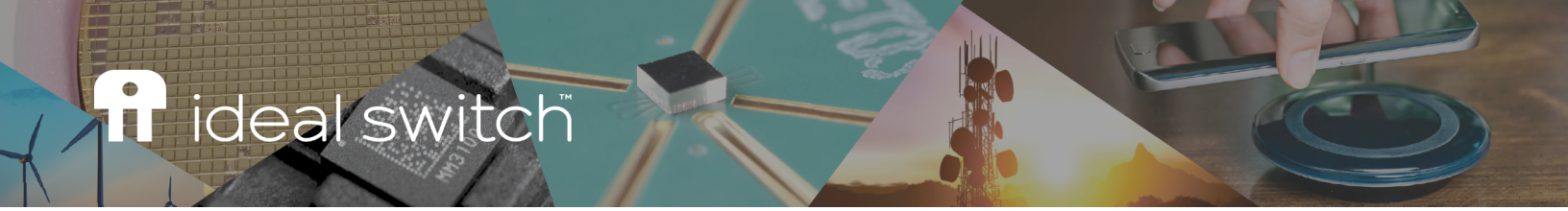


Preliminary Datasheet

MM5130 – DC to 26 GHz High Power RF Switch

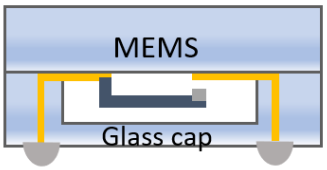
Product Overview

Description:

The MM5130 device is a high-power SP4T micro-mechanical switch offered by Menlo Micro. 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 greater than 25 W forward power. The MM5130 provides ultra-low insertion loss and superior linearity as an SP4T from DC to 18 GHz, with greater than $3.0x10^9$ switching cycles. The MM5130 can also be configured in super-port mode to extend the max frequency to 26GHz. 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 four switch channels are individually controllable by applying a gate voltage to the corresponding RF GATE pin.

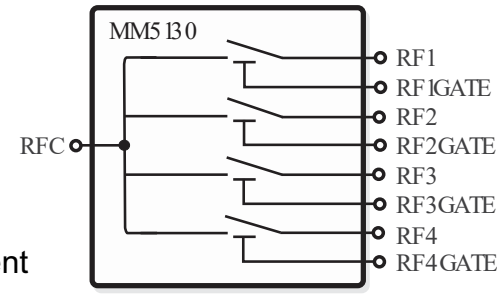
Features:

- DC to 26 GHz Frequency Range
- 25 W (CW), 150 W (Pulsed) Max Power Handling
- Low On-State Insertion Loss: 0.4 dB @ 6.0 GHz
- High Linearity, IIP3 > 85 dBm
- 25 dB Isolation @ 6.0 GHz
- High Reliability > $3.0x10^9$ Switching Operations
- 2.5 mm x 2.5 mm WLCSP Package



Applications:

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



Functional Block Diagram

Markets:

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

Electrical Characteristics

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 recommended operating conditions listed below.

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 below.

Table 1 Absolute Maximum Ratings [1]

Parameter	Minimum	Maximum	Unit
CW Input Power @ 6 GHz		25	W
Peak Input Power @ 6 GHz		150	W
Open State Voltage Rating / Switch RF1-4 to RFC [2]		+/-150	V
Open State Voltage RF1-RF4, RFC to GND, GATE pin to GND Potential [2]		+/-150	V
DC Voltage RFGATE Pins to RF1-RF4, RFC, GND (2)		+/-100	V
DC Current Rating / Switch		500	mA
Hot Switching Current @ 0.5 V		10	mA
Storage Temperature Range	-65	+150	ºC

[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.

Table 2 DC and AC Electrical Specifications

All specifications valid over specified VBB range and valid operating temperature range as specified in "Package Options and Ordering Information" table on page 19.

Parameter	Minimum	Typical	Maximum	Unit
Operating Frequency Range				
Normal SP4T mode	DC		18	GHz
Super-port mode	DC		26	GHz
CW Power @ 6 GHz[3]			25	W
Peak Power @ 6 GHz[4]			150	W
Insertion Loss				
Normal SP4T mode @ 6 GHz		0.4		dB
Super-port mode @ 6 GHz		0.6		
Normal SP4T mode @ 18 GHz		1.3		
Super-port mode @ 18 GHz		1.5		
Normal SP4T mode @ 26 GHz		--		
Super-port mode @ 26 GHz		2.6		
Input / Output Return Loss				
Normal SP4T mode @ 6 GHz		15		dB
Super-port mode @ 6 GHz		25		
Normal SP4T mode @ 18 GHz		10		
Super-port mode @ 18 GHz		18		
Normal SP4T mode @ 26 GHz		--		
Super-port mode @ 26 GHz		17		
Isolation				
Normal SP4T mode @ 6 GHz		25		dB
Super-port mode @ 6 GHz		28		
Normal SP4T mode @ 18 GHz		18		
Super-port mode @ 18 GHz		27		
Normal SP4T mode @ 26 GHz		--		
Super-port mode @ 26 GHz		18		
Channel to Channel Isolation @ 6 GHz		25		dB

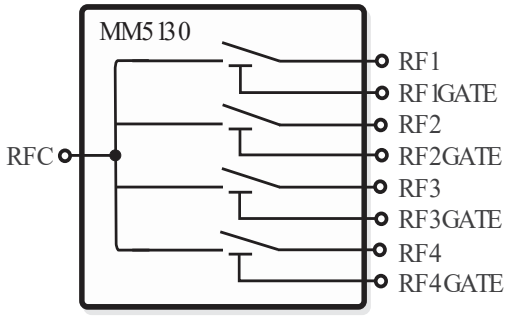
[3] For applications with > 1.0 W @ < 2.0 MHz, Gate Tracking is required, see Gate Tracking application note.
[4] For 10 % Duty Cycle and 10 µs pulse width.

Third-Order Intercept Point (IP3)		> 85		dBm
Second Harmonic (H2) [5]		-130		dBc
Third Harmonic (H3)[6]		-140		dBc
On / Off Switching Time Turn on time[7] Turn off time		 8 2	 15 5	µs
Settling Time[8] Settling time: on Settling time: off		 8.5 2.5	 16 6	µs
Full Cycle Frequency			10	kHz
On / Off Switch Operations		$3x10^9$		Cycles
DC Steady State Carry Current			500	mA
Off-State RFC to RFOUT Leakage Current		15	150	nA
On-State Resistance (R_{On})		0.5	3	Ω
Off-State Capacitance (C_{Off})		15		fF
Video Feedthrough[9]		16		mV_{Peak}
Gate Bias Voltage (VBB)	88	89	90	V_{DC}
Gate Voltage Slew Rate			20	V/µs
Gate Bias Current		15	1000	nA

[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, and measured with 20 V/us slew rate GATE pin voltage.
[8] Switch settling time measured from 50% VGATE to settling to within 0.05 dB of final value.
[9] Performed with 1 MΩ termination.

Normal SP4T Mode

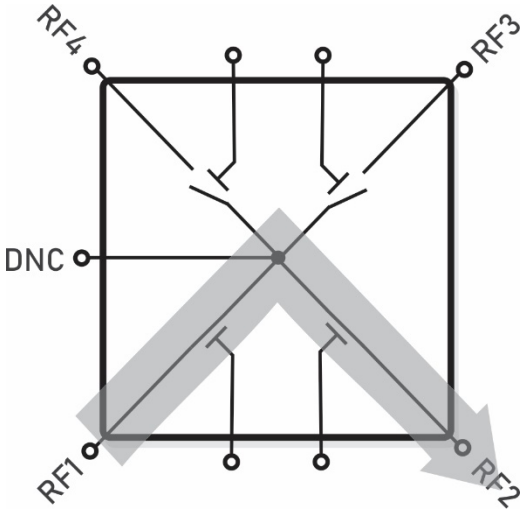
The MM5130 is normally configured as a SP4T, with input on the RFC channel. The RFC is then routed to one of the 4 outputs by biasing the desired RFxGATE pin.



Normal SP4T Mode 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, slight improvements in RF isolation and return loss can be achieved. Please refer to the "Recommended PCB Layout" section with instructions on how to optimize the PCB layout for super-port mode.



Super-port Mode Block Diagram

Package / Pinout Information

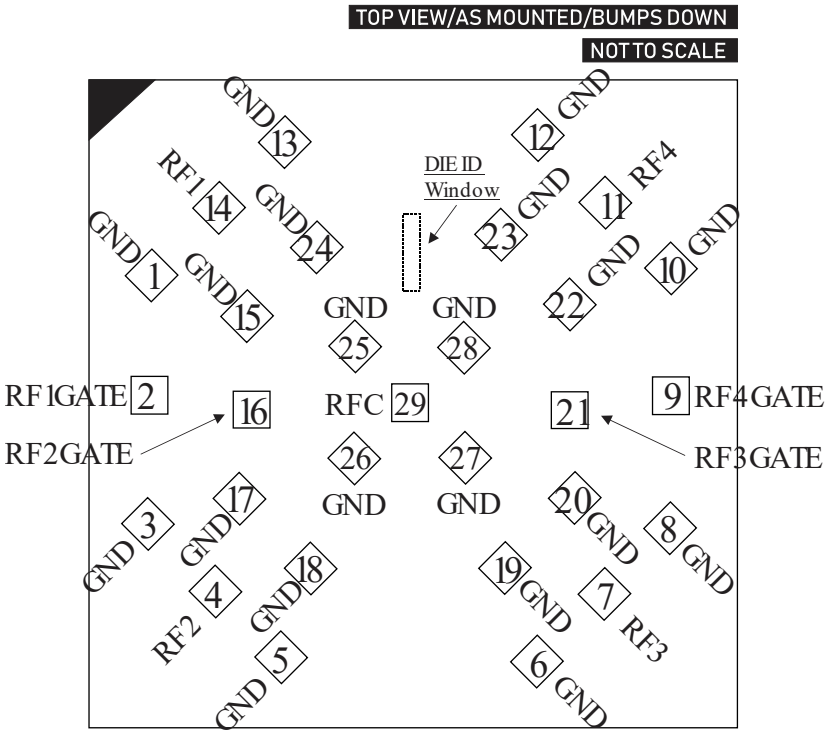


Figure 1:MM5130 2.5 mm x 2.5 mm pinout

Table 2 Detailed Pin Description

Pin #	Pin Name	Description
1,3,5,6,8,10,12,13,15,17, 18,19,20,22,23,24,25,26,27,28	GND	RF Ground
2	RF1GATE	Control for Switch RF1
16	RF2GATE	Control for Switch RF2
4	RF2	RF Switch 2
7	RF3	RF Switch 3
21	RF3GATE	Control for Switch RF3
9	RF4GATE	Control for Switch RF4
11	RF4	RF Switch 4
14	RF1	RF Switch 1
29	RFC	RF Common

Table 3 Applied Gate Voltage vs. RF Switch States (On= Closed, Off = Open). Each switch is individually controllable. Primary usage states are highlighted in **bold**. Multiple branches may be closed simultaneously, however RF performance is not specified for such states.

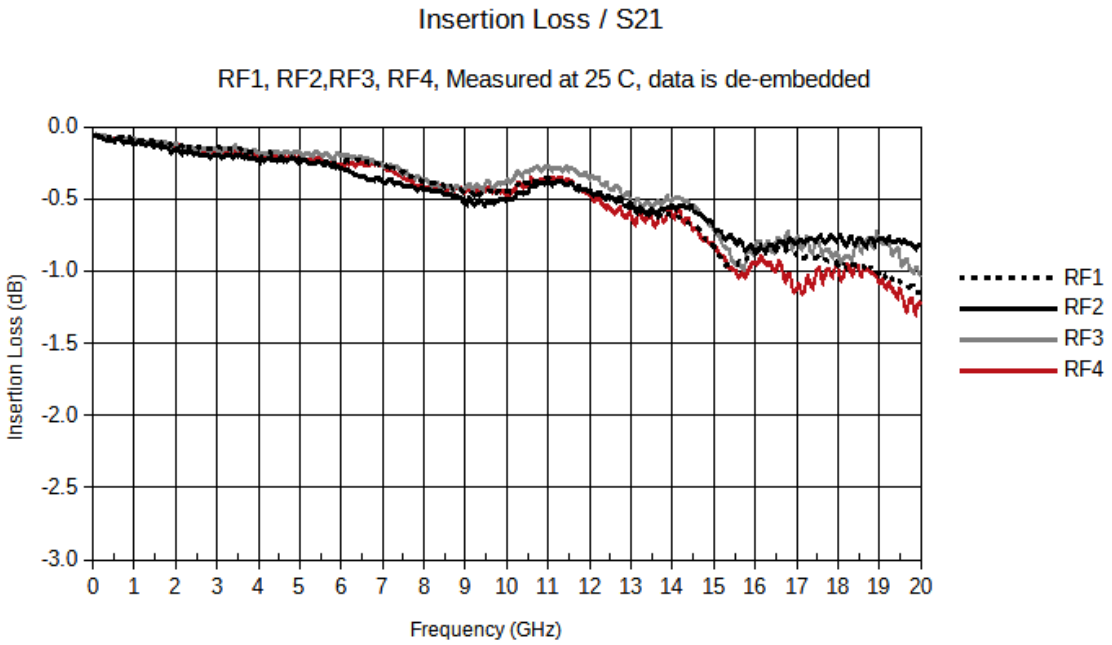
RF4GATE (V)	RF3GATE (V)	RF2GATE (V)	RF1GATE (V)	RFC – RF4	RFC – RF3	RFC– RF2	RFC– RF1
Normal SP4T Mode							
0	**0**	**0**	**VBB**	**Off**	**Off**	**Off**	**On**
0	**0**	**VBB**	**0**	**Off**	**Off**	**On**	**Off**
0	**VBB**	**0**	**0**	**Off**	**On**	**Off**	**Off**
VBB	**0**	**0**	**0**	**On**	**Off**	**Off**	**Off**
0	0	0	0	Off	Off	Off	Off
Other valid states							
0	0	VBB*	VBB*	Off	Off	On	On
0	VBB*	0	VBB*	Off	On	Off	On
0	VBB*	VBB*	0	Off	On	On	Off
VBB*	0	0	VBB*	On	Off	Off	On
VBB*	0	VBB*	0	On	Off	On	Off
VBB*	VBB*	0	0	On	On	Off	Off
VBB	VBB	0	VBB	On	On	Off	On
VBB	VBB	VBB	0	On	On	On	Off
VBB	VBB	VBB	VBB	On	On	On	On
0	VBB	VBB	VBB	Off	On	On	On
VBB	0	VBB	VBB	On	Off	On	On

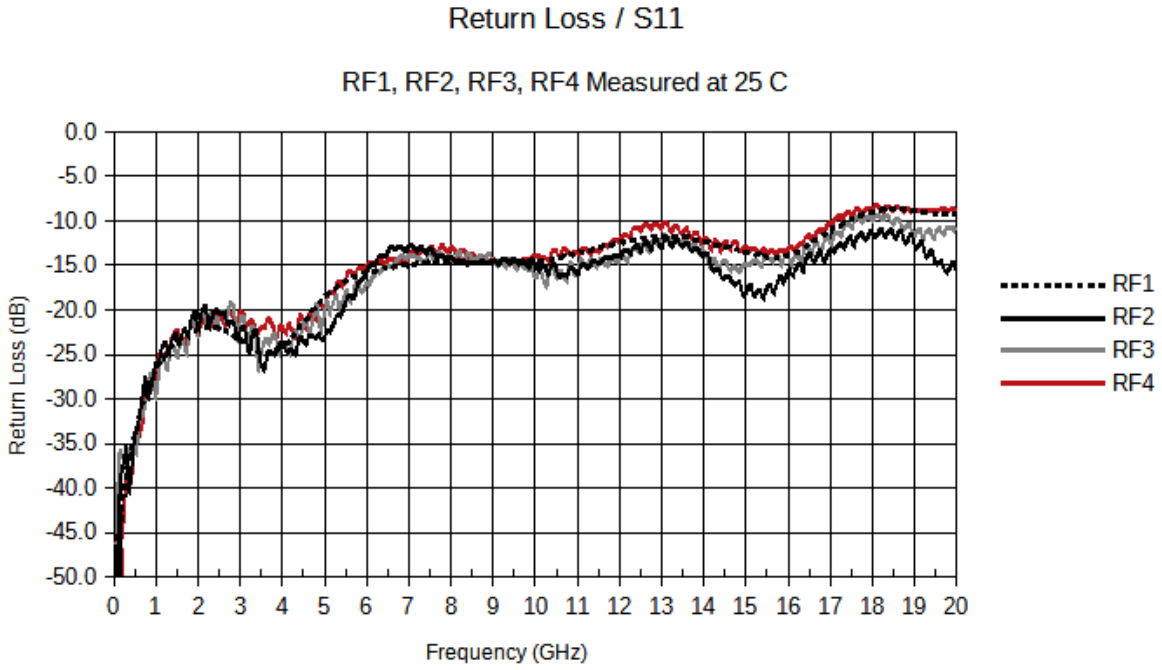
*Valid states for Super-port mode

RF Performance

Normal Mode (SP4T)

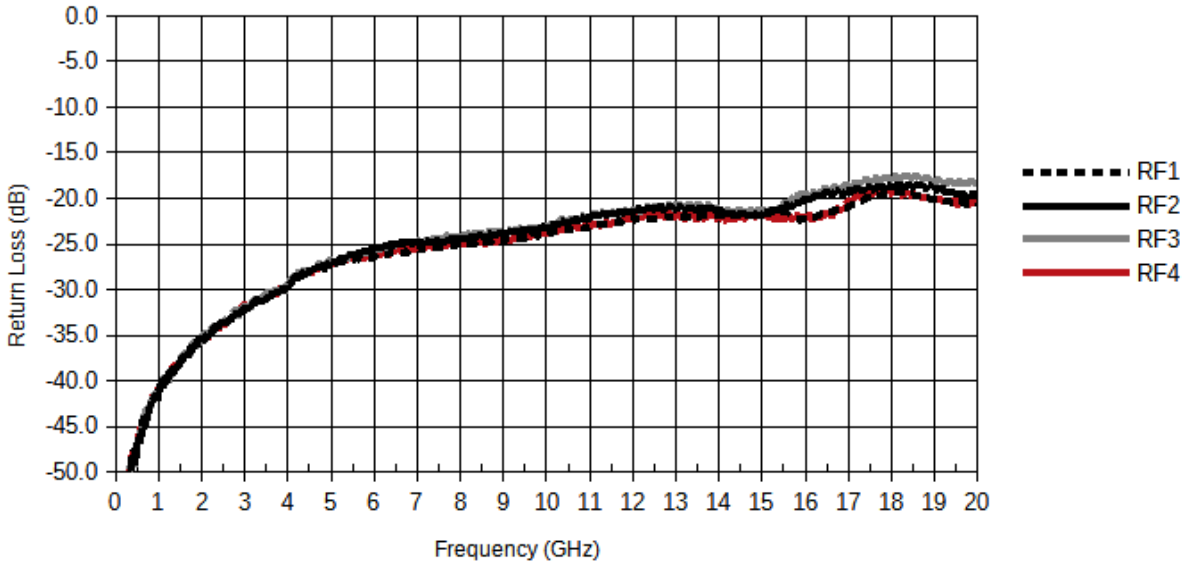
Typical device performance measured on evaluation board, de-embedded. For band-limited applications, the performance may be further improved with narrowband matching techniques.





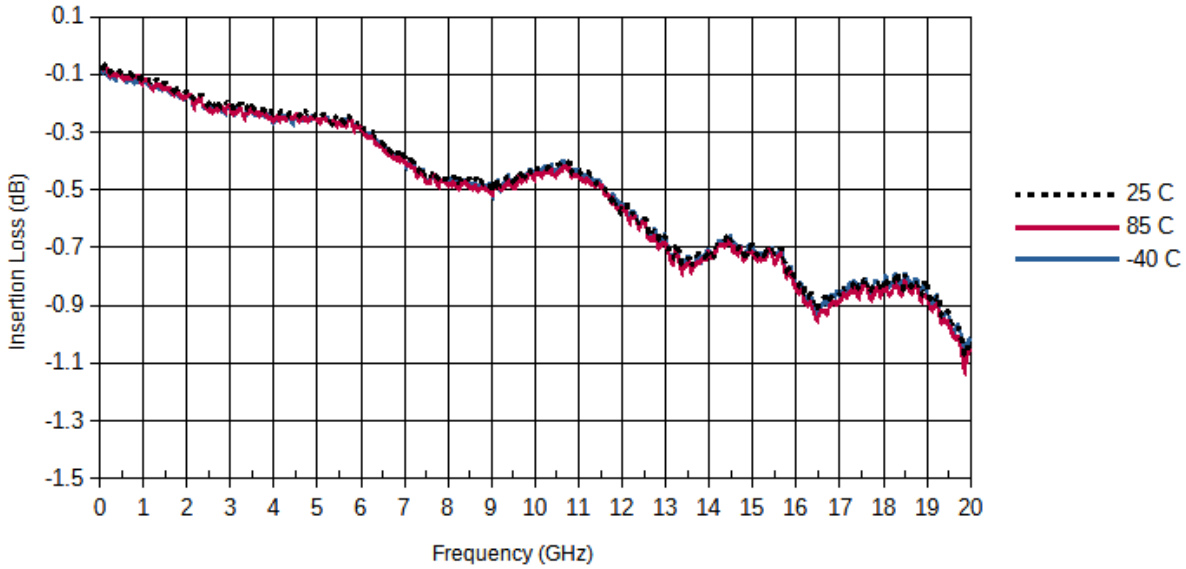
Off-State Isolation / S21

RF1, RF2,RF3, RF4, Measured at 25 C, data is de-embedded



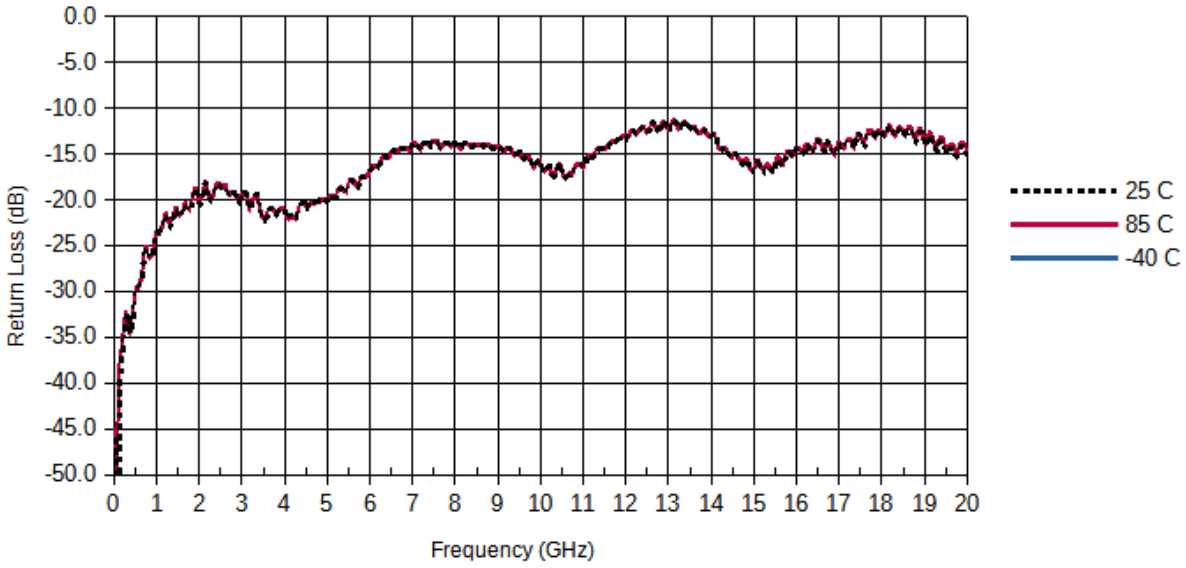
Insertion Loss / S21 for 25 C, 85 C and -40 C

For channel RF2, data is de-embedded



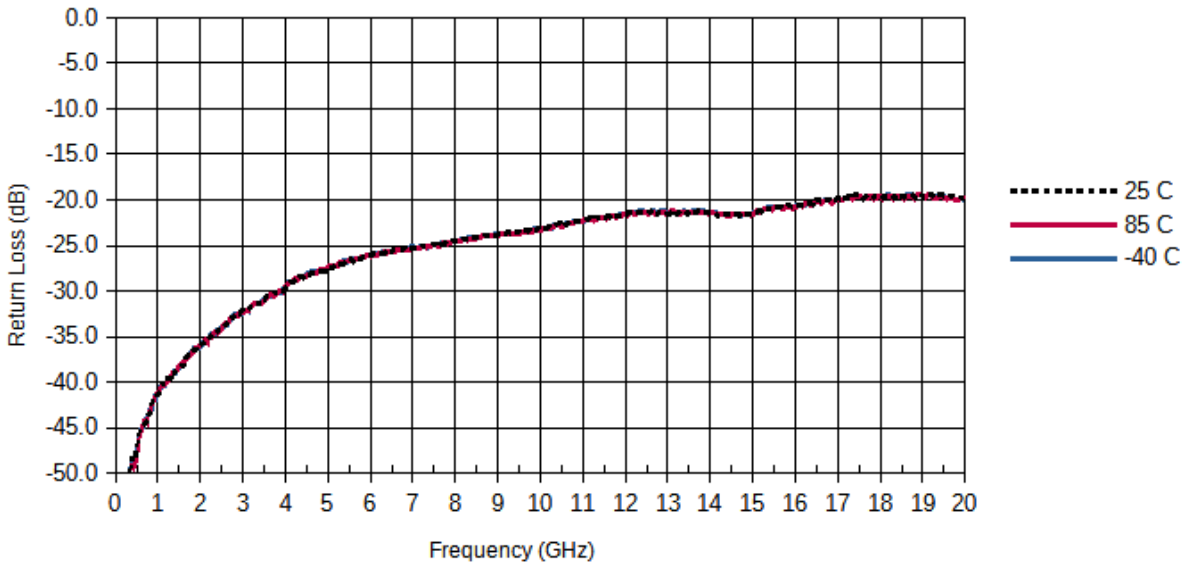
Return Loss / S11 FOR 25 C, 85 C and -40 C

For channel RF2, data is de-embedded



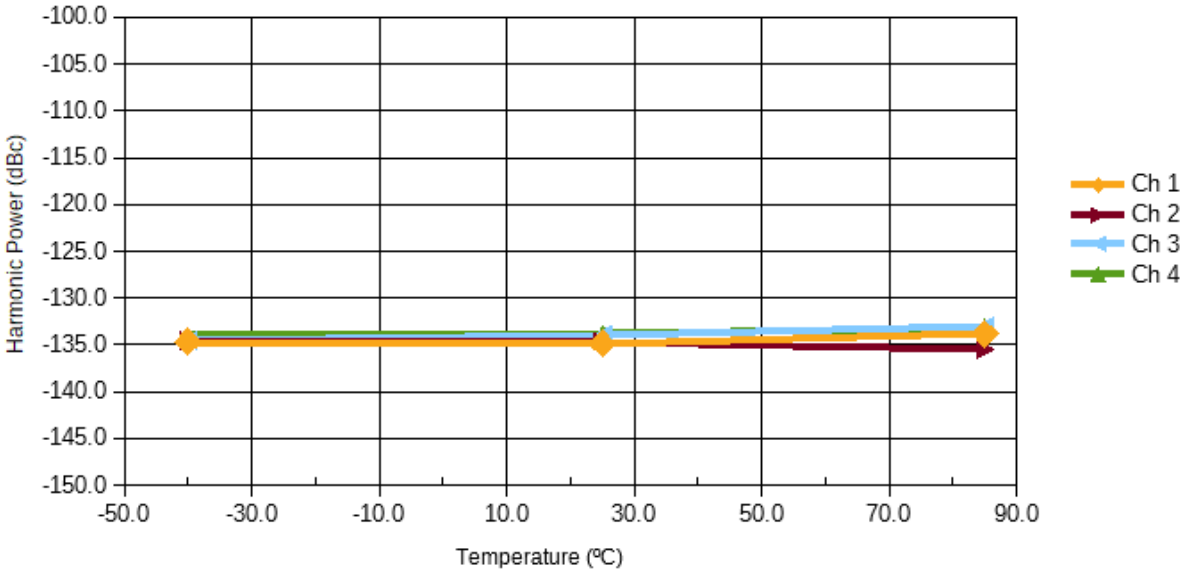
Off-State Isolation / S21 for 25 C, 85 C and -40 C

For channel RF2, data is de-embedded



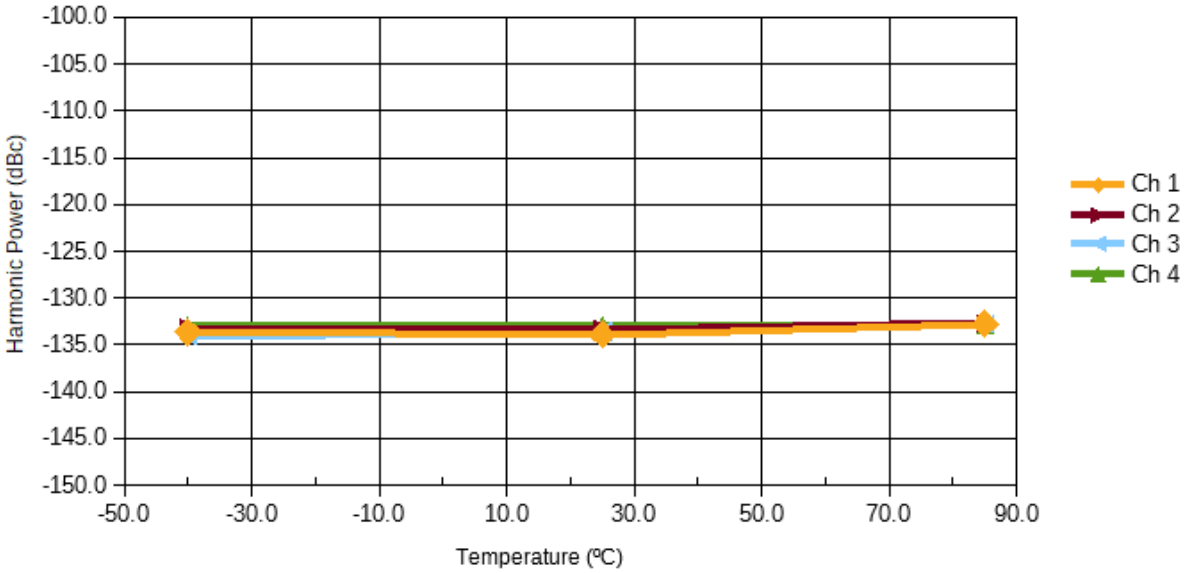
Second Harmonic Power vs. Temperature

f0 = 1.0 GHz, 36 dBm

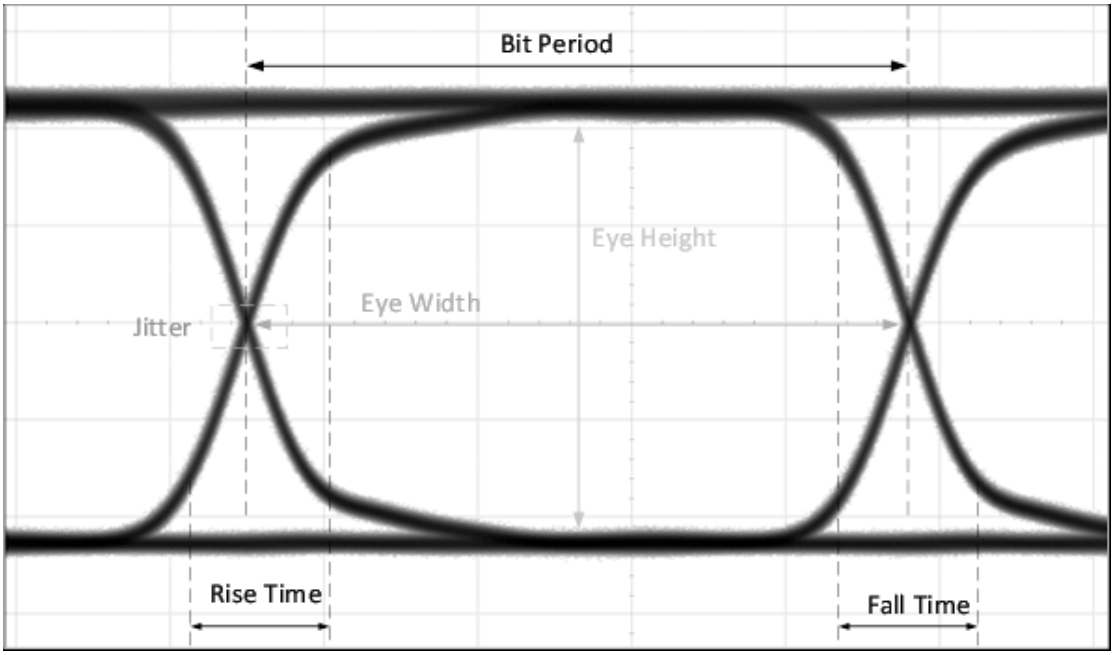


Third Harmonic Power vs. Temperature

f = 1.0 GHz, 36 dBm



Single-Ended Eye Diagram Measurement



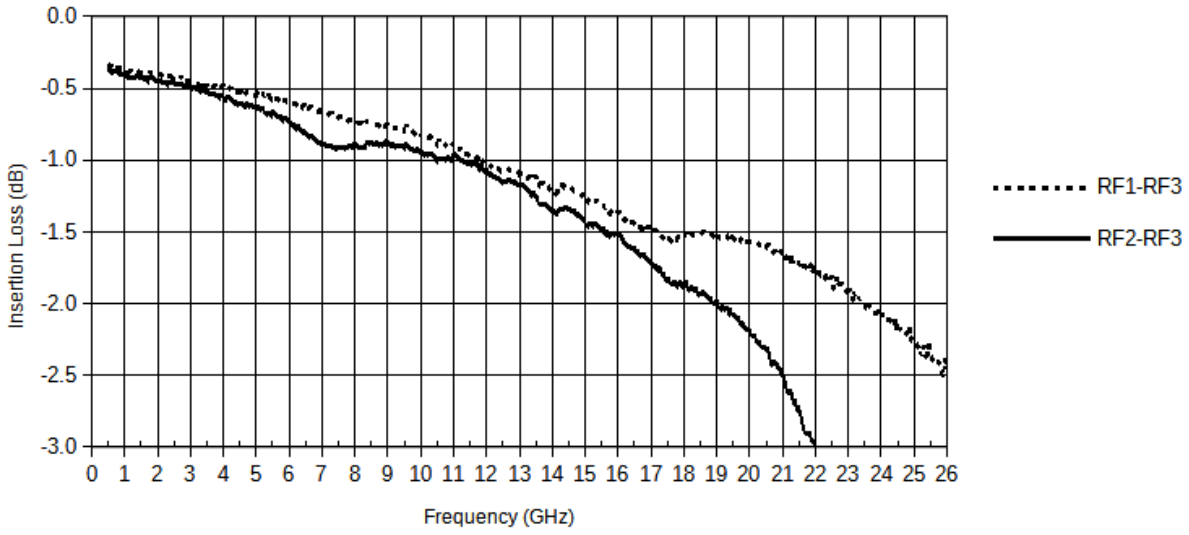
Test Cases	Bit rate	Eye Height	Eye Width	Jitter (Peak to Peak)	Rise Time (20%-80%)	Fall Time (80%-20%)
Baseline-Test System	20.000 Gbps	454.98 mV	45.82 ps	5.38 ps	10.86 ps	12.33 ps
MM5130 EVK (w/cables) *	20.000 Gbps	290.61 mV	44.14 ps	7.82 ps	16.50 ps	17.19 ps

RF Performance

Super-Port Mode

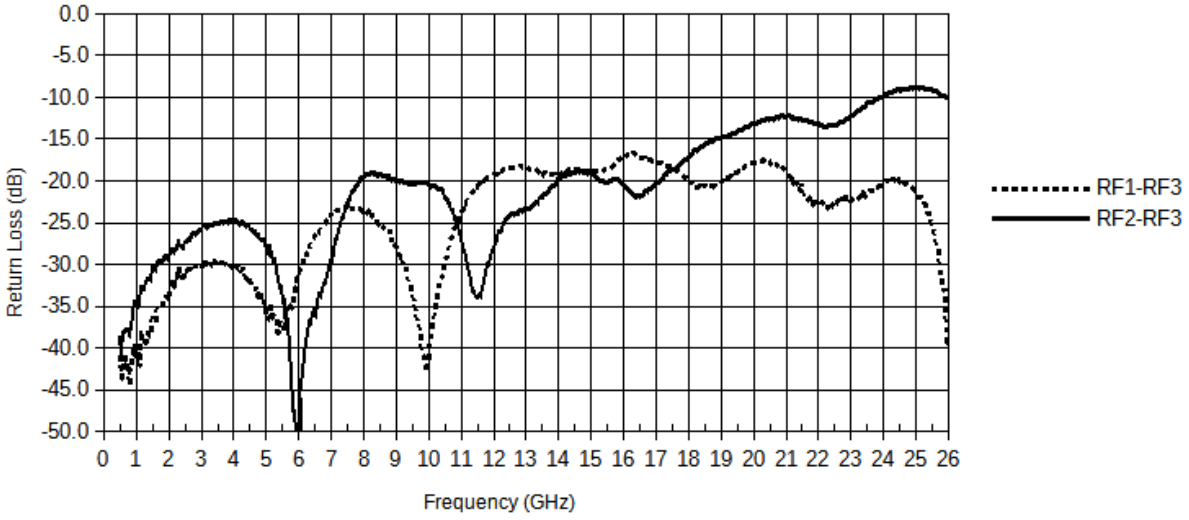
Super-Port Config Insertion Loss / S21

RF1-RF3 & RF2-RF3, Measured at 25 C, data is de-embedded

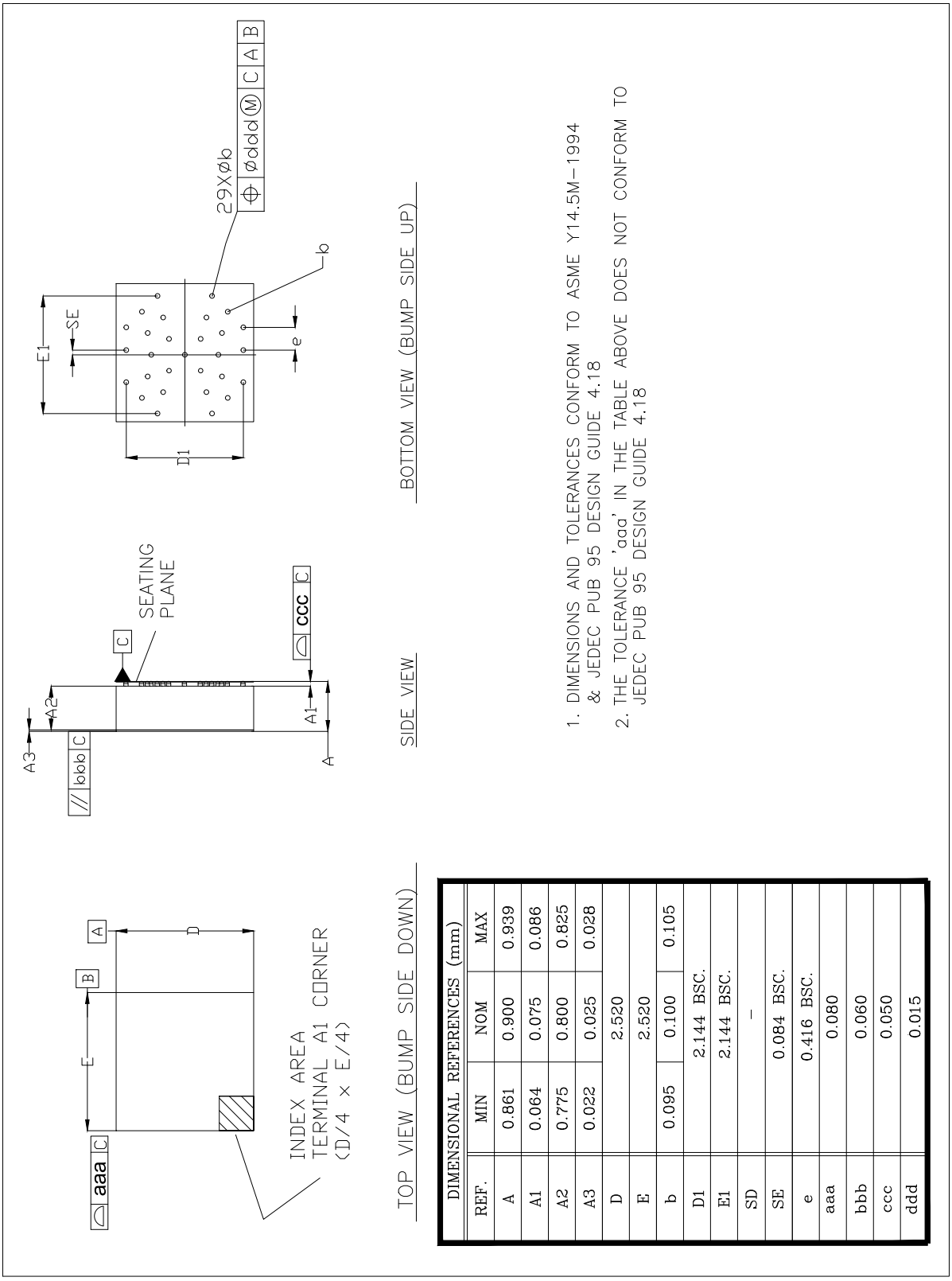


Super-Port Config Return Loss / S11

RF1-RF3 & RF2-RF3, Measured at 25 C



Package Drawing



1. DIMENSIONS AND TOLERANCES CONFORM TO ASME Y14.5M–1994 & JEDEC PUB 95 DESIGN GUIDE 4.18
2. THE TOLERANCE 'aaa' IN THE TABLE ABOVE DOES NOT CONFORM TO JEDEC PUB 95 DESIGN GUIDE 4.18

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	

Bump Coordinates

0.0, 0.0 at die center

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

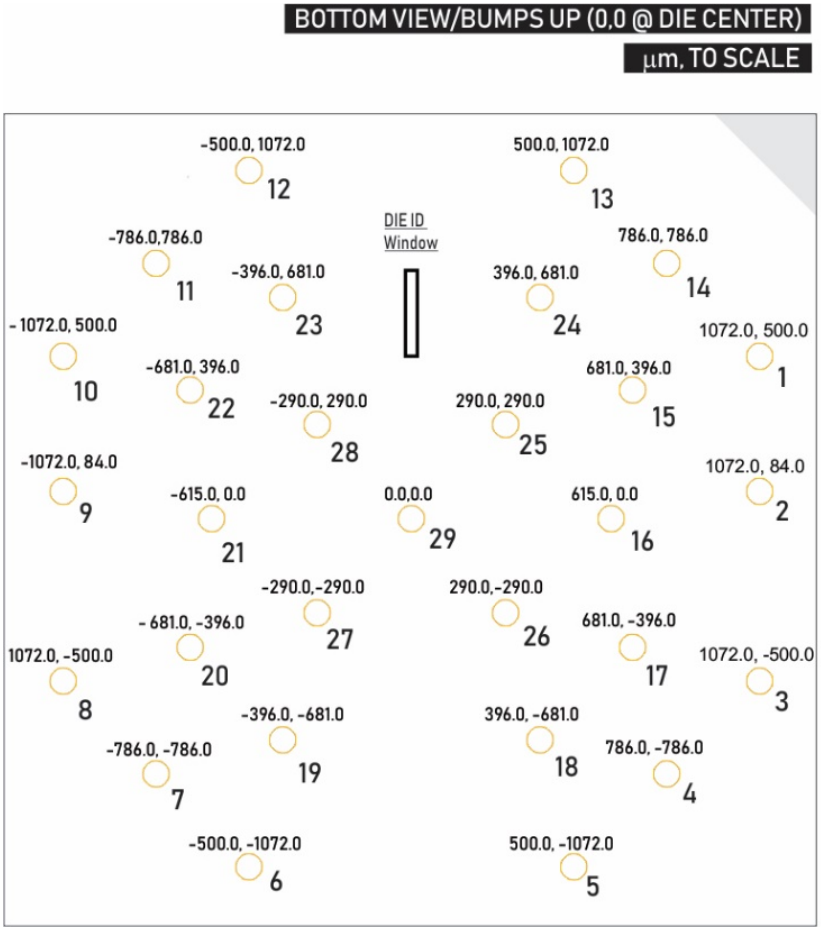


Figure 2: Bump Coordinates

Recommended PCB Layout

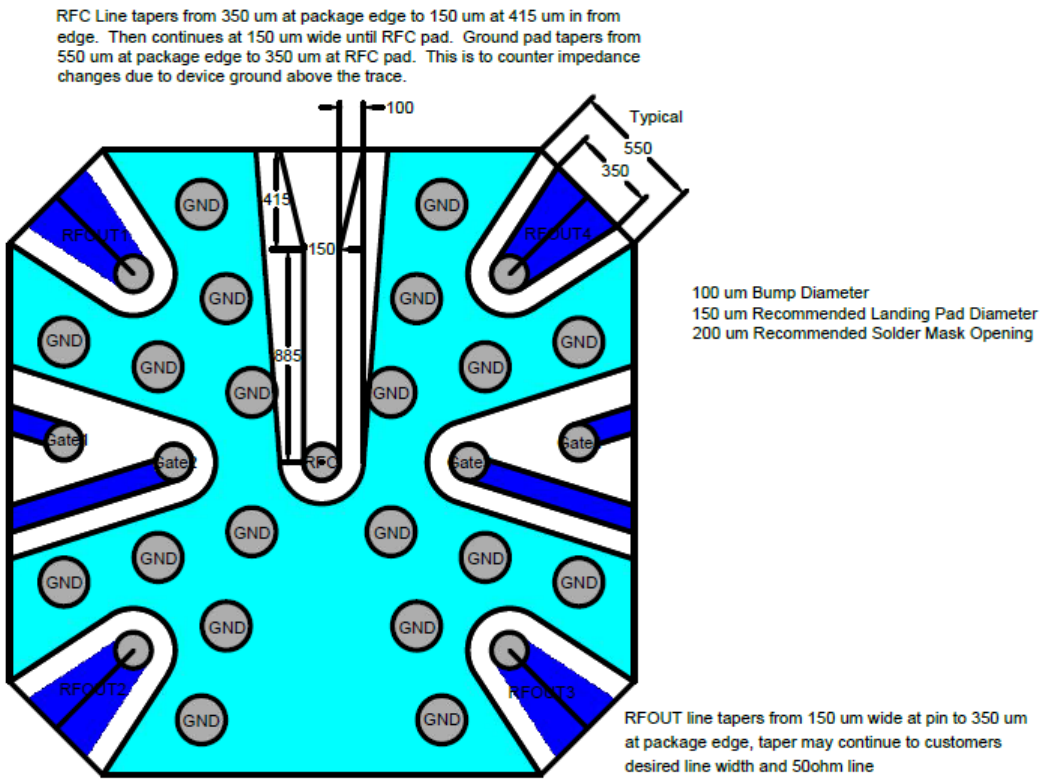
Layout recommendation for connecting the MM5130 with coplanar RF line or grounded coplanar line as used for the MM5130 evaluation board.

For the coplanar RF lines, it is recommended to taper the line to fit the 150 um recommended landing pad while keeping the spacing to the ground metal constant and identical to the spacing used for the line.

In those two examples (Normal SP4T Mode and Super-Port Mode) a 4.0 mil/0.10 mm spacing is used. Recommended maximum solder resist thickness 20 um. Routing of the gate control lines is not critical for RF performance.

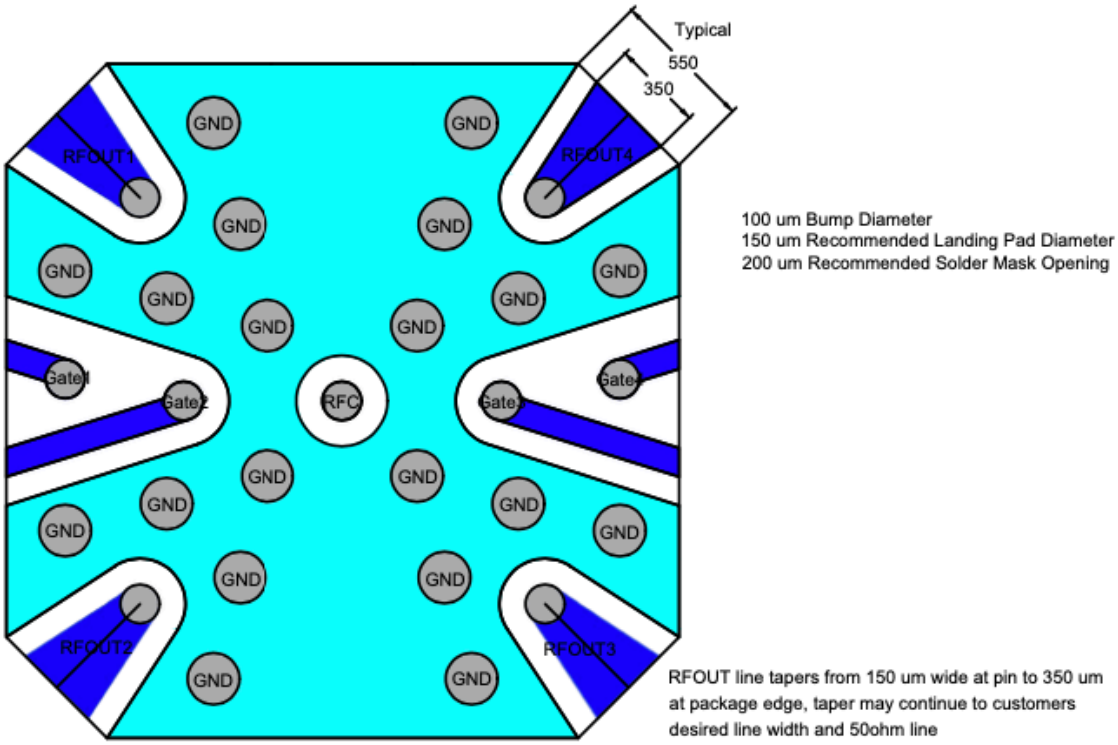
Normal SP4T Mode

Dimensions in um

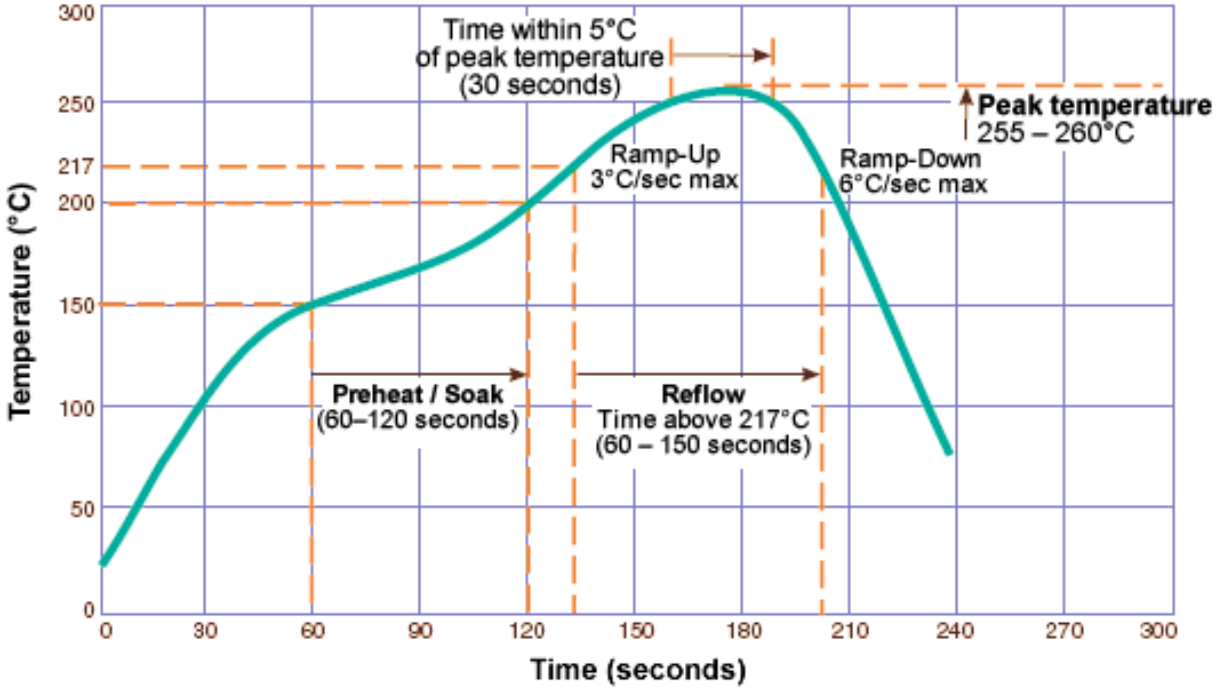


Super-Port Mode

Dimensions in um



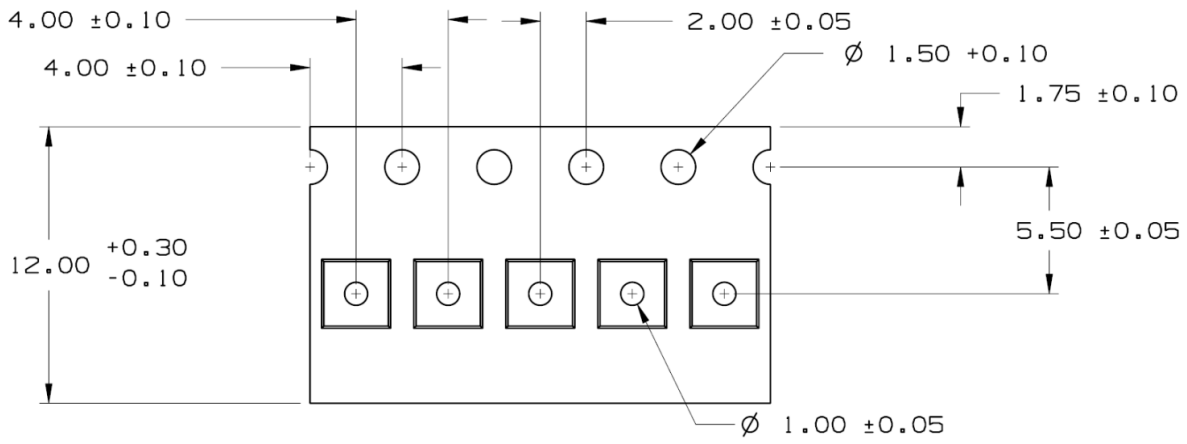
Recommended Solder Reflow Profile



For detailed information on soldering the MM5130, please refer to application note: “WL-FC Assembly Instrunctions”

- *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.*

Tape & Reel Details



Package Options and Ordering Information

Part Number	ECCN	Package	Temperature Range
MM5130-03	EAR99	2.5 mm x 2.5 mm 29 pin WL-FC	-40°C to +85°C
MM5130-03C	EAR99	2.5 mm x 2.5 mm 29 pin WL-FC	-40°C to +40°C
MM5130-03E	EAR99	2.5 mm x 2.5 mm 29 pin WL-FC	-40°C to +100°C
MM5130EVK1	EAR99	Evaluation Board MM5130 10 GHz	
MM5130EVK5	EAR99	Evaluation Board MM5130 18 GHz	

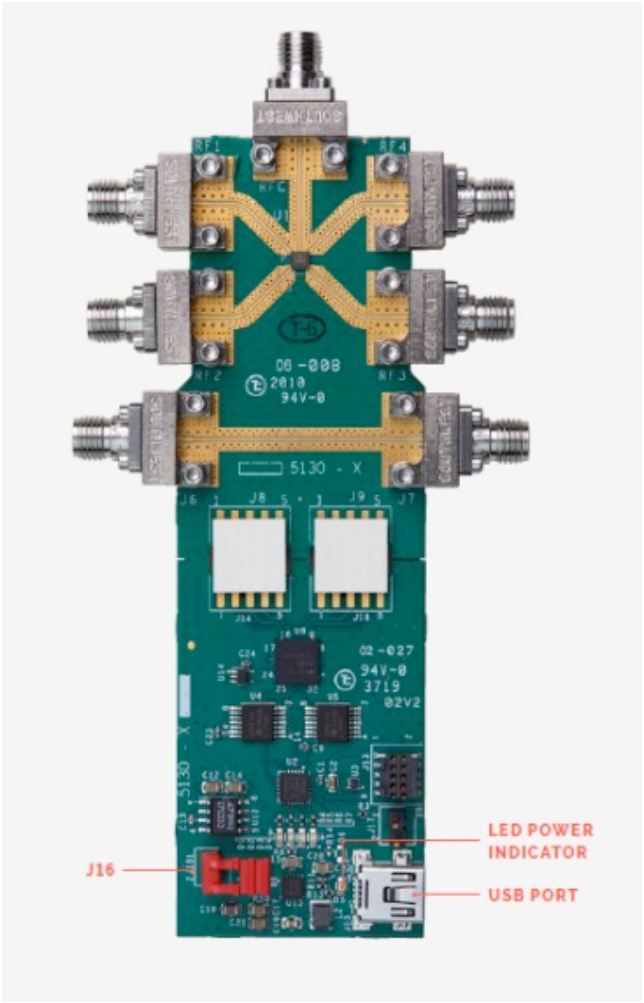


Figure 3:MM5130 EVK5 18 GHz Evaluation Board

Important Information

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2) 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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