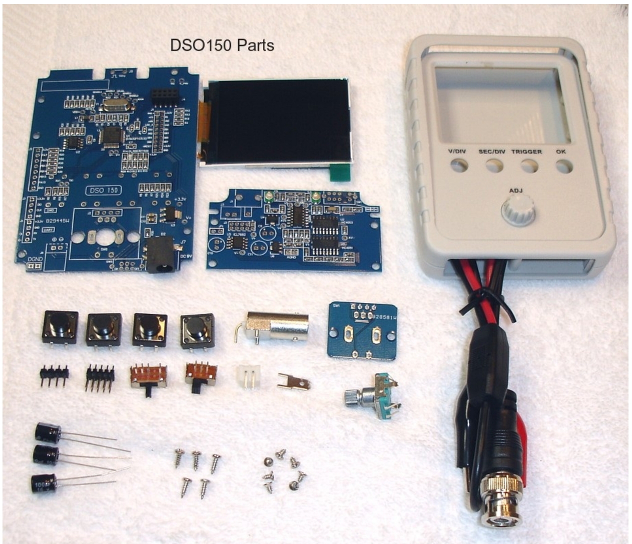


DSO150 Oscilloscope Kit & Manual

By Steven Vagts

Z-100 LifeLine
Insert, Issue #134

DSO150 Oscilloscope Kit Description:

The DSO150 Oscilloscope is a bigger brother to the DSO138 discussed in an earlier issue. It is another inexpensive low-speed miniature oscilloscope with 2.4" color TFT LCD (320 x 240 dot matrix, 262K color display. Based on the ARM Cortex-M3 processor (STM32F103C8), it was developed by JYE Tech, China. It is sold as a full kit, or a partial kit with all the surface mounted parts already installed on the boards, leaving just a few parts remaining.

Designed as a training oscilloscope, the DSO150 contains only the basic oscilloscope functions with no fancy features. Simplicity in structure and easiness in assembly and operation are the main highlights of the design. The MCU has already been pre-programmed and no reprogramming is required.

Please note that a 9Vdc power supply must be purchased separately.

DSO150 Oscilloscope Features:

- ARM Cortex-M3 processor (STM32F103C8)
- 2.4" color TFT LCD (320 x 240 dot matrix, 262K **color** display.
- Analog bandwidth: 0 – 200KHz
- Sampling rate: 1Msps max
- Vertical Sensitivity: 5mV/Div to 20V/Div
- Sensitivity error: < 5%
- Vertical resolution: 12-bit
- Horizontal Timebase: 10us/Div to 50s/Div
  using 1-2-5 progressive manner and
  automatic, regular, or one-shot triggering
- Adjustable rising or falling edge trigger
  with observable previous trigger waveform (negative delay)
- Waveform frozen (HOLD) function available
- Save/recall waveform
- Automatically calculate and report on-screen measurements including:
  Vmax, Vmin, Vavr, Vpp, Vrms, Frequency, Cycle, Pulse Width, & Duty Cycle.
- Sampling Buffer Depth: 1024 points
- Input Impedance: 1 Megohm
- Maximum Input Voltage:
  50Vpp (1:1 probe)
  400Vpp with 10:1 probe (not provided)
- Coupling Modes: DC / AC / GND
- Built-in 1KHz/3.3V square wave test signal source
- Power Supply: Requires 9Vdc AC/DC power supply or
  9Vdc battery with cable adapter

Specifications:

Vertical

Number of Channel:	1
Analog Bandwidth:	0 - 200KHz
Sensitivity:	5mV/Division - 20V/Division
Resolution:	12 bits
Input Impedance:	1M ohm / 20pF
Max Input Voltage:	50Vpk (1x probe)
Coupling:	DC, AC, GND

Horizontal

Max Real-time Sampling Rate:	1MSa/second
Timebase:	10us/Div - 500s/Div
Record Length:	1024 points

Trigger

Trigger Modes:	Auto, Normal, and Single
Trigger Types:	Rising/falling edge
Trigger Position:	½ of buffer size fixed

Display

2.4" color TFT LCD with 320x240 resolution

Power Supply

Supply Voltage:	9Vdc (8-10Vdc acceptable, **Do NOT exceed 10Vdc**)
Supply Current:	120mA @ 9Vdc
Barrel Size:	2.1mm x 5.5mm x 9.5mm (Center tap must be positive)

Physical

Dimensions:	4" tall x 2.88" wide x 1.13" deep in case.
Weight:	4 ounces (without PS)

Physical Layout of the Finished Oscilloscope:

Power:

The DSO150 Oscilloscope requires power from an external 9Vdc AC/DC power supply or 9V battery (NOT included). When the power is ON, the current is about 120mA.

ATTENTION: DO NOT exceed +10Vdc!

The maximum allowed signal input voltage is 50Vpk (volts peak, but some on-line sources report this as peak to peak) with the clip (1:1 or 1X) probe or 400Vpp with a (10:1 or 10X) probe (NOT included).

Assembly:

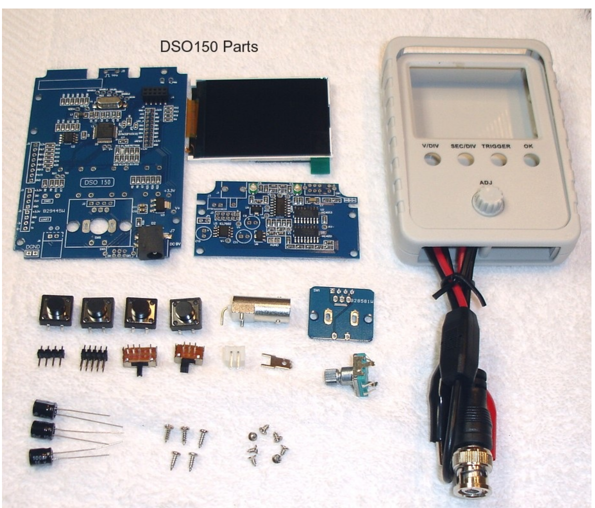
The JYE Tech Ltd DSO150 Oscilloscope can be purchased as a full kit, or with all the surface mount parts already installed. Both come with an excellent set of detailed step-by-step instructions with color photographs. As you can see from the first picture, the partial kit came with only a few remaining parts to install. Additional information can be found at the JYE website:
www.jyetech.com

Assembly will require the following tools:

Volt-Ohmmeter to check voltages and for shorts (recommended)
Needle tip soldering iron or gun
Thin electronics solder w/flux core
Fine solder wick or de-soldering braid for mistakes
Needle nose pliers
Diagonal side cutters
Phillip's head screwdriver
Small flat-head screwdriver
9Vdc AC/DC power adapter or 9Vdc battery (with adapter)

Note: Before beginning construction, identify and compare the parts you received with the enclosed parts list.

Assembly Procedures:



As I already mentioned, with the partially assembled kit, there are only a few remaining parts to install. However, soldering skills are required. If you are new to soldering, I recommend doing some practice before hand. If you do make a mistake and you create a solder bridge, use the solder wick to remove the excess solder (see comments below).

If you purchase the full kit, experienced soldering skills are required. There are full color photographs (though tiny) of each step as you proceed. I recommend you search on-line for DSO150 Oscilloscope assembly procedures.

Just a few comments regarding full assembly:

- Begin assembly by inspecting the bare board. Get a feel for the layout of the parts, part numbers, and what is going to go where. The component side is generally the side with the silk screening, but there may be some silk screening and some parts that may need to be installed on the solder side.

- I always suggest installing those components with the lowest vertical profile first. This keeps the circuit board flat and stable for as long as possible during the assembly and soldering process. So, start with any surface mounted components, while the board is empty and most stable.

- Using a spare cotton towel under the circuit board helps protect the work surface and stabilize the board during soldering.

- Some of the solder pins on this board are a bit tight and close together. If you accidently create a solder bridge across 2 or 3 pins, place solder wick over the solder bridge and carefully heat the wick only until solder flows into the wick. Take care not to overheat the component!

- While you can install components one at a time, I recommend installing all like components at the same time. For example, insert all the resistors, bending the leads slightly to keep them in place. For a small project such as this, the group method ensures that all of the resistors are of the correct value, used correctly and in their proper location, BEFORE soldering any in place! When you have found that all is as it should be, turn the board over and solder all the leads at once, clipping off the excess leads as you go.

- When you install multi-pin components, such as a switch, an IC socket or a header, always solder one lead at each end of the component first, check to insure the component is fully inserted in the board (not tilted to one side or one end is not fully seated), before soldering the remaining pins. It is much easier to fix a tilted socket with only one pin to heat to reposition the socket.

- When all the parts have been installed, it is time to visually check your work looking for solder bridges, parts with cold solder joints (meaning a poor connection, not having the same appearance of smooth solder flow as the other solder joints), or open, unsoldered joints. If you have an ohmmeter, check joints near each other for shorts.

- Finally, clean the solder side of the board. Many use a special flux cleaner product to clean the soldering side. Personally, I check each solder connection and use a fine screwdriver or dental pick to scrape away any flux residue, then use a slightly moistened toothbrush to remove the scraped residue. Do NOT get moisture on any sensitive parts, such as switches, sockets, the display circuitry, etc.

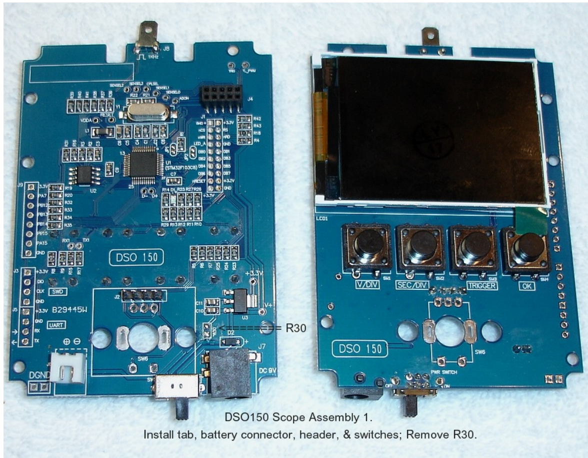
DSO150 Boot Screen 1

DSO150 Boot Screen 2

I purchased the partial kit and it included just a few parts left to install, but, surprisingly, this partially assembled board comes with the screen ready for a warranty check with power!

[ ] So, **BEFORE** mounting any parts to the main board, connect a 9Vdc power supply (center positive) to the power connector, J7, on the board to check the display.

You should see the scope boot up to a screen similar to the photo at left. D1 (LED) blinks twice. If the screen does NOT function as described above, please contact your agent for a replacement.



DSO150 Scope Assembly 1.
Install tab, battery connector, header, & switches; Remove R30.

Main Board: Please review the photo before installing the following parts!

[ ] Install the Test Signal Terminal (4.8 x 0.8mm) at J8. **Note:** Before soldering the terminal, bend the soldering tabs 90 degrees so the terminal will be parallel to the plane of the board (as shown). When complete, this terminal will stick through the top bracket of the case. Do NOT bend too far, nor attempt to adjust it after the initial bend, or the soldering tab will snap off (the voice of experience)!

[ ] There is an OPTIONAL power connector for use with a battery. However, there is no space for an internal battery, and once the case is constructed, there is no access to this connector.

I installed mine, but unless you have plans to use this board with a battery, or anything else but the normal 9Vdc power jack, I recommend skipping this step.

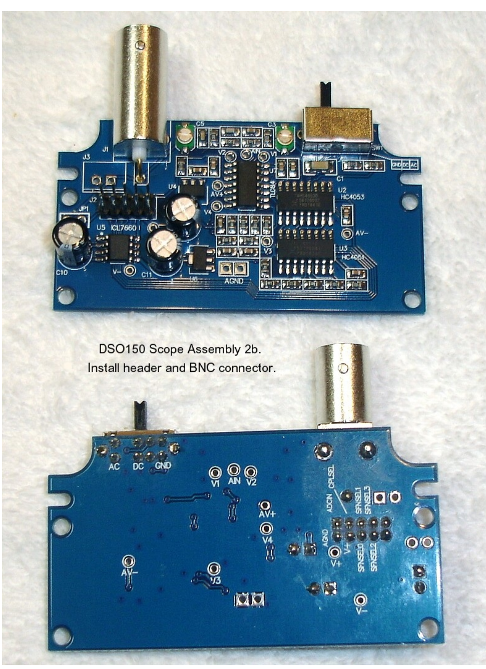
[ ] Install the DPDT (Double Pole Double Throw) switch at SW5.

[ ] Install the 1x4 pin, 0.1" pitch Pin Header at J2.

[ ] Install the four Tact Switches (12x12x7mm) at SW1, SW2, SW3, and SW4.
Note: Be careful. These are installed on the same side as the LCD screen!

[ ] Remove Resistor R30. R30 was used to bypass the uninstalled power switch, SW5, so the main board could be tested without additional circuitry. It must be removed for correct functioning of the power switch.

Note: To remove R30, let the soldering iron stay on one pad of the resistor until solder on the other pad melts, then remove the part by sliding it to the side off the pads.


DSO150 Scope Assembly 2b.
Install header and BNC connector.

[ ] Apply power again to test the power switch and tact buttons for their correct functions.

Analog Board Assembly: Note this board was different from that of the photographs in the instructions. There were no resistors or ceramic capacitors to install.

[ ] Install the 2P3T (Two Pole three position Throw) switch at SW1.

[ ] Install the three 100uF, 16V electrolytic capacitors at C8, C10, and C11.

Note: Electrolytic capacitors come with the longer lead being positive and a negative band on the case. Install each capacitor with the positive lead in the hole marked with a + sign.

[ ] Install the 2x5 pin, 2mm pitch, Pin Header at J2.

[ ] Install the BNC Connector at J1.

Note: The thicker pins need to heat up longer to get good soldering results. I suggest using a higher wattage soldering iron for these connections.

The analog board is complete.

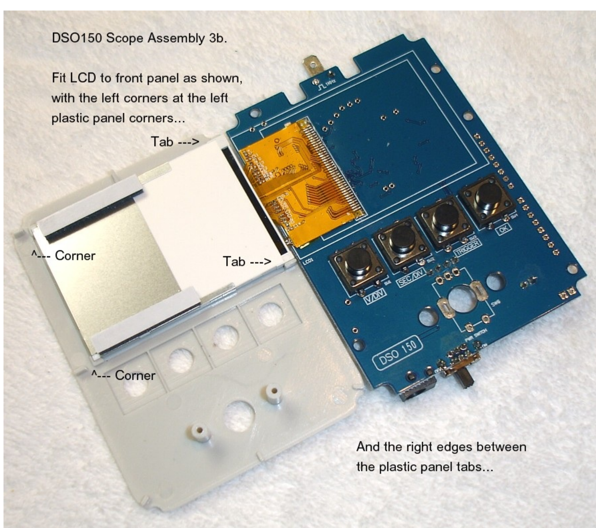
Front Module Assembly: Please pay attention to the orientation of this small PCB!

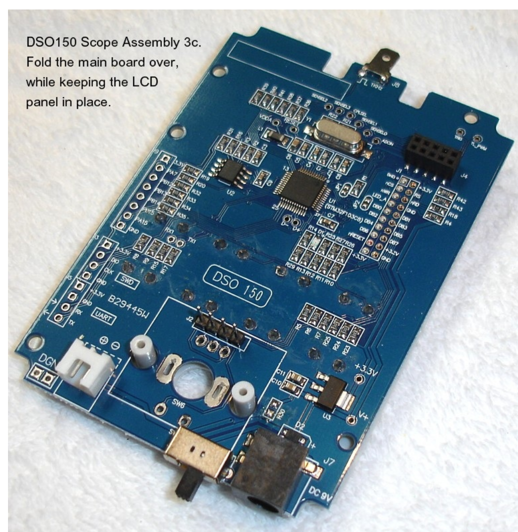
[ ] Mount the Rotary Encoder to the side of the circuit board with the silk screen box. The encoder will snap into the large mounting holes, with the various leads going into their respective small holes.

Do me a favor and before soldering, check once more that the encoder is on the side with the printed white box.

I was interrupted between doing the first and the second and distracted by having to straighten two of the pins of the encoder to fit in the holes... and installed it WRONG! I saw it while taking the photograph! It was a real bear to unsolder it - and I ruined two thin traces while wrestling with it. I finally got it, but had to solder two small wires to replace the bad traces. See the later photographs!

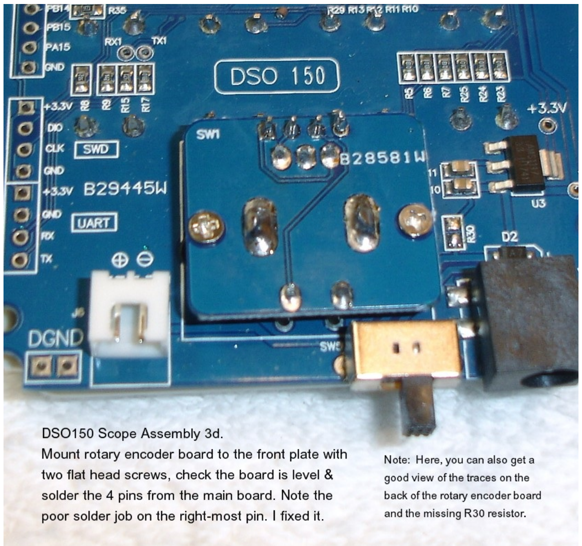
So... Double check **BEFORE** soldering!





[ ] Fit the LCD to the front panel as shown on the left. It should just fit between the plastic tabs and corners of the front panel.

[ ] Fold the main board back over the LCD panel (right photo), while keeping the LCD in place.

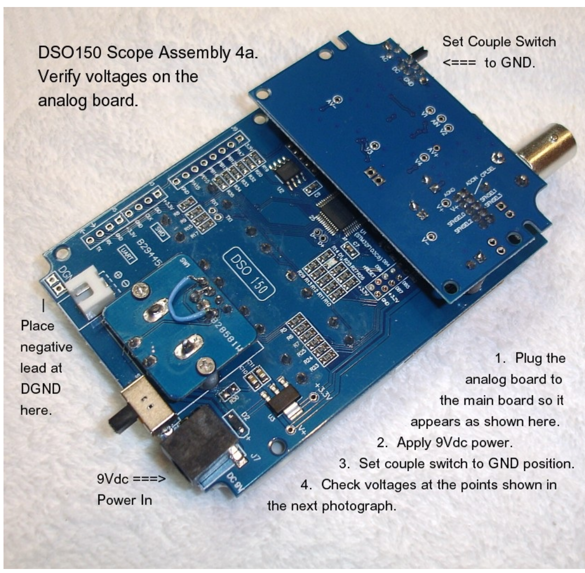


[ ] Mount the rotary encoder board to the front plate with two flat head screws. Make sure the 4 pins from the header on the main board fit in the small holes of the encoder board and that the board is perfectly level with the main board, before soldering.

[ ] Solder the four pins of the header.

Congratulations! This completes the construction of the circuit boards.

We will check all the voltages, next.



Verify voltages on the analog board:

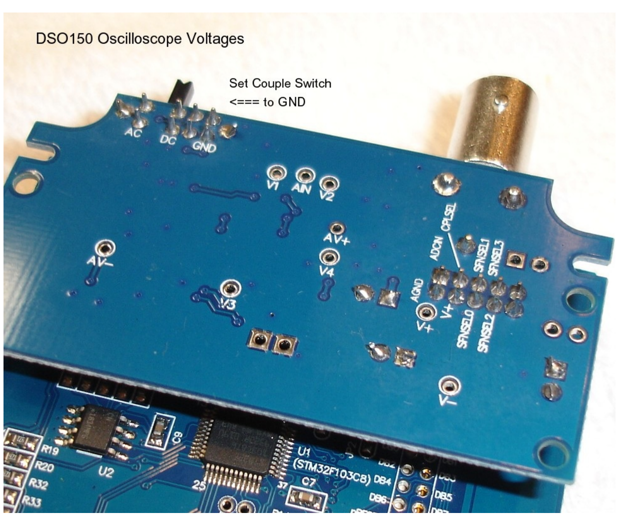
[ ] Attach the analog board to the main board by mating J2 on the analog board to J4 on the main board (see photo).

[ ] Apply 9Vdc power to J7 (or J6) on the main board.

[ ] Set the couple switch to the GND position.

[ ] Connect the voltmeter black lead to DGND, and with the red lead probe, check the voltages at the points shown in the next photo.

Note: these voltages will vary with board versions. The following list is for the "E" version (PN: 109-15001-00E).



Voltage References:

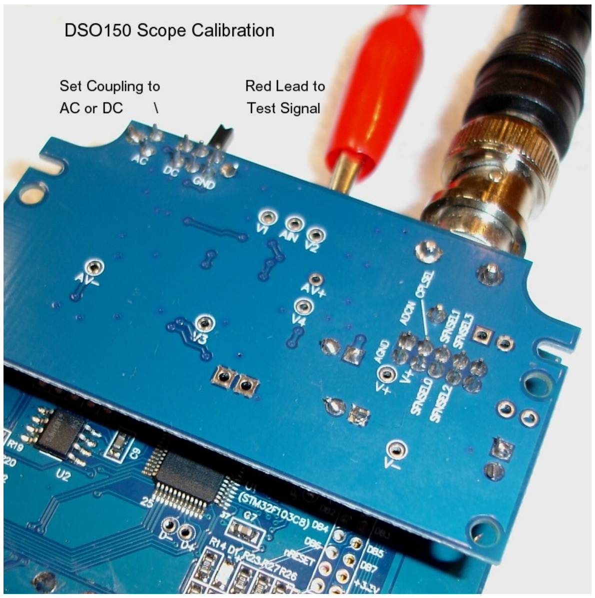
Input:	+9.30Vdc
V+	+8.35Vdc *
AV+	5.0Vdc +/-2%
V-	-7.87Vdc *
AV-	-5.0Vdc +/-2%
V1	0Vdc
V2	0Vdc
V3	0Vdc
V4	~1.65Vdc

Note: Those voltages with an asterisk (*) vary with the supplied input voltage.

Calibration:

Whether you assembled the kit, or bought one already assembled, you should check the calibration. Because there is always some capacitance between the scope input and the ground probe, the unit needs to be calibrated to achieve better measurement results for high frequency signals. If you change probes or probe cables to something of a different length, this becomes particularly important. The calibration can be easily done with the help of the built-in test signal at jumper J8.

The procedures are included with the kit, with color pictures, but in case you lost your instructions, I have included them here with a few pictures of my own:



Calibration Procedures:

[ ] Connect the test leads to the BNC input connector.

[ ] Connect the RED lead to the Test Signal terminal and leave the BLACK lead unconnected.

[ ] Set the coupling switch to AC or DC.

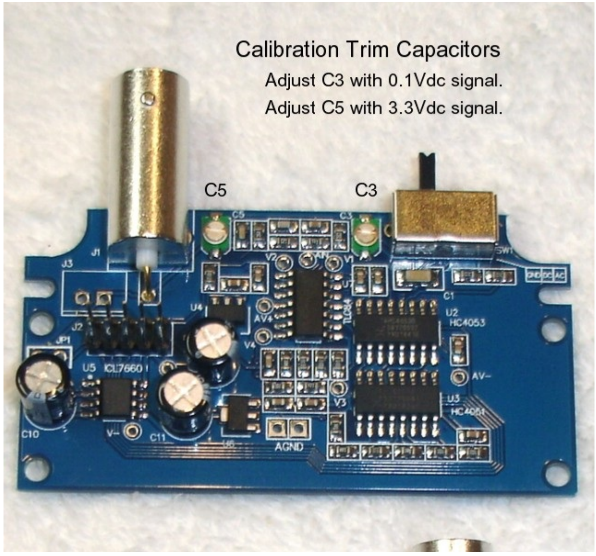
[ ] Apply power and boot. Hold down the ADJ dial for 3 seconds to bring up the Test Signal amplitude display at the lower-left corner of the display. Push ADJ to set the amplitude to 0.1v (With each press, it will alternate between 3.3v and 0.1v).

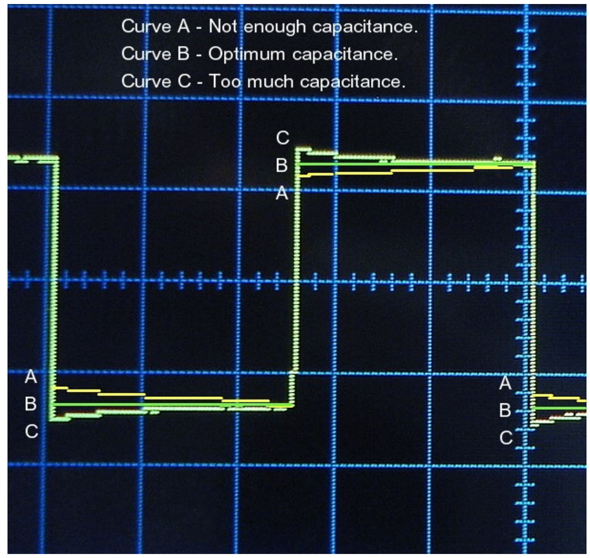
[ ] Perform the VPOS alignment by pressing the V/DIV button for three seconds. This centers the waveform on the vertical axis.

[ ] Set the sensitivity to 50mV and adjust the trigger level (the pink triangle in the right margin of the screen) so that the waveform becomes stable.

[ ] Turn the trimmer capacitor, **C3**, with a small flat-head screwdriver, so that the waveform displays a sharp right angle in the upper and lower left corners (leading edge) of the square wave. Too much and the waveform becomes a descending ramp from the leading edge of the waveform. Not enough and the leading edge will appear rounded or an increasing ramp. See the next photo.

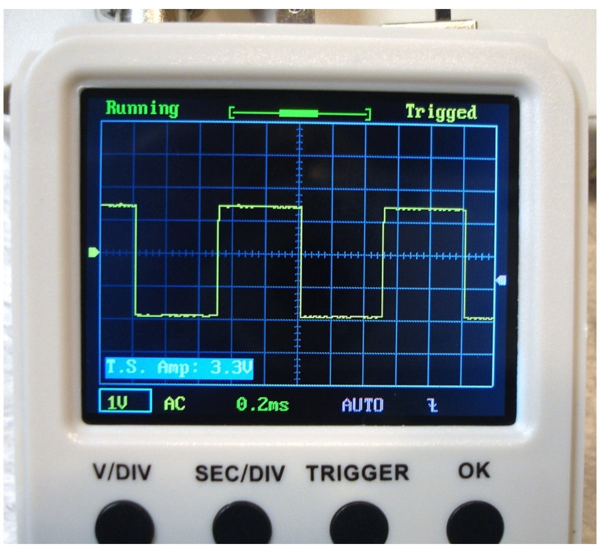
Note: These trimmer capacitors rotate through 360 degrees, generally giving two locations where the setting will be correct; one while increasing capacitance, the other while decreasing capacitance. Either location will be fine.





Note: The two trim capacitors are hard to get to when the top cover is installed, but it can be done. The photo on the left shows the location of each, before mounting on the other board and the cover is installed.

When adjusting the trimming capacitor (left photo) for each test (please refer to the right photo), we desire a right angle on the leading edge of the square wave, as close to curve B as you can get. Too much capacitance and the waveform becomes a descending ramp (Curve C) from the leading edge of the waveform. Not enough and the leading edge will become an increasing ramp (Curve A).



Referring to the photo on the left, perform the following:

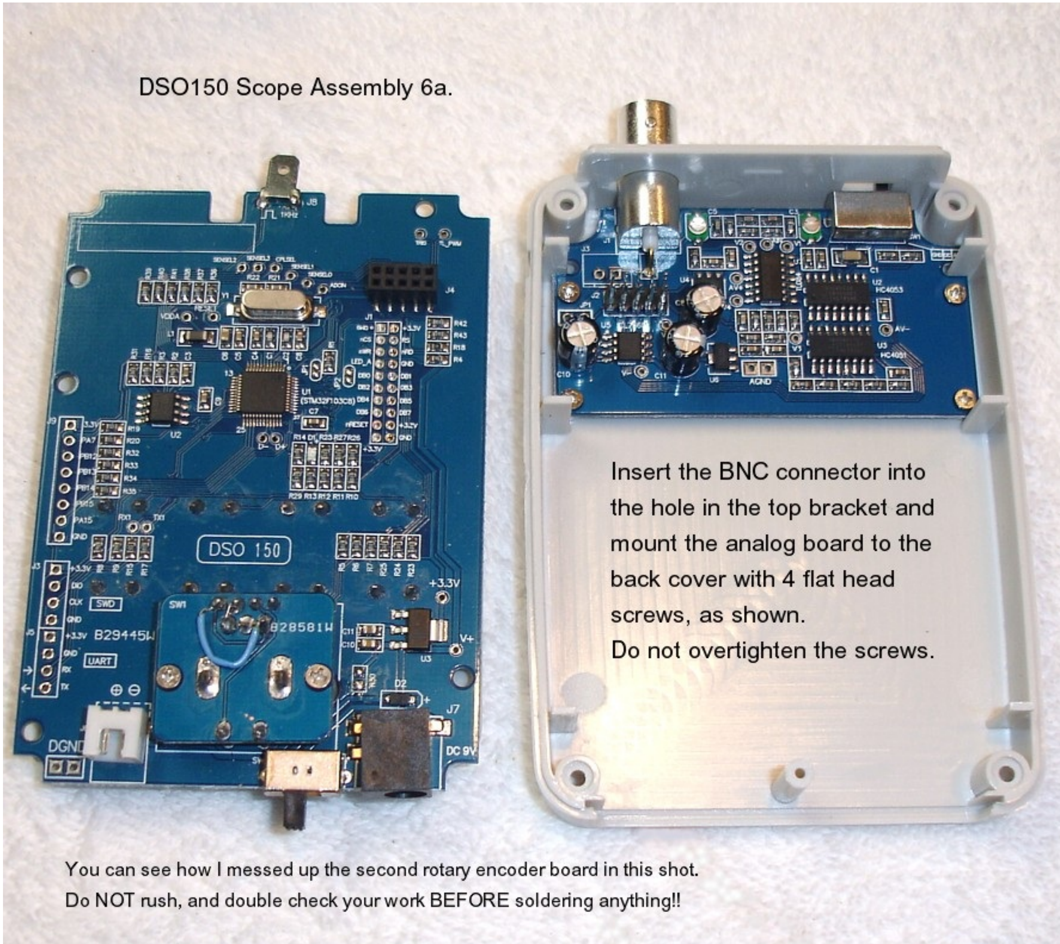
[ ] Push the ADJ dial to set the amplitude to 3.3v (With each press, it will alternate between 3.3v and 0.1v).

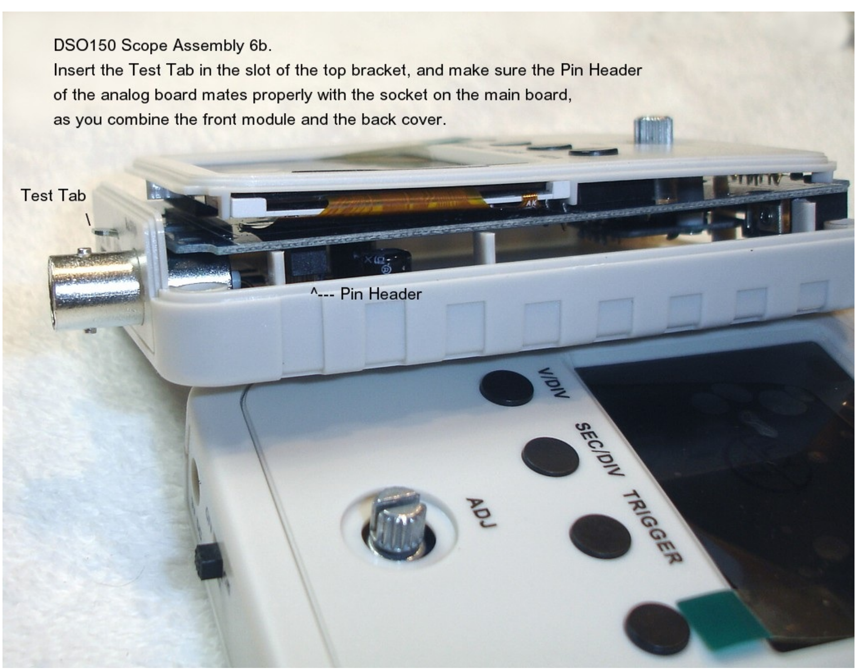
[ ] Change sensitivity to 1V.

[ ] Turn **C5** so that a right-angle leading edge (Curve B) of the square wave is obtained.

The adjustments are complete.

Final Assembly:





[ ] As shown above, screw the analog board to the back cover with the top bracket attached, using 4 flat head screws.

[ ] As shown to the left, insert the test signal terminal through the small slot in the top bracket and combine the front module and the back cover. Make sure the pin header and pin socket mate properly before pressing the two modules together.

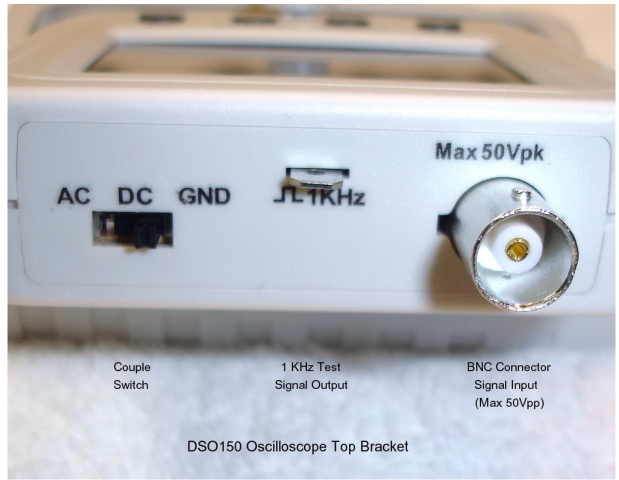
[

] As shown on the left, attach the bottom bracket before holding the two modules together.

[ ] As shown on the right, lower the front frame onto the assembly. Without forcing, press the frame and lower unit together, invert and screw the assembly together using 4 long round-head screws.

[ ] Attach the knob cap, and the unit is complete, ready for use!

Connections and Controls:



DC Power: Connect a 8-10Vdc power source to the DC power jack on the bottom bracket. The connector is 5.5 x 2.1mm with a positive center. Do NOT exceed +10Vdc! There is also a power ON/OFF switch.

Probe: Connect the oscilloscope probe to the Probe Connector. The probe is 1x and the maximum signal input voltage is 50Vpeak (100Vpp) with the clip probe.

Note: There appears to be some confusion in the on-line advertising and literature that shows the maximum is actually 50Vpp (Peak to Peak), so don't take chances. If you can purchase a 10x probe, the limit would be 10x higher, because it would reduce the signal by a factor of 10.

Couple Switch: The couple switch sets the oscilloscope coupling to AC, DC, or GND (Ground). The coupling mode selected is displayed in yellow in the bottom left corner of the screen.

Most oscilloscopes have two types of input coupling to handle both alternating current and direct current signals. Typically, a switch lets you select AC or DC to suit your measurement needs. When you set an input to DC coupling, the oscilloscope displays both AC and DC signals, although AC signals may pose a problem. By switching to AC coupling, the scope displays only AC signals; this simplifies measuring certain electronic circuits.

DC Coupling

The DC coupling setting provides a direct electrical path into the scope. It accepts all types of signals, including unchanging DC voltages, time-varying DC voltages, AC, and combinations of AC and DC. In the last case, technicians call it an AC signal with a DC offset. Sometimes, DC offsets can be bothersome; the total signal voltage may push the signal waveform past the top or bottom of the display, hiding the parts you want to see. However, under most other circumstances, DC coupling is all you need.

AC Coupling

With AC coupling, the oscilloscope's input has a capacitor in the signal path, removing the DC offset from any mixed signal and letting you see the AC part more easily. For example, some transistor and vacuum-tube amplifiers have a significant DC offset; removing it with AC coupling helps you troubleshoot these circuits. Although it is most helpful with mixed signals, AC coupling also works with pure AC signals. Because it blocks DC, it is not suitable for DC signals.

GND Coupling

When GND is selected, the scope input is isolated from the input signal and is connected to ground (0V input), disabling the waveform.

[V/DIV]: The [V/DIV] button selects the Sensitivity OR VPOS (Vertical Position Indicator), alternately with each press.

When Sensitivity is active, a blue box is placed around the yellow sensitivity value in the lower left corner of the screen. The ADJ dial then adjusts the Input Sensitivity between 5mV/div to 20V/div.

When VPOS is active, the yellow Vertical Position Indicator (triangle in the left margin of the screen) turns blue. The ADJ dial will then set the desired vertical position of the waveform.

Finally, the V/DIV button is used for VPOS Alignment, by pressing it for about 3 seconds, while the Couple Switch is set to the GND position.

[SEC/DIV]: The [SEC/DIV] button selects the Timebase or HPOS (Horizontal Position Indicator), alternately with each press. The Timebase is the horizontal axis of the display. When selected, the Timebase value appears green in a blue box at the bottom of the screen. The ADJ dial then adjusts the Timebase value from the lowest of 10us (10 microseconds) to the highest of 500s (500 seconds).

The HPOS (Horizontal Position Indicator) is a thick green line on a thin green line at the top center margin of the screen and represents the portion of the waveform displayed on the screen. When HPOS is active, the thick portion of the line turns blue and the ADJ dial can be used to move the waveform left or right to begin the waveform at any desired location at the left margin.

[TRIGGER]: The Trigger Button selects the trigger function. By repeatedly pushing the Trigger Button, the functions rotate through 3 settings: Trigger Mode, Trigger Level, and Trigger Slope (or Edge), each turning from a purple color to a blue color or blue box when becoming active.

Trigger Mode: In Trigger Mode, the ADJ dial then selects [AUTO], [NORM], or [SING], which is displayed in pink at the bottom of the display. When selected, the Trigger Mode appears pink in a blue box.

Trigger Level: A Trigger Level Indicator (triangle marker) is displayed in pink at the right margin of the screen at the appropriate voltage selected. When selected with the Trigger Button, the Trigger Level Indicator (triangle marker) changes color from pink to blue. Then rotating the ADJ dial adjusts the voltage level for the desired trigger.

Trigger State: The Trigger State, shown in the upper right corner of the screen, can have three functional states - Holdoff, Waiting, or Trigged. These states change automatically depending upon the trigger value and signal.

Holdoff: Displayed in purple, Trigger is disabled until a portion of sample buffer prior to a trigger point is filled with raw data.

Waiting: Displayed in green, Waiting means the Trigger is waiting for a valid signal slope. The desired trigger level may be outside the voltage range of the present signal waveform.

Trigged: Displayed in yellow, Trigged means a valid signal slope has been detected and registered.

Trigger Slope: A Trigger Slope symbol (rising or falling) is displayed in the lower right corner of the display to show the desired slope of the trigger. When selected with the Trigger Button, the Trigger Slope symbol appears pink in a blue box and can be changed from rising or falling by rotating the ADJ dial.

Rolling Mode: When Timebase is set to 50ms or slower and Trigger Mode is set to AUTO, the scope will automatically switch to Rolling Mode, where waveform shifts from right to left constantly. The trigger is disabled under this mode.

[OK]: The [OK] button freezes waveform refresh, entering the HOLD state. The HOLD state allows you to freeze the waveform while you study it and take voltage readings. In the upper left corner of the screen, the Oscilloscope State will show **'HOLD'** in orange. Pressing [OK] again will unfreeze the waveform and the Oscilloscope State will change to **'Running'** in green.

[ADJ]: This is a special switch with numerous press and rotating functions. As mentioned earlier, by rotating the dial it can adjust whichever of the above functions are active.

Short Press: A short press will toggle 'Fast Adjustment' Mode ON or OFF for VPOS, HPOS, and Trigger Level. A '>>' sign appearing at the top of the screen indicates 'Fast Adjustment' is ON.

[ADJ] + [SEC/DIV]: If pressed simultaneously with the [SEC/DIV] button, it will save a waveform.

[ADJ] + [TRIGGER]: If pressed simultaneously with the [TRIGGER] button, it will recall a saved waveform.

More Available Functions:

Function:	Operations:
VPOS Alignment	Set Couple Switch to GND position. Hold down [V/DIV] button for about 3 seconds.
Measurements ON / OFF	Hold down [OK] button for about 3 seconds. This will turn ON or OFF on-screen display of measurements including: Vmax, Vmin, Vavr, Vpp, Vrms, Frequency, Cycle, Pulse Width, and Duty Cycle.
Save Waveform	Press [ADJ] + [SEC/DIV] buttons simultaneously. The currently displayed waveform is saved to EEPROM. The existing data in EEPROM will be over-written.
Recall Waveform	Press [ADJ] + [TRIGGER] buttons simultaneously. The recalled waveform is always displayed in HOLD state.
Default Restore	Hold down [SEC/DIV] + [TRIGGER] buttons simultaneously For about 3 seconds.
Center HPOS	Hold down [SEC/DIV] button for about 3 seconds. This will display the data at the center of the capture buffer.
Center Trigger Level	Hold down [TRIGGER] button for about 3 seconds. This will set the trigger level to the medium value of Signal amplitude.
Fast Adjustment	Short press of [ADJ] toggles 'Fast adjustment' mode ON / OFF for VPOS, HPOS, and Trigger Level. A '>>' sign is displayed at the top of the screen to Indicate 'Fast Adjustment' is ON.

Oscilloscope Waveform Display:

The waveform displayed on an oscilloscope is nothing more than a waveform's voltage over time. Hence the vertical axis shows the voltage, and the horizontal axis represents time, generally in fractions of a second.

And while most waveforms are repetitive, such as the sine wave AC (Alternating Current) electrical power in our homes, the audio signal in our radios, or the picture signal in our televisions, some can be single-shot, like closing a switch in a circuit. All these signals are nothing more than a voltage value over time. However, unless there is some way to tell an oscilloscope where or when to begin displaying a repetitive waveform, the resulting signal is a very confusing changing measure of that voltage over time.

The oscilloscope's display is divided into dotted boxes, with each dotted box representing a division. The vertical scale represents the signal strength in volts; the horizontal scale represents time in seconds (more on this later). So, each box vertically represents the signal strength selected; 1 volt per division (dotted box) if 1V is selected. Each division is further divided by 5 marks and each dot represents 0.2 of a division on the display. Always select a scale that allows the signal waveform to fill as much of the display as possible, without losing the top or the bottom of the waveform. This improves the accuracy of signal measurements.

Example: If the upper trace covers 2 divisions and 2 marks above that, on the 1V scale, the signal would be 2.4 volts peak; and if the signal were symmetric (the same above and below the center, brighter horizontal line on the display), the signal would be 4.8 volts peak to peak.

The Timebase is the horizontal axis of the display. As we discussed regarding the voltage (Vertical) axis, each division is the dotted square, but horizontally, and each dot represents 0.2 of the next division. The ADJ dial then adjusts the Timebase value from the lowest of 10us to the highest of 500s, in the following values:

10us, 20us, 50us,
0.1ms, 0.2ms, 0.5ms,
1ms, 2ms, 5ms,
10ms, 20ms, 50ms,
0.1s, 0.2s, 0.5s,
1s, 2s, 5s,
10s, 20s, 50s,
100s, 200s, 500s

Where us is microseconds, ms is milliseconds, and s is seconds.

Oscilloscope Triggering

An oscilloscope's trigger function is important to synchronizing the horizontal sweep of the oscilloscope to a chosen point of the signal. The trigger control enables users to stabilize repetitive waveforms as well as capture single-shot waveforms. By repeatedly displaying the similar portion of the input signal, the trigger makes repetitive waveforms look static, giving us the opportunity to make measurements and analyze the signal.

Most oscilloscopes offer various types of trigger functions. Edge triggering is the most basic and common type, but threshold triggering is another type of trigger function that is offered both in analog and digital oscilloscopes.

Digital oscilloscopes, however, feature numerous specialized trigger settings not otherwise available in analog oscilloscopes. These triggers enable users to easily detect, for instance, a pulse that is narrower than usual. Such a condition would not be detected by a voltage threshold trigger only. Advance trigger controls allow users to isolate events of interest to enhance the oscilloscope's record length and sample rate. Some oscilloscopes even offer advanced triggering capabilities with highly selective control, allowing users to trigger on pulses defined by time (such as glitch, pulse width, setup-and-hold, slew rate and time-out), defined by amplitude (runt pulses), and delineated by pattern or logic state (such as logic triggering).

Other advanced triggering functions may include serial pattern triggering, A&B triggering, trigger correction, search and mark triggering, parallel bus triggering and serial triggering on specific standard signals.

However, our simple oscilloscope can only trigger on a voltage that we set. Triggers are events that indicate signal voltage crossing a set level (i.e. trigger level) along a specified direction (i.e. trigger slope, rising or falling).

Our oscilloscope has three trigger modes:

Auto Mode - In Auto Mode our oscilloscope will perform display refresh no matter if triggers happen or not. When triggers are detected, the waveform display will be displayed with reference to trigger points. Otherwise, it will display whatever waveform is detected, but at random reference points.

Normal Mode - In Normal Mode our oscilloscope will only perform display refresh when there are triggers. If no triggers happen, the waveform display will stay unchanged.

Single Mode - In Single Mode our oscilloscope works in Normal Mode, except that the display will enter HOLD state after a trigger has been detected and the waveform display has been updated.

Note: Both Normal and Single Modes are useful for capturing sparse or single waveforms.

Note: The Trigger State, shown in the upper right corner of the screen, can have three functional states - Holdoff, Waiting, or Trigged. These states change automatically depending upon the trigger value and signal.

Holdoff: Displayed in purple, Trigger is disabled until a portion of sample buffer prior to a trigger point is filled with raw data.

Waiting: Displayed in green, Waiting means the Trigger is waiting for a valid signal slope. The desired trigger level may be outside the voltage range of the present signal waveform.

Trigged: Displayed in yellow, Trigged means a valid signal slope has been detected and registered.

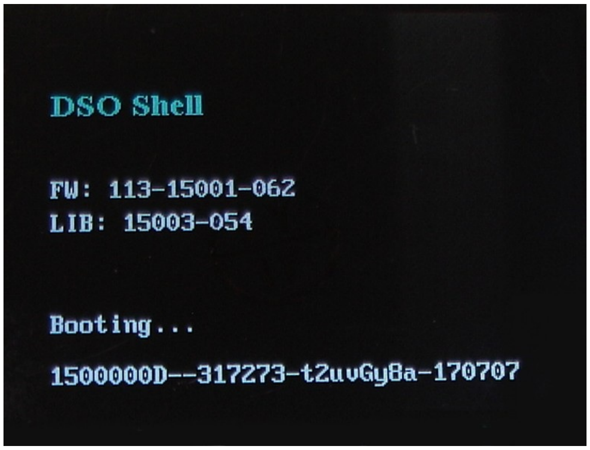
Trigger Slope: A Trigger Slope symbol (rising or falling) is displayed in the lower right corner of the display to show the desired slope of the trigger. When selected with the Trigger Button, the Trigger Slope symbol appears pink in a blue box and can be changed from rising or falling by rotating the ADJ dial.

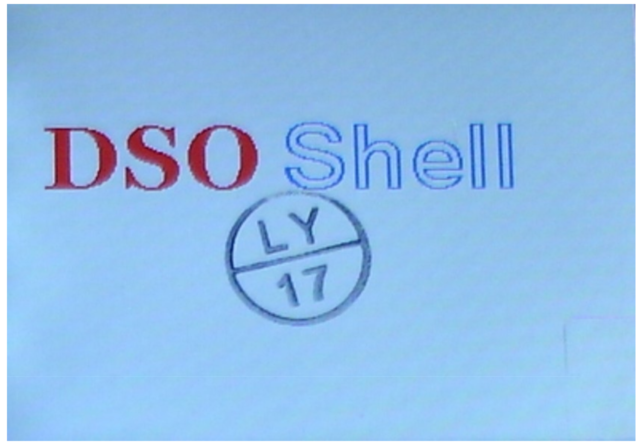
Note: The trigger slope and trigger level are best set for the fastest rising or falling part of the curve. For example, if a waveform had a fast rise time, but a really slow fall time, such as a ramp curve, it would be best to set a positive slope for the trigger and set the trigger level for the fastest rising or falling point in the curve because it would be a more accurate trigger.

Rolling Mode: When Timebase is set to 50ms or slower and Trigger Mode is set to AUTO, the scope will automatically switch to Rolling Mode, where waveform shifts from right to left constantly. The trigger is disabled under this mode.

DSO150 Oscilloscope Operation:

Operation is simple, but will take some getting used to. Plug in the 5-9Vdc power supply and turn the device ON with the ON/OFF switch on the bottom bracket. The DSO150 Oscilloscope will display two screens while powering up (booting):





And then display whatever waveform that may be present at the Oscilloscope’s Input. There is no critical function that must be done first, so let us discuss the buttons on the front panel from the left:

[V/DIV]: The [V/DIV] button selects the Sensitivity adjustment **OR** VPOS (Vertical Position), alternately. When sensitivity is active, a blue box is placed around the yellow sensitivity value in the lower left corner of the screen. The ADJ dial then adjusts the Input Sensitivity between 5mV/div to 20V/div. The object here is to simply fit the whole waveform vertically on the screen. Normally, we wish to see the entire wave, from the high point to the low point, without cutting off the top or the bottom.

[SEC/DIV]: The [SEC/DIV] button selects the Timebase **OR** HPOS (Horizontal Position), alternately. When Timebase is active, the Timebase value appears green in a blue box at the bottom of the screen. The ADJ dial then adjusts the Timebase value from the lowest of 10us to the highest of 500s. The object here is to adjust the waveform so that we see one or two whole cycles. If you see too many, rotate the ADJ dial to decrease the time period. If you see only a partial cycle, increase the time period.

[TRIGGER]: The Trigger Button selects the trigger function. By repeatedly pushing the Trigger Button, the functions rotate through 3 settings: Trigger Mode, Trigger Level, and Trigger Edge, each turning from a purple color to a blue color or blue box when becoming active.

Trigger Mode: In Trigger Mode, the ADJ dial then selects [AUTO], [NORM], or [SING], which is displayed in pink at the bottom of the display. When selected, the Trigger Mode appears pink in a blue box.

Normally, the Trigger is just set to {AUTO], but you may use the other modes, if necessary.

Trigger Level: You may need to adjust the Trigger Level to display the exact waveform or portion that you wish to view. For Triggering to work, however, the Trigger Level (the triangle in the right margin of the screen) needs to be adjusted to be within the vertical displacement of the waveform.

Trigger Slope: The trigger slope is not normally important, but is best set for the fastest rising or falling part of the curve.

Note: The trigger slope and trigger level are best set for the fastest rising or falling part of the curve. For example, if a waveform had a fast rise time, but a really slow fall time, such as a ramp or sawtooth curve, it would be best to set a positive slope for the trigger and set the trigger level for the fastest rising or falling point in the curve because it would be a more accurate trigger and less susceptible to noise.

Horizontal Position Indicator: The [SEC/DIV] button selects the Timebase **OR** HPOS (Horizontal Position), alternately. Located at the top center of the screen display, the HPOS can be adjusted along the horizontal axis so the first point the waveform curve crossing the horizontal centerline is at the left margin of the display. This permits easier calculation along the horizontal (Time) axis for determining period, or frequency of the waveform. One cycle period occurs from the first crossing of the center horizontal axis (set at the left margin, either up or down) to the next time the curve crosses the horizontal axis while headed in the same direction. When selected, the HPOS Indicator (the long, thick bar in the center of a long line representing the horizontal axis) at the top center of the display will change color from green to blue. Rotating the ADJ dial will move the waveform left or right until the waveform is beginning at the desired place at the display's left edge.

Vertical Position Indicator: The [V/DIV] button selects the Sensitivity adjustment **OR** VPOS (Vertical Position), alternately. Located at the left edge of the display screen, the VPOS Indicator is a triangle in the left margin of the display. When selected, the VPOS Indicator (triangle marker) changes color from yellow to blue. Rotate the ADJ dial to move the waveform up or down until both the top and bottom of the waveform can be seen at the same time. If the full waveform is too tall or small to see, change the Sensitivity.

Oscilloscope State: The Oscilloscope State is at the top left corner of the screen. It will display HOLD in orange or Running in green and alternates between the two settings when the [OK] button is pressed.

Trigger State: The Trigger State, shown in the upper right corner of the screen, can have three functional states - Holdoff, Waiting, or Trigged. These states change automatically depending upon the trigger value and signal.

Holdoff: Displayed in purple, Trigger is disabled until a portion of sample buffer prior to a trigger point is filled with raw data.

Waiting: Displayed in green, Waiting means the Trigger is waiting for a valid signal slope. The desired trigger level may be outside the voltage range of the present signal waveform.

Trigged: Displayed in yellow, Trigged means a valid signal slope has been detected and registered.

Couple Mode: The Couple Mode is displayed in the bottom left corner of the display. It is set by the couple switch on the top bracket to AC, DC, or GND (Ground). Please see the Couple Switch discussion above for further information on oscilloscope coupling.

What is a Waveform?

As we briefly mentioned earlier, the waveform displayed on an oscilloscope is nothing more than a waveform's voltage over time. Hence the vertical axis shows the voltage, and the horizontal axis represents time, generally in fractions of a second.

Most waveforms are repetitive. For example, a sine wave (such as 120VAC house voltage) crosses the horizontal axis in a positive direction, then at the positive peak, starts down again, crosses the axis and heads to a negative peak, where it starts heading up again to cross the axis for a second time, but in a positive direction again. A half cycle covers just the positive side (upper part of the curve) or the negative side (lower part of the curve). The entire cycle or period of the wave is the length of time to cover both the positive AND the negative part of the curve (to the exact same position in the next cycle). It does not matter which part of the curve is first (negative or positive), nor does it matter if the negative portion has the same appearance as the positive portion, as long as the period covers both segments of the curve. Also, the cycle can begin at any point in the curve to the next corresponding similar point in the curve.

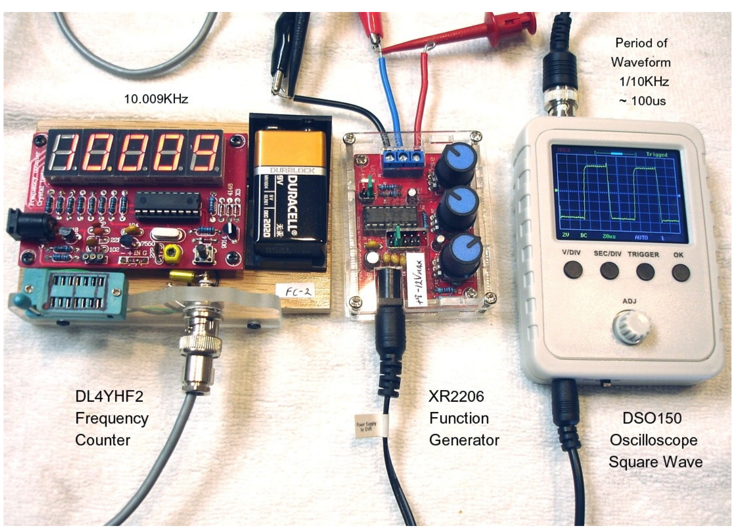
As another example, the period or cycle of the wave in our picture showing the oscilloscope controls, is the time between each negative peak (the wave has both positive going and negative going signal, but need not actually go negative in voltage), and the waveform is similar at each of these points.

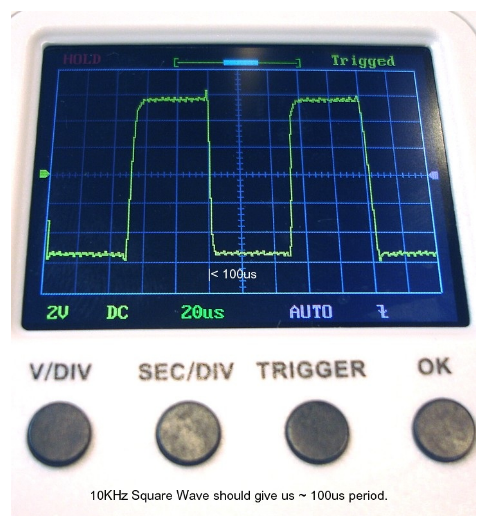
The oscilloscope allows us to measure a waveform using a time scale (the horizontal axis) with the scale determined by the Timebase, measured in us (microseconds), ms (milliseconds) or s (seconds). The cycle mentioned above is called the period of the wave. From the period of a wave, we can determine the wave's frequency, using the formula:

Frequency = 1/Period(or cycle)   or   Hertz = 1 Cycle/1 second (s)
KHertz = 1/millisecond (ms)
MHertz = 1/microsecond (us)

Similarly:
Period = 1/Frequency   or   Period (seconds) = 1/Hertz
Period (mseconds) = 1/Khertz
Period (useconds) = 1/Mhertz

For example, let us try out our new oscilloscope with some of our previous kits:





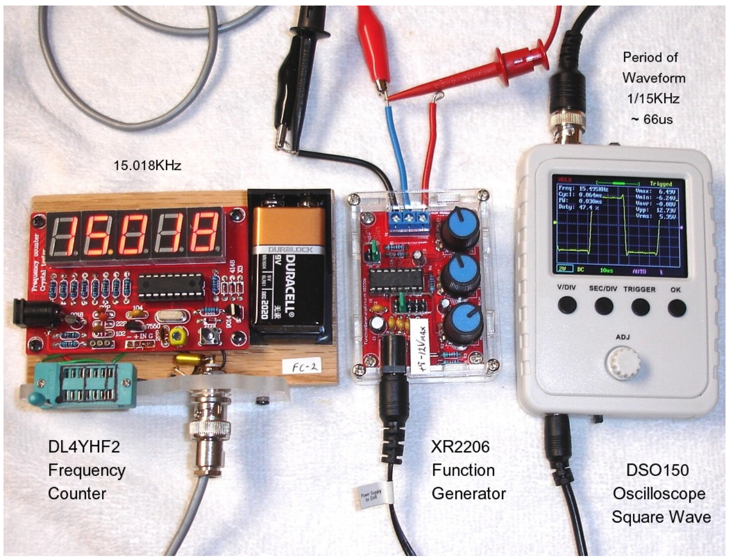
As you can see, I'm using our DL4YHF2 Frequency Counter, our XR2206 Function Generator (set for a 10KHz square wave), and our new DSO150 Oscilloscope to show the waveform.

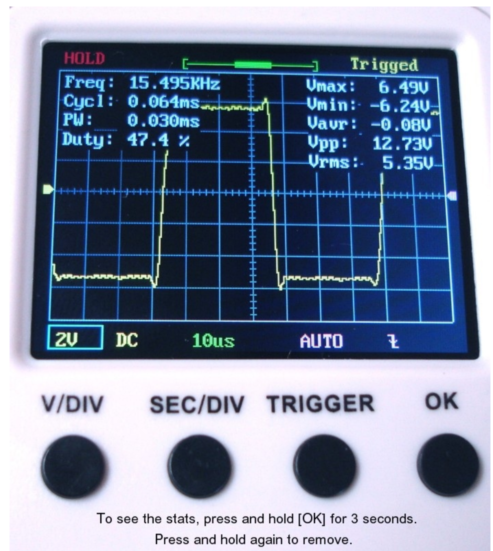
Regarding the frequency and period? As you can see, the frequency is 10.009 KHz and from the oscilloscope with the Timebase on the 10us scale, we get about 100us. Our formula shows:

Period = 1/Frequency or 100us = 1/10.009 KHz

But, which is more accurate? Well, it is obviously much more difficult to see (or determine) 100 microseconds on our small screen, the counter is obviously easier to read. However, I would think that a waveform on an oscilloscope is a more accurate representation of what is shown; it is just harder to measure visually.

Finally I want to show you one more important function with this DSO150 Oscilloscope.





I set the frequency of the square wave to 15.018KHz. If we do our calculations as before, at 15KHz, we should have a period of about 66us. But, this inexpensive oscilloscope can do all the calculations for you automatically. Simply press [OK] to hold the waveform, then press and HOLD the [OK] button for 3 seconds to get this display. Press and hold the [OK] button again to remove the stats from the screen.

As you can see, the oscilloscope reports the actual frequency is 15.495KHz. This has been consistent with all my previous measurements with the oscilloscope - the waveform's period has been slightly high at all the frequencies that I tried. So, perhaps the crystal oscillator that I used to tune the frequency counter was slightly off (low), in this case off by 3.3%. I should try tuning it again, from the oscilloscope (but who can say which is actually the more accurate).

Troubleshooting:

Problems:	Possible Causes:
Bad V+	Connector J7 defective. Diode D2 open or damaged.
Bad V-	Bad C12 and/or C13. U5 (7660) bad soldering or defective. **Hint:** Check with R27 disconnected; would let you know the issue is caused by load or source.
Bad AV-	R27 bad soldering or wrong value. Short between AV- and ground.
Bad AV+	R26 bad soldering or wrong value. Short between AV+ and ground.
V1 not 0V	SW1 not set to GND position. Bad soldering on R1 and/or R2. Bad soldering on U1.
V2 not 0V	SW1 not set to GND position. Bad soldering on R3 and/or R4. Bad soldering on U1.
V3 not 0V	Bad soldering on U1 and/or U2. Bad soldering on R5/or R6.
Bad V4	Bad soldering on R13, R14, and R15.
No Trace	Incorrect V4. If V4 is correct, perform factory default restore: Make sure trigger mode is AUTO and Timebase is 1ms. Hold down [SEC/DIV] and [TRIGGER] buttons simultaneously for 3 seconds.
Trig Level Indicator stuck in upper corner	Perform Default Restore: Hold down [SEC/DIV] and [TRIGGER] buttons simultaneously for 3 seconds.

Final Considerations:

Summary: The DSO150 Oscilloscope is next level up from the DSO138 Oscilloscope, with more functions, but same nice screen and a nicely engineered case is included. I am greatly impressed with the small size and functionality of this oscilloscope. It makes an excellent, useful addition to your electronic toolbox for a reasonable price.

I hope you find this document helpful.

If you have any comments, corrections, changes, or thoughts, feel free to contact me at:

Email: **z100lifeline@swvagts.com**