Injection Probe Models for CompScope

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The Bulk Current Injection (BCI) method is widely used for RF immunity testing of automotive systems. If detected at a late stage, compliance failures may lead to expensive redesigns and increased time to market. Therefore, it is desirable to evaluate the chip immunity at an early design stage using simulation methods. In general, the 3D physical model of the BCI injection probe (also referred to as injection clamp) is not easily accessible from the manufacturer. Moreover, modeling the injection clamp along with the device-under-test (DUT) may lead to large simulation time. An accurate circuit/electromagnetic model of the clamp-cable configuration will enable the designer simulate BCI performance through early design iterations.

(A) Explanation of CompScope injection clamp library model

CompScope injection clamp library uses equivalent circuit/electromagnetic models for injection clamps generated from measurements performed on the injection clamp. For each clamp, CompScope uses 2 different network-parameter models:

I. Injection clamp to cable coupling model

The injection clamp to cable model is captured through measurement as an s3p file. This data is used to generate applicable snp file for any multi-wire harness case using proprietary technology.

To generate the equivalent model, measurement is performed with a single small cable kept inside the injection clamp as shown in Fig. 1. Three port measurement is performed using a network analyzer. The portion of the cable jutting out of the injection clamp and the L-clamps are de-embedded to generate the library s3p model for the particular injection probe.

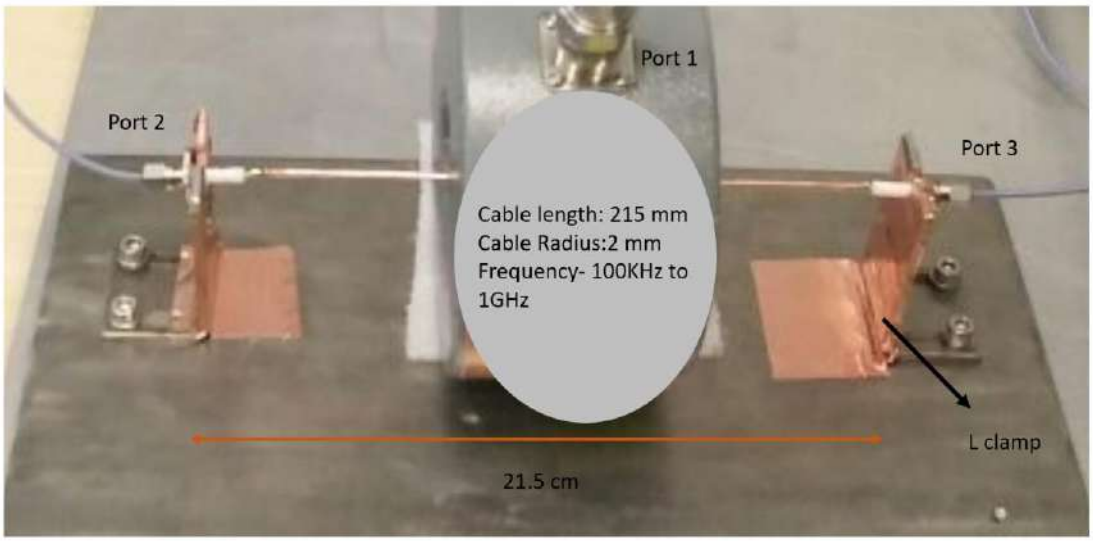

Fig. 1. S parameter measurement with cable inside clamp

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Representative de-embedded measurement data for F140 clamp and a single cable with radius 2mm is shown below:

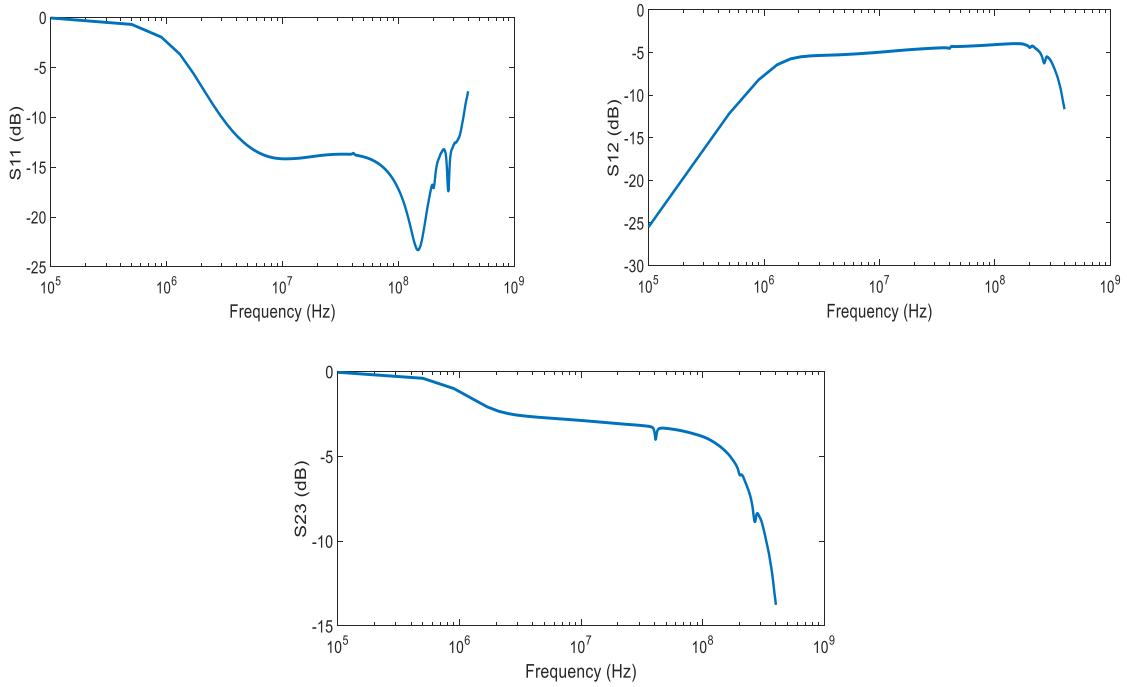

Fig. 2: Measured 3-port S-parameter data for F140

II. Injection clamp calibration model

The injection clamp calibration model is used for calibration to determine power level in open loop and closed loop simulation.

To obtain this calibration model, S-parameter measurement is done with bulk current injection probe fixture as shown in Fig. 3.

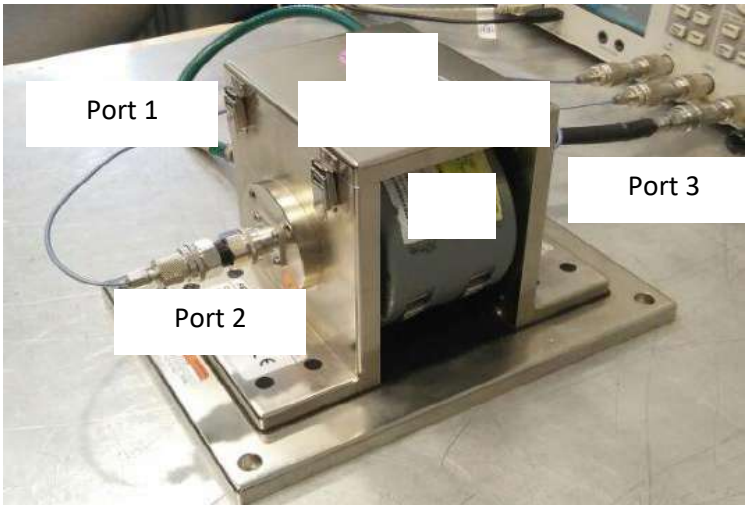

Fig. 3. S parameter measurement with fixture

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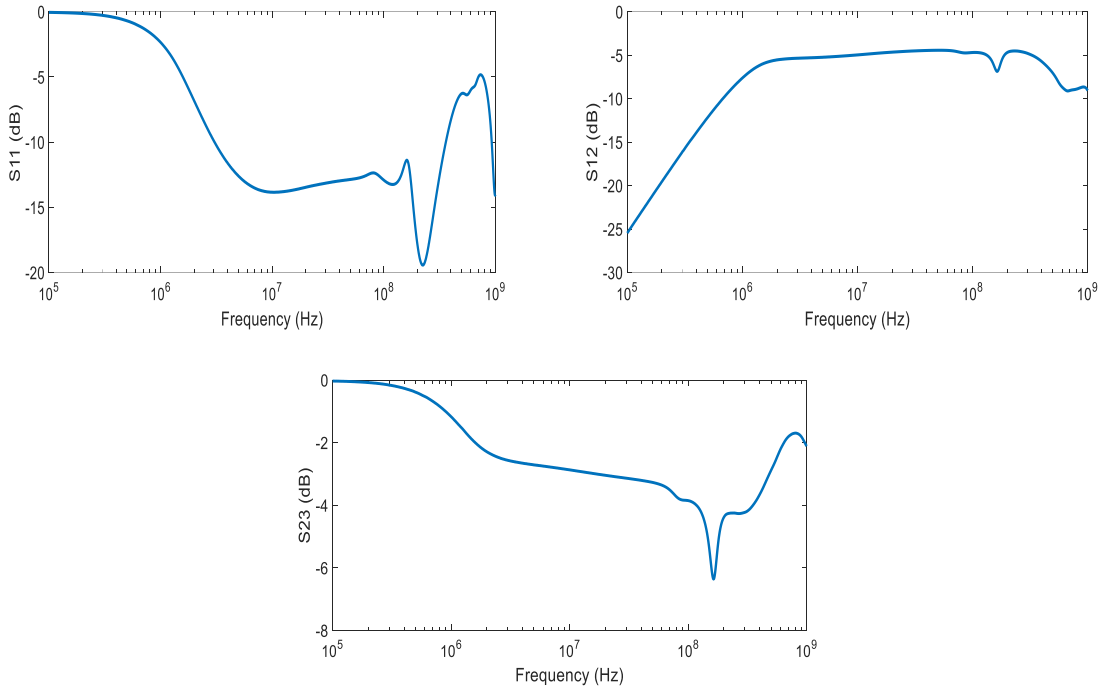

Fig. 4: Measured 3-port S-parameter data for F140 with fixture (observe the match of S12 with datasheet Fig 5 insertion loss)

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III. Injection clamp datasheet

This data is available from the manufacturer and is optional as long as the injection clamp dimensions as set in Table 1 is known.

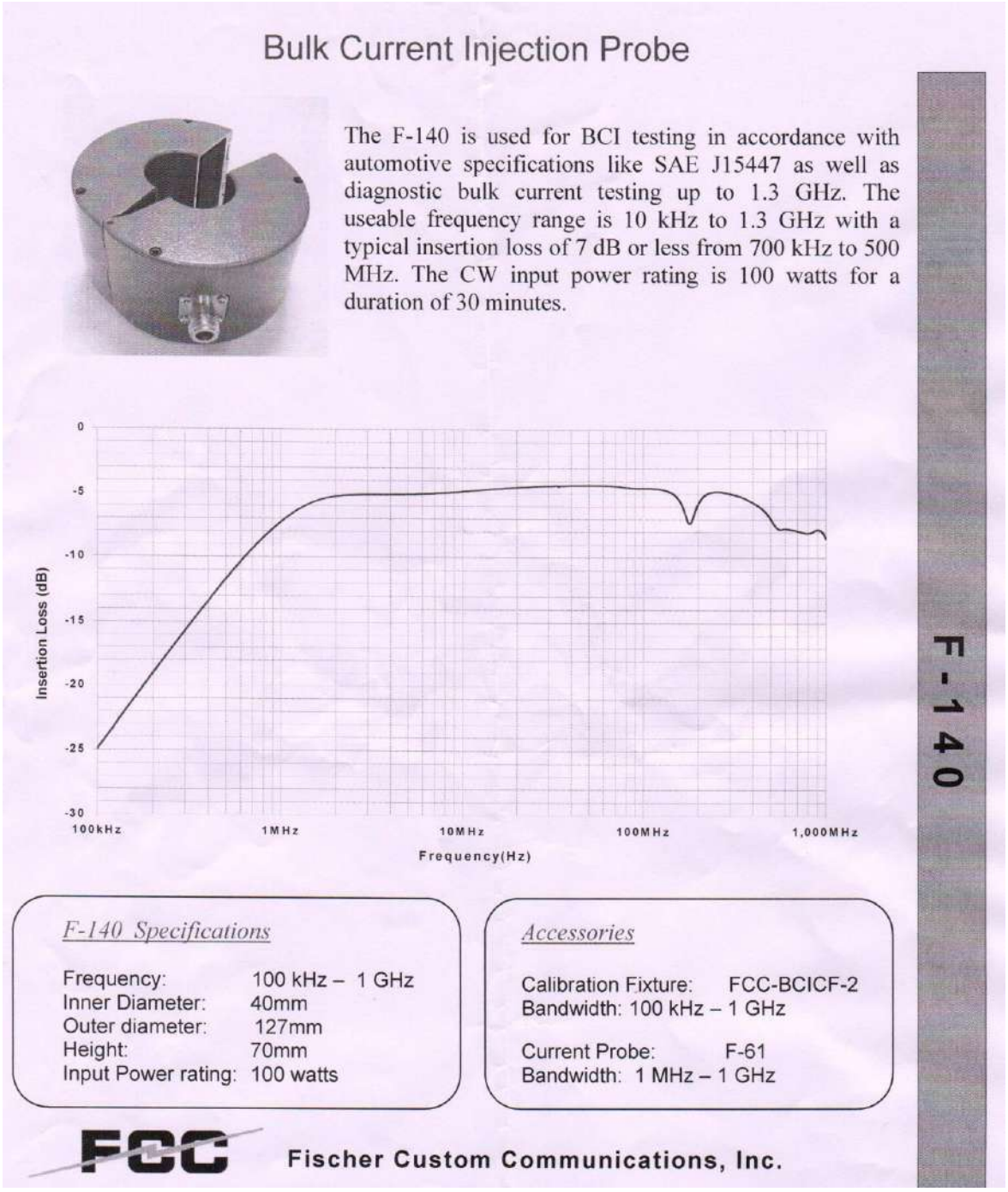

Fig 5. Example datasheet (F140)

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(B) Data required for building a clamp model into CompScope library

Any one of the following options may be used for generating data for building CompScope injection clamp library model.

Option 1:

(1) 3D geometry (sat file) for the desired clamp

Option 2:

(1) De-embedded s3p file for injection clamp-single cable

(2) Injection clamp calibration s3p file

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If available the datasheet of the clamp (similar to Fig. 5)

Table 1: Data required for building CompScope clamp model

Clamp	**Dimension**
	Outer Diameter of clamp
	Inner Diameter of clamp
	Clamp Length
Cable	Cable length (if not de-embedded)
	Cable radius
	Height from measurement plate
L-clamp	Height (if not de-embedded)
	Width (if not de-embedded)
Measurement (100KHz to 1GHz)	**Touchstone (s3p)**
Clamp calibration with fixture	S3p file
Clamp to cable coupling	S3p file

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