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1. Abstract

From digital home electronics to automobiles, a boom has recently occurred in various industries that use embedded systems in which functionality is achieved through processors and software. Even if the I/O to and from a system is an analog signal such as a sensor or voice transducer, the processor handles the A/D-converted digital signal. In order to debug these types of systems, we are now seeing an increasing need to interpret the digital signals and confirm the corresponding action.

Given this need, we have developed the DLM2000 series of mixed signal oscilloscopes which are compact, lightweight, portrait-shaped (293 mm (H) × 226 mm (W) × 193 mm (D), 4.5 kg, see figure 1) models that inherit the shape of our conventional DL1000 series. The DLM2000 comes standard with 8-bit logic, and offers advanced waveform display performance with waveform analysis functions.

The name “DLM2000” represents the familiar “DL” series plus mixed analog/digital system analysis (a mixed-signal oscilloscope), hence the “M.”

Figure 1 DLM2000

2. Outline

The basic characteristics of the DLM2000 series digital oscilloscopes include a frequency bandwidth of up to 500 MHz, a maximum sampling rate of 2.5 GS/s, and a memory length of up to 125 Mpts.

One of their characteristic functions is the ability to switch one of the analog input channels (CH4) to 8-bit logic input and display the signal. They can be used for either traditional 4-channel analog input, or as a mixed signal oscilloscope with 3 channels of analog and 1 channel of 8-bit logic input. Combinations of 4 analog channels and 8-bit logic can be used as trigger sources.

In the development of these products, we developed a “ScopeCORE™” Engine (figure 2) that integrates the functions of: 1) the signal processing section that generates display data from A/D converted data, calculates various waveforms and parameters, and performs other functions; and 2) the trigger detection section. This gave the DLM a 15% smaller footprint and an 80% reduction in power consumption compared to conventional products.

The signal processing section of the “ScopeCORE™” Engine is based on a proprietary architecture and offers a fast waveform acquisition rate, improved data processing and waveform display performance. It has made possible a mixed signal oscilloscope with brightness gradation and the feel of a portable analog oscilloscope.

Figure 2 ScopeCORE™ chip

3. Characteristic Functions

- **Mixed signal oscilloscope with logic input**

With embedded systems such as in digital home electronics or automobile control, there is an increased demand for digital control + analog waveform observation. Existing 4-channel analog scopes have too few measurement channels to handle certain engineering needs, for example: to connect internaldevice control to an SPI bus (3-wire or 4-wire) and observe the motor drive signal in analog;

or to observe timing between digital control signals and internal analog signals in an automobile ECU.

The DLM2000 series comes standard with 8-bit logic for full support of mixed analog/digital systems.

With the ScopeCORE™ Engine, switching of the analog and logic inputs takes place in the data acquisition section. Because acquired digital data is stored in the analog channel 4 area and flows without distinction from analog data (display data processing is logic-specific), a high waveform acquisition rate is maintained even if logic display is enabled, ensuring that rare events are not missed. (Figure 3)
Likewise, logic waveforms can be displayed (overlaid) without distinction from analog waveforms, therefore you can intuitively recognize the relationship in timing between analog and logic signals.

This shows generation of logic display data. The hardware is designed for a compound display: upper/lower data is generated by detecting H/L for each bit (logic only), and the vertical line area interpolates between peaks in the same manner as with analog display.

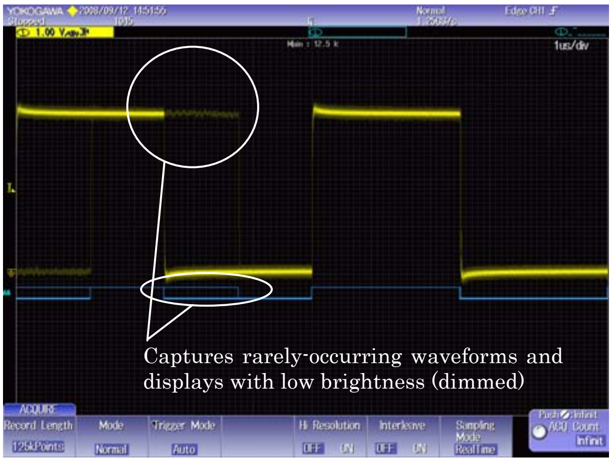
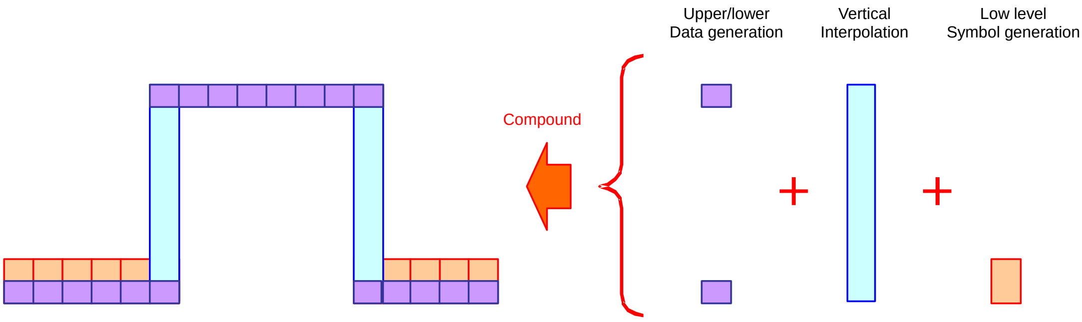
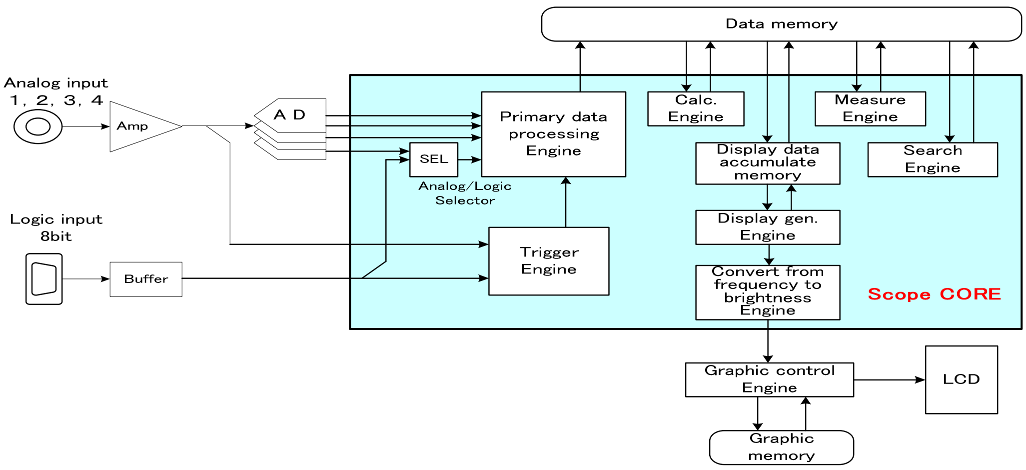


Figure3 Accumulation waveform when logic enabled



Because all analog and logic inputs are connected to the trigger circuit, all trigger combinations are possible regardless of any analog/logic display switching. And with mixed triggers, trigger skews of less than 2 ns are realized between all channels (including logic) and bits.

Shows the ScopeCORE™ Engine block diagram.



Also, with the logic function, you can set thresholds for individual bits when using the newly developed logic probe (model 701989).* This allows observation of both I^2C and SPI bus interfaces that have different levels of 8-bit logic.

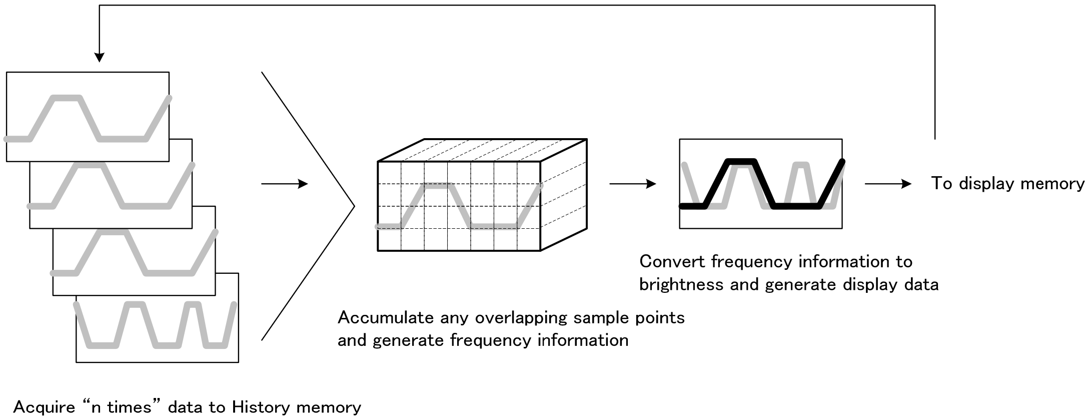
*Logic probe (701989) sold separately.

● Brightness gradation display and History function

In debugging during system design, it is important to confirm rarely occurring phenomena in order to ascertain the circuit operating conditions in a short period of time. To increase the chance of capturing rare phenomena, it is important for engineers to raise data processing performance such as increasing the number of samples handled per second, and to generate images based on as much information as possible, i.e. from large numbers of samples.

With the DLM2000 series, waveform acquisition using the History function is faster. The History function is a proprietary function that sets Yokogawa apart from the competition in that it enables retroactive analysis of past waveforms.

With the ScopeCORE™ Engine, waveforms are no longer acquired in synchronization with the display cycle (60 Hz), but rather data is acquired "n times" to history memory in the primary data processing section asynchronously to the display cycle. The display data generation section generates display data by taking each pixel of n pages of history data and accumulating any overlapping sample points. This accumulated frequency information is converted to brightness and sent to the display memory. The following data acquisition is carried out simultaneously with the sending of the information.



By repeating these processes, waveform acquisition rates of up to 20,000 pages per second can be achieved along with the brightness gradation. (Figure 4)

This shows the relationship between memory length and the maximum waveform acquisition rate.

With a memory length of 1.25 Kpts, 20,000 pages of data are accumulated as history data at the same time as waveform recognition—a very strong point in that offline data analysis can be performed afterward.

Memory length	Max. waveform acq. rate	History pages
1.25 Kpts	20,000 p/s	20,000
12.5 Kpts	8,000 p/s	2,500
125 Kpts	1,000 p/s	250
1.25 Mpts	100 p/s	20
12.5 Mpts	11 p/s	1

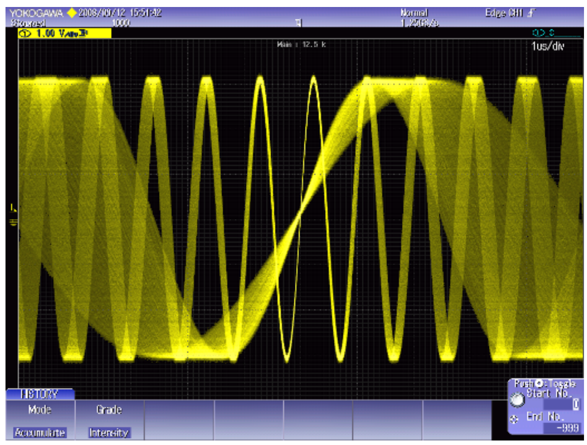


Figure 4 Brightness gradation display

Also, the History function's timestamp information has been enhanced. Previously the resolution of the timestamps of acquired waveforms remaining in history was 10 ms. This meant that for waveforms acquired in a N-Single sequence, the timestamps of several pages of history would be the same. Now, timestamps can be displayed at resolutions as small as 50 ns, in proportion to the sampling rate. (Figure 5)

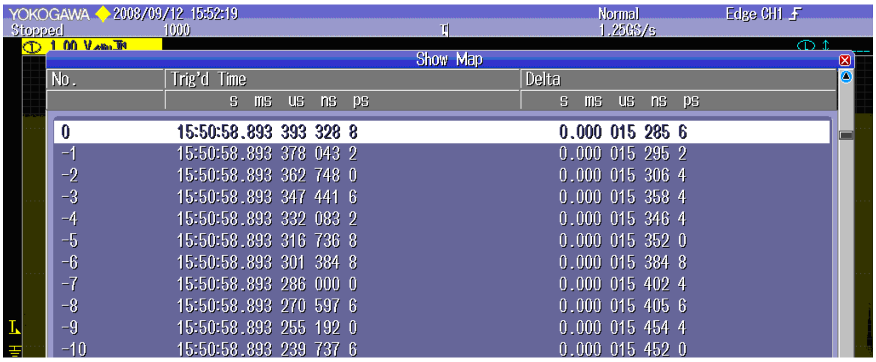


Figure 5 History timestamp screen

By raising the History function's timestamp resolution, time stamping now becomes applicable to observation of ignition pulse waveforms relative to engine RPM. By using the ignition pulse as a trigger condition and accumulating history waveforms, you can deduce the engine RPM—high RPM is indicated if the trigger interval (history timestamp interval) is short, and low RPM is indicated if it is long.

● Long memory support

To make system busses faster, observe power supply fluctuations, and perform other tasks for embedded systems, engineers are calling for long duration waveform observation with the ability to maintain a high sampling rate. Engineers increasingly demand continuous, long-duration capture at high sampling speeds to evaluate communication waveform quality (noise, rise, etc.) such as for in-vehicle electronics, because it requires confirmation of rapidly changing, impossible-to-predict phenomena.

With the DLM2000 series, Yokogawa has achieved a memory length of up to 12.5 Mpts with continuous acquisition. This means that it can perform 500 Kbps CAN (in-vehicle LAN) signal waveform observation at a 2.5 MS/s sampling rate (5 times the bit rate), for 5 seconds of waveform acquisition. (Figure 6)

Figure 6 12.5 Mpts CAN waveform (5 sec. duration) and the Zoom window

Also, the acquisition time range is up to 500 S/s with 5,000 seconds of waveform capture available, allowing observation of—for example—long term changes in power supply voltage.

Single acquisition mode offers a maximum memory length of 125 Mpts. To observe signal operation in detail, one must acquire waveforms at a sampling rate commensurate with single changes. Based on the expression "*sampling rate = memory length / waveform acquisition time*," given the same waveform acquisition time, longer memory lengths allow waveform observation at higher sampling rates.

The ScopeCORE™ Engine provides frustration-free methods for analyzing its long memory. With large amounts of data, it can be difficult to identify information from the main waveform depending on its characteristics. The DLM is equipped with a search engine that offers trigger condition–equivalent searches to derive desired data from embedded waveforms.

Found data can be zoomed in the zoom area. The zoom factor can be set to even higher resolution than T/Div, enabling high resolution viewing of the waveform of interest.

4.Conclusion

The DLM2000 series are mid-range (500 MHz frequency bandwidth, maximum sampling rate of 2.5 GS/s) mixed signal oscilloscopes that come standard with 8-bit logic and offer higher waveform acquisition rates and data processing power—with or without the logic display. Phenomena are intuitively displayed—brightness corresponds to the overlapping of sampling points, and the points are converted to color and displayed on the XGA resolution wide-viewing angle LCD.

Using the compact DLM2000 mixed signal oscilloscope with this superb waveform processing performance raises efficiency substantially, especially in the debugging of embedded systems for digital control in which functions are realized at the software level.

DLM™ [trademark pending]
ScopeCORE™ [trademark pending]