

An Oscilloscope-Like Logic Timing Analyzer

Market research indicated that some customers doing embedded development preferred to work with oscilloscopes instead of standard logic analyzers. The HP 54620 logic timing analyzer offers many oscilloscope features, including direct-access controls, a highly interactive display, computed measurements, delayed sweep, simplified triggering, and a trace labelmaker.

by **Steven B. Warntjes**

The principal contributions of the HP 54620 logic timing analyzer (Fig. 1) are not in its performance specifications but instead in its user interface, optimized feature set, and price. These are significant contributions, as evidenced by the HP 54620's receiving the *Test & Measurement World Best in Test Award* for 1995. Market research for the HP 54620 indicated that some customers doing embedded development work were frustrated with the cost and complexity of standard logic analyzers and preferred instead to work with oscilloscopes. The HP 54620 bridges the gap between standard logic analyzers and oscilloscopes by providing the functionality of a timing analyzer and the usability advantages of an analog oscilloscope.



Fig. 1. The HP 54620 16-channel logic timing analyzer bridges the gap between standard logic analyzers and oscilloscopes by providing the functionality of a timing analyzer and the usability advantages of an analog oscilloscope.

Product Description

The HP 54620 is best described as 16-channel timing analyzer. Each timing analyzer channel has one bit of vertical resolution indicating either a logic high level or a logic low level based on a user-selectable voltage threshold. The HP 54620 leverages HP second-generation logic-analyzer-on-a-chip technology to provide 500-MSa/s or 2-ns timing analysis on all 16 channels simultaneously. This acquisition engine and a custom display processor produce oscilloscope-like, high-throughput displays. Monochrome (HP 54620A) and color (HP 54620C) display versions are available.

The HP 54620 leverages the CPU system and the mechanical design of the HP 54600 Series oscilloscopes for front-panel responsiveness and small form factor. The HP 54620 is positioned as a companion to the user's oscilloscope and therefore has the ability to be triggered from another instrument (trigger in) and to trigger another instrument (trigger out).

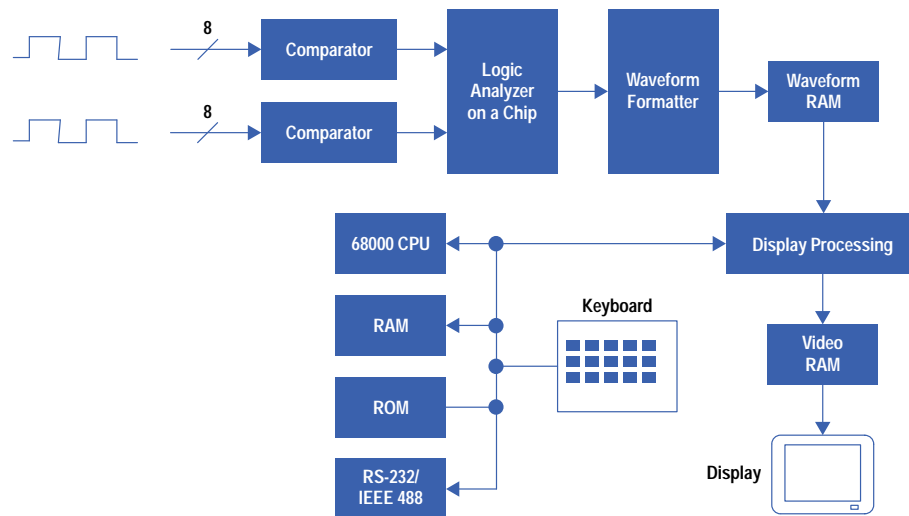


Fig. 2. The HP 54620's multiprocessor architecture yields a highly interactive display that updates the screen about 16 times per second as a result of parallel processing and acquisition of the waveform data.

User Interface Oscilloscope Similarities

Most oscilloscope users will tell you that their oscilloscope is relatively easy to use. While some oscilloscopes are more user-friendly than others, the general feeling is that oscilloscopes are easier to use than logic analyzers. The primary reasons are twofold. First, oscilloscopes usually have direct-access controls, something not always true of logic analyzers. Second, oscilloscope displays are highly interactive because of their fast screen update rates. After all, they are primarily waveform viewing tools, and they feel very responsive. The HP 54620 leverages these two oscilloscope ease-of-use attributes and adds some standard oscilloscope features, previously unavailable in logic analyzers, that make the HP 54620 feel and run like an oscilloscope. The project design goal statement was, "Any user who can use an analog oscilloscope should quickly be able to use this new class of logic analyzer."

Direct-access control of instruments means that the most common controls are available on the front panel, through dedicated knobs or buttons. With an oscilloscope, the user often reaches up to expand or contract the time window, often without thinking. This intuitive control is beneficial because it allows the user to concentrate on the problem at hand and not worry about running the test instrument. The front panel of the HP 54620, shown in Fig. 1, has direct controls for time per division, waveform position, and time base delay. Instruments that contain several layers of menus under each front panel key can often confuse the user. The HP 54620 addresses this concern by keeping most menus to a single level under a given front panel key, allowing the user more direct control of the instrument.

The ability to display unexpected or undesired waveform conditions with a highly interactive display often leads the troubleshooter to a quicker solution of the circuit problem. Instrument displays with fast update rates seldom miss infrequent or random events. If the update rate is slow, say less than five updates per second, the instrument can fail to capture important waveform events because it is processing and not acquiring data when they occur. The HP 54620's multiprocessor architecture (Fig. 2) yields a highly interactive display that updates the screen about 16 times per second as a result of parallel processing of the waveform data.

An important element of oscilloscope operation is how responsive it is to control changes. After a control such as the time per division is changed, the instrument should respond quickly to prevent user confusion. The multiprocessor architecture of the HP 54620 helps address instrument responsiveness.

To make the HP 54620 feel and run like a oscilloscope it was necessary to add a number of features that are standard in digital oscilloscopes. One of the advantages that digital oscilloscopes have over analog oscilloscopes and traditional logic

analyzers is the ability to do automatic measurements such as signal frequency, period, duty cycle, and so on. Since the waveforms are stored in memory, the oscilloscope can postprocess the waveform to determine the frequency of the stored signal. Oscilloscope users have come to expect these measurements in digital oscilloscopes. Consequently, automatic measurements for frequency, period, duty cycle, positive width, and negative width are implemented in the HP 54620.

Delayed sweep capability is considered standard in the minds of some digital oscilloscope users and therefore is implemented in the HP 54620. Delayed sweep is the ability to split the instrument screen horizontally to show the waveform at two different time-per-division settings concurrently. Delayed sweep is valuable because of the additional insight that is often gained from the ability to see the waveform at different levels of abstraction. Fig. 3 shows many cycles of a pulse train in the main window with a specific cycle demonstrating an error in the delayed window. In this case the ability to view the big picture along with specific “little picture” detail gives additional information about the waveforms under test.

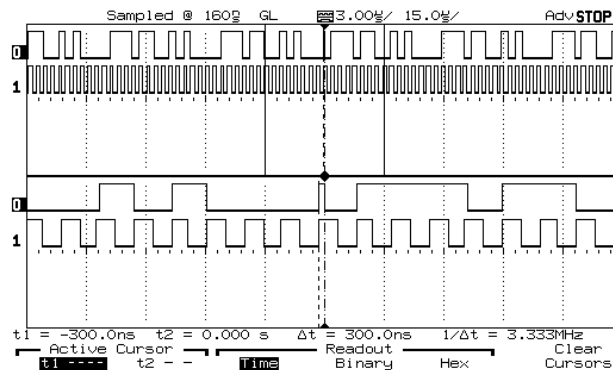


Fig. 3. The main window shows many cycles of a pulse train while the delayed sweep window shows a specific cycle demonstrating an error.

Just Enough Features

When deciding on the feature set of an instrument that is supposed to be easy to use, the team faces a dilemma. Too many features make the instrument hard to use because each additional feature adds more controls. On the other hand, too few features dictate that just when progress is being made the instrument’s reduced capability becomes an obstacle. The optimum point strikes a balance between features and user interface complexity. The design goal in the HP 54620 was “just enough features—an easy-to-use instrument with the capability I need to do my job the majority of the time.”

The best example of just enough features in the HP 54620 is in the area of triggering. The extent of trigger functionality in traditional logic analyzers is broad. Triggering capability ranges from the most basic edge on a single channel to the ability to have up to ten sequence levels in a user-definable state machine using pattern recognizers, range recognizers, timers, and event counters. Conversely, the most basic triggering available and sometimes the only triggering available on oscilloscopes is the ability to trigger on a rising or falling edge at a given voltage on a specific channel. The HP 54620 needed to find a balance between a logic analyzer and an oscilloscope since it is supposed to be an oscilloscope-like logic analyzer. The design team did several rounds of customer visits to understand the target customers, their needs, and their frustrations with traditional logic analyzers before finally arriving at the triggering feature set.

The design team broke the triggering down into three broad categories. First and simplest is edge triggering. This is the logic analyzer version of basic oscilloscope edge triggering. In this category the user selects a channel and an edge polarity. No voltage value is set because it is implied in the logic threshold.

The second category is simple pattern. Simple pattern triggering is defined as highs, lows, and don’t cares specified across the input channels. The analyzer triggers when the specified pattern occurs. Optionally, this simple pattern can be combined with a rising or falling edge on a single channel. This optional edge gives the user the ability to qualify the specified input pattern.

The HP 54620 use model called for users to use edge or simple pattern triggering, or both, 80% of the time. Therefore, these trigger categories are accessible through buttons on the front panel. The user switches trigger category by simply pressing the front-panel key.

The third category of triggering is advanced. This category of triggering is in place for the 20% of the time when edge or simple pattern is not powerful enough. In just-enough-features thinking, the added capability of advanced triggering ensures that the instrument is not underpowered. The advanced triggering feature set is best described by the overview screen shown in Fig. 4. Advanced triggering consists of two pattern and two edge resources that can be combined with the logical operators such as AND, OR, and THEN. In addition, pattern duration and edge occurrence triggers are available. While this advanced triggering capability is far below that provided by the most powerful logic analyzers, customer research showed that this feature set would be acceptable in the majority of situations.

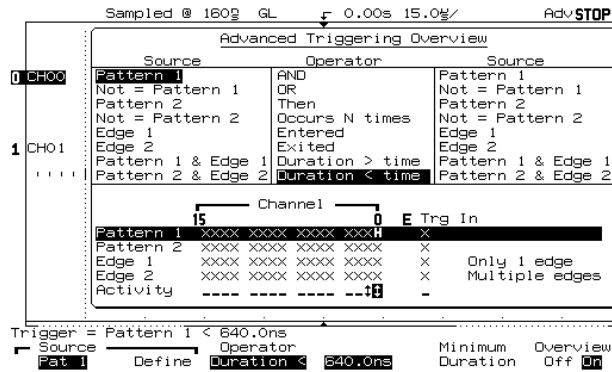


Fig. 4. The advanced triggering feature set is described by the overview screen.

Doing the Right Thing

Customer research on waveform viewing tools indicates that these tools are used for bursts of activity separated by weeks or months of inactivity. This leads to customers relearning the tools for each burst of activity. “Doing the right thing” is an attempt at reducing or eliminating the relearn time. Research has shown that when an interface control does what the user expects, it need not be explicitly remembered. Instead, users remember or attempt to remember controls that are exceptions to what they expect. Unfortunately, user interface exceptions are often forgotten and sometimes remembered incorrectly, resulting in frustrated users who can’t get the instrument to do what they want. Doing the right thing means the instrument responds as expected, perhaps even delighting the user by doing exactly what the user had in mind in a given context.

HP 54620 customer research also determined that users need to be able to label the sixteen input channels so as to better understand the onscreen signals. Since the HP 54620 has no computer keyboard this presents a user interface problem. Our solution was to come up with a labelmaker. The labelmaker needed the ability to combine characters to form meaningful signal names. The labelmaker, shown in Fig. 5, provides control of character selection with a knob on the front panel. Softkeys are used to position the cursor and manipulate the label under construction.

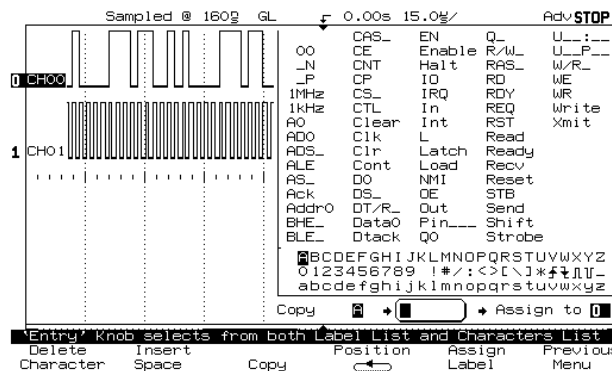


Fig. 5. The labelmaker provides control of character selection with a knob on the front panel. The label dictionary, a nonvolatile label list of 75 entries, is remembered when the instrument is turned off.

Even with our best design effort, customers found inputting labels to be tedious. Several changes were then made to the labelmaker to make it do the right thing and delight the customer. The first change was the inclusion of a label dictionary. This nonvolatile label list of 75 entries is remembered when the instrument is turned off and is seeded by the factory with a number of standard signal names. Research indicated that many customers were using the same label names based on which microprocessor or microcontroller they were using. The label dictionary then becomes customized to the user’s labels over time. As the user constructs a new label, it is saved in the label dictionary and the least recently used label is removed. Using the label dictionary dramatically reduces the number of labels that need to be constructed using the labelmaker, making the product much easier to use. This shortens the setup time of the instrument and leads to more understanding of the signals on the screen.

The second change in the labelmaker has been identified as a “delighter” by customers. In defining labels for input signals, the user is often looking at a bus such as an address or data bus. A typical naming convention for buses is ADDR0, ADDR1, ADDR2, and so on. The prefix can change but the number at the end defines the specific bus bit. In the labelmaker the user assigns the constructed label to the selected channel by pressing the Assign Label softkey. In the normal case, Assign Label simply does the assignment to the channel, not changing the edit field or the selected channel. In the case of a bus assignment, that is, when the new label ends in a number, the Assign Label softkey has a different behavior. It not only does

the label assignment, but also increments the selected channel and increments the label in the edit field to the next logical bus bit. For example, if I have just constructed a label named DATA0 the Assign Label softkey will assign that label to channel 0. Since this is the define bus case (the label ends in a number), the new label in the edit label field will be incremented to DATA1 and the selected channel will increment to channel 1. Thus, to define a bus, the user need only press the Assign Label softkey repeatedly to label the entire bus. In addition, the label dictionary is smart: only the first bus label is saved in the dictionary so that the entire dictionary is not filled with bus label entries.

Conclusion

The HP 54620 shows how contributions can be made in user interfaces and optimized feature sets while leveraging existing Hewlett-Packard technology. Customer research and usability testing are key ingredients this process.

Acknowledgments

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