Using Fischer Bulk Current Injection Probes for Investigating Hardware and Software Radiated Immunity/Susceptibility from 10 kHz to 7 GHz

Introduction

Performing Radiated Immunity or Susceptibility testing typically requires a relatively complex test setup involving an Open Air Test Site (OATS) or an Anechoic Chamber. Such a setup makes it expensive to perform quick preliminary/pre-compliance upset investigations of hardware and software and make timely design improvements.

A Fischer Bulk Current Injection (BCI) Probe can be used as an inductive coupler to inject currents onto Equipment Under Test (EUT) cabling to simulate currents that nearby radiated fields would induce. The BCI Probe is used in conjunction with a Signal Generator and an Amplifier to provide a relatively simple, inexpensive tool that is compact and easy to implement and use. This setup can be used to inductively drive cable bundles, portions of a bundle, or individual wires within the bundle to identify and isolate hardware and software upsets resulting from these induced currents.

The intent of the testing is to isolate and identify specific frequencies and induced current levels on specific cable bundles or individual wires that cause either software or hardware upset. Using the techniques outlined in this Application Note, a major aerospace company, using a Fischer Model F-150-1 BCI Probe, a Fischer Model F-2000-12mm CM Probe, a Signal Generator, and an Amplifier was able to successfully identify and isolate upsets over the 800 MHz to 7 GHz range. In this case, simulation of upset from resulting from the “threat” frequencies stated in Mil Std 464 was of interest.

Test Setups

Figure 1 shows the basic test setup using a Fischer BCI Probe, a Signal Generator (SG) and an Amplifier (Amp). The specific make and models for all 3 units are selected based on the desired frequency range for the upset investigation. A suitable Fischer Current Monitor (CM) Probe is used to measure/monitor the injected current actually induced on the cable/wire(s).

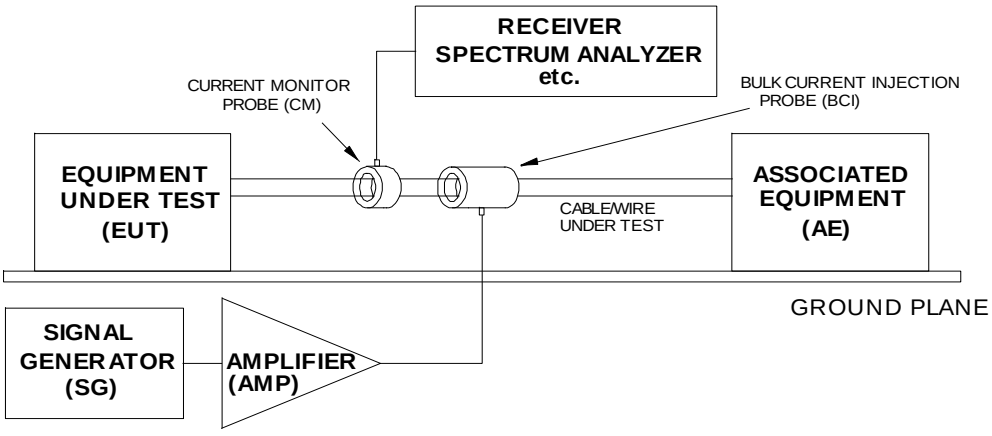

Figure 1 - Basic EUT / AE Test Setup Using a Bulk Current Injection Probe and a Current Monitor Probe to Investigate Upset

Table 1 shows a matrix of Fischer BCI, CM Probes, and calibration fixtures that can be used for this type of upset investigation for a variety of frequency ranges. The specific Model number recommended will be a function of cable size and amplifier output wattage. Please contact our factory for assistance is selecting the optimum set of hardware for your intended application. There are a wide variety of Signal Generators and Amplifiers commercially available covering the frequency ranges shown in Table 1 that complete the test ensemble.

Frequency Range	Fischer Bulk Injection Probes	Fischer Current Monitor Probes	Fischer Calibration Fixtures
10 kHz – 400 MHz	F-120-6A F-120-6B	F-52 F-51	FCC-BCICF-1 FCC-BCICF-1
1 MHz – 1 GHz	F-140 F-130A	F-61 F-61	FCC-BCICF-2 FCC-BCICF-2B
800 MHz – 2.1 GHz	F-150	F-2000-12mm	FCC-BCICF-150
2.1 GHz – 7 GHz	F-150-1	F-2000-12mm	FCC-BCICF-150-1

Table 1 - Recommended Bulk Current Injection Probe, Current Monitor Probe, and Calibration Fixture Combinations for Various Frequency Ranges

Figure 2 shows a commonly employed setup that can be used to pre-set the current drive level into a known loop impedance. Use of the Fischer calibration fixture allows establishing/understanding basic SG/Amp/BCI Probe coupling behavior in a clean setup that excludes resonance and standing waves issues that may be present on a real cable bundle. This Fischer fixture is typically the same fixture used to calibrate the BCI Probe for Insertion Loss for many international Standards. Additional information about BCI Probes, CM Probes, and associated fixtures can be found on the Fischer Website at Fischercc.com.

In Figure 2, this loop impedance is 100 ohm; other loop impedances can be (and have been) used. For example, the 50 ohm load could be replaced by a short to create a 50 ohm loop impedance.

An example of how Figure 2 would be applied is found in RTCA DO-160C, Section 20.5, Figure 20.5. This Figure plots the Conducted Susceptibility (CS) current to be generated in the fixture shown in Figure 2 versus frequency from 10 kHz to 400 MHz. This plot shows the relationship between these currents and the corresponding radiated field level. The current levels in RTCA DO-160C, Section 20.5, Figure 20.5 can be achieved with a standard SG and a 25 Watt amplifier. While this Figure stops at 400MHz, it can serve as a useful starting point to investigate upset at higher frequencies.

Table 2 presents in tabular form the relationship given in DO-160C Figure 20.5 between the Electric field strength and the coupled current. Also shown in Table 2 is the Amplifier wattage required to induce this current into the 100 ohm load of the setup shown in Figure 2. It can be seen that commonly used EMC Radiated Susceptibility field strengths up 30 V/m can be achieved with less than 1 watt of amplifier output.

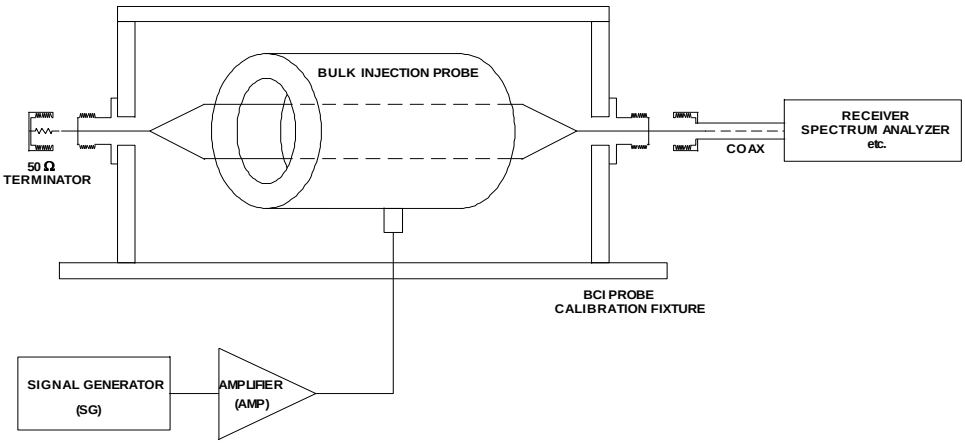

Figure 2 - Test setup to set desired current level in a known configuration

Field Level (V/m)	Coupled Current (mA)	Amplifier Output (Watts)
2	3	
3	4.5	0.006
4	6	
5	7.5	
6	9	
10	15	0.07
11	16.5	
12	18	
20	30	0.27
27	40.5	
30	45	0.61
50	75	1.7
100	150	6.75
200	300	< 25

Table 2 - Relationship between Electric field strength and coupled current to a cable bundle as per DO-160C Figure 20.5 (500 kHz to 400 MHz), and required amplifier output power to achieve this current in the test setup shown in Figure 2 at common EMC field levels

How to Apply the BCI Probe Using Figure 1

- The test configuration shown in Figure 1 is set up
- The SG is set up:
    - If the potential/suspected upset frequency(ies) are unknown, the SG is set up for a relatively high frequency density over the entire frequency range of interest
    - If the potential/suspected upset frequency(ies) are known, the SG is set up for smaller frequency ranges with higher or lower frequency densities depending on what is known about the potential/suspected upset frequency(ies)
    - Variations of the SG signal can be applied such as modulation
- The SG drive level is increased while observing the EUT for signs of upset
    - If an upset is found, the cable bundle can be sub-divided and the process repeated to start to isolate which wire or wires in the bundle are experiencing the upset
    - This process can repeated on smaller and smaller sub-bundles to further isolate the problem wire(s)
    - The frequency range applied from the SG can be reduced to a narrower range around the upset frequency to further speed up testing as knowledge about the upset is acquired
- For an electrically long cable/wire under test, it is suggested that both the BCI and CM Probes be moved up and down along the length of the cable to ensure maximum stress is applied to the EUT interface and that the associated peak current is captured

How to Apply the BCI Probe Using Figure 2

- The current level in the fixture shown in Figure 2, is established as follows:
    - The desired/specified loop impedance is determined (for example, Figure 2 shows a 100 ohm loop impedance) and set
    - The desired current is multiplied by 50 ohms
        - This voltage, as measured on the receiver or spectrum analyzer, is used to establish the current flowing in the loop
        - If the desired current level varies with frequency, the above step needs to be repeated for each test frequency
        - If the potential/suspected upset frequency(ies) are unknown, the SG is set up for a relatively high frequency density over the entire frequency range of interest
        - If the potential/suspected upset frequency(ies) are known, the SG is set up for smaller frequency ranges with higher or lower frequency densities depending on what is known about the potential/suspected upset frequency(ies)
        - Variations of the SG signal can be applied such as modulation
- The test configuration shown in Figure 1 is then set up
- The SG drive level is set to the level established using the test setup of Figure 2 as per steps above
    - Testing can proceed using these established levels, or can be started at a lower level and then increased to the established level
- The EUT is observed for signs of upset
    - If an upset is found, the cable bundle can be sub-divided and the process repeated to start to isolate which wire or wires in the bundle are experiencing the upset
    - This process can repeated on smaller and smaller sub-bundles to further isolate the problem wire(s)
    - The frequency range applied from the SG can be reduced to a narrower range around the upset frequency to further speed up testing as knowledge about the upset is acquired
- For an electrically long cable/wire under test, it is suggested that both the BCI and CM Probes be moved up and down along the length of the cable to ensure maximum stress is applied to the EUT interface and that the associated peak current is captured