MM5130-03NLX

DC to 26 GHz High Power Standoff RF Switch

RoHS COMPLIANT

Product Overview

Description

The MM5130-03NLX device is a high-power and wide frequency range SP3T micro-mechanical switch. Menlo Micro has developed a new Ideal Switch® fabrication process and applied it to DC and wideband RF/microwave switch applications. This innovative technology enables highly reliable switches capable of 25 W power handling. The MM5130-03NLX provides ultra-low insertion loss and superior linearity as an SP3T from DC to 26 GHz, and greater than 3 billion switching cycles.

The MM5130-03NLX is configured in Super-Port mode which extends the frequency operation to 26 GHz. The MM5130 is an ideal solution for replacing large RF electromechanical relays, as well as RF/microwave solid-state switches in applications where linearity and insertion loss are critical parameters. The switch channels are individually controllable by applying gate voltage to the corresponding RF GATE pin.

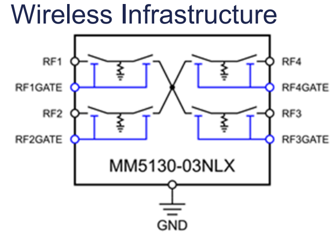
The MM5130-03NLX is tested for high power standoff (open switch) at 3 GHz to a level of 56.8 dBm; refer to Table 2 for test details.

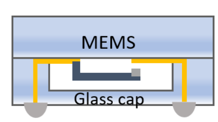
Features

- DC to 26 GHz Frequency Range
- Enhanced temperature stability
- 25 W CW up to 6 GHz power handling
- 17 W (CW) at 10 GHz, >150 W (Pulsed) Max Power Handling
- 480 W standoff Pulsed into Open switch in 50 ohm system (450V peak)
- Low On-State Insertion Loss: 0.3 dB @ 6.0 GHz
- High Linearity, IIP3 95 dBm Typical
- 45 dB Isolation @ 6.0 GHz
- High Reliability > 3.0 x 10^9 Switching Operations
- 2.5 mm x 2.5 mm WLCSP Package

Markets

- Defense and Aerospace
- Medical Equipment
- Test and Measurement
- Wireless Infrastructure





Applications

- Switched Filter Banks and Tunable Filters
- High Power RF Front Ends
- Antenna Tuning
- Low-Loss Switch Matrices & EM Relay Replacement

Electrical Specifications

Operating Characteristics

Absolute Maximum Ratings

Exceeding the maximum ratings as listed in Table 1 below may reduce the reliability of the device or cause permanent damage. Operation of the MM5130 should be restricted to the limits indicated in Table 2.

Electrostatic Discharge (ESD) Safeguards

The MM5130 is a Class 0 ESD device. When handling the MM5130, 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
Open State Voltage Rating / Switch RF1-4 to RFC[2]	-150	150	V
Open State Voltage RF1-RF4, GATE pin to GND Potential[2,3]	-150	150	V
Closed State Voltage GATE Pins to RF1-RF4, GND[2]	-100	100	V
Hot Switching Voltage[4]	-0.5	0.5	V
DC Current Rating/Switch[5]	—	500	mA
Operating Temperature Range	-40	+85	ºC
Storage Temperature Range[6]	-65	+150	ºC
Mechanical Shock[7]	—	500	G
Vibration[8]	—	3.1	Grms

Notes:

1. All parameters must be within recommended operating conditions. Maximum DC and RF power can only be applied during the on-state condition (cold-switched condition).
2. This also applies to ESD events. This is a Class 0 device.
3. RF pins must not be allowed to electrically float during switch operation. See section Floating Node Restrictions for details on avoiding floating nodes.
4. See section Hot Switch Restrictions for more information.
5. Total current of all channels combined.
6. See section Storage and Shelf Life more information on shelf and floor life.
7. See JESD22-B104 for mechanical shock test methodology at 1.0ms, half-sine, 5 shocks/axis, 6 axis.
8. See JESD22-B103 for vibration test methodology at 3.1G and 30min/cycle, 1 cycle/axis, 3 axis.

Electrical Characteristics

All specifications valid over full supply voltage and operating temperature range unless otherwise noted.

Table 2. DC and AC Electrical Specifications

Parameter	Minimum	Typical	Maximum	Unit
Operating Frequency Range				
Super-Port Mode	DC	—	26	GHz
CW Power @ 6 GHz[1]	—	—	25	W
Peak Power @ 6 GHz[2]	—	—	150	W
Standoff Power (Switch Open) Peak Power[11]				
At 3 GHz, 51 µs pulse width, 1.5% duty cycle	—	—	479	W
Input/Output Return Loss				
Super-Port mode @ 6 GHz	—	15	—	dB
Super-Port mode @ 18 GHz	—	18	—	dB
Super-Port mode @ 26 GHz[3]	—	20	—	dB
Isolation				
Super-Port mode @ 6 GHz	—	45	—	dB
Super-Port mode @ 18 GHz	—	32	—	dB
Super-Port mode @ 26 GHz[3]	—	22	—	dB
Channel to Channel Isolation @ 6 GHz	—	25	—	dB
Third-Order Intercept Point (IP3)[4]	—	95	—	dBm
Second Harmonic (H2)[5]	—	-130	—	dBc
Third Harmonic (H3)[6]	—	-120	—	dBc

Parameter	Minimum	Typical	Maximum	Unit
On/Off Switching and Settling Time				
Turn on time[7]	—	8.5	16	µs
Turn off time	—	2.5	6	µs
Full Cycle Frequency	—	—	10	kHz
On/Off Switch Operations[8] (MM5130-03NDB)				
at 25 ºC	3×10^9	30×10^9	—	Cycles
at 70 ºC	—	1×10^9	—	Cycles
at 85 ºC	—	0.1×10^9	—	Cycles
DC Steady State Carry Current	—		500	mA
Off-State RFIN to RFOUT Leakage Current[9]	—	15	150	nA
On-State Resistance[10] (R_{ON})	—	1.4	3	Ω
Off-State Capacitance (C_{OFF})	—	15	—	fF
Video Feedthrough[10]	—	16	—	mV_{Peak}
Gate Bias Voltage (V_{BB})	87	89	91	V_{DC}
Gate Voltage Slew Rate	20	—	200	V/µs
Gate Bias Current	—	2	10	nA

Notes:

1. Measured at +85ºC.
2. For 10 % Duty Cycle and 100 µs pulse width, measured at +85ºC.
3. Measured on non-adjacent paths, see measured data for details.
4. Measured at +25ºC.
5. Measured at 1.0 GHz and 2.0 GHz fundamental frequency and 35 dBm input power.
6. Measured at 1.0 GHz and 2.0 GHz fundamental frequency and 35 dBm input power.
7. Includes any actuator bounce, settling time to within 0.05dB of final value, and measured with 20 V/us slew rate GATE pin voltage.
8. Measured at 5 kHz cycling rate.
9. Measured with 150 V RFx to 0 V RFC.
10. Performed with 1 MΩ termination.
11. Tested at room temperature in Superport mode RF1-RF3 with >1 µs ramp time, and 5 second test duration. Refer to Standoff Power section.
12. Measured at 0.5 A.

Hot Switch Restrictions

The MM5130 is not intended for hot switching applications and care should be taken to ensure that switching occurs at less than 0.5V. If the MM5130 is used in hot switching applications, the number of cycling operations of the device will be degraded. See section Switch Reliability for more information.

Floating Node Restrictions

RF pins must not be allowed to electrically float during switch operation and therefore require some form of DC path to ground to prevent charge accumulation. DC paths can be an inductor or high value resistance which serves as a discharge path. Floating node examples and recommended solutions are:

- Unconnected RF pins, resistively terminate or tie to ground.
- Series capacitance coupling which floats RF pin, shunt with DC path to ground.
- Series connection of switches together such as in Super-Port mode without DC path to ground, shunt with DC path between switches or use sequenced switching.
- RFC port in Super-Port mode, use sequenced switching.

See Menlo Micro application note ***Avoiding Floating Nodes*** for a detailed explanation of the hazard conditions to avoid and recommend solutions.

Standoff Power

During standoff power screening the device is configured in Superport mode with RF1 as input and RF3 as output. Unused ports are terminated in 50 ohms. The switch is in the OPEN state. The test setup is as shown below and a 51 µs pulse width signal with 1 µs risetime and 1.5% duty cycle. Power is ramped to 56.8 dBm and held for 5 seconds. Figure 1 details the test setup for standoff power.

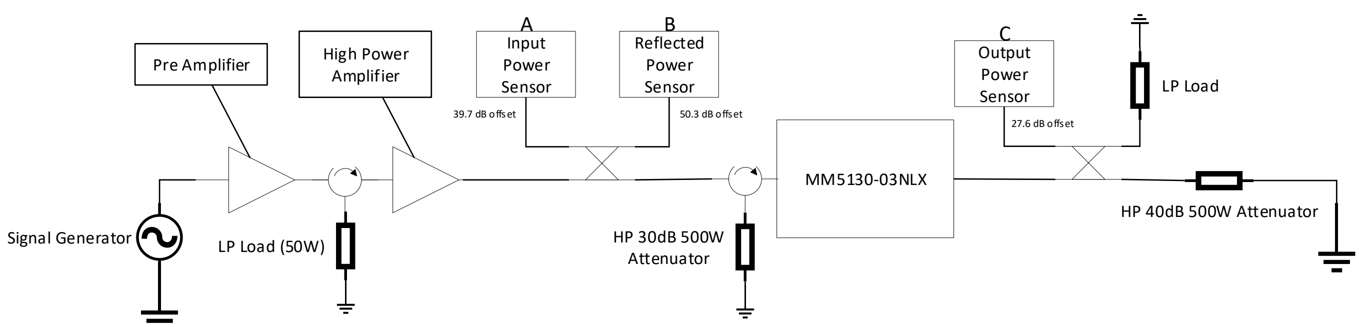


Figure 1. Standoff Power Test Set

- Test program performs low power before and after performance check to ensure switch operation
- Screening performed at 3 GHz. Characterization tests have been performed at 500 MHz, 1 GHz, 2 GHz and over the 2.7-3.6 GHz range.
- Note standoff voltage can be calculated from Input Power.
  - Then $V_{RMS} = \sqrt{(Power*50)}$
  - $Vp=\sqrt{2}*V_{RMS}$
  - And Standoff Voltage $V_{STD} = Vp*2$ (worst case assuming full reflection from open switch)

Thermal and Power Handling Considerations

Under normal low power operating conditions, the MM5130 case temperature mimics the environment temperature. However, during high power operation, the case will heat up due to power dissipation within the device. It is important to keep the device's case temperature below 170 ºC for continued reliable operation. Based on hot environmental temperature of 85 ºC, then an 85 ºC rise is allowable due to power dissipation. This results in a power dissipation limit of 1.13 W within the device. The operating power limit at a given frequency can then be calculated based on the device insertion loss.

Considering an insertion loss of -0.14 dB at 3000 MHz:

Power Handling = Max. Power Dissipation/(1-10^(Insertion Loss/10))

= 1.13/0.032

= 35.6 W

The MM5130 device insertion loss can also be approximated by a third order polynomial:

$$\text{Insertion Loss (dB)} = -1.1\text{E-04}*f^{3} + 1.2\text{E-03}*f^{2} - 0.024*f - 0.076$$

where f is frequency in GHz.

Alternatively, Figure 2 is provided below for the maximum power handling over frequency.

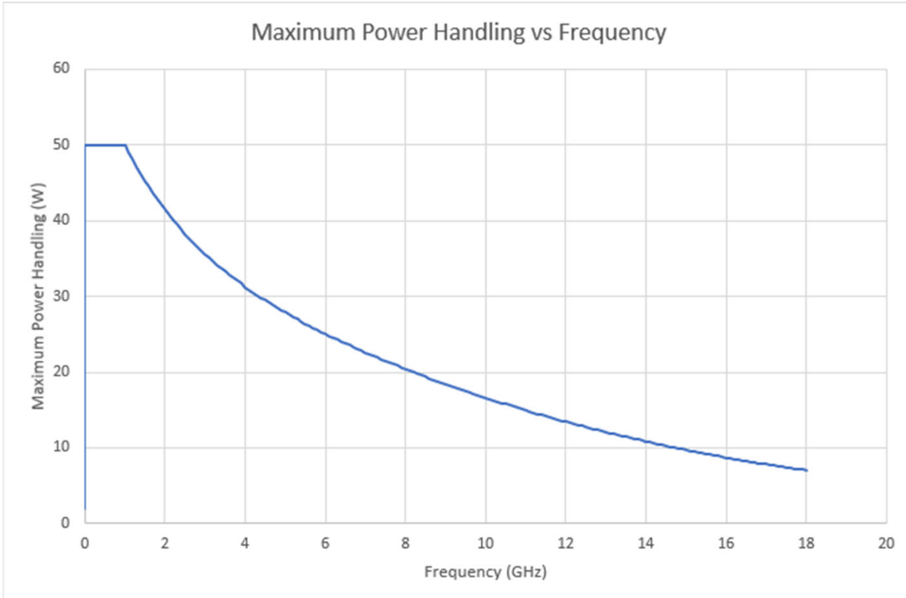


Figure 2. Maximum Power Handling vs. Frequency (1 of 2)

This approach does not hold below 5 MHz, the maximum power handling is shown in Figure for frequencies below 10 MHz.

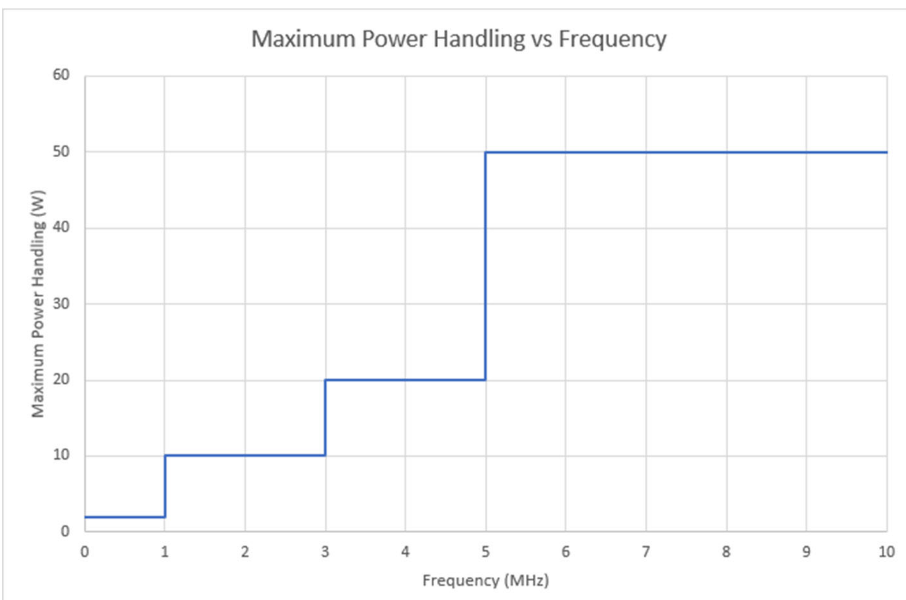


Figure 3. Maximum Power Handling vs. Frequency (2 of 2)

Functional Block Diagram

Super-Port Mode

The MM5130 provides for an alternate connection method which can provide enhanced performance for certain RF parameters. This configuration is called Super-Port. It consists of bypassing the RFC input port and using the remaining 4 channels as a symmetrically oriented SP3T (or SPST or SPDT if preferred). In this manner, any one of the RF1, RF2, RF3, RF4 channels can be connected to any other channel by biasing both desired channels. When operating in Super-Port mode, improvements in RF isolation and return loss can be achieved. Refer to the Recommended PCB Layout section with instructions on how to optimize the PCB layout for Super-Port mode.

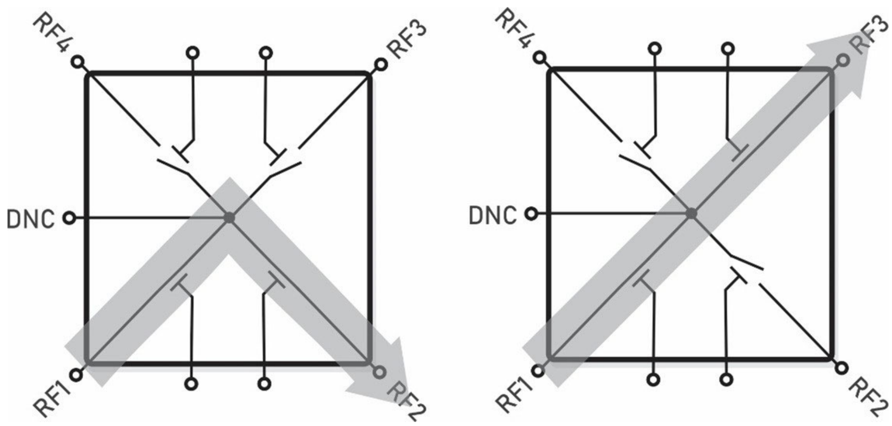


Figure 4. Super-Port Adjacent Path (Left) and Non-adjacent Path (Right)

Package / Pinout Information

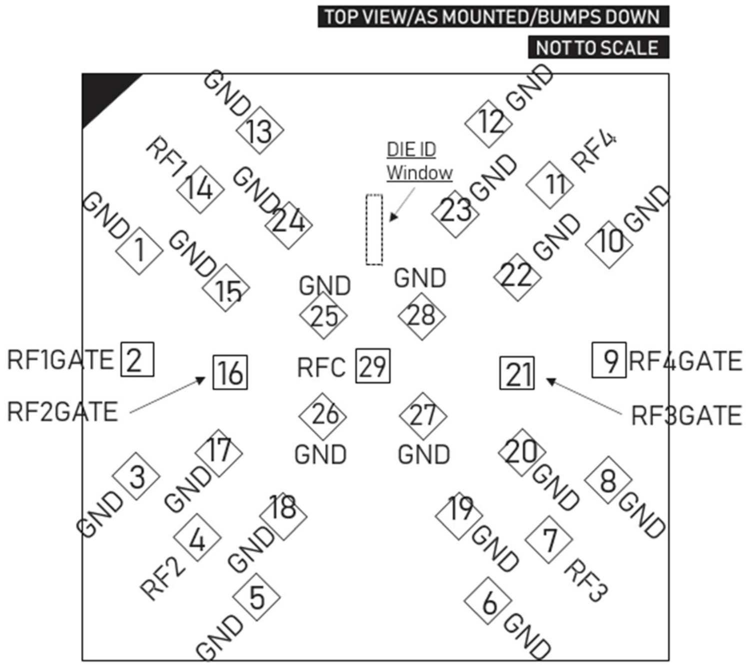


Figure 5. MM5130 2.5 mm x 2.5 mm Pinout

See Table 3 for detailed pin description.

Table 3. Detailed Pin Description

Pin Name	Pin #	Description
GND	1,3,5,6,8,10,12,13,15,17,18,19, 20,22,23,24,25,26,27,28	RF Ground
RF1GATE	2	Control for Switch RF1
RF2GATE	16	Control for Switch RF2
RF2	4	RF Switch 2
RF3	7	RF Switch 3
RF3GATE	21	Control for Switch RF3
RF4GATE	9	Control for Switch RF4
RF4	11	RF Switch 4
RF1	14	RF Switch 1
RFC	29	Do Not Connect

Applied Gate Voltage vs. RF Switch States

Each switch is individually controllable. Primary usage states are highlighted in bold.

Table 4. Applied Gate Voltage vs. RF Switch States (On = Closed, Off = Open)

RF1GATE (V)	RF2GATE (V)	RF3GATE (V)	RF4GATE (V)	RF1-RF2	RF1-RF3	RF1-RF4	RF2-RF3	RF2-RF4	RF3-RF4
VBB	**VBB**	**0**	**0**	**On**	**Off**	**Off**	**Off**	**Off**	**Off**
VBB	**0**	**VBB**	**0**	**Off**	**On**	**Off**	**Off**	**Off**	**Off**
VBB	**0**	**0**	**VBB**	**Off**	**Off**	**On**	**Off**	**Off**	**Off**
0	**VBB**	**VBB**	**0**	**Off**	**Off**	**Off**	**On**	**Off**	**Off**
0	**VBB**	**0**	**VBB**	**Off**	**Off**	**Off**	**Off**	**On**	**Off**
0	**0**	**VBB**	**VBB**	**Off**	**Off**	**Off**	**Off**	**Off**	**On**

Typical Performance Characteristics

RF Performance

Typical device performance measured on evaluation board, de-embedded is shown in Figures 6-8. The devices' superior thermal stability is demonstrated in Figure 9-11. For band-limited applications, the performance may be further improved with narrowband matching techniques

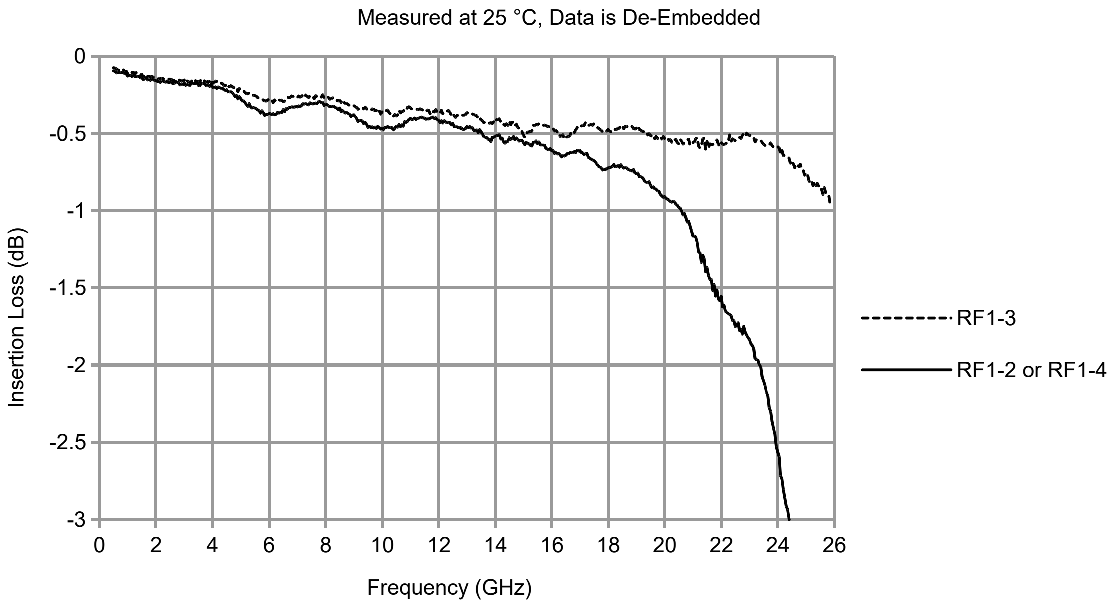


Figure 6. Insertion Loss / S21

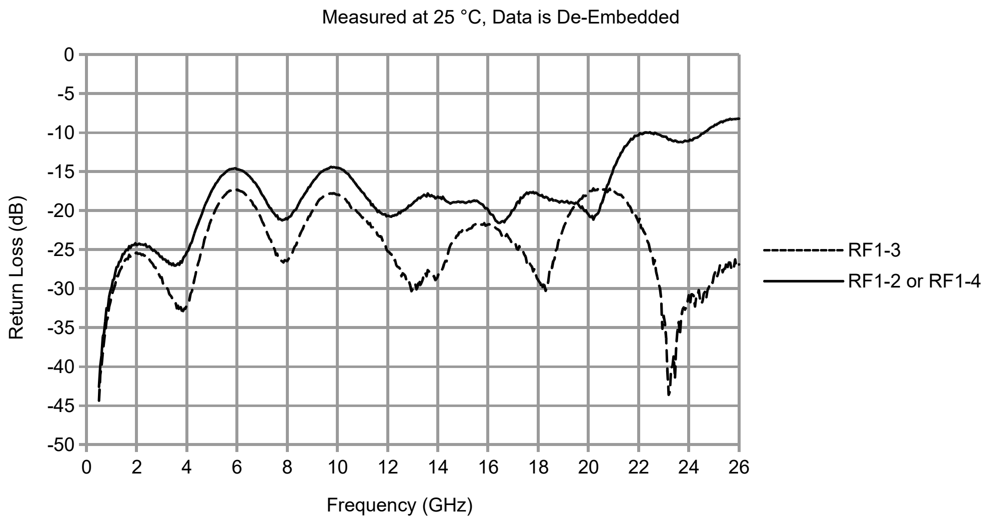


Figure 7. Return Loss / S11

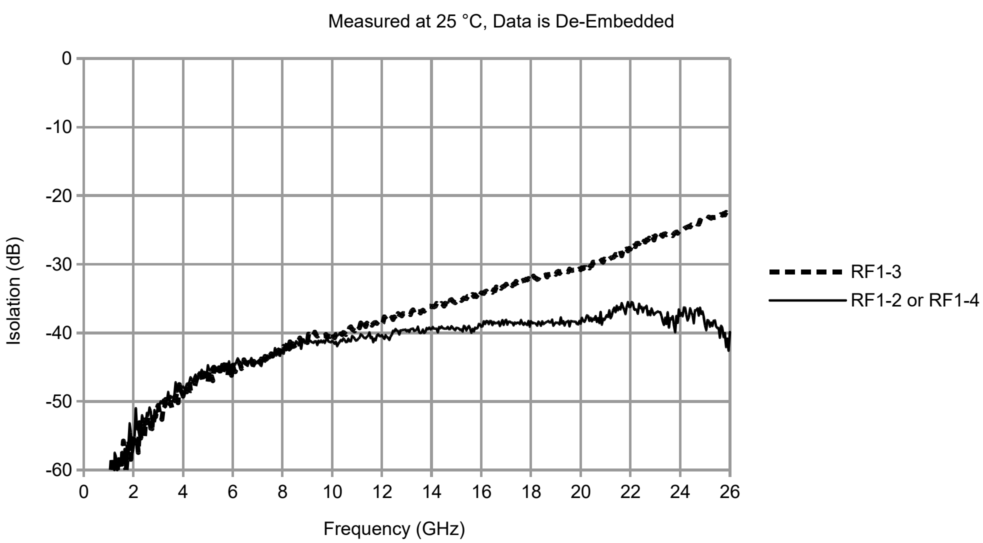


Figure 8. Off-State Isolation / S21

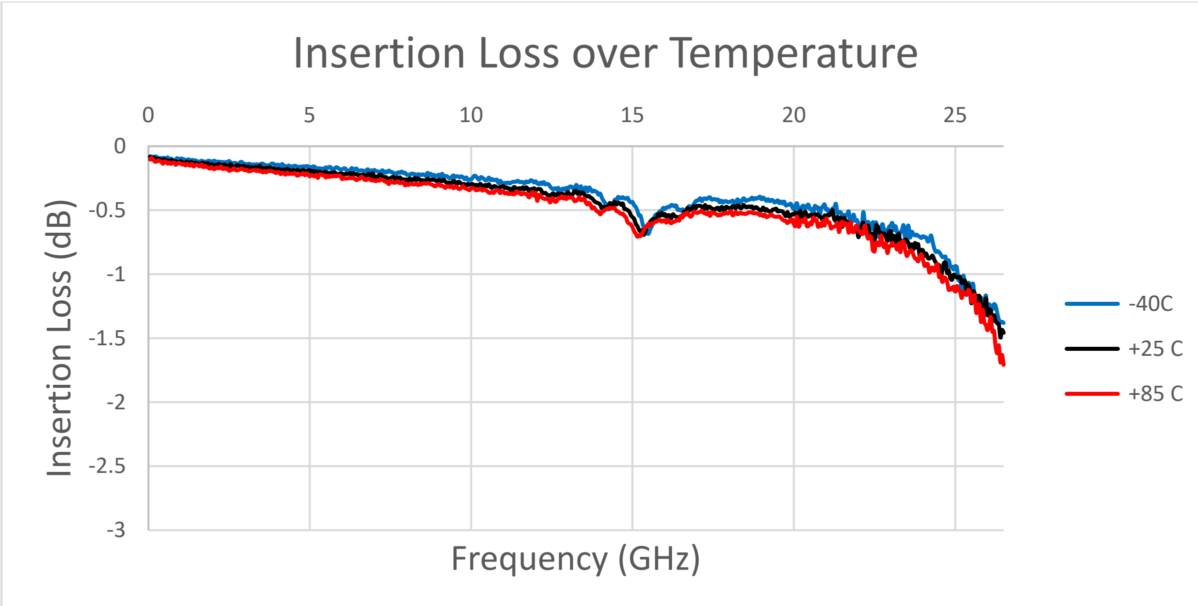


Figure 9. Insertion Loss, RF1-RF3 Path vs. Temperature

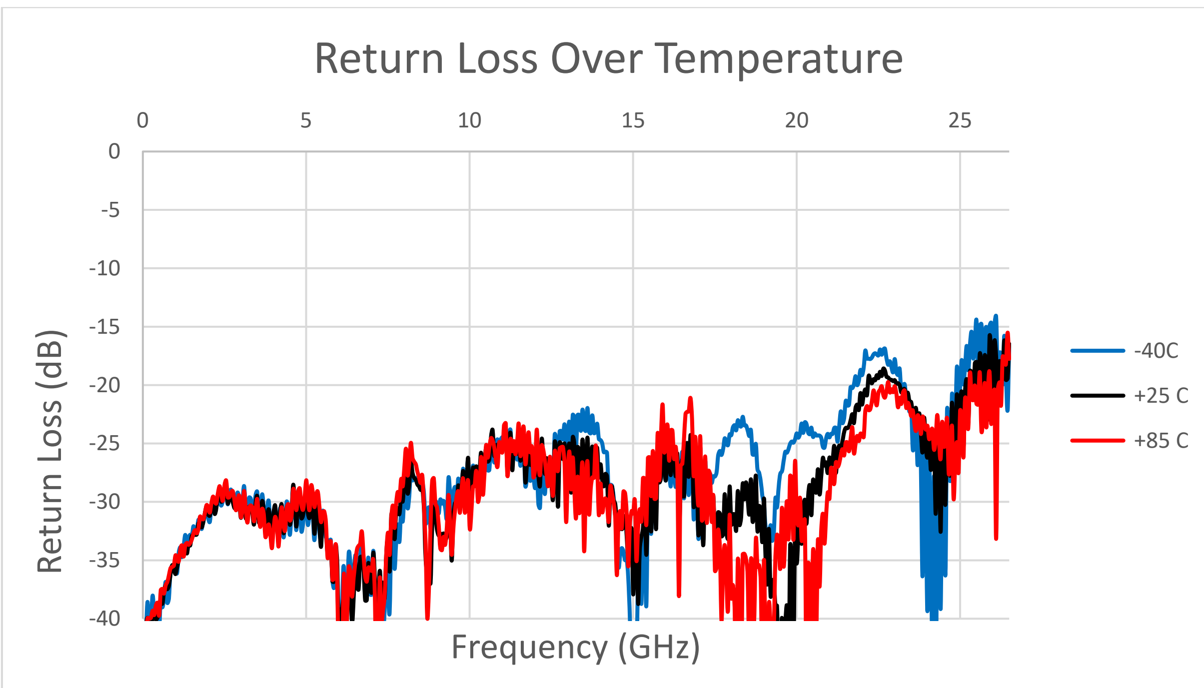


Figure 10. Return Loss, RF1-RF3 Path vs. Temperature

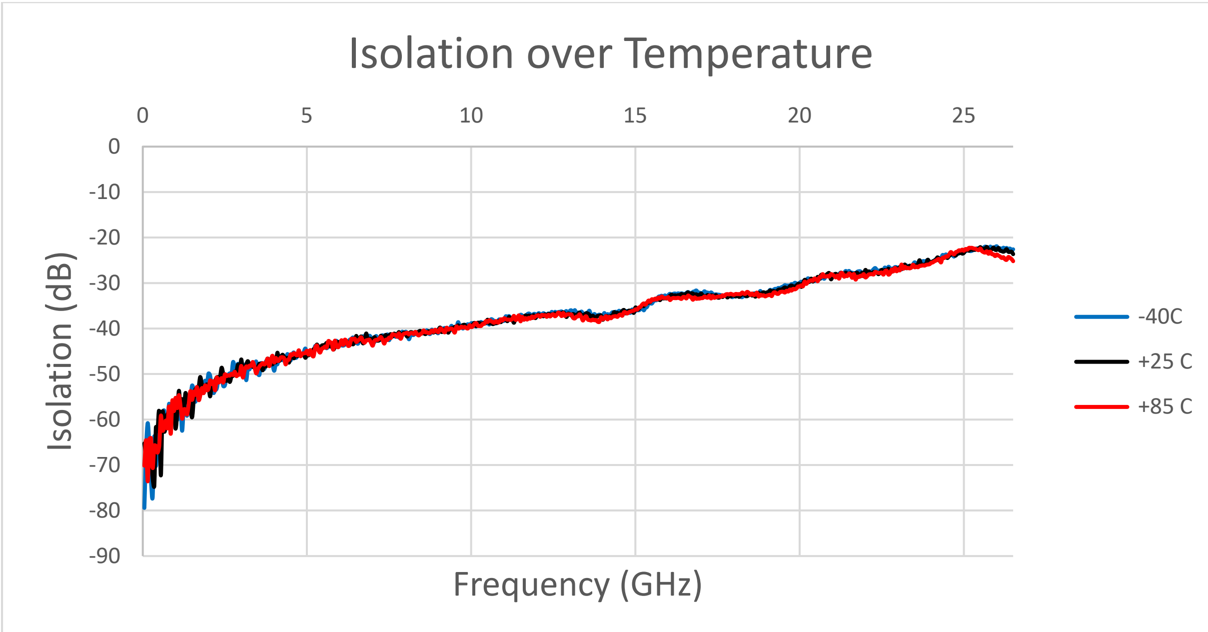


Figure 11. Off-State Isolation RF1-RF3 Path / S21 vs. Temperature

RF Performance: De-Embedding

Typical S-parameter performance is measured using a vector network analyzer on devices soldered to an evaluation kit (EVK) board with edge-launch RF connectors. Device performance is de-embedded using Ataitec's in-situ de-embedding (ISD) with a 2x through calibration line as a reference. De-embedding methods other than ISD may result in excess ripple due to the small size of the MM5230 device relative to the EVK fixture.

On/Off Switching Time

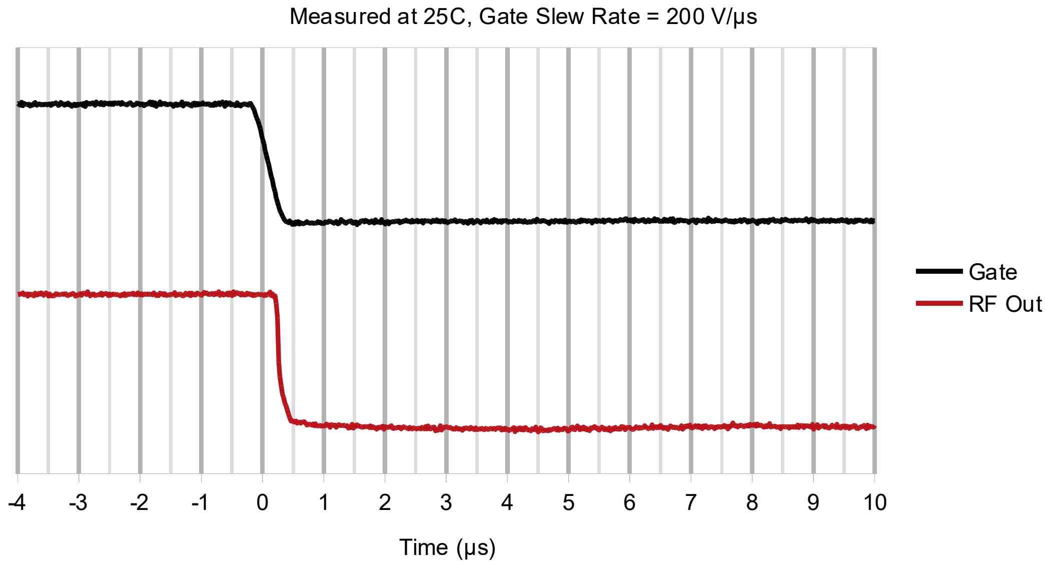


Figure 1. Switch Off Timing

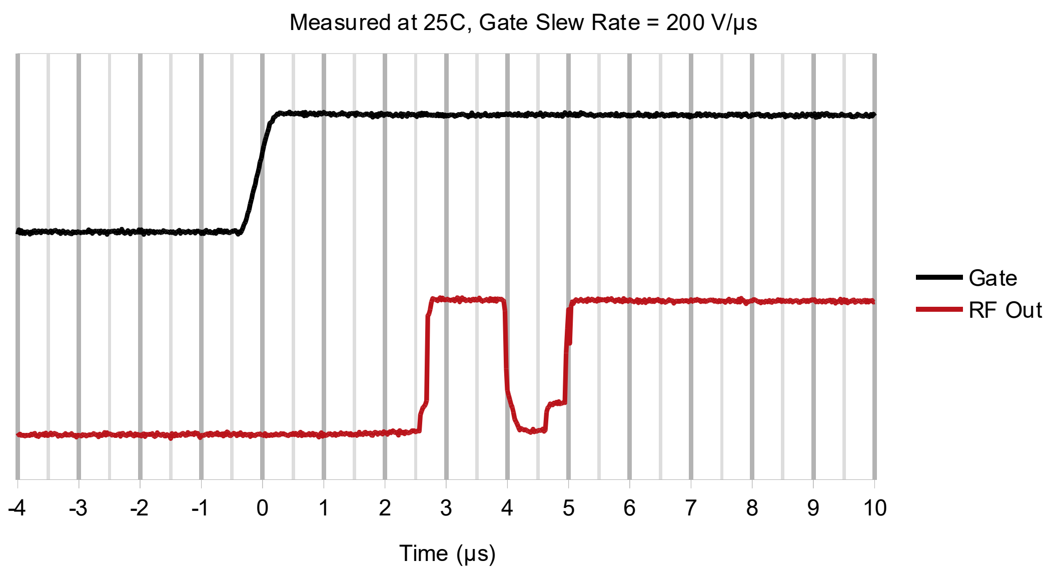


Figure 2. Switch On Timing

Typical Hot Switching Performance

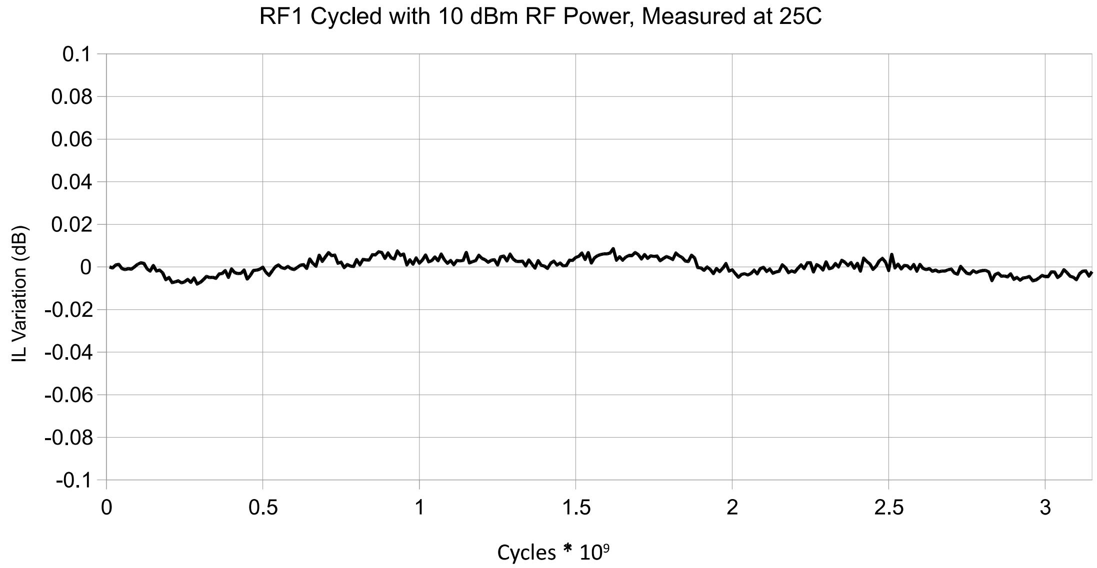


Figure 3. Insertion Loss Variation over On/Off Cycling

Switch Reliability

Switch Hold-Down duration predictions and actuation cycling reliability test results are plotted below. Hold Down median failure is predicted to be >68000 days (>186 years) @ 50ºC and >1800 days (>4.9 years) @ 85ºC. Failure criteria is 20% change in pull in voltage and is based on creep model extrapolation of 1000 hours Hold Down test data.

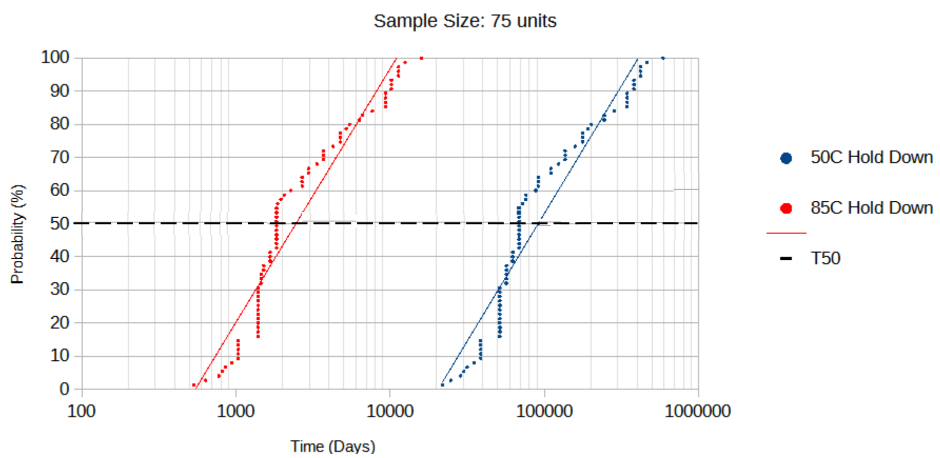


Figure 17. Hold Down: Days to Failure

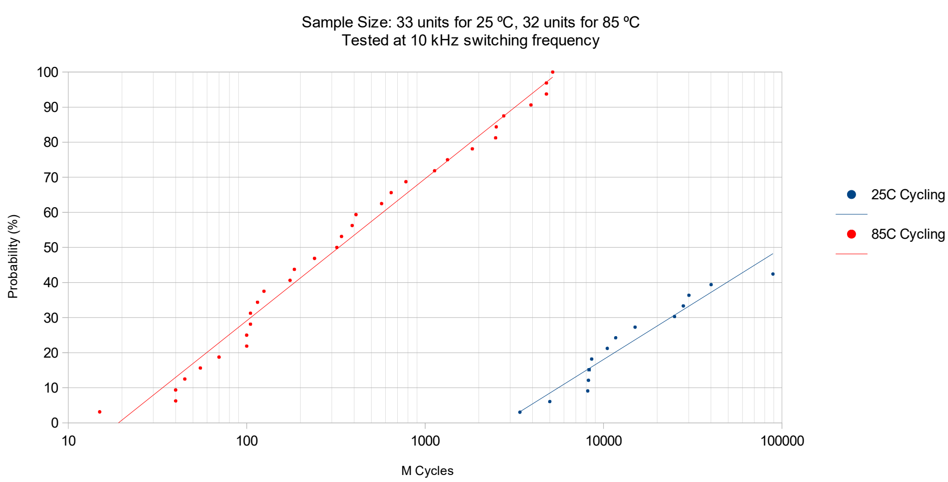


Figure 18. Cycling: M Cycles to Failure[1]

Notes:

1. Failure definition is stuck closed failure.

Hot switched actuation cycling reliability test results are plotted below from 20 dBm to 30 dBm.

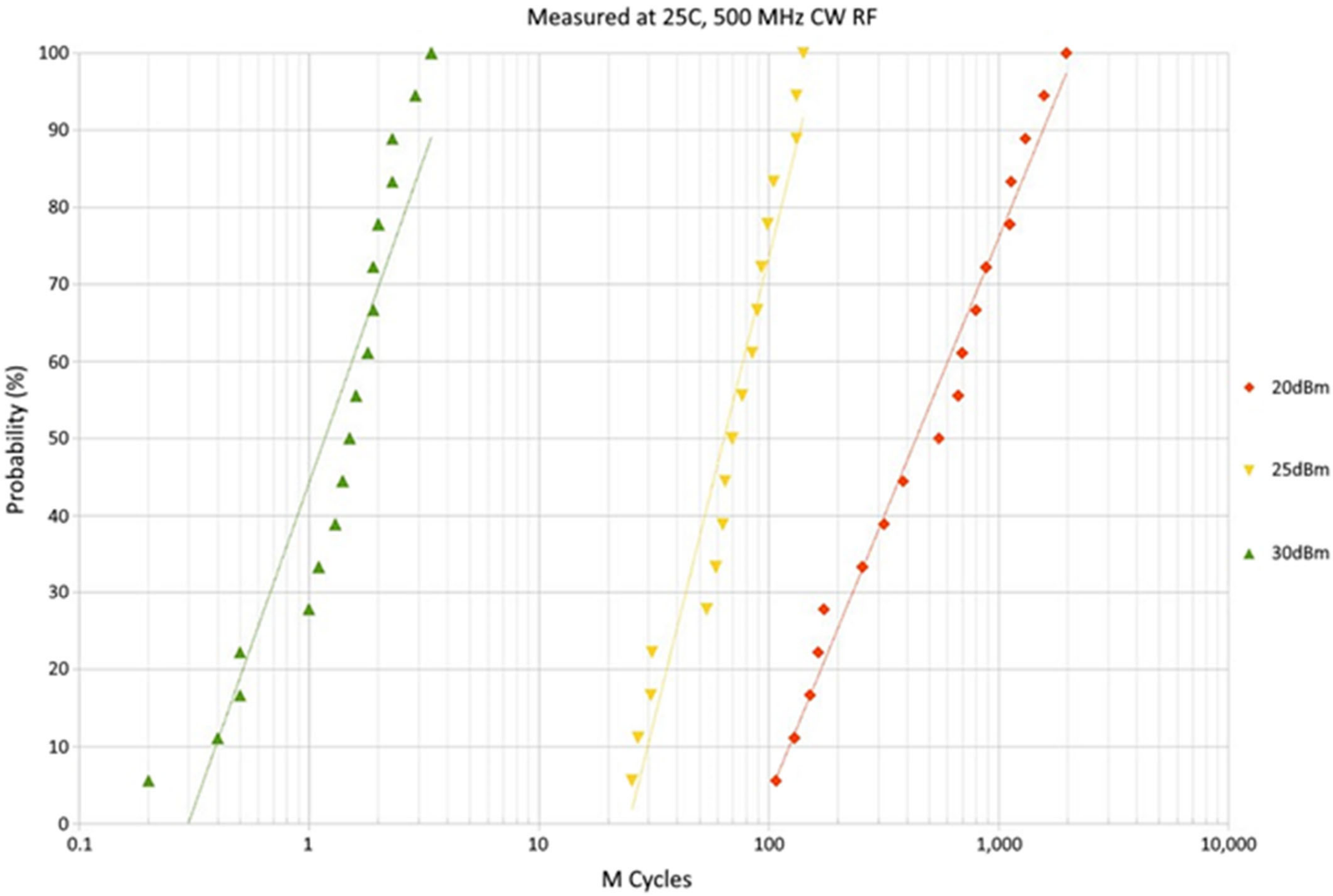
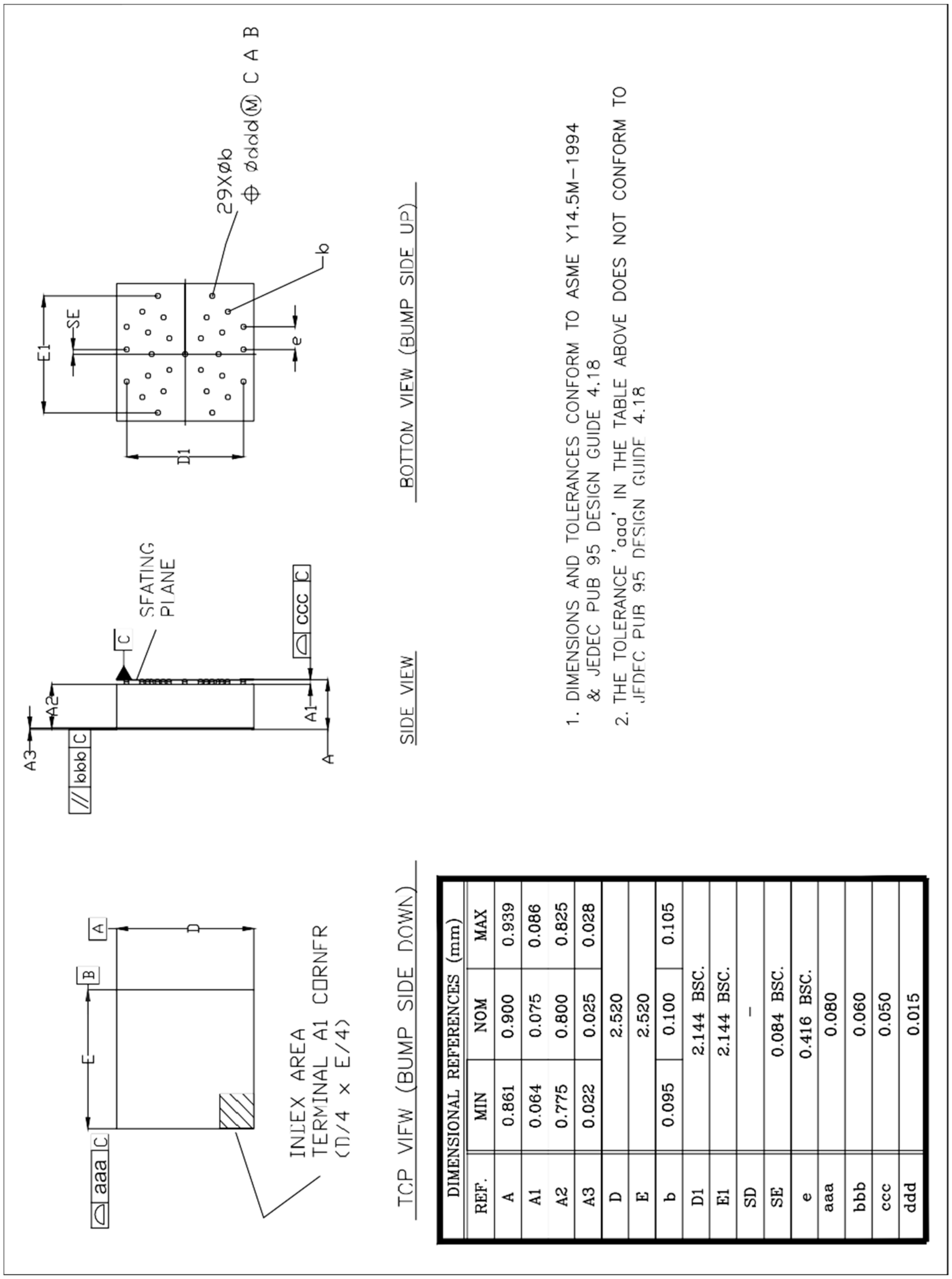


Figure 194. MM5130 Hot Switch

Package Drawing



DIMENSIONAL REFERENCES (mm)			
REF.	MIN	NOM	MAX
A	0.861	0.900	0.939
A1	0.064	0.075	0.086
A2	0.775	0.800	0.825
A3	0.022	0.025	0.028
D		2.520	
E		2.520	
b	0.095	0.100	0.105
D1		2.144 BSC.	
E1		2.144 BSC.	
SD		–	
SE		0.084 BSC.	
e		0.416 BSC.	
aaa		0.080	
bbb		0.060	
ccc		0.050	
ddd		0.015	

Figure 205. Package Drawing

Bump Coordinates

Table 5. Bump Coordinates

Pin	X (µm)	Y (µm)	Pin	X (µm)	Y (µm)	Pin	X (µm)	Y (µm)
1	1072	500	11	-786	786	21	-615	0
2	1072	84	12	-500	1072	22	-681	396
3	1072	-500	13	500	1072	23	-396	681
4	786	-786	14	786	786	24	396	681
5	500	-1072	15	681	396	25	290	290
6	-500	-1072	16	615	0	26	290	-290
7	-786	-786	17	681	-396	27	-290	-290
8	-1072	-500	18	396	-681	28	-290	290
9	-1072	84	19	-396	-681	29	0	0
10	-1072	500	20	-681	-396			

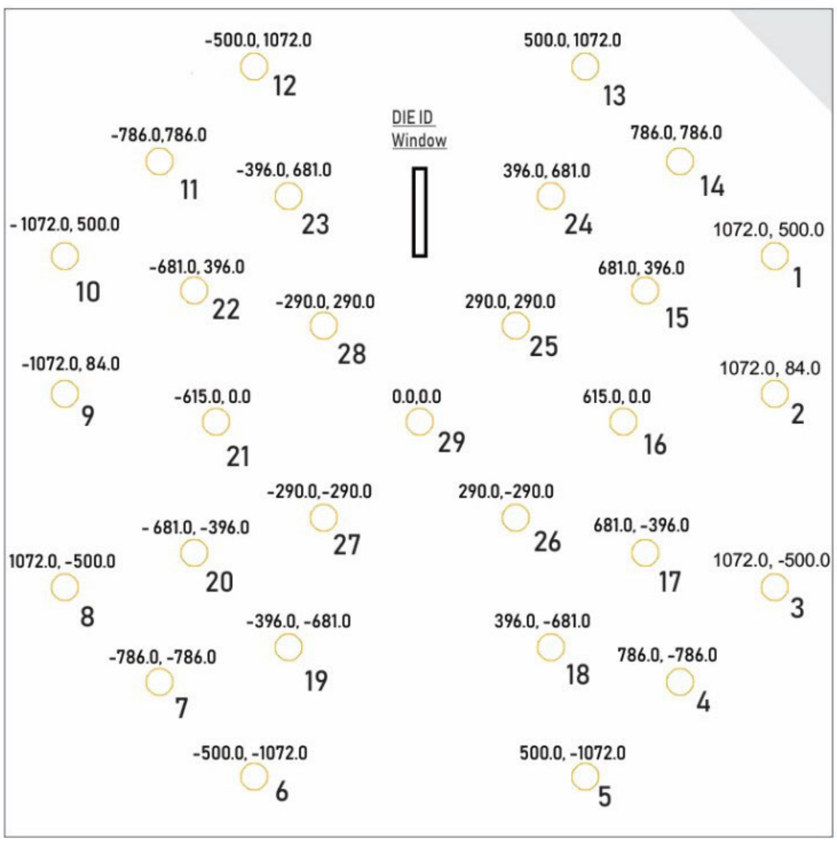


Figure 216. Bottom View/Bumps Up (0.0 at Die Center µm to Scale)

Recommended PCB Layout

Layout recommendation for connecting the MM5130 with coplanar RF line or grounded coplanar line as used for the MM5130 evaluation board. For the coplanar RF lines, it is recommended to taper the line to fit the 150µm recommended landing pad while keeping the spacing to the ground metal constant and identical to the spacing used for the line. A 4.0mil/0.10mm spacing is used. Recommended maximum solder resist thickness 20µm. Routing of the gate control lines is not critical for RF performance. Ensure the substrate x/y coefficient of thermal expansion (CTE) is 15 ppm/ºC or lower. For high standoff power applications it is recommended the line to ground spacing be calculated to withstand the high voltages seen when operating in to an open switch. This is especially important if the board will be subject to higher power levels at higher altitude and temperature. Considerations for conformal coating or solder mask over lines and ground can be made. In addition the MM5130-03NLX device can be underfilled to ensure no breakdown between the pins, refer to Menlo Micro WL-FC Assembly Instructions for underfill details.

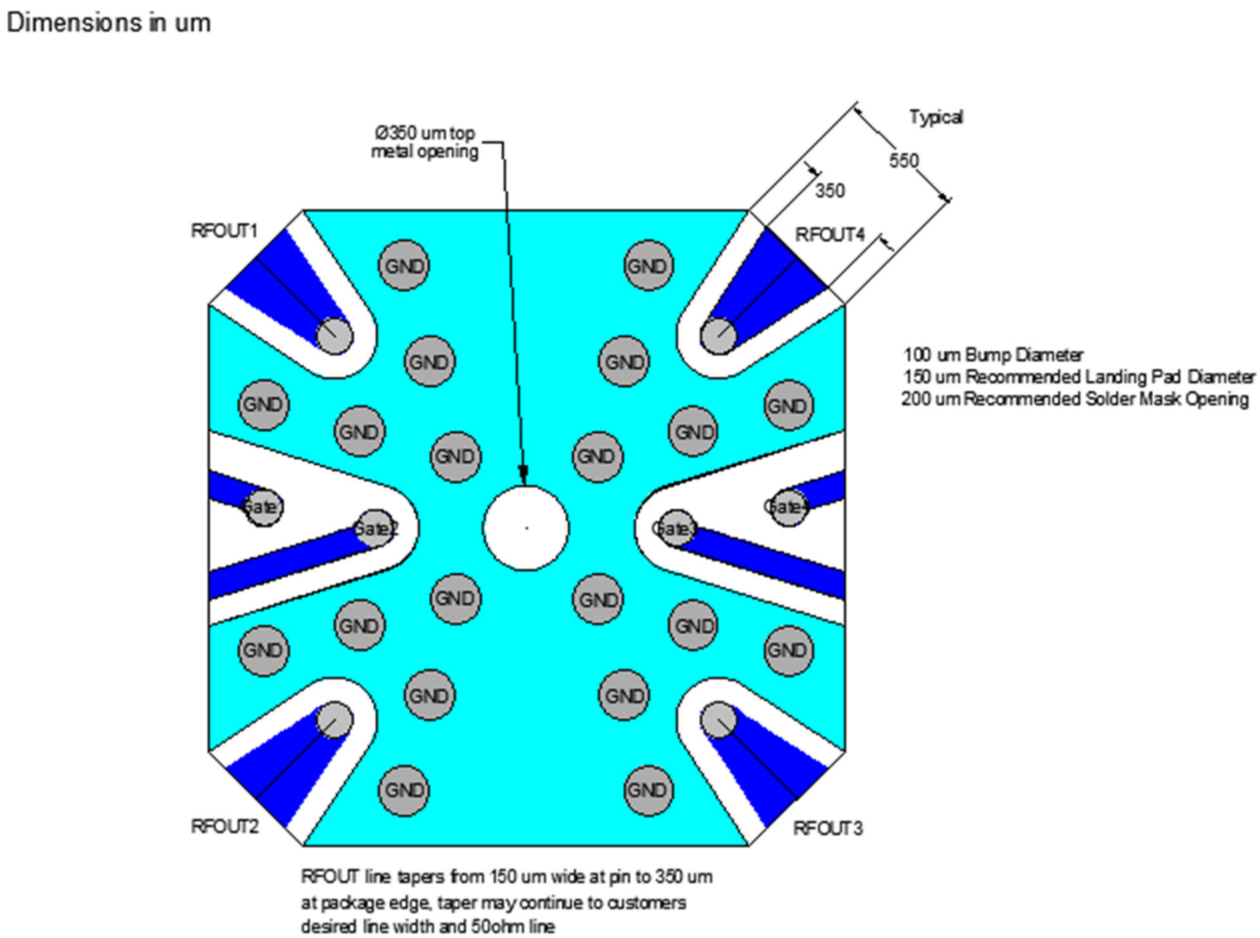


Figure 227. Layout Recommendation

Recommended Solder Reflow Profile

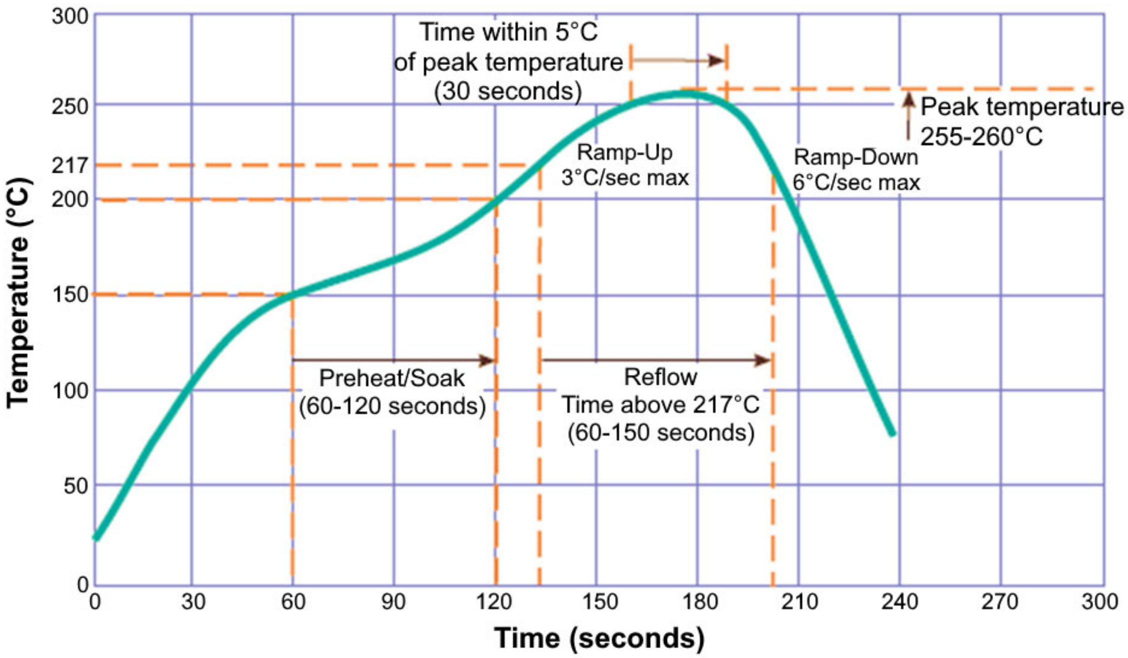


Figure 238. Reflow Profile

For detailed information on soldering the MM5130 along with SnPb soldering profile, please refer to the Menlo Micro application note *WL-FC Assembly Instructions*.

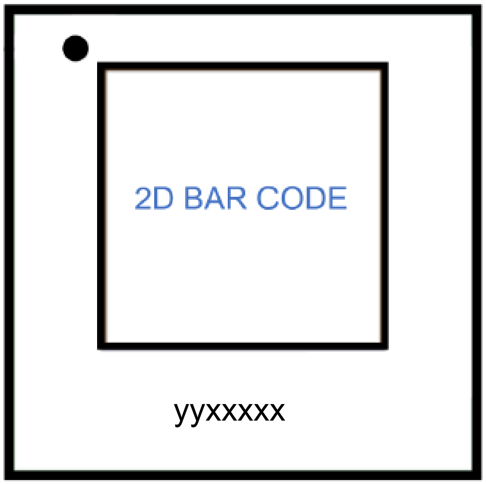
A ROHS-compliant Solder Alloy used is SAC alloy: 96.5% Sn, 3.0%Ag, 0.5%Cu. These are the nominal percentages of the components. This alloy is designed to replace SnPb solders to eliminate Lead (Pb) from the process, requiring a higher reflow temperature. Moisture resistance performance may be impacted if not using the Pb-Free reflow conditions.

Storage and Shelf Life

Under typical industry storage conditions (≤30°C/60% RH) in Moisture Barrier Bags, the following are recommended:

- Customer Shelf Life: 24 months from customer receipt date.
- Extended Shelf Life: 60 months from customer receipt date if re-bagged every 24 months or less.
- Floor life: Moisture Sensitivity Level (MSL) testing is not required for Hermetic package as per JESD47K.
- Do not re-bake.

Package Marking Information



Dot ● = Pin 1 Indicator
Line 1 = 2D Bar Code
Line 2 = Human-readable product code

Figure 249. Package Marking Drawing

Package Materials Information

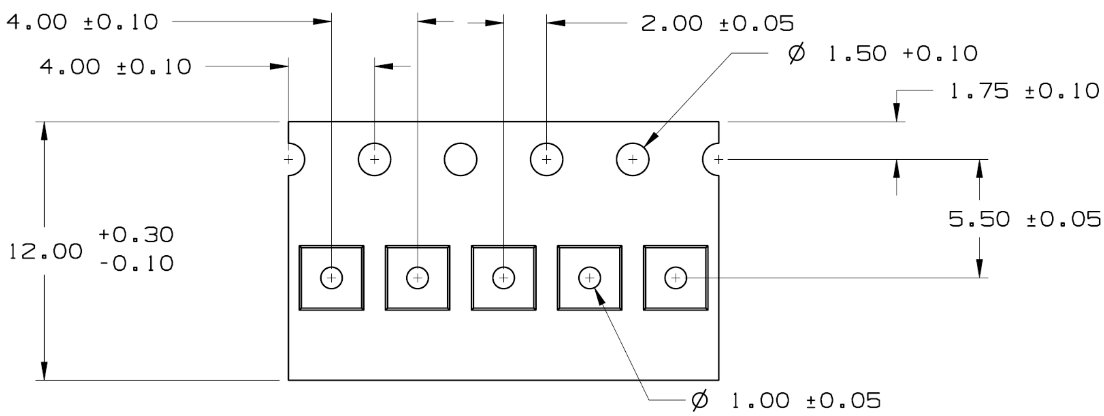


Figure 2510. Tape and Reel Drawing

Package Options and Ordering Information

All Menlo Micro solutions are EAR99 compliant.

Part Number	Package Description	Temp Range	Device Marking[1]
MM5130-03NLX	DC-26GHz - SP4T High Standoff 2.5 mm x 2.5 mm 29 pin WL-FC Industrial Temp	- 40ºC to +85ºC	yyxxxxx

Notes:

1. Additional markings may be present, including logo or lot trace code information. This information may be a 2D barcode or other human-readable markings. Note that 'x' is a placeholder for a 5-digit numerical code and 'yy' is either "BB" or "BC".

Various evaluation boards are available for the MM5130 device. Please see ordering information below and in Table 5.

Table 5. MM5130 Evaluation Boards

Part Number	EVK Description
MM5130EVK4	High-performance evaluation board for MM5130 Superport mode (w/Southwest connector-QTY-6, 26GHz improved performance)

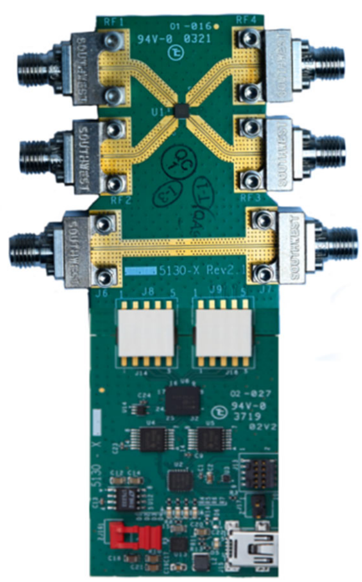


Figure 26. MM5130 EVK4 26GHz Evaluation Board

Important Information

Disclaimer

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- Applications for implanting into the human body, without the express written approval from Menlo Micro.

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Contact Information

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