



# BCI Calibrated Power and Scaling factor

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## 1 Bulk Current Injection Test

The Bulk Current Injection (BCI) method defined by ISO11452-4 [1] is widely used for testing the immunity behavior at the component or module level. Figure 1 depicts a general BCI test bench. The setup consists of a device under test (DUT), cable harness, injection clamp, monitor clamp, and termination box. The DUT is comprised of one or more Printed Circuit Boards (PCBs), housing and connectors. This test is carried out by inducing disturbance signals into the wiring harness by means of a current injection probe.

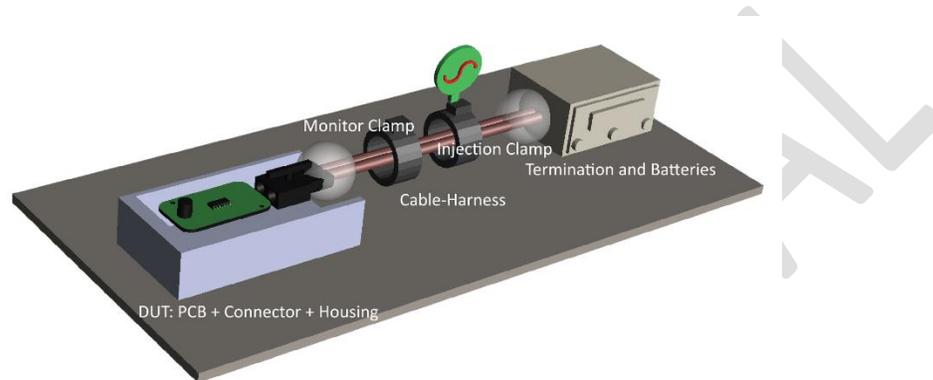


Figure 1: An animation of the BCI test-bench

The two test methods defined in the standard are: the open-loop (substitution), and closed-loop (current monitoring probe) methods. Test is carried out in two steps:

- Calibration (to obtain the power for the required current)
- BCI testing ( DUT exposed to the calibrated power)

## 2 Calibration

### 2.1 Bench setup

The injection probe is mounted on a calibration fixture. The fixture is terminated with 50 ohm load in one side and connected to Spectrum analyzer (50 ohm impedance) through attenuator [2] as shown in Figure 2. RF power is injected into the injection probe to obtain the required current over the required frequency range (1 – 400 MHz). Both the forward power and reflected power is noted using direction coupler. Later, the forward is used in the BCI test performed on the DUT.

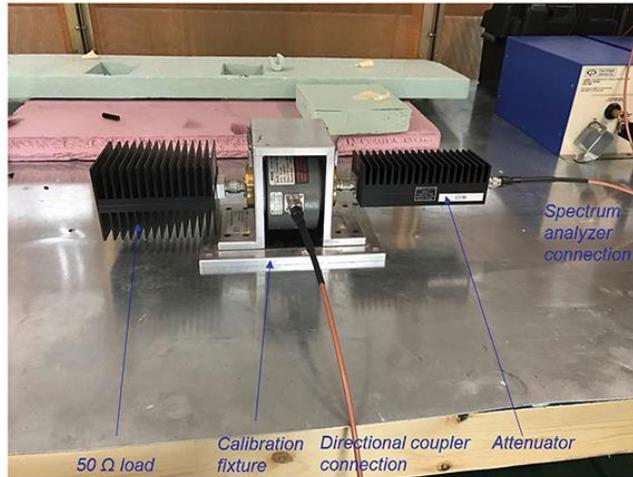


Figure 2: Calibration setup

## 2.2 Calibration in CompScope

In CompScope, a virtual calibration setup is made using the internal library model of the fixture and injection clamp. Simulation is performed to obtain the required current as specified in the BCI options.

Miscellaneous Options	
DUT Current (mA)	50.00
Length of Cable (meter)	2
Height From Table (mm)	50

Figure 3: DUT current setting in CompScope

The calibrated power based on this current is available in the Clamp Apparatus and Result folder after the simulation is complete. In the below figure, forward power and net power is shown for DUT current of 50 milliamp.

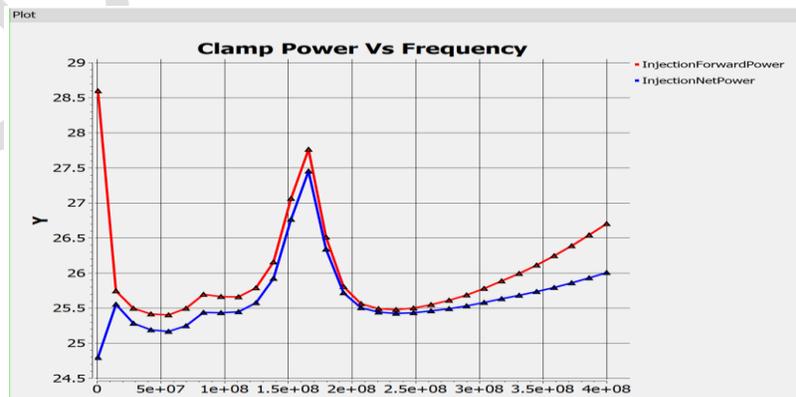


Figure 4: Injection Clamp Power in CompScope

Few facts about calibrated power is noted down as:

- ❑ Calibrated power is based on required current
- ❑ Power varies non-linearly with current and it is directly proportional

This is demonstrated in below figures where DUT current is changed from 100 mA to 10 mA.

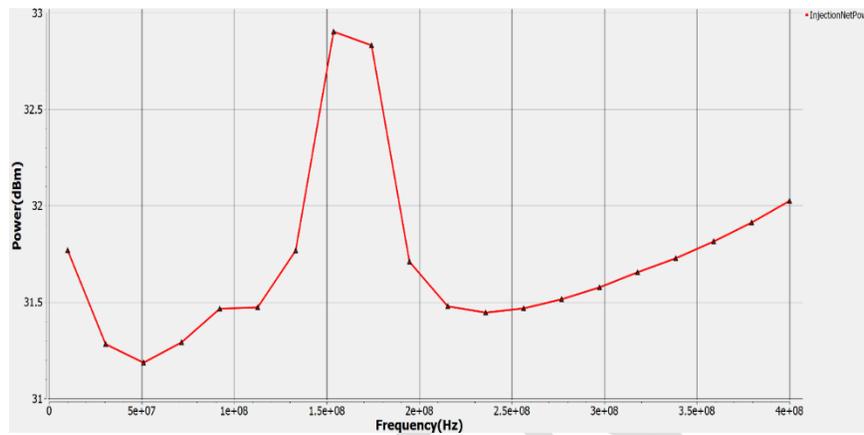


Figure 5: Calibrated forward power for DUT current of 100 mA

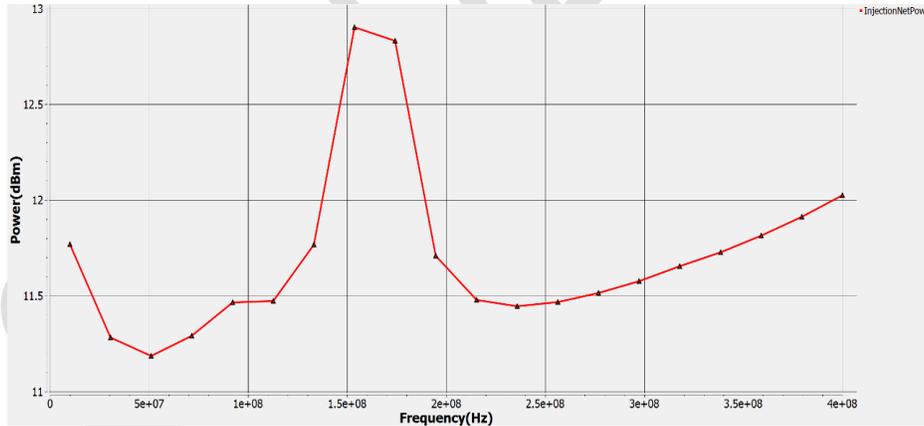
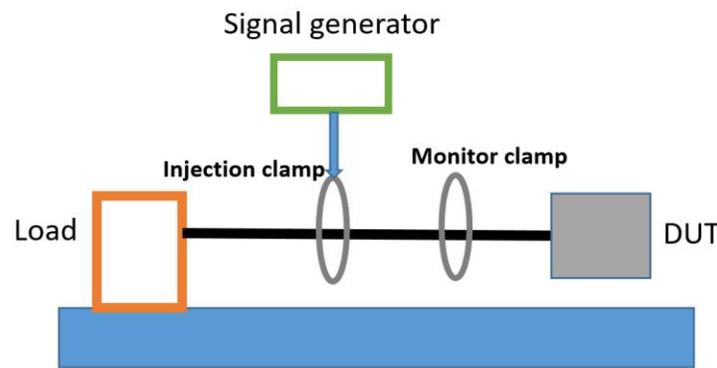


Figure 6: Calibrated forward power for DUT current of 10 mA

### 3 BCI Test methods

#### 3.1 Open loop method

With the 'open loop' test, calibrated forward power level is injected into clamp during the test while the common mode current is observed through monitor clamp. Current seen by DUT is completely depends on the common mode impedance with respect to measuring table. Failure occurs mostly at the resonance frequencies as current seen by device is much higher due to low impedance.



Open loop BCI  
(Pre calibrated forward power injected on harness)

Figure 7: Open loop BCI setup

#### 3.2 Closed loop method

With the 'closed loop' test, the RF current is increased up to a level where the DUT fails or the current limit or the scaled forward power limit is reached. Injected power is controlled through the feedback from monitor current. In closed loop method, the injected power at the probe can be increased, if the required current is not achieved which is monitored at the monitor clamp. Maximum limit of the increased power is governed by the below equation.

$$Power_{Limit} = Calibrated\ Power * Scaling\ factor \dots\dots\dots (1)$$

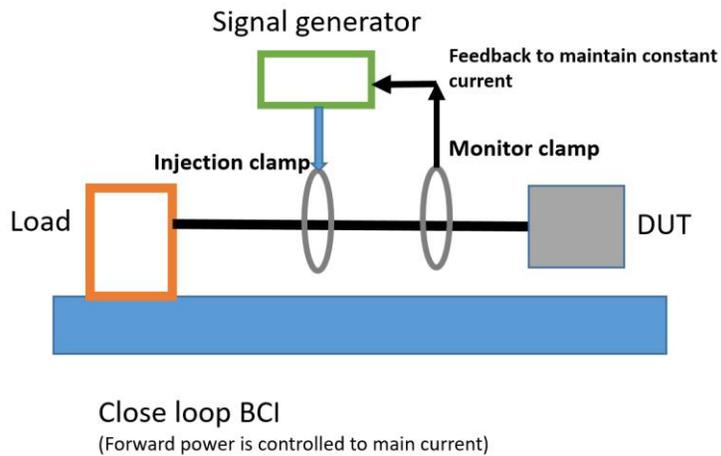


Figure 8: Closed loop BCI setup

### 3.2.1 Closed loop Scaling factor in CompScope

In CompScope, closed loop scaling factor can be adjusted by changing in *BCI options*. This factor has a default value of 4 as specified for automotive application.

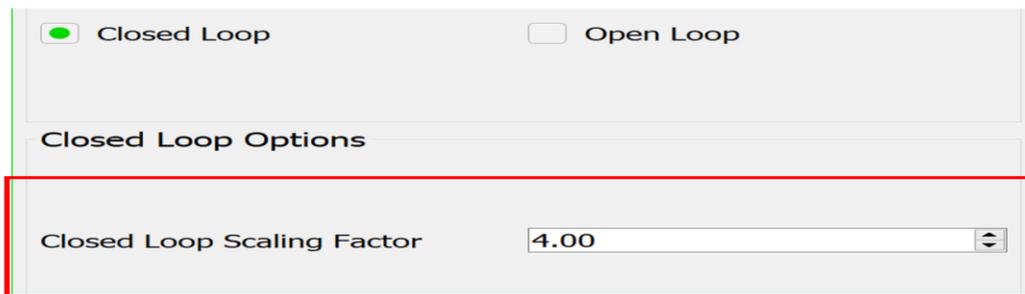


Figure 9: Closed loop scaling factor

Maximum

## 4 Conclusion

DUT current defines the calibrated power. In case of open loop method, harness is exposed to this calibrated power. Whereas, in closed loop method injected power can be increased. The limit of the increased power depends on the scaling factor and DUT current.

## References:

- [1] Road Vehicles-Component Test Methods for Electrical Disturbances from Narrowband Radiated Electromagnetic Energy- Part 4: Bulk Current Injection (BCI), ISO 11452-4, Apr. 2005.
- [2] <https://incompliancemag.com/article/bulk-current-injection-bci-substitution-method-and-closed-loop-method-with-power-limitation/>

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