

API's Standard EMI Probe Characterization

Amber Precision Instruments

San Jose, CA, USA

This document describes the measurement setup for characterization of API's electromagnetic interference (EMI) probes. The block diagram of the measurement setup and the measurement results are presented. The measurements are performed using tracking generator mode of a spectrum analyzer. In this measurement setup, the forward transmission coefficient S_{21} is measured by a spectrum analyzer with internal tracking generator. The spectrum analyzer with tracking generator functions as a scalar network analyzer. Only the magnitude of S_{21} is measured with this method.

Instruments used for probe characterization

- Spectrum analyzer with tracking generator: R&S[®] FSV signal and spectrum analyzer (10KHz ~ 7GHz)
- 50 Ω microstrip with trace width of 3 mm and board thickness of 1.6 mm (SMA female connectors)
- 50 Ω termination: ANNE-50L+ (0 Hz to 12 GHz) (SMA male connector)
- Attenuator 1: 10 dB BW-S10W2+ (0 Hz to 18 GHz)
- Attenuator 2: 20 dB Aeroflex/Weinschel 41-20-12 (0 Hz to 18 GHz)
- Attenuator 3: 5 dB (0 Hz to 18 GHz)
- Amplifier 1 & 2: ZX60-6013E-S+ (20 MHz to 6 GHz)
- Coax 1: 304.8 cm PE 306-120 (SMA female to N male)
- Coax 2: 182.9 cm PE 306-72 (SMA female to N male)
- Coax 3: 75.5 cm (SMA male to SMA male)
- One female to female SMA adapter
- Three male to male SMA adapter
- 12 V DC power supply (for amplifiers)
- Cable with banana connector for DC power supply
- API EMI probes: 2 mm Hx, 5 mm Hx, 4 mm Hz
- API EMI scanning system

The block diagram of the calibration setup

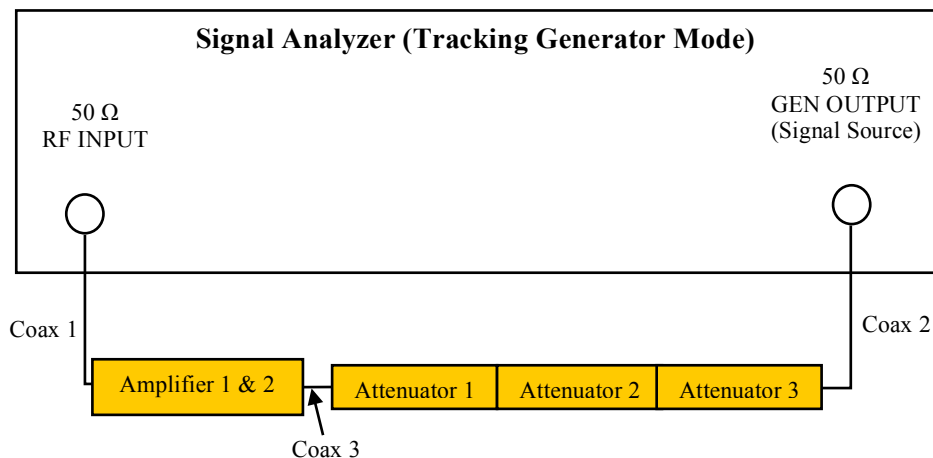


Figure 1: Block diagram of the calibration setup.

Spectrum analyzer settings

- Resolution bandwidth (RBW): 100 KHz
- Video bandwidth (VBW): 100 KHz
- Start frequency: 10 MHz
- Number of frequency points: 8001
- Source power: -20 dBm
- Internal RF attenuator: 20 dB
- Averaging: 1
- X-axis: Log
- Y-axis: Log

The block diagram of the measurement setup

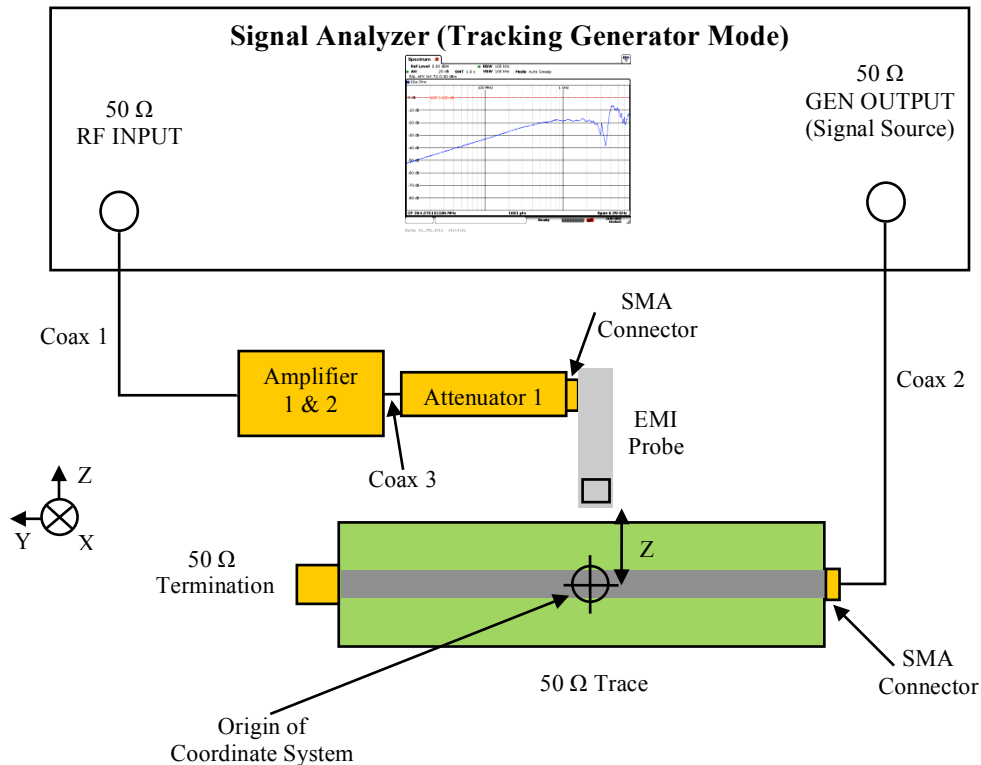


Figure 2: Block diagram of the measurement setup.

The origin of the coordinate system is assumed to be in the middle of the 50 Ω trace both along X and Y coordinates and 0 mm above the trace along Z coordinate. X is perpendicular to the trace, Y is along the trace, and Z is the standoff distance between the tip of the probe and the trace. The azimuth ϕ is the angle between X coordinate and the normal vector to the probe loop/disc.

Spectrum analyzer settings

- Resolution bandwidth (RBW): 100 KHz
- Video bandwidth (VBW): 100 KHz
- Start frequency: 10 MHz
- Number of frequency points: 8001
- Source power: 0 dBm
- Internal RF attenuator: 10 dB
- Averaging: 8
- X-axis: Log
- Y-axis: Log

During the calibration, Attenuator 2 and 3 (25 dB attenuation in total) are used along with Attenuator 1 and during the probe characterization, only Attenuator 1 is used. Therefore, all of the measured frequency responses are 25 dB off and should be subtracted by 25 dB.

S21 measurements

Normalized magnitude of S21 vs. frequency for EMI 2 mm Hx probe at X = 0 mm, Y = 0 mm, and Z = 1.4 mm is shown in Figure 3 (25 dB is subtracted).

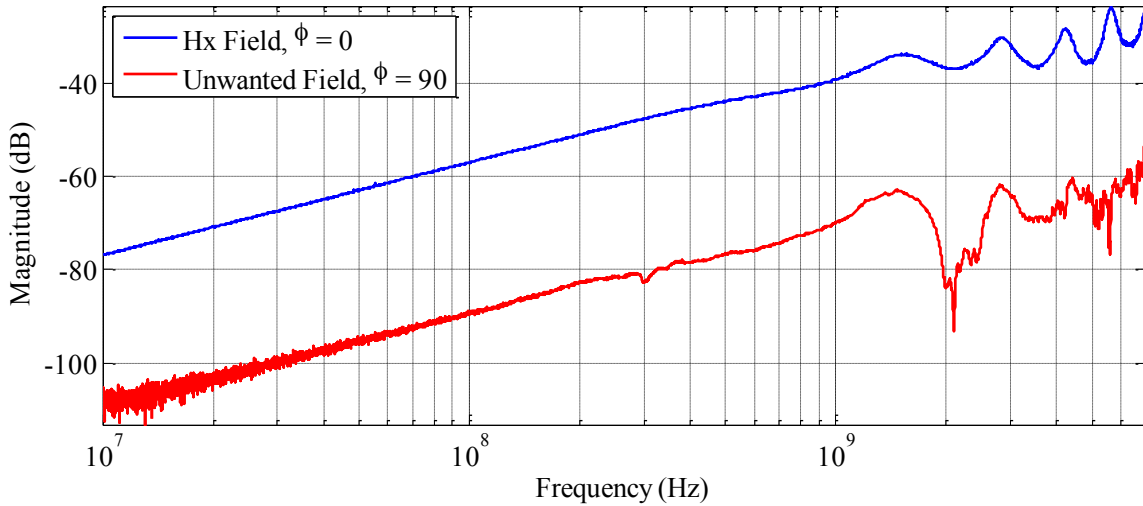


Figure 3: S21 of EMI 2 mm Hx probe.

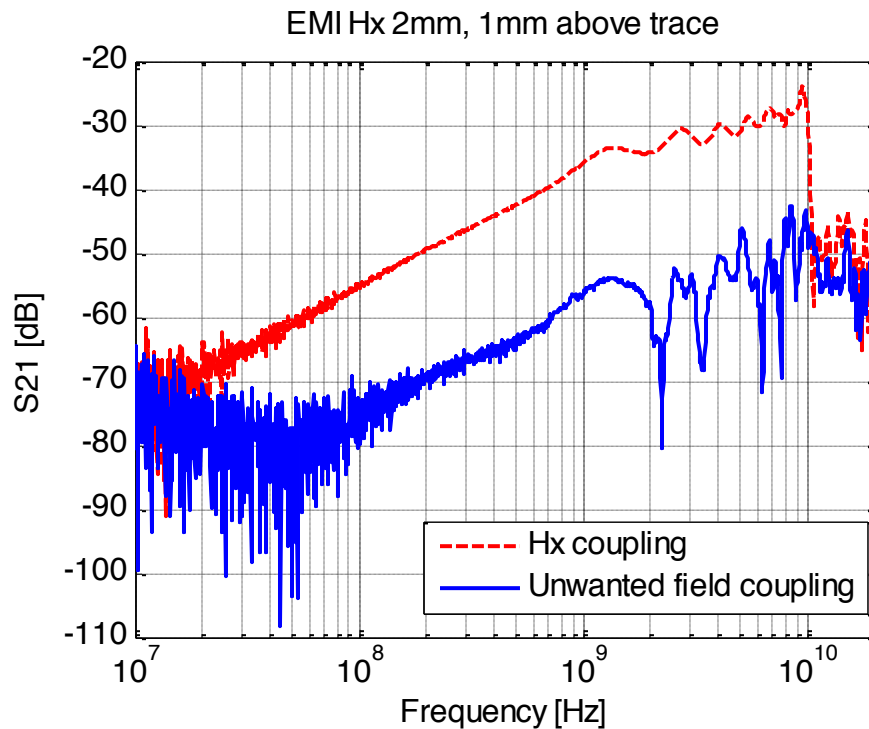


Figure 4: S21 of EMI 2 mm Hx probe with higher BW SA.

Normalized magnitude of S21 vs. frequency for EMI 5 mm Hx probe at X = 0 mm, Y = 0 mm, and Z = 1.4 mm is shown in Figure (25 dB is subtracted).

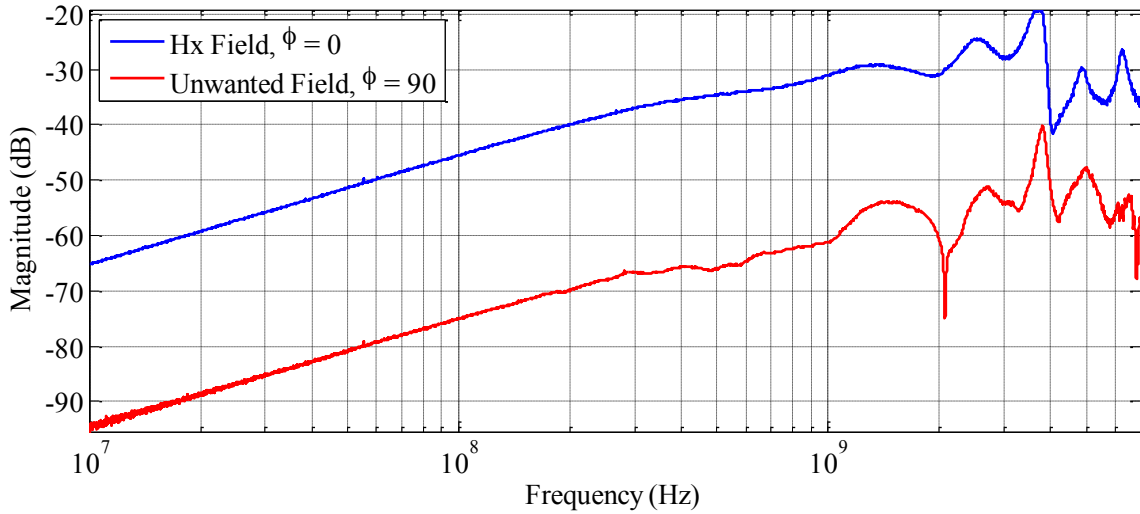


Figure 5: S21 of EMI 5 mm Hx probe.

Normalized magnitude of S21 vs. frequency for EMI 4 mm Hz probe at X = 0 mm, Y = 0 mm, and Z = 1.4 mm is shown in Figure 4 (25 dB is subtracted).

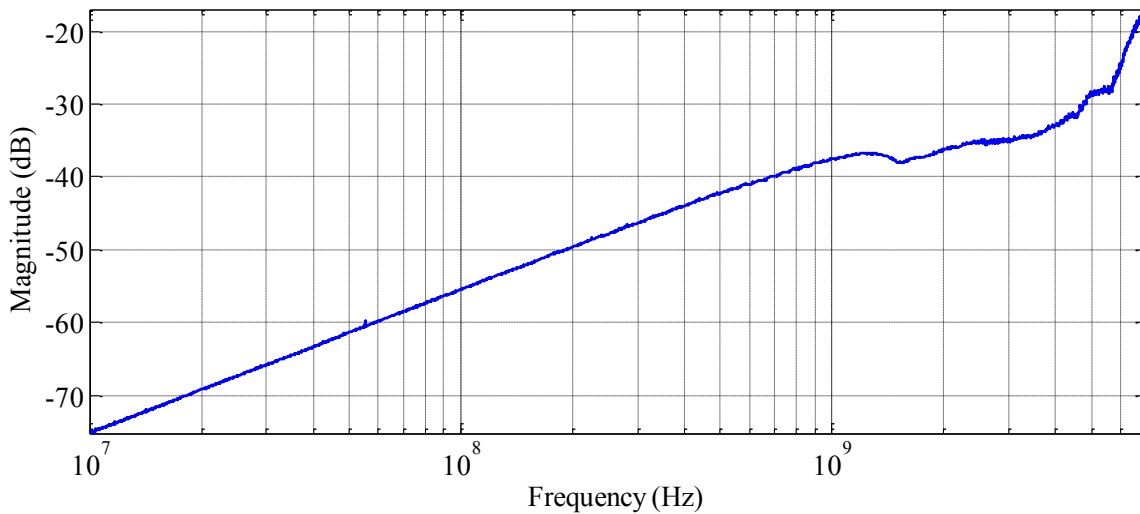


Figure 4: S21 of EMI 4 mm Hz probe.

Frequency range of the probes

Table 1: Usable frequency range of the probes.

Probe	Minimum Frequency*	Maximum Frequency
EMI 2 mm Hx	4.5 MHz	10 GHz
EMI 5 mm Hx	2 MHz	3.5 GHz
EMI 4 mm Hz	1.5 MHz	4.5 GHz

*The minimum usable frequency is determined by finding the frequency at which the magnitude of the response drops 60 dB below the maximal value. For example, Figure 5 shows that in a specified frequency band of interest (e.g. 10 MHz to 2.5 GHz), the maximum sensitivity is about -33 dB at 2.1 GHz when probe is 1 mm above a 50 Ω trace. By looking at the frequency at which magnitude drops by 60 dB, the magnitude is about -93 dB. From the slope of 20 dB/dec, the frequency for -93 dB is approximately at 600 KHz. An estimation of 60 dB dynamic range for this EMI probe is from 600 KHz to 2.5 GHz.

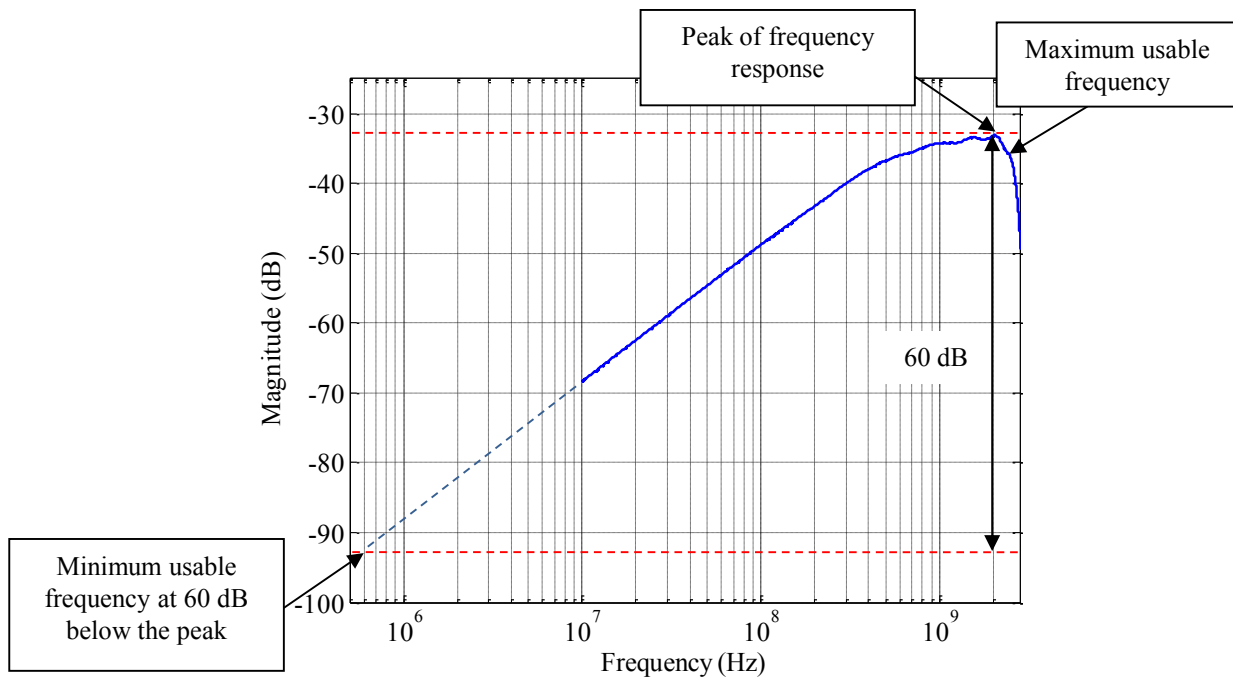


Figure 5: Frequency response of an EMI probe and the method for measuring minimum and maximum usable frequency of the probe.