How the Oscilloscope has evolved to meet modern mixed signal challenges

R.Martin – Field Applications Engineer, Yokogawa MTU Ltd

Yokogawa Measurement Technologies Ltd, Solar House, Mercury Park, Wycombe Lane, Wooburn Green, Buckinghamshire, HP10 0HH.

E-mail: richard.martin@uk.yokogawa.com

The modern world of consumer electronics has driven the measurement market to design new, more compact solutions to the needs of today's design engineers. An increased demand for sophisticated designs that combine both analogue and digital technology, driven forward by shorter development cycles, pushes for lower costs and the finite need for low power consumption to meet stricter regulations has pushed the oscilloscope to break new ground.

These new circuits are increasingly complex and have begun to more readily include advanced components, such as CPU's, FPGA's and flash memories, which have pushed modern engineers to debug systems that no longer rely on just digital or analog signalling, but the comparisons between the signals two differing characteristics.

The tools of choice to carry out these debugging and analysis functions have always been an oscilloscope to look into the analog characteristics, and a logic analyser to display the multi-channel logical signals. However, as the logic speeds have increased, and the signal integrity of the digital components have begun to encroach into the analog effects on their signals, a tool has had to be designed that can look at both of the signals environments.

Therefore, the Test and Measurement equipment manufacturers have responded to this demand by creating a device known as a Mixed Signal Oscilloscope or MSO. This device combines both the aspects of a digital oscilloscope for investigating the analog signals, with digital inputs that allow the logical channels, normally put through a separate logic analyser, to be placed through the same device, allowing the engineer to view all the data on the same display.

Early versions of these devices merely allowed the users to view the logical channels individually, not in the groups that the engineers desired. They also didn't allow any real analysis of the digital signals, as the oscilloscopes main focus had always been the analogue arena. Over time, the logical channel number was increased to 16 as a maximum. However the analysis features were not really improved, mainly allowing a user to bunch the logical channels into groups, and decode these as either hexadecimal or a binary data set.

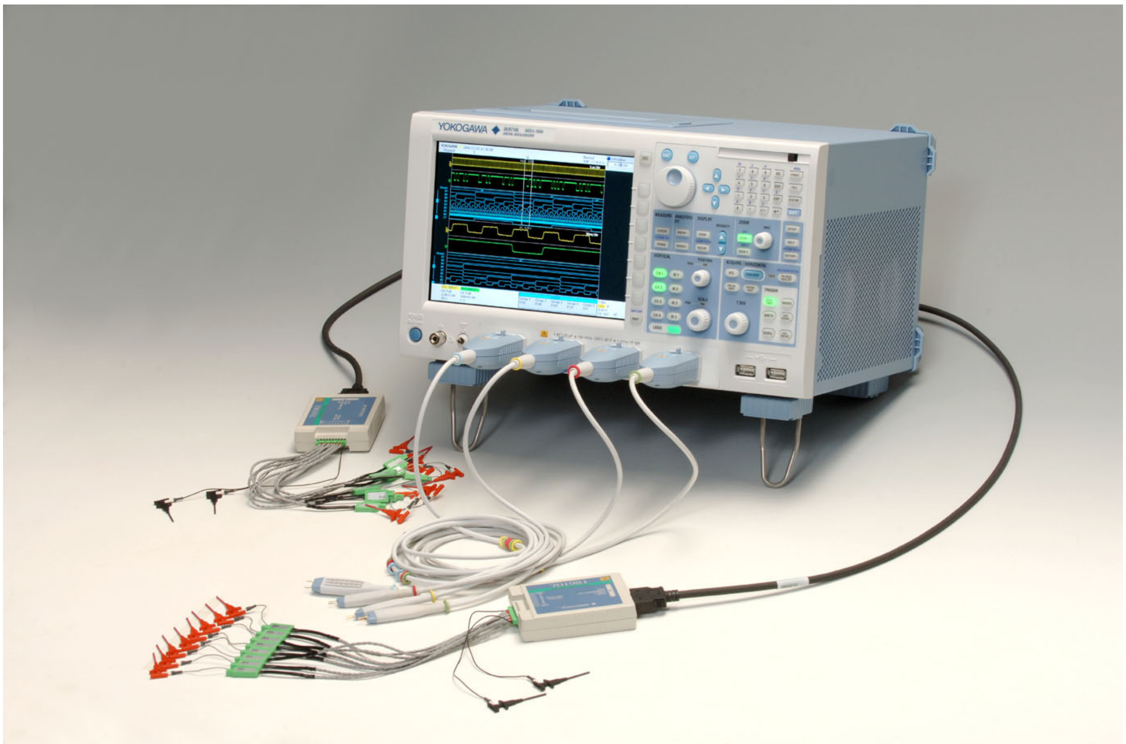

Fig 1. An image of a modern MSO

These instruments have now become insufficient to meet the needs of the modern consumer electronics and automotive markets. The demands for high performance, multimedia applications and the networking environments that they require, means that the current 16 bit embedded processors are rapidly being changed out for newer 32 bit devices. Even domestic appliances, such as washing machines, are moving towards the use of 16 bit processors, meaning that the new generation of the MSO has to be useable by all classes of engineer.

In these circumstances, even 16 bit measurements made by the current MSO's are not enough to analyse both the address and data bus signals, nor to measure the increasing number of IO ports on an embedded processor. These challenges are increased further by engineers who are familiar with modern logic analysers. They have begun to demand that the new generation of MSO is capable of full bus analysis, and state display modes, both staples on logic analysers for a long time, as well as a fast update rate on the logic channels.

These challenges are further increased by the improved resolution of modern analogue to digital, (A-D), and digital to analogue, (D-A) converters. In most cases, new generation video applications require 10-12 bit converters, with audio reaching in excess of 20 bits. Again the current 16 bit MSO models are not capable of analysing the data bus in conjunction with the control bus of the A-D or D-A converter.

These problems are now being addressed by a new generation of oscilloscopes that combine four high bandwidth analogue channels with 32 logical inputs. Unlike the previous generation of Mixed Signal Oscilloscopes, which only offered the limited display characteristics that have been previously mentioned, these new instruments are optimised for the new generation of embedded engineer, who wish to analyse logical signals as well as analog waveforms. They have also been changed to address the needs of engineers who wish to analyse multiple logical busses simultaneously, using bus display, state display, zooming, multiple triggering settings and powerful digital-analog conversions on logical signals.

Fig 2. Display showing a single analog channel monitoring a FlexRay bus, while a bundled logic bus is being zoomed in on.

To fully analyse modern embedded systems, an oscilloscope requires a fast acquisition update rate. Some modern devices can have an update rate of greater than 25,000 waveforms per second. Some modern devices also have a method of saving acquired waveforms into a temporary ‘History’ Memory. This allows a user to display previously captured screens, up to 2000 in some cases. This in turn allows a user to better understand signal behaviour, as it no longer relies on what you can see at that instant.

Other features that are finding their way into modern MSO’s include the ability to search these temporary acquisition memories, and then when the correct one is found, zoom in and observe the waveform in detail. In addition to being able to search the waveform on simple parameters, such as edges, pulse widths or a multi-channel state, the memory can be searched by serial or parallel waveform patterns and parameters. This functionality has allowed users to quickly and efficiently find the waveforms they are looking for in the memory, then analyse them in an enlarged area, scrolling the zoomed data if required.

As the oscilloscope evolves, more powerful triggering capabilities are required to deal with the complex signals being read by the device. These triggers are no longer restricted to the analogue channels though, as most new devices can use their logical inputs as the source for the trigger, even allowing the logical signals to be the source of complex bus triggers, such as CAN, LIN, I^2C and SPI. These enhanced triggering capabilities have made it possible for the analogue channels to be used for other signals that the logical inputs cannot handle, such as current, through the use of current clamps, and higher voltage inputs.

As well as being able to trigger on these more complex bus signals, the modern oscilloscope can also perform decoding functions, allowing an engineer to look at the information being carried by the waveforms, without having to remove it to an external program. This quick and easy decode system can save an engineer time, and with oscilloscopes becoming cheaper all the time, resources as well. Some modern MSO's can actually decode two buses simultaneously, further improving the Engineers efficiency.

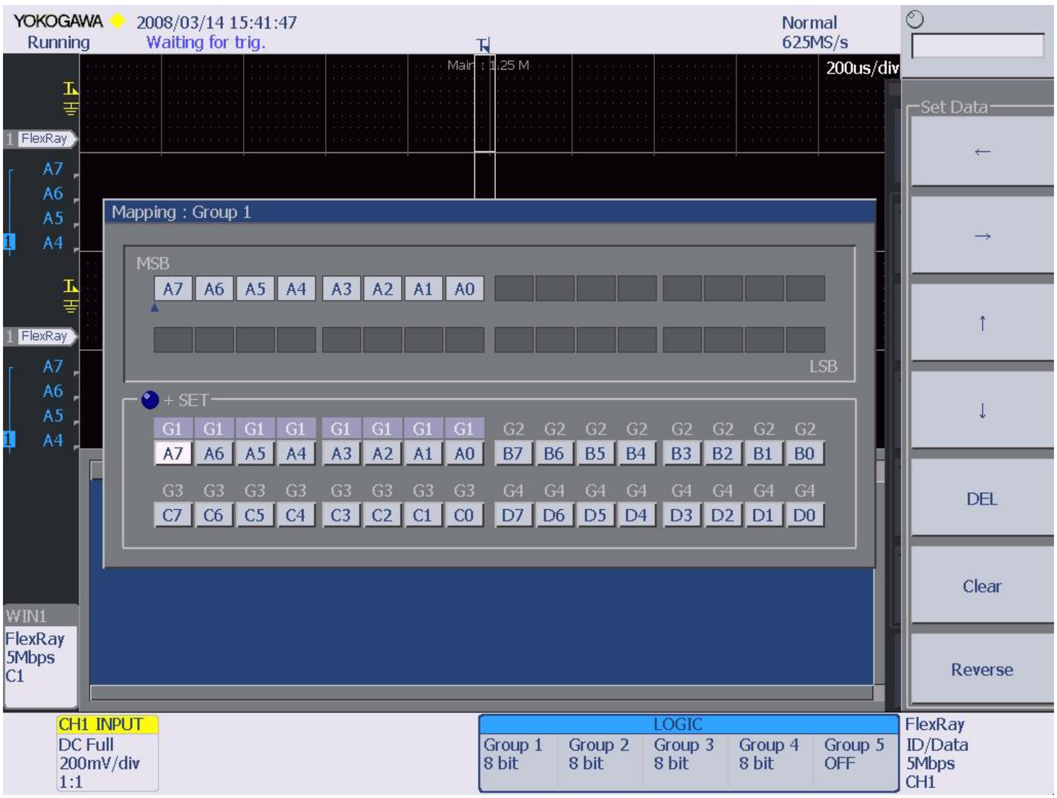

Fig 3. A group mapping screen. This system allows the engineer to quickly assign logical bits into areas of interest, e.g. an address or data bus.

In addition to the analogue channels new functions, the Logical side has been improved as well. Instead of just displaying these inputs, modern MSO's can group the logical channels into simple bundles, allowing the user to decide how they want their channels displayed. These groups can be named, even down to the individual bit level, allowing the user to see basic information at a glance. These groups can be easily manipulated, and analysis features, such as bus display, state display and digital to analogue conversions.

Another key area of the modern Oscilloscope that has been improved is the automated measurement functions. The ability to have your MSO perform measurement instantaneously that would take more time by hand is a real benefit. Parameters such as Maximum and Minimum voltage levels, peak to peak, pulse width, period, frequency, rise-time and fall time can all be quoted by the MSO instantly, over multiple cycles on one acquisition, or over multiple acquisitions. These measurements are no longer limited to the analogue channels, as the logical systems are now capable of being analysed, even down to the bit level.

These automated measurements can also be extended into other current test and measurement applications. Eye-Pattern analysis is essential for evaluating the signal integrity of data communications, which can now be completed using the mask analysis functions. The ability to calculate parameters based on the eye pattern formed by crossing two or more waveforms can provide additional insight to the engineers. These same waveform analysis features can also prove invaluable for tests on power supplies, particularly in the light of more complex and strict compliance regulations for power quality and harmonic behaviour as laid down in IEC61000-3-2.

Conclusion: With the increasing complexity of modern embedded systems, the need for a comprehensive solution for the engineers designing these systems has become a top concern for the test and measurement industry. With the new range of integrated measurement and analysis capabilities now available in the mixed signal oscilloscope, and the increasing numbers of embedded designers in the industry, an MSO is likely to become the test and measurement of choice for many.