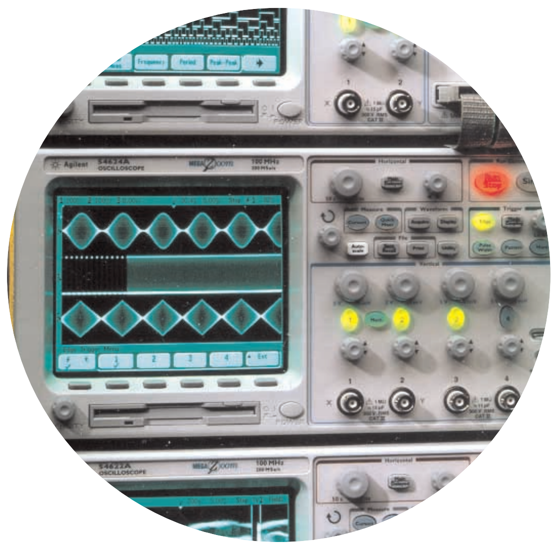
54622D

Agilent Debugging Modern Power Electronics: Seeing the Whole Picture

Application Note 1350



Today's world of digital-to-analog converters, analog-to-digital converters, digital signal processors (DSPs) and microcontrollers has dramatically changed the measurement needs of engineers debugging power electronics.

A brushless DC motor is one example of a modern complex power electronics system, with sensors, digital signal processing functionality and power transistors, in addition to the standard motor components. While the brushless motor is faster, more powerful and reliable than a conventional DC motor, the complex interactions in this system can pose difficulties in determining the root cause of a problem. Specifically, two major debugging problems arise. It is often difficult to capture enough channels simultaneously and second, the analog and digital sides are often operating at drastically different speeds.

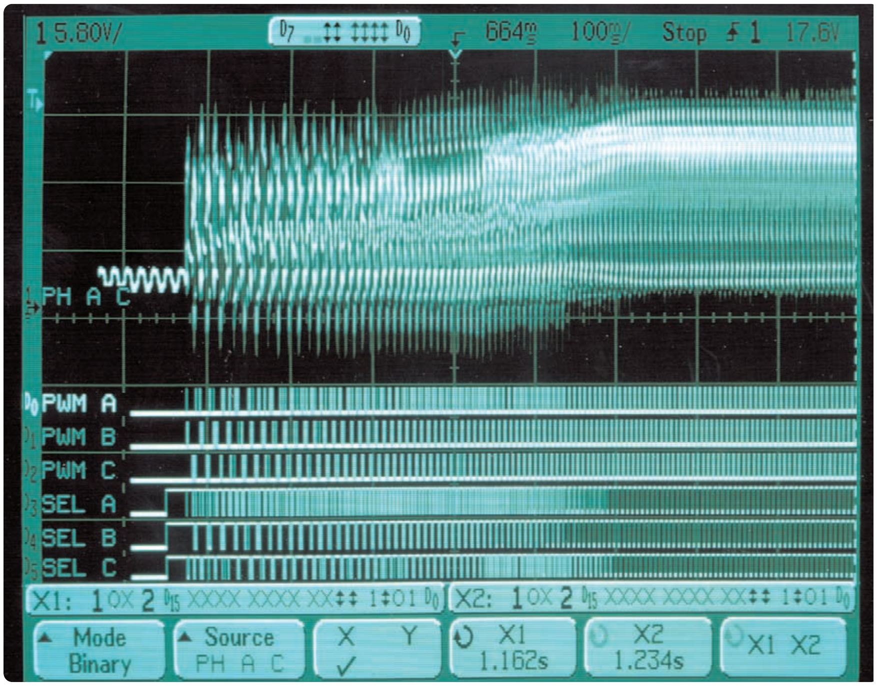


Figure 2. Shows the start-up of the motor

The PWM's duty cycle increases or decreases to accelerate or decelerate the motor. The position and speed of the rotor is sensed by three hall effect sensors. The sensors complete the feedback loop so that the motor can be driven at a constant velocity even as the load changes.

While the combination of analog and digital signals captured by the Agilent 54622D allows more of a circuit's overall behavior to be easily seen, capturing analog and digital signals simultaneously is only half the battle. The second half is capturing both the slow analog and fast digital signals with enough detail to accurately analyze the motor's performance.

Figure 2 shows the start-up of the motor. Channel 1 (labeled PH AC) displays the voltage applied to one phase. Digital channels D0 through D5 display the signals that are controlling whichever of the motor's three phases is being pulled high (labeled SEL A, B, and C) or low (labeled PWM A, B and C) at any one time.

The sequence is captured at 100 ms per division, and the total acquisition time is one second. The motor takes over 600 ms to come up to speed; in the same time period, the digital signals of the 25-KHz pulse width modulators (PWMs) have gone through roughly 17,000 pulses.

The amount of memory required to see the whole picture can be obtained by dividing the longest time interval of interest by the shortest. In the above example, the longest time interval is one second. But what is the shortest? The PWMs are running at 25 kHz, and their period is 40 µs. For debug purposes, it may be a good move to observe the width of the pulses with 1 us accuracy. Therefore, the number of samples required to observe the power-up sequence in adequate detail is 1s divided by 1 µs, or 1 million samples. In essence, it takes one million samples to acquire for 1 second at 1 MSa/s. While most modern digital scopes have maximum sample rates far in excess of 1 MSs/s, many do not have more than a few thousand samples of memory. And it is sample memory size rather than maximum sample rate that is essential for capturing the whole picture when debugging mixed slow analog and fast digital systems.

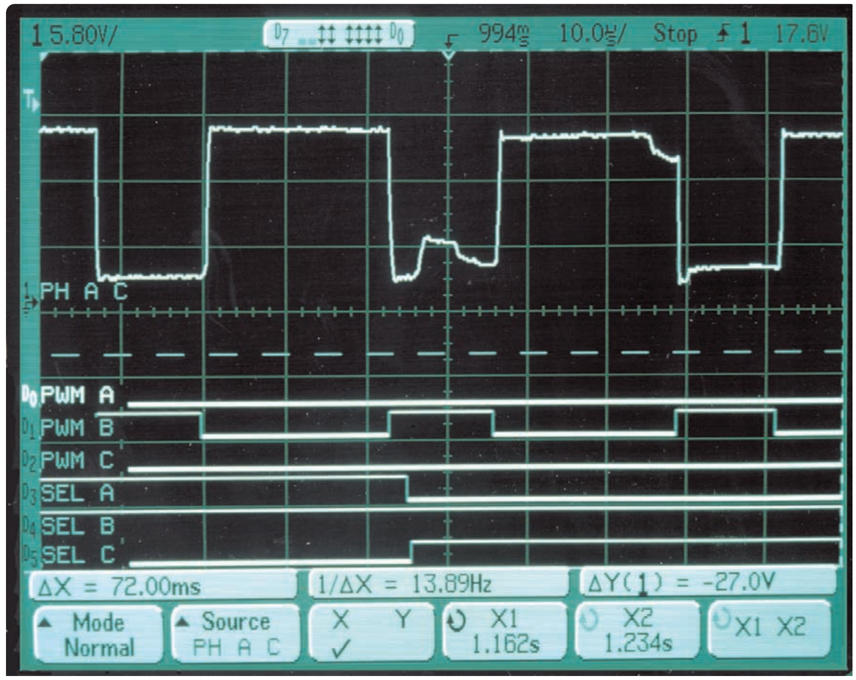


Figure 3. Shows a portion of the same one-second record

Figure 2 shows the same one-second record zoomed to 10µs/div, where individual cycles of the PWM are identifiable and measurable. Figure 3 is zoomed in by a factor of 10,000 from Figure 1.

With the Agilent 54622D's two megabytes of memory, it is possible to zoom in on every single PWM pulse beginning when the power supply first starts to come up to when the motor has reached its final speed -- without having to reacquire or retrigger the scope.

Agilent's 54622D mixed-signal oscilloscope's (MSO) combination of analog and digital channels matched with a large sample, deep-memory capability makes it quick and easy to see the whole picture when debugging modern power electronics. It is especially invaluable when tracking tricky intermittent problems caused by load and temperature variations, or hardware/software interactions.

Figure 4. Five models to satisfy your bandwidth channel count & budget need

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Model Number	Bandwidth	Sample Rate	Channel Count	Memory Depth	Price
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54621D	60 MHz	200 MSa/s	2 + 16	2 MB/ch	$3,995
54622A	100 MHz	200 MSa/s	2	2 MB/ch	$3,295
54622D	100 MHz	200 MSa/s	2 + 16	2 MB/ch	$4,995
54624A	100 MHz	200 MSa/s	4	2 MB/ch	$4,995

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