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Conducted Emissions Example Using CE Analyst™ Software

Introduction

CE Analyst™ provides electronics design engineers and EMI professionals with the ability to accurately predict conducted emissions produced by a wide range of electrical systems. Subtle effects of test setup, circuit characteristics, packaging, and resonant interactions are inherently accounted for in CE Analyst™ to simulate as closely as possible real-world results.

CE Analyst™ can be used as a prediction tool to help optimize system design before fabricating a prototype, or to troubleshoot an existing system by modeling known problems or to “test-run” potential solutions before retrofit. CE Analyst™ is designed to provide electrical engineers with extensive EMI analysis capability in an easy-to-learn, easy-to-use platform that minimizes the need for EMI expertise.

CE Analyst™ is one of four applications in the EMI Analyst™ suite of EMI analysis tools.

Summary

In this example a dc-dc converter is analyzed using CE Analyst™ to determine an appropriate EMI filter design to meet MIL-STD-461E CE102 conducted emissions requirements. The dc-dc converter contains a small EMI filter that is inadequate for meeting CE102 limits. If no additional filtering is used, conducted emissions will be as shown in left-hand graph of Figure 1. At 200 kHz conducted emissions are nearly 70 dB over the limit. Using CE Analyst™ the system will be analyzed and a suitable EMI filter will be synthesized so that conducted emissions are completely below the limit, as shown in the right-hand graph of Figure 1.

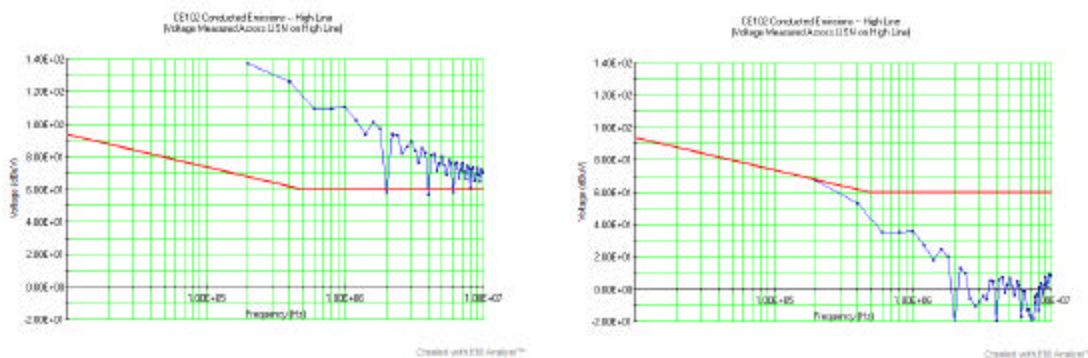


Figure 1 CE102 Summary Graphs

The envelope of the conducted emissions produced by the converter is shown in blue, while the CE102 limit is shown in red. The converter switches at 200 kHz so there are no conducted emissions below 200 kHz. Actually conducted emissions only exist at multiples of 200 kHz, but lines are drawn between the data points for visualization purposes.

Background Information

Product Description

The converter is a flyback design that transforms 28Vdc input power to 5Vdc output power in a piece of equipment that is used aboard an aircraft. A block diagram of the dc-dc converter is shown in Figure 2.

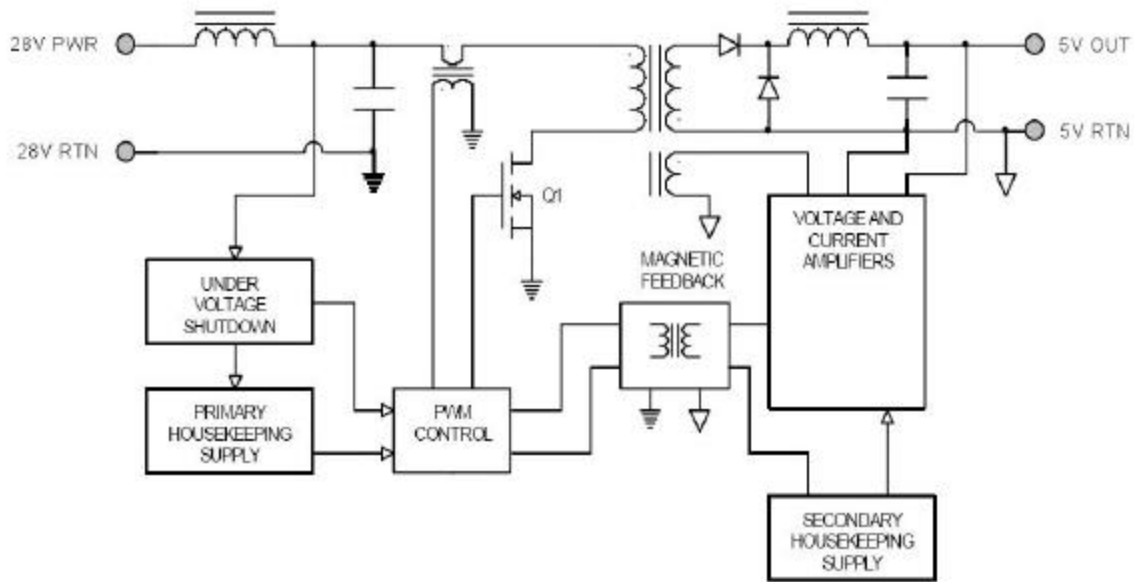


Figure 2 Flyback Converter Block Diagram

EMI Requirements

The conducted emissions limit for the converter is defined in MIL-STD-461E, method CE102.

Analysis Using CE Analyst™

The CE Model

The conducted emissions model in CE Analyst™ for our dc-dc converter is comprised of four main components, as illustrated in Figure 3:

1. A Source – This is the active circuitry in the dc-dc converter that generates the conducted emissions in the first place.
2. A Filter – A collection of passive circuit components whose job it is to attenuate conducted emissions generated by the Source.
3. The Conductors – A couple of wires that connect the dc-dc converter and filter to the Load.
4. The Load – Although it may seem backward, the 28 Vdc power source is the Load for the purpose of CE analysis. Per MIL-STD-461E, LISNs are inserted in the power lines 2 meters from the EUT (our dc-dc converter), so the Load consists of two LISNs and the output impedance of the 28 Vdc power supply.

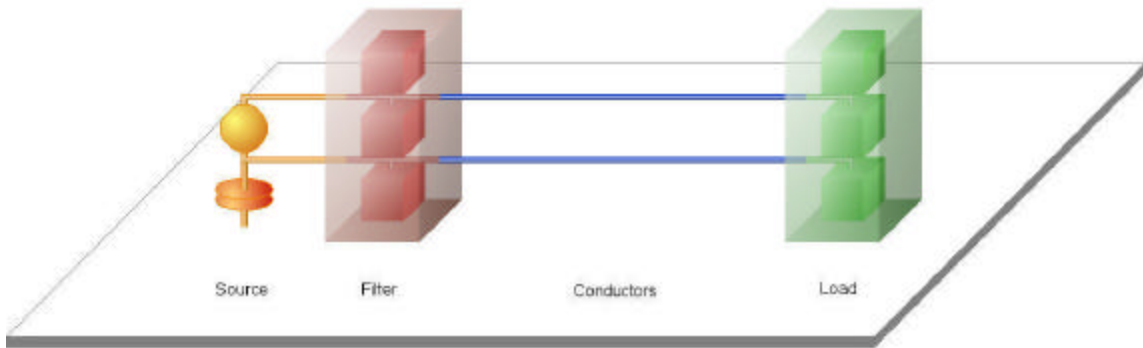


Figure 3 Conducted Emissions Model

Results

As anticipated at the beginning of this analysis, the EMI filter that is part of the dc-dc converter is insufficient to control conducted emissions. If it were, conducted emissions (shown in blue) would be below the Limit line (shown in red). In order to meet the CE102 requirements additional filtering is required.

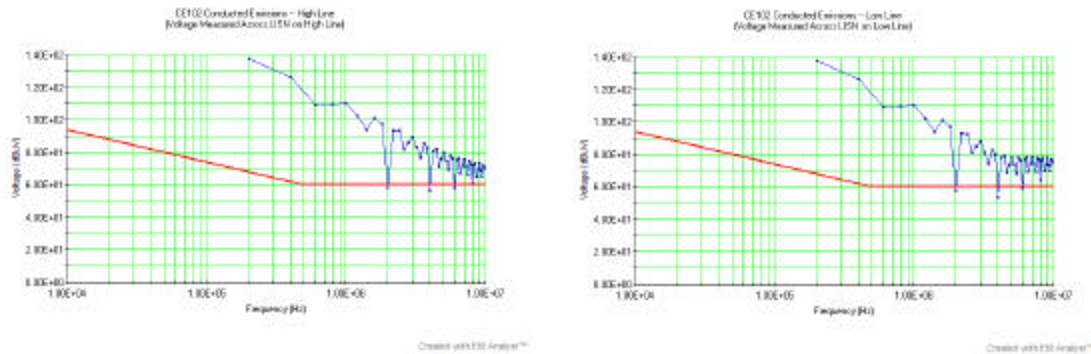


Figure 4 Minimally Filtered Conducted Emissions on 28V Power Lines

Filter Redesign

An EMI filter that meets these requirements is shown in Figure 5. The filter consists of 3-33 uF film caps in parallel from line-to-line, 0.001 uF surface-mount ceramic caps from each line to chassis, two uncoupled 25 uH inductors, and a 0.1 uF film cap from line-to-line. The types of capacitors are somewhat arbitrary for this example. Other capacitor types, which would have different parasitic values, might be more suitable.

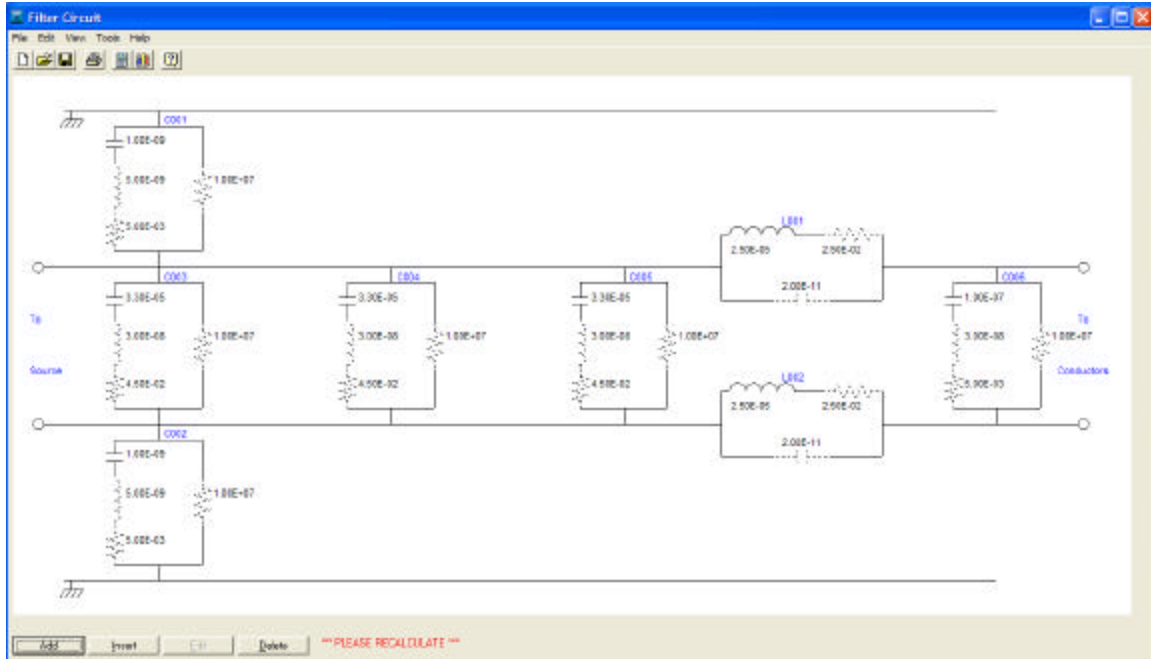


Figure 5 Revised EMI Filter Schematic Diagram

Results

Conducted emissions results using the revised filter are shown in Figure 6. The dc-dc converter is now compliant with MIL-STD-461E CE102 requirements.

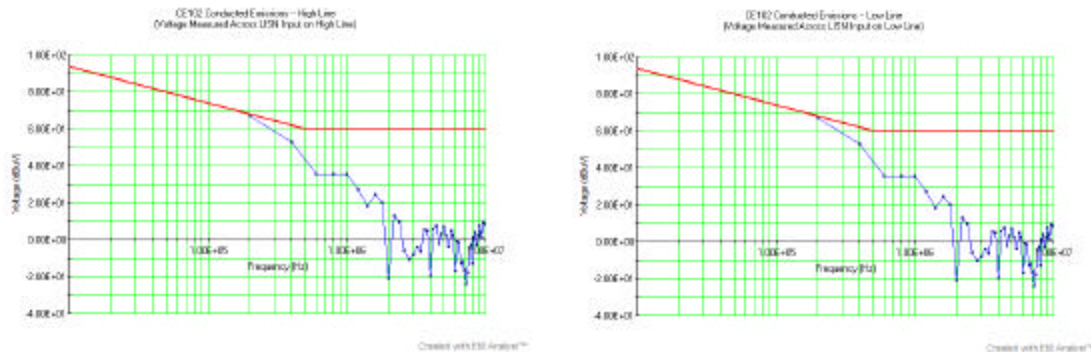


Figure 6 Conducted Emissions, High Line, with Improved EMI Filter

App Note: Since there is almost no margin it is good practice to increase the filter insertion loss slightly to allow for component tolerances, aging, temperature etc. Similarly, if component variations are known component values can be adjusted as desired to see the effects on the conducted emissions.

Conclusion

The dc-dc converter evaluated in this example exceeds the MIL-STD-461E CE102 limit by almost 70 dB. Using CE Analyst™ a relatively simple EMI filter design was synthesized that has sufficient insertion loss to make the unit compliant. CE Analyst™ accounts for the many subtleties of conducted emissions analysis, such as the dc-dc converter noise spectrum, the EMI filter component parasitics, and the MIL-STD-461E test setup. As a result, the dc-dc converter is accurately modeled and the predicted conducted emissions reflect what will be measured in the EMI laboratory.

CE Analyst™ can be a predictive tool to help optimize a system's design before purchasing or building any hardware. Or CE Analyst™ can be used to troubleshoot an existing system, either to model known problematic performance or to “test-run” potential solutions before retrofitting.

CE Analyst™ provides the electrical design engineer with unparalleled EMI analysis capability in an easy-to-learn, easy-to-use platform that minimizes the need for EMI expertise while maximizing EMI performance.