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We would appreciate your feedback for any content, style, format, or grammar issues you care to share. The most recent version is available at www.ShortSniffer.com, and you should check for an updated document before you invest significant time in learning how to use your ShortSniffer. Please send your comments to: Support1@ShortSniffer.com

Using your ShortSniffer – The Prime Directive: Locate That Short!

I know the boss is waiting and your new prototype has a short from VCC to GND and you are in a hurry to fix the problem. If you think you know how the ShortSniffer works, go find the short now, and then come back when you have more time to learn the finer details of the ShortSniffer SS3. If this is not the case, please continue through these lessons to learn how to use all the capabilities of the ShortSniffer SS3 so you will be able to locate even the most challenging shorts in a timely and efficient manner.

Definitions

Different users may refer to concepts and items with alternate terms. To avoid confusion, and to aid communication, we are defining our usage of the following terms used in this document. When these definitions are used in this document, the first letter will be capitalized to highlight the specialized usage:

Clips: The Red and Black bootable alligator Clips for test current injection.

Probes: The inductive pick-up coils (chip inductors) to detect the magnetic field created by the flow of the test current.

Drive: The amplitude control for the injected test current.

Gain: The amplitude control for the ShortSniffer's amplifiers.

Net: Two or more component terminals that are electrically connected by conductive Paths, usually Copper conductors on PC boards.

PC board: Substrate upon which components are mounted, with one or more layers of conductive Paths; often epoxy-fiberglass with chemically etched Copper conductors.

Board (without PC in front of the word): Refers to the ShortSniffer Practice Board.

Tracks or Traces: Thin conductive Paths between component terminals.

Plane or Planes: Wide areas of conductor covering most of a section of a PC board, usually used for power and ground Nets. Without capitalization, plane refers to the geometrical term, and is used as a directional reference.

Sound: The Sound produced when the inductive pick-up coil is sensing the injected test current Path. The relative volume indicates the strength of the received signal, determined by the Probe's orientation and distance with respect to the current Path. The frequency is fixed and is that of the test current.

Null: a condition of balanced or cancelled signals obtained by rotating the Probe 90 degrees from the maximum Sound orientation, resulting in no sound. This orientation produces the best sensitivity when trying to detect the direction of the current flow Path, which is in the plane of the probe PC board at the null rotation.

Path: The Path is the minimum resistance route between the two Clips. Since the current follows the “Path of least resistance”, the center of the Path is the location where the Probe picks up the maximum amplitude Sound. Our goal is to locate and follow this Path as we “Follow the Sound to the short.”

Wave or Waving: This is the action of moving the Probe back-and-forth in the plane of the Probe PC board as the Probe is moved perpendicular to this motion. The Waving action is guided by your ears to stay centered on the injected test current Path.

Sweep or Sweeping: This is the same motion as Waving, but with the Probe rotated 90 degrees about the long axis.

The word Right will be limited to direction (Right-left), and not mean “correct”.

Top, Up, Upwards, Bottom, Down, Downwards Front and Back are defined in the ShortSniffer Practice Board Orientation and Usage section of this document.

ShortSniffer Overview: How can it locate my short circuit fault?

The ShortSniffer injects an audio current into a conductive circuit, allowing the current Path to be followed with the non-contact inductive pick-up Probe. The basic short circuit locating principle can be reproduced with a signal generator, an inductive pick-up coil, an amplifier, and a speaker. The ShortSniffer SS3 has been designed for convenience and optimized for PC board short circuit locating performance. Most short circuits are “dead shorts”, usually less than 1 Ohm, and there is little ambiguity in applying the ShortSniffer motto: “Follow the Sound to the short.” Your ears allow you to guide the pick-up Probe along “the Path of least resistance” towards the short circuit fault. For occasional higher resistance “short circuits,” parallel components may cause a significant fraction of the ShortSniffer’s test current to flow through an alternate Path. Power Planes and power grids can provide multiple current Paths to the short circuit, often cancelling the sensed magnetic fields, producing confusing results. Proper use of Drive, Gain, and Slope controls will improve your ability to follow the correct Path in these special cases.

The ShortSniffer is designed to work on un-powered circuits, so please remember to disconnect power from your circuit to allow the ShortSniffer to perform as intended.

The short circuit locating steps are:

1. Identify the shorted Nets. First, you must know which Nets on your PC board are shorted together so you can select locations to connect the test current injection alligator Clips. This “shorted Net” identification is most often done with an ohmmeter or by observing waveforms with an oscilloscope. The ShortSniffer cannot tell you which Nets are shorted together, but it can show you where the short occurs on a previously identified pair of shorted Nets.
2. Connect the current injection alligator Clips to the two shorted Nets. If there are no easy contact points, you may need to solder short extension wires to the Nets, providing contact points for the the alligator Clips.

3. Connect the pick-up Probe cable to the Probe jack (USB-A style connector) on the side of the ShortSniffer, and then adjust the ShortSniffer controls as necessary for the short location search. The term “as necessary” is a little vague at this point, but the ShortSniffer Practice Board will teach the proper use of the controls.
4. Wave the Probe around the PC board and “Follow the Sound to the short.” Yes, more vague words; but true for a great many shorts. The most difficult shorts can be quite a challenge, like all good puzzles, but finding them will be both entertaining and satisfying.

Motion terminology

The main action of the ShortSniffing process is to move the Probe, guided by the Sounds you hear. The Sounds are related to the current flowing through the Path of least resistance to the short circuit location. To determine the center of the Path, a side-to-side action (parallel to the plane of the Probe PC board) will be used. The Sound gets louder as we approach the center of the injected test current Path, and quieter as we swing the Probe past the center of the Path. This action is called “Waving”, and is typically 1cm to 2cm wide, but reducing in width to finally pinpoint the location of the short. While Waving the Probe and following the center of the Path, we move the Waving Probe perpendicular to the Waving action, traversing the Path of the current, with location of the short as our goal.

An alternative to the Wave is sometimes used, where the action is the same, but the Probe is rotated 90 degrees. This “Sweeping” action is used to follow a Null (no Sound) Sweep along the known center of a current flow Path, yielding better angular direction results. The practice lessons teach this valuable ShortSniffing technique.

Cables and Probes

The current injection cable has an RCA plug on one end and a pair of alligator Clips on the other end. The alligator Clips connect to the shorted PC board, wires, or other grabbers used to make electrical contact with the electrical Nets that are shorted together. We will refer to the cable as the “Clip Cable”, and the current injection Clips as the “Clips”, or “Red Clip” and “Black Clip”. The Red Clip acts as “positive” in conditions where polarity may be important.

The pick-up Probe cable is a standard USB-A to Mini-B cable and can be replaced with any reasonably high-quality cable less than 2m long. The USB-A end plugs into the side of the SS3, and the Mini-B end plugs into the Probe (the inductive pick-up Probe assembly). The basic SS3 package comes with a single Probe (Normal Probe) that covers most short circuit locating needs. The additional Probes that come with the “Pro” package (Sensitive and Tiny Probes) can also be purchased separately. The tip of the Probe holds the inductive pick-up coil and is where the current sensing occurs. The Probe is sensitive to current flowing perpendicular to the plane of the Probe PC board, across the current sensing coil. It cannot sense current that is flowing parallel to the plane of the Probe PC board, along to the length of the current sensing coil. The Red LED near the Probe tip lights when the detected signal is coming towards the LED from the Red Clip. We will refer to the cable as the Probe Cable, the pick-up Probe assembly as the Probe, and to the RED LED on the Probe as the Probe LED. We will often use the term Probe to refer to the tip of the Probe as we are placing it near the current Paths.

Headphones

When instructed to plug in a stereo headset, the headphones can be placed on your head, over, or near your ears. In quiet working environments, I usually just place them around my neck. To detect the most subtle differences in Sounds, you should place the headset over your ears.

Polarity Convention:

For many short circuit location needs, knowing the direction of current flow is not important, but there are times when knowing if the current is “coming or going” helps reduce confusion. In particular, power Plane shorts or circuits that have a grid of interconnected Traces can be quite confusing. The SS3 Clip Cable has color coded (Red and Black) alligator Clips to identify the polarity of the injected current. Since the SS3 detects the direction of current flow, the Probe LED lights when it is picking up a signal coming from the Path to the Red Clip. This condition will also be louder in the Right ear of the stereo headphones. Most headphones are marked so you can find the correct Right-left orientation. These lessons assume that you are using headphones with conventional wiring of the center pin for the left channel.

Remember the “Three Rs”:

1. The pick-up Probe Red LED lights
2. when pointing towards Red Clip
3. and makes Sound in Right ear.

User controls and Connectors

The headphone jack and the Probe connector are on the side of the SS3



Figure 1

The Probe connector fits a standard USB-A type cable.

The user controls protrude from the front of the SS3 on either side of the Clip cable jack (labeled Out) in the center of the front panel. The Drive and Slope controls are on the left side, while the Gain control and Power switch are on the Right side. The green LED will light when the power switch is in the 1 (On) position.

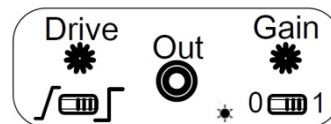


Figure 2

The user adjustable controls (ignoring the power switch) are:

1. Drive: The Drive knob adjusts the peak amplitude of the current pulses fed to the Red and Black Clips and can vary the current over a 50:1 range, with a peak current of about 3 Amps. The injected current amplitude is limited by the resistance of the short, with the peak voltage clamped by a pair of Silicon diodes to limit the voltage applied to your shorted PC board. These diodes also protect the ShortSniffer from accidental connection to charged elements in your circuit.
2. Slope: The Slope switch selects between the Slow Edge (left) and Fast Edge modes for the Drive pulses applied to the shorted Nets. The Fast Edge mode provides stronger signals and superior stereo image resolution for most ShortSniffing work but temporarily switching to the Slow Edge mode can reduce the effects of the injected currents flowing through higher value (>1uF)

parallel capacitors by a factor of 10, helping you to follow the correct Path to the short circuit location.

3. **Gain:** The Gain knob adjusts the amplifier Gain on the pick-up Probe amplifiers. This control is like a volume control and is often used for that purpose. The Gain control can vary the Gain over a 100:1 range, and if it is set too high, there may be objectionable background noise, along with distortion of stronger signals. The Gain is often set to minimum (CCW) and should generally be used at less than 75% maximum rotation. The highest Gain setting allows for detecting the faint current signals in high resistance “shorts” (> 100 Ohms) and some power plane shorts.

ShortSniffer Practice Board Goals:

The ShortSniffer Practice Board was crafted to teach the non-obvious details of the ShortSniffer SS3 short circuit locator product. These lessons will teach both the controls of the SS3, and the actions required for locating the short circuits. Since most short circuits are “random” in occurrence, we have had to resort to trickery to simulate the characteristics of real short circuits for these training exercises. A short circuit caused by a PC board defect or a defective soldering operation, often called a “dead short”, is usually much less than 1 Ohm. Other components in parallel with the short have higher effective resistances so the short circuit fault provides an overwhelmingly obvious low resistance Path for your short circuit location effort. With higher resistance short circuit faults, parallel PC board components often provide alternate Paths for the injected test current to flow, with confusing results to your locating efforts. For example, a parallel 10 Ohm resistor, 1uF capacitor, and a forward biased diode junction may have similar Sounds. Several lessons will help you master the SS3 controls so you can reduce the effects of these false Paths.

The teaching goals of the Board are:

1. Introduce the principles of the ShortSniffer non-contact short circuit locating system.
2. Demonstrate pinpoint location of a short circuit where the Sound indicates that the current Path makes a U-turn or concentrates into a narrow channel where one Plane is shorted to another Plane or a Net.
3. Teach the skills of following a higher resistance Path, and show how to identify, minimize, or ignore the effects of parallel false Paths.
4. Show the techniques to master power Plane ShortSniffing.

ShortSniffer Practice Board Orientation and Usage:

Unless otherwise instructed, position the Board so the end with TP7-TP10 is Down, with TP6 on the left. Directional references will be as follows:

- Top, Up, Upwards: the side of the Board with TP1-TP5
- Bottom, Down, Downwards: the side of the Board with TP7-TP11
- Front Side: TP6 on the left side
- Back Side: TP6 on the Right side (turn Board over)

The Setup section of the ShortSniffer Practice Board lessons will specify both the control settings and the Clip colors, and test point locations (TP1, TP2, etc.). To connect a Clip to a test point, squeeze the back of the Clip to open the jaws, insert one jaw into the test point hole with the other jaw on the outside Board edge, and then release the Clip. You may find it convenient to connect the Clips from the back side of the Board, and to hold the Board in one hand while positioning the Probe with your other hand (but do not try to adjust the Drive and Gain controls with your teeth).

Lesson Troubleshooting

If you lose the Sound while manipulating the Board, a Clip has probably rotated to be parallel with the Board. Re-position the Clips and the Sound should return.

If you allow the Clip wires to get too close to your search Path (like under the Board), you will sense currents flowing in those wires with confusing results.

If you can hear Sound in only one ear (even after rotating the Probe 180 degrees), or if there are intermittent audio drop-outs, press the headphone plug so it seats firmly in the headphone socket.

If you are ever in doubt of the ShortSniffer's functionality (no Sound can be heard), set Drive and Gain to maximum (CW), connect two Clips together and Wave the Probe across the Red and Black wires. If you hear Sounds when you do this, and you don't hear Sounds when you connect the Clips to your circuit, your circuit is not shorted at the location of the Clip contacts.

If you are hearing strange sounds as you move the Probe around your environment, you may be picking up magnetic signals from nearby power transformers or fluorescent lighting. Move to more "electrically quiet" location to continue your ShortSniffing.

If you hear a continuous tone, regardless of Probe position, the battery may be providing less than 7V and needs to be replaced.

If the Green Power indicator LED does not come on, replace the 9V battery.

As you go through the lessons, you will master the controls of the ShortSniffer and discover the relationship between many of the confusing ways that current will flow in Traces, Planes, and components. Each lesson will show at least one of these principles, with some lessons teaching both the adjustments of the controls, and the various ways to attack difficult short circuit locating problems.

Lesson contents

The lessons will also contain reasons for the actions and additional guidance to help you understand the finer details of locating the most difficult short circuits. The major concepts have been highlighted to not be lost in the process details.

Lesson 1: A simple short circuit between two parallel Traces.

The common parallel Trace shorts are the easiest to locate, even if the Trace routing goes all around a large PC board with many branches, like the data bus on a mother board. Once you have identified the Nets that are shorted together, connect the Clips to those two Nets. It doesn't matter that the data bus branches all over the PC board, because the injected test current follows the Path of least resistance to the short. This lesson teaches the most basic principle as you "Follow the Sound to the short."

Goal: Locate the short.

Setup:

1. Connect the Clip Cable to the OUT jack on the front of the ShortSniffer. Plug the Probe Cable into the side of the SS3 and attach the "Normal" Probe to the other end of the Probe Cable.
2. Set the power switch to the "1" (ON) position. The front panel green LED should be on.
3. Set the "Slope" switch to the "Fast Edge" (Right) position.
4. Rotate the "Drive" knob CW (clockwise) for maximum Drive.
5. Rotate the "Gain" knob CW for maximum Gain.
6. Connect the Red Clip to TP6 and the Black Clip to TP10.
7. Hold Probe so the Probe LED faces Down (towards you).
8. Do not plug in the stereo headphones at this time.

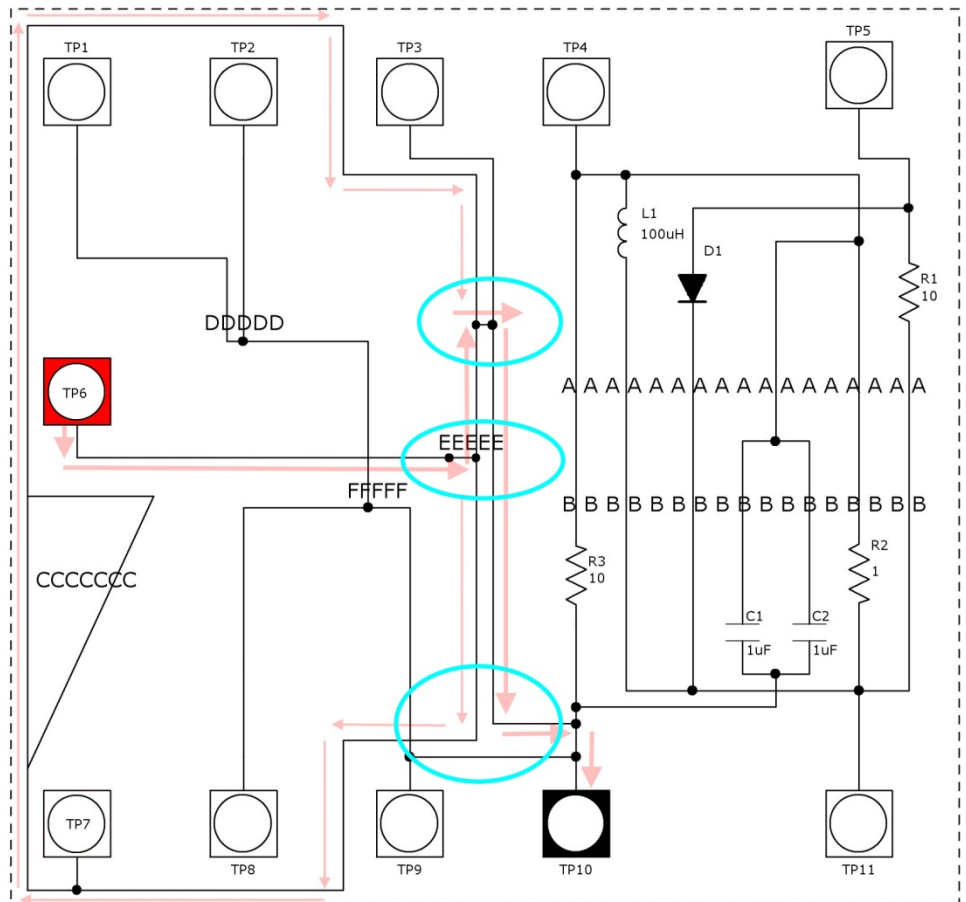


Figure 3 – Lesson 1

Actions:

1. The highest Gain settings amplify noise signals that can turn on the LED. Slowly rotate the Gain control CCW until the LED turns off.
2. Bring the Probe near the Red wire of the Clip Cable. You should hear a Sound, and the Probe LED will light.
3. Move the Probe over the Black wire. You should hear a similar Sound, but the Probe LED will not be lit. If you rotate the Probe 180 degrees, the LED will light on the Black wire and not on the Red wire.
4. Wave the Probe tip over the two current wires at different distances (5-10cm) to become familiar with the Sound and distance characteristics of the system. **Notice that there is a Null point between the two wires where no Sound is produced (where the magnetic fields of the outgoing and incoming currents cancel).** Notice, also, that the system is way too sensitive for fine-detail location at the higher Gain settings.
5. Locate the Probe over the Red wire and rotate the Probe about its long axis. Notice that the maximum Sound volume can be obtained for about +/- 60 degrees of rotation. Continue rotating the probe to notice the extreme sensitivity of the Null (no Sound) condition as the Probe reaches 90 degrees. Deviations of less than +/- 5 degrees from the Null condition are easily heard. By observing the Null orientation, you can obtain a very good indication of the direction of the current flow, which is parallel to the Plane of the Null-oriented Probe PC board, which is also to the axis of the leads of the pick-up coil. Practice by moving the probe along the wire, adjusting the rotation as necessary to maintain the Null.
6. Rotate the Gain control to the full CCW (counter-clockwise, minimum) position, and then Wave the Probe over the wires. Notice that the Probe must be much closer to the wires (0.5-1cm) to produce Sounds.
7. Place the Probe on the Board between TP9 and TP10. Begin Waving the Probe back-and-forth, listening to the Sounds, and then slowly moving the Probe Up. As you pass the EEEEE text, notice that the Sound changes to a double pulse with a Null (no Sound) between the two Sound pulses. The left Sound will also light the Probe LED. Continue slowly moving the Probe Up, guided by the Sound pulses as you Wave the Probe Right and left over the Traces on the Board. Notice that the Sounds will stop about 1cm above the EEEEE. Wave the Probe around the area where the Sounds stop while you look at Figure #3 and think about what's going on here. The injected test current is flowing from the Clips through the Traces on the Board, out to the short circuit, and back to the Clips. The Probe is picking up the Sounds, and the area where the double pulse cannot be heard is beyond the short circuit current Path. **The area where the Sounds stop is the place where the current jumped from one Trace over to the other Trace, to head back to the Clips.** If you look closely in this area, you can see the small Trace that shorts the two main Traces you were following. You have found the short circuit location! Notice the 2 parallel current paths between EEEE and the short in Figure #3. Current in the primary Path (fat arrows) flows from TP6 across to EEEEE, branches Up, jumps across at the short, and then Down (reversing direction) towards TP10. The secondary Path (thin arrows) branches Down at EEEEE, traveling CW around the outside

loop, and then rejoins the primary Path at the short, continuing towards TP10. Since both Path's Traces are of similar widths, but their lengths are different, the resistance of the primary (short) Path is much less than that of the secondary (longer) Path, so the sound is much louder in the primary Path. The currents flowing in the secondary Path can be heard at higher Gain settings or by using the headphones.

8. Locate the Probe between the EEEEE text line and the short, where you can hear the Sound, and then rotate the Probe about 90 degrees for a Null. If you do hear Sound while moving the Probe, rotate more or less to maintain the Null condition. Move the Probe Up, and you will hear a Sound where the current jumps across from one Trace to the other Trace. If you slide the Null oriented Probe up and down over this location, the maximum Sound volume is the center of the location of the short.
9. Advanced Actions:
 - a. Reduce the Drive level until you can barely hear the Sound. Move the Null-oriented Probe up and down. Notice that the target area has been reduced from several mm to a much smaller area.
 - b. Plug in a stereo headset and turn down the Drive level even further to get an even smaller short location radius.
 - c. Explore both current Paths to become familiar with the nature of stereo headphone ShortSniffing.
 - d. Turn the Board over, and then try to find the short from the back side of the Board.

Lesson 2: Current flow direction, and when it might be important.

Most shorts are relatively easy to locate, with a direct Path from the test current injection points to the location of the short. “Follow the Sound to the short.” is quick and easy. Sometimes, the direction of the current flow can help you avoid the confusion when your Path begins to lead you away from the short instead of towards the actual location. This lesson will try to fool you, and then teach you how to not be fooled again.

Goals: Follow the current Path and watch for current direction.

Setup:

1. Connect the Clip Cable and the Normal Probe to the ShortSniffer.
2. Set the power switch to “1”, “Slope” switch to “Fast Edge” (Right), “Drive” to maximum (CW) and “Gain” to minimum (CCW).
3. Connect the Red Clip to TP6 and the Black Clip to TP7.
4. Do not plug in the stereo headphones at this time.

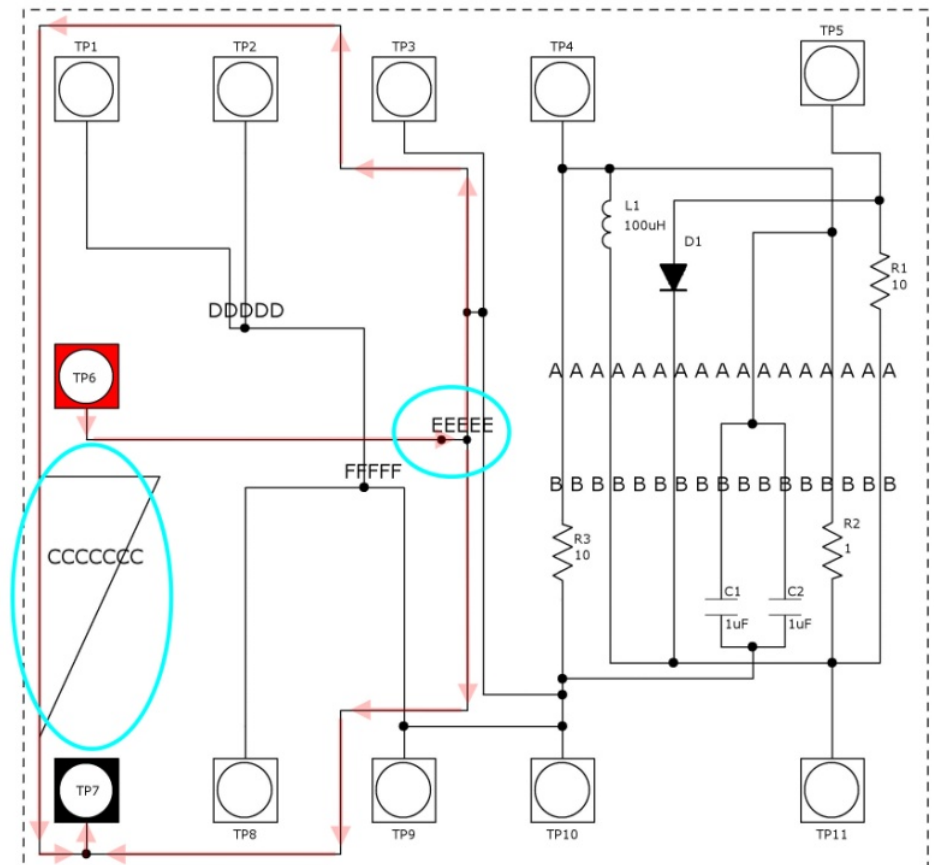


Figure 4 – Lesson 2

Actions:

1. Position the Probe over the vertical Trace above TP9 and TP10, with the Probe LED facing Up.
2. Start Waving the Probe across the Trace. Continue the Wave action and start moving the Probe Up, while listening to the pulsing of the Sound. Stop the action when you reach TP3

and TP4. You may have noticed a discontinuity in the audio Sound as you passed the “EEEEEE” label.

3. Again, position the Probe over the vertical Trace above TP9 and TP10, but with the Probe LED facing towards you.
4. Begin Waving the Probe across the Trace and moving the Probe Up while listening to the pulsing of the audio Sounds. Watch the Probe LED as you pass the “EEEEEE” label and notice that the Probe LED lights. Bring the Probe back towards the “EEEEEE”, and then rotate the Probe CW 90 degrees and continue to follow the Sound (and Probe LED) to the Red Clip. This circuit was designed to have a confusing, but educational dual current Path, with the current from TP7 splitting, flowing opposite directions in the two Paths forming a rectangle around the left half of the Board. The Paths join at the Trace that leads to TP6.
5. Advanced Actions:
 - a. Plug in a stereo headset and place the Probe on the vertical Trace above TP9 and TP10 with the Probe LED towards you. The Probe LED should be off. You should hear a fairly loud Sound in the left-center of your head. As you slowly rotate the Drive knob CCW, you will hear the volume reduce, while the Sound moves more to the left of your head, and then back to the left-center of your head as the volume is reduced to a minimum.
 - b. Rotate the Gain knob CW, listening as the faint center Sound gets louder, shifts over to the left side of your head, and then shifts back to left-center with significant background noise. Try various combinations of Drive and Gain to hear the similar, yet different effects they produce. For best directional determination, the near-maximum Drive and minimum Gain generally give the best signal to noise ratio. **If the amplified signal is too large, it bleeds into the opposite stereo channel, moving the apparent Sound towards the center of your head.**
 - c. Place the Probe over the Trace above TP9 and TP10, and then re-adjust the Gain to minimum (CCW) and adjust the Drive for the most volume that still has the stereo position at the left side of your head. Move the Probe to the “CC..CC” text, and then begin a Waving and Sliding action as you explore the narrow and wide ends of the triangular Trace/Plane shape. Notice how the increased current density produces louder Sounds as the current conduction Path narrows. Explore the “split current” rectangular Path, following the Sound completely around the Trace loop. **Remember that if you lose the Sound, the current has gone somewhere else and a 90-degree rotation of the Probe will usually bring back the Sound.**
 - d. Your ears are very sensitive, but the Probe LED driver circuit won't respond to the weaker signals that you can hear. Position the Probe around above the “EEEEEE” text line and adjust various Drive and Gain settings while watching the Probe LED to observe the limits of the Probe LED on weaker signals. If the Probe LED is important for your tracing needs, adjust the Drive and Gain controls above these minimums.
 - e. For extra practice, turn the Board over and perform the same actions from the back side of the Board.

Lesson 3: Current flow in overlapping Planes with current crowding.

Signal Paths in Planes suffer from low current densities (lower volume levels of the Sound you hear) as the current spreads out in the Plane, but the current still has to concentrate at the short circuit. This lesson illustrates the reduced signal strength resulting from the lower current densities and shows that the current must crowd back together at the location of the short.

Goals: Follow the current Path, locate the short, and explore current density.

Setup:

1. Connect the Clip Cable and the Normal Probe to the ShortSniffer.
2. Set the power switch to "1", "Slope" switch to "Fast Edge" (Right), "Drive" to maximum (CW) and "Gain" to minimum (CCW).
3. Connect the Red Clip to TP8 and the Black Clip to TP9.
4. Do not plug in the stereo headphones at this time.

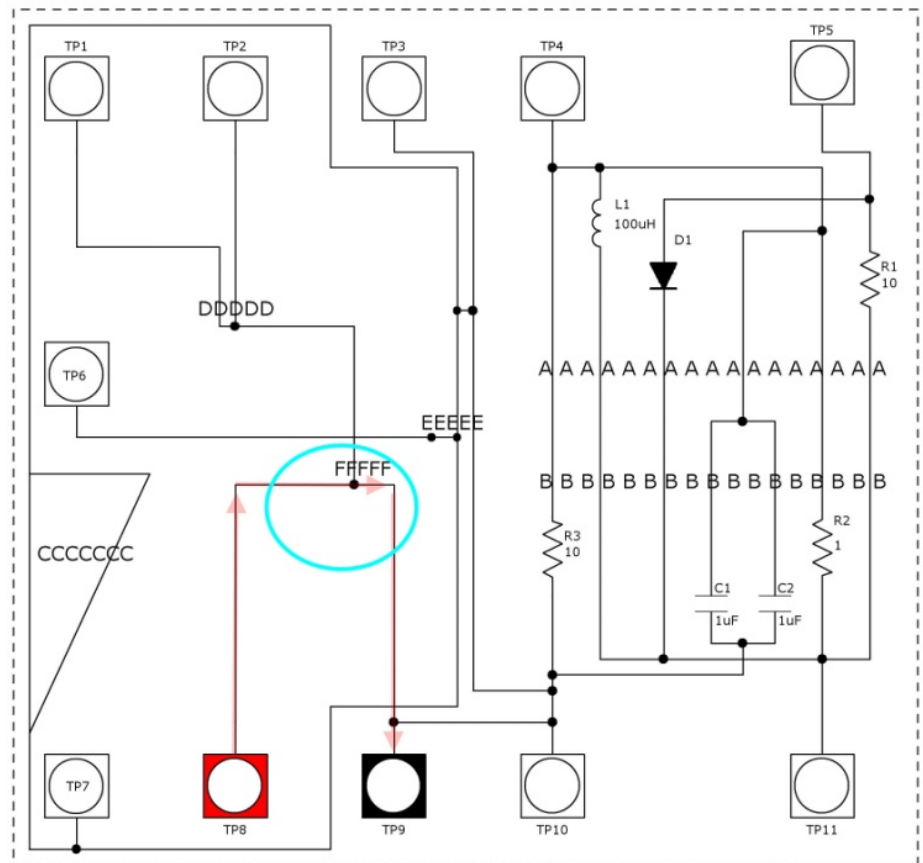


Figure 5 – Lesson 3

Actions:

1. Position the Probe at the TP8 label with the Probe LED facing you. The Probe LED should be lit and the Sound audible.
2. Move the Probe Up, along the current Path, while listening and watching the Probe LED. Follow the wide Trace up from TP8 and onto the wider Plane area, and then back down towards TP9, rotating the Probe (or the Board) to maintain the Sound and Probe LED status. This is the

general Path of the current. Notice that we were moving “backwards”, travelling away from the way the Probe LED was pointing. The direction used to follow the Path is not important, since the Path is a loop between the two Clips. The Probe LED lights when sensing signals and pointing towards the Red Clip. If the Clips were reversed, the Probe LED would light when pointing in the opposite direction.

3. Start again at TP8, Waving the Probe from TP7 to TP10. While maintaining this wide Waving action, slowly move up towards the middle of the Board. Notice that the Sound volume reduces as you approach the “FFFFF” label.
4. Start again at TP8, with a Sweeping action (rotate the Probe 90 degrees CW, Probe LED to the left) while you slowly move up towards the middle of the Board. Notice that you begin the Sweeping action with no Sound, and that the Sound starts as you near the wider Plane area. This is because the current in the two wide Traces is parallel to the length of the coil, so it provides no signal to amplify. As you reach the larger Plane areas, the current starts to flow horizontally, and the coil can pick up the signal. Pay careful attention as you cross the area around the “FFFFF” label.
5. With the Probe still pointing left, change the Sweeping action to an up-down motion as you slowly scan across the height of the large Plane area. Notice the sharp Sound amplitude peak as you pass below the middle of the “FFFFF” label. **The current spreads out as it travels through wide Traces, but if there is a short between the Planes, it usually occurs at a single point. The current must converge at this point to flow from one Plane to the other. This “current crowding” is the main clue as to the location of a short from a pin to a Plane, or from one Plane to another Plane.**
6. Advanced Actions:
 - a. Plug in a stereo headset, place the Probe at TP8 (PROBE LED facing you), and adjust the Drive level, reducing it for a little less volume with the Sound more towards your Right ear.
 - b. Perform the previous actions, noticing that you can detect more detail with the headset. Adjust the Drive to a couple of different levels, louder and quieter than your original adjustment to see if you can sense a smaller area of current concentration (the location of the short).
 - c. For extra practice, turn the Board over and perform the same actions from the back side of the Board.

Lesson 4: Current flow in overlapping Planes with signal canceling.

When there are similar current densities with opposite directions in power Planes, there can be significant signal cancellation, but the current still has to concentrate at the short circuit. This lesson demonstrates the cancellation effect, and then shows how you can still locate the short.

Goals: Follow the current Path, locate the short, and explore current density and directional current cancellation.

Setup:

1. Connect the Clip Cable and the Normal Probe to the ShortSniffer.
2. Set the power switch to "1", "Slope" switch to "Fast Edge" (Right), "Drive" to maximum (CW) and "Gain" to minimum (CCW).
3. Connect the Red Clip to TP1 and the Black Clip to TP2.
4. Do not plug in the stereo headphones at this time.

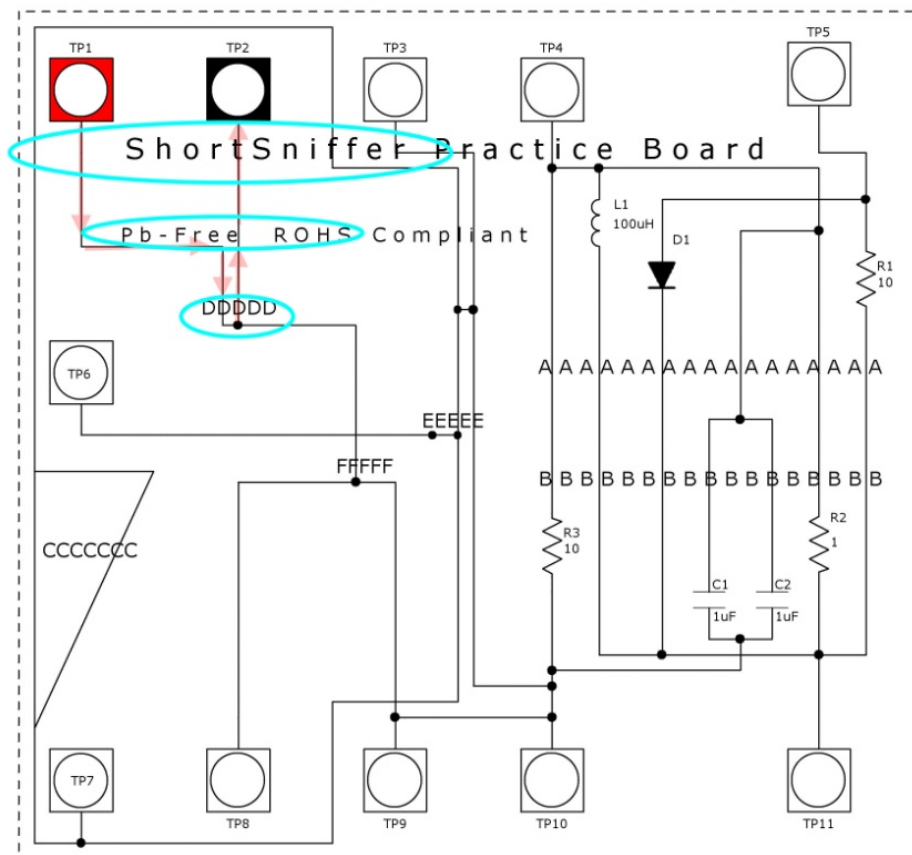


Figure 6 – Lesson 4

Actions:

1. Position the Probe at the TP2 label with the Probe LED facing you. The Probe LED should be lit and the Sound audible.

2. Wave the Probe Right and left between TP1 and TP3, listening to the current Sounds as you slowly move down the Board. As you pass the ShortSniffer text, you will notice that the Sound volume starts to decrease, becoming silent as you pass the "Pb-Free ROHS Compliant" text. This is where the uninitiated might give up, but you know better than that . . . Keep Waving and continue Down. Still nothing . . . should we give up yet?
3. Rotate the Probe 90 degrees and start Sweeping across the areas where the signal was lost and continue Sweeping as you move down the Board. Did you find the "hot spot" at the "DDDDD" line? **This is where the current had to concentrate to jump from one Plane to the other Plane (at the short).** The dead area between the current injection point and the short had current flowing one direction on the front layer of the PC board, and the opposite direction on the back layer of the Board. **These two current Paths were in opposite directions, cancelling most of the magnetic field they were producing.**
4. Advanced Actions:
 - a. Plug in a stereo headset, set the Drive level at maximum and the Gain at minimum.
 - b. Perform the previous actions, noticing that you can detect much more detail with the headset. As you get a little below the Pb-Free text, notice that if you rotate the Probe about 30 degrees you can get a stronger signal on the Right and left Sounds. Use these two peak volumes as the limits to your Waving action as you move further down the Board. The volume peaks are the centers of the "coming and going" currents, and they get closer together as you approach the short circuit location. You already know where the short is but pretend you don't as you follow the narrowing Wave action towards the short. When you do find the short, continue a narrow Wave action as you rotate the Probe through about 180 degrees and think about what you are hearing. Position the Probe at various places around the shiny hole under the middle of the "DDDDD" text, about 5mm from the hole. Rotate the Probe 360 degrees around each position. The maximum volume occurs when the Probe face lines up with the current flow, and the Null (minimum) occurs when the Probe pick-up coil ends are parallel to the current flow. **Rotating the Probe to find the Null is a much more accurate method to find the direction of current flow.**
 - c. Move the Black Clip to TP8. Trace the current flow from TP1 to TP8, following the peak Sound and rotating the Probe as necessary to obtain the maximum volume. Notice the continuous Sound (current flow) as you follow the Path between the two Clips, with no significant indication of the signal cross-over at the short circuit location. Now retrace the same "maximum volume Path" while rotating the Probe to maintain the "Null" (no Sound) condition. As you pass the short circuit location, you will find a significant Sound where the current concentrates. When placing Probes at opposite sides of the Board, it is sometimes difficult to tell where the current jumps from one Net to the other Net. **It is usually easier to locate short circuits when the current injection points are both on the same edge of the Board, forcing the current to go "out and back" instead of just flowing across the Board.**

If you must follow a Path across a PC board, this method of identifying the Path, and then following the same Path in a “Null seeking” mode will often locate the short.

- d. For extra practice, turn the Board over and perform the same actions from the back side of the Board.

Lesson 5: Current flow in parallel components – Semiconductor junction.

This lesson follows the Paths through a 10 Ohm resistor and a parallel diode junction. Reducing the Drive amplitude eliminates the parallel diode Path.

Goals: Follow multiple current Paths, and then eliminate the effects of parallel semiconductor Paths by reducing the Drive amplitude.

Setup:

1. Connect the Clip Cable and the Normal Probe to the ShortSniffer.
2. Set the power switch to “1”, “Slope” switch to “Fast Edge” (Right), “Drive” to maximum (CW) and “Gain” to about 75% of maximum.
3. Connect the Red Clip to TP5 and the Black Clip to TP11.
4. Do not plug in the stereo headphones at this time.

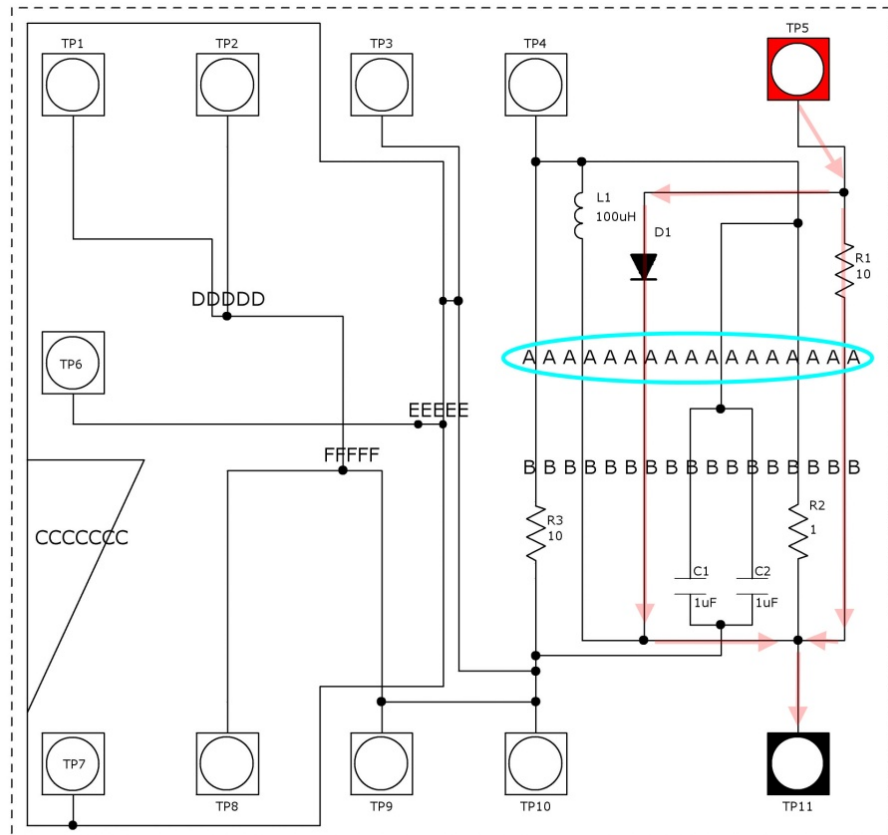


Figure 7 – Lesson 5

Actions:

1. Position the Probe at the TP5 text label with the Probe LED facing you. The Probe LED should be off and the Sound audible.
2. Move the Probe to the "AA...AA" text line and Wave the Probe along the length of the line. Notice that there are 2 distinct "hot" areas. The Right Path is the Trace that goes to R1, a 10 Ohm resistor, while the left Path is the Trace that goes to D1, a diode that is being forward biased by the positive pulses from the Red Clip.
3. Follow both Paths (R1 and D1) between TP5 and TP11 with the Probe, while observing that either Path could be the short circuit that you are trying to locate.
4. Position the Probe on the "AA...AA" text line, over the left Path (the Trace to D1), and then rotate the Drive knob slowly CCW until there is no Sound at this location. You have reduced the amplitude of the Drive voltage below the turn-on threshold of the diode.
5. Move the Probe to the Right to hear the Sound in the remaining Path. If you follow the Sound from TP5 to TP11, there will be only one Path to follow for your "high resistance" short circuit Path.
6. Turn the Drive amplitude back to maximum and swap the Red and Black Clips. Notice that there is no false Path for the reverse biased diode. If there is only one diode polarity in the parallel Path, swapping the Drive polarity may yield better results than reducing the Drive amplitude.
7. Advanced Actions:
 - a. Plug in a stereo headset, set the Drive level at maximum and the Gain at minimum.
 - b. Wave the Probe Right and left between along the "AA...AA" text line. Notice the 2 "hot" areas, and that the left one Sounds slightly different. This Sound difference is caused by the test current's effect on the forward biased diode junction. Rotate the Gain control (to reduce current flow in the diode) until the Sound is gone, and then move over to the Right area to hear the Sound still present in the R1 Path.
 - c. For extra practice, turn the Board over and perform the same actions from the back the Board.

Lesson 6: Current flow in parallel components – Capacitors.

A high resistance (1-10 Ohms) power supply short has parallel capacitors that will allow alternate current Paths for a significant fraction of the injected test current. By reducing the slope of the test current signal, much less of the current will flow through the parallel capacitors, reducing the Sounds of the false Paths. This lesson uses a 10 Ohm short with a pair of parallel 1uF capacitors to show how the slope control can improve your ShortSniffing results.

Goals: Follow the current Paths and minimize the effects of parallel capacitors by reducing the Drive Slope.

Setup:

1. Connect the Clip Cable and the Normal Probe to the ShortSniffer.
2. Set the power switch to "1", "Slope" switch to "Fast Edge" (Right), "Drive" to maximum (CW) and "Gain" to 50%.
3. Connect the Red Clip to TP10 and the Black Clip to TP4.
4. Do not plug in the stereo headphones at this time.

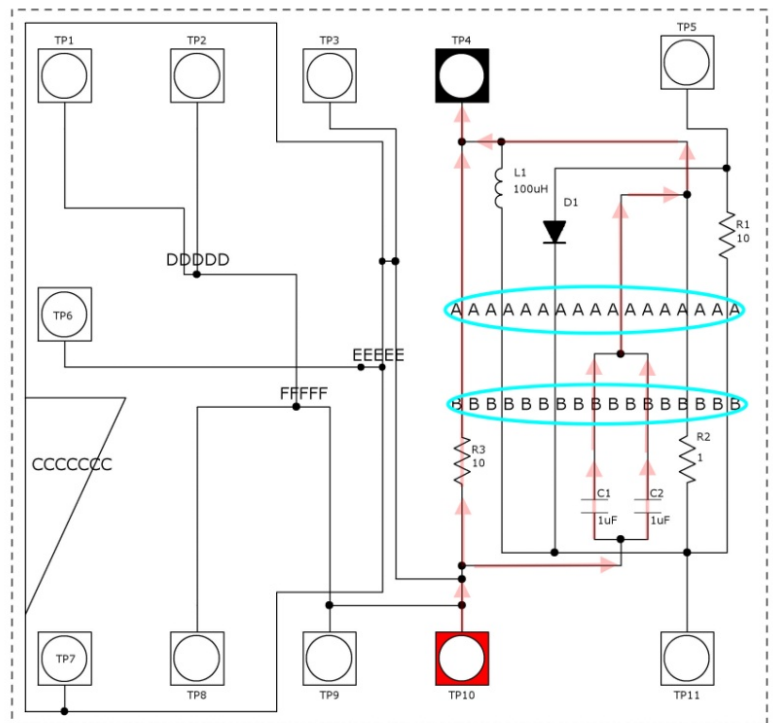


Figure 8 – Lesson 6

Actions:

1. Wave the Probe Right and left along the "AA...AA" text line. Notice that there are 2 distinct "hot" areas. The left Path is a Trace that follows our "short circuit" Path through R3 (10 Ohms), while the Right Path is the Trace to C1 and C2 (a parallel pair of 1uF caps).

2. Re-position the Probe and Wave it along the “BB...BB” text line. Notice that there are two “hot” areas here, with the Right Path being wider than the left Path. The Right Path is the pair of Traces going to C1 and C2.
3. To reduce the effect of false Paths caused by the parallel capacitors, move the Slope switch to the left to select “Slow Edge” for the injected test current. Re-Sweep the “A” and “B” text lines to see that the false capacitive Paths have been eliminated.
4. Advanced Actions:
 - a. Plug in a stereo headset, set the Drive level at maximum, the Gain at minimum, and the Slope to Fast.
 - b. Perform the same actions as before. Notice that the current flowing through the capacitors produces a “sharper” Sound with more harmonics. When the Slope switch is moved to the “Slow Edge” position, the Sound can still be heard in the capacitive Path, but at a much-reduced level.
 - c. Follow the Paths from TP4 to TP10 with both positions of the Slope switch to become familiar with this mode of operation. Notice that the 2 parallel capacitor Traces act if they are a single, much wider Trace. The Tiny Probe would resolve these as two separate Traces.
 - d. For extra practice, turn the Board over and perform the same actions from the back the Board.

Lesson 7: Current flow in parallel components – Inductors make bad neighbors.

An inductor in parallel with the short may effectively magnify the Sound. This lesson follows a 1 Ohm short with a parallel inductor to show the confusing effects of an inductor in the current Path so you can identify the condition and not be fooled.

Goals: Follow the current Paths and investigate the signal amplifying effects of inductors.

Setup:

1. Connect the Clip Cable and the Normal Probe to the ShortSniffer.
2. Set the power switch to "1", "Slope" switch to "Fast Edge" (Right), "Drive" to maximum (CW) and "Gain" to minimum (CCW).
3. Connect the Red Clip to TP11 and the Black Clip to TP4.
4. Do not plug in the stereo headphones at this time.

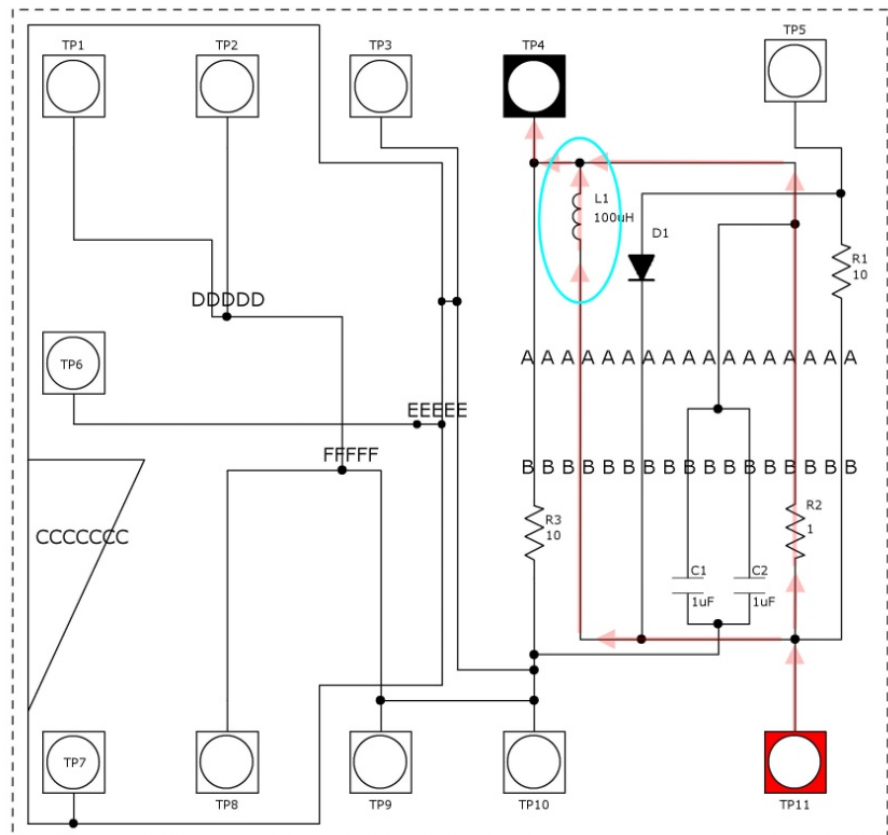


Figure 9 – Lesson 7

Actions:

1. Position the Probe at TP4 with the Probe LED facing you. The Probe LED should be lit. Using your training and talents, follow the Path through R2 Down to TP11.
2. There is a second current Path that was not noticeable in your previous Path traversal. Position the Probe at TP4, and then start moving Down. When you get to L1, circle the Probe around this part, trying different angles of rotation at the various positions around that area. There is only a

small fraction of the injected test current flowing down the Path and through this inductor, but the magnetic field is effectively amplified by the inductor. These types of results will add confusion to your short circuit locating process. If you find “strange” hot spots in your current flow Path, an inductor may be to blame. A transformer in the current Path can also produce similar confusing results.

3. Advanced Actions:

- a. Plug in a stereo headset, set the Drive level at maximum and the Gain at minimum.
- b. Position the Probe on the “AA...AA” text line, over the Right-side Sound volume peak. Reduce the Drive until the Sound slides more to the Right of center. Now move to the left Sound peak to notice the much lower volume. With this combination (1 Ohm and 100uH) the resistive Path is much louder than the inductive Path. Other component ratios will have different Sound volume ratios.
- c. Move the Probe back to circle around L1. You will notice that the much louder Sounds coming from around the inductor can be in either ear, since the inductor’s magnetic field-shape can produce opposite polarity signals.
- d. For extra practice, turn the Board over and perform the same actions from the back the Board.

Lesson 8: Complex Path with complex actions.

Some ShortSniffing efforts require a creative approach to determine the actual location of the short circuit Path when there are many alternative Paths or when a Path folds back upon itself. Care and cunning may be required to be successful.

Goals: Follow complicated current Paths and try not to be confused by overlapping fields and parallel Paths.

Setup:

1. Connect the Clip Cable and the Normal Probe to the ShortSniffer.
2. Set the power switch to "1", "Slope" switch to "Fast Edge" (Right), "Drive" to maximum (CW) and "Gain" to minimum (CCW).
3. Connect the Red Clip to TP10 and the Black Clip to TP5.
4. Do not plug in the stereo headphones at this time.

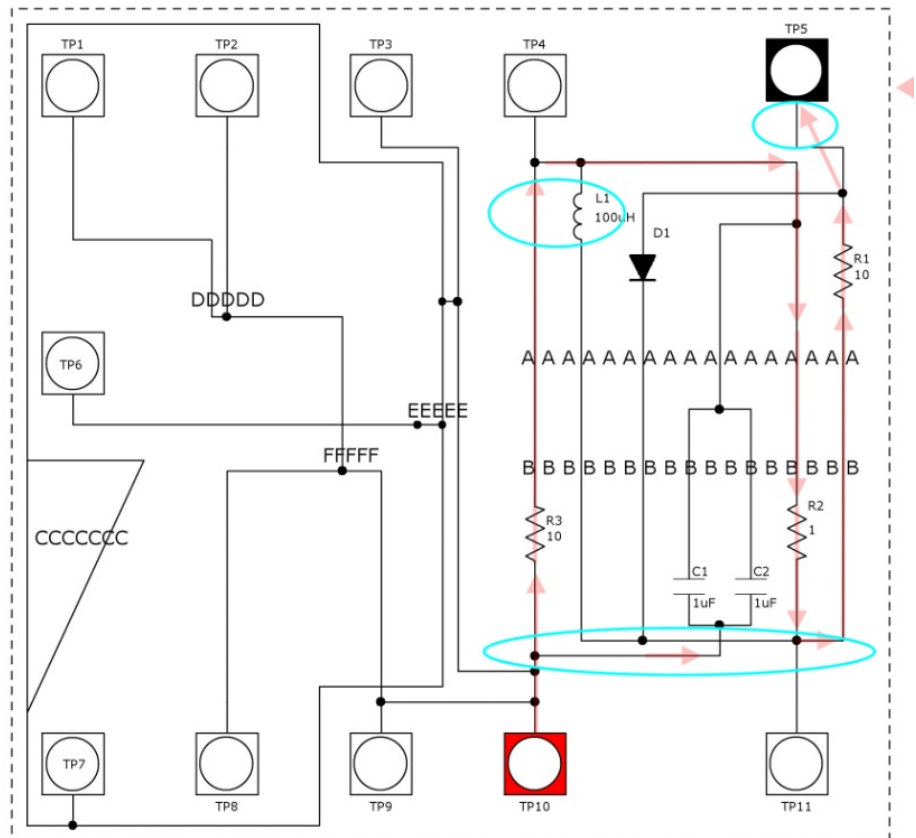


Figure 10 – Lesson 8

Actions:

1. Position the Probe at TP5 with the Probe LED facing Down. The Probe LED should not be lit because the Path has too much resistance. Increase the Gain and the Probe LED will turn on. Continue increasing the Gain until you hear a reasonable volume. If the volume peaks and then diminishes, possibly peaking again, reduce the Gain to find the first volume peak. Excessive Gain

can cause distortion that may make the speaker produce less volume and may confuse the direction sensing functions.

2. Follow the current Path Down, using the Sound as your guide, but also watch the LED, since there is a reverse Path just to the left of your forward Path. The LED can keep you on the correct Path. You may have trouble rounding the bend near TP11. If you are not careful, you may jump to the nearby branch of the Path through the capacitors and end up at TP10 instead of looping back up through R2, towards TP5. Investigate this confusing area, and then take the Upwards Path towards TP5.
3. Near TP5, the Trace jumps to the other side of the Board, but you can follow it if you make the sharp left turn just below TP5.
4. Taking the left turn under TP5 gets you heading towards TP4 but watch out for the confusion as you pass L1!
5. Advanced Actions:
 - a. Plug in a stereo headset, set the Drive level at maximum and the Gain at minimum.
 - b. Perform the same actions as above. You will notice that the Sound coming from around the inductor can be in either ear.
 - c. Swap the Red and Black Clips, and then Probe around the Paths to discover that the forward biased diode has been added to the confusing mix. A slight reduction in Drive will remove the current from this Path.
 - d. For extra practice, turn the Board over and perform the same actions from the back the Board.

Lesson 9: Alternate Probes; - why more than one?

The basic SS3 comes with a Probe named Normal. The SS3 Pro kit includes extra Probes (Sensitive and Tiny), along with a variety of connection extensions, allowing for easy contact to Nets that are too small for the alligator Clips.

The Normal Probe (Yellow) is good for most ShortSniffing tasks, combining good sensitivity with small size.

The Sensitive Probe (Red) can follow the Drive currents in “shorts” that are above 1k Ohm and is better at following the faint signals in the most difficult power Plane shorts where the current Path is spread out over a wide area. This Probe tip is much wider than the Normal Probe, so the location radius is larger, but the added sensitivity is best for weaker signals.

The Tiny Probe (Blue) is less sensitive than the Normal Probe, but the smaller size allows for a smaller location radius. On fine-pitch PC boards, this reduced location radius will better identify the location of the short.

Goals: Explore the differences between the 3 pick-up Probes and learn which to select based on the requirements of a particular short circuit.

Setup:

1. Connect the Clip Cable and the Tiny Probe to the ShortSniffer.
2. Set the power switch to "1", "Slope" switch to "Fast Edge" (Right), "Drive" to maximum (CW) and "Gain" to maximum (CW).
3. Connect the Red Clip to TP10 and the Black Clip to TP5.
4. Do not plug in the stereo headphones at this time.

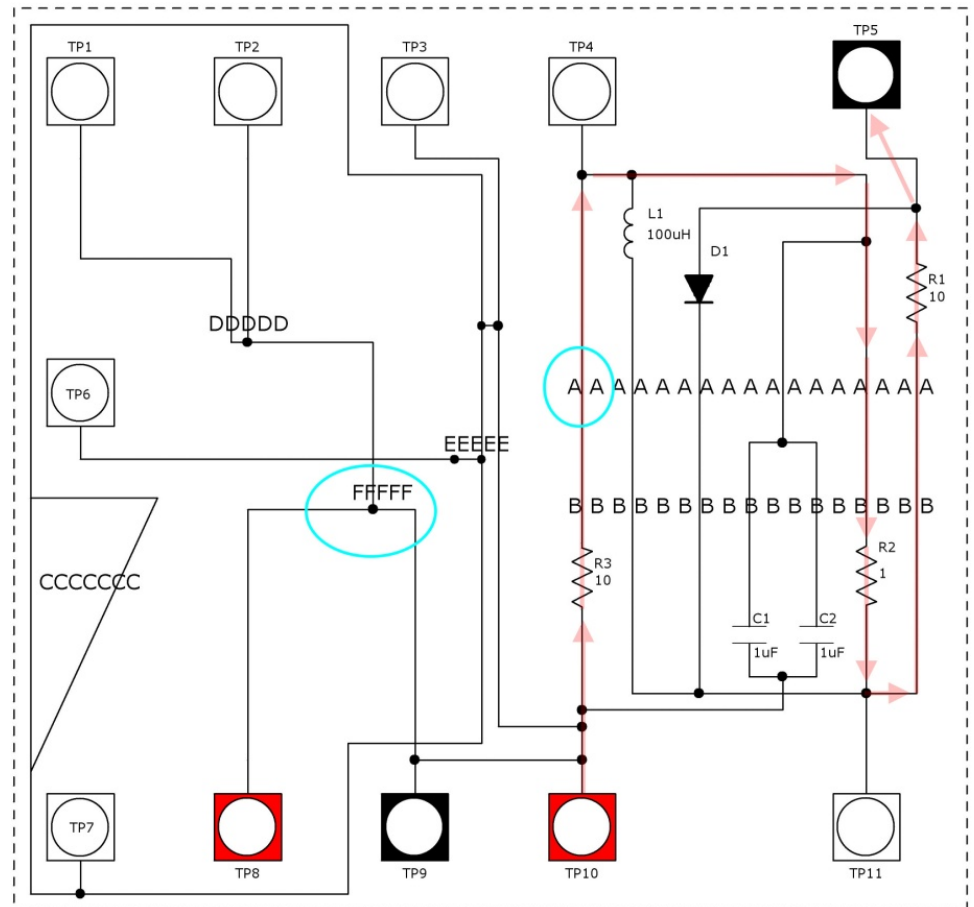


Figure 11 - Lesson 9

Actions:

1. Place the Probe at the Sound peak at the left end of the "AA...AA" text line, and then reduce the Gain (CW) until you can hear no Sound from the speaker.
2. Replace the Tiny Probe with the Normal Probe and position the Normal Probe at the same location. Notice that you can now hear the Sound, since the Normal Probe is more sensitive than the tiny Probe. Reduce the Gain until you can hear no Sound from the speaker.
3. Replace the Normal Probe with the Sensitive Probe and position the Sensitive Probe at the same Sound peak location. Notice that you can now hear the Sound, since the Sensitive Probe is more sensitive than the Normal Probe.
4. Move the Clips; Red to TP8 and Black to TP9 and set the Gain to Minimum (CCW). Wave and rotate the sensitive Probe around the "FF..FF" text label, noticing that you can hear the Sound, but that there are no sharp discontinuities in the volume level as you move across the previously discovered short (under the middle of the "FF..FF" text label). You have found the area of the short, but the detection radius is too large for fine details.

5. Change to the Normal Probe and repeat the Waving and rotating actions. You will notice a strong Sound volume “pulse” as you cross the area of the short, with the maximum strength radius at 3 to 5mm.
6. Change to the Tiny Probe and position the Probe at the same location. Increase the Gain until you hear a reasonable Sound, and then repeat the Wave and rotate actions, noticing that your horizontal and vertical detection radius is about half that of the previous results.
7. Advanced Actions:
 - a. Plug in a stereo headset, and then adjust the Gain control as you Wave the Tiny Probe over the location of the short. Notice that when the Gain is reduced, the search radius is usually reduced. Experiment with various Gain settings, listening for the complex changes to the Sound as the Probe Sweeps across and around the short circuit location.
 - b. For extra practice, turn the Board over and perform the same actions from the back the Board.

Final challenge

The ShortSniffer Practice Board teaches many combinations, but real life is much more creative. If you don't have a “bone-yard” pile of unfound shorts to practice on, try making a few of your own. Start with an easy one, maybe shorting a pair of data or address lines on a motherboard. If you make the short on the front side of a PC board, try to locate it from the back side. If you have a friend with ShortSniffing interests, take turns placing shorts on a PC board for the other to locate. If you have a short that you can't locate, maybe you should send it to me to see if I can find it (call first, please). There have been only 2 boards in more than 10 years of ShortSniffing that have confused me for long periods of time. Both boards were 4-layer boards with power Plane shorts to the inner layers. The shorts seemed to be “everywhere”, but that couldn't be happening. Both boards were manufactured with offsets between layers so that every pin that went through the PC board shorted the power Planes together at that point. It was very confusing until I discovered that the short was “everywhere” on the board.

Happy ShortSniffing!

Carl