Keysight Technologies
How Product Innovation Happens: Customer Frustrations Spark Oscilloscope Triggering Idea

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Scott Genther
Key inventor of Agilent Zone Trigger

How Product Innovation Happens:
The Origin of Agilent's Oscilloscope Trigger

Engineers who use oscilloscopes are typically focused on solving problems and looking for ways to make better products. It turns out that engineers who design oscilloscopes are essentially doing the same thing.

More than a decade ago, an Agilent Technologies oscilloscope designer named Scott Genther was getting ready to launch a massive, multiyear project to design a new chip for an advanced algorithmic oscilloscope trigger—affectionately known in the Agilent R&D lab as the "nerd trigger." Before the project even got off the ground, he came up with a remarkably simple idea for a trigger that ultimately redefined how engineers use Agilent oscilloscopes.

Where do innovative ideas like Genther's come from? And how do you get from the original spark of inspiration to its implementation in an innovative product? Genther's story sheds light on how product innovations happen.

CONNECTING WITH CUSTOMER FRUSTRATIONS

In a quest to define the features he needed to include in his trigger ASIC, Genther visited oscilloscope customers to understand how they used triggering and what stumbling blocks they faced. "In the lab here at Agilent, R&D engineers know how to use all the triggers on their scopes," said Genther. "But I quickly discovered our customers don't. They don't like thinking about triggers. A lot of customers just pick a mode and turn the knob to clean up the display. They don't have time to sit down and think about it."

The first customer Genther visited was having trouble defining a trigger to capture the clock edge reads he wanted to see. In frustration, he jabbed a finger at the screen and wondered why he couldn't just click on a piece of a waveform and get what he wanted. At the time, Genther just assumed it was impossible.

The second customer Genther visited had come back from lunch and discovered a bad trace on his oscilloscope screen. The scope's infinite persistence showed him something had happened when he was away. To figure out what caused it, he wanted to get a view of the trace by itself so he could correlate it to activity on other channels.

The customer had been doing single-shot acquisitions for days trying to locate the infrequently occurring glitch. He pushed the "single" button over and over and still couldn't locate the problem. Watching the engineer laboriously pecking away at the button, Genther experienced his big "aha" moment. He could see that pressing the "single" button a million times is a painful way to find a one-in-a-million glitch, and he realized he could make both customers' jobs easier using Agilent's existing oscilloscope technology.

"The nerd trigger was going to take forever to complete, but I figured we could create very similar functionality using the scope's mask test infrastructure," Genther said. "We could qualify acquisitions with mask testing and use that feature to push the button for him."

Mask testing shows all the waveforms that fail or exceed the limits of the mask. Genther's brainstorm was to ignore all the waveforms that fail and just display the ones that do meet the mask limits. This process could happen behind the scenes, using digital technology to accomplish what the customer was doing manually.

CHAMPIONING THE IDEA

Coming up with the idea to use a reverse mask test to achieve an easier version of the trigger was just the first step in the process of bringing it to market. Next, Genther had to convince his boss and teammates the project was worth pursuing.

Figure 1: Example of a hard-to-capture signal anomaly with infinite persistence turned on

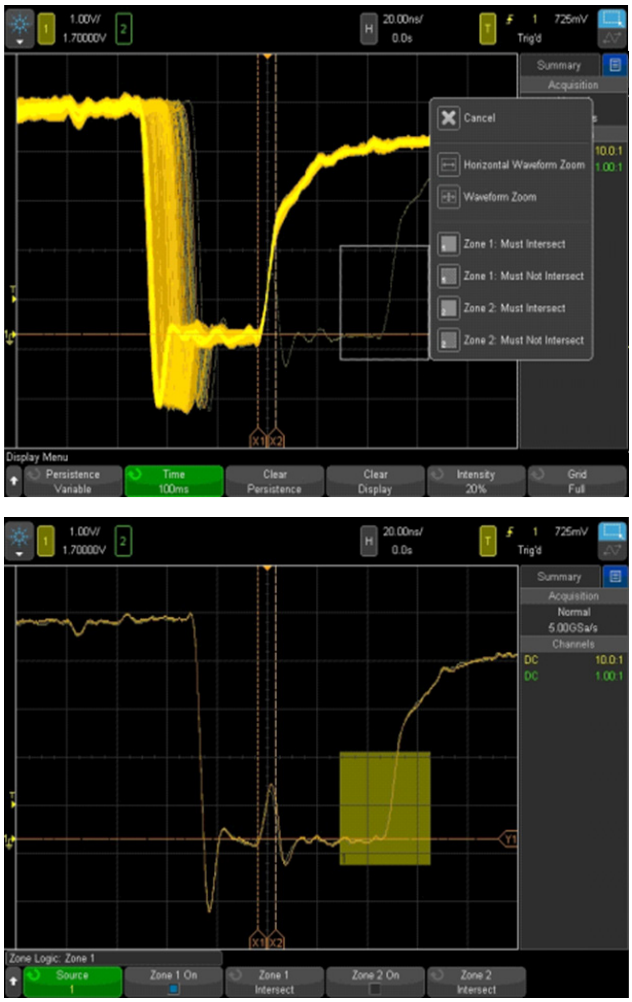

Figure 2 & 3 Demonstrate how thw zone trigger was eventually implemented with a touch screen. Touch the signal of interest and then select must intersect - the scope then displays only the signal of interest.

He got software designers and hardware designers together in the same room and lobbied for his idea. He stressed that the new feature required no new technology to be developed. "We already had the infrastructure in place for qualified triggers, so I had to convince the team we could use that infrastructure to address a user-interface problem," said Genther.

The breakthrough came when one of the software developers on his team agreed to create a mockup of the zone trigger.

Genther was doing some troubleshooting, looking for bad signals on a bus, when the software developer brought the completed mockup to his desk. "I used it on the spot," he said. "It was clear to me this was going to be a useful feature."

"Once you have a mockup, it is an easier sell than if you are just trying to sell an idea," said Genther. "You can say, 'Come on over here and take a look,' and immediately show it to your boss or teammates."

At the last minute, the team agreed to use the new feature in the original release of the InfiniiScan event identification software package for Agilent DSO80000B Series Infiniium oscilloscopes, introduced in February 2006. The software is designed to help engineers identify signal integrity issues in their electronic designs more easily.

Before the feature could be released, the team had to figure out what to call it. "We had a huge debate about whether it was OK to call it a trigger," said Genther. "Technically, it is a mask, not a trigger, and we didn't want to confuse customers."

The team did some research and discovered that most engineers think of triggers as "anything that gives them the picture they want." The team ultimately decided to call it a software trigger. "It ended up being the star feature of the InfiniiScan software package," Genther said.

MOVING BEYOND SOFTWARE

The software trigger's success as part of the InfiniiScan package made the next step easy: incorporating the feature directly in an oscilloscope. When the scope designers were defining the high-performance Infiniium 90000 Series oscilloscopes, the team didn't hesitate to include it. In fact, this technology enabled the world's first three-stage triggering system, where the first two stages are hardware-based triggers and the third stage is a software trigger.

At that point, advanced trigger features in general, and the software trigger in particular, were incorporated only in high-end oscilloscopes.

Several years later, Agilent's oscilloscope team designed a new chip that dramatically changed

the game by allowing engineers to control and use a scope's features via a capacitive touch screen. Shown in Figure 4 the new "MegaZoom IV" chip enabled scopes with extremely fast update rates -- a million waveforms per second – and it implemented mask test and Genther's inverse mask test, rebranded as InfiniiScan Zone triggering, as hardware features. Implementing the zone triggering functionality using high-speed digital ASIC hardware made it much faster. It could capture 1,000,000 waveforms per second, which made it much more likely that engineers would be able to see the glitch or anomaly they were looking for. The InfiniiScan Zone trigger, even when it is implemented in hardware, can produce the signal of interest only as fast as the oscilloscope can capture it.

The chip made its debut in the InfiniiVision 4000 X-Series oscilloscopes, introduced November 13, 2012, and it revolutionized how engineers use oscilloscopes. The combination of the capacitive touch screen capability and the hardware-based InfiniiScan Zone trigger makes it easy to trigger on signals by drawing a box around the ones of interest. The 4000 X-Series oscilloscope then creates the trigger based on the mask.

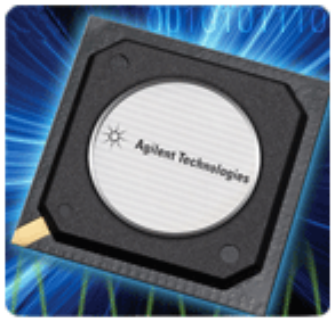

Figure 4: Agilent MegaZoom IV" chip

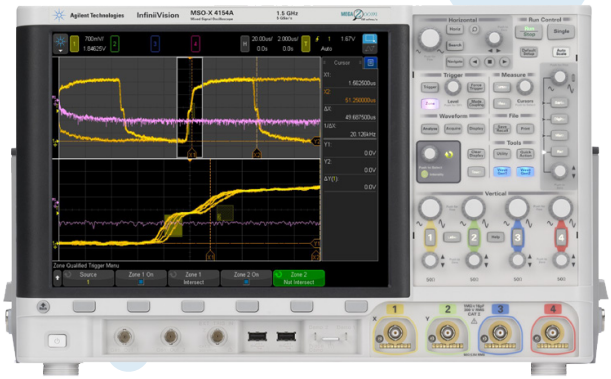

Figure 5: InfiniiVision 4000 X-Series Oscilloscope

"It would be very clumsy to try to draw a box by turning knobs and pushing buttons," Genther said. "With the touch screen, if you can see it, you can trigger on it simply by pointing at it- exactly what the engineer from my original customer visit was asking for. Using this method, you can easily isolate things you see only infrequently.

It is the combination of these features that sets the InfiniiVision 4000 X-Series apart. The hardware-based InfiniiScan Zone trigger and capacitive touch screen are the most obvious innovations, but without the fast update rate of the MegaZoom IV ASIC, you wouldn't even know the infrequent events are there.

"Any engineer who does digital design will appreciate the InfiniiScan Zone touch trigger," said Genther. "The classic case is working on memory devices. You have a clock, and you have reads and writes on top of each other. It is a mess. The bus goes one way with the reads and the other way with the writes, and the timing is completely different. You are probing the bus and seeing both. So you draw a box around something that happens only with the writes, and boom—you have just the writes."

MEANINGFUL INNOVATIONS

The most important product innovations happen when designers respond to customer frustrations and work toward ways to help them solve their problems more easily.

"With zone triggering, it was like figuring out we could slice the bread before we sell it to customers so they don't have to slice it themselves," said Genther. "The whole thing was about the user interface. The result is that customers no longer have to think about how to set up an oscilloscope trigger."

Combing the trigger innovation with the MegaZoom IV chip takes it to the next level. Now Agilent's customers can see their glitches and trigger on them without needing to understand nerdy triggering concepts.