

The Impact of MEMS-based RF Multiplexers for Next-Generation Test Systems

March 19, 2024



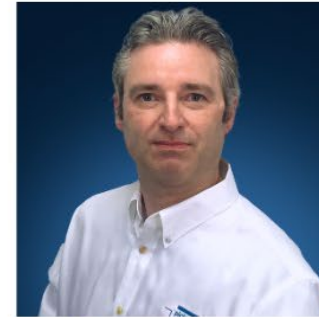
The Impact of MEMS-based RF Multiplexers for Next-Generation Test Systems

Panelists

The Impact of MEMS-based RF Multiplexers for Next-Generation Test Systems



Presented by:
Stewart Yang
Sr. RF Systems Applications Engineer,
Menlo Microsystems



Presented by:
Steven Edwards
Switching Product Manager,
Pickering Interfaces

March 19, 2024
8am PT / 11am ET

Organized by:

GlobalSpec

How Ideal Switch[®] Works – The Unit Cell

Technology platform with breakthrough innovations in materials and processing

Contact **Beam** **Gate**

TGV **Glass Cap**

Beam **Contact** **Gate**

Bump **Beam** **Contact** **Gate**

50µm x 50µm

Glass Substrate

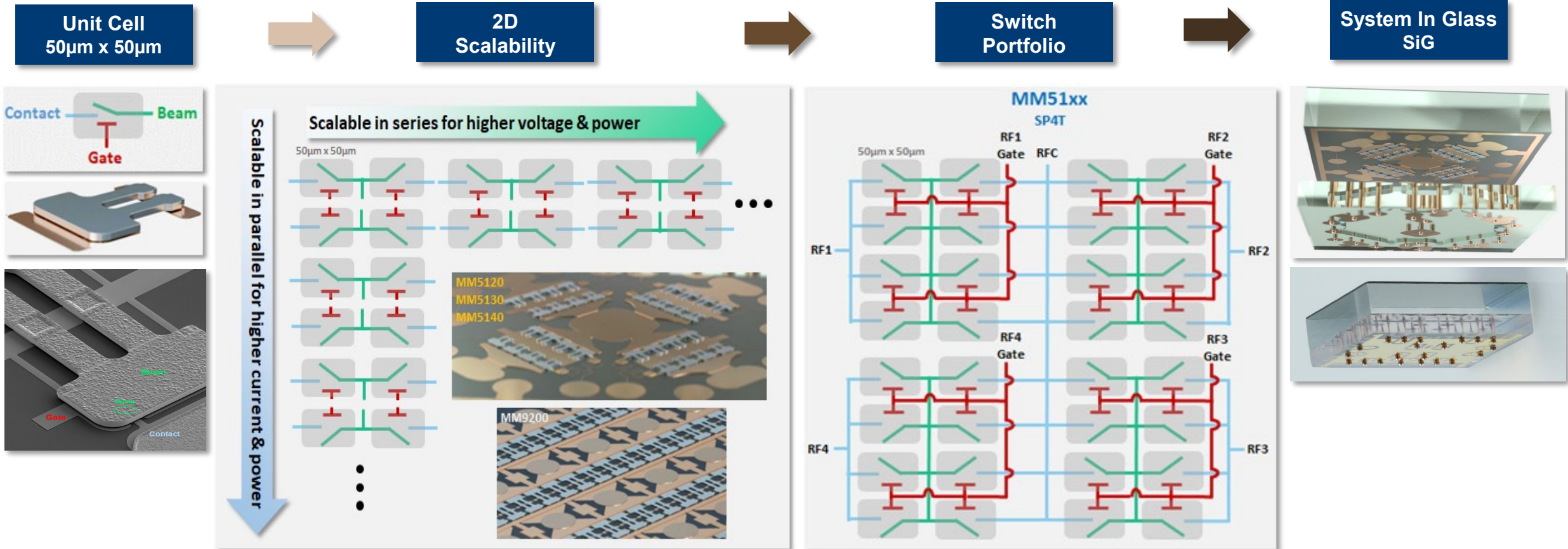
Unique Glass Packaging
Improved RF & thermal performances
High RF power handling

Through-Glass-Via
Low parasitics and resistance
Small-size package

High Reliability
>3B switching cycles
Hermetic-sealed package

Scalability
50µm x 50µm (unit cell)
Scalable switch arrays for high voltage, high current, high power

Scalable Switch Arrays With Ideal Switch[®]



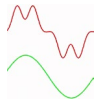
Advantages of Ideal Switch®



- **High RF power handling** – up to 25 W (CW) /150 W (Pulsed)
vs solid-state



- **Low insertion loss** – less than 1 dB
vs solid-state



- **High linearity** – unmatched >90 dBm IP3
vs solid-state and electromechanical



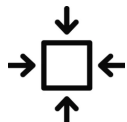
- **Fast Switching** – less than 20 μ s
vs electromechanical



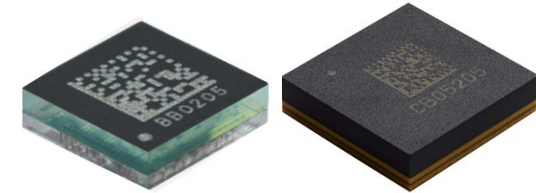
- **Long life** – minimum 3 billion switch cycles
vs electromechanical



- **Low DC power** – from 0.1 mW to less than 10 mW
vs electromechanical and solid-state



- **Small size** – from 6 mm² to 22 mm² footprint
vs electromechanical



Low Cost of Ownership

Product Portfolio – High Frequency



	RF & Microwave			High-Speed Digital		
Model	MM5130	MM5120	MM5140	MM5600	MM5620	MM5622
Markets	Telecommunication, Wireless Aerospace & Defense, Test & Measurements			Semiconductor Test & Measurement, Automated Test Equipment, Aerospace & Defense Equipment		
Applications	Tunable & Programmable Filters, High-Power Low-Loss RF Switch Matrices, Programmable RF Beam Steering			High-Speed Digital SoC Loopback Testing, PCIe, DDR5, MIPI, USB-C, High-Speed Ethernet		
Switch Type	SP4T			DPDT	2x DP3T Diff AC Coupled	2x DP3T Diff DC Coupled
Frequency Range	DC – 26 GHz	DC – 18 GHz	DC – 8 GHz	40 Gbps	64 Gbps	64 Gbps
RF Power	25 W (CW), 150 W (pulsed)			---		
Insertion Loss	0.4 dB @ 6 GHz	0.4 dB @ 6 GHz	0.3 dB @ 3 GHz	1.3 dB @ 10 GHz	2.3 dB @ 16 GHz	2.3 dB @ 16 GHz
Linearity (IP3)	>90 dBm			---		
Control	Direct	SPI/GPIO	SPI/GPIO	Serial to Parallel I/F	SPI/GPIO	SPI/GPIO
DC Supply	89 V (gate)	3.3 V (control), 5 V (V _{CP})	3.3 V (control), 5 V (V _{CP})	5 V (control), 89 V (gate)	3.3 V (control), 5 V (V _{CP})	3.3 V (control), 5 V (V _{CP})
Lifetime	>3B cycles			> 3B cycles		
Package	2.5 mm x 2.5 mm WLCSP	5.2 mm x 4.2 mm LGA		8 mm x 8 mm LGA	8.2 mm x 8.2 mm LGA	8.2 mm x 8.2 mm LGA
Availability	In production			In production		Samples: Q2 2024 Production: Q3 2024

Product Portfolio – Signal Relay and Power



	Signal Relay	Drivers and Smart Power	
Model	MM1205	MM101	MM9200
Markets	Test & Measurement, Wireless Charging, Scientific & Medical, Telecommunication	All	Industrial Automation, Sustainable Buildings Transport Electrification, Solid-State Circuit Breaker & Relay
Applications	High-Density Switch Matrices, Test & Measurement, Mechanical & PhotoMOS Replacement	All	LV Industrial Controls Solid-State & Electromechanical Relay Replacements
Switch Type	6x SPST	High voltage CP & 8-channel driver	SPST
DC Current	1 A per channel, 2 A per device		10 A (AC or DC), 10 mΩ
DC Carry/Standoff Voltage	30 V/100 V	---	300 V (AC or DC)
Frequency Range	DC – 3 GHz	---	---
Control	SPI/GPIO	SPI/GPIO	Direct
DC Supply	3.3 V (control), 5 V (V _{CP})	3.3 V (control), 5 V (V _{CP})	90 V (gate)
Lifetime	>3B cycles	---	1B cycles
Package	8 mm x 8 mm LGA	5 mm x 5 mm QFN 1.6 mm x 2.4 mm WLCSP	5 mm x 5 mm WLCSP 6 mm x 6.5 mm QFN
Availability	In production	In production	Samples: Available Production: Q4 2024

Product Roadmap

Driving and accelerating product roadmap from customers applications

Current Product Portfolio

Future Product Roadmap

RF & MICROWAVE SWITCHES

MM5130
DC-26GHz
25W, SP4T

MM5120
DC-12GHz
SP4T w/CP

MM5230
DC-26GHz
25W, SP4T

MM5170
DC-40GHz
SP4T

MM58xx
SPDT, 70GHz+

MM5140
DC-8GHz
SP4T w/CP

MM1205
DC-3GHz
6xSPST

MM5815
400W RF Limiter
SPST

MM5600
40Gbps
DPDT

MM5620
64Gbps
Diff. Loop.
AC Coup.

MM5622
64Gbps
Diff. Loop.
DC Coup.

MM56xx
128Gbps+

- Higher frequency, isolation
- Smaller form factor
- Higher reliability

HIGH SPEED DIGITAL SWITCHES

- Higher data rate (beyond PCIe 6...)
- Smaller form factor, higher density
- Custom/multichip switch configurations

RF & MICROWAVE REFERENCE DESIGNS

MM4xxx
DC-18GHz
Switch Matrix
Systems

MM60xx
DC-18GHz
Switched &
Tunable Filters

MM61xx
DC-18GHz
TDU, Phase
Shifters

Integrated subsystems:
Wideband TDU, Miniature
filter banks

- System-in-package (SiP) heterogeneous integration with RF/digital/mixed signal ICs
- 3D glass integration with passive devices

SMART AC/DC POWER SWITCHING

MM9200
25mm²
400V/10A
<10mohm, SPST

MM93xx
16mm²
>400V/10A
<10mohm, SPST

MM94xx
10mm²
>400V/10A
<10mohm, SPST

MM9xxx
Smart Monitor
Protect Control

- Higher voltage & current
- Smaller die size: higher power density & lower Ron/mm²
- Integrated smart protection devices with embedded sensing and control

Website Resources – Menlo Micro and GlobalSpec

Additional product support and documentation on website

- Users can sign up by clicking on “Login” and then “Request Access”

<http://www.menlomicro.com>

- Access Menlo’s product information through GlobalSpec website

<https://www.globalspec.com/supplier/profile/MenloMicro>



Resources

What's New

Video Tutorials

All Products >

RF Switches

MM5620 64 Gbps High-Speed Differential Switch	MM5130 26 GHz SP4T RF Switch
MM5120 18 GHz SP4T RF Switch	MM5600 40 Gbps High-Speed Differential Switch
MM1205 6 Channel SPST High Frequency Signal Relay	MM5140 8 GHz SP4T RF Switch



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Announcements

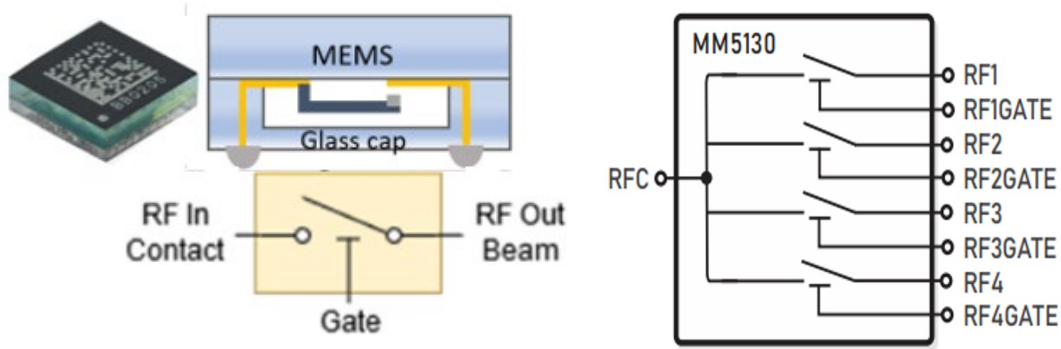
Technical Articles

Product Catalog

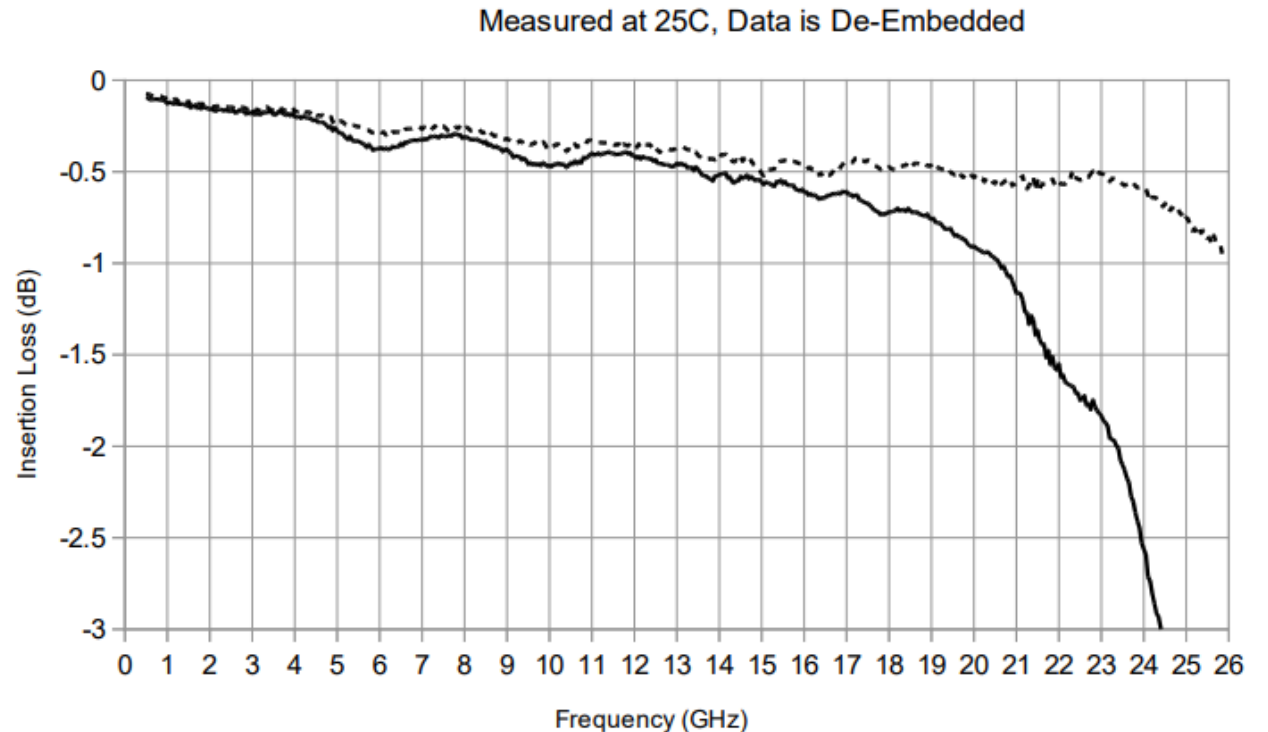
 Delay Lines (1 Product)	 Electromechanical Relays (1 Product)
 Gate Drivers (1 Product)	 High Voltage Relays (2 Products)
 Matrix Switching Systems (1 Product)	 RF Band Pass Filters (1 Product)



MM5130 – DC to 26 GHz High Power RF Switch



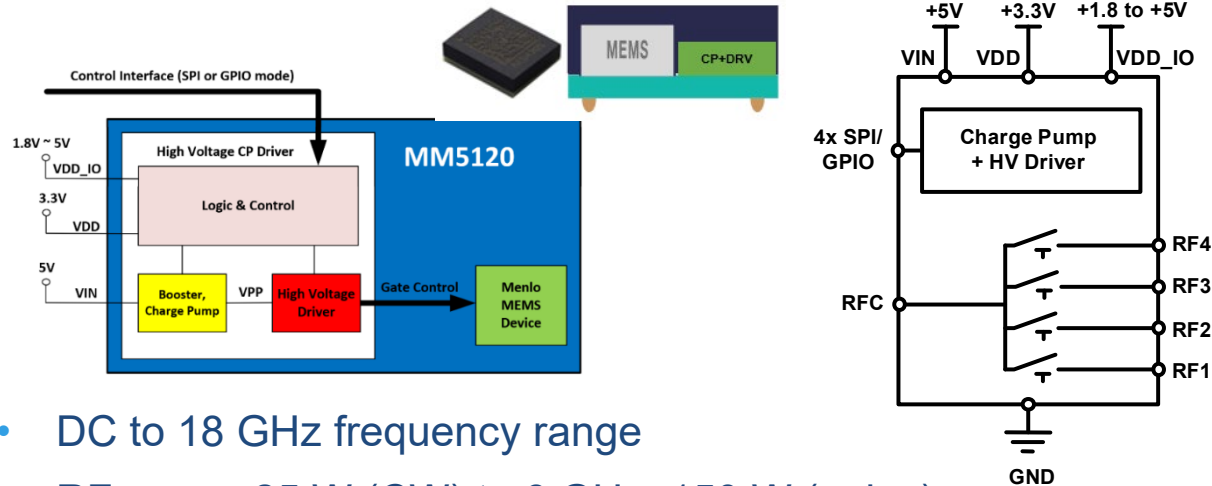
- DC to 26 GHz (super-port) and 18 GHz (standard-port) frequency range
- RF power 25 W (CW) to 6 GHz, 150 W (pulse)
- High linearity IP3 >90 dBm
- <0.8 dB on-state insertion loss @ 18 GHz (super port)
- High reliability >3B switching cycles guarantee
- 2.5 mm x 2.5 mm WLCSP
- Key Application: Test and measurement, aerospace & defense, tunable filters, switch filter bank, antenna tuners, phase shifters, time delay units, digital attenuators



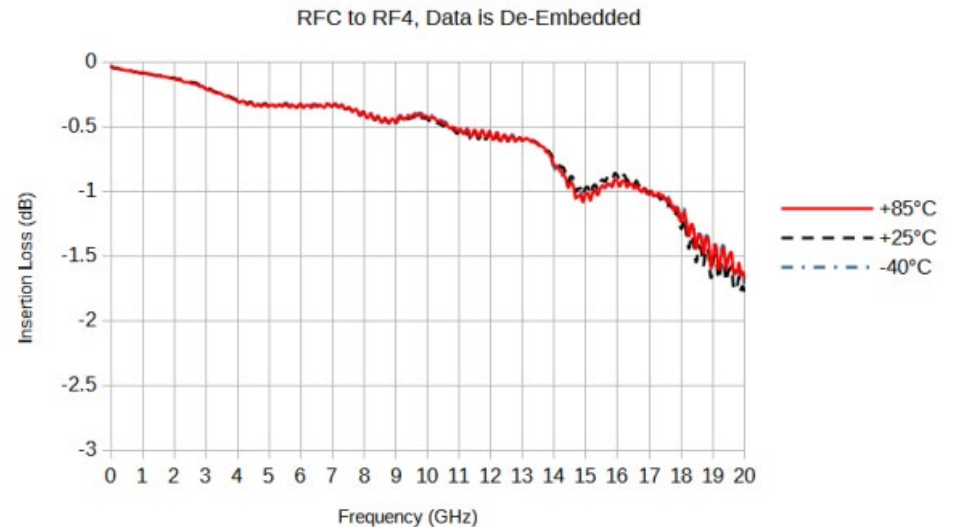
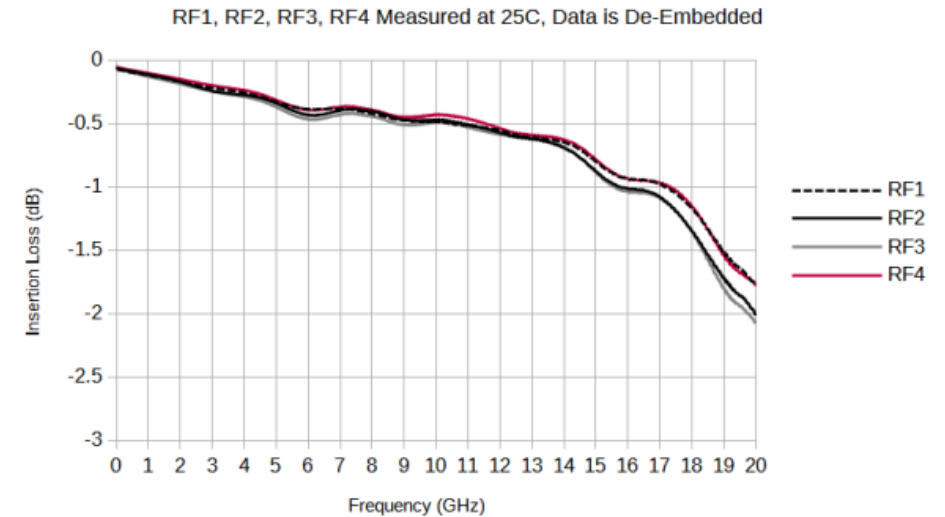
Insertion Loss (Super-Port Configuration)

[Menlo MM5130 Datasheet \(menlomicro.com\)](https://www.menlomicro.com/datasheet/MM5130)

MM5120– DC to 18 GHz SP4T RF Switch



- DC to 18 GHz frequency range
- RF power 25 W (CW) to 6 GHz, 150 W (pulse)
- High linearity IP3 >90 dBm
- 0.7 dB on-state insertion loss @ 12 GHz
- Integrated high-voltage driver
- High reliability >3B switching cycles
- 5.2 mm x 4.2 mm LGA
- Key Applications: Test and measurement, aerospace & defense, tunable filters, switch filter bank, antenna tuners, phase shifters, time delay units, digital attenuators, and network I/O modules, high-performance RF switching.



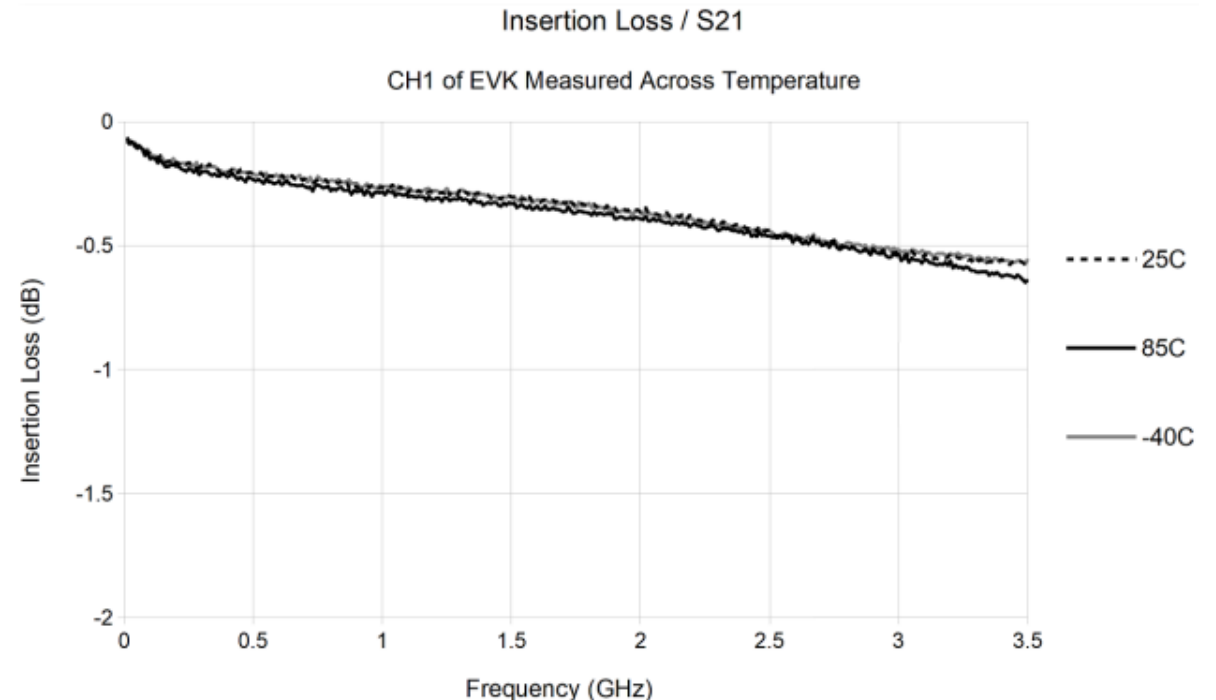
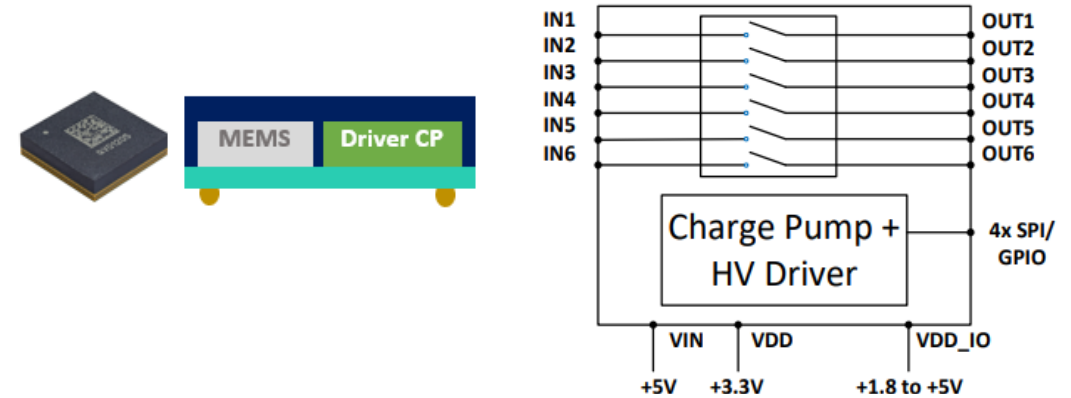
[Menlo MM5120 Data Sheet \(menlomicro.com\)](https://www.menlomicro.com/data-sheet/mm5120)

[Menlo MM5140 Data Sheet \(menlomicro.com\)](https://www.menlomicro.com/data-sheet/mm5140)

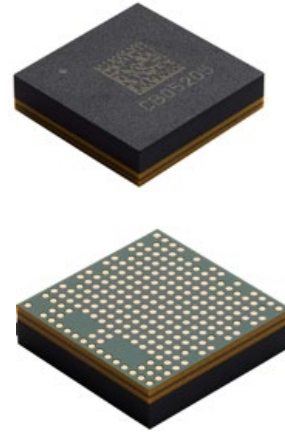
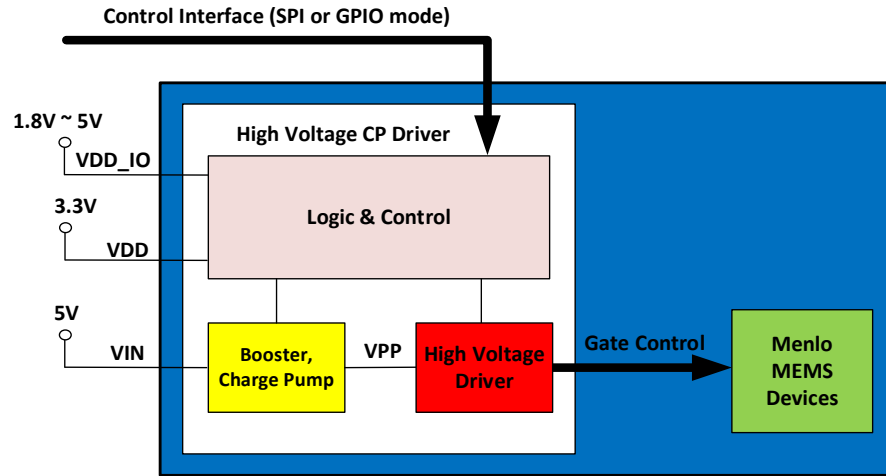
MM1205 – 6 Channel SPST High Frequency Signal Relay

- DC to 3 GHz frequency range
- 1 A per channel on-state DC carry current, 2 A per package
- Up to 30 V per-channel on-state DC carry voltage
- ~1.0 Ω on-state resistance (per channel)
- RF power 25 W (CW) to 300 MHz, 2000 W (pulsed)
- Low on-state insertion loss 0.5 dB @ 3 GHz
- 17 dB input to output off-state isolation @ 3 GHz
- Switching + settling time 17 μ s
- Integrated high-voltage driver
- High reliability >3B switching cycles
- 8 mm x 8 mm LGA package
- Key Applications: Test & Measurement, Broadcasting and Audio-Visual Equipment, Network I/O Relay Module

[Menlo MM1205 Datasheet \(menlomicro.com\)](https://www.menlomicro.com/datasheet/MM1205)

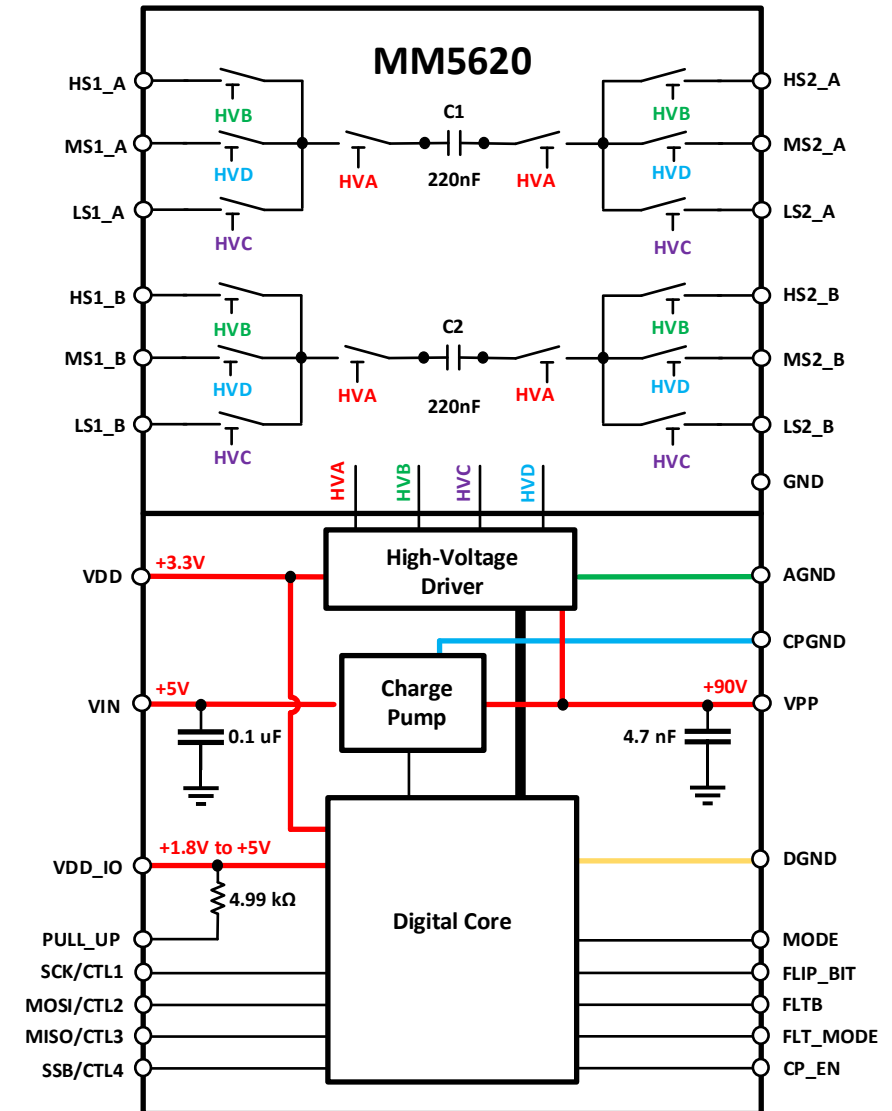


MM5620/MM5622 – 64 Gbps High-Speed Differential Switch



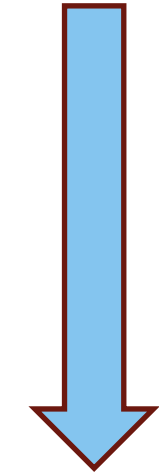
- Dual DP3T Differential Loopback Mode
- DC to 20 GHz range, support 64 Gbps
- Optimized for PCIe Gen 5 & 6, SerDes
- Integrated high-voltage driver
- High reliability >3B switching cycles
- 8.2 mm x 8.2 mm LGA
- Key Application: Test and measurement
- Road map: Smaller form factor, greater than 128 GT/s

[Menlo MM5620 Datasheet \(menlomicro.com\)](https://www.menlomicro.com/datasheet/MM5620)



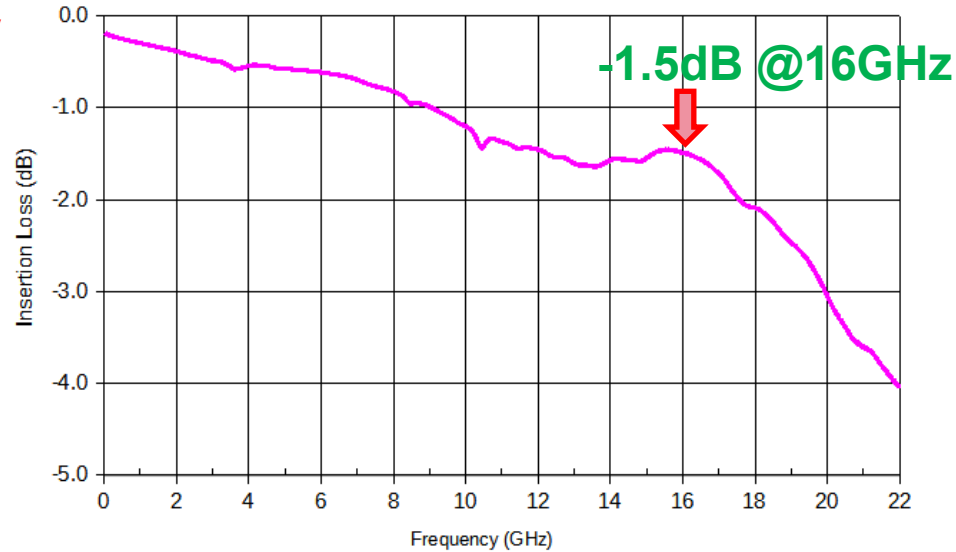
MM5620 S-Parameter Performance (HS1 to HS2 Signal Path)

Frequency Domain Analysis

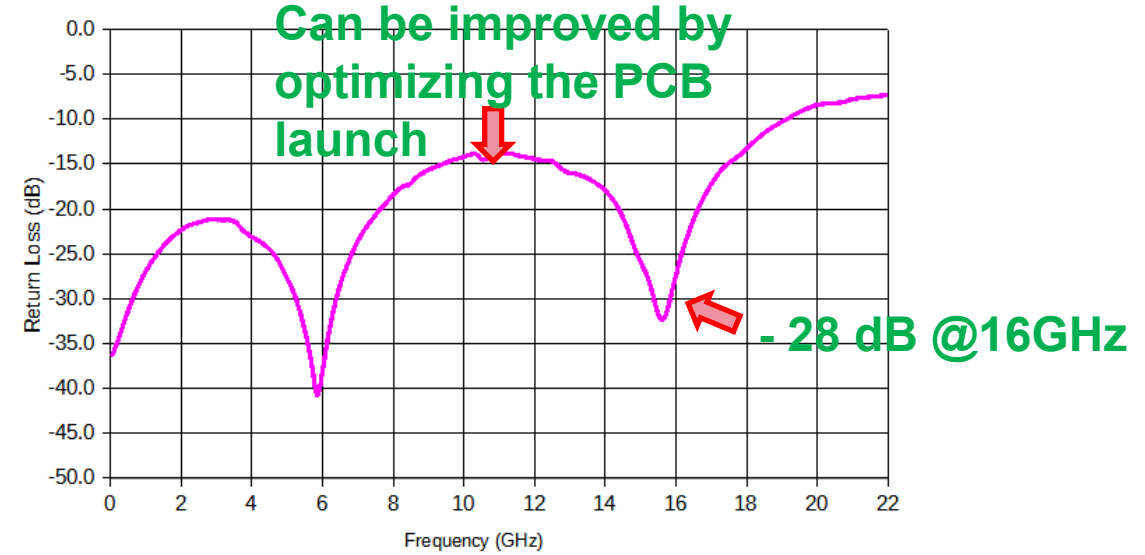


Time Domain Analysis

Insertion Loss / SDD21
MM5620 HS1 TO HS2, De-embedded

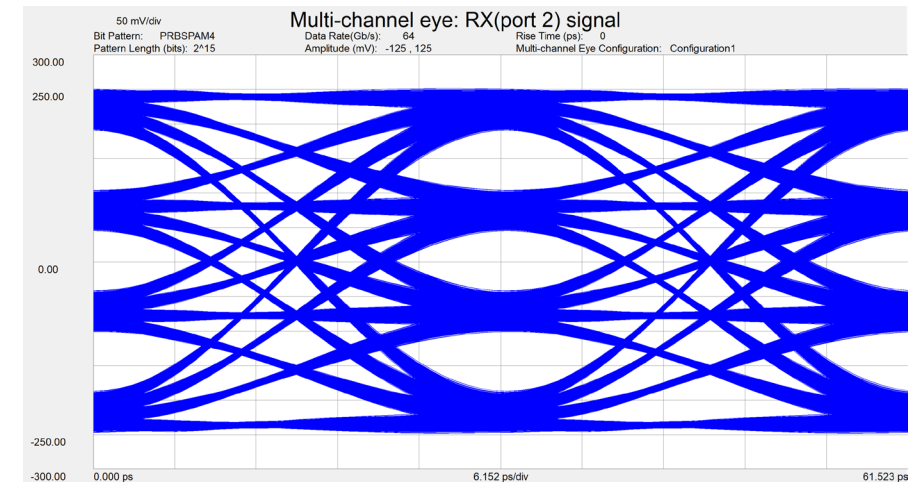


Return Loss / SDD11
MM5620 HS1 TO HS2, De-embedded

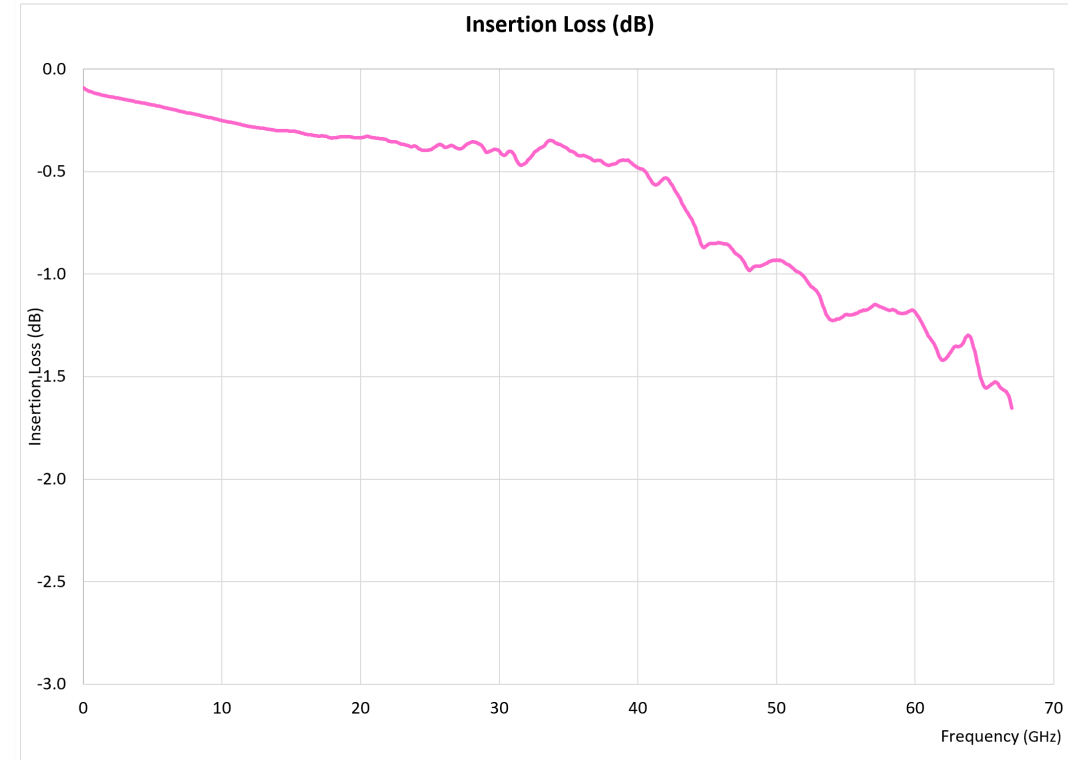
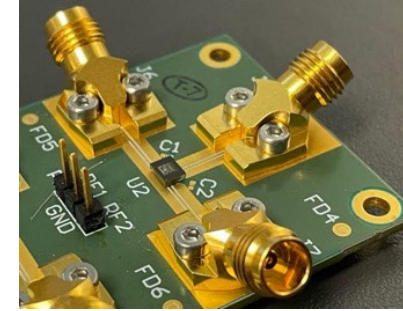
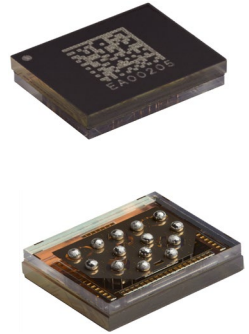
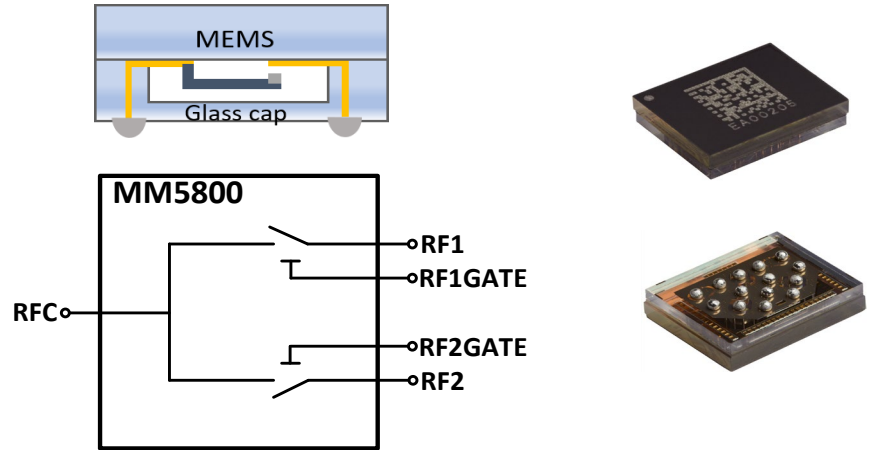


Eye-Diagram Test Conditions

- PCIe Gen6
- PAM4, 32 Gbaud (64Gbps), PRBS $2^{15}-1$
- 500mVpp (+250 mV/-250mV)

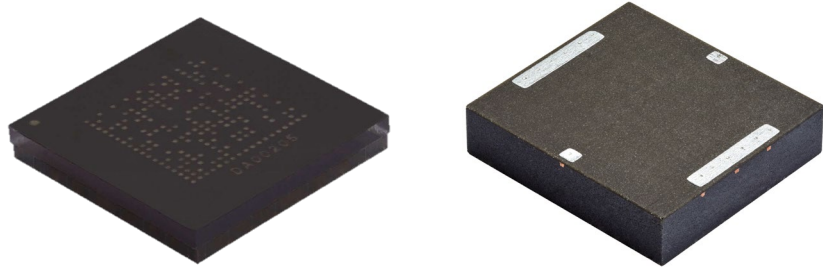


MM5800 - 70 GHz SPDT Millimeter Wave Switch



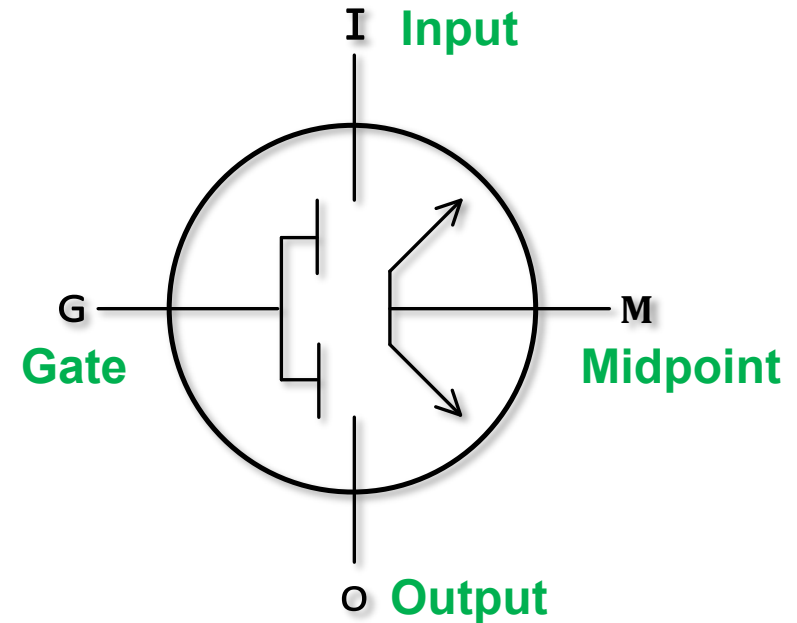
- Single SPDT: Small WL-CSP package
- Low-loss: 0.5dB @ 40 GHz
- High Isolation: 30 dB @ 40 GHz
- High Reliability: >3B switch cycles
- Key Application: Test and measurement

MM9200 – 300V/10A SPST Power Switch



- Low On-State resistance: <math>< 10 \text{ m}\Omega</math> over full temp range
- Off-State Contact Leakage Current: 5 pA (typical)
- Voltage standoff (AC peak or DC): 300V
- Rated continuous current (AC or DC): 10A RMS
- Fast switching time: 10 μ s to open, 10 μ s to close
- Low-profile 6.5 mm x 6.0 mm QFN package
- Key Application: Replacement of EMR & solid-state relays, solid state circuit breakers. Load controllers for buildings

[Menlo MM9200 Product Brief \(menlomicro.com\)](http://menlomicro.com)



Pin Name	Description
GATE (G)	Gate control to turn switch on/off, referenced to MIDPOINT pin.
MIDPOINT (M)	Beams Reference
INPUT (I)	Switch Input Pin
OUTPUT (O)	Switch Output Pin

Pickering – PXI/PXIe 50 Ω 4-Channel RF MEMS Multiplexers



One Slot



Performance Characteristics

What does the Pickering 40/42-878 offer to the user?

- **Speed of operation** (50 us)
 - EMR solutions, 3 ms (MEMS, 60x faster)
- **Long service life** (>3 Billion operations)
 - EMR solutions, 10 Million (MEMS, 300x improvement)
- **Very low insertion loss** (<1.4 dB to 4 GHz)
- **Increased frequency** (4 GHz Bandwidth)
 - EMR solutions, 3 GHz
- **Test system implications:**
 - Increases throughput
 - Minimizes downtime
 - Future-proofing



Technology Comparisons

How does MEMS compare to alternate RF Solutions?

Typical Characteristics

MEMS:

Best fit for long life, cold switch only with good RF characteristics (insertion loss, signal integrity), and best power handling capability.

EMR:

Best for general purpose, cost-effective, decent life, better tolerance to hot switching, good RF characteristics, and power handling capability.

Solid State:

Best for long (indefinite) life when used to spec, AC signals only, some hot switching, a high insertion loss, and low power handling capability.

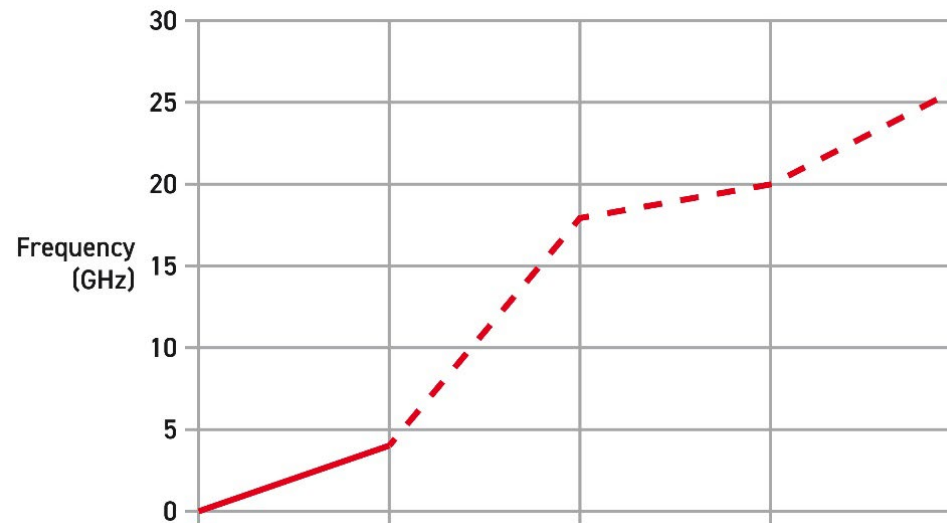
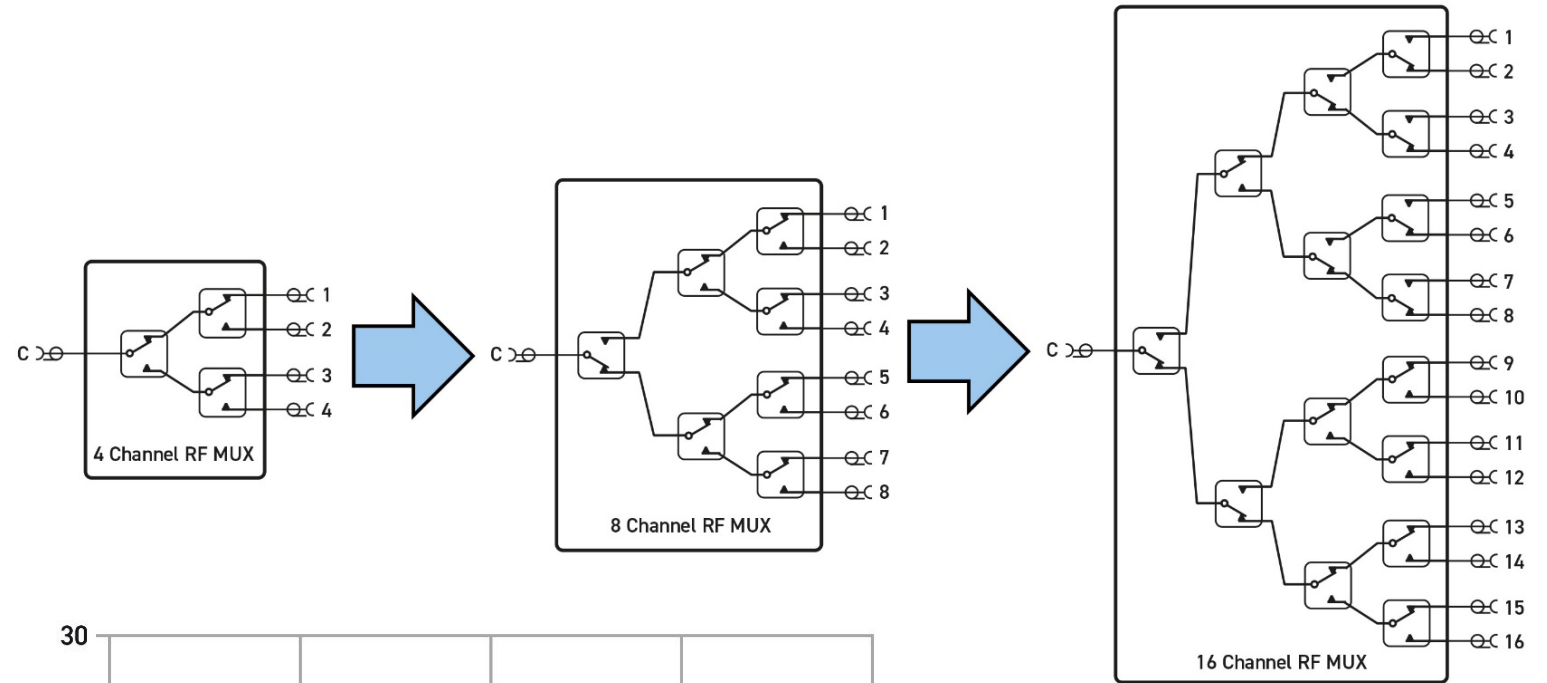
*All specifications relate to specific Pickering PXI & PXIe products.

	MEMS	EMR	Solid State
Frequency Range	DC to 4 GHz (usable to 5 GHz)	DC to 3 GHz	10 MHz to 8 GHz
Insertion Loss	<1.4 dB to 4 GHz	<1.0 dB to 3 GHz	<6.0 dB to 8 GHz
VSWR	<1.5:1 to 4 GHz	<1.4:1 to 3 GHz	<1.95:1 to 8 GHz
Max RF Power	25 W to 4 GHz	10 W at 3 GHz	4 W at 8 GHz
Operating Time	50 microseconds	3 milliseconds	50 microseconds
Life Expectancy	3 billion operations	10 million operations	Indefinite
Hot Switching	None	Better tolerance	Some tolerance
Price per channel normalized to EMR	1.3	1	1.9

Potential Developments

What Does The Future Hold?

- **Higher channel count multiplexers**
- **Alternate frequencies (to 26 GHz)**
- **Additional topologies**
 - Uncommitted
 - Matrix
 - Fault insertion
- **New applications**
 - Differential switching





Thank you.