MM4250

POWERED BY ideal switch®

DC to 10 GHz SP6T Cryogenic RF Switch Module

Product Overview

Description

Menlo Micro's MM4250 is a DC to 10 GHz SP6T RF switch module designed for cryogenic applications. Built with Ideal Switch® technology, it offers reliable, low power switching in a compact form factor suitable for ultra-low temperatures.

The switch uses electrostatic actuation, consuming less than 1 microwatt—minimizing heat generation and enabling faster testing compared to electromechanical relays.

It includes built-in calibration standards (OSL), preserving RF channels for measurements. Its low energy use, integrated calibration, and compact design make it ideal for cryogenic & quantum computing applications.

Features

- RF switching to 10mK
- Extremely low actuation power eliminates joule heating
- Tight channel-to-channel matching: < 2 ps
- Built-in internal RF calibration standards
- Low actuation energy, no impact on sensitive electronics
- External USB High Voltage (HiV) Driver board available

- DC to 10 GHz Frequency Range
- On-State Insertion Loss: 4 dB @ 10 GHz
- Off-State Isolation: 40 dB @ 10 GHz
- 25 ms switching time
- High Reliability > 1.0 x 10^9 Switching Operations

- All brass construction, Au-plated finish
- 6 x SMA connectors, standard 4-hole mounting plate
- Micro-D Female 25P control interface
- 4.5 cm x 4.5 cm x 3.6 cm dimensions

Markets

- Quantum Computing
- Cryogenic Device Characterization

Electrical Specifications

Operating Characteristics

Exceeding the maximum ratings as listed in Table 1 below may reduce the reliability of the device or cause permanent damage. Operation of the MM4250 should be restricted to the limits indicated in Table 3.

Electrostatic Discharge (ESD) Safeguards

The MM4250 is a Class 0 ESD device. When handling the MM4250, observe precautions as with any other ESD sensitive device. Do not exceed the voltage ratings specified in Table 1.

Table 1. Absolute Maximum Ratings[1]

Parameter	Minimum	Maximum	Unit
RF1-RF6 / RFC Connector Voltage (Open State)[2]	-150	150	V
Micro-D Connector Pin / Control Voltage[2]	-150	150	V
Closed State Voltage Micro-D Pins to RF1-RF6, RFC, GND[2]	-100	100	V
Hot Switching Voltage[3]	-0.5	0.5	V

Notes:

1. All parameters must be within recommended operating conditions.
2. This also applies to ESD events. This is a Class 0 device.
3. See section Hot Switch Restrictions for more information.

Table 2. Recommended Operating Conditions

Parameter	Minimum	Typical	Maximum	Unit
Micro-D Connector Pin Voltage (VBB)	87	89	91	V_{DC}
Micro-D Connector Pin Current	—	2	—	nA
Operating Temperature Range	0.01	—	295	K
Closed State Carry Voltage	-5	—	+5	V
USB On/Off Switching Time[1]	—	25	—	ms

Notes:

1. The specified USB switching time is an estimate of the time from issuing a single software command via USB to the switch state changing. The host computer's CPU processing and USB physical layer play a significant factor in switching time.

Electrical Characteristics

All specifications valid over full supply voltage and characterized at room temperature (295K) unless otherwise noted. Refer to Cryogenic Temperature Measurements for typical performance over temperature.

Table 3. DC and AC Electrical Specifications

Parameter	Minimum	Typical	Maximum	Unit
Operating Frequency Range	DC	—	10	GHz
CW Power @ 6 GHz	—	—	5	W
Insertion Loss @ 10 GHz	—	4	—	dB
RFC Return Loss @ 10 GHz	—	7	—	dB
Isolation @ 10 GHz	—	40	—	dB
Channel to Channel Isolation @ 10 GHz[1]	—	40	—	dB
On/Off Switch Operations[2]	—	1×10^9	—	Cycles
On-State Resistance (R_{ON})	—	2.4	—	Ω
Channel to Channel Delay	—	2	—	Δps

Notes:

1. Measured RF1 to Channel Isolation with RF1 ON.
2. Measured at room temperature (295K) at 1 kHz cycling rate.

Hot Switch Restrictions

The MM4250 is not intended for hot switching applications and care should be taken to ensure that switching occurs at less than 0.5V. If the MM4250 is used in hot switching applications, the number of cycling operations of the device will be degraded.

Functional Block Diagram

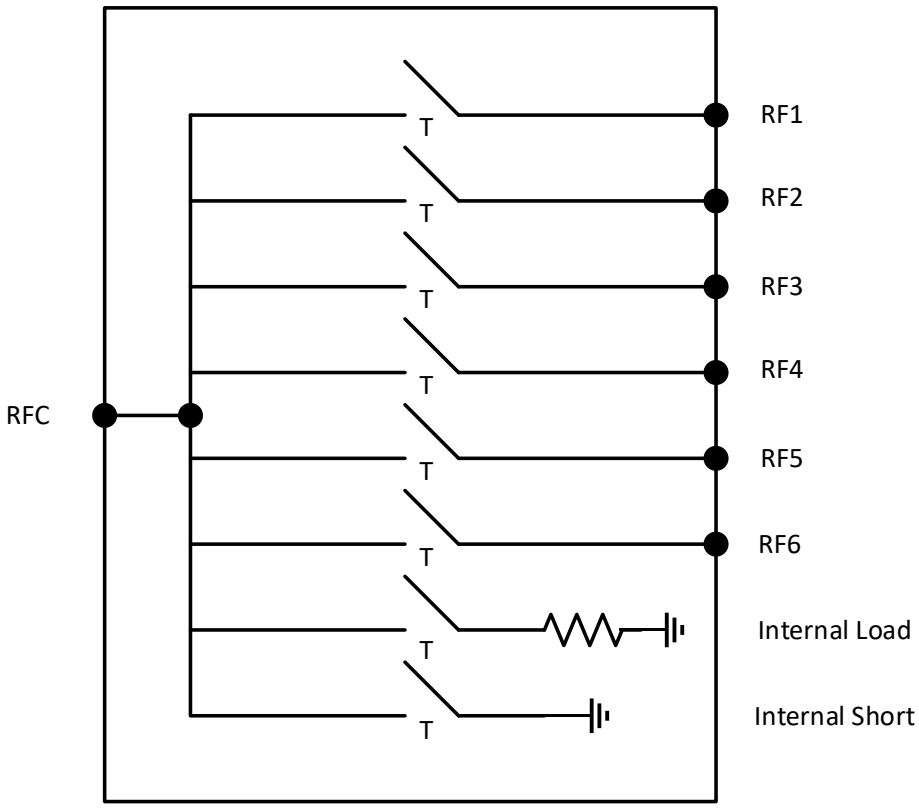


Figure 1. SP6T Block Diagram with Internal Calibration Standards

Pinout Information

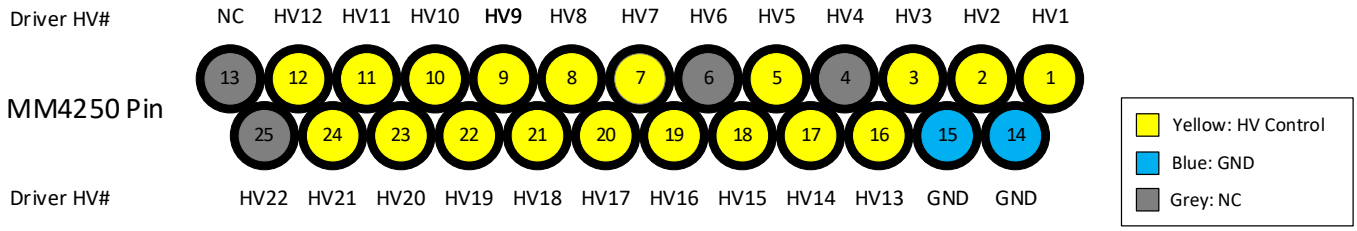


Figure 2. MM4250 Micro-D Female 25pin Connector Pinout (facing connector)

Table 4. Detailed Micro-D Pin Description

Pin Name	Micro-D Female Pin #	Description
GND	14,15	RF Ground
HV#	1,2,3,5,7,8,9,10,11,12,16,17,18,19,20,21,22,23,24	+89V High Voltage Channel Control
HV4, HV6, HV25	4,6,25	Unused HV pins (no connect)
NC	13	No Connect

Applied HV Control vs. RF Switch States

Table 5. RF Switch States Active HV Control Pin Summary

Switch State	Active VBB	
	MM4250 Micro-D Pins	Driver HV#
All Open	None	None
RFC-RF1	3,17,22,24	HV3,HV14,HV19,HV21
RFC-RF2	3,7,16,22	HV3,HV7,HV13,HV19
RFC-RF3	2,8,9,20	HV2,HV8,HV9,HV17
RFC-RF4	2,8,10,19	HV2,HV8,HV10,HV16
RFC-RF5	2,8,11,21	HV2,HV8,HV11,HV18
RFC-RF6	3,18,22,23	HV3,HV15,HV19,HV20
Internal Load	1	HV1
Internal Short	12	HV12

RF Performance

Room Temperature Measurements

Typical device performance measured on MM4250 at 295K, all results are de-embedded.

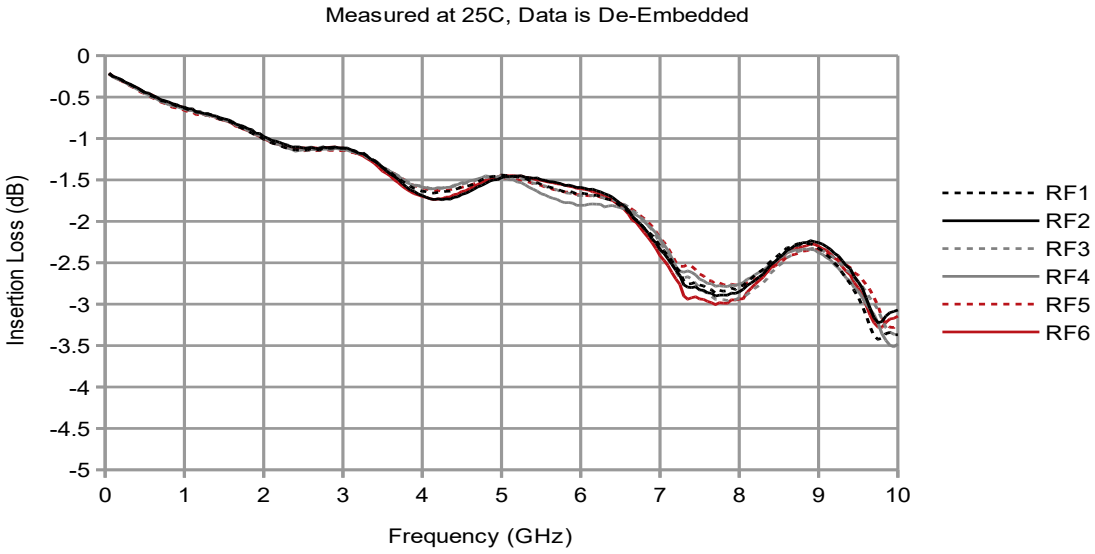


Figure 3. Insertion Loss / S21

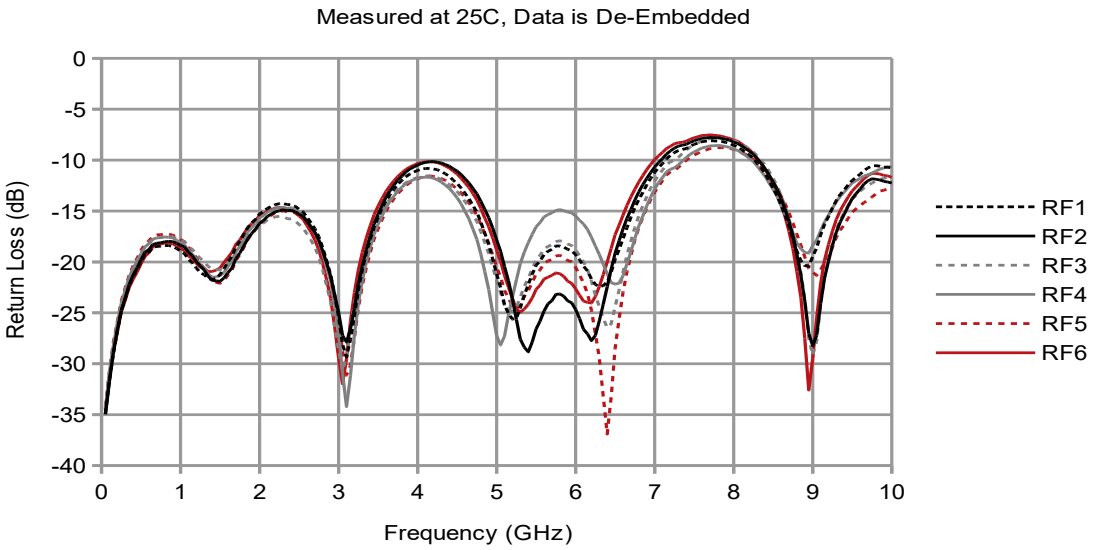


Figure 4. Return Loss / S11

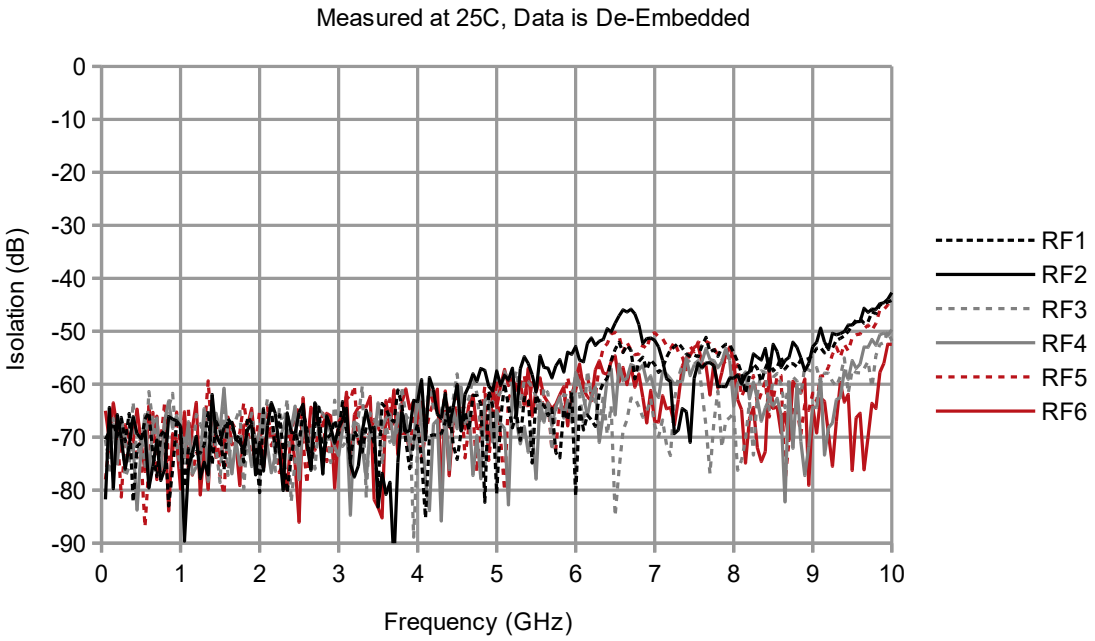


Figure 5. Off-State Isolation / S21

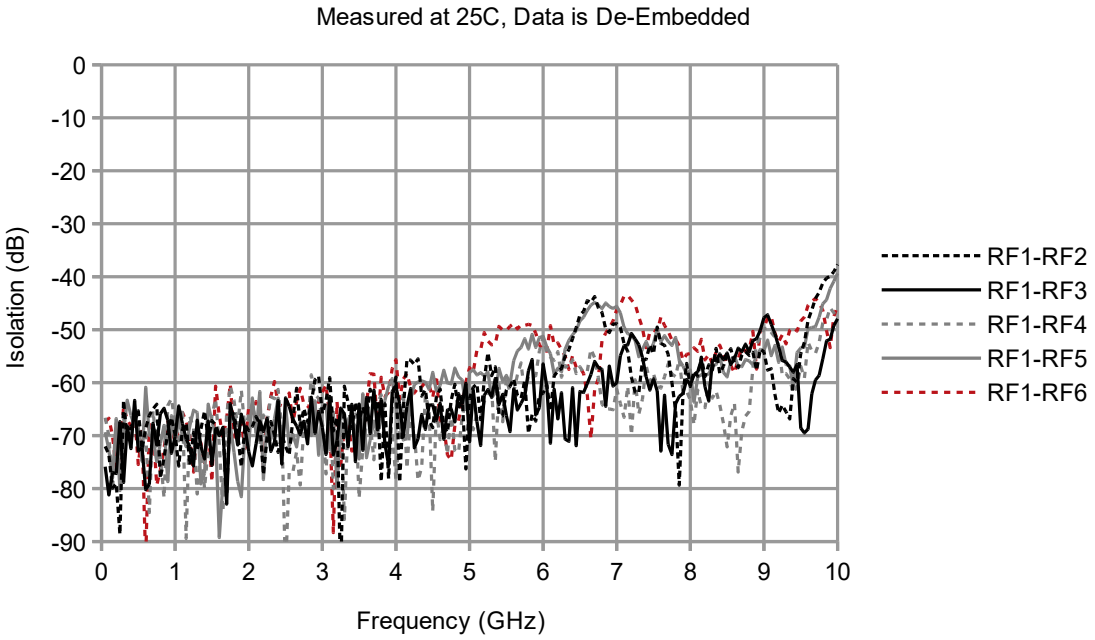


Figure 6. RF1 to Channel Isolation with RF1 ON / S21

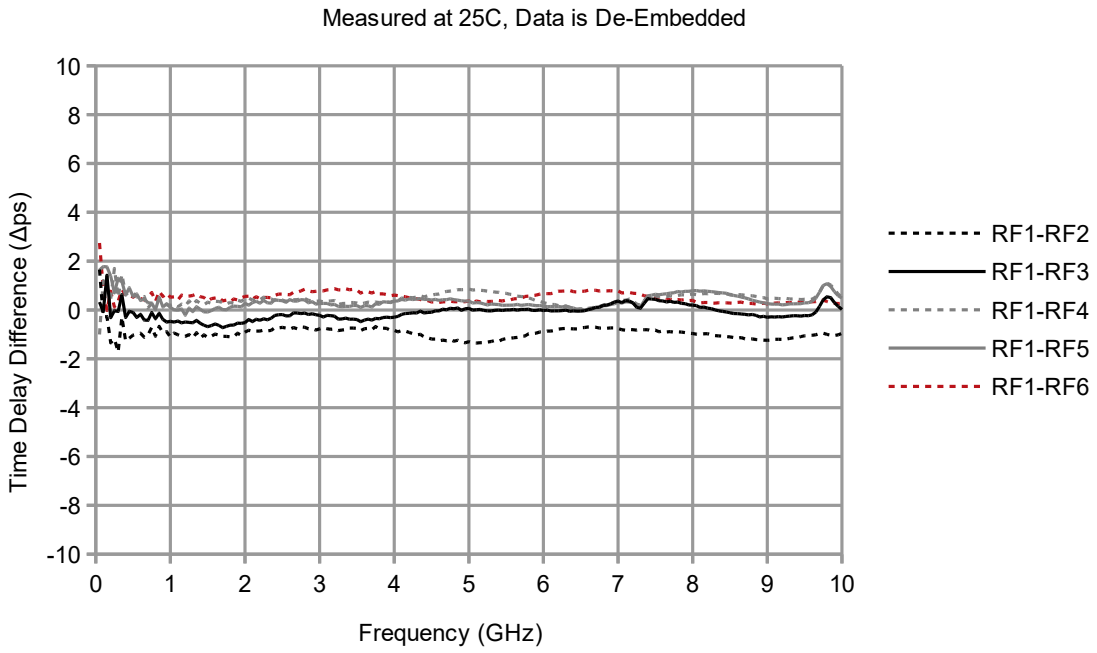


Figure 7. Time Delay Matching from RF1

Cryogenic Temperature Measurements

Data presented for cryogenic temperature measurements come from the following paper. The paper and full set of characterization data can be downloaded from the following location:

Link will be added after publication.

L. F. Spietz, C. Giovanniello, B. Takaki, W. Ye, B. Boiko, C. Long, N. E. Flowers-Jacobs, A. J. Sirois, P. F. Hopkins, S. P. Benz, and D. Williams, *"Cryogenic RF MEMS Switch with Electronic Calibration Capability,"* in preparation for submission to IEEE Journal of Microwaves, 2025.

Typical device performance measured on MM4250 at 295K and 3K, all results are de-embedded.

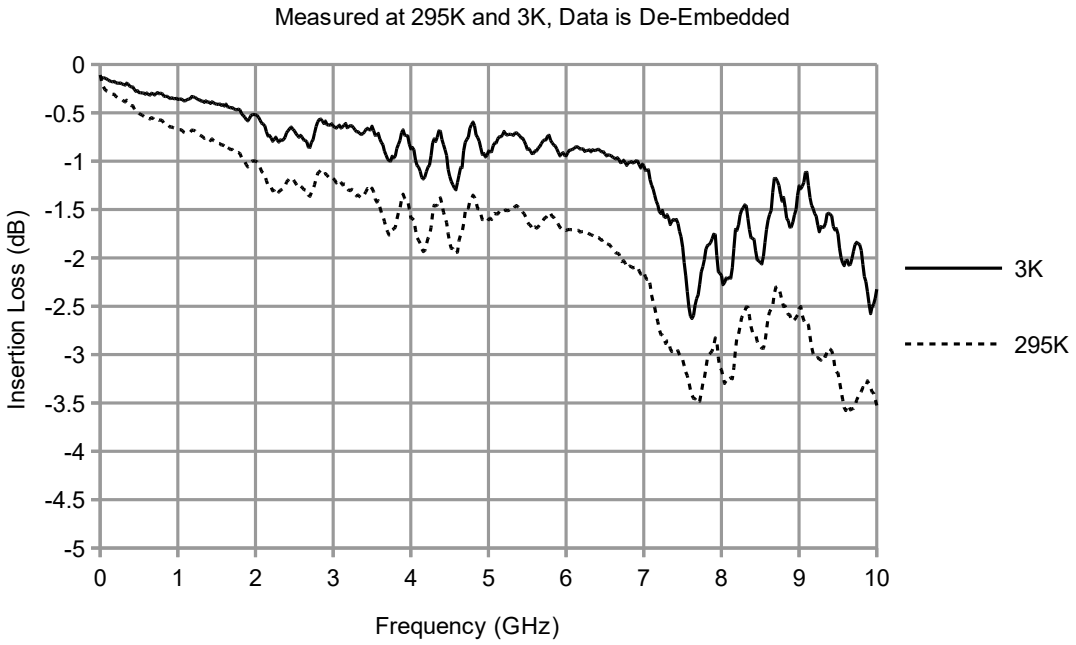


Figure 8. Insertion Loss / S21 vs. Temperature

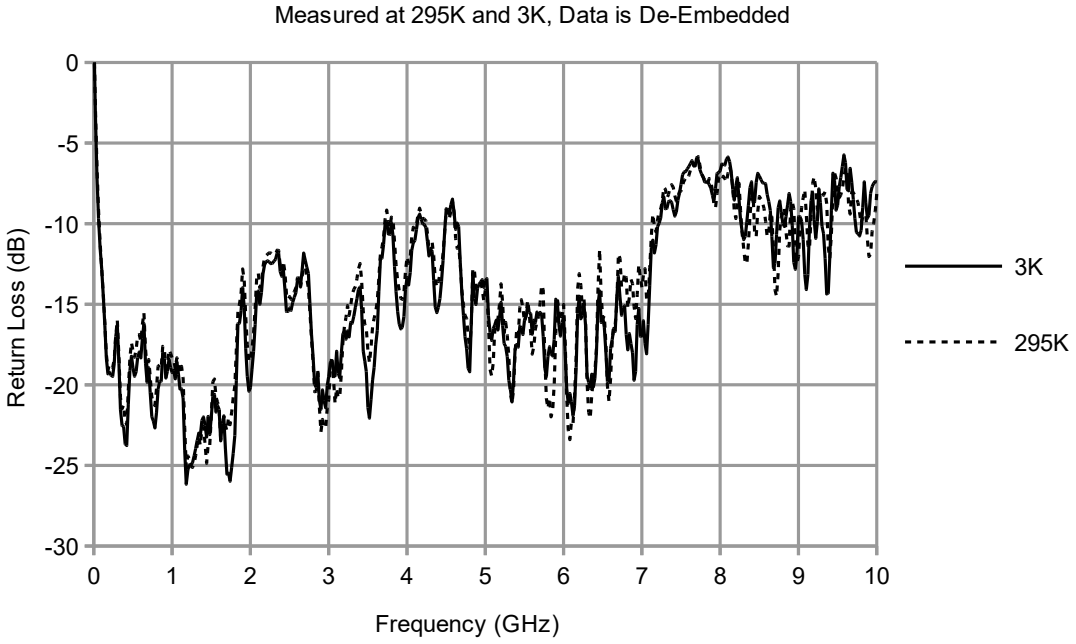


Figure 9. Return Loss / S11 vs. Temperature

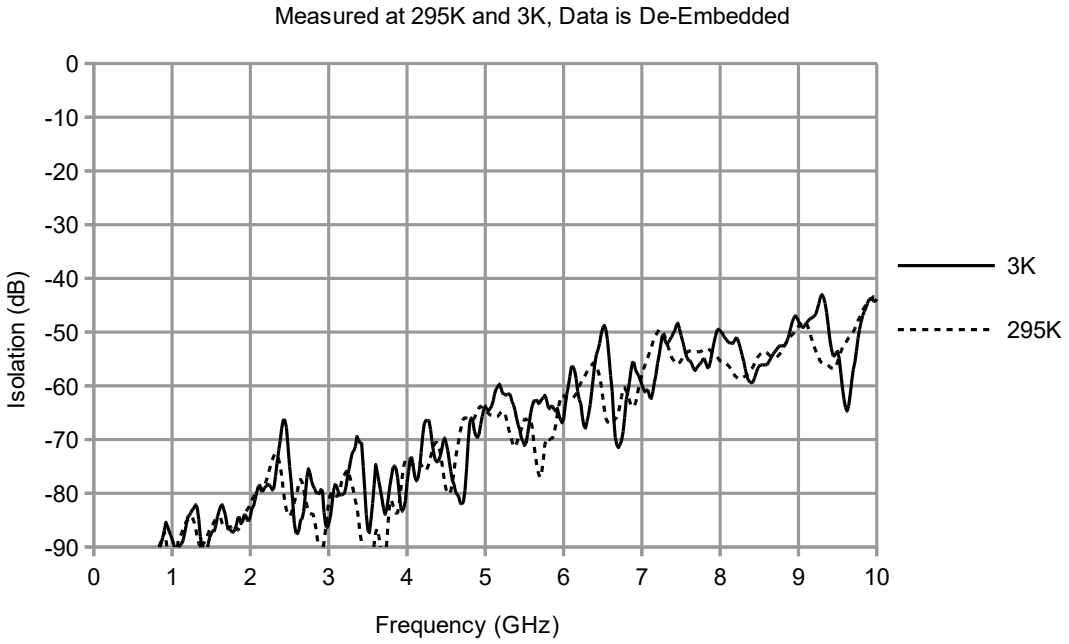


Figure 10. Off-State Isolation / S21 vs. Temperature

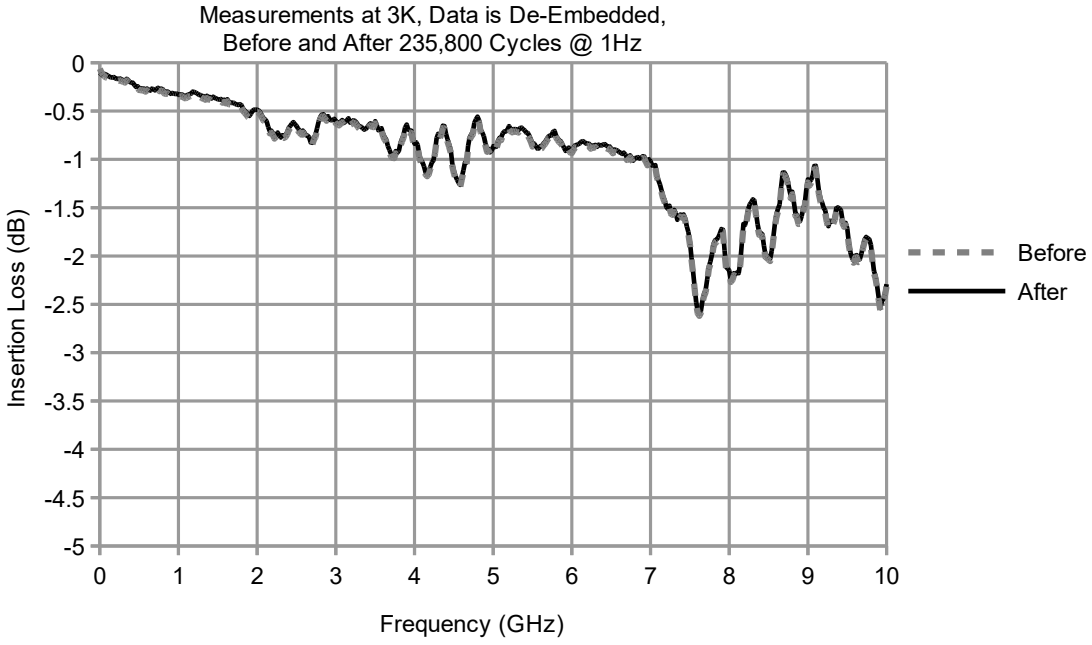


Figure 11. Insertion Loss / S21 Before and After Cycling

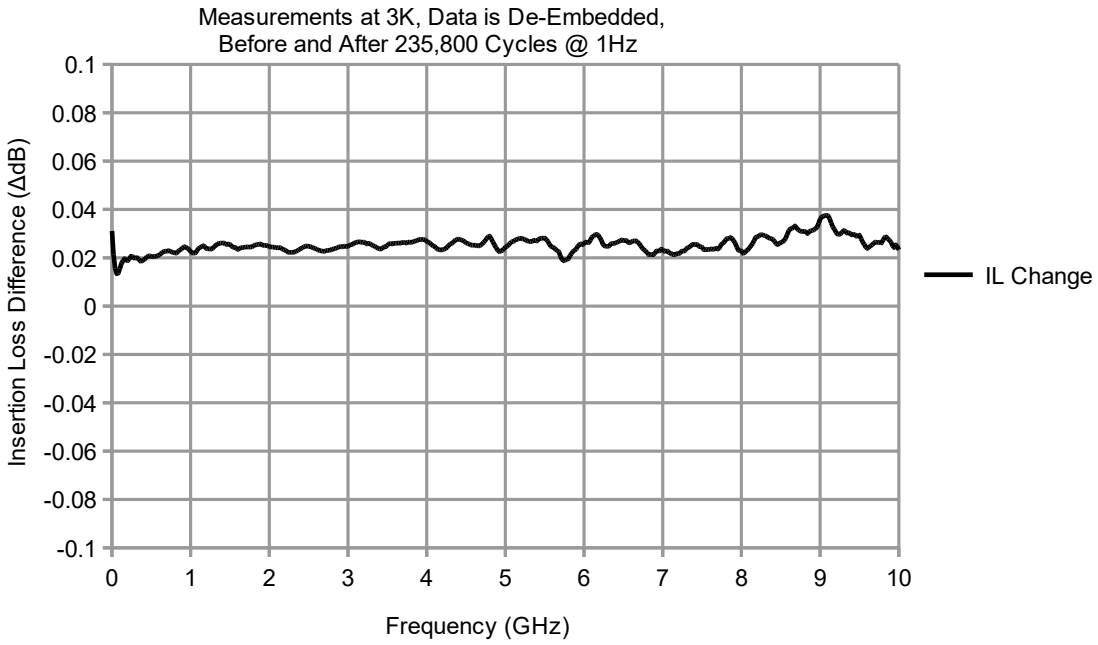


Figure 12. Insertion Loss / S21 Difference After Cycling

Includes any VNA measurement drift after ~65 hours.

Table 6. DC and AC Electrical Specifications at 3K

Parameter	Minimum	Typical	Maximum	Unit
On-State Resistance (R_{ON})	—	1.2	—	Ω

Package Drawing

Not available yet.

Figure 13. Package Drawing

Package Marking Information

Line 1 = Menlo Micro branding
Line 2 = ideal switch® branding
Line 3 = Human-readable serial number

Figure 14. Package Marking Drawing

Package Options and Ordering Information

Part Number	Package Description	Device Marking[1]
MM4250-ENG	ENGINEERING SAMPLES: MM4250 SP6T RF Switch Module for cryogenic applications - DC-10GHz	Serial No. xxxx
MM4250-KIT1-ENG	ENGINEERING SAMPLES: MM4250 Starter Kit: (2) SP6T RF Switch Module for cryogenic applications - DC-10GHz (1) USB HiV Driver board (1) Micro-D 25P, Male to Female Cable Assembly	Serial No. xxxx

Notes:

1. Additional markings may be present, including logos. Note that 'x' is a placeholder for a 4-digit numerical code.

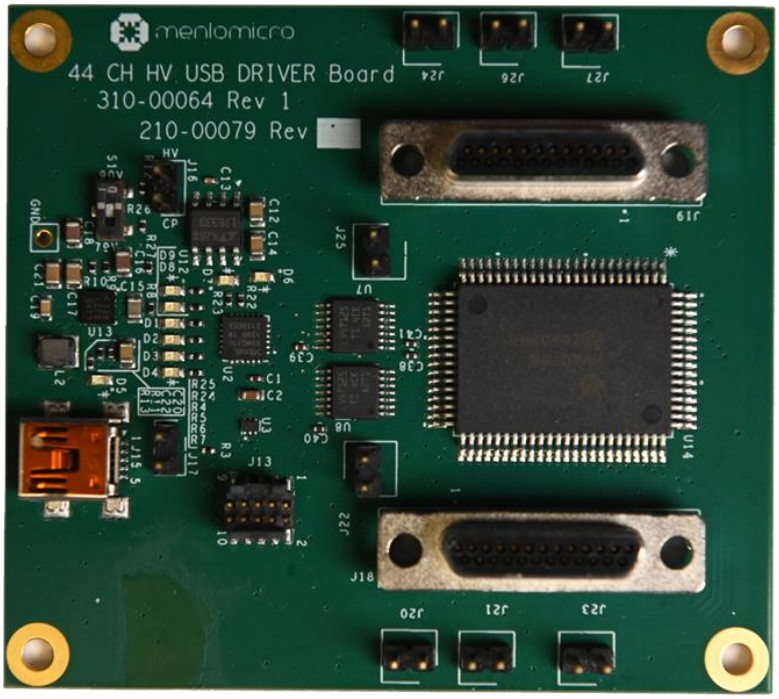
USB HiV Driver Board

The MM4250 SP6T device requires 90V to be supplied to the Micro-D connector pins to actuate the channels of the device. See Applied HV Control vs. RF Switch States.

Purchase of MM4250-KIT1-ENG comes with a USB HiV driver board for controlling one or multiple MM4250 devices. By connecting the driver board to a computer via USB, the user can control one or both Micro-D Male 25p connectors to be able to synchronously control one or two MM4250s at once.

The USB Driver Board can be controlled with an installable PC application or directly programmed with HID in any common programming language. For a how to use the USB HiV Driver Board, see “MM4250 Driver Board Instructions” in the Menlo Support Portal. The application and programming package are also available for download on the portal.

On our website, www.menlomicro.com, click the login button on the top right corner. There is an option to "Request Access". In the comments, note interest in “MM4250 Driver Board Instructions”. Accounts are approved within 24 hours. After logging into the portal, navigate to MM4250 → Evaluation Kits. The instructions should be listed and downloadable.



Built-in Internal Calibration Standards

Application notes for utilizing MM4250 built-in internal RF calibration standards are currently in development. Please contact Menlo Micro to be notified when information is released.

Important Information

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Contact Information

Please contact Menlo Micro for the latest specifications, additional product information, test and evaluation boards, product samples, worldwide sales and distribution locations:

Internet: www.menlomicro.com
E-mail: sales@menlomicro.com

For product technical questions and application information: support@menlomicro.com.

