Signal Integrity and current return paths

By Donald L. Sweeney

When designing an electronic system, it is important that it function as intended; this requires an understanding of many aspects of EMC including signal integrity (SI). One of the principal ways we can learn to understand SI is by knowing where our currents are flowing, as they move from one area on the circuit board to another and return. It is always easy to know where the intended signal flows, as it will be contained in the trace you place on a circuit board, but where does the return signal current flow? If you have a ground plane the signal is "expected" to flow under the signal trace, as mirror current, as shown in Figure 1. At higher frequency "most" of the return current will flow under the signal trace but at lower frequencies this is not necessarily the case. The unsuspecting designer might be surprised to learn the return current at lower frequencies might take a totally different path than expected. (See Figure 2)

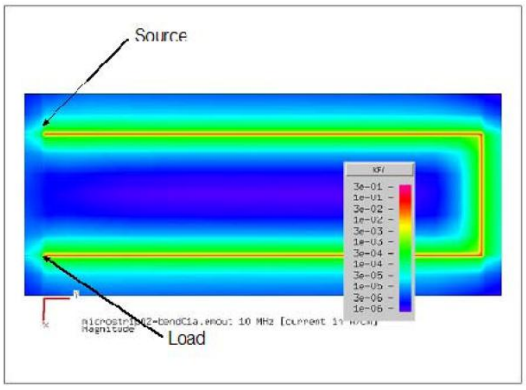


Figure 1: Return Current at 1 MHz

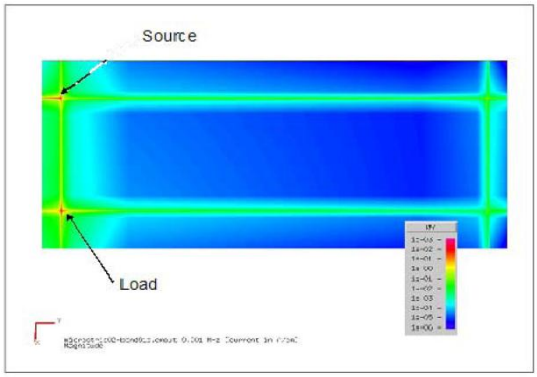
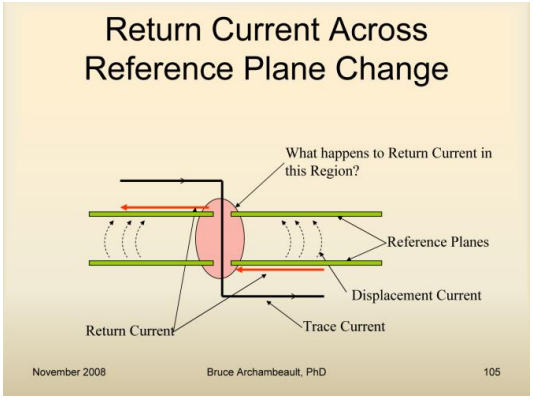


Figure 2: Return Current at 1 KHz

When a signal moves across a circuit board it often must transfer from one layer to another using a via. What happens to the return current? If the mirror current on one layer is not common with the mirror current on the layer the signal is now flowing above or below, how will it transfer from one plane to another? If you don't make it happen the return current must find its own way. It might be through a decoupling cap far from the via, or it might transfer using only the layer-to-layer capacitance of the planes as seen on the left of Figure 3. When this happens the current is spread over a large area, which greatly increases the possibility of cross contamination with other signal currents creating a loss of SI. A better way would be to add decoupling capacitors near the via as shown in Figure 3. This contains the current to the vicinity of the via the signal was passing through.



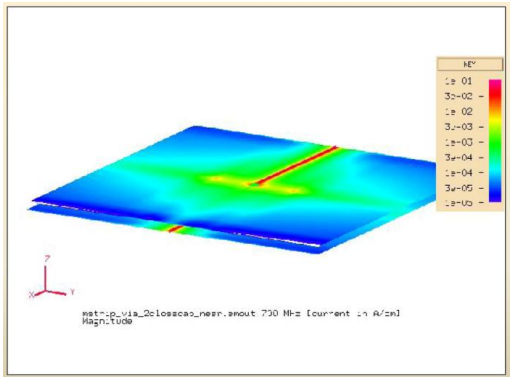


Figure 3: Return Current from plane to plane no control and with control

There are many aspects of EMC a design engineer needs to understand when designing electronics. Signal Integrity is

just one. Members can get a more detailed understanding of this and other technical concepts in the upcoming 3-day course *EMC By Your Design: An EMC Practical Applications Seminar and Workshop* being held Tues. Oct. 26 – Thurs. Oct. 28, 2010, Hilton Hotel, Northbrook, IL. The course includes: Lecture, discussion and hands-on workshop; two textbooks and a large workbook of slides used in class; take-home proprietary EMC design software; free optional design evaluation of your product; and instructors with over 75 years combined engineering experience. For registration information contact Carol G. at cgorowski@dlsemc.com or at 847-537-6400. D.L.S. Electronic Systems, Inc., 1250 Peterson Drive, Wheeling, IL 60090 www.dlsemec.com ☐

About the Author: Donald L. Sweeney has been teaching for over 30 years, at the University of Wisconsin, Oakton College and independent EMC design seminars. He is a senior EMC Engineer and President of D.L.S. Electronic Systems, Inc. He is a graduate of the Department of Electrical Engineering at the University of Illinois at Urbana and has over 40 years experience in the EMC and electrical engineering fields. Don specializes in EMC, RFI and EMI consulting and testing, and is known worldwide for his problem solving abilities. He has served as a special consultant to the Lawrence Livermore National Laboratory and the Nuclear Regulatory Commission. He is past chairman of the Chicago area IEEE EMC Society, founding chairman of U.S. Council of EMC Laboratories (USCEL), served on the board of directors of the IEEE EMC Society for twelve years, and is a NARTE certified EMC Engineer.

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