High Power Ferrite Switches for Spacecraft Millimeter Wave Hopping Spot Beam Antennas

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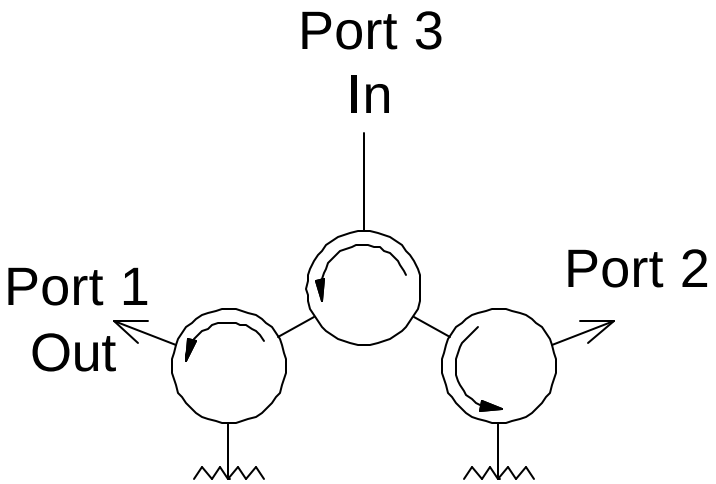
Motivation for Development

- Next generation Ka-band communications satellites currently in development will use high gain multiple spot beam antennas to maximize frequency re-use across the coverage area
- In this approach, pioneered by NASA's ACTS Satellite, some of the beams hop dynamically to handle changing traffic patterns, serving customers on a TDMA basis
- Transmitter power on all satellites is increasing in response to the demand for higher throughput and smaller user terminals
- Implementation of the downlink hopping spot beam with a multiple beam antenna requires a switching element which can handle >100 W of microwave power and switch in less than a microsecond
- The ferrite triad described here was developed to address this market

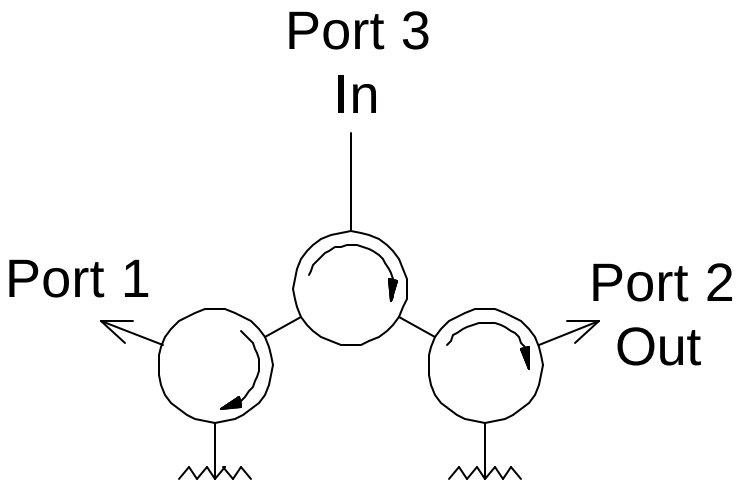
Triad Performance Requirements

- **Center Frequency: 19.95 GHz**
- **Bandwidth: 2.5%**
- **Input Power: 135 W CW**
- **Insertion Loss: 0.25 dB**
- **Return Loss: 25 dB**
- **Isolation: 40 dB**
- **Switch Rate: 14 kHz**
- **Switch Time: 350 ns**
- **RF Interface: WR-51 Waveguide**
- **Application: Geosynchronous orbit**

Triad RF Schematic



Port 1 Selected

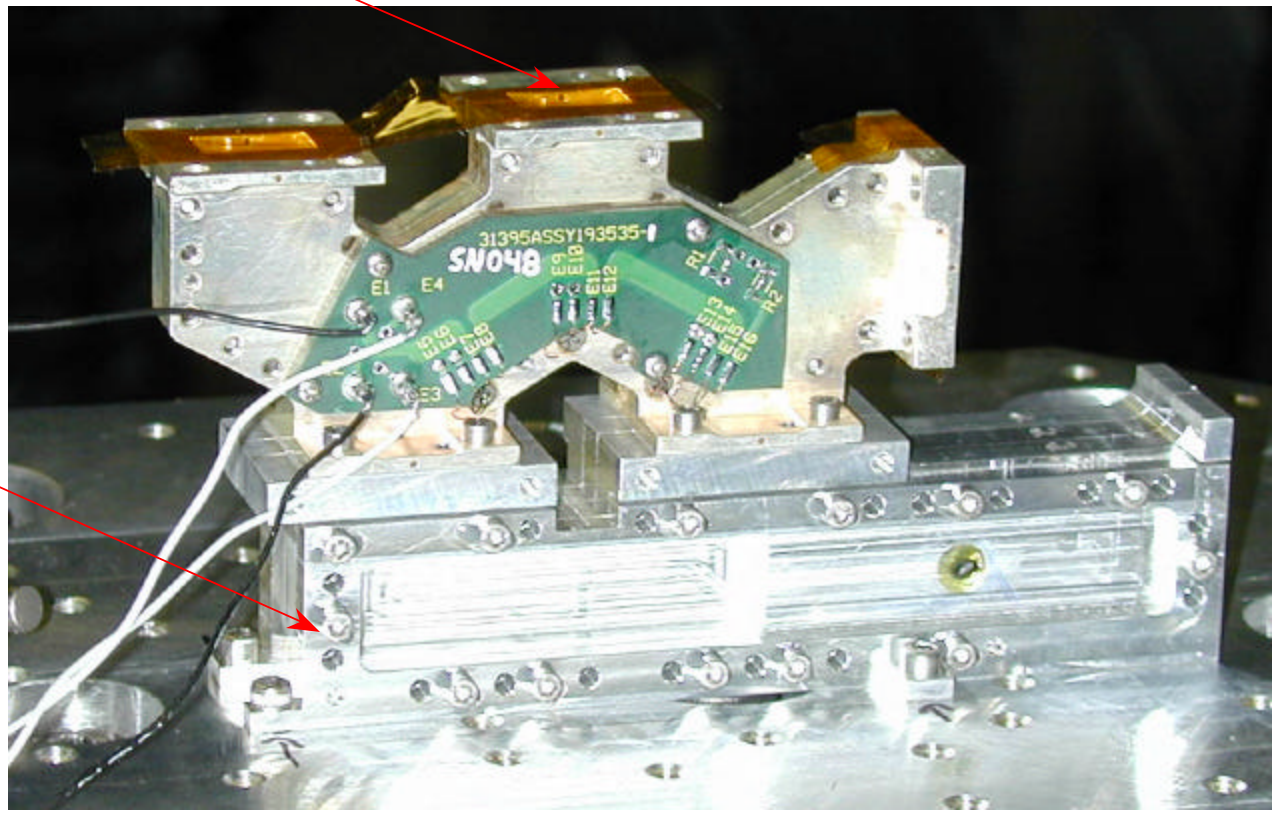


Port 2 Selected

Triad/Load Assembly

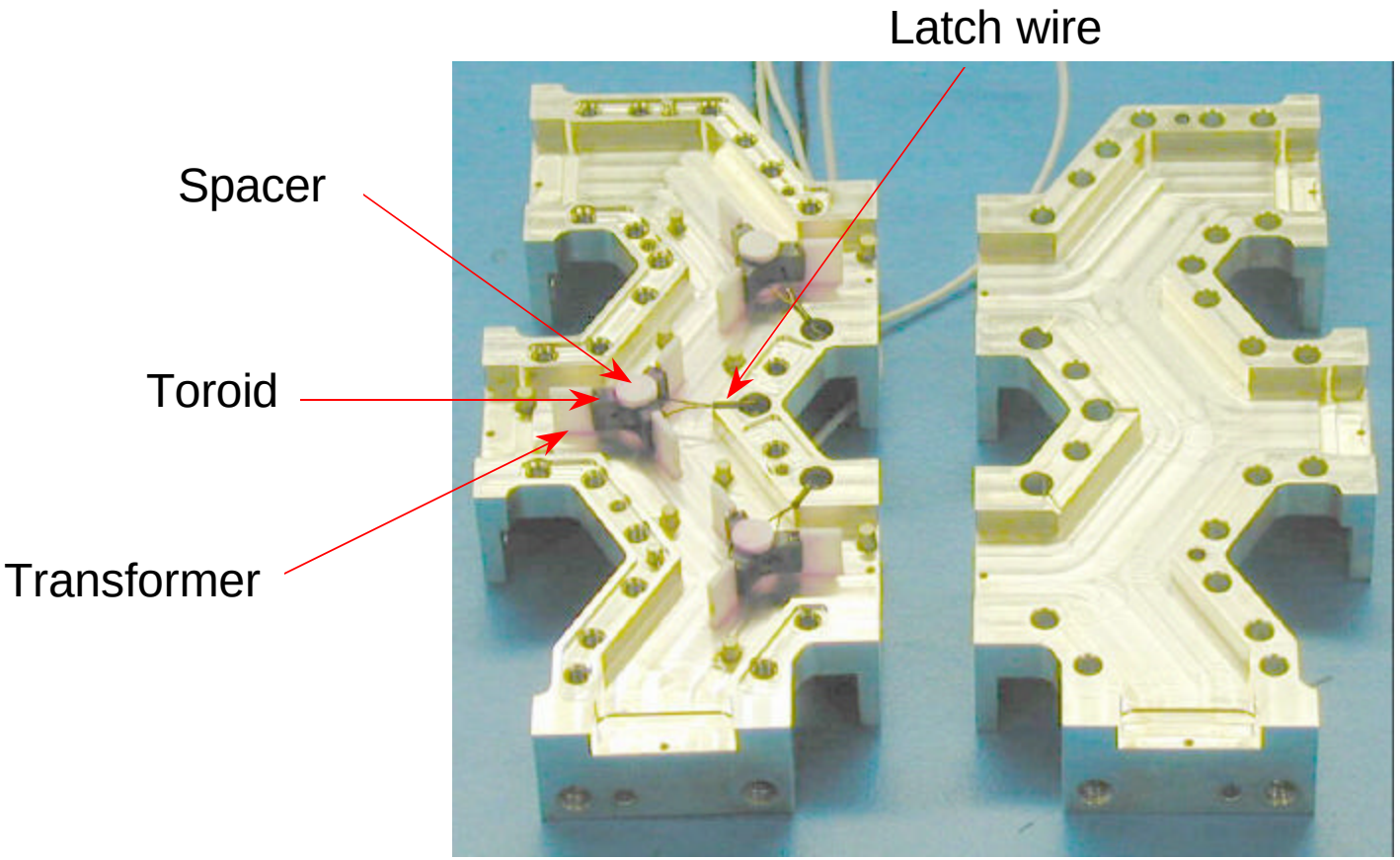
Input

Load Assembly

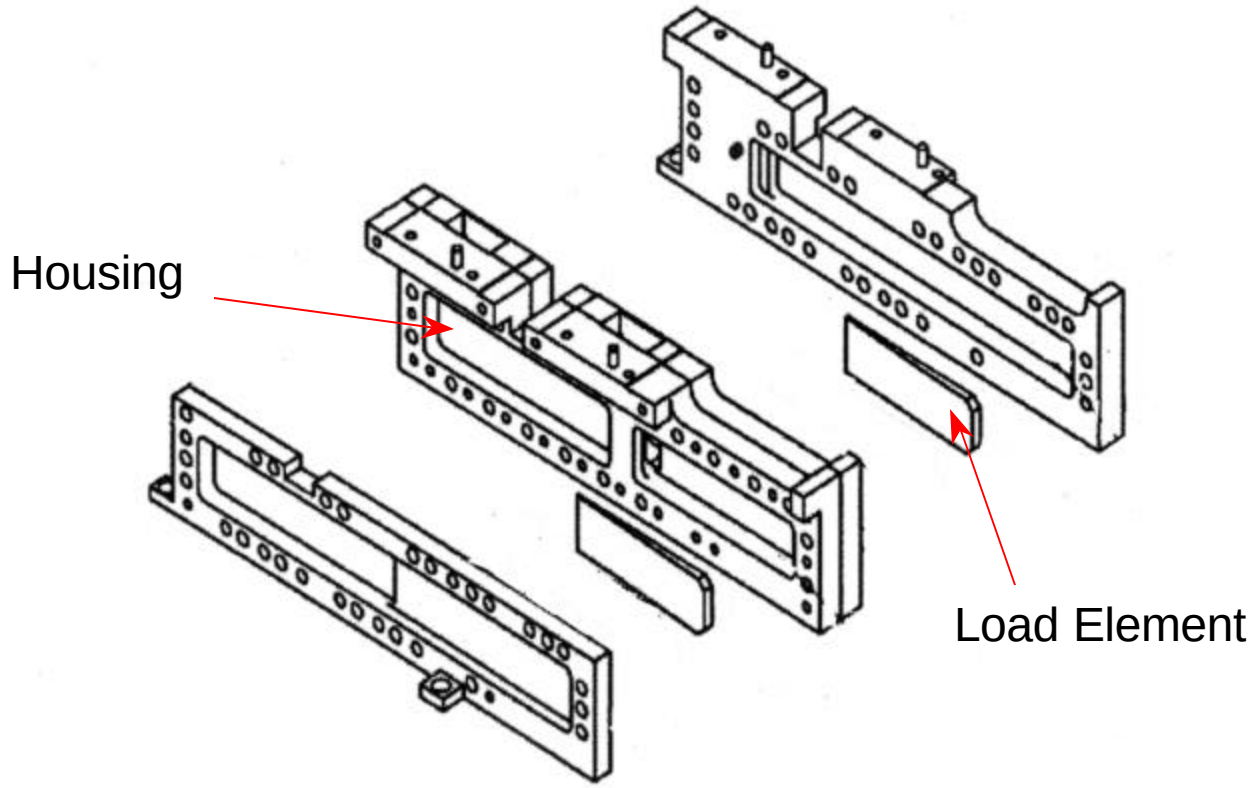


Size: 12.7 x 6.4 x 1.3 cm
Mass: 135 gm

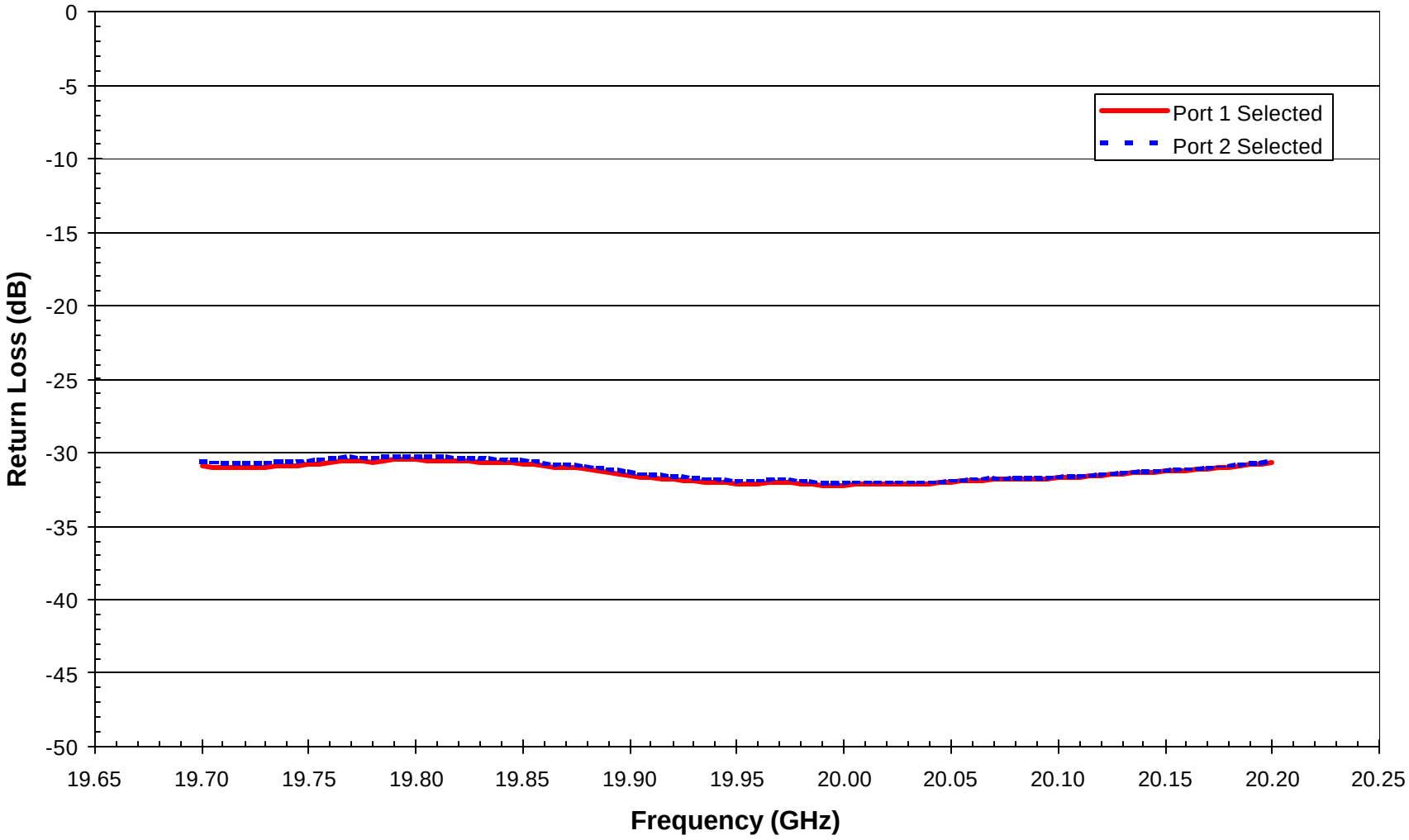
Triad Assembly



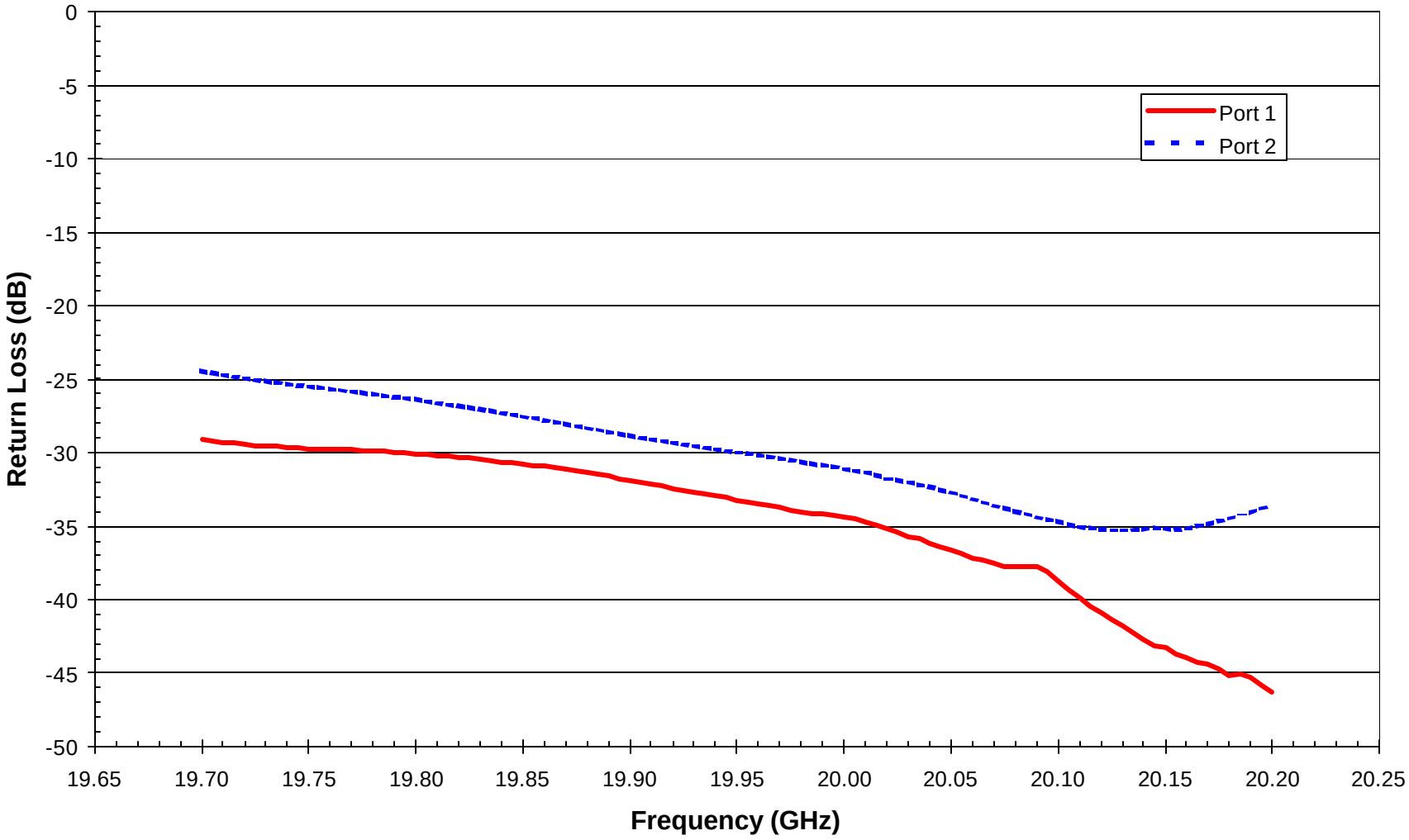
Load Assembly



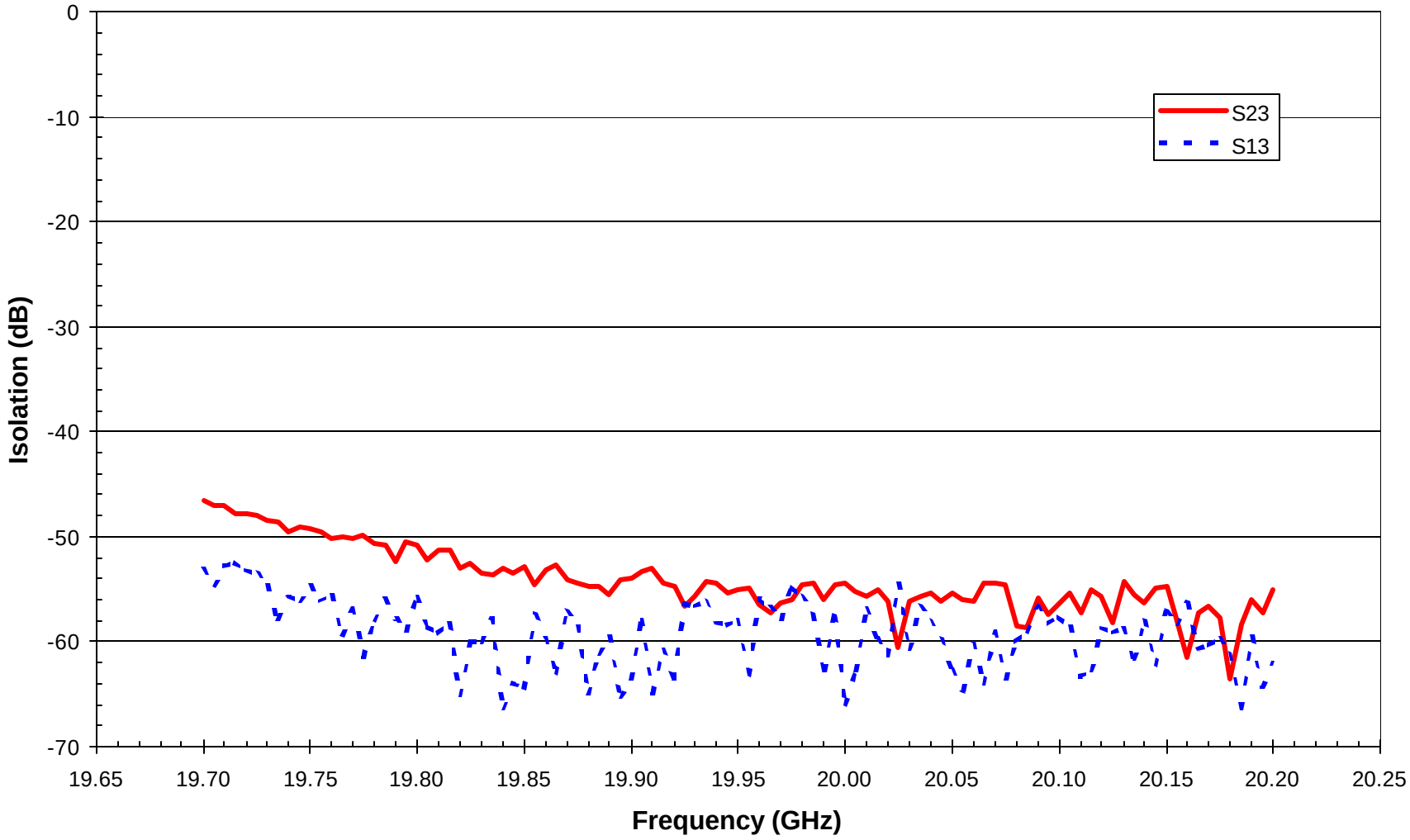
Measured Input Return Loss



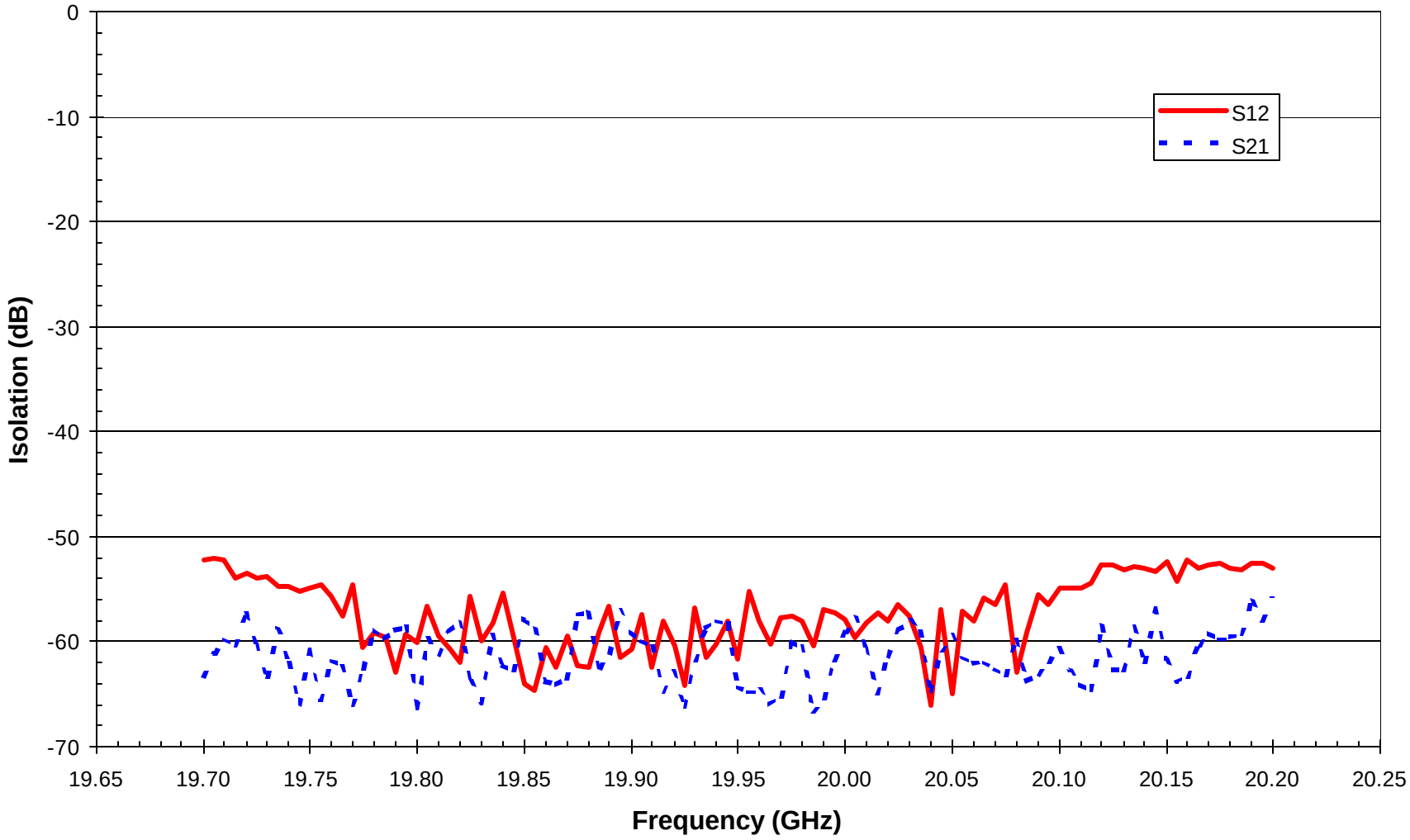
Measured Output Return Loss



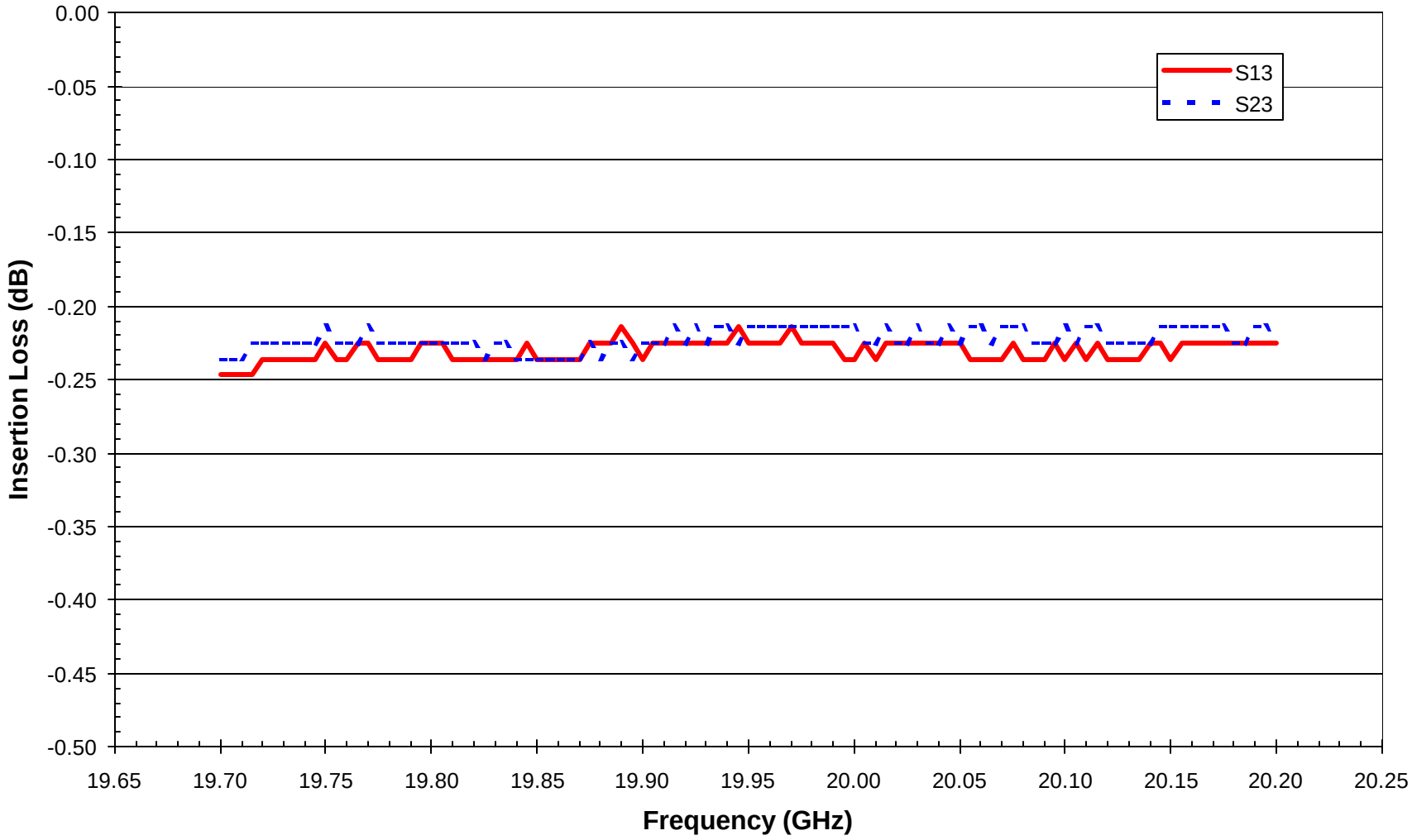
Measured Input-to-Output Isolation



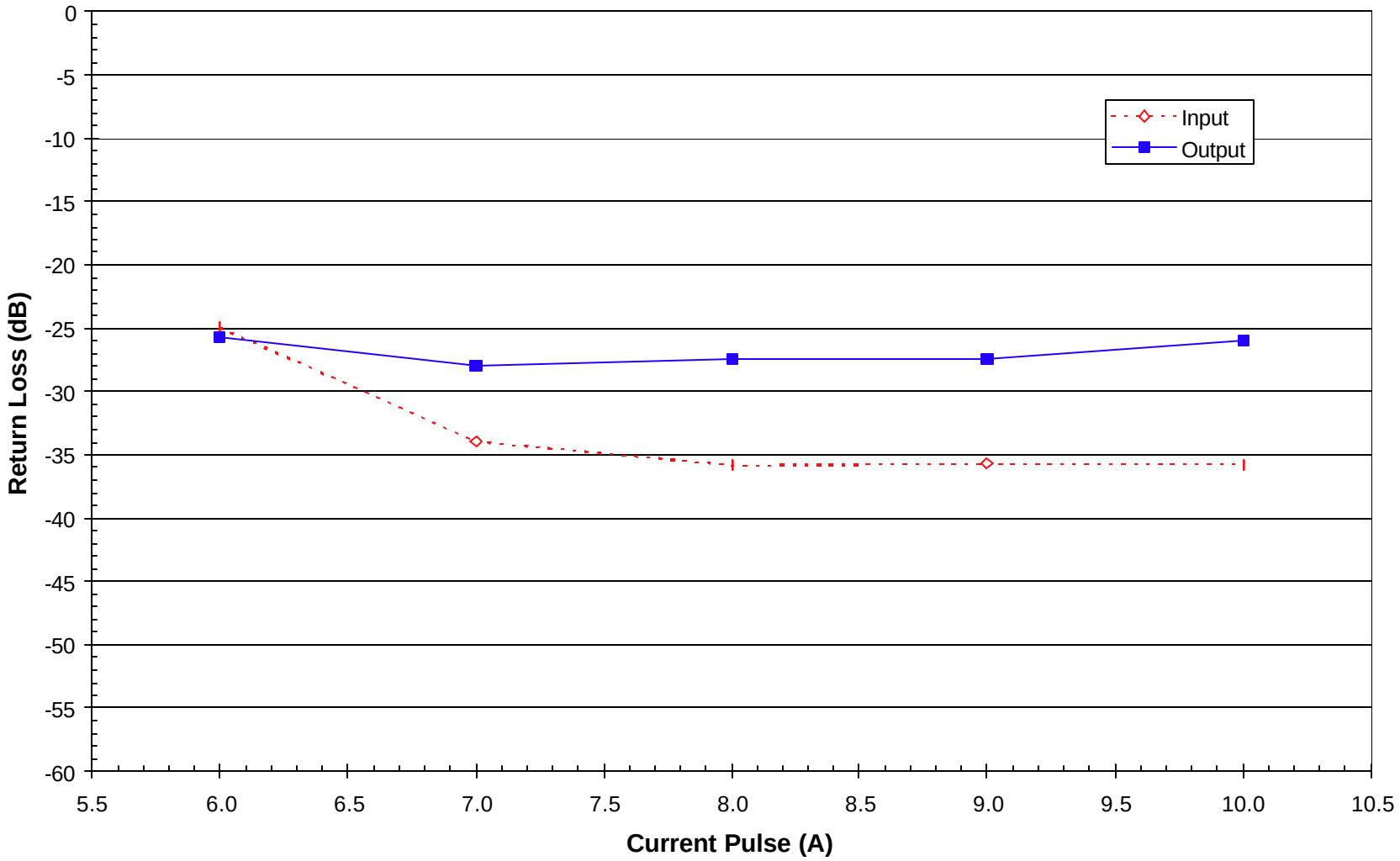
Measured Output-to-Output Isolation



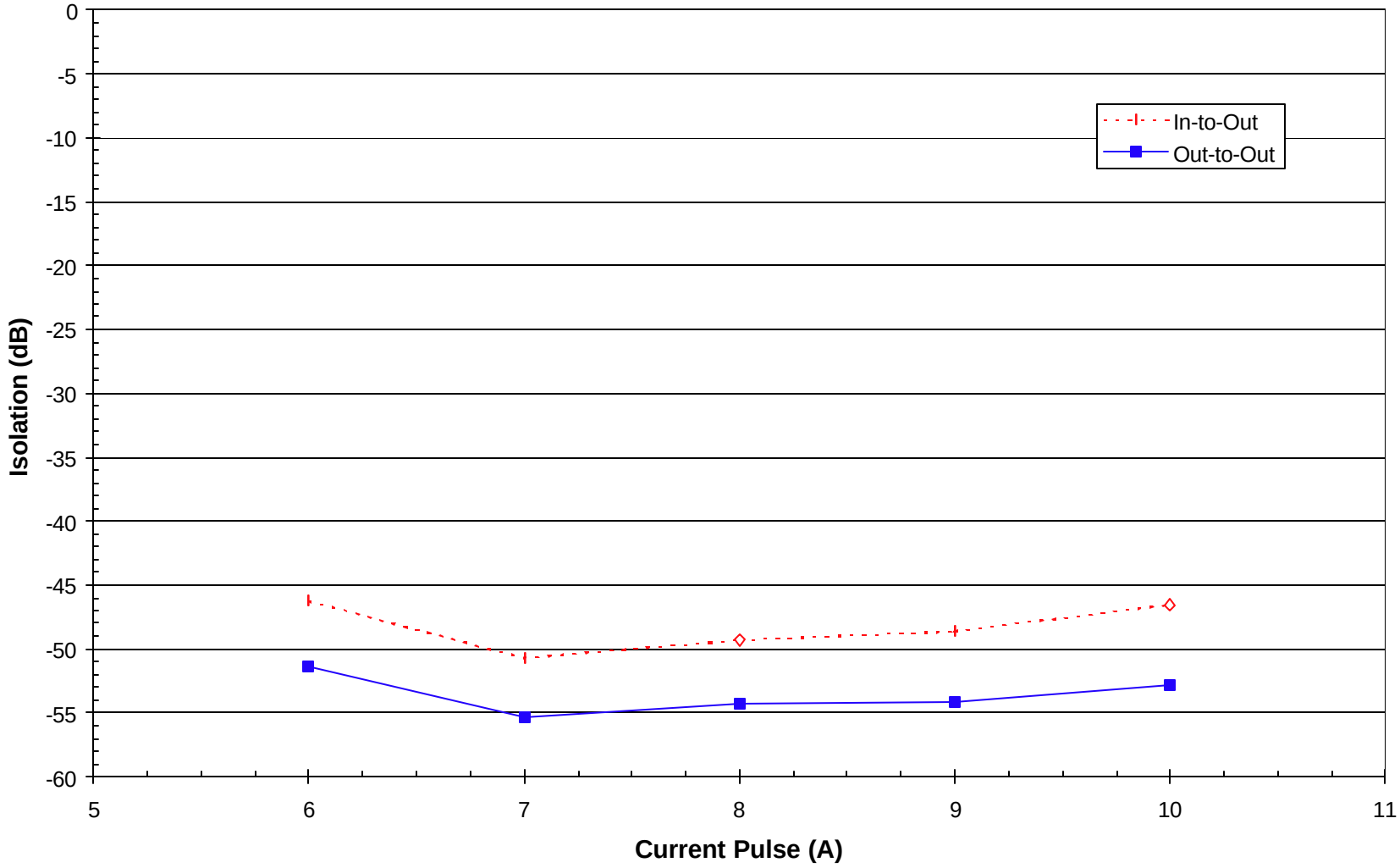
Measured Insertion Loss



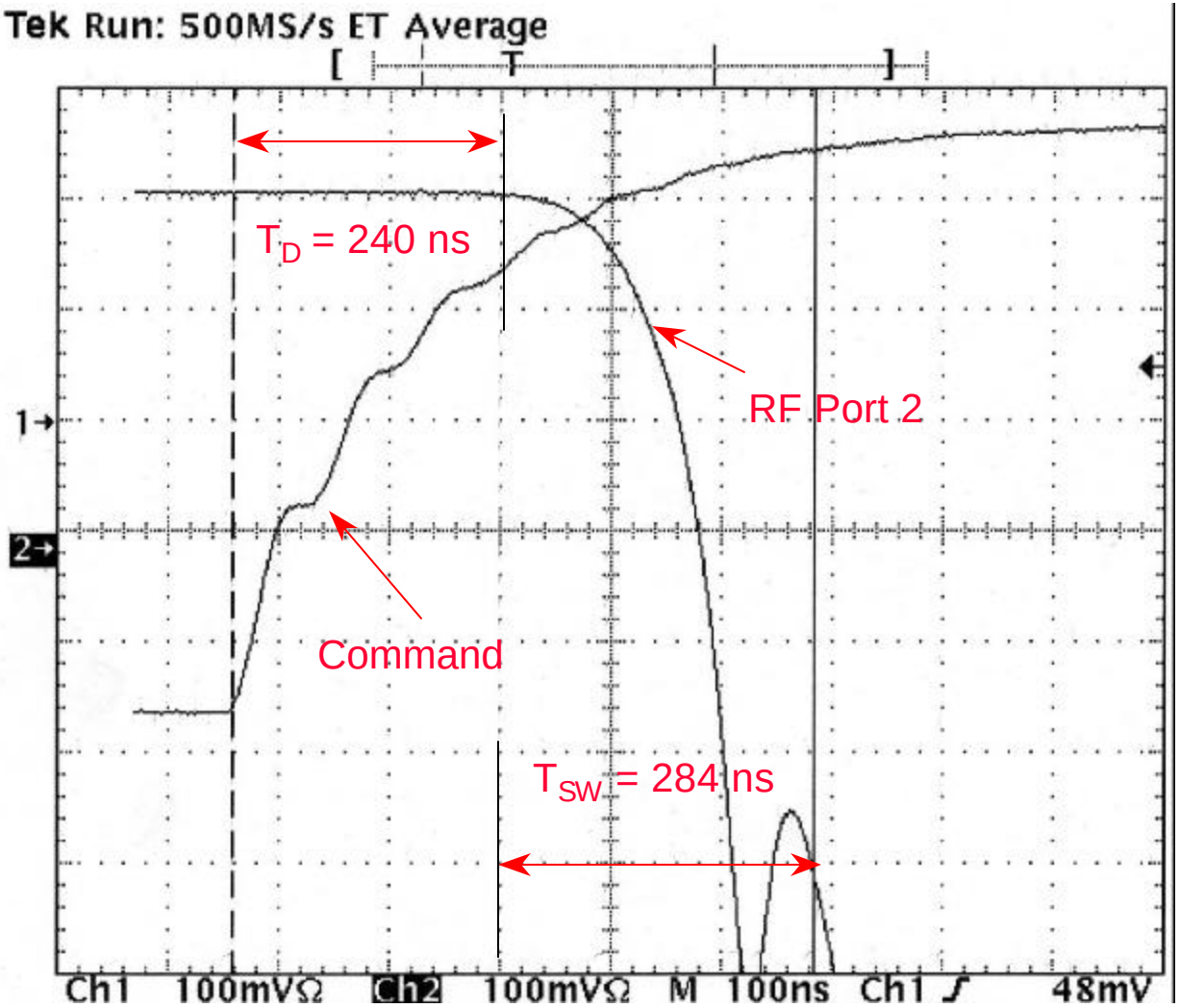
Measured Return Loss vs. Current Pulse



Measured Isolation vs. Current Pulse



Measured Switching Time



-40 dB

High Power Test Results

- Baseplate temperature: 71 °C
- Pressure: < 1x 10^{-5} Torr
- Input Power: 135 W
- Durations:
  - 1 hour with port 1 selected
  - 1 hour with port 2 selected
  - 2 hours switching at 14 kHz
- Insertion loss increased ~ 0.05 dB at high power
- Post high power RF performance was compliant
- Post high power inspection showed no damage

Multipactor Analysis

- **Methodology**
  - **“Investigations into Multipactor Breakdown in Satellite Microwave Payloads”**
  - **A. Woode & J. Petit**
  - **ESA Journal, 1990, Vol. 14**
- **Results**
  - **12.11 dB Margin for 135 W input**

Summary & Conclusions

- **A ferrite switch triad capable of handling 135 W CW in vacuum and switching in less than 350 ns has been built and tested**
- **The unit features a compact housing and an integral high power load, compatible with space flight requirements for low mass and small size**
- **The overall performance capabilities of this switch triad meet the requirements for the downlink hopping spot beam antennas of next generation Ka-band data communications satellites.**