

Test&Measurement

YOKOGAWA ◆



# no.5

October 2017

# Test & Measurement magazine

[tmi.yokogawa.com](http://tmi.yokogawa.com)

# ScopeCorders

## Precise data acquisition and analysis

### Colophon

Yokogawa Test & Measurement magazine is published twice a year.

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Printed in The Netherlands 2017.

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By: Clive Davis, Marketing Manager, Yokogawa Europe T&M

Plan B – Assendelft, creative communication.

### 3 Precision measurements in the laboratory and now also in the field

Electrical and electronic design tools attempt to model and predict the behaviour of systems in their working environment. However as systems become ever more complex and the all possible usage scenarios cannot be imagined, the need to test products and systems both in the laboratory and in real world conditions in the field will continue.

When faults are discovered in such things as vehicles and large domestic products, it has been usual to return the product to the laboratory for testing to take advantage of the stable and known characteristics of the measurement equipment and test environment. However it can be difficult to replicate the exact conditions which caused the problems seen in the field.

ScopeCorders are powerful data acquisition recorders which combine features of a multi-channel digital oscilloscope and a high performance oscillographic recorder. As such they can capture and analyse both short term transient events and long-term trends for periods up to 200 days. Using flexible and isolated modular inputs, they combine measurements of electrical signals, physical (sensor) parameters and CAN/LIN/SENT serial bus signals.

With the addition of the DL350 to the ScopeCorder family, we are pleased to be able to bring these high precision measurements into the field using a single portable instrument. This enables comprehensive testing regimes to be conducted in real-world conditions using the same technology used in the development laboratory.

#### Clive Davis

Marketing Manager, Yokogawa Europe T&M





# Complete measurements, complete portability

The Yokogawa DL350 ScopeCorder has been designed to be the most comprehensive, fully portable, measuring instrument available for capturing, displaying, recording and analysing a wide variety of electrical and physical parameters, aligned with the key vertical industries; automotive, electronics, energy, transport and mechatronics.

A key feature of the DL350 ScopeCorder, which is not offered by other portable instruments, is its plug-in modularity. This allows the instrument to be configured to suit a variety of user applications. Whether it's carrying out straightforward, high-precision voltage measurements or handling a blend of signals coming from such things as current probes, temperature sensors, strain gauges, accelerometers and serial buses, the DL350 delivers, without any extra boxes or cables.

Two module slots provide the DL350 with ultimate flexibility and can be populated with any of 18 different types of user-swappable input modules. This means, for example, that four isolated 16-bit voltage inputs can be measured at speeds of one megasample per second (MS/s) alongside 16 temperatures or two separate CAN or LIN buses each containing 60 signals. Changing a single module enables measurement at 100 MS/s with 12 bits and 1 kV of isolation. Meanwhile there are 16 continually accessible logic inputs with even more available by swapping a further module. Amongst other modules available are AC measurements using an RMS module in real time and a mathematics channel for signal processing and analysis after the recording is finished.

The DL350 has a capacity to record up to 5 Gpoints of data per module directly to an SD card which means that the DL350 can be used for continuous recording up to 50 days. Or, it can record up to 100 Mpoints per module of internal memory to capture fast transients in high speed signals – this is up to 10,000 times more than other similar portable devices.



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An 8.4-inch resistive touch screen has been adopted to deliver superior noise-free performance. In environments with the highest levels of electrical noise, such as motors and inverters, measurement precision is maintained whilst enabling the unit to be operated using gloved hands or a stylus.

A ScopeCorder is sometimes referred to as 'the ultimate trigger machine', and the DL350 is no different; it is packed with basic and enhanced triggers. A feature called 'action on trigger' allows the user to leave a DL350 unattended and automatically saves the waveform to a file, or sends an email notification of a trigger event.

The DL350 is based on an A4-sized compact chassis and weighs less than 2.6Kg, excluding battery, and under 4Kg when populated with a battery and 2 x 4 channel modules.

The built-in rechargeable battery provides three hours of continuous operation which, when combined with either mains or 10-30 V DC power, provides the DL350 with a highly reliable power supply making it worry-free.

In addition to being a lightweight portable instrument, the DL350 also provides operating compatibility with its bigger laboratory brother and can share many modules and functions thus preserving the investment in training and equipment, which means engineers will have a familiar tool when going out into the field.

Engineers can now see what precisely happens to systems in the field in a production environment rather than trying to simulate/emulate conditions in the laboratory or to build complex test rigs into development mule vehicles to understand issues and find real performance improvements.

## Laboratory performance in a portable package.

# DL850E ScopeCorder vs. DL350 ScopeCorder

## – How to choose

The DL850E and the compact DL350 are complementary data acquisition, measuring and analysis solutions which provide high levels of precision and accuracy both in the laboratory and in the field.

**Versatility is achieved using** a modular design with slots to accommodate different types of input module, most of which are compatible across the ScopeCorder range. This means that test configurations can be shared between the lab and the field, where a compact battery operated portable instrument is indispensable. So when should an engineer choose a DL850E rather than a DL350?

### Enough memory to capture and diagnose up to 200 days of data

With up to 2 Gpoints of internal memory, the DL850E has more than enough memory to sample a few inputs over long periods of time, or a large number of inputs over a short period at higher sample rates. The Giga Zoom 2 engine seamlessly accesses this memory and enables all ScopeCorders to quickly display and analyse the cause and effect of anomalies using 2 separate zoom windows. The ‘History’ memory in a ScopeCorder is always active and automatically divides the available acquisition memory in up to 1,000 “history memories” in the DL350 and 5,000 in the DL850E, which also offers condition based searches

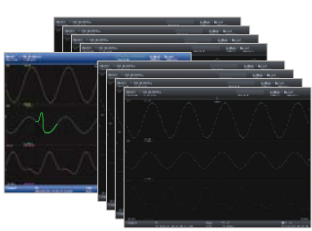


Figure 1: History memory

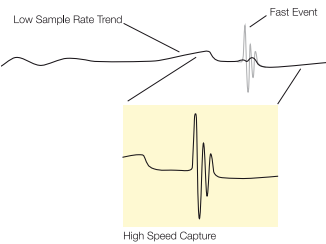


Figure 2: Dual capture

to quickly isolate specific waveforms. The history waveforms can be viewed individually or superimposed in a single screen. The parameters of the history waveforms can be automatically measured and statistically processed to provide a measurement of how captured waveforms vary for each trigger. See figure 1.

### Capture high speed transients during long term recording

When the DL850E is being used for a long term durability test at slower sample rates, the details of high speed events or failures will still be captured. The ScopeCorder’s ‘dual capture’ function allows recording at two different sampling rates, making it possible to set waveform triggers and capture 5000 high-speed transient events at 100 MS/s while at the same time continuously recording a trend measurement at 10 kS/s for 50 hours. See figure 2.

### isoPRO™ isolation ensures precision and accuracy at high voltages

We repeatedly hear from engineers using a ScopeCorder

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that input channel isolation is essential for their measurements. All ScopeCorders benefit from Yokogawa’s isoPRO isolation technology which is key to allowing them to be used to measure multi-phase voltages (up to 1000 VAC rms) and low noise with the highest precision and accuracy at high sample rates (100 MS/s with 12 bits). A great example is the design optimisation of a high-speed inverter. The overall inverter waveforms look similar but the overshoot only becomes apparent by increasing the sample rate from 10 MS/s to 100 Ms/s.

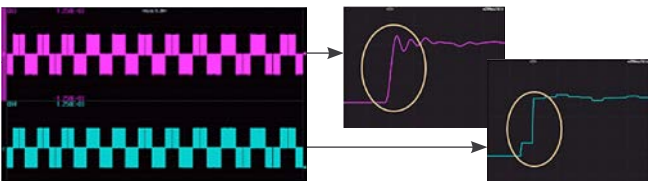


Figure 3: Inverter output waveform. Both waveforms look similar. (left) 100 MS/s waveform (right) 10 MS/s waveform

### A vast suite of user programmable analysis tools

The DL350 provides the capabilities needed in a field tool, such as cursor measurements, automatic parameter measurements, power and harmonics measurements and basic maths computation. Building on these fundamentals, The DL850E also provides unique capabilities to solve the most complex measurement tasks.

#### User define computation (/G2)

This enables waveforms to be calculated and displayed

based on input waveforms and a combination of differentials, integrals, digital filters and a wealth of other functions.

#### Real-time maths (/G3)

Using digital signal processing (DSP), mathematical computations are performed in real-time. This means that the results appear as live traces regardless of the length of the test and the results can also be used as trigger sources.

#### Real-time electrical power measurement (/G5)

The trends of up to 125 types of power related variables for single and multi-phase systems can be derived and displayed. This includes active and reactive power, power factor, integrated power and the ability to show harmonics as bar graphs and vectors.

### Unique benefits for automotive engineers – CAN/LIN & SENT bus monitoring

All ScopeCorders solve the challenge of combining measurements of electrical signals, physical parameters, indicated by on-board sensors, together with CAN bus, LIN bus or SENT data transmitted by the powertrain management system. >>>

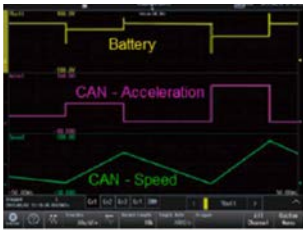


Figure 4: Bus monitoring

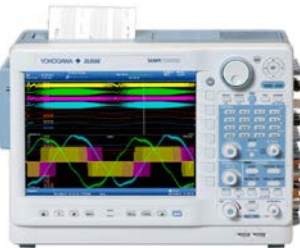


>>> Additionally the GPS unit for the DL350 enables coordinate and time information to be saved and thus correlates the location of the vehicle with the measured signals. For example, the efficiency and performance of an Electric/Hybrid vehicle's drive train can be evaluated under real world conditions. The fluctuation of the input/output voltage of the drive train inverter, and the speed, acceleration and breaking rates from the CAN data can be

simultaneously and continuously captured for up to 2.5 hours at a sample rate of 200 kS/s.

Simply put, the portable DL350 ScopeCorder is more than a test tool and provides the combination of capabilities and precision previously only found in laboratory instruments. The DL850E is the solution for larger channel counts and the most stringent measurement and analysis requirements.

DL850E ScopeCorder  
versus  
DL350 ScopeCorder



DL850E



DL850EV



DL350

| Feature  | DL850E  |                        | DL350   |
|--|---|------------------------|---|
| Main features  | Multi-input, Real time maths, dual capture, bigger memory |                        | Compact size, battery operation, touch screen     |
| Number of module slots                                 | 8   |                        | 2   |
| # Channels   | 128 max. (analogue and/or digital)                        |                        | 32 max. + 16 digital                              |
| Display size   | 10.4"   |                        | 8.4" Resistive touch screen                       |
| Display Resolution                                     | 1024x768  |                        | 800x600   |
| Max. memory size (internal)                            | 2 Gpoints   |                        | 100 Mpoints                                       |
| Max. memory size (external)                            | 20 Gpoints  |                        | 5 Gpoints   |
| External recording media                               | Hard drive  |                        | SD Card   |
| Recording time   | 200 days max.   |                        | 50 days max.                                      |
| History memories                                       | 5000 max.   |                        | 1000 max.   |
| Basic Computation                                      | ■   |                        | ■   |
| Harmonic analysis                                      | ■   |                        | ■   |
| Power measurement                                      | ■   |                        | ■   |
| User defined Computation (/G2 Option)                  | ■   |                        | ■   |
| Real time maths (/G3 Option)                           | ■   |                        | ■   |
| Power MATHS (/G5 Option)                               | ■   |                        | ■   |
| Dual capture   | ■   |                        | ■   |
| GigaZoom2 Engine                                       | ■   |                        | ■   |
| IsoPRO Isolation (high resolution & high sample rates) | ■   |                        | ■   |
| 1000 Vrms (CAT II)                                     | ■   |                        | ■   |
| 600 Vrms (CAT III)                                     | ■   |                        | ■   |
| Weight   | 8.0 kg, including modules                                 |                        | 3.9 kG, including battery and modules             |
| Operating temperature                                  | 5 to 40 Degrees C   |                        | 0 to 45 degrees C                                 |
| Main applications                                      | R&D, laboratory testing                                   |                        | In-vehicle testing, field maintenance             |
| Power supplies   | Mains   | Mains, DC (10 to 18 V) | Rechargeable battery mains adapter DC (10 to 30V) |
| # Supported modules                                    | 17 types  | 20 types               | 18 types  |
| CAN/LIN/SENT Bus monitoring                            | ■   | ■                      | ■   |
| GPS Global timing                                      | ■   | ■                      | ■   |
| GPS Positioning  | ■   | ■                      | ■   |

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# Problem solving with a ScopeCorder

Limitless possibilities



As configurable and programmable standalone products, ScopeCorders occupy a unique segment in the test & measurement market where the capabilities and purpose of most instruments are fixed and normally evident from the name of the product. >>>



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>>> In many applications however, it is the combination of the capabilities of a ScopeCorder which enable the user to solve their measurements and analysis needs, and bring their products to market quicker and more cost effectively.

**Applications in automotive and transportation**

The benefits of the fully portable DL350 are quickly apparent for the road or rail test engineer. With GPS location, serial bus decoding and precision measurements, engineers can evaluate the dynamic behaviour of the complete electromechanical system under real world conditions. In high speed inverter applications, where the performance of such things as multiple SiC power devices need to be measured, the ability of the DL850E to sample at 100 MS/s on up to 16 isolated 12-bit inputs, means that signals can be recorded for long periods, problems detected and the converter system can be tuned to cope with unexpected transient phenomena. Additionally, for Interior permanent magnet (IPM) motors, by using the real-time power calculation capability, the interrelationship between the inverter’s control signals, the motor’s rotation angle and the vibration & torque can be recorded to be able to improve the control and regeneration rates in electric and hybrid vehicles, and maximise the efficiency of their inverter systems.

An example of where real-time maths can be creatively used was in the development and testing of adaptive headlights. Sensors are used to detect the speed of the car, how far the driver has turned the steering wheel and the yaw of the car. This information is then used to turn the headlights so that they remain on the road when driving through bends. By chance, while pursuing a malfunction, some very small glitches were observed in the headlight motor control signals but the trigger of a conventional oscilloscope could not be set due to their very small amplitude. By differentiating the waveform using real-time maths, the glitch became apparent and all occurrences of the glitch could then be captured once a trigger was applied to this calculated waveform.

**Factory maintenance and power line monitoring**

The all-round capabilities of the DL350 mean that it is the go-to instrument for factory maintenance and fault finding. With wave window triggering, harmonics and FFT measurements, it can detect and record sags, surges and interruptions in mains supplies and even send notifications of faults automatically by e-mail. Extending this to larger power systems, a ScopeCorder is capable of detecting bus voltages and ground faults on up to 32 channels and measure

the start-up control timing and performance of back-up power supplies such as generators or UPS systems using both analogue and digital inputs.

Where changes in frequency, for example, also need to be detected, this can be achieved in several different ways. The wave window trigger will detect changes in frequency, as well as voltage, for testing such things as PV Solar inverters. If a frequency module is installed in the ScopeCorder, or real-time maths is used on an AC input waveform, specific values of frequency can be used to trigger the data capture.

**Industrial applications**

An industrial robot is a typical example of a mechatronics application where high speed sampling and the direct connection of accelerometers is needed to be able to analyse the continuously changing acceleration and velocity of the robot arm and all of its joints. These signals can be captured along with the servomotor control signals and built-in tools like automatic parameter measurements

and FFT can then be applied to analyse the control signal timings and vibration.

Paper chart recorders were traditionally used for long term monitoring in environments such as paper or steel mills, where the thickness of the sheet steel or paper needs to be precisely controlled and recorded. A ScopeCorder is an ideal replacement, as not only can it record the thickness of the product, but it can also use pulses from the roller’s

position as the sampling clock. Measurements can thus be more meaningful as they are related to the position of the roller rather than time.

Moreover, by utilising the dual capture capability of a DL850E, the ScopeCorder

can not only record the thickness for weeks or months, where relatively slow sample rates are used, but also trigger and capture the details of faults at much faster sample rates. This enables faults to be analysed along with the long term signals and the causes of faults can be more quickly identified.

**An industrial robot  
is a typical example  
of a mechatronics  
application**



# Complete measurements, inside and out

Software tools complement a ScopeCorder and enable users to remotely control the instrument and analyse their data the in the way that suits them.



These tools include a simple PC data and setup file software for the DL350 and an advanced utility for the DL850E which allows waveform data to be pre-analysed on a PC even while the acquisition is still in progress.

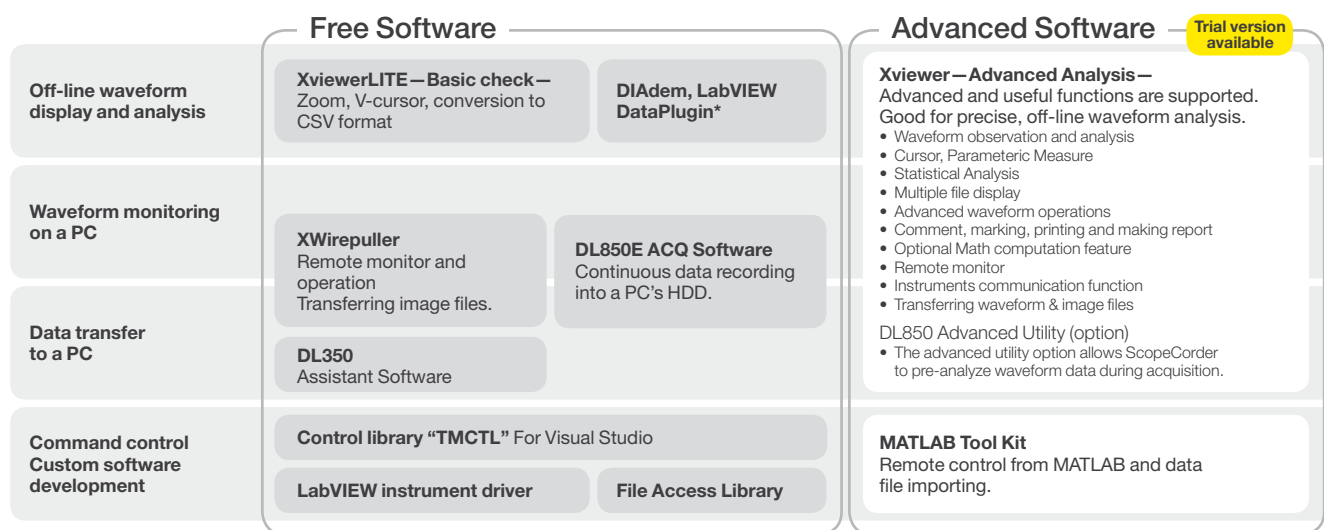
**Support for third party simulation** and analysis software is wide-ranging. Measurement data can be directly saved in MATLAB format and drivers & data plugins for NI Diadem, LabVIEW, FAMOS and DADiSP can be downloaded. A toolkit is also available which enables the ScopeCorder to be remotely controlled from within MATLAB and data files to be imported.

To aid custom software development, a control library and sample programs are available for Visual Studio.

Xviewer is the harmonised Yokogawa software suite for all ScopeCorders. Available in three strengths, from free to the advanced maths computation edition, it enables waveform files to be transferred, viewed, measured and converted, and maths functions such as full FFT and digital filtering to be utilised.

For more information on software on [www.tmi.yokogawa.com](http://www.tmi.yokogawa.com) under products and oscilloscopes

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\*The DataPlugin software can be downloaded from the National Instruments (NI) web site.

## From the archives 30 years ago, the forerunner of the modern ScopeCorder

Weighing just 18 kg, the Model 3655E analysing recorder provided a powerful new concept in waveform measurement and analysis capabilities.

It had four channels for voltage or thermocouple inputs for waveforms up to +/- 60 V. Input signals were digitized at 50 kS/Sec with 14-bit resolution.



There was an easy-to-read 7-inch CRT display, four colour plotter, and a variety of powerful computing functions, including optional FFT analysis. Maximum memory was 32 kwords per channel and a non-volatile 32 kword data memory module using AA batteries was also optional.

At the forefront of digital acquisition technology, the pioneering 3655E was introduced in November 1986 and helped leading companies to dramatically improve the precision in their R&D and testing regimes.