via channel position rotary dial (position) <sup>232</sup>	Via submenu (Ref Level) Drag and pinch on touchscreen	<b>PHYSICAL</b> via dedicated math position rotary dial (offset)
	V scale	<b>PHYSICAL</b> via channel scale rotary dial control (steps: 1 thru 9 and 10 thru 40 dB/DIV) <sup>232</sup>	Via submenu (Scale) Drag and pinch on touchscreen	<b>PHYSICAL</b> via dedicated math scale rotary dial controls FFT scale (steps: 1-2-5-10-20-50-100dB/DIV)
Zoom		Possible via drawing a rectangle via the finger. But no way to return to previous screen	Yes, second zoomed waveform is shown in lower part when in split mode	Yes, well implemented using split window
Auto setup		With <b>Autoset</b> both the channel parameters and the FFT parameters are automatically set.	With <b>Autoset</b> But in my tests, it switches back to a time base setting that produces no usable FFT graph.	Auto Setup as (as soft menu) <sup>233</sup>
Time base settings		When FFT is activate, an appropriate time base is set automatically. The automatic selection works quite well but deprives the user from making his/her own choices.	In the regular way (via horizontal scale rotary)	In the regular way (via horizontal scale rotary) as long as an overlay time base trace of the analogue signal is visible (if not, this button has a combined span and center functionality)
Cursors		Same cursor functionality as in time mode (where cursor can be set to math). Tracking can be selected for average, top, min or average. (See also at Peaks, below)	Same cursor functionality as in time mode (where cursor must be set to math channel used for FFT, like F2). Tracking/values only for max.	Same cursor functionality as in time mode (where cursor can be set to math) <sup>234</sup>
Tools	Peaks	Two tracking cursors ( <b>v-marker</b> ) can each be moved to next or previous peak (FW2.0)	<ul style="list-style-type: none"> <li>• Up to 10 peaks shown in graph</li> <li>• Automatic peak search</li> <li>• Search threshold and search excursion can be set</li> <li>• Optional table display. Frequency can be switched on/off in table. Table can be sorted on amplitude or frequency<sup>235</sup></li> </ul>	
	Markers		<ul style="list-style-type: none"> <li>• Can be placed (a) manual, (b) on peaks or (c) on harmonics</li> <li>• If set on peaks, search threshold and excursion can be set</li> <li>• Optional table. Frequency and delta can be switched on/off in table.</li> </ul>	

<sup>225</sup> The device sample rate is shown as it always is (at the top right of the screen) but experiments suggests that is not (always) the same as the actual FFT sample rate (which might be decimated, but perhaps also be upsampled?)

<sup>226</sup> The FFT sample rate may have to be decimated. As soon as the record length exceeds the FFT length - either by limiting the FFT size to something small like 64k or selecting slow timebases where the scope needs a lot of memory, the FFT sample rate may not be able to keep up time base sample rate. In the SDS we see both: the FFT sample rate in the FFT parameters info window at the top, and the time base record rate at the bottom of the screen in the 'Timebase' at the bottom.

<sup>227</sup> It is shown in SI style rather than 'binary' style, so showing "131072pts" equaling 128k FFT points (128x1024).

<sup>228</sup> Screen shortcut is a box that is always visible on the screen when in FFT mode, regardless of (sub)menu settings.

<sup>229</sup> For instance, when center is set to 1.5MHz, span can be set to 1MHz or 2Mhz, but not 1.5MHz (which would be required to see the range from 0 to 3 GHz).

<sup>230</sup> One needs to turn anti-clockwise to increase frequency for the center and span parameters.

<sup>231</sup> As alternative for center/span selection.

<sup>232</sup> This is one of the very few values on the RTB than cannot be (also) set via a menu and the numerical pad.

<sup>233</sup> Manual p 58: "sets the frequency Span and Center to values that will cause the entire available spectrum to be displayed. The maximum available frequency is half the FFT sample rate, which is a function of the time per division setting. The FFT resolution is the quotient of the sampling rate and the number of FFT points (fs/N). The current FFT Resolution is displayed."

<sup>234</sup> CURSORS -> Source -> toMath N.

<sup>235</sup> The sort function, in the manual described as "Sort peaks by amplitude or frequency", does not sort the numbers shown with the peaks, as one may understand from the interface in the device and the text in the manual. Instead, it determines the order in which rows are shown in the table.

<b>Measure</b>	FFT cannot be selected as measure source	FFT can be selected as measure source, <b>but only "Max" is available as measurement.</b>	FFT can be selected as measure source and units properly change to FFT (e.g., dBV). 6 functions: Max, Min, Peak-Peak, Average Full Screen, X at min Y, X at max Y.
<b>Display of vertical and horizontal values on the axes</b>	Shown in clear format (like '12.6 dB' or '350 MHz')	Shown but not so clear format ('20.000dBV' or '20.1542kHz')	No values shown on the axis. Parameters (scale, offset, center span) sometimes shown, depending on selected menu, but user needs to count divisions. <sup>236</sup>
<b>Create reference waveform</b>	Yes (via Reference -> Source). Can select any of the waveform arithmetic (spectrum, min hold, max hold, average)	Yes (via Reference -> Source). (Where source must be set to math channel used for FFT, like F2).	
<b>Save FFT result</b>	CSV file. Can save values for all waveform arithmetic (spectrum, min hold, max hold, average) in the same file (all visible FFT waveforms)	Since 1.3.9R4. CSV file. Via Save > CSV -> Source: F1 (or F2). For each frequency, file contains values for 'Real part', 'Imaginary part', 'Magnitude', 'Angle'. Not documented.	
<b>Tips and tricks</b>	With Hi-Res mode (acquisition menu) the FFT noise floor goes substantially down	With 10-bit mode (acquire menu) the FFT noise floor goes down Higher memory depth (e.g., 100M) gives better FFT results	

<sup>236</sup> When all submenus disabled, the parameters scale, offset, center and span are shown in right side of screen. In FFT submenu, only the parameters scale and offset are shown. Unless when you are in the specific sub-submenu where center and span are set.

## Power Analysis (TBA)

Location on instrument		All settings in Analysis > Power Analysis	
		Power quality, Current Harmonics, Inrush current, Switching loss, Slew rate, Modulation, Output ripple, Turn on/turn off, Transient response, PSRR, Efficiency	

## Signal generators

### Function generator (except ARB)

	RTB2000	SDS 2000X+	DSOX 1200
Location on instrument	All settings in Gen GEN	All settings in Utility > Awg Menu AWG	[WAVE GEN]
Resolution, sample rate	14 bit, 250 MSa/s	14 bit, 125 MSa/s	[Not specified]
Output definition <sup>237</sup>	High-Z, 50Ω	High-Z, 50Ω	High-Z, 50Ω
Max amplitude (PP) 1MHz sine into open circuit	5Vpp	6Vpp <sup>238</sup>	Sine: 12Vpp S19 <sup>239</sup> Square, Pulse, Ramp: 20Vpp S19 Supports logic presets: TTL, CMOS (5.0V, 3.3V, 2.5V), ECL
DC Offset	±5V	±1V	±2V
Max frequency sine/square/noise	25/10/25 MHz	50/10/25 MHz	20/10/20 MHz
Basic waveforms	Sine SinC Rectangle (=square) Pulse (Duty Cycle, Edge Time) Triangle (Symmetry {FW02,400}) Ramp (Polarity) Exponential (Polarity) [Noise as DC+Noise] DC	Sine Square (Duty Cycle) Ramp (Symmetry) Pulse (Pulse Width) Noise (StDev, Mean)	Sine Square (Duty Cycle) Ramp (Symmetry) Pulse (Pulse width) Noise DC
DC offset	For all waveforms	For all waveforms except noise	For all waveforms
Invert	For all waveforms except DC		For all waveforms except DC
Add noise	For DC		Add noise {0-66%} for all waveforms except DC and Noise
Modulation	For all waveforms		For Sine and Ramp only
AM modulation	Function {Sine, Rectangle, Triangle, Ramp Pos, Ramp Neg.} AM Frequency AM Depth		Function {Sine, Square, Ramp} AM Frequency AM Depth
FM modulation	Function {Sine, Rectangle, Triangle, Ramp Pos, Ramp Neg.} FM Frequency FM Deviation		Function {Sine, Square, Ramp} FM Frequency FM Deviation
ASK modulation	Polarity Frequency Depth		
FSK modulation	Polarity Hop Frequency FSK Rate		FSK Hop Freq FSK Rate
Burst (output wave for a defined number of times)	For any waveform except DC {FW02,202} (# cycles, idle time, start phase, trigger {Const./Manual})		

<sup>237</sup> All devices have a fixed actual 50Ω output. The output definition is only for showing correct amplitude and offset values.

<sup>238</sup> Yet, in Bode plot, the amplitude is apparently up to 24Vpp. See [https://siglentna.com/wp-content/uploads/dlm\\_uploads/2021/10/SDS2000X-Plus-Firmware-Revision-Record-And-Upgrade-Instructions.pdf](https://siglentna.com/wp-content/uploads/dlm_uploads/2021/10/SDS2000X-Plus-Firmware-Revision-Record-And-Upgrade-Instructions.pdf)

<sup>239</sup> Manual conflicts by stating 5Vpp (M207) but specifications mention 12Vpp (S19) and on the device one can indeed selected 12Vpp.

Sweep	For any waveform except DC Start Freq., Stop Freq., Sweep Time, Sweep {Linear, Log, Triangle}		
Other		Over voltage protection (On, Off) when output higher than 4V. Current limit. S15	Protection: Overload automatically disables output S19.
Other		Zero Adjust automatic calibration	

## Function generator – arbitrary waves (ARB)

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
Resolution, sample rate	14 bits, [250 MSa/s] Specs mention a too low figure <sup>240</sup>	14 bits, 125 MSa/s (S16)	
ARB waveform memory	32 kpts Specs mention a too low figure <sup>241</sup>	16 kpts (S16)	
Max frequency ARB	10 MHz <sup>242</sup>	5 MHz (S15)	
ARB waveform source	<ul style="list-style-type: none"> <li>From uploading file           <ul style="list-style-type: none"> <li>CSV files (such as saved as a regular waveform)<sup>243</sup> should not use BOM<sup>244</sup></li> <li>TRF files (such as saved as a reference waveform)</li> </ul> </li> <li>Copy from active analogue channel</li> <li>Copy from active math channel</li> <li>Copy from active reference channel</li> </ul>	<ul style="list-style-type: none"> <li>From uploading file           <ul style="list-style-type: none"> <li>CSV files. File format not defined in manual (but) did get one specific CSV format to work<sup>245</sup> Header settings in file (amplitude, etc.) do not work.<sup>246</sup></li> </ul> </li> <li>Copy from analogue channel (S16) The way to do this is not very intuitive and not explained in the ARB section of the manual<sup>247</sup></li> <li>Transfer from EasyWave software on a Windows PC (did not get this to work)<sup>248</sup></li> </ul>	
ARB waveforms: presets		45 build-in plus 2 custom <sup>249</sup>	
Waveform preview	Yes, including min and max values		
Waveform cut tools	Graphic 'cut waveform' editor (FW02.202).	No such function, and because the horizontal system does not have fine control of the time base, there is no way to control which part of the input signal goes into the ARB	
Burst (output wave for a defined number of times)	(# cycles, idle time, start phase, trigger {Const./Manual})		
Sweep	Start Freq., Stop Freq., Sweep Time, Sweep {Linear, Log, Triangle}		

<sup>240</sup> The specs S13) mention a sample rate of 10 MSa/s but this is much too low as it would not be able to generate the ARB waveforms it actually generates at the output. Probably this number is mistaken with the max frequency of 10MHz.

<sup>241</sup> While the specifications (S13) mention 16k points, but own tests show that the generator supports up to 32k points, like mentioned document R&SRTx-B6: ARBITRARY WAVEFORM AND 4 BIT PATTERN GENERATOR. (Points in the upload file beyond the 32k point do not lead to load errors but are discarded.)

<sup>242</sup> Determined on device.

<sup>243</sup> Exact formatting of that CSV file is straightforward and is provided in the manual (M181).

<sup>244</sup> The CVS file should not start with a so-called Byte Order Mark (BOM), which is something relevant for 16 and 32 bit text representations, but not relevant (and not recommended) for the more usual 8 bit representation. But should a BOM be present, the RTB will give a "CVS Parses Error -21". To check whether a file starts with a BOM, use for instance the BBEdit editor and check the status line at the bottom. If that says "UTF-8, with BOM", you have a problem. In that same status line, one can change the file to remove BOM and then it works.

<sup>245</sup> The manual is silent on supported formats and specificities of the file. After a lot of trying, I managed to create a CSV file that worked. To do so, download the ZIP file from <https://siglentna.com/wp-content/uploads/2017/12/EasyWaveCSV.zip> and open the file HaversineExampleFile.csv in a text editor. This is a file meant for the EasyWave program but it also works when directly loaded into the oscilloscope. In that file, replace the actual values with your own values (take care to use the same length for the scientific notation fields) and add the number of actual data points to the first line.

<sup>246</sup> In my own experiments, settings in the CSV file such as {frequency,750} and {amp,20} do not work at all.

<sup>247</sup> When you first try this and select 'Stored' and then 'Channel' as the ARB input, a "File does not exist" error. The section in the manual on ARB (§28.3) has no further information on how to do this. The solution is as follows: Go to the Vertical Channel Menu and chose "Apply to" and then "ARB" as the destination. This is in §12.2 in the manual (but this is not where you'd expect this information to be).

<sup>248</sup> In EasyWave, one can create a waveform. (Strangely, creating a new waveform only allows to choose between 20Vpp and 20mVpp, I had to choose the latter as the SDS does only support up to 6Vpp for ARB, confirmed by both SDS and the EasyWave software). When the waveform is ready, it can be sent to store location "ARB1" to "ARB4" in the SDS. When done so, I hear some relays in the SDS click. Problem is that after that, these files cannot be found anywhere in the ARB selection menu of the SDS, and cannot be found in the File Manager of the device either... The same procedure, however, DOES work on my Siglent SDS2042X function generator ☺

<sup>249</sup> The manual (M311) mentions "45 built-in and 2 custom arbitrary waveforms" but the two 'custom' forms are actually the menu item to select a waveform from an USB drive and "channel" (which does not work for me, see footnote 247).



## Pattern generator

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Location on instrument</b>	All settings in Patt. Gen.		 Training Signals
<b>Number of output pins</b>	4 pins (bits)		1 pin
<b>Sample rate</b>	50 Mbit/s <sup>250</sup>		
<b>Square wave</b>	1 pin; Frequency (up to 500kHz) (or Period), Polarity, Duty Cycle		
<b>Digital counter</b>	4 pin counter (0000 0001 0010 etc.) Frequency (up to 50MHz) Direction (Up, Down)		
<b>Arbitrary pattern</b>	4 bits Bit time, Period Burst function (# bursts, idle time between) Pattern length up to 2048 symbols Build-in graphical draw tool Trigger (1 shot or repeat) Load/safe patterns in SCP format (remote commands format; command for pattern is on p.555 of manual). User utility allows Excel creation <sup>251</sup>		
<b>Burst</b>	[part of arbitrary pattern, see above]		<ul style="list-style-type: none"> <li>Burst of digital pulses that occur every 50 µs.</li> <li>Burst of 6 digital pulses (plus infrequent glitch) that occurs once every 80 µs.</li> </ul>
<b>Manual</b>	Manual (static level) setting of the 4 pins		
<b>UART (for RS-232/ RS422/ RS-485)</b>	2 pins (Rx, Tx) 9600 Bit/s, 115.2 kBit/s, 1 MBit/s The "App" training protocol transmit the 115.2 kBit/s version. <i>Instrument own decode shows parity &amp; stop error in "IDN?" message<sup>252</sup></i>		
<b>SPI</b>	4 pins (Clk, Mosi, Miso, CS) 100, 250 kBit/s, 1 MBit/s The "App" training protocol transmit the 100 Mbit/s version. <i>Instrument own decode shows no errors</i>		
<b>I<sup>2</sup>C</b>	2 pins (SCL, SDA) 100, 400, 1000, 3400 kBit/s The "App" training protocol transmit the 400 kBit/s version. <i>Instrument own decode shows no errors</i>		
<b>CAN</b>	2 pins (CAN-H, CAN-L) 50, 100 kBit/s, 1 MBit/s <i>Instrument own decode shows NACK, CRC and FD/RM errors in various frames.<sup>253</sup></i>		Training signal: 1 pin (CAN-L), 125 kbp DEMO signal: 1 pin (CAN-L), 125 kbp, very useful sequence <sup>254</sup> <i>Check Same or not?!</i>
<b>LIN</b>	2 pin (High, Low) 9.6, 10.417, 19.2 kBit/s [LIN2.0 protocol <sup>255</sup> ] <i>Instrument own decode shows CHECKSUM, PARITY and SYNC errors in various frames.<sup>256</sup></i>		1 pin, 19.2 kbs, [LIN1.3] <sup>257</sup>

<sup>250</sup> Specifications from document R&SRTx-B6: ARBITRARY WAVEFORM AND 4 BIT PATTERN GENERATOR

<sup>251</sup> See <https://www.eevblog.com/forum/testgear/rohde-schwarz-rtb2002-rtb2004-question-importing-cvs-in-pattern-generator/>

<sup>252</sup> Not clear whether these errors are inserted intentionally or not; this is not documented.

<sup>253</sup> Not clear whether these errors are inserted intentionally or not; this is not documented.

<sup>254</sup> This long training sequence (16 messages) that includes short (11 bit) and long (29 bit) ID, data and remote packets, and varying message lengths (1, 4, 5 and 8 bytes). Quasi randomly inserted over training sequences there are a variety of different errors (CRC error, bit stuffing error, NACK), very suitable for testing serial decoders. Apart from these frames where a NACK error is deliberately inserted, the ACK is already added (unlike most demo/training CAN signals on other oscilloscopes). Occasionally, the ASCII character sequence "IGILENT" is shown, not "KEYSIGHT" ;-) Tip: because it's such a rich sequence, you will want to trigger it properly to a steady point. To do so, you can trigger on a data frame with ID = 0x7F and first data byte 0xE4 and set trigger holdoff to 35ms.

<sup>255</sup> The protocol version of this LIN signal is not documented. But when decoded by the DSOX as LIN1.3 on the DSOX it fails altogether, and when on the DSOX as LIN2 x on the DSOX it all works. That's why I assume its LIN2.0.

<sup>256</sup> Not clear whether these errors are inserted intentionally or not; this is not documented.

<sup>257</sup> This long training sequence (21 messages) in LIN1.3 format with various addresses and varying message lengths (2, 4, 8 and 9 bytes). Quasi randomly inserted over training sequences there are different errors (Checksum error, Parity Errors, but not Synchronization errors),

## Training signals, demo modes

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Location on instrument</b>	APP > App -> Demo		HELP, Training Signals HELP, Demo
<b>Training signals</b>	Serial protocols (8), using up to 4 wires (see Pattern Generator)		14 (glitches, bursts, distortion) <sup>258</sup> 2 serial busses (CAN, LIN)
<b>DEMO modes</b>	Basic (3) Advanced (9) Serial/parallel protocol (9) <sup>259, 260</sup> Track (2) (FW02.400)		(Demo since FW2.10) Triggering (2) Math (2) Advanced features (4) Serial buses (2: CAN, LIN)

## Memory, history, search

### Segmented memory and history (TBA)

(For memory specifications, see above)

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Location on instrument</b>	@@	@@	@@
<b>History</b>	13,107 segments	Up to 90,000 frames Analyse > Menu > History All settings in Analysis > History <b>HISTORY</b>	
<b>Segments</b>		Acquire > Sequence... M89	Up to 500 (FW2.10)
	@@ In Acquisition memory at Sample etc the Nx Singwe can set the number of samples into the memory. Acquisition, M69		
	@@ check record length in acquisition memory Acquisition, M67	Acquisition>Menu>	
<b>Record memory depth</b>	Setup > Language M198	20k, 200k, 2M, 20M, 200M (half for four channel operation) Acquisition > Menu, M80-81	
<b>Navigate</b>		All settings in Analysis > Navigate <b>NAVIGATE</b>	

### Search (events) (TBA)

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Location on instrument</b>	All settings in Search <b>SEARCH</b>	All settings in Analysis > Search <b>SEARCH</b>	

<sup>258</sup> See Programming Guide page 232.

<sup>259</sup> The DEMO modes for serial protocols as the same as those that can be generated from the pattern generator (see above). While the pattern generator allows different bus speeds, the demo's have the following speeds: CAN: 9.6 kbps, @@@

<sup>260</sup> The LIN DEMO works but has some unusual choices. First, it instructs the user to use the P0 pattern generator pin and starts the decode function in Idle Low mode. That works, but can confuse users, because P0 provides an inverted LIN bus signal. Actually, pin P1 provides the correct LIN bus signal, and if you put the decoder at Idle High, the results are the same, but the shown bus is much more correct. Second, this demo puts the decode function in LIN1.3 protocol mode whereas the actual signal is likely a LIN2.x protocol. Can be changed manually in the decoder though. Third, the default vertical amplitude is too high and the channel clips. Easily corrected, but still. Fourth, the LIN signal has quite some errors. As already discussed above, this may be intentional (or not). Such errors can be very useful for problem solving and decode testing but I rather wish it was documented they are there for that purpose.

## Computer access and automatization

### Web-based remote access

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Remote Front Panel</b>	Remote Front Panel (full panel with screen & buttons) {fixed res, autoscale}  Works well with iPads.	Remote Front Panel (screen only)  Remote Front Panel does not work properly with Apple iPad (tested regular 10.5" as well as the 10.2" Pro and 12.9" Pro). All have truncation and/or compression problems.	Remote Front Panel (full panel with screen & buttons)  Works well with iPads. Remote instrument control requires separate firmware install  Slow screen update rate.
<b>Live screen</b>	Live screen {fixed res, autoscale}		Live screen fixed res
<b>Screenprint</b>	Resolution 1280×824 Auto refresh (6 time settings) {PNG, BMP} {Color, Greyscale} {Non-inverted, Inverted}	Resolution 1024×600  (Screenshots part of remote panel)	Via Get Image : PNG 800×503 Option for inverted (=printer friendly colours)  Via Save menu also {PNG (24 bit), BMP (8 or 24 bit)} {Color, Greyscale} {Non-inverted, Inverted}
<b>Save waveform from instrument to PC</b>  (See also section <i>Save and Recall</i> for saving to USB).	Selectable: 4 analogue channels 2 digital sets (D0-D7; D8-D15) 4 Reference waves 5 Math waves  File formats {TXT, CVS, BIN-MDB, BIN-LSB, FLT <sup>261</sup> -MSB, FLT-LSB} Type {Display Data, Acq. Mem}  Possibility to save to instrument memory itself (instead of to a PC)	Waveform data is saved as *.BIN file. For Windows PC users, a "Convert_bin_to_csv" tool is provided, along with a Python source file and an unreadable read.me file (!). (1.3.5R3)  Not clear which waveform is saved (regardless of wave activation, the file is 20MB in size).	(FW2.10) File formats: <ul style="list-style-type: none"><li>• CSV data (*.csv)</li><li>• ASCII XY data (*.csv)</li><li>• Reference Waveform data (*.h5)<sup>262</sup> {Ch1, Ch2, Ref} (No Ch.3, Ch.4, Math, Ref)</li><li>• Multi Channel Waveform data (*.h5)<sup>263</sup></li><li>• Binary data (*.bin)</li></ul> (See @@ for details)  Separate text file contains relevant instrument settings for saved data.  For all the above formats, length is selectable.
<b>Save other type of files from instrument to PC</b>  (See also section <i>Save and Recall</i> for saving to USB).	Setup Self-alignment Report		(FW2.10) Setup Lister data (=serial decode table) Mask Frequency Response Analysis Data
<b>Upload from PC to instrument</b>  (See also section <i>Save and Recall</i> recalling from USB).	Setup Waveform to Reference 1-4.		(FW2.10) Any file type
<b>SCPI Device Control (direct command entry screen)</b>	SCPI Device Control List if commands is <a href="#">here</a> in the <a href="#">online manual</a> here.	SCPI Device Control	SCPI Device Control (Includes extensive HTML Quick Reference Guide) (FW2.10)
<b>Device I/O settings information</b>	Extensive	Basic	Very extensive
<b>LAN configuration</b>	See & edit Setup > Ethernet. M201	See & edit Utility > I/O setting > System Setting > LAN conf.. M37	See & edit. UTILITY > I/O > Configure LAN. M234
<b>Password for Web Server</b>		Can be set. Utility > I/O setting > System Setting > Web Server. M334	

<sup>261</sup> FLT is a Floating Point format.

<sup>262</sup> A format that can be recalled to one of the oscilloscope's reference waveform locations, or opened by the N8900A Infinium Offline oscilloscope analysis software.waveform locations or read by the N8900A Infinium Offline oscilloscope analysis software..

<sup>263</sup> A format that can be opened by the N8900A Infinium Offline oscilloscope analysis software.

## Computer software, automation interfaces

PS. Software described is for free unless otherwise noted.

	 R&S RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Microsoft Windows application software</b>	R&S InstrumentView. Download and analyze waveforms on the computer. Very extensive.  RSCommander ( <a href="#">for Windows</a> ). File manager, screenshots, trace download, trace markers, SCPI commands, scripting. But less extensive than R&S InstrumentView.	No software listed at all on the Siglent website for this instrument. <sup>264</sup>  (The manual refers to Siglent EasyWave software to make ARB patterns for this. But I do not manage to get this to work, see at ARB above)	BenchVue. Connect, record results, and visualize measurements across multiple instruments simultaneously. License included with instrument. Very extensive. For free for recent purchases.  D9010BSEO Infinium Offline - Base Software. At a monthly fee (around €150 per year) or perpetual licence (about €400).
<b>MacOS application software</b>	<a href="#">RSCommander</a> (via MacOS App Store). File manager, screenshots, trace download, trace markers, SCPI commands, scripting. But less extensive than R&S InstrumentView.		
<b>Instrument drivers</b>	Drivers for IVI, LabVIEW, LabWindows, VXI, various computer platforms	<a href="#">IVI</a> Driver	Drivers for IVI and MATLAB
<b>LXI (LAN eXtensions for Instrumentation)</b>	No	Yes (FR 1.5.2R1) but only with the Uboot-OS Version 5.4 (This may only be the case for newer hardware versions, possibly hardware D4-xx version introduced around august 2022)	Yes <sup>265</sup>
<b>USB device modes (USB-B connector on back panel)</b>	<ul style="list-style-type: none"> <li>USB TMC (Test &amp; Measurement Class.). For SCPI via VISA library.</li> <li>USB VCP (Virtual Com Port). Supports any terminal program to send SCPI commands</li> <li>USB MTP (Media Transfer Protocol)<sup>266</sup>  Screen shortcut Setup &gt; USB M204</li> </ul>	USB TMC (Test & Measurement Class.). (SI) Utility > I/O setting > System Setting > USB ID (shows ID).  There is no USB MTP (Media Transfer Protocol) or another way to easily transfer files between instrument and PC via USB.	Communication to Keysight IO Libraries [I assume NI VISA]  USB (USBTMC/488)  There is no USB MTP (Media Transfer Protocol) or another way to easily transfer files between instrument and PC via USB.
<b>LAN</b>	<ul style="list-style-type: none"> <li>For access to web server</li> <li>For SCPI via VISA library. VXI-11 Port can be set in instrument (default 1024). The assigned VISA address is shown.  Screen shortcut Setup &gt; Ethernet M201</li> </ul>	<ul style="list-style-type: none"> <li>[For access to web server]</li> <li>SCPI commands via NI-VISA, Telnet, or Socket.</li> </ul> VNC number can be set (necessary when accessing more than two Siglent instruments through the web browser) Screen shortcut Utility > I/O setting > System Setting > LAN conf. M37	Communication to Keysight IO Libraries [I assume NI VISA] <ul style="list-style-type: none"> <li>HiSLIP LAN protocol</li> <li>VXI-11 LAN protocol (FW2.10)</li> <li>GPIB over LAN protocol</li> <li>TCP/IP SOCKET protocol</li> <li>TCP/IP TELNET protocol</li> </ul>
<b>Emulation modes</b>		Tektronics emulation mode Not documented in manual <sup>267</sup>   Utility > Menu	
<b>Network share storage</b>		Network share storage (FW1.3.9R4). Stores on a Windows SMB mounted disk. It is fully supported for any save/recall operations. Not documented in manual. Posts from users not getting this to work, have not checked current status @@  Utility > Menu > System Settings > I/O > Net storage	

<sup>264</sup> Siglent has a Windows program called 'EasyScopeX', which controls a variety of their scopes. According to the software documentation and revision history, those include the SDS1000, SDS1000X/X+, SDS1000X-E, and SDS2000/X, SDS1000X-U. The SDS2000X Plus series, however, is not mentioned as supported oscilloscope. Some people seem to have used it with this SDS2000X Plus (see <https://www.eeyblog.com/forum/testgear/siglent-sds2000x-plus-coming/1875/>). I did a little bit of testing, it starts up, some functions do work but others (like the remote virtual panel) do not seem to work well (even if it nicely confirms its talking to the X Plus model...). I assume this is the reason Siglent does not mention support for this software.

<sup>265</sup> Shown on screen in UTILITIES, I/O

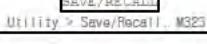
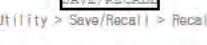
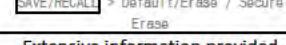
<sup>266</sup> With USB MTP (Media Transfer Protocol), the memory in the instrument (or part thereof) is presented on the PC as if it is a flash drive. Great on Windows. Unfortunately, Apple MacOS does not natively support this, and the add-on programs seems to work only with MTP smartphones etc. and not test equipment instruments etc. that offer MTP.

<sup>267</sup> Might be similar to the Tek mode in the Siglent SDS5000X, see [here](#).

		Remote Command Logging
	UTILITY	> Options > Remote Log. M244

## System

### File system

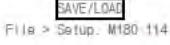
	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>General</b>	File names in load/save/manager menus truncated to 8 characters (e.g., 'wavefo~2')	Internal and external memory seem to be total separated. Some save/recall only works for internal files, some only for external files.	
<b>File Management</b>	<p>Copy between internal memory and USB drive Supported File &gt; Setup<sup>268</sup> M187</p> <p>For reference waveforms, the file can also be converted between file formats.</p> <p>PS if no USB flash drive inserted, the menu stays grey File &gt; References.. M187</p>	<p>Icon based file manager available in the Save/Recall menu</p> <p>Icons and explanation are somewhat unclear (for instance, icon that looks like 'save' is actually a load icon in a recall action). Icons updated as per (FR 1.5.2R1)</p> <p>In the Recall menu, image files (e.g., PNG) are shown as medium sized previews. Has zoom option but because of limited window size this is limited in use.</p> <p>Copy between internal and external possible via a clipboard-alike method<sup>269</sup></p> <p></p>	
<b>Saving multiple type of files at once</b>	"OneTouch" allows to save any combination of the below at the same time when touching the "photo" button on the front panel: Setup, Waveform <sup>270</sup> , Reference Waveforms, Search Results, Decoded Bus Data, Statistical Results. They are saved as up to 7 files in one ZIP container. File > Onetouch.. M187		
<b>Secure erase</b>	Deletes all configuration and user data. Setup > Secure Erase.. M187	<p>Not discussed in the User Manual. Is in a weird spot in the menu structure.</p> <p></p>	<p>Performs a secure erase of all non-volatile memory in compliance with National Industrial Security Program Operation Manual (NISOPM) Chapter 8 requirements.</p> <p></p>
<b>Documentation on saved file formats.</b>	Extensive information provided	Minimal or no information, often inconsistent with instrument	Extensive information provided
<b>Free user memory (for local storage)</b>	Approx. 370MB Setup > Memory Usage.. M178	Approx. 73MB Can be seen in File Manager menu while loading/saving	
<b>Other</b>			File name entry is via rotary dial (keyboard is no option for saving to external memory as the USB slot is occupied)

<sup>268</sup> Even though this is in the 'Setup' [file] menu, this function works for any type of file.

<sup>269</sup> To do so, go into a Save or Recall screen that both supports internal and external memory (for example: SAVE | SETUP). Activate the selection mode via the rightmost item. Tick the files to be copied, then fifth icon from the left to copy them into the clipboard. Go to the destination memory location and click the 6<sup>th</sup> icon from the left to paste the clipboard.

<sup>270</sup> Waveform is saved according settings possible in Waveform Save menu. These settings are shown in the OneTouch menu.

## Save and recall

	 RTB2000	 SIGLENT SDS 2000X+	 KEYSIGHT TECHNOLOGIES DSOX 1200
<b>Device setup</b>	<p>Save, Load To and from internal or external File format: SET (instrument-specific<sup>271</sup>), based on SCPI commands</p> <p>Precise content of setup not specified<sup>272</sup></p> <p>Setup files have small screenshot (preview) embedded for easy identification. These are visible in file manager in instrument when loading a file.</p> <p> File &gt; Setup. M177</p>	<p>Save, Load To and from internal (10 positions max) or external File format: XML (instrument-specific<sup>273</sup>), in XML style format</p> <p>Precise content of setup not specified<sup>274</sup></p> <p>(I cannot reproduce the steps in Manual p.32 on the instrument...)</p> <p>Current setting can be saved as default set-up.</p> <p> Utility &gt; Save/Recall. M317, 315</p>	<p>Save, Load To and from internal (10 positions max) or external File format: SCP (instrument-specific<sup>275</sup>), in XML style format</p> <p>Saves the horizontal timebase, vertical sensitivity, trigger mode, trigger level, measurements, cursors, and math function settings</p> <p> P219</p>
<b>Waveform data (save)</b>	<p>Save To internal or external File formats {TXT, CSV<sup>276</sup>, BIN-MDB, BIN-LSB, FLT<sup>277</sup>-MSB, FLT-LSB}.</p> <p>Source: • Selected waveform (4A, 16D) • All visible waveforms</p> <p>Choice of • Displayed waveform(s) • Acquisition Memory (for stopped acquisitions) • History Data (waveform plus CSV file with information about segments)</p> <p>Waveform data formats are discussed in detail, including examples, on p.180-182 of the manual; History &amp; Segment files on p. 114-115</p> <p> File &gt; Setup. M180-114</p> <p>Waveforms can also be saved as a "Trigger Action" or a "Mask Action".</p>	<p>Save (3 formats) According to manual only to external (M319) but in practice also to internal memory is possible.</p> <p>File formats: CSV, BIN, MAT (Matlab format), DAT (Matlab format)</p> <p>Source (only for CSV and MAT): • Selected waveform (4A, 2M (1.3.7R5)). Not FFT (inconsistent below) • All visible waveforms (1.3.7R5)</p> <p>For CSV, option to include the scope configuration parameter information (horizontal time base, vertical scale, etc.) ParaSwitch</p> <p>BIN is a binary format. A Microsoft Windows Bin2CSV Tool is available.<sup>278</sup> This way, the file from instrument to PC can be smaller (in a test, a 4MB BIN file extracted to a 66MB CSV file). Works but does have issues.<sup>279</sup></p> <p> Utility &gt; Save/Recall. M318</p>	<p>Save Only to external File formats: CSV, ASCII XY, BIN, H5 (single waveform/reference waveform<sup>280</sup>), H5 (Multi Channel Waveform data<sup>281</sup>)</p> <p>Detailed information on waveform formats is in manual on pages 266, 273, 274.</p> <p>Number of data points to be saved (Length); detailed explanation M221</p> <p>If segmented memory is active {Selected segment only, All segments}</p> <p>Setup Info option saves additional setup information in a separate TXT file (vertical, horizontal, trigger, acquisition, math, and display settings).</p> <p> P220</p>
<b>FFT data (save)</b>	<p>CSV file. Can save values for all waveform arithmetic (spectrum, min hold, max hold, average) in the same file (all visible FFT waveforms)</p>	<p>Since 1.3.9R4. CSV file. Via Save &gt; CSV -&gt; Source: F1 (or F2). For each frequency, file contains values for 'Real part', 'Imaginary part', 'Magnitude', 'Angle'. Not documented, not exactly sure about meanings</p>	

<sup>271</sup> This is a device specific format and files are not intended for analysis outside the instrument.

<sup>272</sup> But the file can be opened in a standard text editor and shows some 1400 comment lines of setup data.

<sup>273</sup> This is a device specific format and files are not intended for analysis outside the instrument.

<sup>274</sup> But the file can be opened in a standard text editor – there are roughly 3000 lines of XML language, a bit harder to understand by humans but might still be investigated.

<sup>275</sup> This is a device specific format and files are not intended for analysis outside the instrument. Yet, it is in an XML type of language so can be investigated.

<sup>276</sup> Files stored as \*.CSV can be later loaded in the instrument again as reference waveforms.

<sup>277</sup> FLT is a Floating Point format.

<sup>278</sup> The ZIP file containing that tool is already in the instrument. Using the Save/Recall menu, it can be copied to a USB Flash drive and moved to the computer.

<sup>279</sup> Some parts of the user interface are in Chinese language and

<sup>280</sup> A format that can be recalled to one of the oscilloscope's reference waveform locations, or opened by the N8900A Infinium Offline oscilloscope analysis software.waveform locations or read by the N8900A Infinium Offline oscilloscope analysis software.

<sup>281</sup> A format that can be opened by the N8900A Infinium Offline oscilloscope analysis software.

Reference waveforms	<p>Save, Load To and from internal or external File formats: CSV (load only), TRF (binary, instrument-specific<sup>282</sup>)</p> <p>Waveform files saved as CSV format can also be loaded as reference and are converted into TRF by the instrument</p> <p>Reference files have small Screenshot embedded for easy identification. These are visible in file manager in instrument when loading a file.</p>  <b>M187</b>	<p>Save, Load According to manual only to external (M319) but in practice also to internal memory is possible.</p> <p>File format: REF (instrument- specific<sup>283</sup>)</p> <p>Bit confusing and possible mismatch between instrument and manual. On the instrument it seems you can:</p> <ul style="list-style-type: none"> <li>- save a source (4A, 2M) into *.REF.</li> <li>- recall (load) a *REF file into REFA to REFD position</li> </ul> <p>But this is at odds with the manual.<sup>284</sup></p>  <b>M317</b>	<p>Save, Load Only to external File format: HS<sup>281</sup></p>  <b>P222</b>
Math sets (equation sets; formularies)	<p>Load, Save To and from internal or external File format: FML (instrument- specific<sup>285</sup>)</p> <p>FML files are instrument-specific<sup>286</sup></p> <p>To/from internal or external (sets with up to 5 formularies)</p>  <b>M187, 101</b>		
Statistics	<p>Save To internal or external File format: CSV; content described on page 134 of manual.</p> <p>Save icon overlaps with other icon<sup>287</sup></p> <p>Save button shown right of statistics table. M183</p>		
Decoded busses (results table) (see also above at @@)	<p>Save To internal or external File format: CSV</p> <p>Possible for any parallel or serial bus</p> <p>Protocol... 187, P16</p>		<p>Save Only to external File format: CSV</p>  <b>M222</b>
Search results	<p>Save (CSV file)</p>  <b>M17</b>		
Screenshots	<p>Save (PNG, BMP) To internal (FW02.300) or external File formats: PNG, BMP</p> <p>Resolution 1280x824 {Color, Greyscale} {Non-inverted, Inverted}</p> <p>Option to disable device logo in screenshot (FW02.300)</p> <p>Option to close all menu's before screenshot (so they do not mask the results)</p> <p> or  File &gt; Screenshots. M187</p>	<p>Save According to manual only to external (M319) but in practice also to internal memory is possible.</p> <p>File formats: PNG, BMP, JPG</p> <p>Resolution 1024x600 {Normal, Inverted}</p> <p>Print Area {Grid, Full} (FW 13.9R4)</p> <p>In the Recall menu, image files (e.g., PNG) are shown as medium sized previews. Has zoom option</p>	<p>Save Only to external File formats: PNG (24 bit), BMP (8 or 24 bit)</p> <p>Resolution 800x503 {Color, Greyscale} {Normal, Inverted} (Invert Grid)</p> <p>Setup Info option saves additional setup information in a separate TXT file ({vertical, horizontal, trigger, acquisition, math, and display settings}).</p>

<sup>282</sup> This is a device specific format and files are not intended for analysis outside the instrument.

<sup>283</sup> This is a device specific format and files are not intended for analysis outside the instrument.

<sup>284</sup> Manual (p 317) states "The reference waveform data are saved to external memory with the \*.ref file extension." But I did not manage to do so.

<sup>285</sup> This is a device specific format and files are not intended for analysis outside the instrument.

<sup>286</sup> This is a device specific format and files are not intended for analysis outside the instrument.

<sup>287</sup> The SAVE icon overlaps with the R&S Menu logo on the right bottom. While one can still select either, one must take care.

<sup>288</sup> If only 'screen shot' is selected in OneTouch, a simple screenshot is saved. If other file types are also selected, a ZIP is created with all files including the screenshot.

		<p>but because of limited window size this is limited in use.</p> <p> Utility &gt; Print</p> <p> Utility &gt; Save/Recall.. M318</p>	or  M19
Patterns (for pattern generator)	Load, Save To/from internal or external File format: SCP (remote commands format; command for pattern is on p.555 of manual). User utility allows Excel creation <sup>289</sup> 	[instrument has no pattern generator]	[instrument has no pattern generator]
Arbitrary waveforms (for signal generator)	Load From internal or external File formats: - TRF files (binary, instrument-specific, such as saved as a reference waveform) - CSV files (such as saved as a regular waveform)		[instrument has no ARB generator]
Mask	Load, Save (MSK) To/from internal only <sup>290</sup> File format: MSK (instrument specific) <sup>291</sup> > Mask > Mask.. M147		Save, Load (MSK) To and from internal (4 positions max) or external  File format: MSK (instrument specific) <sup>292</sup> P223
Bode plot results	Save To internal or external File format: CSV file Save button shown in bode plot control menu.. M171		Save To external only Format: CSV  File with Frequency Response. In the saved file, there are three data columns: frequency (Hz), gain (dB), and phase (degrees). P219

## Other system features (TBA)

	RTB2000	SIGLENT SDS 2000X+	KEYSIGHT TECHNOLOGIES DSOX 1200
Self alignment / user calibration	Self alignment "The self-alignment aligns the data from several input channels vertically and horizontally to synchronize the timebases, amplitudes and positions."  Can save log file. > Self alignment.. M196	Self-calibration "The self-calibration program can quickly calibrate the oscilloscope to reach the best working state and the most precise measurement."  Yes TBA > Do Self Cal.. M343	User Calibration "User Calibration performs an internal self-alignment routine to optimize the signal path in the oscilloscope. The routine uses internally generated signals to optimize circuits that affect channel sensitivity, offset, and trigger parameters." Follow key sequence explained on page 246 of user manual  To display the user calibration status > Service > User Cal Status.. M247
Hardware test		Screen test LED test Keyboard/button test. Also fairly cool in its implementation  > Do Self-Test > Screen Test > Do Self-Test > LED Test > Do Self-Test > Keyboard Test	Hardware self-test Front panel self-test. Quite cool in its implementation; check the three function check of rotary dials!  > Service > Diagnostics / Hardware Self Test.. M346

<sup>289</sup> See <https://www.eevblog.com/forum/testgear/rohde-schwarz-rtb2002-rtb2004-question-importing-cvs-in-pattern-generator/>

<sup>290</sup> But can be copied with file manager to external storage.

<sup>291</sup> This is a device specific format and files are not intended for analysis outside the instrument.

<sup>292</sup> This is a device specific format and files are not intended for analysis outside the instrument.

		M340-342	<b>UTILITY</b> > Service > Diagnostics / Front Panel Self Test. M246
<b>Probe compensation</b>	Extensive visually aided procedure  > Probe Vertical > Channel > Probe Setup > Probe Adjust. M86, 461, 462	Via general auto-setup procedure, no specific procedure.  M32	Aided procedure.  M26
<b>Settings on power-on</b>	From last session M34	[From last session] (Not discussed in manual)	[From last session] (Not discussed in manual)
<b>Default setting</b>	PRESET "Resets the instrument to the scope mode and to default state, without analyzing the signal. The user-defined configuration, measurements and other settings are removed and all channels and waveforms, except for channel 1, are disabled."	Default can be set as either: <ul style="list-style-type: none"><li>• Factory set-up</li><li>• A saved user set-up</li></ul>  Acquire > Default  <b>Unusual UI implementation:</b> you go to save/recall menu and 'save' to the key on the front panel.  Saving user setup:  Utility > Save/Recall. M317  For both, the device pops up a screen window for confirmation. But you can also tap the button just twice.	Returns device to a default setup but 'leaving some user settings (not specified). Also described as bringing the "oscilloscope in a known operating condition"  M24   > Default/Erase / Default Setup  <b>Undo option:</b>  It is also possible to restore the device to factory setting via de   > Default/Erase / Factory Defaults. M225
<b>Autoset</b>	See at section 'Analogue channels'	See at section 'Analogue channels'	See at section 'Analogue channels'
<b>Print to external printer</b>			Print to a USB of network-attached print. (FW2.10) The printer must support Direct PDF printing over USB/IPP (Internet Printing Protocol). <sup>293</sup> A standard PCL3 or PCL5 printer will not work. Various setting options  > Print M229-232
<b>Export crash log files</b>			Export crash log files. Never needed this because it never crashed! <b>UTILITY</b> > Service > Diagnostics > Export Log. M246

Not yet in any of the above categories

		 Acquire > Clear sweep	
--	---	--	--

SCPI

<sup>293</sup> See <https://edadocs.software.keysight.com/kkbopen/which-printers-are-supported-by-the-infinivision-oscilloscopes-588283271.html>

## Firmware and manual improvements wish list (TBA)

### Firmware improvements wish list (TBA)

Below are issues that I would appreciate to be addressed in new firmware releases. On the first two lists, I focus on issues that I believe should not be very hard to tackle. The third list has issues that require (much) more work, and the fourth list presents further wishes.

Why so few comments for the DSOX? Well, I think this instrument has quite some limitations, but these are mostly due to the overall design and focus of the instrument, not things that (I believe) can be easily changed by updating the firmware...

	 RTB2000	 SDS 2000X+	 DSOX 1200
Urgent improvements wish list ('bugs, or features that should not have been missing')	Switch DVM to AC mode when channel is set to AC (instead of showing incorrect DC values)	For SPI, I2C, CAN, LIN, show occurred errors in telegram or table	If DVM and measurement statistics are both on, the display jumps erratically between both.
	Solve the problem that "identity and data" in CAN trigger only works when frame length is set (other decoders in the RTB do require that)	Prevent instrument to show serial decoded messages if they are plainly wrong	
		Fix communication between EasyWave software and ARB	
		Fix remote web mode for tablets etc.	
		Update waveform update rate so real-life performance is somehow close to specification	
		Provide override setting for automatic probe sensing	
		Limit label entry length to actual allowed label length	
		Fine control of time base	
		Overall stability and responsiveness of operating system	
Desired improvements	Increase update rate of bus table in serial decode	Improve user interface for using channel waveform for ARB (so user does not get 'file not found' error.)	Add axis values
	When editing labels, show last value of that label (not last value of another edited label)	On the vertical and horizontal axis, show only digits after the period when it makes sense (not 600.0000). <a href="#">Solved in FW 1.3.9R12</a>	Keep displaying serial decode lister when leaving submenu
	Increase labels length from 8 to 12 or 16 characters; slightly increase label display size	Improve readability of labels (add clear background)	Keep large DV display window when leaving submenu
	Allow math as input for serial decode	Allow math as input for serial decode	
	Allow reference as input for serial decode	Allow reference as input for serial decode	
	Allow digital channels as input for math	Allow digital channels as input for math	
	Solve some smaller UI quirks <sup>294</sup>	In ASCII mode in serial decode, show HEX for non-valid ASCII characters, and show addresses etc. always in HEX	
	Turn measurements on/off globally (without deleting their settings) e.g., via push MEAS button	Increase update rate of measurements	
	In the parallel clocked mode, allow analogue channels for CS and CLK		

<sup>294</sup> In modes where the lower half of the screen is used for showing tables or measurement data, the right bottom (text) elements are sometimes masked by the R&S logo or vertical menu. In serial decode, the rightmost column (for most decoders it is 'status') is often not completely seen (especially a problem when two or three errors are observed in a single frame). Also, when closing a menu, the table sometimes does not restore to full size, while sometimes it does.

	so the full 16-bit bus can be maintained.		
	Allow (CAN) serial trigger to find a message with a known data content without having to know the length of that message in advance.		
	Show more than 8 characters of filename in load and save screens		
	Do not show (or grey out) a "?" icon when the user is then presented with a "No help available for this function" message.		
	When channel is set to current (A), adapt the FFT scales to dBA, dB $\mu$ A, and Aeff (RMS)		
Desired changes that would (assumingly) require more drastic effort	Allow the entire (segmented) memory to be used entirely by <i>any</i> channel	Reduce over-hierarchical menu structure (for instance, show all PIN settings of SPI in one menu, not four separate menu's)	Improve web interface update rate
	Show relevant data for (each) measurement mode as X and Y cursors	Integrate relevant serial decode settings into the serial trigger module (instead of having to copy them there)	
	Allow serial decode of two bidirectional buses	Speed up boot time	
	Show small histograms for measurements (and a large histogram for a selected measurements)	Make on-screen help contextual	
	Display uploaded ARB file properties (points, amplitude, etc.)	Display uploaded ARB file properties (points, amplitude, etc.)	
		Reduce ventilator noise (e.g., adaptive ventilator) <sup>295</sup>	
Further wishes...	Add more complex and varied serial decode training signals (timing, ID, payload, (n)ack), including some with deliberately inserted errors	Offer serial decode training signals	
	Offer analogue training signals (glitches, runt, etc.)	Offer analogue training signals (glitches, runt, etc.)	

### Manual and specs improvements wish list (TBA)

	RTB2000	SIGLENT SDS 2000X+	KEYSIGHT TECHNOLOGIES DSOX 1200
	Some small improvements, including: - Updating text on single cycle measurement (are relative to trigger, not left-most part of screen) - Update part on the counter (since FW2.000 supports all analogue channels)	Vastly improve user manual, especially on implementations which are not trivial	
	Desire to document also many SCPI commands that are not documented	Update user manual with later firmware releases (many functions such as tracking are completely undocumented)	
	Desire to document how user can make 'apps' by saving a file with SCPI commands	Explain in function generator / ARB section how analogue channel to ARB function works.	
	Correct the sample rate of the ARB in the specs (its actually higher than listed there)		
	Correct the ARB memory length in the specs (its actually higher than listed there)		

<sup>295</sup> Not sure this is possible via firmware; it might be when ventilator speed is controlled and there are appropriate temperature sensor(s) in the device.

@@ RTB: 'App' is set of SPCI commands, you can make your own