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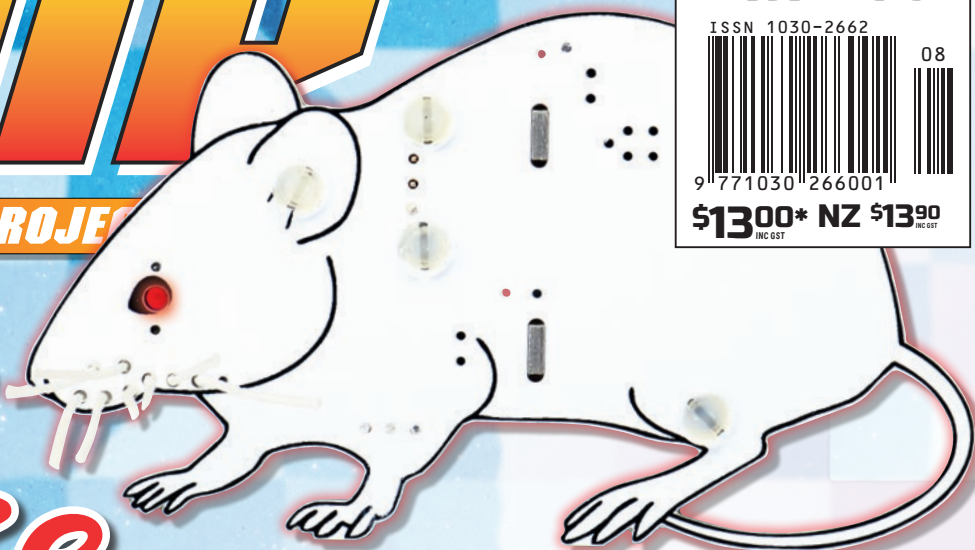
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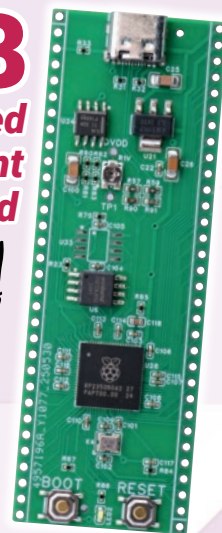
Mic the Mouse



DUCTED HEAT TRANSFER CONTROLLER

RP2350B

Pre-Assembled
Development
Board



USB-C Power Monitor



Measure current, voltage, power, energy & time on all modern USB-C devices

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CHIP** 

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RIGOL DH0924S



Digital Oscilloscope

Review by Tim Blythman

It's been a while since we have reviewed an oscilloscope, and Rigol's new DH0900 series has a slew of modern features with a compact footprint. This review covers these new features and looks at what it's like to use out-of-the-box. We'll also have a brief look at their DM858 digital multimeter.

4 channels 125MHz or 250MHz bandwidth Parallel, UART, I²C, SPI, LIN, CAN protocol analyser

Sampling rate of 1.25Gps (shared between active channels) 12 bits analog resolution

Optional 25MHz, 10V peak-to-peak waveform generator 7in touchscreen LCD (1024 × 600 pixels)

Sine, square, ramp, noise, arbitrary waveforms (from CSV file) Sample memory of 50 million points

Period, frequency, rise time, fall time, duty, count, delay, phase and more measurements

Maths functions, FFT, Bode plot (using the AFG as a source), pass/fail

USB device, HDMI, LAN, USB host (mouse, flash drive) interfaces 15V DC, 3A (65W USB-C PD) PSU

After seeing this oscilloscope at Elextronex and being impressed, Emona loaned us a unit to review. The first thing we noticed about the DHO924S is its compact size. For comparison, the Rigol MSO5354 that we reviewed in February 2019 (siliconchip.au/Article/11404) measures 37 × 20 × 13cm (9.62L), while the DHO924S is only 26 × 16 × 8cm (3.33L). The enclosure is also a striking black colour.

The DM858 digital multimeter appears to use the same case as the DHO924S, so it is a similar size, shape and layout. We also borrowed one of those; our review of it is in a panel later in the article.

The DHO900 series

The DHO900 series comprises four models: DHO914, DHO914S, DHO924 and DHO924S. S-suffixed parts include an arbitrary function (waveform) generator output, while the DHO914 variants offer 125MHz bandwidth against the DHO924's 250MHz bandwidth. The DHO924S has the highest specifications in the series.

Rigol's DHO naming refers to a high-resolution digital oscilloscope; it has a 12-bit ADC (analog-to-digital converter), while many 'scopes we have seen only offer 8-bit resolution. There are four analog inputs, so that's the '4' in the naming scheme.

The DHO924S also has a 16-input logic analyser, but an optional active logic probe is required to use this feature, so we did not test it. We find that four channels are ample for most scenarios, and the analog channels can also be used as inputs to digital features, such as the serial protocol decoder.

There is also a DHO800 series, which offers 12-bit resolution in a mix of two- and four-channel options but lacking the logic analyser option. They have a lower bandwidth and lack some of the other features of the DHO900 'scopes, but are similar in that they have the same compact form factor.

Out of the box experience

The photos show the front and back of the DHO924S. The back panel has two BNC connectors; one of these is for the arbitrary function generator, the other an auxiliary output. By default, the latter emits a pulse when a trigger event occurs. There are also Ethernet, USB-B, HDMI and USB-C connections.

The legs pivot out during use or fold flat for storage. When the legs are extended, the unit leans back about 20°. The legs and base of the unit have chunky rubber feet and the 'scope does not feel like it will tip or slide away while the controls are being operated.

There is an Earth socket for a banana plug, and the brass insets are threaded for M4 VESA mounts with a 100mm spacing. With the DHO924S being so thin, it becomes practical to mount it to an adjustable monitor arm, so it no longer takes up any desk space. Apparently, users are also 3D-printing a variety of adaptors to suit the VESA mounts to adapt to their 'scopes.

The four input BNC connectors are along the bottom of the 'scope next to the ground and test signal clips. The connector for the optional active logic probe is under the display, along with a USB-A socket and the power button.

Compared to the likes of the Rigol MSO5354, there is only one pair of vertical scale knobs, despite there being four channels. The active channel is selected by the same numbered, colour-coded pushbuttons that are used to switch channels off and on. We found this to be intuitive enough and, as it offers more room for the main display, it seems like a reasonable compromise.

The oscilloscope package includes four switchable probes (more on them later), a USB-A to USB-B cable, an Earth lead terminated with banana plugs and a USB-C PD (power delivery)

power supply, which indicates that it can deliver 5V, 9V, 12V, 15V or 20V. The oscilloscope uses 15V, according to our USB-C Power Monitor.

The USB-C plug has a pin and latch arrangement that secures it. That means that the power supply cannot be easily used to power other devices, but does not stop another suitable power supply from being used to power the oscilloscope instead.

Being an isolated power supply necessitates the inclusion of the Earth lead, since USB-C does not provide a means for Earthing. In other words, the oscilloscope is floating unless the separate Earth lead is connected.

This is an interesting pitfall that may not be immediately apparent to those accustomed to 'scopes that are normally Earthed via their mains lead. Also, since it isn't directly mains-powered, it is not possible to trigger off the mains waveform without a separate connection.

After powering on the 'scope, it took almost a minute to start up and display the expected screen. Along the way, the message "Android starting" appeared, hinting at the underlying software. The DHO924S we tested ran Android 7.1.2, which dates from 2019.

The LCD has a touch panel, which works as you might expect for an Android device. You can tap on virtual buttons, drag the cursors around and even perform a pinch-to-zoom. There is a "Touch Lock" button to disable the touch panel.



There are several ways to connect to a PC or external monitor. The VESA mounts allow the unit to be mounted on a monitor arm, freeing up bench space. While this is a DHO800 series 'scope, the back of the DHO900 series is identical except for having a black case.



Four PVP2350 350MHz switchable passive probes are included, along with the accessories shown here. The 'scope also includes a power supply & USB cable.



Screen 1: despite the numerous features, it's easy to find most menu options. A good place to explore is the R menu at the lower left corner of the screen. This also gives a good overview of the advanced features.



Screen 2: once we had the 'scope's IP address from this screen, it was easy to connect to the Web Control interface. The Utility menu also includes the setup and self-calibration options.

The 'R' icon at the bottom-left corner of the display opens a menu that includes features beyond what you might expect from a traditional 'scope, such as settings, operating system utilities and the like. Screen 1 shows the contents of this menu.

The front panel looks much like any other 'scope, with the familiar adjustment knobs for vertical and horizontal scale, trigger and RUN/STOP controls, along with other controls to operate the custom features that are seen in modern oscilloscopes. The "Quick" button can be programmed to perform one of several different actions; by default, it saves a screenshot.

The two 'Flex Knobs' near the top do not have a fixed use; their function changes depending on the items selected in various menus. The functions are marked on-screen by small '1' and '2' icons.

The Flex Knobs allow all manner of values to be adjusted instead of being manually entered into a keyboard on the touch panel. This will be handy when values just need to be tweaked by a small amount. These knobs can also adjust the cursors when they are turned on.

Probes

The DHO924S comes standard with four Rigol PVP2350 350MHz passive probes, which are switchable between 10:1 and 1:1 attenuation (as usual, the full bandwidth is only available at 10:1). Each probe includes an assortment of colour-coding rings and a ground spring, as well as the requisite compensation adjustment tool.

The leads are 1.2m long, and their slim cords are light enough to not take up too much space. There is no probe detection (for automatic probe attenuation setting), so these must all be set manually.

Using it

Since we were keen to try out the more modern features of the DHO924S, we hooked up an Ethernet cable. We found the IP address of the 'scope from the Utility menu, as seen in Screen 2. Typing that into a browser's address bar gave us a Web Control Page, allowing us to open a Web Control window that shows the oscilloscope's screen.

Screen 2 was captured on our PC using the Web Control window; it's identical to what appears on the



Screen 3: hooking the 'scope's function generator back to one of its inputs shows off its sensitivity. The 2mV peak-to-peak square wave is the lowest amplitude that it can deliver.

Screen 4: tapping on each channel's vertical settings shows the full signal path and its associated parameters. You can still see the waveform under the transparent window, allowing the trace to be adjusted with ease.



'scope's screen and even gives access to the controls that would otherwise require the touch panel. Any device with a browser and WiFi connection should work. We had no trouble controlling and viewing the 'scope on an Android mobile phone's browser.

This makes it much easier to explore the features of the 'scope, although we think it's a bit of an omission that there aren't controls for the various hardware buttons and knobs. Still, most settings can be set via menu panels.

The HDMI interface just works. We plugged in a HDMI cable, connected it to a monitor and the 'scope's display appeared on the screen without having to change any settings. The output appears to be identical to that on the LCD, scaled up to use the entire viewable area of the monitor.

We'll delve further into the various interfaces a bit later, including some software that Rigol offers. The relevant downloads can be found at www.rigolna.com/download/

There is a self-calibration mode that is recommended to be performed after the 'scope has warmed up to operating temperature (after about 30 minutes). The self-calibration process took

about 24 minutes to run on the unit we were testing.

The sampling rate is shared between the four channels, since there is only one analog-to-digital converter IC. Using two channels halves the available sampling rate, while using three or four channels will reduce it to a quarter. So the maximum sampling rate can only be achieved if only one channel is in use. Similarly, the sample memory is also shared between the channels in use.

Noise performance

Using the inbuilt arbitrary function generator, we looped a 2mV peak-to-peak 1kHz square wave signal back into the 'scope with no attenuation and with the bandwidth limited to 20MHz. The result is seen in Screen 3. Some of this noise will be from the function generator, but clearly, the DHO924S has no trouble resolving signals below 1mV, which is pretty impressive.

Inputs

Opening the menu options for the inputs reveals the signal flow diagram seen in Screen 4. Some of the options can be adjusted by tapping on the diagram itself. You can use the Flex Knobs, as indicated by the yellow hexagons.



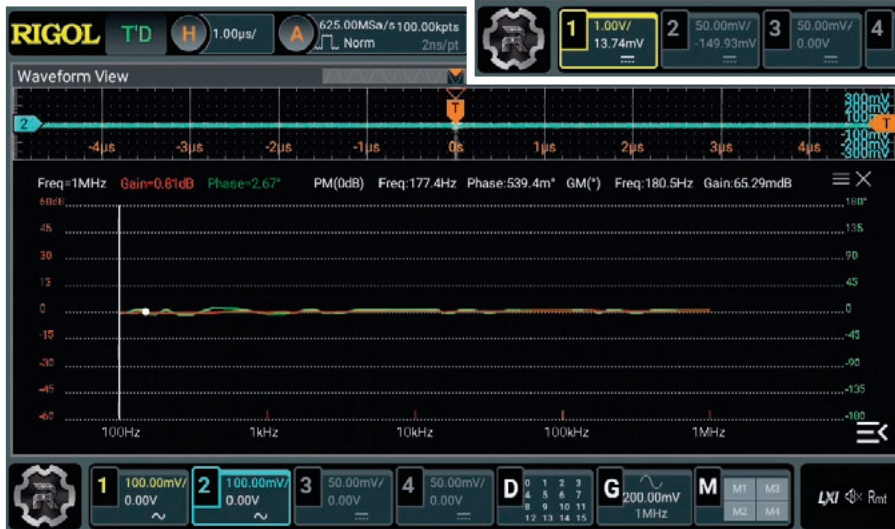
The front of the DHO924S is compact, thanks to the channel vertical controls being shared. The channel to adjust is selected by one of the numbered buttons. Above these are the Flex Knobs, which adjust values depending on the current sub-menu.



Screen 5: measurements are added to the Result panel at right. This panel can scroll up and down, so more than five results can be added. The options relating to the horizontal (time) axis are shown here.



Screen 6: this display has both reference waveform (orange) and pass/fail mask (blue) active. The auxiliary output at the rear of the 'scope can be set to produce a pass/fail signal.



Screen 7: a Bode plot expands to take up most of the available screen space. Most of the windows are movable and adjustable, so you can customise the viewport to suit your preferences.

Section	Description	Page
1	Quick Start	1
1.1	Front Panel Overview	1
1.2	Touch Screen Gestures	6
1.2.1	Tap	6
1.2.2	Drag	7
1.2.3	Pinch&Stretch	8
1.3	Parameter Setting Method	8
2	Vertical System	15
2.1	To Enable or Disable the Analog Channel	16

Screen 8: the 'scope's help system includes a PDF copy of the manual that can be viewed on the 7-inch display.

For numerical values, a pop-up keyboard can also be used to enter values.

The main parameters are also displayed on the channel widget near the bottom of the screen, and you can see the appropriate parameters for the arbitrary function generator displayed on the G channel too.

Maths and measurements

Handy features on most modern 'scopes include various mathematical functions and trace measurements; the DHO924S is no exception. The measurement menu can be accessed from a fixed button on the right-hand side or via the 'Measure' button at the top-right of the screen, on the touch panel or even via the main 'R' menu button.

The area at top-right actually hides several different buttons that can be accessed by swiping left or right. Fortunately, most menu items can be accessed in different ways, so you can choose whatever option is most intuitive.

There are 41 different measurements available; Screen 5 shows some of these active, as well as the horizontal (time-based) measurements that are available. The vertical options include voltage-based (peak-to-peak, RMS etc) measurements, while the remainder are time and phase delay measurements between two input channels.

The Setting option allows thresholds to be set. These default to 10%, 50% and 90% levels of the waveform, which worked quite well for us during our tests. You can also view various statistics, such as average, minimum or maximum of the measured parameters, or view a histogram of the measurements as they are gathered.

Four 'Math' channels are available, including operations such as summing or differencing two channels. Single-channel operations such as logarithm, exponent, derivative, integral and square root are available. FFT (fast Fourier transform) or spectrum analysis is also possible.

Functions

The menu shown in Screen 1 gives an idea of the DHO924S's built-in functions. When measurement or maths windows are open, they can be dragged around and reorganised (something we're not used to on a 'scope).

A Reference waveform can be captured ("Ref") from an active channel to be visually compared with the

changing input. A more rigorous signal check can be performed using the Pass/Fail function. This requires a mask against which the active channel is compared; the results of the Pass/Fail can optionally be fed to the auxiliary BNC connector on the rear of the scope.

The mask can be loaded from a file or can be easily created by applying margins (in time and voltage) against a sampled input channel. A typical example of such a mask is the so-called eye diagram used to verify high-speed signals, such as USB or HDMI. Screen 6 shows the Reference and Pass/Fail functions.

The protocol decoding feature supports Parallel, UART, I²C, SPI, LIN and CAN signals, although you would probably need the optional active logic probe to do much with a parallel bus. There are many parameters available to adjust, including polarity, parity and bit order, although the defaults look to be sensible for commonly used configurations.

There is a button to swap SDA and SCL in I²C mode, so it's reasonable to just hook the 'scope up without worrying too much about which wire is which. It can decode up to four separate buses at once, which is more than sufficient for most applications.

The Bode plot function is only available on models with an arbitrary function generator, since the generator is used to provide the input waveform. The Bode plot window expands to take up most of the display, as seen in Screen 7.

The Auto function is the same automatic configuration utility that is found on other 'scopes to quickly set up the timebase, voltage scale and trigger selection based on the active signal. It can also be accessed from the hardware button in the top right corner of the 'scope.

The Display settings can select trace persistence and change other parameters as trace and grid intensity, as well as window transparency. On the bottom row are functions related to the operating system functions of the unit. The Help feature is actually an on-screen viewable PDF version of the manual, which can be seen in Screen 8.

Other connections

The front USB-A socket can be used for either a mouse or flash drive (a USB hub allows both to be connected

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simultaneously). The mouse is used as you might expect, to interact with items on the screen. We think that support for a keyboard or numeric keypad might be handy for parameter entry, since this can sometimes be awkward to do with an on-screen keyboard.

A USB flash drive can be used to transfer screen captures or waveforms for the arbitrary function generator. It can also be used to upgrade the firmware. The 'scope has internal storage and can connect to an SMB (network) file server via Ethernet.

We often use screen captures or 'scope grabs for articles in the magazine, so we thought we would use a USB flash drive to transfer the necessary files for this article. But it turns out that the web control and network interface mean that is unnecessary, since we can download captures directly to a PC.

The Web Control's Print Screen tab has buttons to take a screenshot or record a video; the image or video is displayed in the browser window and can be simply downloaded onto the PC from there. We noted in our review of the MSO5354 that its web control response was a bit slow; in comparison, the DHO924S feels much snappier.

The USB-B socket on the rear of the 'scope can be used to control the DHO924S, but we found that the Ethernet connection was more useful, since the PC does not need to be near the 'scope as is required for a USB connection.

Other notes

There is a sleep mode which can

be used instead of a full shut-down. This has the advantage that the 'scope only takes about 20s to be ready from sleep, and also retains its last operating state. The main downside is that the power supply must remain active to retain this state.

Using our USB-C Power Monitor, we recorded a peak of 2.6A at 15V, consistent with the 3A maximum recommended in the user guide. During sleep, we recorded a draw of around 230mA at 15V, while a full shutdown reduces this to about 1mA.

The web control view would occasionally reset, changing the window size and stealing the focus from another window if it did not already have focus. If the network connection is lost, a message is displayed in Chinese. The same message is shown if a second browser window attempts to connect to the web control.

Software

SCPI (Standard Commands for Programmable Instruments) is a standard for the control of test equipment and instruments. The DHO924S presents an SCPI interface on Ethernet port 5555, and it can also be accessed via USB.

In the April 2023 issue, we wrote about the free TestController software (siliconchip.au/Article/15740), which can interface with SCPI-capable devices. Rigol provides a Programming Guide which outlines the SCPI commands specific to the DHO900 series if you wish to control the DHO924S this way.

Rigol also provides software that can connect to its 'scopes and other

hardware. The Ultra Sigma software can connect to the DHO924S via Ethernet or USB, and has an SCPI Panel Control, which can send commands and read data using the SCPI interface. Screen 9 shows the main window for Ultra Sigma with both the DHO924S and DM858 connected.

Ultra Sigma appears to be only available for Windows, although the web control should work on a browser under most operating systems. We have heard, but it has not been confirmed, that Rigol will release updated PC software later this year.

Overall impressions

With the numerous menu options, it was easy enough to find a specific function and everything feels intuitive. The 'scope feels like it has all the features we might need and probably a few we don't realise we need yet.

All the controls of the DHO924S feel quite snappy and responsive, whether using the knobs and buttons, the touch panel or the web control interface, although the waveforms will freeze while dragging.

We didn't often touch the wrong item on the touch panel, since most objects are quite large, but it happened at times, and felt slightly fiddly. Using a mouse was much more precise, so that is a good option. We mostly used the web controls for much the same reason.

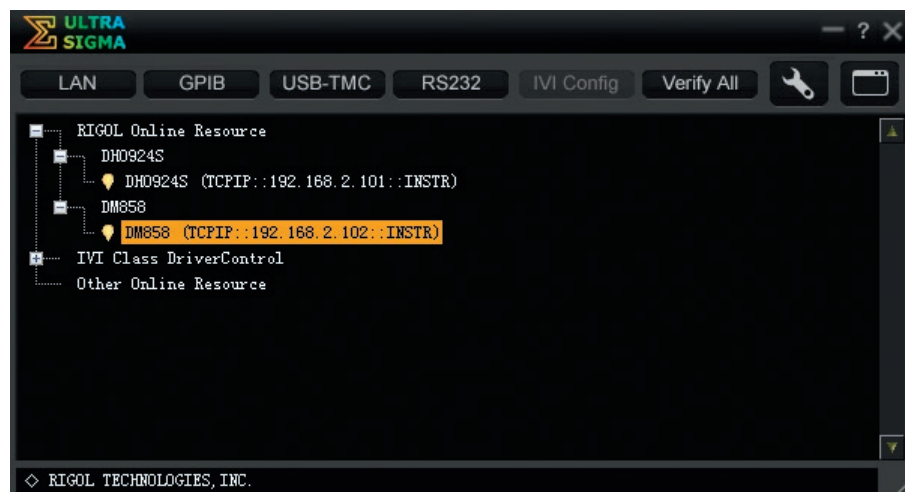
The noise level, bandwidth and number of channels makes this oscilloscope suitable for a wide range of jobs, for which an expensive high-end 'scope would have been required in the not-too-distant past.

Conclusion

If we were looking for a 'scope right now, the DHO924S would definitely be on the shortlist. The web control and Ethernet interfaces make it very easy to capture screen grabs and other waveforms and analyses. It also makes it easy to control the many functions of the 'scope.

The unit is compact and light. It's responsive and intuitive to use, and most of the specifications easily exceed the 'scopes that we currently use.

The DHO924S is available from Emona Instruments for \$1448 + GST: <https://emona.com.au/products/electronic-test-measure/dho-924s.html> 



Screen 9: the Ultra Sigma program can interface with many Rigol instruments. Here, both the DHO924S 'scope and DM858 benchtop multimeter are connected. Ultra Sigma includes an SCPI control panel.

DM858 Digital Multimeter Review

We haven't had much need for a benchtop multimeter, with the handheld variants being sufficient for most purposes. A benchtop multimeter falls between a handheld multimeter and an oscilloscope, including a 5.5 digit display capability and features like those you might normally see on an oscilloscope.

The DM858 comes with a power supply and a pair of CAT II multimeter leads, as well as a pair of alligator clip adaptors that screw onto the ends of the probes. Like the DH0924S, the power supply is a 65W USB-C PD (power delivery) PSU. The DM858 only requires 12V at up to 10W, with our USB-C Power Monitor indicating a typical draw of just 7W.

The back panel connectors are almost the same as the DH0900 series 'scopes, with only the HDMI socket missing. It has a USB-B socket for connection to a computer, and an RJ45 jack for Ethernet. One BNC socket is for an external trigger input, while the other can output a pulse after each measurement. Since it is much the same case, the same 100mm VESA mounts are present.

Apart from the HDMI output, most of the user interfaces are the same as the DH0924S; the Ethernet and USB connections on the back of the unit can be used for remote access. Web Control for the DM858 works similarly, as does access to the SCPI interface over Ethernet.

The front USB-A socket supports a USB flash drive or a mouse, and it has five banana sockets on the front panel, along with the fuse for high-current measurements.

Three of these sockets are used as you might expect, with one common input used in conjunction with another input for high-range current measurements. The third input is used for all other measurements, such as voltage, resistance, capacitance and so forth.

The other two connections can be used for Kelvin (four-wire) resistance measurements. The Kelvin technique is often used to measure low resistance values, since it eliminates contact and lead resistance that might interfere with the measured resistance.

In use

The DM858 takes about a minute to boot up and it then shows a DC voltage reading. The default, slow update rate is easy to follow. There are two faster update rates available.

There are buttons for typical multimeter measurements, such as voltage, current (DC and AC), resistance, continuity, diode, capacitance and frequency; standard operations are fairly obvious. Some features, including four-wire resistance measurement and diode mode, are accessed by pressing the Shift key.

The overall interface is very similar in feel to the DH0924S, with a 7-inch touch panel offering menu items above and below the main display. An 'R' menu in the bottom-left corner offers a range of functions that duplicate some of the controls, besides allowing access to the system controls and settings.

Other features

Despite being labelled a multimeter, the DM858 can display a slow-moving trace, but it's more like a chart recorder than an oscilloscope. The fastest update rate is around 10Hz. There are simple 'Math' functions, such as applying an offset to a reading, as well as statistical results such as minimum, maximum, average and standard deviation. Voltages can be converted to dB values.

The DM858 can also interface to sensors such as thermocouples and thermistors, with several inbuilt probe types and presets being provided. An adjustment for cold junction temperature can be added.

Other custom sensors can be monitored by supplying a list of measured value (resistance, voltage, current etc) and display value (such as temperature) pairs. This makes it possible to set

the meter up as a custom display to suit just about any type of sensor.

Summary

We found the DM858 easy to use. It offers numerous handy features above those of most multimeters. We would make good use of the Web Control interface to allow remote viewing and operation. The DM858 digital multimeter can be purchased from Emona Instruments at: <https://emona.com.au/dm858/dm-858.html>

The DM858 is small enough that it can be mounted using a VESA mount. It also has an Ethernet connection on the rear, as shown in the photo above.



Using the DM858 is easy for anyone who has used a multimeter. The extra banana sockets allow four-wire (Kelvin) resistance measurements.

