

EMC Analysis User's Guide

LineSim EMC and BoardSim EMC

HyperLynx

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Chapter 1: What is the EMC Analysis Option?

LineSim EMC and BoardSim EMC

Overview

The EMC Analysis option to BoardSim and LineSim adds to either program a *spectrum analyzer*. The spectrum analyzer predicts (one net at a time) the radiated emissions from your board's or schematic's nets and presents results in the *frequency domain* (as compared to LineSim's/BoardSim's oscilloscope, which displays in the time domain). You can compare the predicted radiation levels at every frequency to government limits (U.S. FCC, European CISPR, or Japanese VCCI) and decide if design changes are required.

Note: *When you add the EMC Analysis option to LineSim, the result is called "LineSim EMC." Similarly, adding to BoardSim results in "BoardSim EMC." The EMC versions of the programs retain all of the signal-integrity features of the basic programs, and add additional EMC-related features.*

A Better Approach to EMC Problems

Traditionally, EMC problems have been found only near the end of the design cycle, after a prototype is built and can be taken to an EMC laboratory for measurements. The drawback to this approach is obvious: if problems *are* found, it's so late in the design cycle that fixes are very expensive. Clearly, if EMC problems could be identified and fixed before layout, significant savings would result. Finding problems early also avoids another aspect of the traditional approach to EMC: “band-aiding” a product by adding shielding and other expensive “kludges” rather than solving radiation problems at their source.

With BoardSim EMC and LineSim EMC, you can:

- ◆ find out before you build a board whether EMC problems are likely to exist
- ◆ reduce costly revisions by fixing problems before building prototype boards
- ◆ avoid failing an emissions test, at the last minute, after the product is built
- ◆ determine how to fix potential EMC problems, with methods like termination and stack-up changes
- ◆ if a failure does occur, quickly isolate the signals responsible for the measured radiation peaks
- ◆ learn more about radiated emissions - how it is caused and how you can prevent it

Radiated Emissions and Signal Integrity

In addition to focusing purely on EMC effects, LineSim EMC/BoardSim EMC also demonstrates the important link between signal-integrity problems and radiated emissions. Differential-mode radiation from a PCB is caused by current flow in the unintended antennas formed by a board's traces. Traces that suffer from signal-integrity problems (e.g., ringing or long settling times) harbor excess currents and therefore generate excess radiation. Correcting

these integrity problems can reduce a trace's radiated emissions at critical frequencies by as much as 20 dB.

Yet determining whether a proposed change on a board increases or decreases the *radiation* at a particular frequency is difficult without frequency-domain tools like LineSim EMC and BoardSim EMC. For example, if you change a net's driver IC from one technology to another with a similar switching speed, will the net's radiation increase or decrease? If you want to terminate a net in order to decrease its radiation, should you use an end-of-line method or a series terminator? Determining the effects of such changes from a *signal-integrity* standpoint (in the time domain) is one matter; determining the effects from an *EMC* viewpoint (in the frequency domain, and for radiation) is another.

Chapter 2: Brief EMC Technical Background

Overview

This chapter describes what kinds of radiation effects LineSim EMC/BoardSim EMC simulates, and gives some brief technical background about the subject of EMC and radiated emissions.

For additional technical information on the algorithms used by HyperLynx to predict radiation, Chapter 3.

Why Radiation Occurs

The traces on a PCB form unintended antennas that can generate electromagnetic radiation and cause EMC problems. Radiation is generated when currents flow in the trace antennas; the more and longer the current flows, the greater the risk of excess radiation being produced. There are basically two ways to reduce the radiation generated by a net: diminish the effectiveness of the antenna that the trace forms, or reduce the current that flows in the antenna.

Differential-Mode versus Common-Mode Radiation

Differential-mode radiation is generated when a current and an equal-but-opposite current flow in close proximity to each other. On PCBs with ground/power planes, the current in a trace has exactly this configuration: as

the current flows down the trace, an “image” current immediately above or below the trace returns to the driving source.

Even though the oppositely directed currents tend to cancel each other's radiation, the cancellation is not perfect because of the non-zero spatial and temporal (time) separation between them. The residual, differential-mode radiation is what LineSim EMC/BoardSim EMC predicts.

Common-mode radiation is generated when a current flows *without* a nearby current to oppose it. Under these circumstances, the radiation generated can be much larger than typical differential-mode radiation. In real digital systems, common-mode currents tend to result from system-level conditions, for example, poorly designed cables (without adequate ground returns) or compromised/missing ground planes (One classic way of “compromising” a ground plane is to cut it and allow signals to pass over the cut.) Double-sided PCBs (boards with no ground planes) produce inherently non-differential radiation, because no pathways are provided for tight differential-mode return currents.

LineSim EMC/BoardSim EMC predicts differential-mode radiation.

Far-Field versus Near-Field Radiation

The radiation generated by a PCB trace is complex. Near the trace, for example, the electric field includes a radial (outward-directed) component; further away, the E-field's radial component diminishes. EMC labs typically take measurements designed to measure far-field radiation: the sensing antenna is located 3, 10, or 30 meters away from the PCB under test, so that (except for at the lowest frequencies), only far-field radiation is sampled.

LineSim EMC/BoardSim EMC predicts far-field radiation.

Radiation from Periodic versus Random Signals

The data content of a digital signal greatly affects the way in which it radiates. Periodic signals (like clocks or regularly repeating control signals like RAS or CAS) have their energy “bunched” into tight peaks with large amplitudes. Random signals (like a data line) have their energy spread broadly and tend to have no peaks. Therefore, except in unusual cases, it is the periodic signals on a PCB that cause radiated-emissions failures.

LineSim EMC/BoardSim EMC is designed to show the frequency content of periodic signals. Before you run a simulation, you specify the frequency and duty cycle of the driving ICs' waveforms (see Chapter 4, section “Choosing the Driver IC Waveform” for details.)

Radiation from Component Packages (BoardSim EMC Only)

The radiation generated by a PCB comes not only from the board's traces, but also from the ICs and other components on the board. In fact, on many modern boards, the IC packages (i.e., the IC die and the package's lead frame, bond wires, and pins) produce more radiation than the signal traces. This occurs because as currents leave and enter the IC packages, the package's and die's structures also act as antennas, and often as antennas that have less-favorable differential-mode behavior than do board traces.

One of the major strengths of BoardSim EMC is that it is able to predict radiation from not only PCB traces, but also component packages. And it does so without requiring the user to input any modeling information about the components' packages.

Note: *LineSim EMC cannot predict package radiation because, unlike BoardSim EMC, it does not have any information about the physical packages of the ICs it is simulating.*

Effect of System Components and Enclosure

In practice, PCBs are almost always packaged in some manner before being deployed for real use. A computer motherboard, for example, may be tested for radiated emissions as a bare board, but in real use will reside in a case (i.e., an enclosure). (It will also be surrounded by additional electronics, e.g., a power supply and perhaps several plug-in cards.) Additional system components like a package or enclosure may have a significant effect on the radiation actually observed outside the unit.

LineSim EMC/BoardSim EMC predicts only the radiation produced by a single PCB. It does not attempt to predict what happens when multiple boards are interconnected, or when a board is enclosed in a case.

Government EMC Regulations

Ultimately, the reason designers are forced to be concerned about EMC and radiated emissions is that governmental bodies throughout the world require that electronic products not generate excessive amounts of radiation. EMC standards vary from country to country. The most important sets of regulations are FCC (applicable in the United States), CISPR (throughout Europe Community), and VCCI (Japan). Other, similar regulations apply in other markets. If a product generates radiation in excess of one of these standards, it may not be allowed for sale in the target market.

Within each standard, distinctions are made between two classes of products: “Class A” for industrial products, and “Class B” for commercial (or consumer) products. The standards are more-stringent for commercial products.

Chapter 3: Limitations to EMC Simulations

Overview

LineSim EMC/BoardSim EMC's radiation-prediction algorithms are designed to offer a careful balance between accuracy, performance, and affordability. The following sections provide some useful information about the what HyperLynx's EMC algorithms can — and can't — do.

Planes are Assumed to be “Whole”

LineSim EMC/BoardSim EMC's radiation-prediction algorithms assume that a board being analyzed has at least one properly functioning ground plane. Specifically, this means that:

- ◆ the board must have at least one ground plane
- ◆ the plane must not be seriously compromised, e.g., must not be cut without regard for digital signals that pass over the cut

Strictly speaking, LineSim EMC/BoardSim EMC does not require that a ground plane not be cut or split. But the program does assume that for any signal being analyzed, there is a tight return path for the signal's current in a nearby plane layer. This means that if you have a PCB with a split ground plane and attempt to analyze signals that pass over the ground-plane gap, LineSim EMC/BoardSim EMC will give erroneously optimistic results. On the other hand, if you analyze only nets that remain above or below their section of the ground plane, the analyses will be valid.

Note: *It is ironic that PCB-layout tools are finally making it fairly easy to split plane layers, at exactly the time in the history of PCB development when — thanks to increasing IC switching times and frequencies — it is becoming critical **not** to compromise plane layers. Cutting gaps in a plane layer forces return currents flowing in the layer to deviate wildly from the paths they would otherwise take. These deviant return-current paths, in turn, severely increase the loop area of the differential-mode antennas on the board, causing big jumps in radiation levels. You should avoid compromising your boards' plane layers at nearly all costs — unless EMC and signal integrity are not important to you.*

Only Differential-Mode and Component-Package Radiation is Predicted

There are numerous means by which a PCB can radiate. LineSim EMC/BoardSim EMC predicts the two most unavoidable types of board radiation: the differential-mode radiation that comes from signal traces traveling over ground and power planes, and the radiation that is generated by component packages. However, there are plenty of other mechanisms by which a PCB can radiate, and if your board allows these other means, LineSim EMC/BoardSim EMC will predict lower radiation levels than the PCB will actually generate.

For example, LineSim EMC/BoardSim EMC does not attempt to predict common-mode radiation. (See Chapter 2 for an explanation of the difference between differential- and common-mode radiation). If you add a poorly designed cable to your board, for example, it may radiate very strongly, more so than the entire PCB. Common-mode problems can also result from improperly designed systems which have unopposed currents flowing through their ground structures.

However, well-designed boards and systems tend to be dominated by differential-mode trace radiation, and the radiation that comes from component packages. LineSim EMC/BoardSim EMC accurately predicts these effects.

BoardSim EMC Does Not Predict Radiation for Crosstalk Aggressor Nets

BoardSim EMC predicts radiation only for those nets that are “associated,” i.e., electrically connected to, the selected net. If you own BoardSim’s Crosstalk option, and are running simulations with crosstalk enabled, any aggressor nets in the simulation (nets coupled to the selected net) are NOT included in the radiation analysis.

The following table gives more detail:

| Type of net in BoardSim EMC | Included in radiation prediction? |
|--|-----------------------------------|
| selected net | yes |
| nets associated through a resistor, capacitor, or any other passive component | yes |
| differentially associated nets, i.e., nets associated through a differential IC model | yes |
| aggressor nets, i.e., coupled nets included in crosstalk analysis that are NOT connected to the selected net by a passive component or differential IC | no |

About Accuracy

It is mathematically more difficult to predict radiated-emissions levels than to predict signal-integrity effects. Therefore, EMC analysis tends to be somewhat less precise than signal-integrity simulation. However, HyperLynx has carefully implemented its radiation-prediction algorithms so that they give results as close as practically possible to actual lab measurements (and better

than some other commercially available programs that are much more expensive).

HyperLynx's evaluations show that LineSim EMC/BoardSim EMC is accurate to within 5-10 dBuV/m. More importantly, you can always rely on LineSim EMC/BoardSim EMC to accurately tell you whether a net will be a source of EMC trouble, and whether proposed fixes (like termination or a different driver IC) will improve or worsen results.

For details in the algorithms that HyperLynx uses for radiation prediction, see Chapter 4.

Note: *The best EMC labs are not able to measure radiated emissions to better than +/-3 dBuV/m accuracy.*

Special Limitations in LineSim EMC

LineSim EMC differs significantly from BoardSim EMC in that it does not have access to all the physical information that BoardSim EMC does. For example, whereas in BoardSim EMC the exact physical positioning of trace segments is known, in LineSim EMC, the schematic does not contain this information. Also, in BoardSim EMC, the physical footprint of a component's package is known; it is not in LineSim EMC. Accordingly, several limitations to radiated-emissions prediction exist in LineSim EMC:

- ◆ LineSim EMC cannot predict component-package radiation; you cannot enable package radiation in the user interface
- ◆ LineSim EMC places all transmission lines at the origin, with the same angular orientation; the effect of differently oriented segments cannot be analyzed
- ◆ When you simulate differential traces in LineSim EMC (i.e., a differential pair), because LineSim does not have physical information about the separation between the traces, the traces are assumed NOT to be separated. This results in better field cancellation than the traces will

actually exhibit; hence, LineSim EMC's differential-pair simulations are "optimistic."

Regarding placement of all transmission lines at the origin, more specifically, the left end of all lines in the schematic are placed at location 0,0, and the right ends extend rightward from 0,0. This means that you can get different radiation results depending on how you draw a schematic: two transmission lines stretched horizontally in one row will radiate differently than the same two lines laid out in a "U turn" fashion in two rows but only one column. This occurs because the left end of the second trace is at the junction of the lines in the first case, but at the far end of the trace run in the second. When these left ends are placed at location 0,0, the radiation results will differ.

If you find the preceding caveat confusing, you may want to limit your LineSim EMC simulations to single-trace cases.

When you simulate differential traces in LineSim EMC (i.e., a differential pair), because LineSim does not have physical information about the separation between the traces, the traces are assumed NOT to be separated. This results in better field cancellation than the traces will actually exhibit; hence, LineSim EMC's differential-pair simulations are "optimistic." **This restriction applies in the current version of the program even if the transmission lines in the trace pair are coupled and have their separation specified in a coupling region.**

Chapter 4: Brief Description of EMC Algorithms

Overview

This chapter briefly describes the algorithms used by HyperLynx to predict differential-mode radiation.

Types of Radiation-Prediction Algorithms

HyperLynx predicts differential-mode radiation using a 3-D radiation prediction algorithm developed by university experts in computational electromagnetics. This algorithm provides a good balance between techniques that are excessively intense computationally (resulting in poor simulation speed) and methods that are purely quantitative (e.g., exclusively rules-based, and therefore very approximate).

More specifically, the following techniques have been used in various EDA tools to predict differential-mode radiation. The methods are listed in order from least to most quantitative:

Rules-based — No calculation; provides a rough estimate based on driver slew rate, trace length, board cross section; fast, but simplistic

First-order calculated — Simple calculation; assumes driver is a linear ramp when calculating frequency-domain characteristics; does not use real currents and may miss the effect of terminators

HyperLynx method — Detailed calculation; uses full non-linear driver model and accounts for terminations; analyzes currents found from time-domain signal-integrity simulation

“Full wave” or “method of moments” — Intense calculation; solves for current densities at the same time as predicting radiation; may run slowly and may exceed the limits/tolerances of the problem being modeled

Outline of HyperLynx's Trace-Radiation Algorithm

HyperLynx's “detailed calculation” algorithm is incorporated in its EMC simulations of PCB traces as follows:

“Flow” of the HyperLynx trace-radiation algorithm:

1. User chooses trace to analyze. Software “pulls in” chosen net plus any non-power-supply nets connected by components (resistors, capacitors, differential driver ICs, ferrite beads).
2. User specifies EMC-measurement-antenna characteristics: distance; automatic scanning for maximum radiation versus manual positioning; sensitive to package radiation or not.
3. User specifies trace's repetition frequency and duty cycle; also chooses IC models; clicks “Start” button. Time-domain (signal-integrity) analysis runs. Software automatically runs for as many cycles as needed for a valid conversion to frequency domain.
4. Time-domain data is tightly filtered in preparation for conversion to frequency domain (anti-aliasing).
5. Fast Fourier Transform (FFT) is run on time-domain data, so that currents' components are known at every frequency of interest.
6. Path-delay algorithm runs to determine time delay between driver IC(s) and each metal segment comprising the net(s) being simulated.

7. *For each metal segment on the net(s) and for each frequency at which any significant energy exists, and accounting for the segment's delay from driver IC(s), electric-field-intensity vector is calculated ("E," measured in units of volts/meter) for specified antenna characteristics.*
8. *Repeat step 7 for each metal segment on trace.*
9. Vectorially sum all segments' contributions together, and display results in spectrum-analyzer screen or board report.

Assumptions of Core Radiation Algorithm

The "core" differential-mode radiation-prediction algorithm (used segment-by-segment) is a powerful, general 3-dimensional radiation predictor. However, in order to maintain reasonable calculation speed, it makes several assumptions:

- ◆ There are no large, grounded metal objects near the trace(s) being analyzed (e.g., enclosure walls or grounded heat sink)
- ◆ The antenna is sufficiently distant that the radiation is far-field only

The far-field assumption precludes the antenna's being any nearer than 3 meters from the board being simulated. (This restriction — far-field prediction only — may be removed in future versions of the software.)

Outline of HyperLynx's Package-Radiation Algorithm

On many modern boards, the component packages themselves (especially IC packages) generate significant amounts of radiation. In order to better match actual lab results, BoardSim EMC automatically creates a radiation model for the package of each component attached to the trace being simulated (not available in LineSim EMC). This modeling is performed automatically so as not to burden the user with extra modeling requirements.

It should be noted that prediction of package radiation is necessarily more approximate than prediction of trace radiation. For this reason, modeling package radiation is always optional in BoardSim EMC; it can be turned on or off at the user's discretion. Nevertheless, HyperLynx believes it has a very good automated method for creating package radiation models, described as follows:

“Flow” of the HyperLynx package-radiation algorithm:

1. User chooses trace to analyze. Software “pulls in” every component attached to trace.
2. Each component package footprint is analyzed. Footprint information is combined with knowledge of component's type (IC, resistor, etc.) to allow automatic matching to physical package type (e.g., DIP, SOIC, 1206 discrete, etc.)
3. Two “active” pins on each component automatically determined: “input” and “output” pin for series passive component (e.g., resistor), or I/O pin and matching power-supply pin for IC.
4. Active pins are modeled as radiators standing vertically on a conducting plane (with multiple dielectric boundaries); opposing current directions in two pins gives differential effect.
5. Radiation from component pins is added to trace radiation during simulation.

Assumptions of Package-Radiation Algorithm

Several simplifying assumptions are built into the package-radiation algorithm (listed below). If any of these is substantially violated by a particular component (e.g., a microprocessor with sophisticated package), the user may wish to disable package radiation and concentrate exclusively on trace radiation.

- ◆ Packages are referenced to the nearest power/ground plane in the PCB stackup, and lack any significant internal grounding

- ◆ Current out of an IC is sourced by (or current into an IC is sunk by) the nearest appropriate power-supply pin; ICs do not have multiple power rails
- ◆ ICs are not socketed, i.e., they stand off of the PCB by their intrinsic package height only

These assumptions may be removed in future versions of the software.

How Maximum Radiation is Found

In general, the fields around a real PCB are not symmetric: they have “lobes” that cause the radiation to be stronger in certain directions from the PCB than from others. In EMC lab testing, then, the PCB is rotated and the sensing antenna raised and lowered to find the positions of maximum radiation.

BoardSim EMC automatically finds the position of maximum radiation for each frequency at which there is significant radiation. The software’s method closely matches that of a real testing lab: the PCB is rotated through 360 degrees in small increments and the antenna is raised from the plane of the PCB up to 45 degrees elevation (again incrementally), all as the radiation is constantly recalculated in search of a maximum.

Chapter 5: Running EMC Simulations

Overview

This chapter describes how to set up LineSim EMC's/BoardSim EMC's spectrum analyzer, and how to run simulations. Specifically, it discusses:

- ◆ requirements before simulating
- ◆ setting the spectrum-analyzer probe
- ◆ setting up the spectrum analyzer
- ◆ radiation prediction in LineSim EMC
- ◆ running an EMC simulation
- ◆ copying a simulation to the Clipboard
- ◆ printing a simulation

Requirements Before Simulating

You can open LineSim EMC's/BoardSim EMC's spectrum analyzer as soon as you've entered a schematic or loaded a board, but before it will actually run a simulation, you must:

- ◆ have an electrically valid stackup
- ◆ choose a driver IC for the net you're simulating

If you try to simulate before having a valid stackup or selecting a driver IC, LineSim EMC or BoardSim EMC will give an error. (For details on these topics, see the appropriate sections of the LineSim or BoardSim manual.)

Note: For LineSim EMC, the requirement to have a valid stackup applies even if you have no transmission lines in the schematic which are modeled with the stackup method. LineSim EMC always starts a new schematic with a valid default stackup, so if you have no stackup-based transmission lines and you don't edit the default stackup, you should never encounter this problem.

See “Setting Up the Spectrum Analyzer” below in this chapter for details on opening the spectrum analyzer.

Additional Requirements for Simulating Differential Nets

In addition to the requirements listed above, if you are simulating a pair of differential-signal nets, you must:

- ◆ use an IBIS differential model for the driver-IC pin pair; if you use a non-IBIS model (.MOD or .PML) or a non-differential IBIS model, the spectrum analyzer will not run (error message “too many drivers”)
- ◆ set one side of the differential model to state Output and the other to state Output Inverted, to ensure that the canceling effect of the opposed differential currents is properly modeled

Setting the Spectrum-Analyzer Probe

In LineSim EMC/BoardSim EMC, the “probe” means either an antenna or a current probe. The antenna is used to measure electric-field strength like you would in an EMC lab. The current probe gives you a way of viewing the current flowing at a point in your circuit. For the antenna, you specify a distance from the board; for the current probe, you specify a component pin on the net(s) you are simulating. The spectrum analyzer supports a single antenna or current probe.

Current probing is used rather than voltage because radiation is generated by current flow. Antenna probing accounts for both the source currents on the net and how effective the net is as a radiator (i.e., its unintended antenna characteristics); the antenna measures electric-field strength directly. The current probe measures only the source current, but displays it in the frequency domain, so you can see how much current is present at various frequencies of interest. Normally, you will use the antenna; in certain cases where you want to focus directly on current and reducing it, you might use the current probe.

Selecting between Antenna and Current Probe

To choose between the antenna and a current probe:

1. From the Spectrum/Sim menu, choose Attach Probe.
OR
With the spectrum analyzer open, in the Probe area, click the Settings button.
The Set Spectrum Analyzer Probing dialog box opens.
2. In the Probe Type area, click on either the Antenna or Current radio button.

When you make your selection, an icon in the Probe Type area changes to illustrate your choice.

Units for Radiation Measurement

If you choose LineSim EMC/BoardSim EMC's antenna as a probe, measurements are made and displayed in dBuV/m, i.e., microvolts/meter (the unit of electric-field strength) on a logarithmic decibel scale.

If you choose a current probe, measurements are made in mA, on a logarithmic scale.

When is the Current Probe Useful?

Since currents flowing in nets are ultimately the source of radiation from your board, one approach to EMC design/analysis is to focus only on those currents,

and reducing them or re-distributing where their energy lies. If this is the way you prefer to do EMC design, then the current probe is valuable. Switching to the antenna adds the additional element of weighting the source currents by the antenna characteristics of the trace segments on the board, and predicting actual electric-field strengths off-board.

Another advantage to the current probe is increased simulation performance. Radiation prediction is mathematically complex, so running with the antenna enabled entails additional, time-consuming mathematical steps. Turning on the current probe instead eliminates the radiation-prediction steps and so produces faster results.

The disadvantage of the current probe is that its results do not compare directly to EMC-lab measurements (i.e., current is measured instead of electric-field strength). The current probe **is** valuable as a way of understanding the frequency composition of your signals, but direct correlation to radiation levels is not easy to make.

Setting Up the Antenna

There are several aspects to setting up LineSim EMC's/BoardSim EMC's antenna: setting its distance; choosing its position; and deciding to which radiation sources it will be sensitive (traces, component packages).

To set up the antenna, first open the Set Spectrum Analyzer Probing dialog box:

1. From the Spectrum/Sim menu, choose Attach Probe.
OR
With the spectrum analyzer open, in the Probe area, click the Settings button.

Then, follow the steps in the sections below.

Choosing Antenna Distance

In an EMC lab, you typically have the choice of making measurements at one of several standard distances (usually measured in meters). Your results are

compared to the appropriate government regulations, with the limits scaled for the distance you choose. The most-typical distances are 3 meters, 10 meters, and 30 meters. As the popularity of anechoic (shielded) chambers increases, the 3-meter distance is becoming most-common, since building a large chamber is prohibitively expensive.

To set the antenna distance:

1. In the Antenna Probe area, pull down the Distance from Antenna to PCB combo box, and choose 3, 10, or 30 meters.

The distance you choose is arbitrary. If you plan to perform real EMC-lab measurements on your board, you may want to use the same distance you will later use in the lab.

Setting the Antenna and Board Position

In an EMC lab, the board under test is rotated and the measurement antenna raised and lowered so that the maximum radiation at each frequency is found. (See Chapter 4, section “How Maximum Radiation is Found” for details.) In LineSim EMC/BoardSim EMC, this positioning is performed automatically for you — or you can disable it and fix the board's and antenna's positions. The advantage to a fixed position is that simulations run faster. The advantage to checking all positions is that the maximum radiation at each frequency is found automatically.

To have the maximum radiation at each frequency found automatically:

1. In the Antenna and Board Position area, click on the Automatically Find Positions for Maximum Radiation check box.

To use a fixed antenna and board position:

1. In the Antenna and Board Position area, click off the Automatically Find Positions for Maximum Radiation check box. The Antenna Height and PCB Rotation Angle selections become active.
2. In the Antenna Height box, type the value in meters of the antenna's elevation.

3. In the PCB Rotation Angle box, type the value in degrees of the board's rotation angle.

The antenna height is measured from the plane of the board (i.e., it measures how much higher than the board the antenna is set). Typical values range from 0 to 3 meters. PCB rotation specifies the rotation angle of the board measured in its own plane. Maximum radiation may occur at any angle between 0 and 360 degrees.

Choosing from Which Sources to Measure Radiation

The radiation from a PCB comes not only from the board's traces, but also from the ICs on the board. On many modern boards, the ICs may radiate as much or more than the PCB's traces. (See Chapter 2, section "Radiation from Component Packages" for details.) BoardSim EMC is able to predict component-package radiation.

Enabling Package-Radiation Measurement (BoardSim EMC Only)

To enable measurement of the radiation from a board's component packages:

1. In the Include Radiation From area, click on the Component Packages check box.

One of BoardSim EMC's strengths is that it is able to predict the radiation emanating from component packages. It does so without requiring you to enter any special information about the packages; all the required modeling data is determined automatically from an examination of your PCB.

When to Turn Package Radiation On and Off

You can toggle package radiation on and off to see the contribution that your components' packages (especially ICs) are making to a net's radiation levels. For example, start with package radiation enabled and run a simulation; then disable package radiation and re-simulate; then compare the two sets of results. (See "Re-Simulating; Comparing Results" below in this chapter for

details on how to compare.) Generally, the radiation levels will be significantly higher with package radiation enabled than without.

Package Radiation Not Available in LineSim EMC

LineSim EMC is not able to predict package radiation, because there is no physical information available about the ICs in a LineSim schematic. Radiation is from the stacked-up traces in the schematic only.

Quick Terminators and EMC Simulations

You can add a Quick Terminator to a net for which you are running EMC simulations, to see whether adding the terminator to your board would improve the net's radiation profile. However, be aware that unlike real passive components (components that are actually included in your layout), Quick Terminators do not contribute any package radiation to the spectrum analyzer's results. This occurs because BoardSim EMC does not have any information about a Quick Terminator's physical package or its orientation on your board.

Warning about Power-Supply Pins in BoardSim EMC

The position of power-supply pins affects the amount of radiation generated by an IC package. BoardSim EMC searches for power-supply pins by looking at the nets to which the pins on each IC are connected. Even though you can run simulations with an IC that is not connected to power-supply nets (by choosing the "typical" Vcc and Vss values; see the BoardSim User's Guide for details), in this case BoardSim will not know the locations of the power-supply pins on the IC, and will use the positions of the pins farthest from the pin being simulated. In some cases, this may lead to prediction of too much radiation.

If you have such a situation (e.g., on a partially routed PCB where power-supply connections have not yet been made), turn off prediction of package radiation and focus entirely on the radiation being generated by nets' trace segments.

Enabling Trace Radiation

To enable measurement of the radiation from a board's traces:

1. In the Include Radiation From area, click on the Printed Circuit Traces check box.

Normally, you would always leave trace radiation enabled, unless you want to completely isolate a net's package radiation.

Enabling Multipath Correction

The government EMC standards (e.g., FCC and CISPR) require that tests be performed at a site with an earth-grounded metal floor. The reason is that a grounded floor is non-absorbing, i.e., it will reflect back up to the sensing antenna radiation that emanates from the bottom of the board under test. The ability to measure radiation that travels both directly and indirectly to the antenna is called “multipath” sensing.

If you test a board in an open-field chamber, odds are high that an actual grounded floor will be present. If you test in an anechoic chamber, there may not be a grounded floor, but if not, the measured results will usually be corrected with software to compensate.

To enable multipath-sensing capability:

1. In the Include Radiation From area, click on the Multipath from Earth Ground check box.

Normally, you would always leave multipath sensing enabled, so that LineSim EMC/BoardSim EMC shows you results as if a grounded floor was present (“non-absorbing”). Turn multipath off only if you're interested in seeing how large a difference it makes (“absorbing”).

Attaching the Current Probe to a Pin

In most cases, you will use the antenna probe in LineSim EMC/BoardSim EMC, so that the spectrum analyzer measures electric-field strength directly. However, you can optionally use a current probe instead.

To attach a current probe, first open the Set Spectrum Analyzer Probing dialog box:

1. From the Spectrum/Sim menu, choose Attach Probe.
OR
With the spectrum analyzer open, in the Probe area, click the Settings button.
Verify that the Probe Type is set to Current.
2. In the Current Probe area, in the Pin list box, double-click on the pin to which you want attach the probe.

In BoardSim EMC, all pins have names of the form:

```
<reference_designator>.<pin_name>
```

For a description of how pins are named in LineSim EMC, see below.

Note that the current probe requires you to choose a particular component pin for probing. (This works like when you're using an oscilloscope probe, with some sort of current probe attached. The antenna, by contrast, functions differently; it makes measurements remotely.) In LineSim EMC, if you want to probe at a point in the schematic where there is no component, see below for details.

Pin Names in LineSim EMC

Passive Components

Pins on passive components have names of the form:

```
<component_type>(X,Y).<pin_number>
```

where <component_type> is:

- ◆ RP for a pull-up resistor
- ◆ RD for a pull-down resistor
- ◆ C for a capacitor

- ◆ RS for a series resistor
- ◆ L for a series inductor
- ◆ BD for a series ferrite bead

(X,Y) is the component's cell label in the schematic, and <pin_number> is "1" or "2".

Pin Numbers

Terminating-component pin numbers are assigned as follows:

For pull-up and pull-down resistors, and capacitors:

- ◆ pin 1 is the side farthest from the power-supply net
- ◆ pin 2 is the side attached to the power-supply, or nearest to it

For series components:

- ◆ pin 1 is the left side
- ◆ pin 2 is the right side

ICs

Signal pins on ICs have names of the form:

$$U(X, Y)$$

where (X,Y) is the IC's cell label in the schematic. Unlike with passive components, there is no explicit pin number (i.e., "1" or "2").

Probing Where There is No Component (LineSim EMC Only)

In LineSim EMC, if you want to probe at a position in your schematic where there is no component (e.g., between two transmission lines), use the following “trick.” (In BoardSim EMC, you can probe only at component pins.)

To probe at a cell where there is no component:

1. Modify the schematic by activating an IC at the cell you want to probe. Assuming that the IC has not been activated previously, so that it has an unknown model (i.e., is labeled “????”), leave the model unspecified. ICs with unknown models have no effect on simulation, i.e., act like open circuits.

If an IC model *has* been previously specified, right-click on the IC and remove its model. (See the appropriate section of the LineSim or BoardSim manual for details on removing models.)

2. Follow the steps described in above to add a probe at the new IC.

Hint: *An alternate method is to activate a 10K pull-up or pull-down resistor at the cell. Such a large resistor will have no effect on your circuit (it's a very small load), but gives you a component pin at which you can probe.*

Changing the Current-Probe Location

To change the current probe's location, when the probe is already attached:

1. In the Set Spectrum Analyzer Probing dialog box, in the Pin list box, double-click on the new pin to which you want to change the probe.

The new pin overwrites the old assignment.

How Probes Display

In LineSim EMC

With the Current Probe Attached

In LineSim EMC, if you're using the current probe, when you exit the Attach Spectrum Analyzer Probe dialog box the schematic editor updates to show the probe location. The probe is displayed in the editor as a colored, circled arrow labeled with the pin to which it is attached. The circle around the arrow distinguishes it from oscilloscope probes.

In BoardSim EMC

With the Antenna Probe Attached

In BoardSim EMC, if you're using the antenna probe, an “antenna” icon appears in the corner of the board viewer as a reminder. The icon shows an antenna shape and a readout of the antenna's distance setting. (For details on settings the antenna's distance, see “Setting Up the Antenna” above in this chapter for details.)

With the Current Probe Attached

In BoardSim EMC, if you're using the current probe, when you exit the Attach Spectrum Analyzer Probe dialog box the board viewer updates to show the probe location on the currently selected net. The probe is displayed in the viewer as a colored, circled arrow labeled with the pin to which it is attached. The circle around the arrow distinguishes it from oscilloscope probes.

Setting Up the Spectrum Analyzer

To open the spectrum analyzer:

1. From the Spectrum/Sim menu, choose Run Spectrum Analyzer.
OR

Click the Open Spectrum Analyzer/Simulator button on the toolbar. The Spectrum Analyzer dialog box opens.

Before you simulate, there are several parameters to set up. See the following sections for details.

Choosing the Driver Waveform

LineSim EMC/BoardSim EMC predicts radiation for repetitive signals, i.e., nets that carry a regular, periodic signal. (Aperiodic signals rarely cause EMC problems; see Chapter 2, section “Radiation from Periodic versus Random Signals” for details.) Therefore, before you simulate, you must specify the frequency and duty cycle of the driver switching waveform.

To specify the frequency:

1. In the Driver Waveform area, type a value (in megaHertz) into the Freq box.

To specify the duty cycle:

1. In the Driver Waveform area, type a percentage value into the Duty Cycle box.

The duty cycle value defines the percentage of time that the driver spends high.

If you enter a perfect 50%-50% duty cycle, LineSim EMC/BoardSim EMC reminds you that perfectly balanced duty cycles almost never exist in a real system. You can simulate with the duty cycle set to 50%, but LineSim EMC/BoardSim EMC defaults to a slightly asymmetric duty cycle. See “How Duty Cycle Affects EMC Simulation” below for more details.

About Non-Repeating Signals

It is periodic signals, i.e., signals with a regular repeating pattern, that cause EMC problems. The reason is that periodic signals have most of their energy “bunched” at frequencies that are multiples of the signal's base frequency, i.e., at harmonics. Aperiodic (non-repeating) signals, by contrast, have their energy

spread out over a wide range of frequencies. It is the high concentrations of energy at harmonic frequencies that usually cause EMC failures.

This does not mean that only clock signals should be simulated in LineSim EMC/BoardSim EMC, however. Any signal, regardless of its logic function, that regularly repeats is a candidate to be simulated. In addition to clocks, you may also want to consider:

- ◆ strobe and control lines with regular patterns (e.g., RAS and CAS in a DRAM subsystem)
- ◆ low-order address lines (e.g., A0 - A3)

For these kinds of repeating but non-clock signals, adjust the frequency and duty cycle to best match the shape of the expected waveform.

How Duty Cycle Affects EMC Simulation

EMC simulations are very sensitive to a signal's duty cycle. This is particularly true when comparing results from a simulation run with a perfect 50%-50% duty cycle to results from a simulation with a non-ideal duty cycle, e.g., 48%-52%. If you set the duty cycle to exactly 50%-50%, the signal's even-harmonic radiation may be low or non-existent (depending on how "clean" the net is from a signal-integrity standpoint; recall that a perfect square wave has only odd harmonics). Since real signals are rarely perfectly balanced, you may want to simulate at a duty cycle that is slightly off of perfect (like 49%-51%), to remind yourself that even-harmonic radiation may exist in your system.

Note: When you enter a duty cycle in LineSim EMC/BoardSim EMC, you enter only a single number: the percentage of time that you want the signal to spend in its high state.

Setting the Center Frequency and Bandwidth

Both the center frequency and horizontal scale (MHz/div) settings for the spectrum analyzer are set in the Horizontal area. The two settings are completely independent.

To set the center frequency:

1. Type a value (in megaHertz) into the Center Freq box.

You can also make fine adjustments to the center frequency, without having to re-type the value.

To fine-adjust the center frequency:

1. To the right side of the Center Freq box, click on the up or down arrows to increase or decrease the center frequency.

The fine-adjust mechanism works in increments of 1 MHz.

To set the horizontal scale (MHz/div):

1. Next to the MHz/div knob, click on the right or left arrows to increase or decrease the number of megaHertz per division that appear on the spectrum analyzer's screen.

The spectrum analyzer's frequency-scale increments are logarithmic (1,2,5,10,...).

Red Display if the Center Frequency is Not Valid

It is possible to set a combination of center frequency and horizontal scale such that the specified center frequency cannot be displayed (i.e., some other frequency has to be at the center of the display in order to avoid showing negative frequencies). When this occurs, the frequency value in the Center Freq box turns red.

Setting the Vertical Offset

To set the spectrum analyzer's vertical offset:

1. In the Vertical area, click on the right or left arrows to increase or decrease the vertical offset (effectively, the vertical “magnification.”)

If you are running with the antenna probe (see “Selecting between Antenna and Current Probe” above in this chapter for details on choosing the probe type), the display is measured vertically in dBuV/m (a decibel measurement of electric-field strength), and the offset's increments are 10 dBuV/m. If you are running with the current probe, the display is measured vertically in mA, and the offset's increments are in decades (e.g., 10mA, 100mA, 1A, etc.).

Setting IC-Model Operating Parameters

If there are IC models in your simulation, you can control from the spectrum analyzer whether the models run with best-case, typical, or worst-case operating parameters.

What IC Operating Settings Mean

The IC operating settings are actually combinations of the min and max data in an IC model. The combinations are named Slow-Weak, Typical, and Fast-Strong, to be as descriptive as possible. The following table shows how the combinations are defined:

| Parameter | for Fast-Strong/for Slow-Weak |
|------------------------|--------------------------------------|
| driver current: | max/min |
| slew rate: | max/min |
| clamp-diode current: | max/min |
| component capacitance: | min/max |

| Parameter | for Fast-Strong/for Slow-Weak |
|----------------------|--------------------------------------|
| package inductance: | min/max |
| package capacitance: | min/max |
| package resistance: | min/max |

(See the appropriate sections of the LineSim or BoardSim manuals for details on IC modeling formats.)

Setting the Operating Conditions

To set the IC operating parameters:

1. Click the appropriate radio button in the IC Modeling area.

Choosing Regulatory Limits

LineSim EMC/BoardSim EMC allows you to check your EMC simulation results against government regulations, so you can see whether or not your nets' radiation exceeds those limits. The spectrum analyzer displays the appropriate limits directly on its display, so you can do easy visual comparisons.

You can choose between the following regulatory limits:

- ◆ FCC — United States
- ◆ CISPR — European Community
- ◆ VCCI — Japan
- ◆ user — your own custom limits

For each type of limit, you can choose either or both product “classes”:

- ◆ Class A — for industrial products

- ◆ Class B — for consumer (i.e., commercial) products

The user limits allow you to create your own specification to check against. You might have a rule, for example, that you want no single net on your board to exceed 70% of the FCC or CISPR limits. You could use the user limits to define this requirement.

To choose one or more limits to check against:

1. In the Regulations area, click on one or more of the regulation types (FCC, CISPR, VCCI, user).
2. In the Class area, click on one or both of the class selections.

The limits are plotted in the spectrum-analyzer display as soon you enable them. Each type of limit (FCC, CISPR, etc.) has its own color, so you can display several sets of regulations simultaneously.

Defining User Limits

To define your own custom “user” EMC limits:

1. In the Regulation area, click the Edit User button. The Edit User-Defined Limits dialog box opens.
2. In the Class A Limits and Class B Limits areas, type frequency and electric-field-strength values that define your desired custom limits. Enter values that define your limits at a distance of 3 meters; LineSim/BoardSim EMC will scale the values if you simulate at other distances.
3. When all values are entered, click OK.

Rules for Defining Limits

- ◆ Define limits for an antenna distance of 3 meters.
- ◆ All data boxes must be filled, even if you do not need all of them to define your limits.

- ◆ Limit 1 sets the testing level for frequencies between the Start Frequency and Frequency 2; Limit 2 sets the level between Frequency 2 and Frequency 3; and so forth.
- ◆ If you do not need all four limit levels, fill the unused data boxes with the value of the last-used frequency and limit. For example, if the last boxes you need are Frequency 4 = 1000 MHz and Limit 3 = 40 dBuV/m, then set the End Frequency also to 1000 and Limit4 to 40.
- ◆ LineSim/BoardSim EMC will not accept your values if the frequencies do not increase or stay the same as you move from Start to End frequency. For example, if Frequency 4 is 1000 MHz and you enter 0 MHz for End Frequency, LineSim/BoardSim EMC will give an error and force you to correct the values.

To employ your user limits:

1. In the Spectrum Analyzer dialog box, in the Regulations area, click on the User check box, and either or both of the Class A and Class B check boxes.

***Note:** You can also check against user limits automatically, in batch mode. See the appropriate sections of the LineSim or BoardSim manual for details on batch-mode EMC, called the “Compliance Wizard.”*

Entering a Spectrum-Analyzer Comment

The Spectrum Analyzer dialog box includes an area above the screen labeled “Comment.” The Comment box allows you to enter a description or comment that prints or is copied to the Windows Clipboard with your spectrum-analyzer results. (See “Printing a Simulation” below in this chapter for details on printing, and “Copying a Simulation to the Clipboard” below for details on using the Clipboard.)

To enter a printable comment in the spectrum analyzer:

1. In the Comment box above the screen, click once with the mouse. A cursor appears in the upper left of the box.

2. Type the description or comment.

Running an EMC Simulation

To run a simulation:

1. In the Spectrum Analyzer dialog box, click the Start Simulation button.

The Simulation Status dialog box opens, and simulation begins.

Transient Steps

When the pre-transient steps are completed, LineSim EMC/BoardSim EMC begins its time-domain transient simulation. The results of the time-domain simulation are not displayed until after the entire simulation is complete, including conversion of data to the frequency domain and radiation analysis. The transient simulation may take some time to complete, as the simulator needs multiple cycles on which to base its analysis.

Anti-Aliasing Filter

Before converting the transient data to the time domain, LineSim EMC/BoardSim EMC runs a sharp, 36-dB/octave low-pass filter to ensure that no aliasing occurs when the data is converted to the frequency domain. The cut-off point of the filter is determined automatically by the simulator.

Time-to-Frequency-Domain Conversion

After the time-domain simulation is complete, LineSim EMC/BoardSim EMC converts the time-domain results to the frequency domain, using a Fast Fourier Transform.

Radiation Simulation (Antenna Probe Only)

If you are using the antenna probe, after conversion to the frequency domain, LineSim EMC's/BoardSim EMC's radiation-prediction algorithms run. These perform a sophisticated 3-dimensional field analysis to determine, at every point in space for which they're called, what radiation levels are generated by the net or schematic being simulated. Radiation prediction is a mathematically intense process, and may take a considerable amount of time to run. The Simulation Status dialog box advises you of the program's status.

Percent Done and Status Messages

The Simulation Status box displays the completion percentage during each phase of the simulation. The dialog box also displays text messages from the simulator telling you what steps are currently being run, etc.

The Simulation Display

LineSim EMC/BoardSim EMC shows two views of the simulation:

- ◆ at the top, a time-domain display, showing a time-domain current waveform at the driver IC
- ◆ below, a frequency-domain display, showing the frequency-domain results of the simulation

The program automatically determines how to create the time-domain data needed for a valid frequency analysis. The time-domain (or “mini oscilloscope”) display may help you understand why you're seeing in the frequency domain the results you are. Note that the waveform is of driver current (not voltage).

“Hatched” Bandwidth-Limitation Zone

As you change the settings in the spectrum analyzer's Horizontal area, you may see a hatched region on the right side of the analyzer's display. The hatching covers the frequency area in which the spectrum analyzer's response has fallen by 3 dB or more, so that data there is not valid. The bandwidth of

the spectrum analyzer is automatically controlled by LineSim EMC/BoardSim EMC.

Stopping a Simulation

To stop a simulation before it has completed:

1. In the Simulation Status dialog box, click the Stop button.

Printing a Simulation

You can print your simulation results in order to document them.

To print simulation waveforms:

1. In the Spectrum Analyzer dialog box, click the Print button.
2. In the Print Setup dialog box, check your printer setup. Click OK to begin printing.

LineSim EMC and BoardSim EMC support color printers; simulation results sent to a color printer are output with colored waveforms.

Setting Up for Printing

You can set up printing-related defaults — e.g., printer choice, paper size, page orientation, etc. — once, then have them apply for the remainder of your work session, and for all types of printing (schematics, stackups, oscilloscope results, etc.).

To set up “persistent” printing defaults:

1. From the File menu, choose Print Setup. The Print Setup dialog box opens.
2. Change any parameters you wish, then click OK.

BoardSim EMC/LineSim EMC now remembers the choices you’ve made, and will continue to use them.

Copying a Simulation to the Clipboard

You can copy your simulation results to the Windows Clipboard in order to paste them into other Windows applications. The image sent to the Clipboard is formatted, and includes information such as the name of the .TLN or .HYP file and a time and date stamp.

To copy simulation results to the Windows Clipboard:

1. In the spectrum analyzer, click the Copy to Clip button.

Exporting Simulation Data to Another Application (.CSV File)

Occasionally, you may want to export the radiation- or current-versus-time simulation data displayed in the spectrum analyzer to another application, like Excel or Mathcad. To facilitate this need, the spectrum analyzer can output a comma-separated-values (.CSV) file which includes all of the data displayed in the analyzer window for the present simulation. .CSV files can be read directly by Excel (and most other spreadsheet programs), and are easily read by an input routine in mathematical programs like Mathcad.

To write a .CSV file representing the results of a simulation:

1. In LineSim EMC/BoardSim EMC, open the Spectrum Analyzer dialog box and run the simulation whose results you want in a .CSV file.
2. Click the Save As CSV button. The Save Spectrum Analyzer Output dialog box opens.
3. Choose a directory and name for the .CSV file, then click the Save button.

Format of the .CSV File

The top of the .CSV file records the creation date and other similar data. Then, below, arranged in columns, is the frequency and either radiation or current

data (depending on which probe type you simulated with) for the present simulation.

The .CSV file will open directly in programs like Microsoft Excel (in Excel, use choose File/Open or double-click in the Windows Explorer on the .CSV file). If you are reading the file with a mathematics-package program and do not want the header information at the top (creation date, etc.), you can remove it using any text editor.

The frequencies in the file are in megaHertz; electric-field strengths are in uV/m; currents are in mA.

Re-Simulating; Comparing Results

You can simulate a given board or schematic multiple times to see the effects of different IC models, line terminations, and so forth.

Displaying the Previous Results

For purposes of comparison, you can switch between the results of both the current simulation and the previous simulation (subject to certain caveats; see “When Previous Results Cannot be Displayed” below for details).

To display the results of the previous simulation:

1. In the Spectrum Analyzer dialog box, click on the Show Previous radio button.

To return to the results of the current simulation:

1. In the Spectrum Analyzer dialog box, click on the Show New radio button.

When Previous Results Cannot be Displayed

The results of the previous simulation cannot always be displayed. In particular, any change that adds or subtracts transmission lines to/from the simulator's circuit model may change the simulator's internal timebase and preclude displaying the previous results. This occurs if a new net is selected,

for example, or sometimes when a Quick Terminator is added to the previous simulation's net.

To save the results of a previous simulation that cannot be displayed:

1. Before closing the spectrum analyzer after the previous simulation, click the spectrum analyzer's Copy to Clip button. This copies the results to the Windows Clipboard.
2. Paste the clipped results into any Windows program that allows Clipboard pasting, e.g., Word or any Windows picture viewer.
3. Compare subsequent simulations to the clipped results.

Erasing a Simulation

You can force the current simulation to be erased from the spectrum analyzer's screen.

To erase the spectrum analyzer screen:

1. Click the Erase button.

This causes the current simulation to disappear. Results of the previous simulation's results are still available.

Radiation Prediction in LineSim EMC

Which Transmission-Line Types Radiate

In LineSim EMC, radiation can be predicted for only those transmission-line types for which exact-enough physical information exists. Specifically,

radiation is predicted for:

- ◆ stackup-based transmission lines
- ◆ microstrips

- ◆ buried microstrips
- ◆ striplines

radiation is **NOT** predicted for:

- ◆ “simple” electrical transmission lines
- ◆ cables
- ◆ connectors
- ◆ wires over ground

If you construct a schematic that contains only elements from the “not predicted for” list, and simulate it, you will see no radiation in the spectrum analyzer's output.

How to Simulate Lines Types that Don't Radiate

For transmission-lines types for which LineSim EMC doesn't predict radiation (due to lack of physical information), you can still perform meaningful simulations: use the current probe rather than the antenna. The current probe shows you the frequency content of the current in your schematic (at whatever component pin you attach it); that current in turn, is what generates radiation.

Using the current probe, you can reduce your design's radiation by making changes that reduce the current shown by the probe, or that re-distribute in a more-optimal way the frequencies at which the current has energy.

Additional LineSim EMC Caveats

LineSim EMC has two other important limitations (for more details, see Chapter 3):

- ◆ LineSim EMC cannot predict IC-package radiation
- ◆ LineSim EMC places all transmission-line segments physically at the origin, with the same angular orientation

Neither of these limitations exist in BoardSim EMC, where detailed package footprints and routing information exist.

EMC Simulation with “Serpentined” Traces (BoardSim EMC Only)

Some PCB autorouters have a feature that artificially increases the length of a net if the user provides a “minimum length” or “minimum delay” constraint. (This is often done in an attempt to reduce clock skew, by equalizing the lengths of two or more nets.) The increase is implemented by “serpentineing or tromboning” the trace through a series of tight, repeated turns that significantly increases the length of the net compared to a straight route.

When BoardSim EMC simulates the radiation from a trace, it calculates the radiation from each individual metal segment on the trace. However, in an effort to improve simulation speed, trace segments shorter than a certain threshold length are omitted from the calculations (since their contributions to the overall radiation levels should be low).

But if a trace is composed of nothing but short segments, the omission of short segments will cause the predicted radiation levels to be too low. To work around this, the short-segment threshold is available as a user-definable parameter. If you have nets (like the “serpentine” cases discussed above) that are composed mostly of short segments, decrease the threshold so that most or all of the segments on your nets are included in analysis.

To change the EMC-algorithm short-segment threshold:

1. From the Options menu, choose Preferences. The Options dialog box opens.
2. Click the Advanced tab, and the “Yes” button when prompted.
3. In the BoardSim area, in the For EMC Ignore Traces Shorter Than edit box, type the value (in mils) to which you want the threshold reduced.

Running EMC Simulations

Note that you should only change this parameter if you truly need to; otherwise you're simply wasting simulation time. Also, if you reduce the threshold for a particular board or group of traces, you should set it back to the default value (100 mils) afterward so that you don't waste simulation time in the future.

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