0. General:

- a. These procedures describe FEE S11 measurements using the Copper Mountain Technologies M5045 VNA, FEE Test Fixture V2, and custom Calibration Fixtures.
- b. The Calibration Fixtures are V2 with the MCL AMT-32+ 180° hybrid coupler. The Calibration Fixtures have been characterized by measurements and loaded into the VNA as Data-Base Standards. Refer to Calibration Fixture Measurements & Associated Data-Based Standards. The FEE Test Fixture V2 Coupler PCB 180° hybrid coupler (MCL AMT-32+) is de-embedded during calibration by using custom Calibration Fixtures.
- c. Dual assembly FEEs are mounted using all four studs (feedpoints) in the FEE Test Fixture. For reference, FEE Side A = Side facing up and FEE Side B = Side facing down when mounted in the Test Fixture.

d.

- e. The instrument calibration protocol is as follows: Calibrate at the beginning of each measurement day. Recalibrate if any of the following are changed after initial calibration: Frequency range; IF Bandwidth; or Resolution; Lab temperature. Notes: 1) These procedures do not require changing any of these settings and the lab temperature and humidity is stable; 2) Output power of the CMT VNA can be changed without affecting calibration.
- f. The measurement frequency range is 5 to 200 MHz.

1.1. Preliminary:

- a. The 30 dB attenuator on the FEE Test Fixture RF Input, if equipped, is to be removed and not reconnected until all measurements are completed. This attenuator is used only when a spectrum analyzer with tracking generator is used to measure FEE gain.
- c. Test equipment:
 - FEE Test Fixture V2 (equipped with MCL AMT-32+ on Coupler PCB and MCL 141-SMRSM+ internal Jumper Cable), custom
 - 2) Calibration Fixtures V2, Open, Short, and Load, custom
 - 3) Copper Mountain Technologies M5045 vector network analyzer
 - 4) Test cable, 1 m long, SMA-M: N-M, MCL ULC-1M-SMNM+ (Red)
 - 5) Jumper Cable, 6 in long, MCL 141-6SMRSM+ (proxy Jumper Cable)
 - 6) 50 ohm termination, SMA-M
 - 7) Torque wrench, 5/16 in (8 mm), Pre-set to 5 in-lbs (0.56 N-m)
- d. Test set status as of 18 January 2023:

| Mfr | Туре | S/N | Cal due |
|-----|------------------------------|----------|-------------|
| CMT | Compact M5045 VNA, SW 22.4.3 | 22160017 | 15 Jul 2024 |

1.2. S-Parameter Measurements:

- a. These procedures measure only the FEE feedpoint impedance as the S11 reflection coefficient in terms of dB and angle.
- b. The VNA Port 1 is calibrated using Full 1-Port procedures with output power set to 0 dBm. The Port 1 output power is then reduced to –35 dBm for the S11 measurements to prevent compression in the FEE. This level provides a 16.5 dB margin below the 1 dB output compression level of the FEE.
- c. To compensate for the reduced dynamic range when the output power is reduced, the IF bandwidth is reduced to 1 kHz. Moderate sweep averaging also is used if needed.
- d. S11 is measured on both sides (A & B) of each FEE while in the FEE Test Fixture. This requires reconnecting and rotating the FEE in the FEE Test Fixture. The FEE serial number and side (SNxxx-A or SNxxx-B) is placed in the filename when saving the measurements.

1.3. Setup:

| - | cap. | |
|----|---------------------------|---|
| a. | FEE | Test Fixture V2: |
| | | Set FEE Test Fixture switches for Internal Power and turn <u>OFF</u> Install a 50 ohm termination on the FEE Test Fixture RF Output |
| b. | Stimulus setup: | |
| | | Start → 5.0 MHz, Stop → 200.0 MHz Points → 1001 Sweep type → Lin Freq IF Bandwidth → 1 kHz |
| | | Port Power → Port 1 → 0 dBm Trigger → Continuous |
| c. | c. <u>Display setup</u> : | |
| | | Allocate Channels → x1 Number of Traces → 1 Allocate Traces → x1 Trace 1 → S11 → Log Mag, 5 dB/div, -25.0 dB Ref |
| d. | . Average setup: | |
| | | Averaging → Off Average Factor → 10 (default) Smoothing → Off |
| e. | <u>Con</u> | nections for analyzer calibration: |
| | | Connect the VNA Port 1 to the Calibration Fixture Side A through the Test Cable and proxy Jumper Cable as shown in Diagram 1.3.1 below. With this setup, the 180° hybrid coupler on the Test Fixture Coupler PCB and associated Jumper Cable are de-embedded by proxy of the three Calibration Fixtures and identical external Jumper Cable |

| f. | <u>Cali</u> | <u>libration</u> : | | |
|--|-------------------------------|--|--|--|
| | | Select the Red Side A Data-Based Standards Cal Kit from the Cal Kit list: Calibration → Cal Kit → LWAF_Red-A → Select Calibrate → Full 1-Port Cal Select → Port → Port 1 (S11) Start Calibration, follow in sequence to Calibrate VNA Port 1 Port 1 Open -F- → Port 1 Short -F- → Port 1 Load -F- Apply Save/Recall → Save Type → State & Cal Save State → File → Cal_5-200MHz_CalFixt_Date.Time Averaging → Off Remove the proxy Jumper Cable from the VNA Test Cable Connect the VNA Test Cable to the FEE Test Fixture RF Input | | |
| g. | . Reduce Port 1 output power: | | | |
| | | Stimulus → Power → Port Power → Port 1 → –35 dBm | | |
| h. | . Markers: | | | |
| | | Markers → Add Marker → 5M, 10M, 20M, 40M, 80M, 160M Marker Properties → Stimulus Digits → 5, Response Digits → 5, Discrete → OFF, Marker → Couple | | |
| i. <u>Connections for FEE measurements</u> : | | nections for FEE measurements: | | |
| | | Check that FEE Test Fixture power is <u>OFF</u> Refer to Diagram 1.3.2 below and connect the FEE side A (B) to the internal RF output cable Install the FEE in the FEE Test Fixture using all four studs | | |
| j. <u>Mea</u> | | asure FEE as DUT and save data: | | |
| | | Turn ON FEE Test Fixture power Averaging → On if needed to reduce trace noise; otherwise Off After Averaging completes, Save/Recall → Save Data to Touchstone File → 1 Port (s1p) → Format → dB-Angle Save File → Filename SNxxxx-A(B)_S11_ Date.Time.s1p System → Print → Print Color → Color → Invert Image → Print Date & Time → Print to File Save File → Filename SNxxxx-A(B)_S11_Date.Time.png Averaging → Off Turn OFF FEE Test Fixture power and prepare to measure FEE side B or the next FEE | | |
| | | Repeat measurements from beginning of step i | | |

Diagram 1.3.1 (Analyzer Calibration)

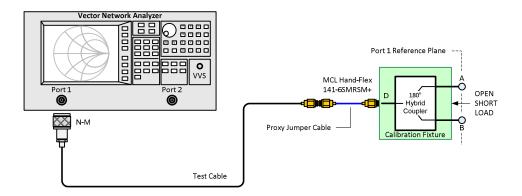
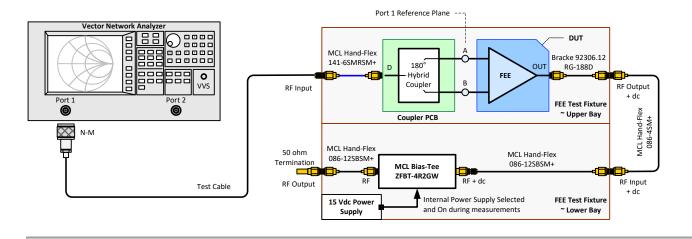


Diagram 1.3.2 (FEE S-Parameter Measurement)



Document Information

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0.1 (First pass thru procedures, 02 Jan 2023)

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0.4 (Record, 21 Jan 2023)