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RF Ingress Measurements for STP Cables from Automotive ALSE Test

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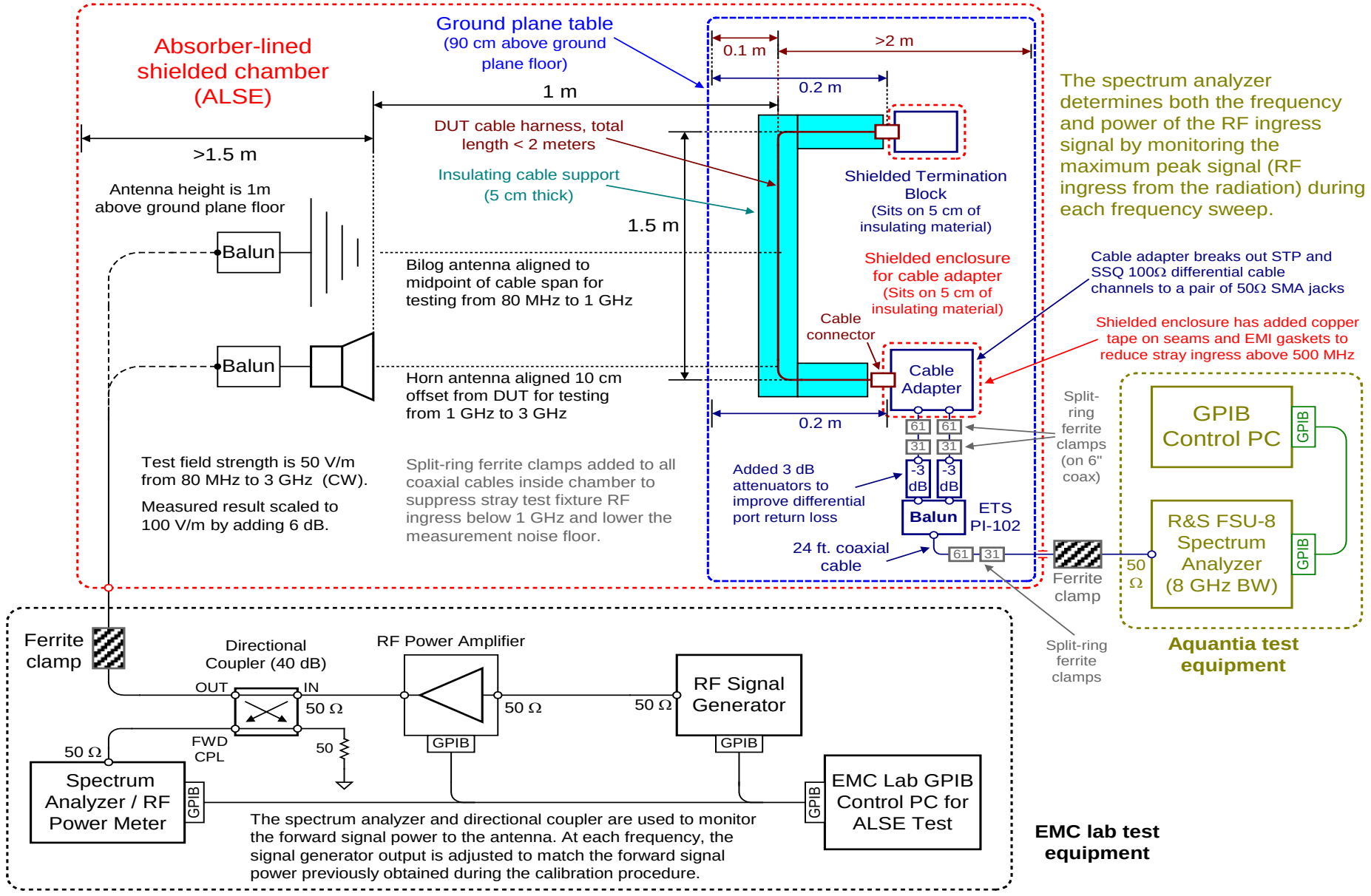
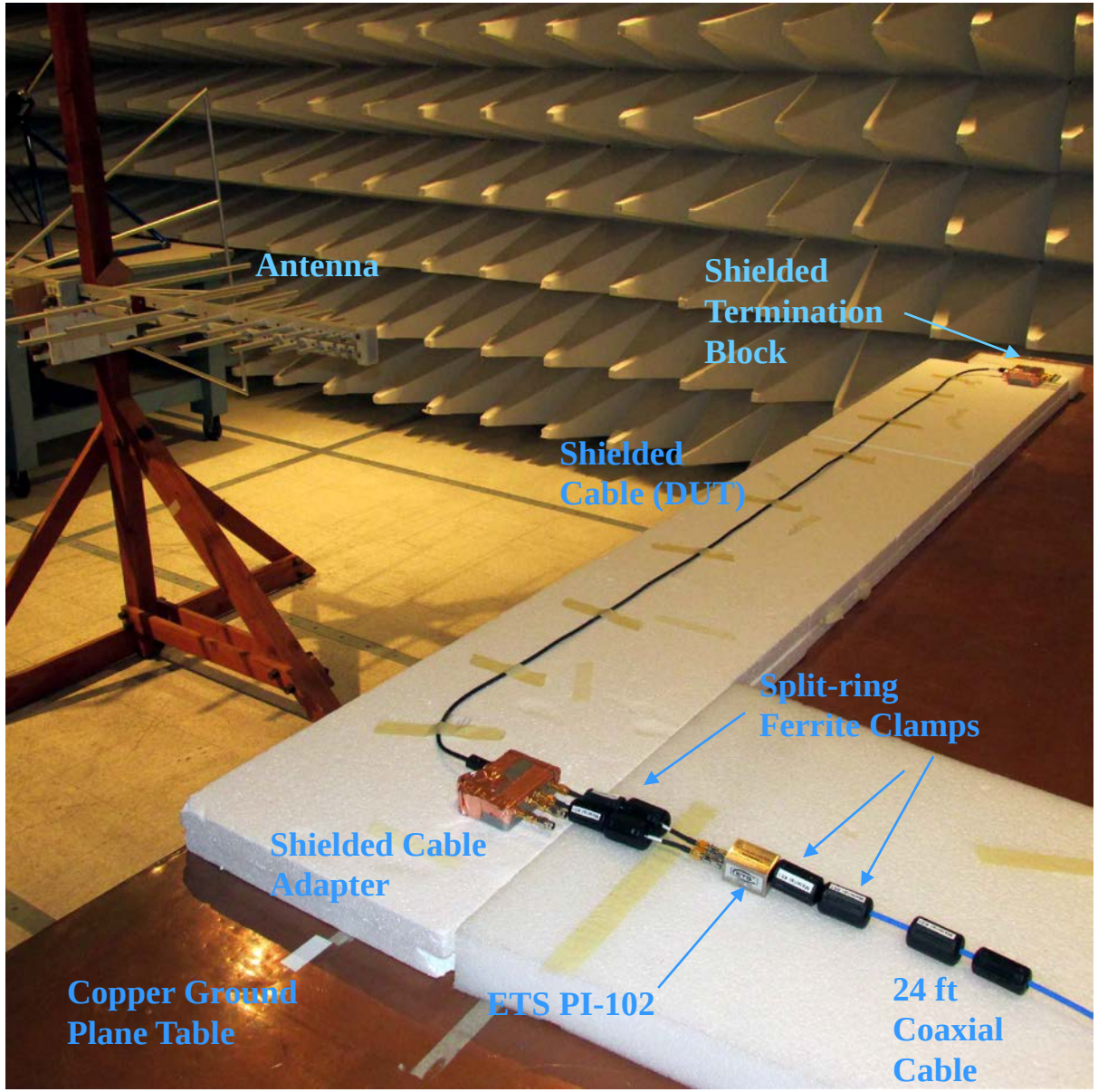
Overview

- Measurement of the differential RF ingress voltage induced at the termination of an automotive shielded cable (STP) based on standard automotive radiated immunity absorber-lined shielded enclosure (ALSE) test method described in ISO 11452-2
  - Test results from 80 MHz to 1 GHz and 1GHz to 3GHz
  - Direct measurement of RF ingress voltage at cable terminations; no PHY MDI port interface
  - Results are for differential rms voltage vs frequency at cable termination (100 Ohms differential impedance)
  - Test performed on STP with H-MTD connectors and STP with HSD connectors; both cable assemblies were 2 meters long with only end connectors

ALSE Automotive Cable RF Ingress Measurement Test Setup



ALSE Automotive Cable RF Ingress Measurement Test Setup (80 MHz to 1 GHz)



Test Setup

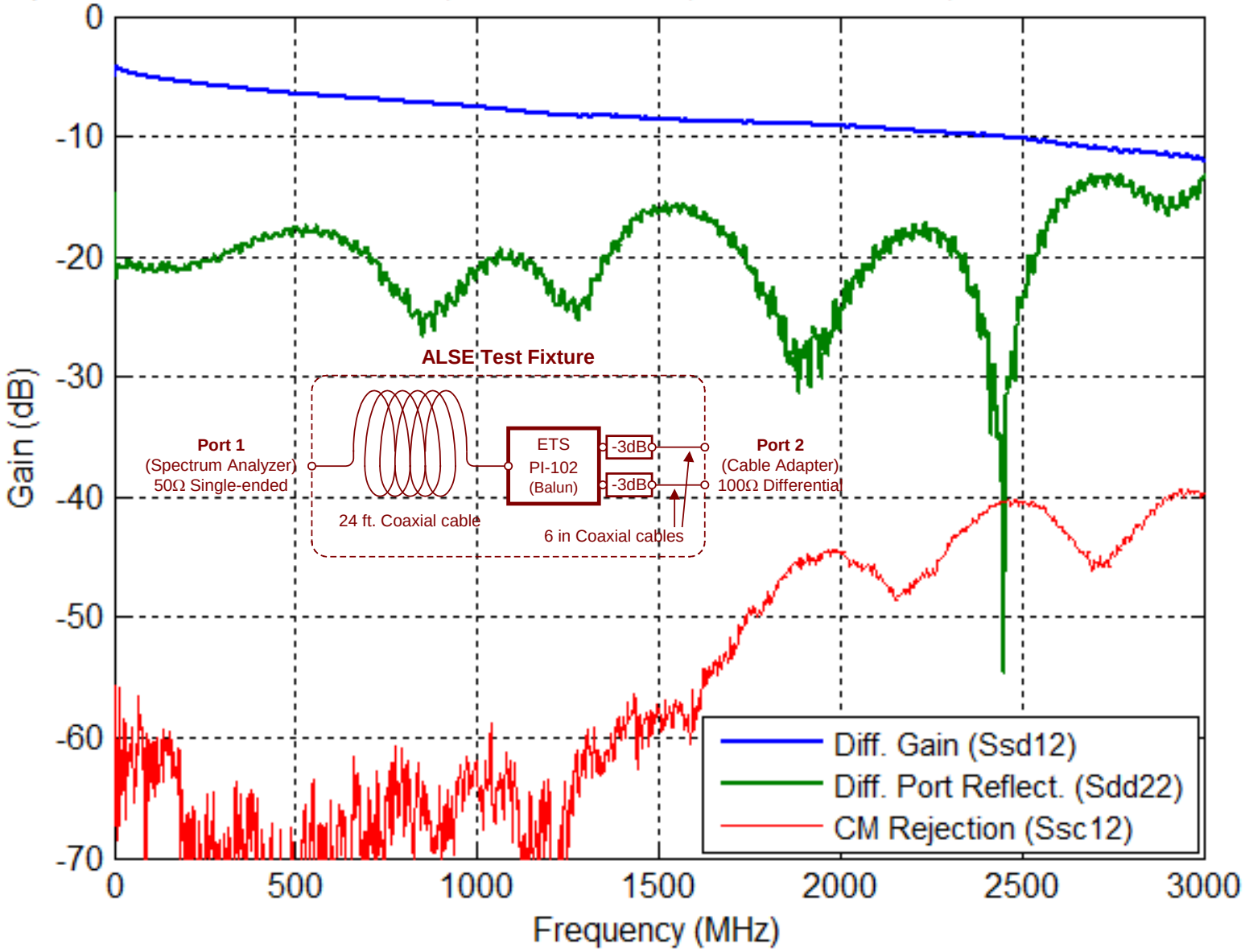
- Measurement noise floor is the measured stray RF ingress from the stand-alone test fixture
  - Measured under ALSE test conditions with the cable DUT disconnected from the cable adapter and all unconnected cable ports on the test fixture covered with copper tape
  - Cable adapter enclosures have EMI gasket seals between the cable connectors and enclosure and copper tape on seams to reduce stray ingress above 500 MHz
  - Added split-ring ferrite clamps to the exposed coaxial cables inside the chamber to reduce stray ingress coupling below 500 MHz; moderately effective below 200 MHz

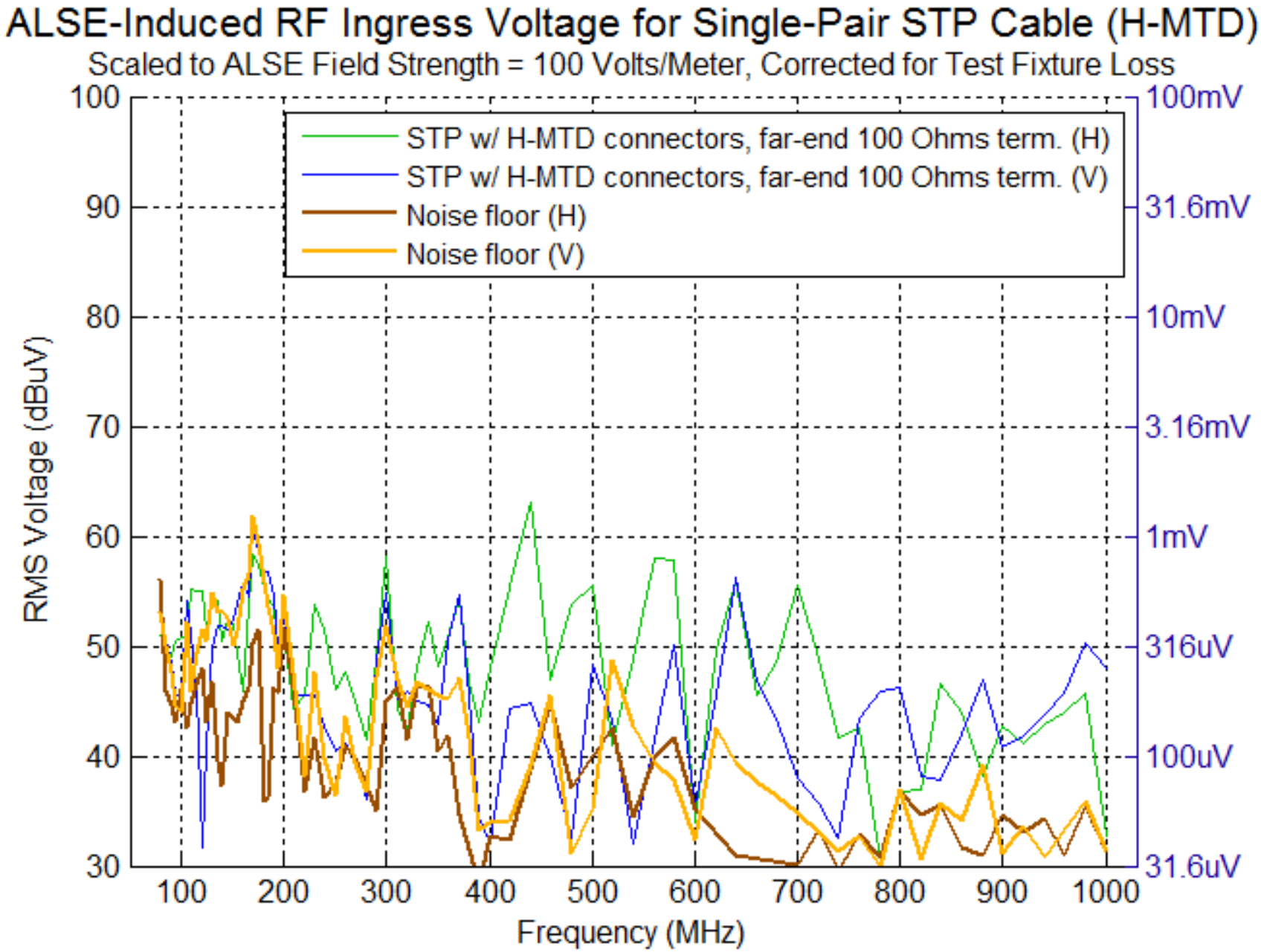
- Spectrum analyzer operated in free running sweep mode; measures both frequency and level of maximum peak signal during each frequency sweep
  - Proper measurement requires a spectrum analyzer measurement noise floor < -150 dBm/Hz to observe weak ingress signals, otherwise an additional pre-amplifier is necessary

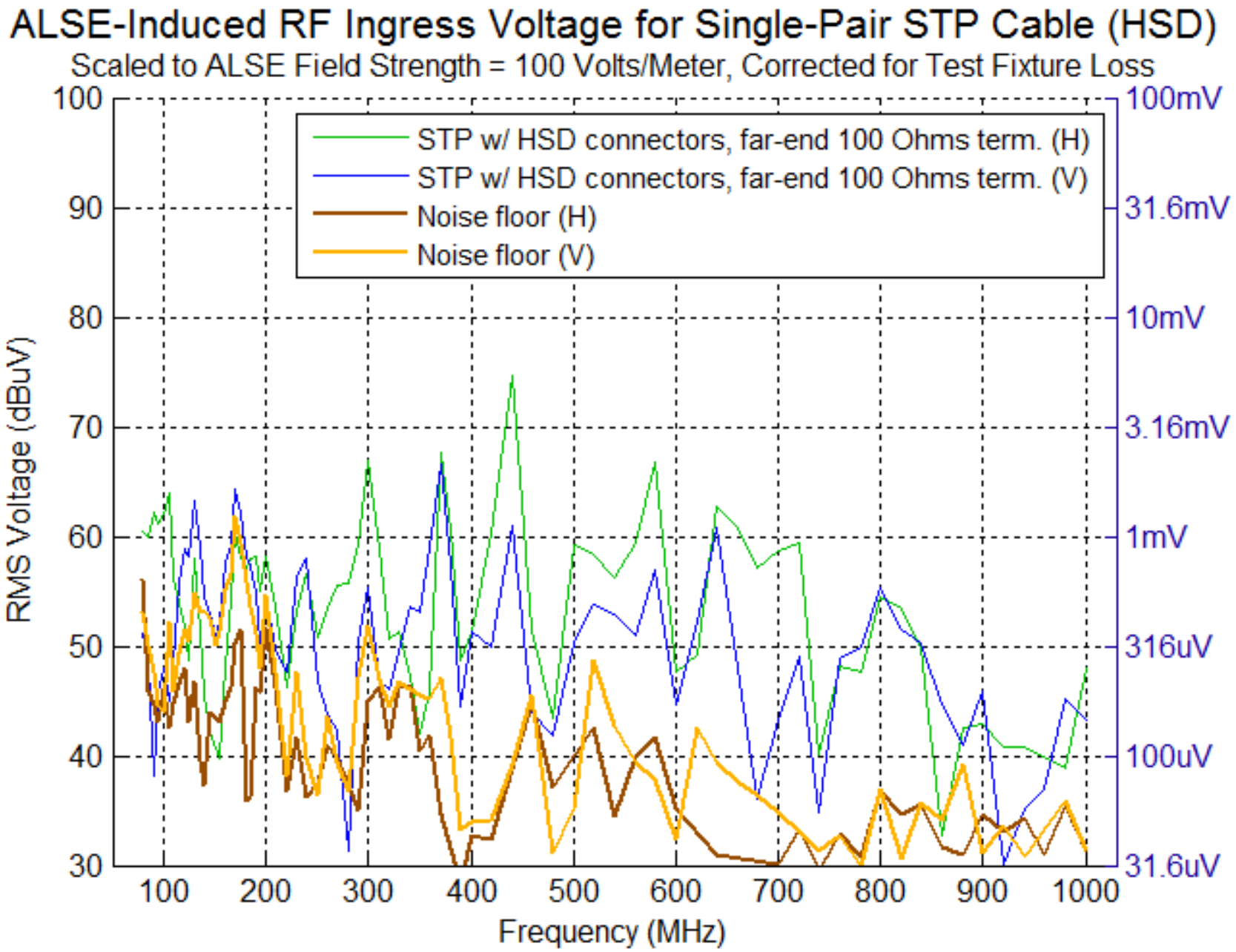
- RF disturber field calibrated to 50 V/meter using a CW signal (no 80% AM)
  - Reduced field strength to minimize harmonic distortion from the EMC lab RF amplifier
  - Harmonic distortion can introduce measurement errors for this test setup by causing the spectrum analyzer to observe the wrong (harmonic) peak
  - Test level a compromise between harmonic distortion and improved signal observability
  - Used linear spaced frequency sweep step size(s) from ISO 11452-1 Table 2; dwell time set at 2 sec.

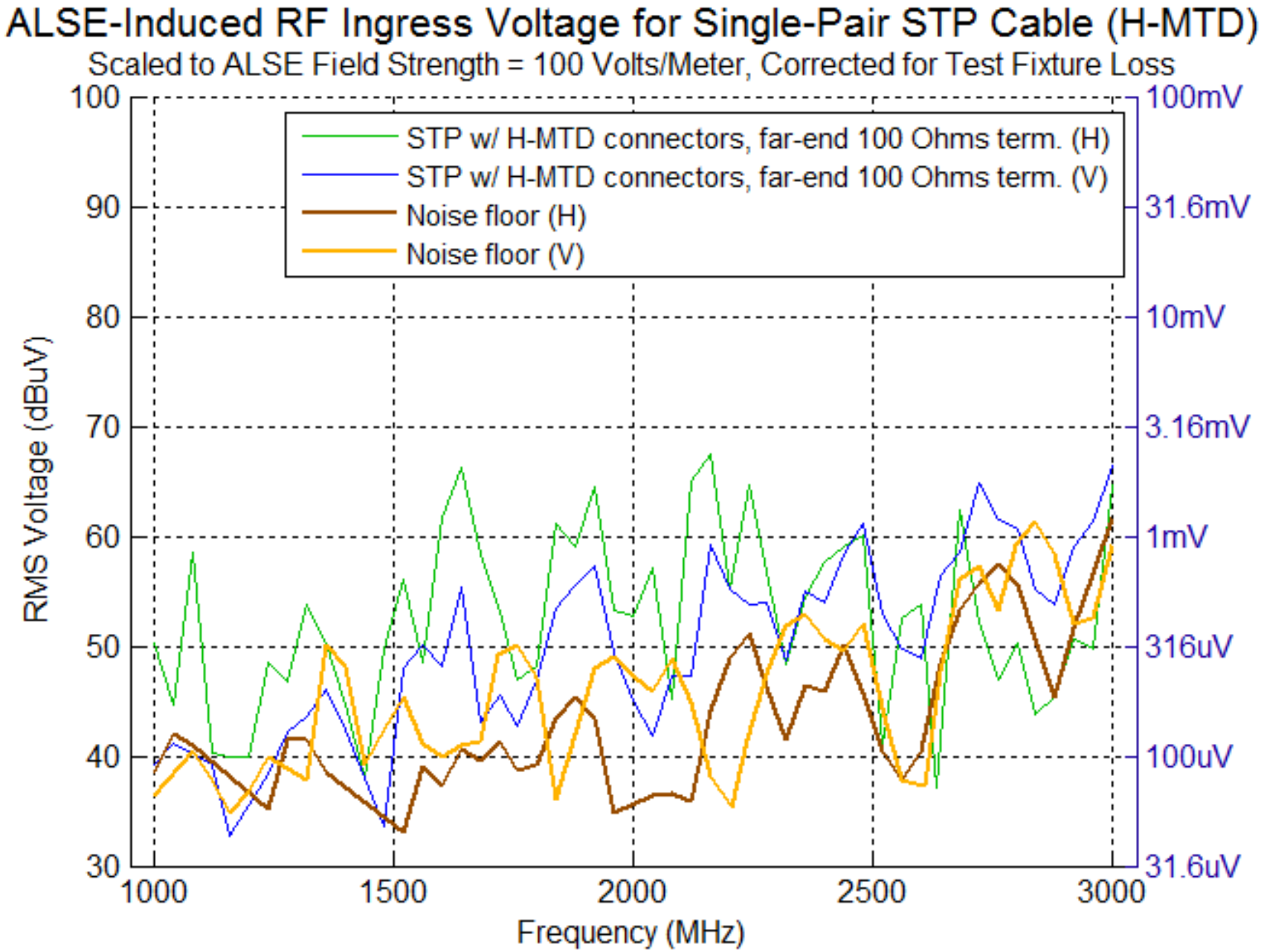
Measured ALSE Test Fixture Diff. Gain, Diff. Port Reflection, and CM Rejection

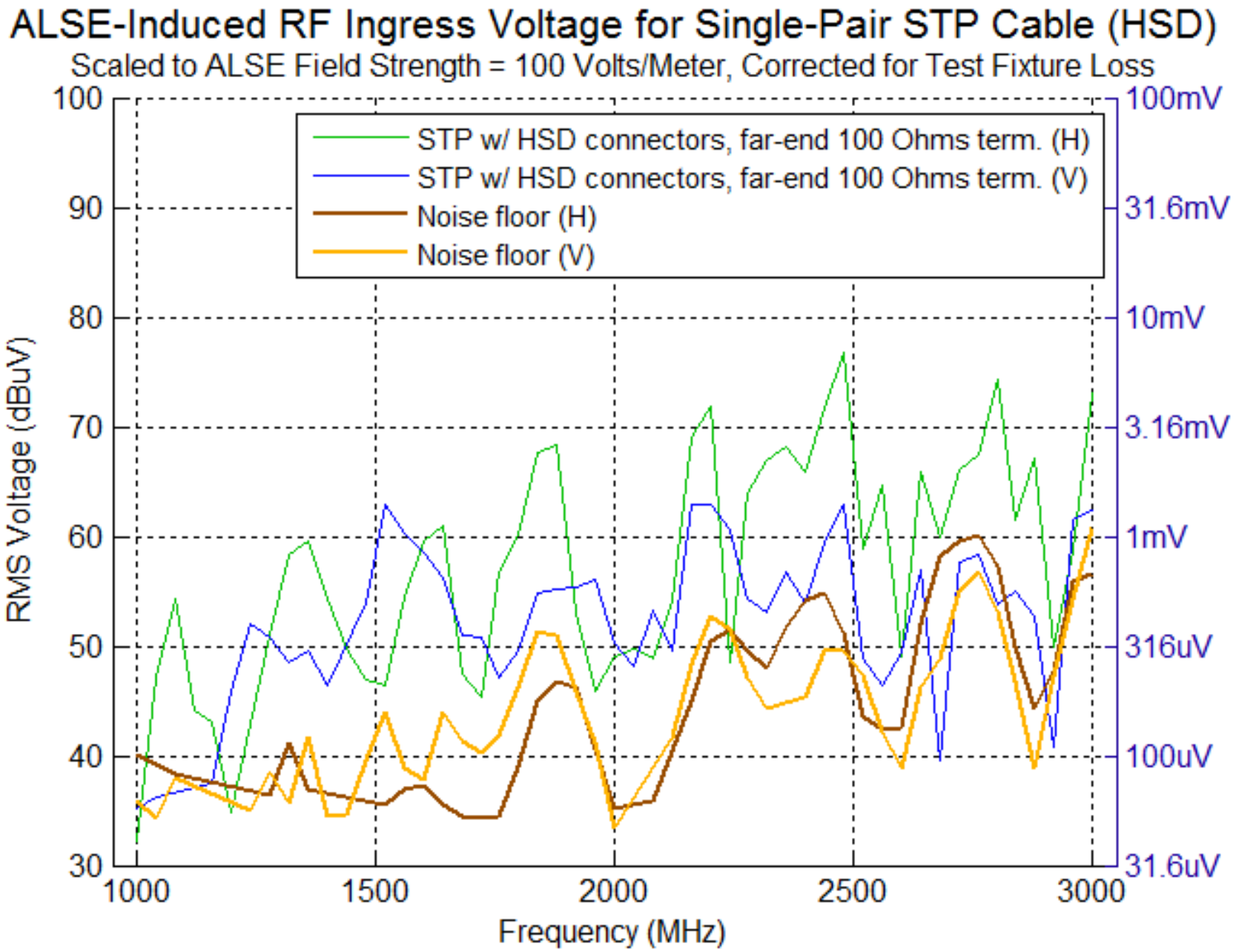
(Includes Short Coaxial Cables, 3 dB Attenuators, ETS PI-102 Balun, and 24 ft Coaxial Cable)




ALSE-Induced RF Ingress Voltage for Single-Pair STP Cable (H-MTD)
Scaled to ALSE Field Strength = 100 Volts/Meter, Corrected for Test Fixture Loss
STP w/ H-MTD connectors, far-end 100 Ohms term. (H)
STP w/ H-MTD connectors, far-end 100 Ohms term. (V)
Noise floor (H)
Noise floor (V)
RMS Voltage (dBuV)
100
90
80
70
60
50
40
30
100mV
31.6mV
10mV
3.16mV
1mV
316uV
100uV
31.6uV
100
200
300
400
500
600
700
800
900
1000
Frequency (MHz)


ALSE-Induced RF Ingress Voltage for Single-Pair STP Cable (HSD)
Scaled to ALSE Field Strength = 100 Volts/Meter, Corrected for Test Fixture Loss
STP w/ HSD connectors, far-end 100 Ohms term. (H)
STP w/ HSD connectors, far-end 100 Ohms term. (V)
Noise floor (H)
Noise floor (V)
RMS Voltage (dBuV)
100
90
80
70
60
50
40
30
100mV
31.6mV
10mV
3.16mV
1mV
316uV
100uV
31.6uV
100
200
300
400
500
600
700
800
900
1000
Frequency (MHz)


ALSE-Induced RF Ingress Voltage for Single-Pair STP Cable (H-MTD)
Scaled to ALSE Field Strength = 100 Volts/Meter, Corrected for Test Fixture Loss
STP w/ H-MTD connectors, far-end 100 Ohms term. (H)
STP w/ H-MTD connectors, far-end 100 Ohms term. (V)
Noise floor (H)
Noise floor (V)
RMS Voltage (dBuV)
100
90
80
70
60
50
40
30
100mV
31.6mV
10mV
3.16mV
1mV
316uV
100uV
31.6uV
1000
1500
2000
2500
3000
Frequency (MHz)


ALSE-Induced RF Ingress Voltage for Single-Pair STP Cable (HSD)
Scaled to ALSE Field Strength = 100 Volts/Meter, Corrected for Test Fixture Loss
STP w/ HSD connectors, far-end 100 Ohms term. (H)
STP w/ HSD connectors, far-end 100 Ohms term. (V)
Noise floor (H)
Noise floor (V)
RMS Voltage (dBuV)
100
90
80
70
60
50
40
30
100mV
31.6mV
10mV
3.16mV
1mV
316uV
100uV
31.6uV
1000
1500
2000
2500
3000
Frequency (MHz)

Observations and Next Steps

- Overall, the RF ingress in the STP cable with the H-MTD connectors was lower than the STP cable with the HSD connectors
  - The peak RF ingress in the **STP** cable with the **H-MTD** connectors (~**1.5 mV rms**) was lower than **STP** cable with the **HSD** connectors (~**5 mV rms**) over 80MHz to 1GHz
  - The peak RF ingress in the **STP** cable with the **H-MTD** connectors (~**3 mV rms**) was lower than the level in the **STP** cable with the **HSD** connectors (~**6 mV rms**) over 1 GHz to 3 GHz
- There is a measurement discontinuity at 1 GHz because of the change in relative antenna position with the (slightly) different test setups for measurements above and below 1 GHz
- RF ingress measurements below 200 MHz may not be accurate because of a higher measurement noise floor from stray RF ingress into the test fixture cabling
  - Some reduction in the measurement noise floor below 200 MHz obtained by adding split-ring ferrite clamps to the exposed coaxial cables inside the chamber
  - Passing the 24 ft coaxial cable outside the chamber through a bulkhead connector at the chamber wall instead of a shielded aperture should provide some additional improvement
- **Next steps**
  - Extend measurements to 5 GHz; insertion loss notches reported in this range (possibly caused by helical shield construction) may have important implications for radiated immunity
  - Test on different cable types (e.g. SSQ) and cable spans with connector junctions
  - Test on cable bundles