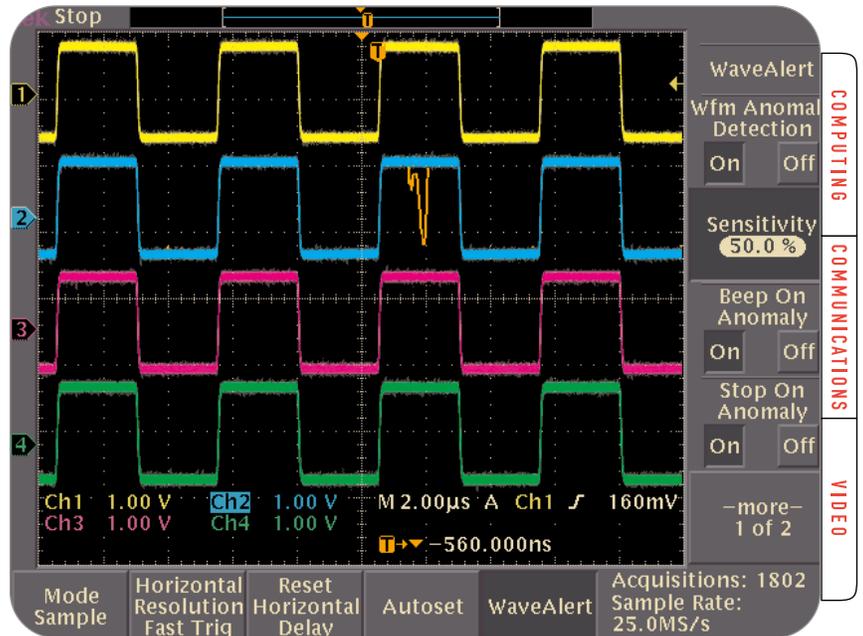


# TDS3000B Series DPO with WaveAlert™ Helps You Find the Anomalies You Didn't Suspect



## ► Enhanced Troubleshooting Ability

WaveAlert™ waveform anomaly detection is a patented signal acquisition capability that makes troubleshooting faster and easier, especially when you are chasing elusive intermittent problems.

A standard feature of the Tektronix TDS3000B Series digital phosphor oscilloscopes (DPO), WaveAlert helps you spot “exceptions” in your signal stream. Whether those exceptions are transient pulses, noise bursts, or brief signal dropouts, WaveAlert detects and alerts you to the events that deviate from the normal cycle-by-cycle information that makes up your waveform display.

WaveAlert doesn't require you to trigger on what you “guess” is wrong, such as a timing violation or glitch. It doesn't require you to set voltage or timing limits. WaveAlert automatically tracks and reveals events that differ from the norm, based on the sensitivity parameters you choose.

### Origins in Digital Phosphor Oscilloscope Technology

WaveAlert is a direct offshoot of Tektronix' patented digital phosphor oscilloscope (DPO) technology. DPO's unique processing architecture delivers a much faster waveform capture rate—in some cases, thousands of times faster—than conventional digital storage oscilloscopes (DSO). As a result, each pixel on a DPO display can be refreshed, stored, or manipulated much more frequently than common DSO displays.

A DPO display closely emulates the persistence of a phosphor-based analog oscilloscope screen, with the added dimension of color. The DPO display is an intensity-graded waveform image that shows, at a glance, where the trace is occurring most often.

A key feature of DPO architecture is its ability to keep a running record of every single pixel on the screen. Each pixel has a “history” that determines whether its intensity is sustained (if the trace passes through the pixel again) or dimmed with each successive screen refresh. This characteristic is the basis of the WaveAlert function.

WaveAlert detects and responds to the pixels that have been “lit up” since the last screen refresh. When the trace passes through a pixel that is not currently lit (thereby causing it to light up) that change is recorded and displayed on an amber-colored trace. By this means, WaveAlert exposes anomalous events that might otherwise go unnoticed. By defining the number of pixels that must be affected before WaveAlert responds—you can determine its “sensitivity” to anomalies.

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WaveAlert takes the DPO acquisition technology in an innovative new direction in the TDS3000B Series. Using WaveAlert, you can spot many anomalies that normally would require the high bandwidth and capture rate of a full-featured laboratory DPO like the Tektronix TDS7054.

## WaveAlert Responses

WaveAlert takes its name from its most powerful benefit: its ability to alert you to passing changes in your signal without requiring continuous viewing of the oscilloscope screen. You can set up a measurement, enable WaveAlert, and leave the oscilloscope to do its work. When you return, the instrument will have captured any errant events.

In addition to highlighting the anomaly in an amber color, WaveAlert can respond in several other ways that support unattended monitoring. Any or all of these modes may be used concurrently:

- Sound a “beep” alarm
- Stop the waveform acquisition
- Save the waveform to on-board floppy disk
- Print the waveform

Unless the Stop on Anomaly option is specifically chosen, the instrument continues acquisition after an anomaly is detected and/or recorded in any of these modes. Thus, you can use the TDS3000B oscilloscope to locally log errors over a long, uninterrupted period of time.

When an anomaly is detected, you have two display choices: you may display just the anomalous portion of the waveform, or the entire waveform including the highlighted anomaly.

## How WaveAlert Works

WaveAlert capitalizes on the high capture rate and the unique waveform rasterizer architecture of the TDS3000B DPO. In the Fast Trigger mode, up to 3600 waveforms per second are acquired and displayed on the TDS3000B. This means, in effect, that the instrument evaluates the waveform for anomalies up to 3600 times per second. All active waveforms, including DPO math, are processed by WaveAlert.

## DPO and WaveAlert

To understand WaveAlert, first it is necessary to take a brief look at both analog and Digital Phosphor Oscilloscope (DPO) operation. DPO mimics the behavior of an electron beam tracing a waveform through X (time) and Y (voltage) deflectors on an analog CRT.

On an analog oscilloscope, each new waveform refreshes the brightness of the trace wherever it crosses the same screen location repeatedly. The phosphor inherently decays anywhere it is refreshed less frequently,

producing a range of brightness levels on the display at any one time. This is known as “intensity gradation.” Oscilloscope users value this characteristic because it helps them judge signal qualities such as amplitude variations or brightness variations in a live video signal. However it is difficult to capture a rare anomaly in the midst of a stable signal stream, since the anomaly doesn't occur often enough to produce a visible trace.

DPO technology brings intensity gradation to digitizing oscilloscopes for the first time. Fundamentally, two complementary processes are always at work in the DPO. First, each new waveform increments the brightness of every pixel it touches. It does this by adding a value to a display memory for each point that it crosses. Concurrently, an independent decay process reduces the values at every point in the display memory (and therefore every pixel on the screen) 60 times per second. The result is a display that behaves very similarly to a traditional analog display, with the addition of powerful digitizing oscilloscope capabilities such as infinite persistence, analysis functions, automated measurements and more.

The values in the display memory are mapped through color look-up tables to produce 16 brightness levels on the display. At any instant, when a new waveform is about to be drawn, points in the display memory have values ranging from 0 to 511. Cumulatively, the non-zero points provide a history of recent waveform acquisitions. Conversely, every zero value stored in the memory indicates no waveform activity at its location.

WaveAlert uses this history to determine whether the new waveform has changed significantly from those preceding it. The initial determination is made by counting the number of former zero-valued points that are written for the first time while drawing a new waveform. If this count exceeds a primary threshold set by the sensitivity control, the points adjacent to the new waveform are examined to determine the number of “really new” points. Really new points are those whose neighbors are also new, and if that total exceeds a secondary threshold, then the waveform is assumed to be an anomaly and is displayed.

Due to the frequency of its updates, the continuous WaveAlert record inherently adapts to long-term variations in the signal. For example, the running WaveAlert database tends to follow a slow DC shift in the signal rather than detecting it as an anomaly. If you need to capture a slowly drifting waveform, the TDS3000B's TDS3LIM application module is the preferred tool.

### **Intensity Effects**

Again looking at the basic DPO architecture, waveform intensity and persistence control are achieved by changing the incremental amount that is added for each new waveform update and/or by changing the decay reduction factor. Increasing waveform intensity or persistence creates a thicker trace and increases the number of non-zero points in the display memory. In effect, this tends to reduce WaveAlert sensitivity because it means that anomalies must exhibit more “change” to get outside the range of non-zero points.

WaveAlert’s ability to detect waveform changes depends on the dynamic balance between new waveforms being drawn and old waveforms decaying away. While the default values of waveform intensity, persistence and WaveAlert sensitivity give good general performance, it is usually advisable to fine-tune these settings to accommodate the specific waveform’s behavior. This is explained in the “Getting Started” section to follow.

When WaveAlert is active, the Waveform Intensity knob controls the decay rate of highlighted anomalies. Waveform intensity cannot be modified when the oscilloscope is in the WaveAlert mode.

### **Sensitivity**

At its default setting of 50%, the sensitivity control attempts to set a threshold so that one waveform per second will be highlighted as anomalous. In the absence of real anomalies, any highlights will be due to noise, and the actual number of anomalies found can vary. Theoretically, a 6% increase in sensitivity will double the number of anomalies per second, and a decrease of 6% will halve their frequency. For example, a sensitivity of 62% (that is,  $50\% + [2 \times 6\%]$ ) should produce 4 anomalies per second, while a sensitivity of 38% should produce an anomaly every 8 seconds. Note that these are estimated figures.

WaveAlert uses the number of “new points” written to the display memory after each acquisition to detect unusual waveforms (anomalies). It creates and then maintains a frequency histogram of these numbers of new points. Each frequency is proportional to the probability that a new waveform will have the corresponding number of new points. Similarly, the sum of frequencies corresponding to counts greater than a specified threshold is proportional to the probability that a new waveform will have at least that number of new points. After two hundred acquisitions or 5 seconds, WaveAlert uses the elapsed time

and the actual number of acquisitions to compute an acquisition rate. It then uses the acquisition rate and the frequency distribution to determine a “new points threshold” which will theoretically produce  $N$  anomalies per second where  $N$  is determined from the sensitivity setting.

### **Anomaly Decay (Persistence of the WaveAlert Display)**

A single waveform trace decays very quickly and disappears, so WaveAlert uses the decay reduction factor (persistence) described earlier to retain anomalous waveforms long enough to be useful. In the WaveAlert mode, the Waveform Intensity knob controls the anomaly decay rate; that is, the decay of the separately-drawn amber WaveAlert trace. To adjust the intensity of the trace, simply turn off WaveAlert and use the Waveform Intensity knob.

Anomaly processing affects the dynamic balance between new waveform drawing and the decay process. WaveAlert evaluation takes finite time, and during that time the decay mechanism continues to do its job—driving pixels back toward zero brightness. In a sense, the decay gets ahead of the re-drawing process. To counteract this, WaveAlert, after detecting an anomaly, waits for another 20 acquisitions to pass before it allows another.

## **Getting Started With WaveAlert**

Like any other measurement tool, you will need to get acquainted with WaveAlert waveform anomaly detection to get its full benefit. The following section introduces some basic techniques.

### **Displaying the Signal and Setting the Intensity**

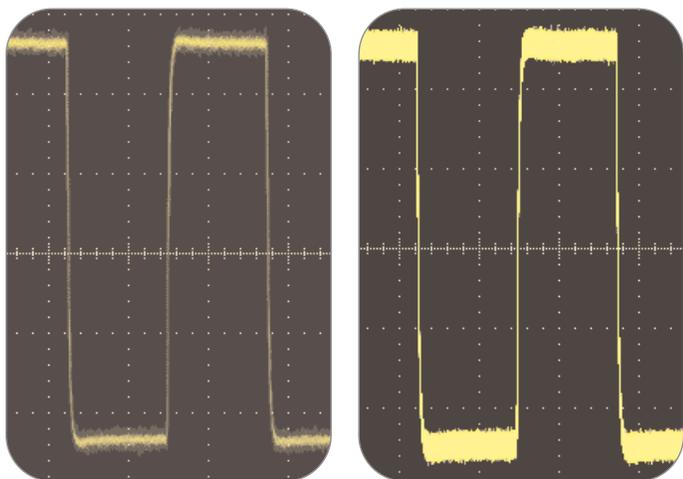
Because WaveAlert is a tool for finding rare or intermittent anomalies in a steady-state signal, its first requirement for WaveAlert is an unchanging input signal with stable triggering. The oscilloscope must be operating in the normal RUN/STOP mode (not the SINGLE SEQ mode), and the incoming waveform must be consistent in frequency, phase, and amplitude. The remaining discussion assumes you have acquired and displayed a signal with these characteristics.

When the signal is on-screen in the triggered RUN mode (and WaveAlert is not yet enabled), you can set up the waveform intensity as usual. Remember, this control is used for another purpose—setting the persistence of the highlighted anomaly—when WaveAlert is on.

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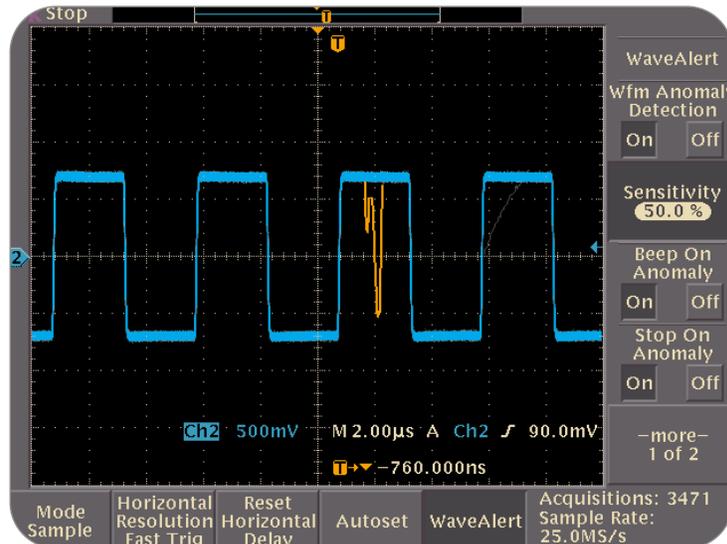
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Note that the *waveform intensity setting has an effect on WaveAlert behavior*. This is because WaveAlert works on information that actually appears on the display. To understand the effect of waveform intensity, keep in mind that an “ideal” waveform trace would be a line just one pixel wide at any point. In practical terms, this ideal is not achievable, but many oscilloscope users have learned to approximate it by dimming the trace as shown in Figure 2a. This image looks like an ideal waveform, and the WaveAlert process is based on how things look on-screen. WaveAlert’s sensitivity is based on the number of new pixels that are lit up on each successive screen capture, and their distance from the baseline waveform. In Figure 2a, WaveAlert evaluates the narrow trace and if the sensitivity is set appropriately, detects very small deviations (anomalies).



► **Figure 2a & 2b.** The TDS3000B’s Waveform Intensity setting changes WaveAlert’s definition of a “normal” waveform. Figure 2a is the baseline normal waveform, dimmed to minimize visible noise. As intensity is increased in Figure 2b and the trace gets thicker, WaveAlert’s sensitivity to changes in the baseline waveform decreases.

If the waveform display intensity is increased, the oscilloscope brightens any noise or small amplitude variation that occurs in (or around) the signal, and in doing so lights up more pixels as shown in Figure 2b. The trace becomes thicker even though the actual signal is the same. WaveAlert now perceives this broader trace as the new baseline signal that must be evaluated for exceptions. In effect, WaveAlert now looks at the noise as part of the unchanging signal. This makes WaveAlert less “sensitive” since it requires a bigger departure from the ideal trace; that is, a bigger anomaly. A good rule of thumb is to turn up the intensity when viewing noisier signals; turn it down for “quieter” signals.



► **Figure 3.** WaveAlert screen menu.

## Starting Up WaveAlert

Access the WaveAlert menu (in which all of the basic WaveAlert settings are implemented) by pressing the MENU button under the ACQUIRE column on the oscilloscope’s front panel, and then pressing the soft button under the WaveAlert tab on the screen. The menu in Figure 3 appears.

Under the tab labeled “Horizontal Resolution,” press the soft button to bring up the Horizontal Resolution menu. This gives you the choice of Fast Trigger or Normal modes. Select Fast Trigger mode. This delivers the fastest update rate, in turn providing the most opportunities for WaveAlert to encounter an anomaly. Then re-open the WaveAlert menu.

## WaveAlert Controls

With the Acquire menu displayed, you will see a WaveAlert submenu in the column to the right of the waveform graticule. Here there are eight parameters displayed four at a time. Press the “-more-” button to switch between the two pages. Listed in the following table are the WaveAlert control functions.

WaveAlert Control	Function
Wfm Anomaly Detection (On/Off)	Enables and disables WaveAlert. WaveAlert does not need to be activated during setup procedure described above.
Sensitivity	Numerical readout of the current Sensitivity setting. The General Purpose knob is used to set the Sensitivity. Values range from 0% to 100%.
Beep On Anomaly (On/Off)	When On, this enables the audible alarm which sounds when an anomaly is detected.
Stop On Anomaly (On/Off)	When On, this sets WaveAlert to stop waveform acquisition when an anomaly is detected, and display the anomaly and/or the waveform. The anomaly appears as an amber trace on the display. The Stop On Anomaly mode gives you a means to analyze a single captured event without saving it permanently.
Hard Copy On Anomaly (On/Off)	When On, WaveAlert sends a hardcopy to the connected printer when an anomaly is detected. This function also stores waveforms in various publishable image formats, including EPS, TIFF and JPEG.
Wfms to Disk On Anomaly (On/Off)	When On, the waveform is stored on the instrument's built-in floppy disk, along with a timestamp that records exactly when the anomaly occurred.  The size of a single waveform file can be very small—only about 2 kbytes in the case of a 500-point file in the internal .ISF format. These files can be retrieved and reconstructed as a full display for later analysis, and even re-archived in a publishable format using the Hard Copy command. A common 1.4 Mbyte floppy disk can store hundreds of waveform files.  Waveforms can also be stored in Mathcad or spreadsheet formats for analysis on an external PC.
Highlight Entire Wfm	When On, this highlights and displays the entire waveform acquisition that contains the anomaly. The amber WaveAlert trace is superimposed on the baseline trace.  This display mode is especially effective when coupled with Stop On Anomaly.
Highlight Anomalies	When On, this highlights and displays only the detected anomaly in amber, while preserving the original trace in the color assigned to that channel.

### Setting WaveAlert Sensitivity

Setting the sensitivity to an optimal level is essential for getting the best results with WaveAlert. Setting the sensitivity too low causes WaveAlert to miss anomalies that might be important. Conversely, setting the sensitivity too high causes WaveAlert to detect trivial noise variations as “anomalies” and display them almost continuously. What follows is a simple procedure to establish your initial sensitivity settings:

1. Before entering the WaveAlert mode, minimize the display intensity using the Waveform Intensity knob on the front panel. This increases the likelihood of detecting a variation from the baseline trace.
2. Activate the WaveAlert menu using the Acquire/Menu button. Be sure to set Horizontal Resolution to Fast Trigger.
3. Turn off the Beep On Anomaly, Hard Copy On Anomaly and Wfms To Disk On Anomaly modes. This ensures that your setup process won't be interrupted if an anomaly is captured.

4. Increase the WaveAlert persistence (using the Waveform Intensity knob, which in WaveAlert mode is a persistence control). This causes the anomaly to remain onscreen so you can determine whether it is the kind of error you want to capture. You can “erase” the anomaly by reducing the WaveAlert persistence.
5. Using the General Purpose knob, vary the sensitivity until you have arrived at a setting that captures the anomalies of interest.
6. Set the Stop On Anomaly, Beep On Anomaly, Hard Copy On Anomaly and Wfms To Disk On Anomaly modes as needed for your application.

The default sensitivity level is 50%. This is a good starting point for setting up. Use the COARSE setting on the General Purpose knob to scroll more quickly through the range. Or, you may enable Stop On Anomaly until you have found a sensitivity threshold that doesn't cause WaveAlert to detect too many anomalies. You will need to press the RUN/STOP button to resume acquisition after every anomaly. When you have found a suitable sensitivity threshold, be sure to disable Stop On Anomaly unless you intend to use it for your measurements.

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## WaveAlert in Everyday Use

WaveAlert's strengths are twofold: detecting intermittent anomalies that occur in the midst of stable waveform streams, and issuing alerts that free you from the need to constantly supervise the oscilloscope. Its primary use is in troubleshooting new circuit designs that may be plagued by transients resulting from race conditions, or by power supply aberrations, or external interference. WaveAlert will routinely capture these random anomalies. It is an ideal tool for revealing glitches that occur erratically every second or two, or even longer. If you enable WaveAlert and set up the sensitivity correctly, and if the glitch is repetitive, it usually will be captured within a few seconds.

## Summary

The WaveAlert waveform anomaly detection capability in the TDS3000B Series oscilloscope is the answer to almost any troubleshooting problem that involves sporadic and unpredictable events such as glitches and pulse aberrations.

WaveAlert relies on the processing power of digital phosphor oscilloscope architecture to detect and alert you to deviations from the "normal" wave shape on the screen. With WaveAlert, the TDS3000B handles the task of monitoring the incoming signal, freeing you to concentrate on the design and troubleshooting work that requires your full attention. WaveAlert is a fast, easy, cost-effective way to capture and record intermittent problems.

### **WaveAlert Applications Range From Design Engineering to Remote Monitoring**

WaveAlert makes an already-versatile instrument, the TDS3000B oscilloscope, into an efficient solution for design troubleshooting, engineering documentation, research, and much more.

The audible beep alarm is an ideal troubleshooting tool for finding intermittent faults without requiring your undivided attention.

Monitoring, for example, a 4-bit bus on a new machine controller circuit design, the oscilloscope can detect transient errors that result from timing problems in the device that drives the bus. On a four-channel oscilloscope such as the TDS3054B, WaveAlert monitors all four channels simultaneously and beeps when an anomaly appears on any channel.

WaveAlert's ability to support unattended capture, display and recording of intermittent anomalies is ideal for a range of engineering applications, including:

- ▶ Controller bus monitoring—capture errors resulting from race conditions, bus contention or metastable states.
- ▶ Machine control—monitor the effects of turn-on currents, motor noise and power variations.
- ▶ Clock distribution systems—detect amplitude and pulse width variations and frequency instability.
- ▶ DC power monitoring—capture noise bursts and ground bounce phenomena.

The Save to Disk feature is also aimed at engineering applications. Using WaveAlert Save to Disk, you can accumulate a long-term database that documents your circuit's behavior. The database will contain waveform images (or just the anomalies, if you prefer) along with a timestamp to distinguish each entry. By this means, you can monitor the frequency with which errors occurred.

The Stop Acquisition function is a useful supplement to the beep alarm. If the user is normally on hand to respond to WaveAlert's alarms, he or she can quickly view and assess the event that caused the beep, and then take appropriate action. This may range from making a corrective adjustment on the device under test, moving the probe to a different test point, etc.

WaveAlert and Save to Disk are also helpful when running acceptance procedures or evaluating beta product performance at customer sites. It allows you to reliably document waveforms and anomalies onsite and bring them back to the lab for analysis or emulation.

WaveAlert's Hardcopy on Anomaly command automatically prints the detected anomaly and (if selected) its associated waveform on an attached or networked printer. Both WaveAlert Hardcopy and Save to Disk are well suited to unattended monitoring during stress tests, life cycle tests, burn-in, etc.



▶ **Figure 4.** The TDS3PRT Plug-in Printer provides instant portable documentation of your work.

## TDS3000B Series DPO with WaveAlert

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► TDS3000B Series of Digital Phosphor Oscilloscopes

### For Further Information

Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology.

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