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Response to FCC January 14, 2025 Information Request
File No. 1009-EX-CN-2024

January 20, 2025

MITRE Corporation ("MITRE") hereby responds to the above-referenced request for information regarding MITRE's Satellite Experimentation Lab ("M-SEL") satellite. In particular, MITRE updates its application to: (1) remove the 4990-5000 MHz band request; (2) provide measurements regarding unwanted emission power levels into the 1559-1610 MHz and 2200-2290 MHz bands; (3) address a power level discrepancy between the SpaceCap and Narrative/Form 442; (4) clarify certain propulsion and de-orbit aspects of its orbital debris assessment report ("ODAR"); and (5) ensure all application materials reflect the current request.

Consistent with these updates, MITRE is concurrently filing revised application attachments which replace those currently in the record, including: (1) a revised narrative, with updated technical parameters shown in Narrative Appendix A; (2) a revised ODAR; (3) an updated compatibility analysis (attached hereto as Appendix A ("Updated Analysis")); (4) unwanted emissions measurement data (attached hereto as Appendix B); and (5) revised ITU/NTIA documentation, including SpaceCap ("Revised SpaceCap"), GIMS, and NTIA Space Record Form addressing the questions raised in the request for information.

1. *NG 282321 and 328: Overlaps the 4990-5000 MHz band, which is protected by US246, so [MITRE will] either need to shift the center frequency or decrease the emission bandwidth.*

MITRE hereby withdraws its request to access the 4990-5000 MHz band segment for uplink operations from the Bedford Ground Station and concurrently amends its requested bandwidth for the 4900-4990 MHz band to reflect 90 megahertz. This change is reflected in the application Form 442 and updated application attachments concurrently filed with this response and resolves this comment from NTIA.

2. *NG 282323-324: Please have the applicant provide the measured unwanted emission power levels into the 1559-1610 MHz band, which is used by GPS L1.*

See attached Appendix B for measurement data regarding unwanted emission power levels.

3. *NG 282325: Please have the applicant provide the measured unwanted emission power levels into the 2200-2290 MHz band, which is used for space-to-space links by Federal space systems.*

See attached Appendix B for measurement data regarding unwanted emission power levels.

4. *Please see the CR validation errors in the attached Excel document. All fatal errors, besides operating agency ID, must be resolved prior to submission. Please update your SpaceCap software version 10, resolve any outstanding issues, rerun validation and resubmit the CR SpaceCap.*

See Revised SpaceCap and GIMS files submitted concurrently with this response. As detailed in the updated SpaceVal reports, all fatal errors have been resolved except those pertaining to operating agency ID. Version 10 SpaceCap software was utilized for the updated API and CR Revised SpaceCap reports. The Revised SpaceCap for API and CR further resolves discrepancies with the Narrative and Form 442 that reduce maximum and minimum peak power, and reduce maximum and minimum power density, and removes the 4990-5000 MHz band segment.

5. *Please redo the interference analysis in dB units and not watts. We are unsure in certain cases if EIRP or ERP is being used. Additionally, the radiated power values in Table 1 of your December 20 response doesn't appear to match the power values derived from the SpaceCap.*

The Updated Analysis reflects changes to align the power levels with those specified in the Revised SpaceCap. The Updated Analysis also addresses the FCC's request to show certain figures in dB as well as in Watts and provides both equivalent radiated power and equivalent isotropically radiated power for clarity. Moreover, the Updated Analysis also reflects the removal of the 4990-5000 MHz band. As with the previous analysis, the Updated Analysis continues to demonstrate that the proposed experimental testing of M-SEL will be below the system noise floor of authorized receivers in the 1525-1559 MHz; 2170-2180 MHz; 2483.5-2500 MHz; 2500-2520 MHz; 4900-4990 MHz; and 6875-7055 MHz bands. Accordingly, MITRE's proposed experimental operations are fully compatible with incumbent operations in the requested frequency bands.

6. *What will the propulsion unit be used for? You have indicated that station-keeping will not be performed, nor is there any information provided on any propulsion-related testing over the duration of the mission. Will any orbit lowering be performed at the end of the mission?*

See the revised Narrative and ODAR files submitted concurrently with this response. Specifically, MITRE updated the response to ODAR Section 2.6 regarding the description of the propulsion system to clarify that the M-SEL will not use the propulsion unit at any time during the mission, not for station keeping nor de-orbiting, and M-SEL will instead de-orbit due to atmospheric drag as discussed in ODAR Section 6. ODAR Section 2.6 further clarifies that the on-board propellant, indium, is non-toxic and non-combustible, ensuring there is no risk of orbital debris generation. Conforming edits were also made to ODAR Section 6.1 consistent with MITRE's December 20, 2024 response clarifying that the spacecraft will promptly commence de-orbit following the conclusion of experimental testing. MITRE also updated the description of its Phase 4 de-orbit plans to align with the foregoing ODAR updates.

7. *Please update both the ODAR and Narrative to align with the new mission duration information provided in the recent response.*

See the revised ODAR submitted concurrently with this response addressing the 24-month mission duration specified in the application form. Specifically, ODAR Section 1.6 now reflects a 24-month mission duration. The narrative also reflects a 24-month mission request and further clarifies (as noted in MITRE's December 20, 2024 response) that additional regulatory authority may be requested to the extent additional time is needed for experimental operations. (Narrative, 5).

Appendix A

Updated Compatibility Analysis

The FCC has asked that MITRE Corporation ("MITRE") provide an analysis of the interference potential from proposed experimental testing with the M-SEL satellite in several downlink (space-to-Earth) frequency bands, including: 1525-1559 MHz; 2170-2180 MHz; 2483.5-2500 MHz; 2500-2520 MHz; 4900-4990MHz; and 6875-7055 MHz. As demonstrated herein, MITRE's proposed operations are expected to be well below the noise floor in each of the analyzed frequency bands. Thus, MITRE's operations are not expected to pose any harmful interfere risks to incumbent authorized operations.

Conducted and radiated (EIRP) power levels: The conducted and radiated power levels used in the analysis are described in Table 1 below.

Frequency Band (MHz)	ERP (From FCC Form 442) (Watts)	ERP (dBW)	EIRP (dBW)
1525-1559	19.3	12.9	15.0
2170-2180	18	12.6	14.7
2483.5-2500	29.2	14.7	16.8
2500-2520	29.2	14.7	16.8
4900-4990	71.6	18.5	20.7
6875-7055	15.8	12.0	14.1

Table 1: Conducted and Radiated (EIRP)

***Power Flux Density ("PFD") at the Surface of the Earth*:** We determine the PFD at the surface of the earth from the M-SEL satellite for each of the frequency bands identified by the FCC. The PFD is calculated using the formula below.

$$S = \frac{P}{4\pi d^2}$$

Where S = PFD at the earth surface;
P = radiated power (Watts)
d = height of the satellite above the earth surface (510 km for M-SEL)

The values for each band are given in Table 2 below.

Frequency band (MHz)	**EIRP (dBW)**	**EIRP (Watts)**	**PFD (W/m^2)**	**PFD (dBW/m^2)**
1525-1559	15.0	31.6	9.7×10^{-12}	-110.1
2170-2180	14.7	29.5	9.0×10^{-12}	-110.4
2483.5-2500	16.8	47.9	1.5×10^{-11}	-108.3

2500-2520	16.8	47.9	$1.5x10^{-11}$	-108.3
4900-4990	20.7	117.5	$3.6x10^{-11}$	-104.4
6875-7055	14.1	25.7	$7.9x10^{-12}$	-111.0

Table 2: PFD at the Surface of the Earth

***Received Power at Surface of the Earth*:** The PFD is then used to calculate received power on the surface of the earth, assuming that the receiving system uses an isotropic antenna, which has an aperture described by the formula below.

$$A = \frac{\lambda^2}{4\pi}$$

Where A = antenna aperture in m^2
λ = wavelength at the center of the band in m

Band (MHz)	**Wavelength (m)**	**Aperture (m^2)**	**PFD (W/m^2)**	**Received Power (W)**	**Received Power (dBW)**
1525-1559	0.19	0.003	$9.7x10^{-12}$	$(2.78x10^{-14})$	-135.6
2170-2180	0.14	0.0015	$9.0x10^{-12}$	$1.41x10^{-14}$	-138.5
2483.5-2500	0.12	0.0011	$1.5x10^{-11}$	$1.68x10^{-14}$	-137.7
2500-2520	0.12	0.0011	$1.5x10^{-11}$	$1.68x10^{-14}$	-137.7
4900-4990	0.061	0.0003	$3.6x10^{-11}$	$1.06x10^{-14}$	-139.7
6875-7055	0.043	0.00015	$7.9x10^{-12}$	$1.16x10^{-15}$	-149.3

Table 3: Received Power at the Surface of the Earth

The received power calculated in Table 3 considers the full power of the transmitted signal across the entire bandwidth identified in the emission designators specified in the application.

***Power Spectral Density*:** To determine the worst-case received power in each frequency band, the analysis below considers the smallest bandwidth used in each frequency band of 5 megahertz. The received power is converted to a power spectral density ("PSD") by dividing each received power level by 5,000,000 Hz (or by subtracting 67 dB) as calculated in Table 4 below.

Band (MHz)	**Received PSD (W/Hz)**	**Received PSD (dBW/Hz)**
1525-1559	$5.56x10^{-21}$	-202.5
2170-2180	$2.82x10^{-21}$	-205.5
2483.5-2500	$3.36x10^{-21}$	-204.7
2500-2520	$3.36x10^{-21}$	-204.7
4900-4990	$2.13x10^{-21}$	-206.7
6875-7055	$2.32x10^{-22}$	-216.3

Table 4: Received PSD

***Interference-to-Noise Ratio ("INR")*:** The received PSD values can be compared to the thermal noise level to determine the INR in each frequency band. The thermal noise level is calculated using the following formula:

$$N = kTB$$

Where N = noise power level
k= Boltzmann Constant (1.38×10^{-23})
T = Temperature (290 K)
B = Bandwidth (1 Hz)

The thermal noise is calculated to be 4.00x10-21 Watts/Hz, or -203.9 dBW/Hz.

Assuming that the receivers in each of the identified bands operate with a noise figure of 3 dB (representing internal noise generated within the receiver), the system noise level is then calculated to be -198.9 dBW/Hz for an incumbent receiver. Table 5 below shows the INR for each band used by the M-SEL satellite.

Band (MHz)	**INR (dB)**
1525-1559	-3.6
2170-2180	-6.6
2483.5-2500	-5.8
2500-2520	-5.8
4900-4990	-7.8
6875-7055	-17.4

Table 5: Interference to Noise Ratio

As can be seen in Table 5, the INR ratios are all below the system noise level of any incumbent receiver, and in all but one case are approaching 6 dB or greater below that system noise level. Moreover, given that the experimental operations are for a single non-geostationary satellite and any potential impact to receivers on the earth is expected to be extremely limited. Thus, no harmful interference is anticipated from the proposed experimental downlink operations of the M-SEL satellite. Nevertheless, to the extent any harmful interference is reported in a given frequency band, MITRE will immediately cease operations in such band until the harmful interference is resolved. Accordingly, MITRE's proposed experimental operations are fully compatible with incumbent operations in the requested frequency bands.

Appendix B

M-SEL Unwanted Emission Measurements

RF Measurements Conducted

- Checking for unintended RF emissions at:
  - 1559-1610 MHz (Band A)
  - 2200-2290 MHz (Band B)
- Output measured while transmitting at MITRE's FCC requested center frequencies
  - DVB-S2, 10 Msps, 35% roll-off:
    - 1531 MHz
    - 1552 MHz
    - 2185 MHz
    - 2492 MHz
    - 4945 MHz
    - 7052.5 MHz

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Measurement Configuration

Antenna "hat" used to measure RF emissions from FUSE and X -band antennas

- Hats provide RF 'spill proof' container for mock-up of over the air testing
  - Portable anechoic chamber

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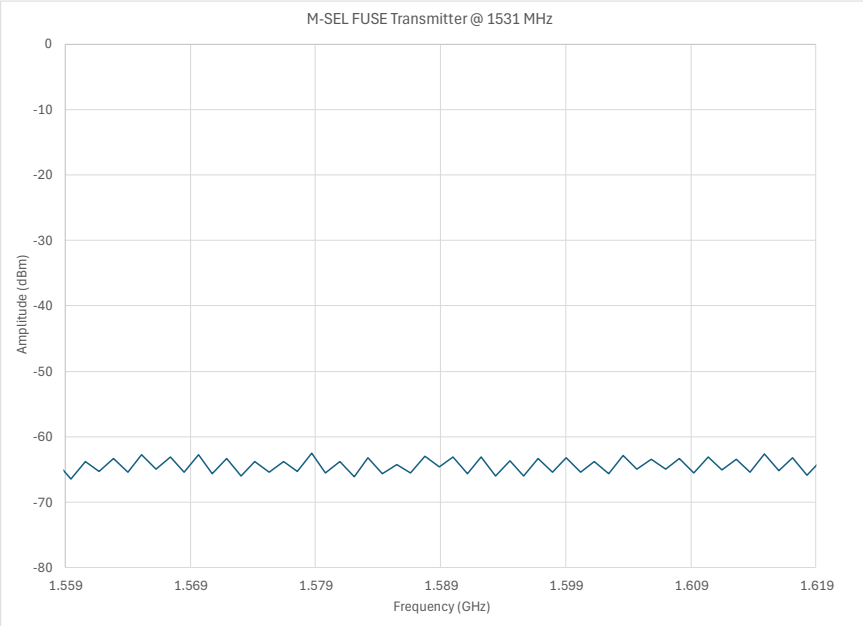
1531 MHz - A



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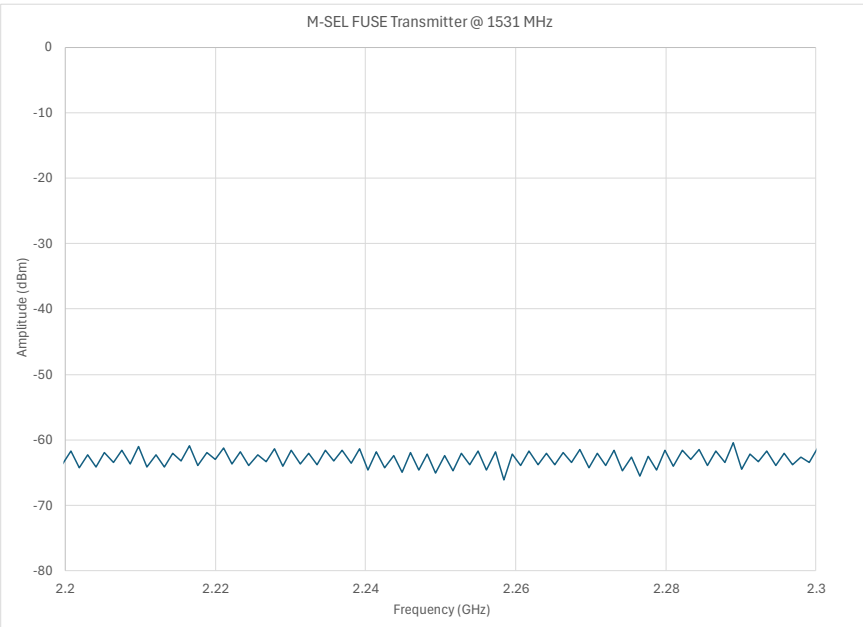
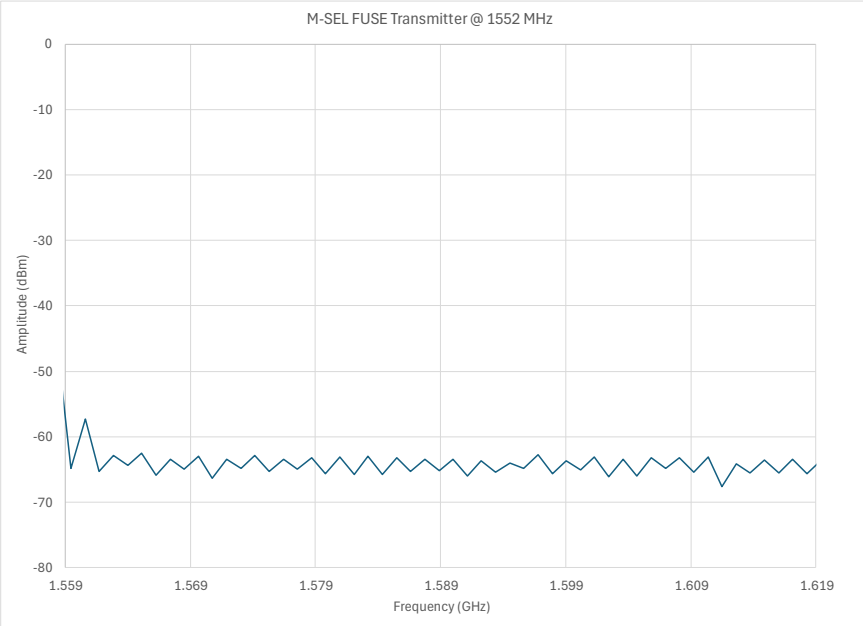
1531 MHz - B



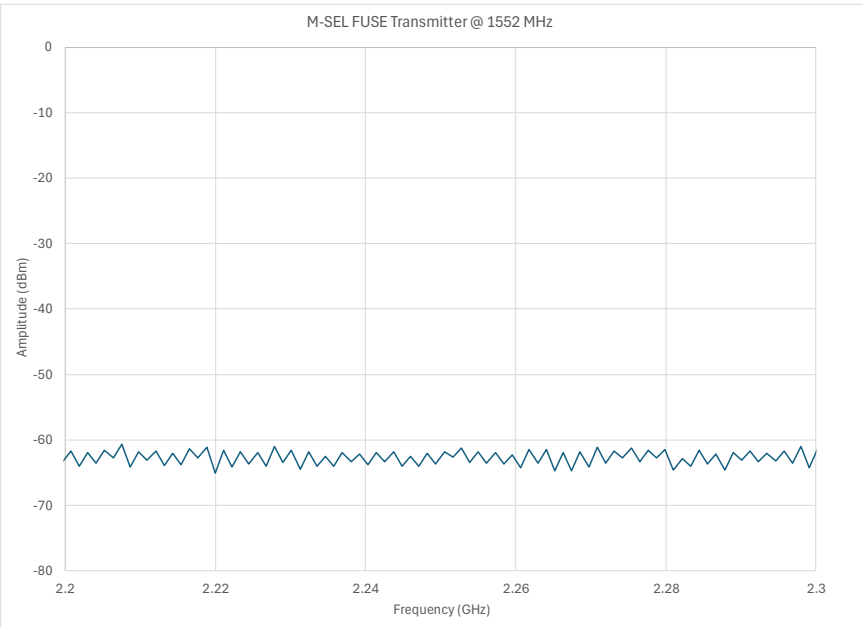
MITRE

1552 MHz - A



MITRE

1552 MHz - B



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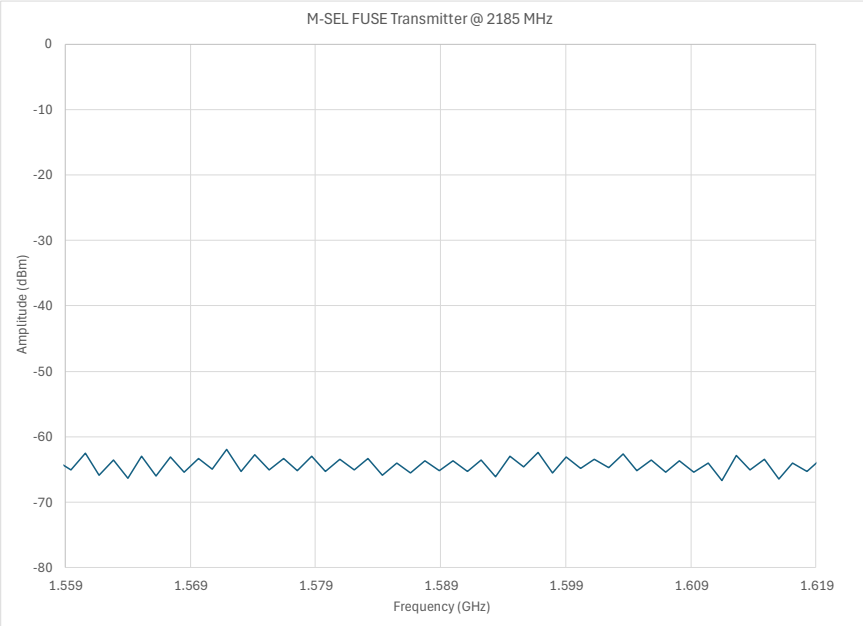
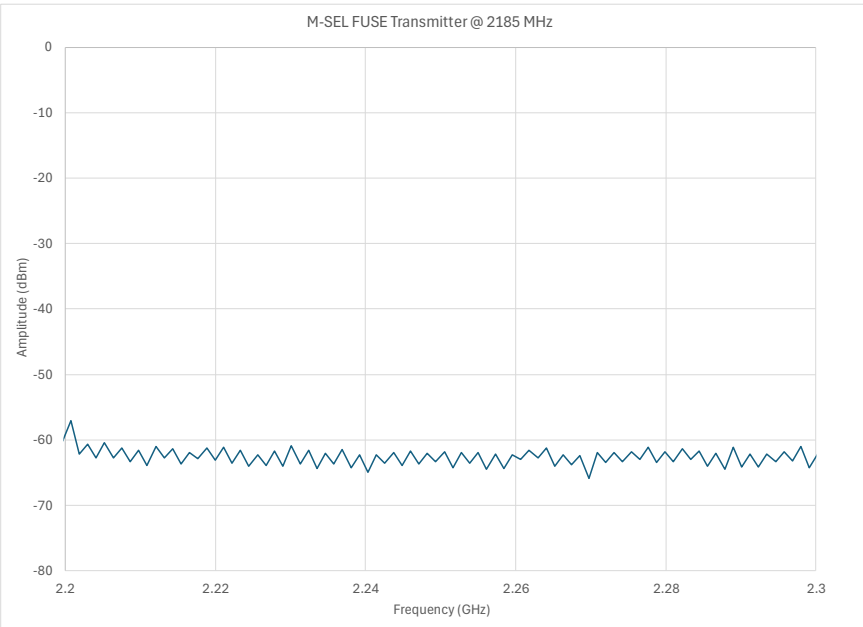
2185 MHz - A



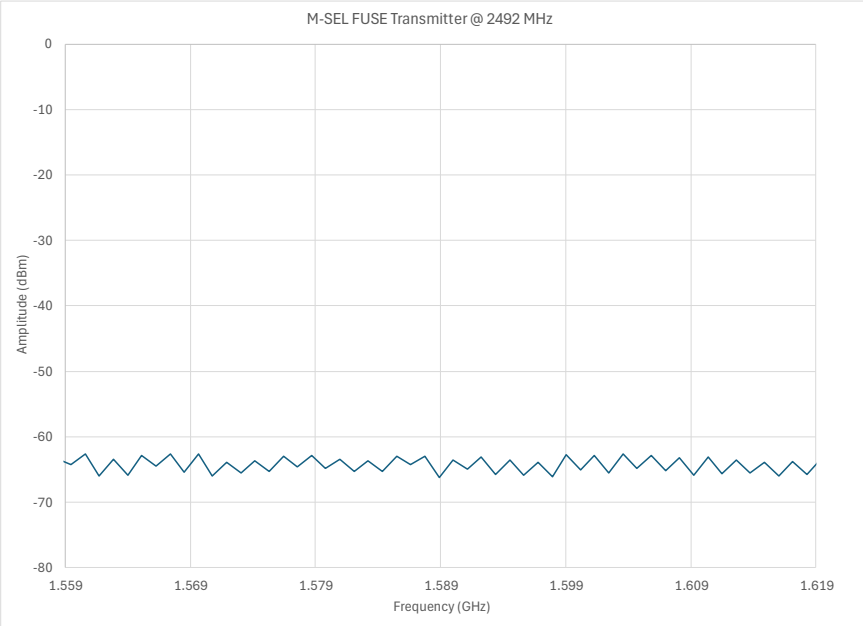
MITRE

2185 MHz - B



MITRE

2492 MHz - A



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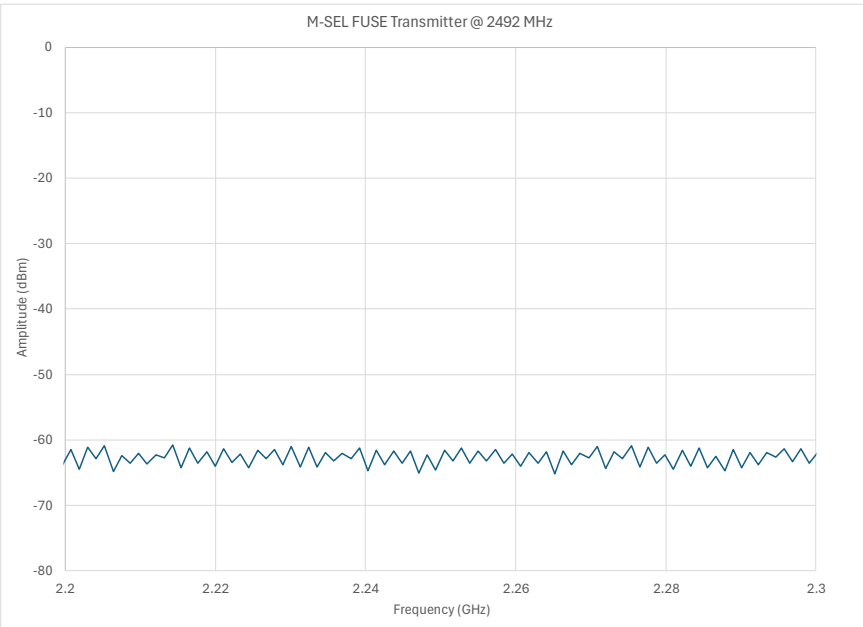
2492 MHz - B



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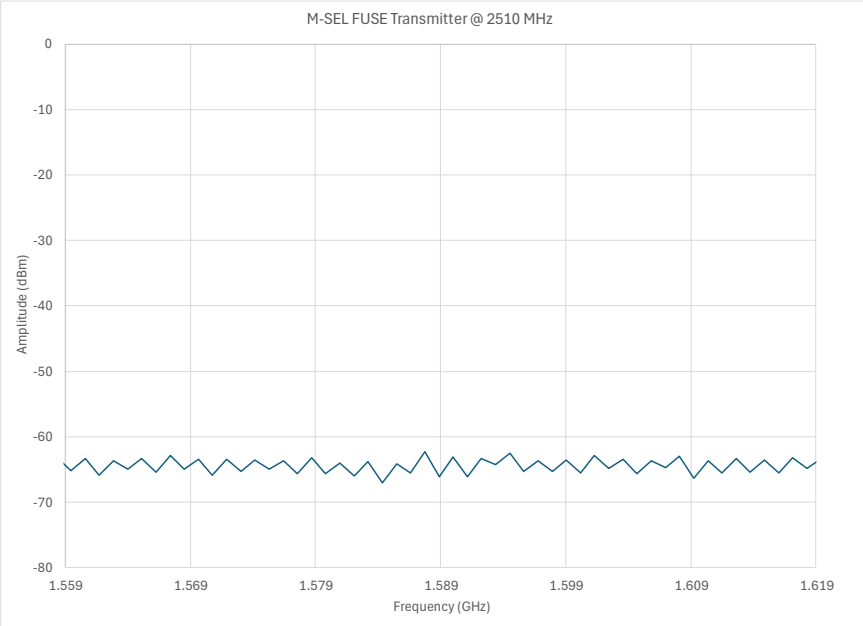
2510 MHz - A



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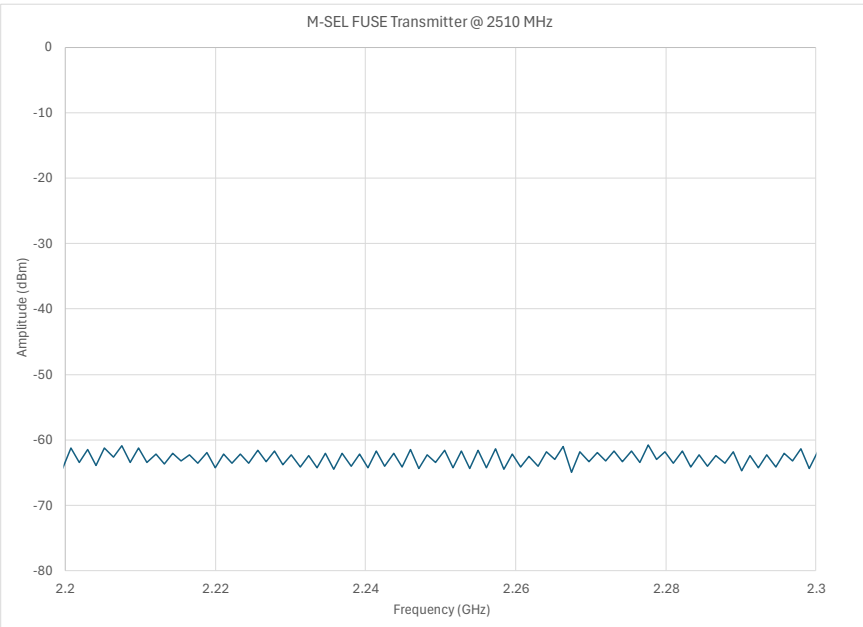
2510 MHz - B



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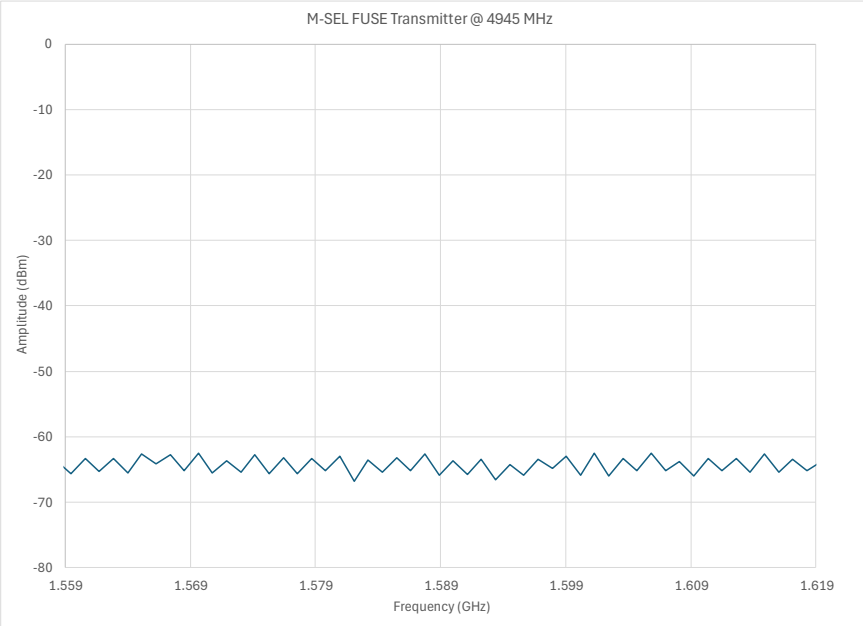
4945 MHz - A



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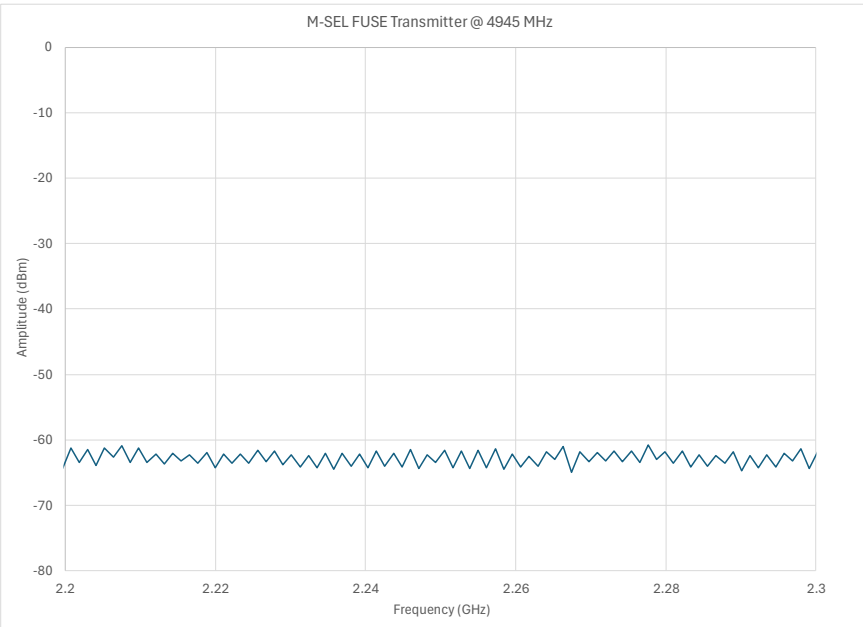
4945 MHz - B



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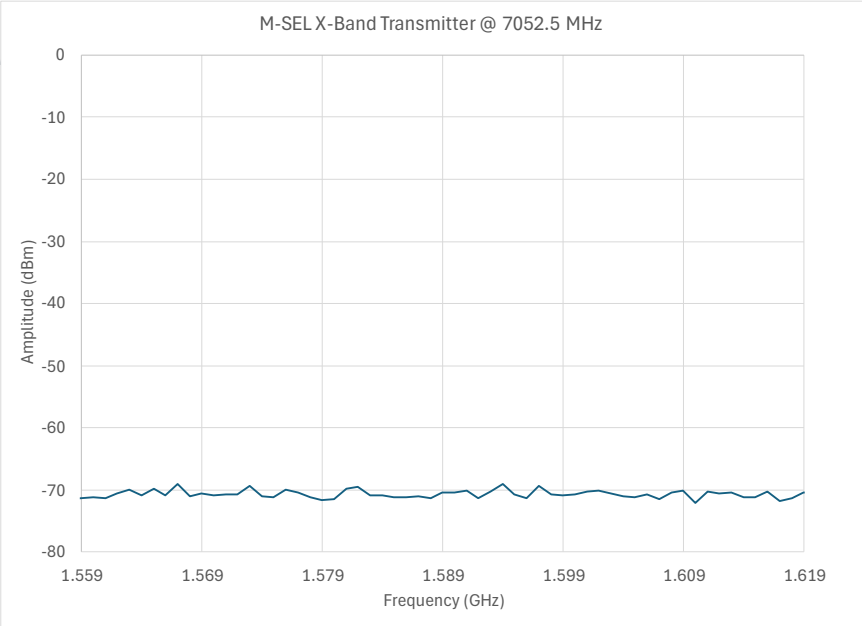
7052.5 MHz - A



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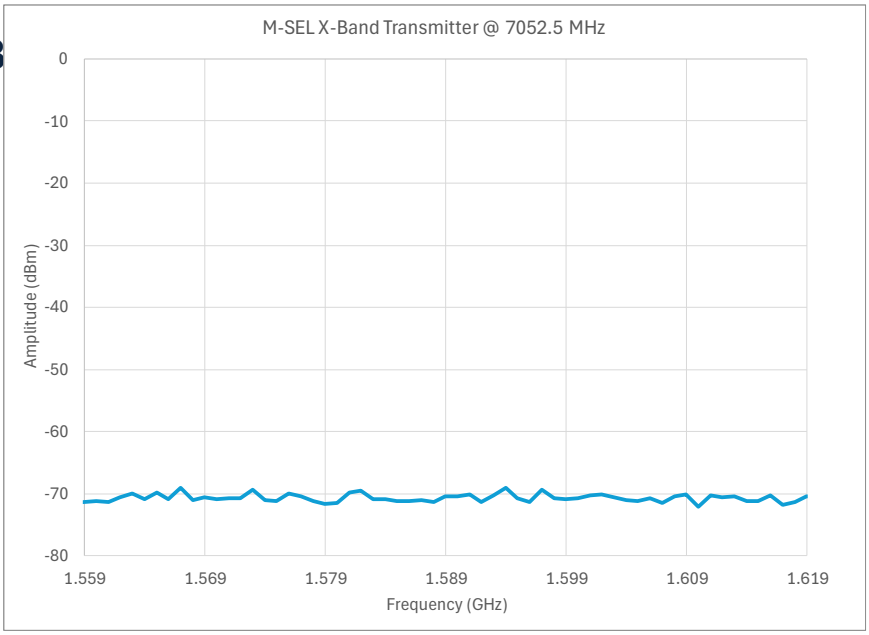
7052.5 MHz - B



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