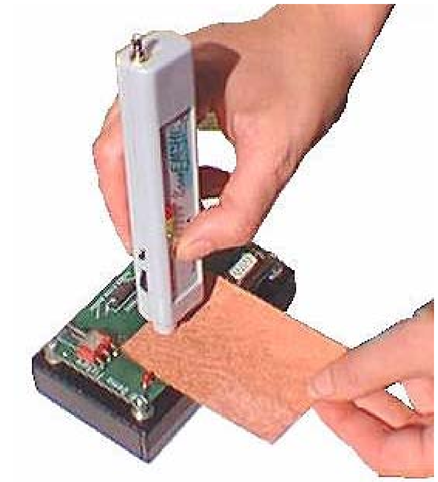
EMC Training Kit

Model CTK031



User's Guide

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Experiment 8: Observe Waveform of Current Using an Oscilloscope

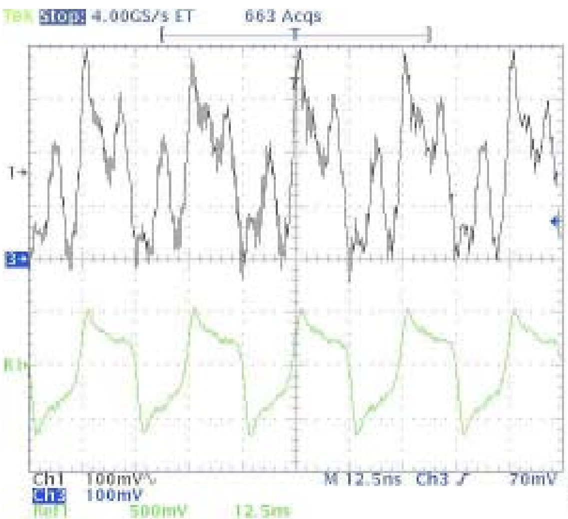
Often overlooked due to lack of proper instrumentation, high-frequency currents can cause significant emission and signal integrity problems

- Connect ScanEM-HC probe to a high-speed oscilloscope (at least 300MHz). Set Level dial to 0 and an oscillscope input to AC..
- Bring the tip of ScanEM-HC to different areas of the board -- traces and ground plane. Observe the waveform of the currents. Rotate the ScanEM-HC probe and observe changes in the waveforms.

Conclusion: High-frequency currents can be hidden contributors to the signal integrity and emission problems. Always monitor high-frequency currents during product design.

Experiment 7: Observe Waveforms of Signals Without Contact Using an Oscilloscope

High-speed digital circuits are, in effect, high-frequency RF circuits. A regular oscilloscope probe (bottom trace) loads the trace and introduces distortions of a signal. ScanEM-C probes (top trace) can help you to observe waveforms of both voltage and currents without disturbing the signal.



- Connect ScanEM-EC to a high-speed oscilloscope (300MHz min.)
- Set ScanEM-EC Level dial to 0 and the scope input to AC.
- Bring the tip of ScanEM-EC to the trace above the ferrite as shown.

Observe the waveform of a signal on the screen of an oscilloscope.

- Connect regular scope probe to a via above the ferrite. Use the handle of the Power switch as ground.
- Observe the waveform of the signal.
- Observe the waveform from ScanEM-EC probe as you remove and re-apply the conventional probe.

Conclusion: A conventional probe loads the circuit and alters its behavior. It is not uncommon to make a malfunctional circuit working by connecting to it an oscilloscope with the conventional probe. Use only tools that do not affect the signal that you are measuring.

Thank you for purchasing the EMC Training Kit. With this kit you will be able to get hands-on experience with electromagnetic emission and get on your way to becoming an EMC expert.

This EMC Training Kit will give you hands-on practical knowledge on how to diagnose and troublesoot emission problems as well as how to recognize signal integrity problems. This User's Guide is in no way a substitute to a formal course or a comprehensive book on Electromagnetics. Please refer to any good text book on the subject to understand a theory behind the experiments. After that repeat the experiments again -- you will become a real pro.

We strongly recommend that you read User's Guide for ScanEM-C probes (included) before doing any of the experiments. Then use this EMC Training Kit to get hands-on experience with EMC diagnostics and troubleshooting.

With this EMC Training Kit learn and see for yourself:

- The difference between E and H fields
- Directional characteristics of the magnetic field
- Ferrite as a suppressor of high-frequency signals
- Copper as shielding
- Ground plane currents
- Hidden traces generating electromagnetic field
- EMC and signal integrity

and more.

And after you are done learning -- use ScanEM-C probes (included) for your EMC and signal integrity work.

ScanEM-C probes included in this training kit are designed for board-level EMC pre-compliance and diagnostics. For product-level EMC diagnostics use ScanEM-QC kit model CTK019 -- please visit our web site at http://www.credencetech.com

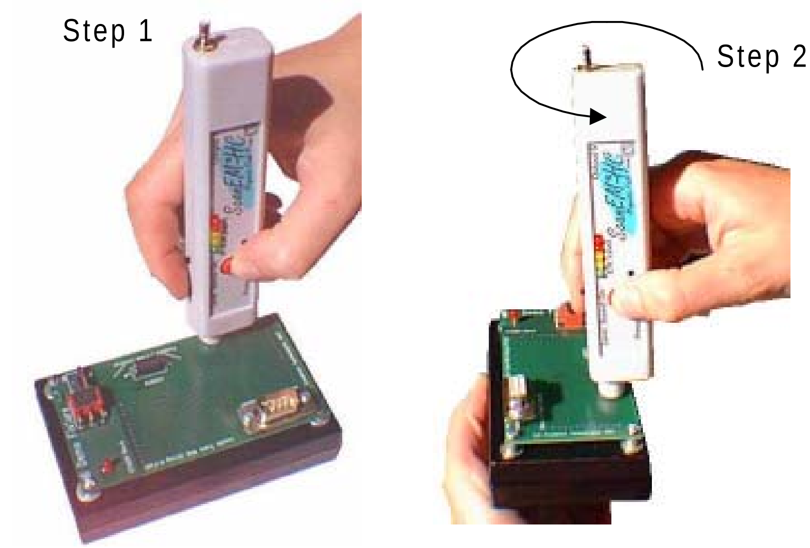
Contents of the Kit

EMC Training kit model CTK031 consists of:

- ❑ one ScanEM-EC probe (electric field) model CTM030
- ❑ one ScanEM-HC probe (magnetic field) model CTM032
- ❑ one 6' (~1.8m) SMB to BNC cable model AWD001
- ❑ AAA batteries (2 per each probe - already installed)
- ❑ Demo Fixture model CTA211
- ❑ Two 9V alkaline batteries (one installed in a Demo Fixture)
- ❑ BNC-to-Banana adapter
- ❑ BNC-to-N adapter
- ❑ a patch of shielding material
- ❑ plastic storage box model CTA131
- ❑ this User's Guide
- ❑ ScanEM-C User's Guide

Experiment 6: Locate Hidden Trace and Determine its Direction

Non-connuctive materials are essentially transparent to the electromagnetic field. A trace on the opposite side of the PC board generates as much electromagnetic emission as if it were located on the top of it.



♦ Turn the tip of ScanEM-HC probe away from the demo fixture and set its Level dial to the green LED.

♦ Bring the tip of ScanEM-HC probe to the clear area on PCB of the Demo fixture as shown.

The high pitch of the sound and lit LEDs indicate that ScanEM-HC tip is over a hidden trace.

♦ Rotate ScanEM-HC around its longest axis as shown. The seam in the tip of the probe indicates the orientation of the probe's sensor.

The direction of the current in the hidden trace is indicated by the highest pitch of the sound and the most LEDs that are lit.

Conclusion: PC board material is transparent to electromagnetic field. The emission created by hidden traces create compliance problems.

If Using a Spectrum Analyzer: The strongest signal indicates that you have found the trace and determined its direction.

Experiment 5: Locate Current in the Ground Plane

Demo Fixture has very small ground plane, however it is sufficient for demonstration of the ground currents. These currents may create magnetic fields that cause compliance problems. Often, ground plane currents also cause signal integrity problems.

- Place the tip of ScanEM-HC probe over the small ground plane between the switch and the LED of the Demo fixture as shown.
- Rotate ScanEM-HC around its longest axis as shown. The direction of the current in the ground plane is indicated by the highest pitch of the sound and the most LEDs that are lit.

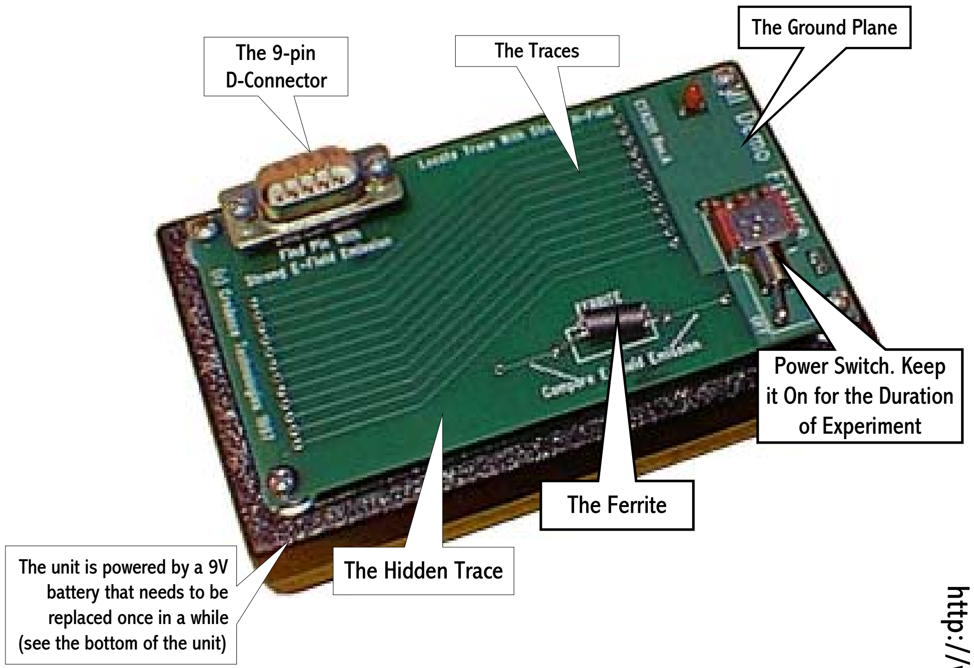
Conclusion: Ground planes carry high-frequency currents that generate H-field. Minimizing the length of such current paths reduces the emission.

If Using a Spectrum Analyzer: Observe on the screen the change in the magnitude of the signal as you rotate the probe.

Demo Fixture

This Demo Fixture was intentionally designed poorly. It exhibits the kinds of emissions you can find in a typical product, i.e. electric fields from the traces and components, magnetic fields from traces, components and ground plane, unterminated wires carrying high-frequency signals, etc. In addition, you will be able to conduct signal integrity tests since the performance of this Demo Fixture from signal integrity stand point is also intentionally very poor.

The signals in this Demo Fixture are generated by a crystal oscillator with the frequency of 40MHz. Knowing this should help you with the setup of the spectrum analyzer and an oscilloscope for experiments.

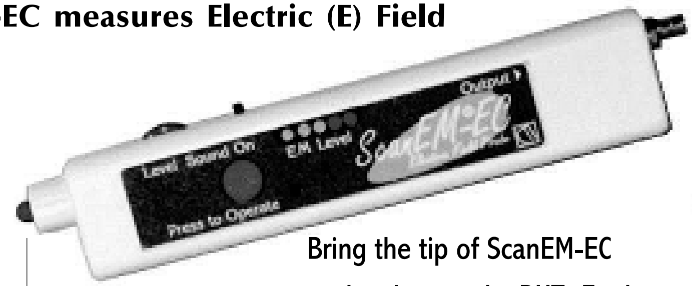


Turn on Demo Fixture with the Power switch and keep it on for the duration of an experiment. Red LED indicates that the Demo Fixture is On. Don't forget to turn it off when you are done. Demo Fixture uses 9V alkaline battery. There are no user-serviceable parts inside of a demo fixture.

Learn to Use ScanEM® Probes

Please read thoroughly the ScanEM-C User's Guide included in this Training Kit first. Below is just a brief summary of how to use ScanEM-C probes.

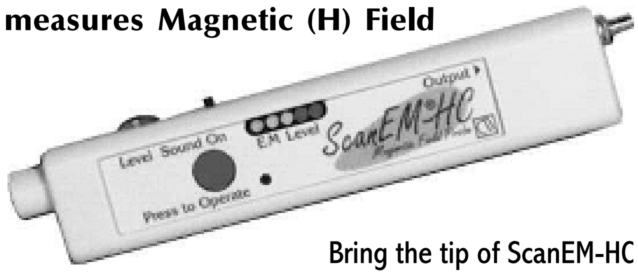
ScanEM-EC measures Electric (E) Field



ScanEM-EC Tip

Bring the tip of ScanEM-EC probe close to the DUT. For better results try not to touch it.

ScanEM-HC measures Magnetic (H) Field



ScanEM-HC Tip

Bring the tip of ScanEM-HC probe to the top of a trace or a component you want to check. Direct contact is OK.

Sensitivity Adjustment

Turning the tip away from the emission source, set the Level dial so that only the green LED is on as a starting reference.

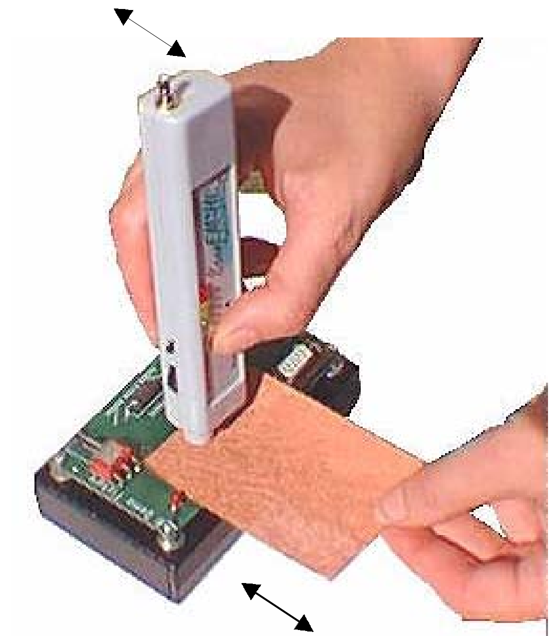
Less Sensitive

More Sensitive

The sound can be turned off if desired.

Experiment 4: Verify Efficiency of Shielding

Shielding materials, such as copper, block electromagnetic waves and reduce electromagnetic emission.



- Perform Experiment 3 first.
- Hold the enclosed piece of copper shielding over the traces as shown.
- Move the tip of ScanEM-HC probe across the traces over the shielding as shown. Observe the low emission level.
- Remove the shielding and repeat the test.

You can perform the same test with ScanEM-EC probe

Conclusion: shielding reduces emission level.

If Using a Spectrum Analyzer: quantify attenuation introduced by the shielding.

Experiment 3: Locate the Trace with the High-Frequency Current

Magnetic field is highly directional. Its direction correlates with the orientation of the current in wire or trace.

Step 1

Step 2

♦ Place the tip of ScanEM-HC probe over the traces of the Demo Fixture as shown and slide the tip across the traces keeping the seam of the tip in line with the traces (the seam indicates the orientation of the probe's sensor).

The highest pitch of the sound and the most LEDs that are lit indicate the trace with the high-frequency current. Try to follow that trace.

♦ Rotate ScanEM-HC around its longest axis to demonstrate the directional characteristics of the magnetic field.

Now the probe's sensor is perpendicular to the direction of the current and the probe indicates almost no magnetic field.

Conclusion: a magnetic field is directional. ScanEM-HC, which clearly indicates the trace with the high-frequency current when the probe's sensor is in line with the trace, barely registers the field when the probe's sensor is perpendicular to the current.

If Using a Spectrum Analyzer: observe the magnitude of the signal at different orientations of ScanEM-HC.

The Proper way to Hold ScanEM Probe

❑ Hold ScanEM-C probe in your right hand just as you would hold a pen.

❑ Press the red Operate button with your thumb and keep it down for the duration of each test.

❑ Adjust the Level dial with your index finger. To zero in on the exact source of emission gradually reduce the sensitivity of ScanEM-C by slowly turning the Level dial toward the lower numbers.

❑ Connect ScanEM-C to a spectrum analyzer (set frequency range to 30MHz to 200MHz for the tests) to work as an active near-field probe.

❑ Connect ScanEM-C to an oscilloscope to be an ultra-high bandwidth non-contact voltage or current probe.

❑ Connect ScanEM-C to a multimeter to monitor field strength.

FOR ALL EXPERIMENTS DESCRIBED IN THIS BOOKLET FIRST TURN THE TIP OF SCANEM PROBE AWAY FROM THE DEMO FIXTURE AND SET ITS LEVEL DIAL TO THE GREEN LED.

Experiment 1: Observe That Ferrite Suppresses High-Frequency Signals

Ferrites introduce losses for high-frequency signals by converting current into heat. Ferrite filters (chockes) are used to reduce high-frequency content of the signals.

In this experiment we will observe the behaviour of the ferrite filter and will quantify its performance.

♦ While holding the tip of ScanEM-EC probe over the trace leading to the ferrite as shown (next to word "Compare"), adjust the Level dial to the green LED. This is the signal "after the ferrite."

♦ Move the tip of the probe to the trace on the other side of the ferrite. Do not re-adjust the Level dial. Now more LEDs are lit. This is the signal "before the ferrite."

Conclusion: observe the change in pitch of the sound and in the LED bar graph as you move the probe. The signal is much weaker after it is attenuated by the ferrite.

If Using a Spectrum Analyzer: observe the amplitude of the signal before and after the ferrite. Note the amount of attenuation introduced by the ferrite (it is about 10..12dB)

Experiment 2: Identify Sources of E-Field and H-Field

Electric field is generated by presence of voltage in wires, and magnetic field is produced by the current. In absence of current, there is no magnetic field.

♦ Bring the tip of ScanEM-EC probe to the top of the 9-pin D-connector.

♦ Observe high level of E-field emission coming from the connector.

♦ Do the same test with ScanEM-HC probe.

♦ Observe that there is very little or no H-field registered.

There is no current coming through the 9-pin connector, therefore it generates just electric field, but no magnetic field.

Conclusion: One needs to use BOTH E and H field probes in order not to miss emission sources.

If Using a Spectrum Analyzer: observe the magnitude of the signal from ScanEM-EC and ScanEM-HC on the screen.