Oscilloscope Guide
Tektronix TDS3034B & TDS3052B

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1 – Basic Information

This guide provides basic instructions for operating the Tektronix TDS3000 Series Digital Phosphor Oscilloscopes. The TDS3000 oscilloscopes provide these features (depending on model):

- 100 to 500 MHz bandwidth[1]

- Up to 5 GS/s sample rate[2]

- 2 or 4 channels[3]

- Full color LCD with graphical user interface

- GPIB and LAN interfaces

- Automatic measurements and built-in FFT

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2 – Oscilloscope Overview

An oscilloscope measures an electrical signal and displays a graph of how the signal varies over time. The vertical axis of the graph is the voltage, while the horizontal axis is time. Important signal characteristics can be extracted from the graph, such as the amplitude of the signal, the frequency or period of a repetitive waveform, and the amount of noise and distortion.

A probe is used to connect the circuit being tested to the inputs of the oscilloscope. Most oscilloscopes support either two or four inputs. Each input, or *channel*, can independently measure and display a signal.

In a digital oscilloscope, an analog-to-digital converter samples the measured voltage signal and converts the analog value into digital form. To generate a waveform for display on the screen, the sampling is performed repeatedly over a specific time interval. This process is the horizontal sweep.

The front panel of a typical digital oscilloscope has these control sections:

- **Vertical** – Adjusts the vertical (voltage) scaling and positioning of the waveform
- **Horizontal** – Controls the horizontal (time) scaling and positioning of the waveform
- **Trigger** – Stabilizes repetitive signals and captures one-shot waveforms
- **Acquire** – Controls how the input signal is acquired or sampled

Some oscilloscopes have menu-based user interfaces, which can be accessed through menu buttons or by a touch screen. Oscilloscopes often have built-in computing capability, which allows advanced data processing algorithms to be applied to the measured signals.

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[1] The bandwidth specifies the highest frequency signal that can be measured with the instrument.
[2] The sample rate determines how often the input signal can be digitally sampled (in giga-samples per second).
[3] The number of channels determines how many independent signals can be measured simultaneously.
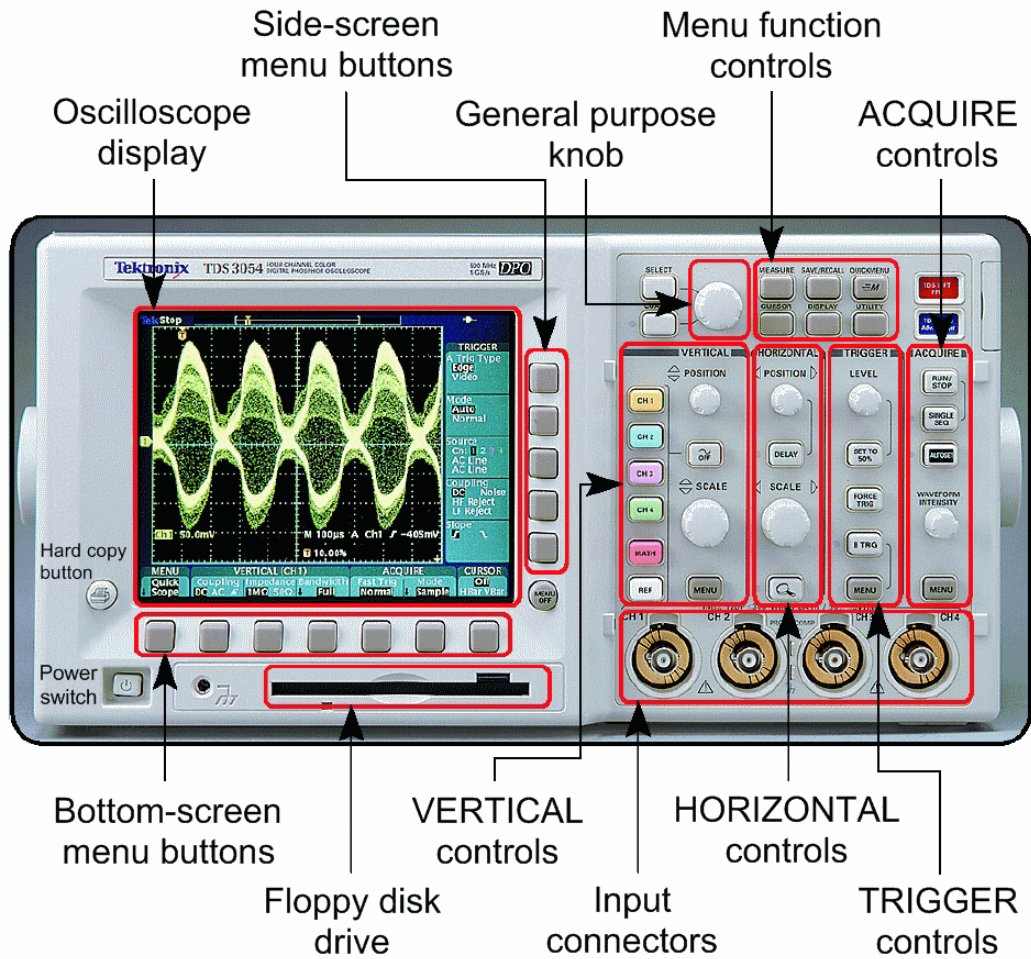
3 – Instrument Front Panel

Figure 1: Tektronix TDS3000 series front panel - Copyright © Tektronix, Inc.

► Power Switch

The power switch turns the oscilloscope on or off.

► Floppy Disk Drive

The oscilloscope has a built-in 3.5" 1.44 MB floppy disk drive. Oscilloscope setups and waveform data can be saved to or recalled from a formatted disk that is inserted in the drive.

► Hard Copy Button (looks like a printer icon)

Pushing this button captures the screen image and sends it to a printer or saves it to a graphic file.

► General Purpose Knob

For some oscilloscope functions, the general purpose knob can be used to change the value of a setting.
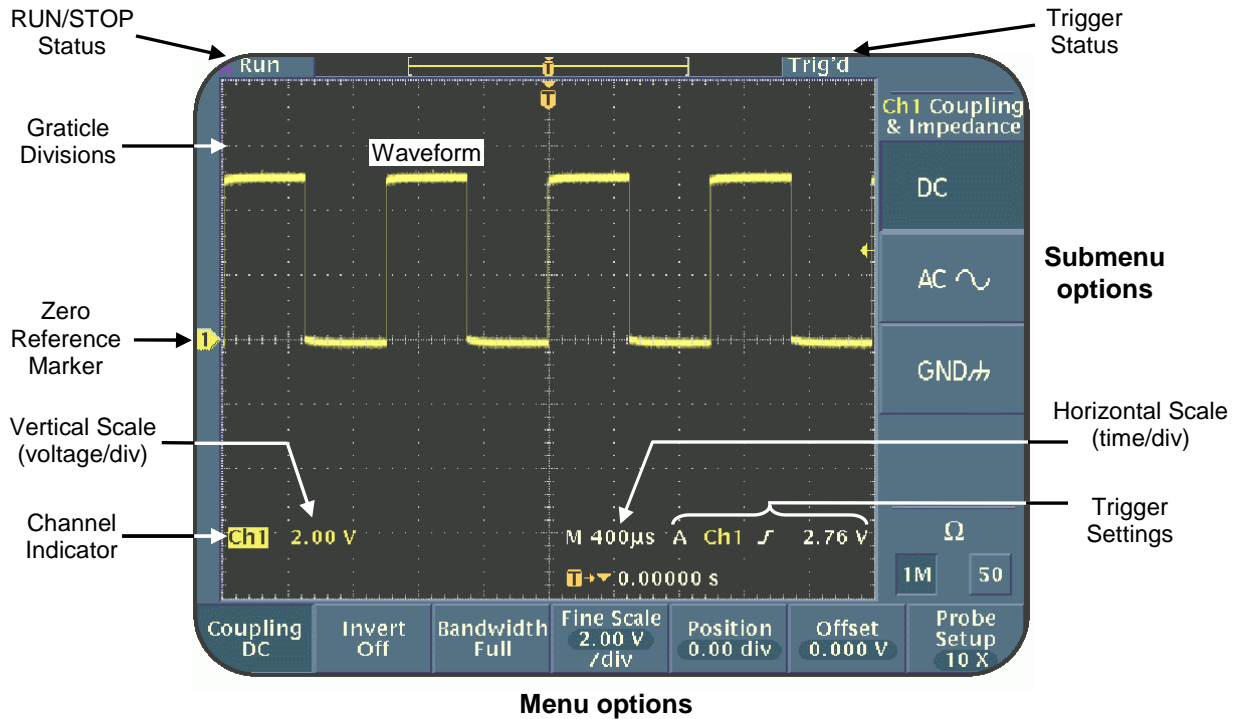
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Figure 2: Screen interface on the LCD display - Copyright © Tektronix, Inc.

► Oscilloscope Display

The LCD screen shows a color-coded graph of each channel's signal waveform. The graph area is divided into a grid to aid in reading the amplitude and timing of the waveforms. The vertical axis has units of voltage per division, while the horizontal axis has units of time per division. The LCD always shows the current numeric values of the vertical and horizontal scales for each channel.

► Bottom-screen and Side-screen Menu Buttons

The TDS3000 series support an on-screen menu system for accessing oscilloscope functions that are either not used very often, or are too complex to assign to a single button.

If an oscilloscope function requires menus, then they are displayed on the bottom edge of the LCD screen. When a menu option is selected, additional submenu options may appear on the right edge of the screen. The content of the menus and submenus will vary depending on the oscilloscope's current function.

The actual menu buttons are located on the plastic bezel that surrounds the LCD. By pressing a button, the menu item associated with the button will be selected.

There is a dedicated MENU OFF button that turns off the on-screen menus.

► **VERTICAL Section Controls**

The vertical section adjusts the vertical scaling and positioning of the waveform. Certain channel input parameters are also configured here. Each channel has its own independent vertical settings.

Dedicated Controls

CH 1, CH 2, CH 3, CH 4 CHANNEL SELECTION buttons   (Only **CH 1**, **CH 2** on two channel models)

> All of the available oscilloscope inputs (i.e., channels) share a single set of controls. The channel selection buttons determine which channel is currently chosen to be controlled. When a channel button is pressed, the associated channel becomes active and appears on the LCD screen.

VERTICAL **POSITION** knob

> This knob moves the position of the currently selected waveform either up or down on the LCD screen. It does not change the vertical scale.

VERTICAL **SCALE** knob

> This knob adjusts the vertical scale of the currently selected waveform. It does not change the vertical position. The vertical voltage scale is specified in units of volts per division (V/div). Example: If the scale is 2 V/div, then each graticle division on the vertical axis represents 2 V.

OFF button

> The OFF button removes the currently selected waveform from the display.

MENU button

> The MENU button activates additional on-screen menus for the vertical section.

Menu-based Controls

[Coupling]   This selects the channel's input coupling (DC, AC, or Ground).

> - DC – Allows both AC and DC signals to get through (default)
> - AC – Filters out any DC signals, so only AC signals can get through
> - Ground – Waveform is temporarily replaced by a 0 V signal reference

> It is also used to select the channel's input resistance (1 MΩ, 50 Ω).

> - 1 MΩ – Used for typical voltage measurements (default)
> - 50 Ω – Used to properly match impedance with other 50 Ω systems

[Invert]   This button inverts the polarity of the selected waveform.

[Bandwidth]   This controls the oscilloscope bandwidth (Full, 150 MHz, 20 MHz).

[Fine Scale]   This enables finer adjustment of the vertical scale using the general purpose knob.

[Position]   This controls the waveform's vertical position using the general purpose knob.

[Offset]   This adjusts the waveform's vertical offset using the general purpose knob.

[Probe Setup]   For probes that do not use the TekProbe interface, this option allows the probe attenuation factor to be changed using the general purpose knob. (1mX to 1kX full range, 1X or 10X typical)

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► **HORIZONTAL Section Controls**

The horizontal section adjusts the horizontal (time base) scaling and positioning of the waveform. All channels share the same horizontal settings.

Dedicated Controls

HORIZONTAL **POSITION** knob

> This knob moves the position of the currently selected waveform either left or right on the LCD screen. It does not change the horizontal scale.

HORIZONTAL **SCALE** knob

> This knob adjusts the horizontal scale of the currently selected waveform. It does not change the horizontal position. The horizontal time scale is specified in units of time per division (e.g., ms/div). Example: If the scale is 5 ms/div, then each graticle division on the horizontal axis represents 5 ms.

DELAY button

> The DELAY button is used to delay signal acquisition relative to the triggering event by using the HORIZONTAL POSITION knob.

ZOOM button (looks like a magnifying glass)

> The ZOOM button magnifies the currently selected waveform along its horizontal axis. When in zoom mode, the HORIZONTAL SCALE knob controls the magnification factor, while the HORIZONTAL POSITION knob selects the portion of the waveform that should be magnified.

► TRIGGER Section Controls

For a periodic signal to appear stable on the screen, the horizontal sweep must be synchronized at the proper point of the signal. If the sweep is not synchronized, the waveform may "roll" horizontally and be difficult to see.

For each horizontal sweep, the oscilloscope needs a trigger event to know when to start acquiring the input signal. The trigger can be derived from the input signal itself (Source=input channel), from the AC power line (Source=AC line), or from an independent signal (Source=external signal).

The TDS3000 series supports two triggers, which are known as the A trigger (default) and the B trigger (optional).

Dedicated Controls

TRIGGER **LEVEL** knob

> This knob adjusts the trigger level of the currently selected waveform. A horizontal line temporarily appears on the screen to indicate the trigger level. The level should be adjusted until the waveform appears stable on the screen.

SET TO 50% button

> This button automatically sets the trigger level to 50% of the peak-to-peak amplitude of the source trigger waveform.

FORCE TRIG button

> The FORCE TRIG button manually causes a trigger event to occur, even if there is no input signal.

B TRIG button

> This button provides a B trigger in addition to the existing A trigger.

MENU button

> The MENU button activates on-screen menus for the trigger section.

Menu-based Controls

These are the menu options for edge triggering:

[Source]   This selects the edge trigger signal source (input channel, AC line, external signal)

[Coupling]   This allows selection of the coupling (DC, HF Reject, LF Reject, Noise Reject).

[Slope]   This determines whether to trigger on the rising or falling edge of a signal.

[Level]   This is used to modify the trigger threshold voltage level.

► ACQUIRE Section Controls

The acquire section controls how signals are acquired and processed.

Dedicated Controls

RUN/STOP button

> This button allows the user to start and stop the continuous waveform acquisition.

SINGLE SEQ button

> This enables a single-sequence acquisition of a signal, after which the acquisition stops.

☆ **AUTOSET** button

> This button automatically adjusts the VERTICAL, HORIZONTAL, and TRIGGER controls to acquire a usable display. The controls may need further manual adjustment for best results.

WAVEFORM INTENSITY knob

> This knob adjusts the intensity of the displayed waveform. At maximum intensity, the view is like a standard digital oscilloscope. At medium intensity, the view simulates an analog oscilloscope.

MENU button

> The MENU button activates on-screen menus for the acquire section.

► MENU Controls

The MENU controls activate on-screen menus for performing various functions. The menu appears at the bottom of the screen, while submenu options appear on the right side of the screen.

MEASURE	This button is used to access the oscilloscope's built-in automated measurements. Some examples include finding the amplitude and frequency of a signal, finding the min/max values, and computing rise and fall times.
SAVE/RECALL	This is used to save or recall oscilloscope setups and waveforms to nonvolatile memory or to the floppy disk. Measured waveform data can be saved as a Mathcad data file, or as a CSV file that can be imported into a spreadsheet.
☆ **QUICKMENU**	This bypasses standard menus to provide quick access to basic oscilloscope operations.
CURSOR	This is used for making amplitude and time measurements. For example, vertical or horizontal bars can be superimposed on the screen to mark key points on waveforms.
DISPLAY	This button controls display options such as persistence, format, and contrast.
UTILITY	This button gives access to system utilities such as setting the hard copy parameters, adjusting the system date/time, and running diagnostics.

Note: The buttons marked with a star are very useful for quickly setting up the oscilloscope.

► Input Connectors

External probes are attached to the female BNC input connectors on the front panel of the oscilloscope.

Each input connector is surrounded by the TekProbe interface ring. If a probe supports the interface, the oscilloscope can autodetect the probe attenuation factor (e.g., 1X or 10X), the coupling, and the termination resistance. If the probe does not use the interface, then these settings must be manually set.

4 – Passive Attenuation Probes and Compensation

A typical passive probe consists of a cable with a male BNC connector on one end and a retractable hook tip (or a pointed tip) with ground clip on the other. The BNC side attaches to one of the oscillocope's inputs, while the probe tip is attached to a measurement point in the test circuit.

The probe tip is where the voltage signal enters the probe and is then carried through the cable to the center pin of the BNC connector. The ground clip provides the ground reference from the test circuit to the outer shield of the BNC connector.
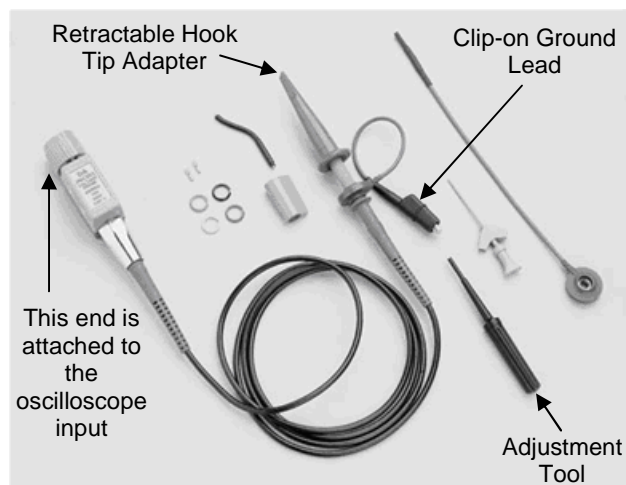

Figure 3: General purpose voltage probe with accessories – Copyright © Tektronix, Inc.

Many Tektronix-brand probes support the TekProbe interface for automatic setup, but probes from other companies might not. The attenuation factor and input resistance settings in the vertical section of the oscilloscope should be changed to match the values recommended by the probe manufacturer.

Probe Description	Attenuation	Input Resistance	Comment
General purpose probe - TekProbe	Automatic	Automatic	
General purpose probe	1X or 10X	1 MΩ	
BNC–MicroClips	1X	1 MΩ	Red=Signal, Black=Ground
BNC–BNC coax 50 Ω	1X	50 Ω	

Table 1: Vertical channel settings (Attenuation, Input Resistance) for various types of probes

Understanding how a probe interacts with a test circuit is critical to getting an accurate measurement. Some of the key performance aspects of a probe are described next.

Dynamic Range

The dynamic range defines the smallest and largest voltages that can be measured with the probe. A 1X probe directly matches the range of the oscilloscope. A 10X probe attenuates the input signal by a factor of ten, which shifts the range to allow higher voltages to be measured. A 1X probe is still useful if very low voltage levels need to be examined. (Note: While many probes are exclusively 1X or 10X, some probes support switching between 1X and 10X modes.)

Source Loading

This is the resistive load of the probe on the test circuit. A 10X probe has a higher terminating resistance than a 1X probe, which imposes less of a load on the test circuit.

Probe Tip Capacitance

The capacitive loading at the probe tip can adversely affect the bandwidth and rise time of the measurement. This problem can be minimized by selecting a probe with a low tip capacitance.

Attenuation	R (term)	C (tip)	Bandwidth
1X	1 MΩ	100 to 200 pF	Low
10X	10 MΩ	1 to 25 pF	High

Table 2: Typical probe values

Probe Compensation

Some probes have a built-in compensation network that can be adjusted to match the characteristics of the probe to the oscilloscope inputs. The following procedure is used to compensate a probe:

1. Connect the probe to the desired input channel on the oscilloscope.

2. On the front panel of the oscilloscope, attach the probe tip to the PROBE COMP point and the ground lead to the chassis ground point. On the TDS3000 series, these points are located between the Channel 2 and 3 input connectors. PROBE COMP generates a 5 volt square wave at 1 kHz.

3. Push the AUTOSET button to acquire the test signal.

4. Use the probe's adjustment tool to make the square wave have a flat top (see Figure 4).
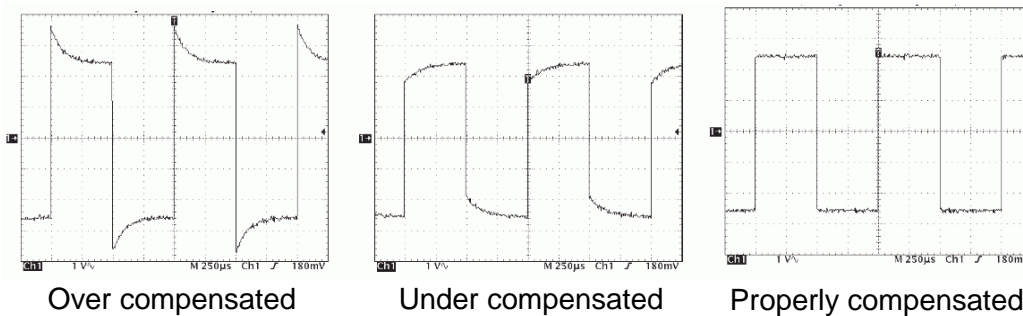

Over compensated   Under compensated   Properly compensated

Figure 4: Effects of probe compensation on a square wave

5 – *Simplified Setup Procedure*

1. Before making any connections, verify that the test circuit will not produce voltage or current levels that could damage the oscilloscope.

2. Turn on the oscilloscope. The instrument is more accurate if allowed to warm up for a while.

3. Choose probes that are appropriate for the measurement. Each channel requires a separate probe.

4. For each channel that will be used:

    a. Attach the probe's BNC connector to an input connector on the oscilloscope.

    b. If necessary, configure the attenuation, coupling, and input resistance for the channel.

    c. If the probe has a built-in compensation network, then compensate the probe.
       (Perform compensation whenever a probe is connected to the oscilloscope for the first time.)

    d. Connect the probe to the test circuit. If you will be working with static-sensitive parts, then wear a grounding strap before making the connections.

        i. Attach the ground clip of the probe to a ground point in the circuit.

        ii. Attach the probe tip to the voltage measurement point in the circuit.

5. If the test circuit is not turned on yet, then apply power to the circuit.

6. Adjust the oscilloscope's controls to achieve a stable display of the waveform.
   (The AUTOSET button can be used to get a reasonable initial display.)

7. Voltage measurements are done by counting the number of graticle divisions that a waveform spans in the vertical direction. Timing measurements are performed similarly, but in the horizontal direction.

6 – Saving Waveform Data

After performing a measurement, it is often desirable to store the waveform data on a floppy disk for transfer to a PC. Data can be saved as a graphic[4] file, which is essentially a screen capture, or as a Mathcad[5] or spreadsheet[6] file, which would be the raw numeric data.

Note: The oscilloscope automatically generates consecutively numbered file names when saving files.

Saving as a Graphic file

1. Insert a formatted 3.5" 1.44MB floppy disk into the oscilloscope's disk drive.

2. Press the UTILITY button on the front panel.

3. Select "System" from the lower menu. Keep pushing the same menu button until "Hard Copy" is selected. The lower menu will change to show only hard copy options.

4. Select "Format" from the lower menu. The right submenu will now show a long list of available printers and graphic file formats. Cycle through the options to select the desired format.

5. Select "Options" from the lower menu. On the right submenu, select either "Landscape" or "Portrait" for the orientation of the image.

6. Select "Ink Saver" from the lower menu. On the right submenu, select either "Off" (to capture the screen colors as-is) or "On" (to change the background color from black to white).

7. Press the MENU OFF button to turn off the menus.

Once the hard copy options have been set, the current screen image can be captured to the floppy disk at any time by pressing the Hard Copy button.

Saving as a Mathcad file or a Spreadsheet file

1. Insert a formatted 3.5" 1.44MB floppy disk into the oscilloscope's disk drive.

2. Press the SAVE/RECALL button on the front panel.

3. Select the channel you want to save by pressing the appropriate Channel Selection button.

4. Select "Save Waveform ChX" from the lower menu.

5. Select "To File" from the right submenu.

6. To save the data as a Mathcad file: Select "Mathcad File Format" from the right submenu
   To save the data as a Spreadsheet file: Select "Spreadsheet File Format" from the right submenu

7. Select "Save ChX To Selected File" from the right submenu.
   (It may take a while for the oscilloscope to finish writing the data to the floppy disk.)

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[4] Supported graphic file formats include TIFF, PCX, BMP, EPS, and PNG.
[5] Mathcad is an engineering calculation program (see www.ptc.com).
[6] The spreadsheet file is in CSV (Comma-Separated Values) format. The resulting text file can be imported into a compatible program, such as MS Excel or MATLAB.

Appendix 1 – Specifications

	TDS3034B	**TDS3052B**
Bandwidth	300 MHz	500 MHz
Channels	4	2
Sample Rate on Each Channel	2.5 GS/s	5 GS/s
Maximum Record Length	10 K points	
Vertical Resolution	9 bits	
Vertical Sensitivity (/div)	1 mV to 10 V	
Vertical Accuracy	±2%	
Maximum Input Voltage (1 MΩ)	150 V_{RMS} CAT I	
Position Range	±5 div	
BW Limit	20, 150 MHz	20, 150 MHz
Input Coupling	AC, DC, GND	
Input Impedance Selections	1 MΩ in parallel with 13 pF or 50 Ω	
Time Base Range	2 ns/div to 10 s/div	2 ns/div to 10 s/div
Time Base Accuracy	20 ppm	

Table 3: Manufacturer's instrument specifications

Appendix 2 – References

[1]   *Tektronix TDS3000B Series Data Sheet*, Tektronix, Inc.

[2]   *Tektronix TDS3000 & TDS3000B Operator Training Kit Manual (071-1051-00)*, Tektronix, Inc.

[3]   *Tektronix TDS3000B Series Digital Phosphor Oscilloscopes Reference (071-0923-00)*, Tektronix, Inc.

[4]   *Tektronix TDS3000B Series Digital Phosphor Oscilloscopes User Manual (071-0957-04)*, Tektronix, Inc.

[5]   *XYZs of Oscilloscopes - Primer*, Tektronix, Inc.

[6]   *ABCs of Probes - Primer*, Tektronix, Inc.

[7]   *Introduction to the Oscilloscope*, ECE Dept, Portland State University (2005).