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

March 19, 2024

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Panelists

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

Presented by:
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Menlo Microsystems

Presented by:
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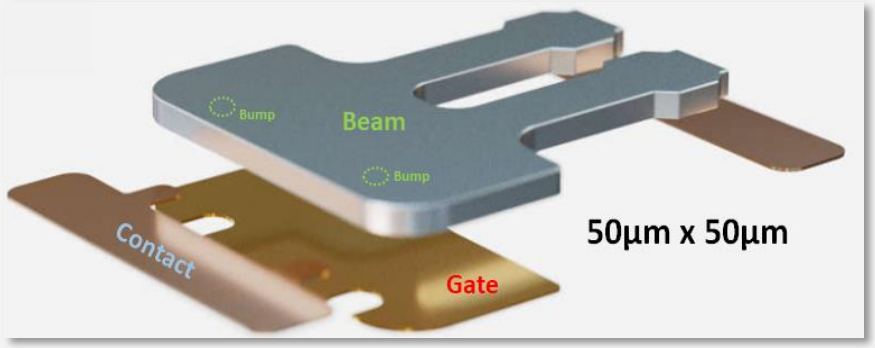
Pickering Interfaces

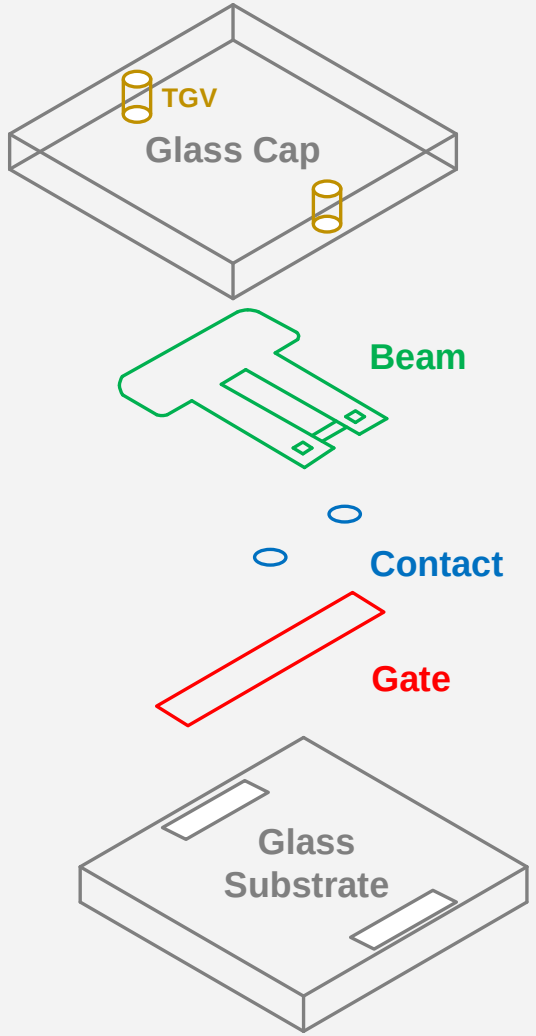
March 19, 2024
8am PT / 11am ET

Organized by:
GlobalSpec

How Ideal Switch® Works – The Unit Cell

Technology platform with breakthrough innovations in materials and processing





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

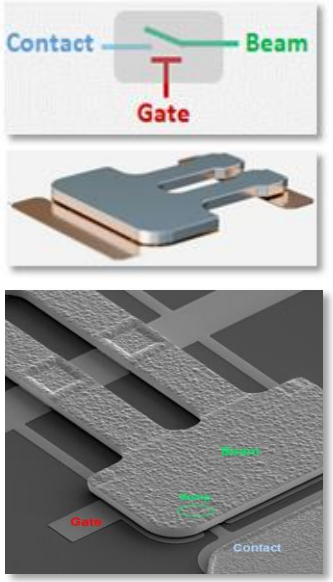
Scalability

50µm x 50µm (unit cell)

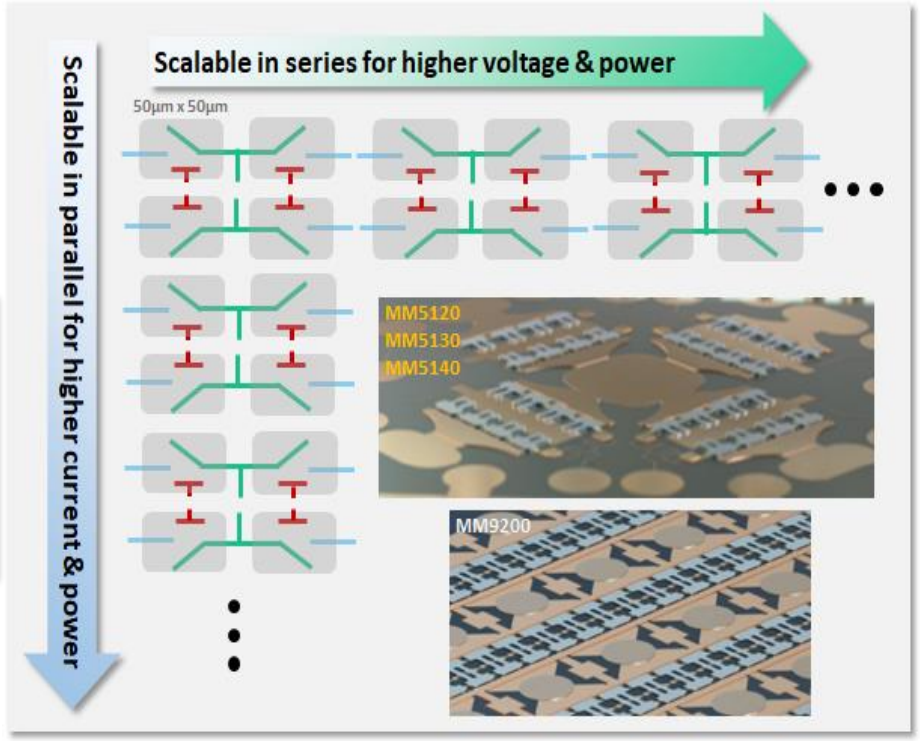
Scalable switch arrays for high voltage, high current, high power

Scalable Switch Arrays With Ideal Switch®

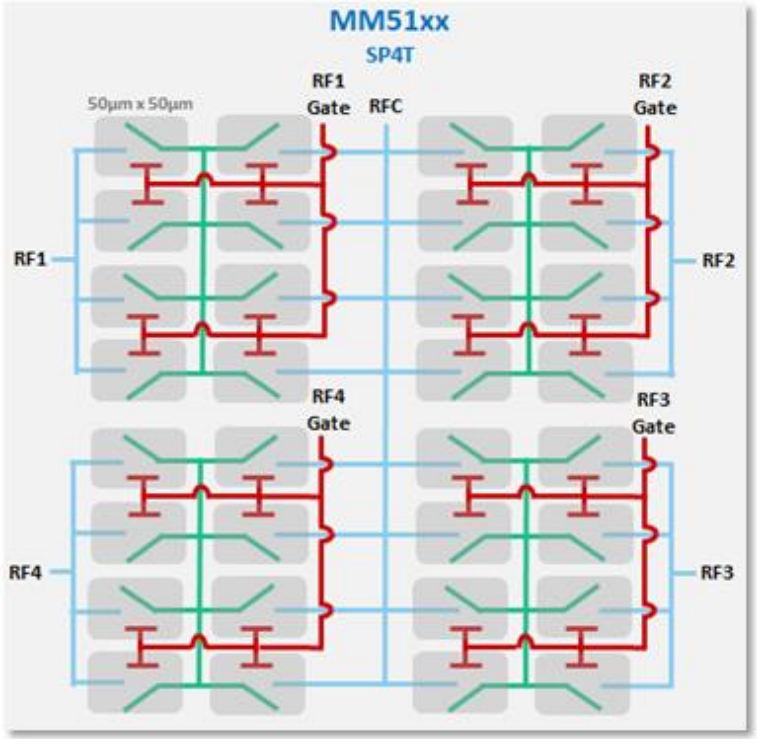
Unit Cell
50µm x 50µm



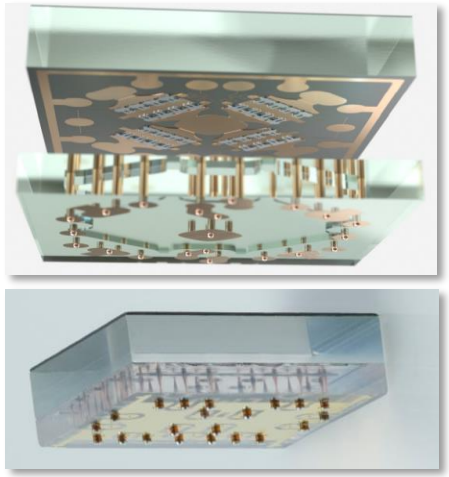
2D Scalability



Switch Portfolio



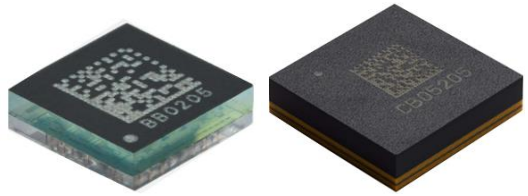
System In Glass SiG



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 µs
  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 mm^2 to 22 mm^2 footprint
  vs electromechanical

POWERED BY ideal switch™



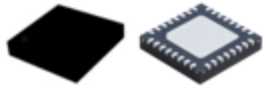
TCO

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	SPI*	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 – Power Management



	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

- Higher frequency, return loss, isolation
- Higher cycling lifetime at 85C°
- Lower noise figure

HIGH SPEED DIGITAL SWITCHES

MM5600
40Gbps
DPDT

MM5620
64Gbps
Diff. Loop.
AC Coup.

MM5622
64Gbps
Diff. Loop.
DC Coup.

MM56xx
128Gbps+

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

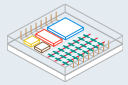
RF & MICROWAVE REFERENCE DESIGNS

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

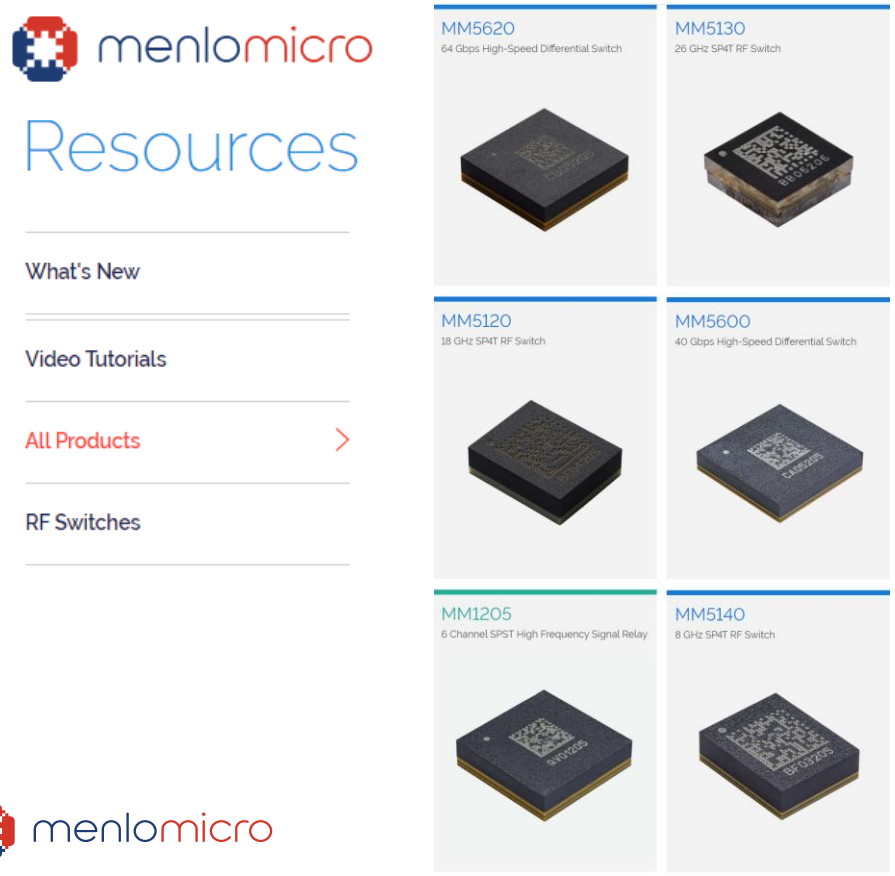
Additional product support and documentation on website

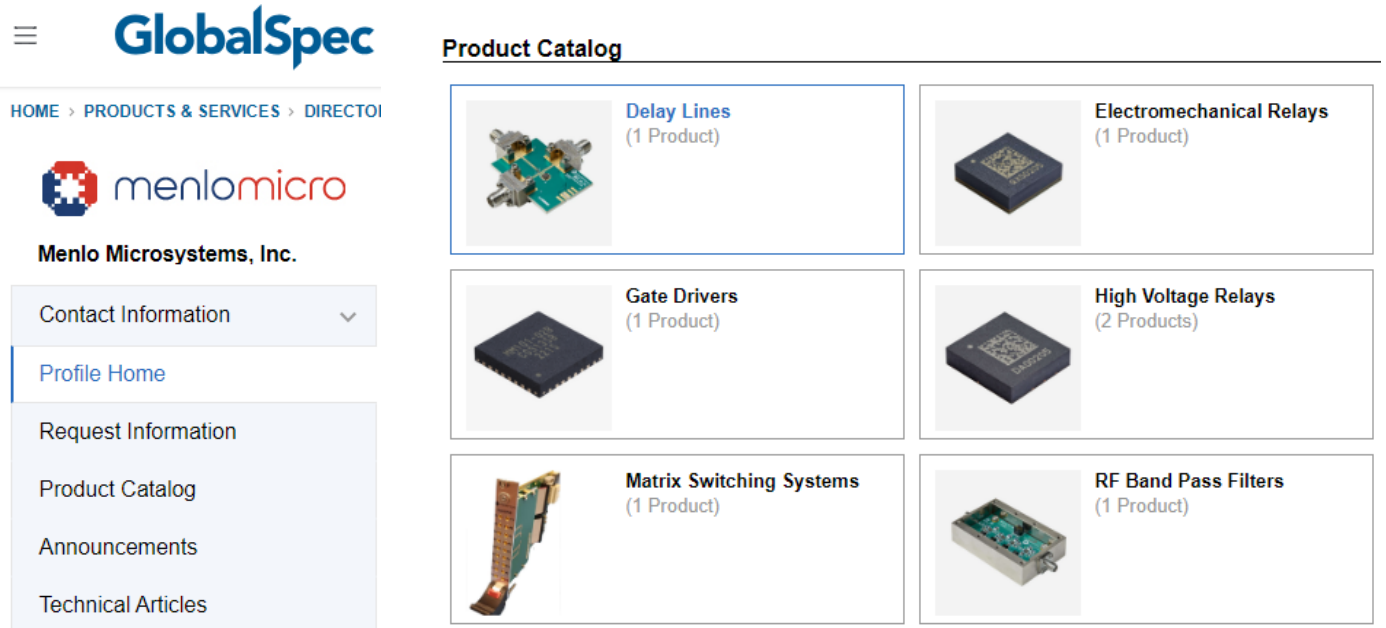
- **Users can sign up by clicking on “Login” and then “Request Access”**

  http://www.menlomicro.com

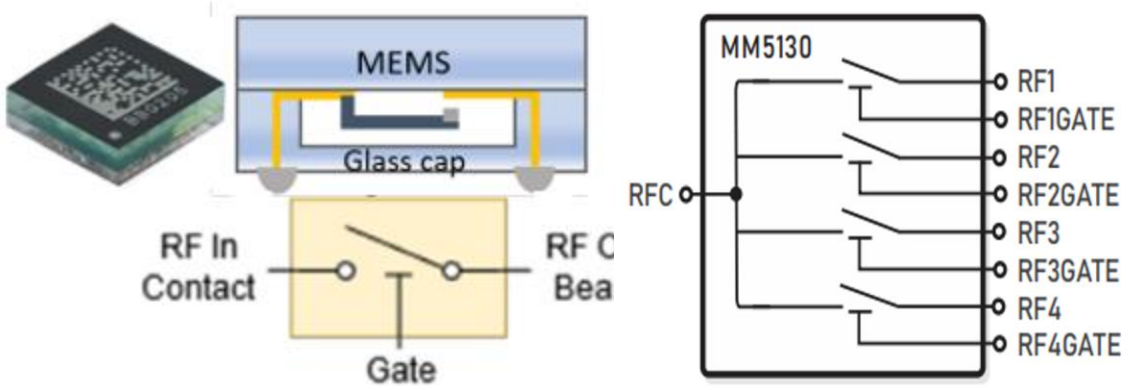
- **Access Menlo’s product information through GlobalSpec website**

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

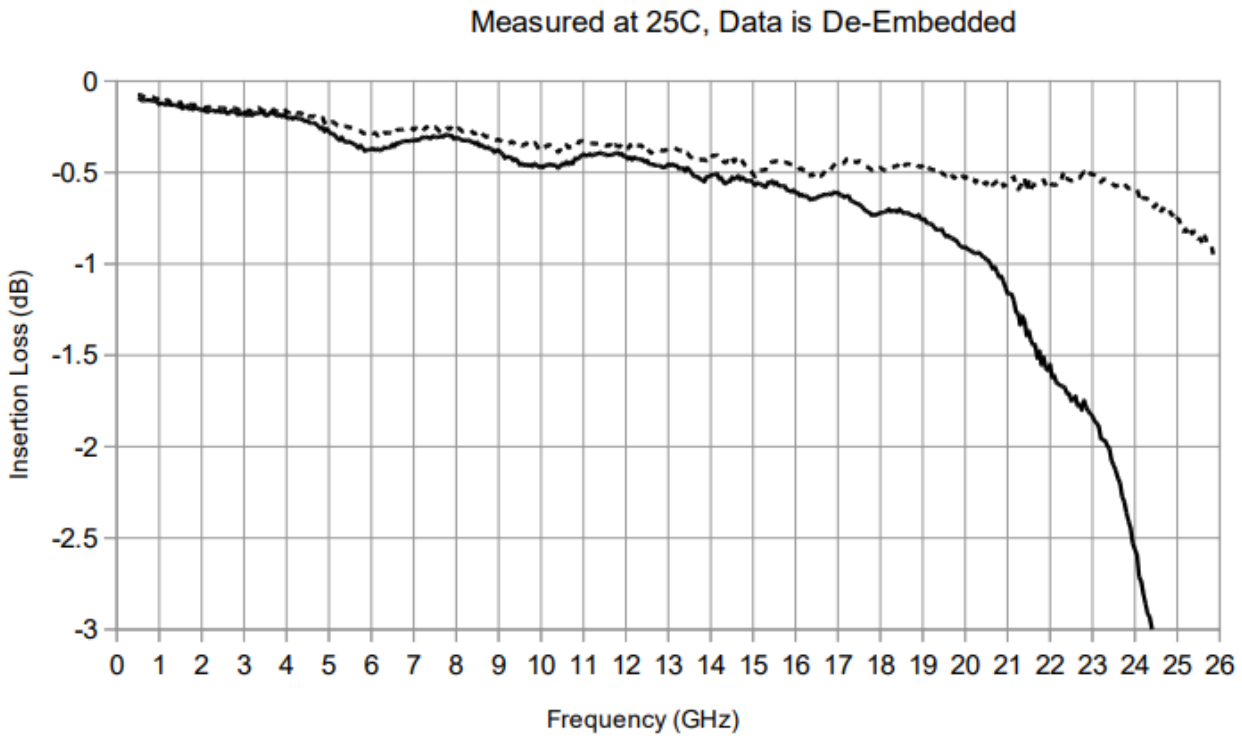




MM5130 – DC to 26 GHz High Power RF Switch



- 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)
- <30 dB isolation @ 18 GHz (super port)
- Power supply - requires 89 V gate control
- High reliability >3B switching cycles guarantee
- 2.5 mm x 2.5 mm WLCSP



Insertion Loss (Super-Port Configuration)

Menlo MM5130 Datasheet (menlomicro.com)

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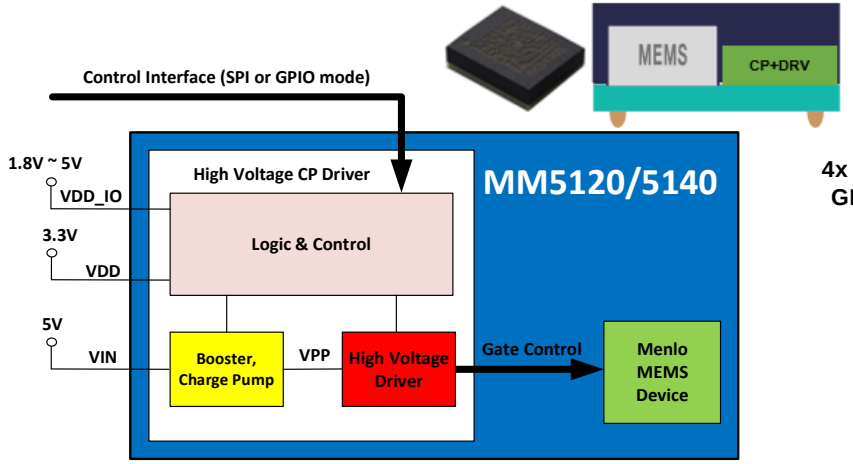
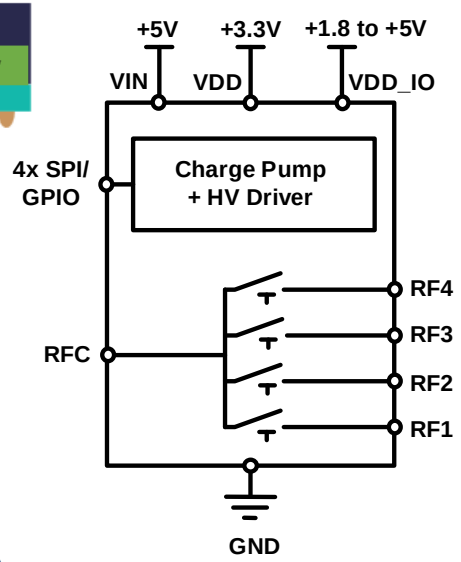
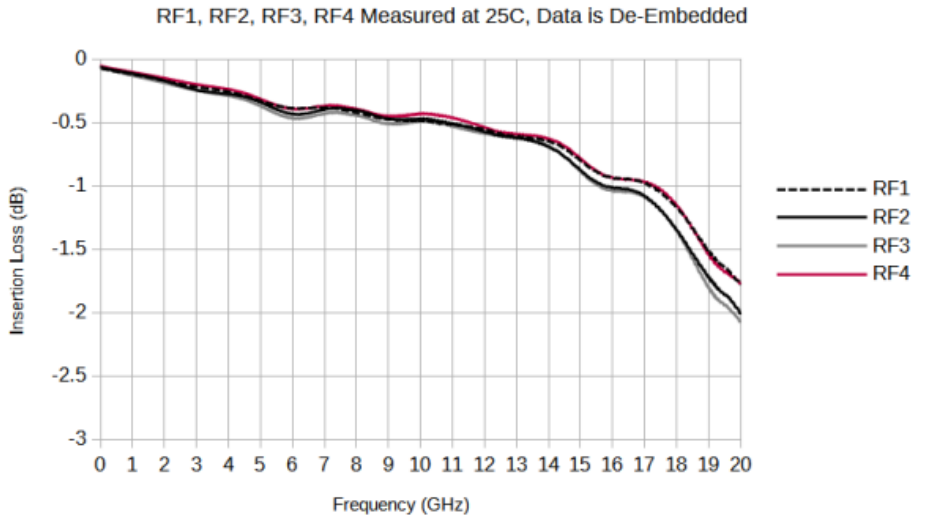
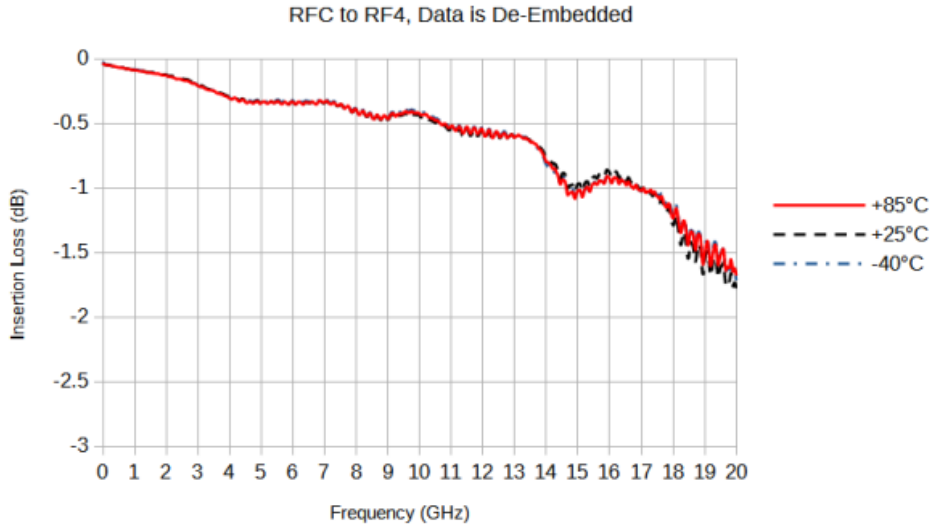
MM5120/MM5140– DC to 18/8 GHz SP4T RF Switch









- DC to 18 GHz frequency range
- RF power 25 W (CW) to 6 GHz, 150 W (pulse)
- High linearity IP3 >90 dBm
- 25 dB isolation @ 6 GHz
- 0.7 dB on-state insertion loss @ 12 GHz
- Integrated high-voltage driver
- Power supply 5 V (voltage booster) 3.3 V (driver)
- SPI and GPIO interface
- High reliability >3B switching cycles
- 5.2 mm x 4.2 mm LGA

[Menlo MM5120 Data Sheet (menlomicro.com)]

[Menlo MM5140 Data Sheet (menlomicro.com)]

menlomicro

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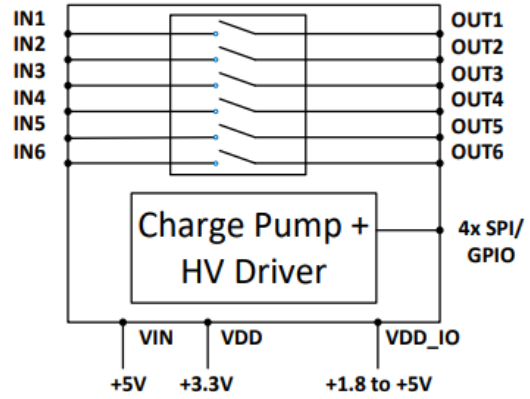
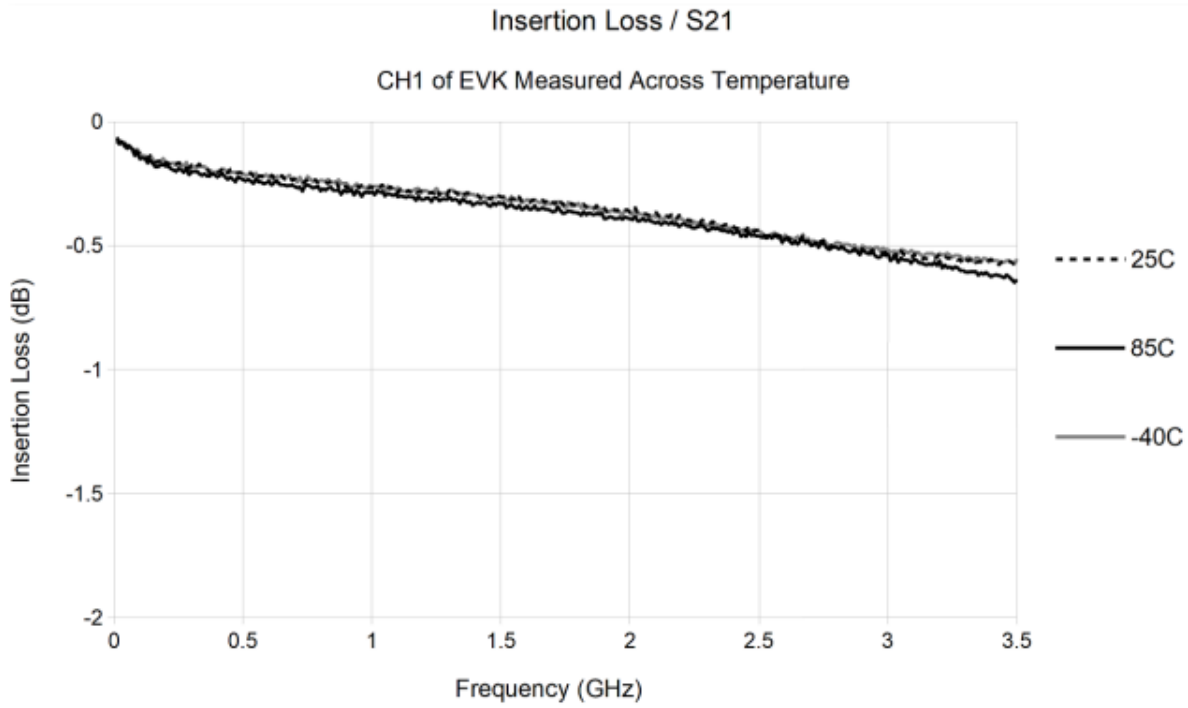
MM1205 – 6 Channel SPST High Frequency Signal Relay

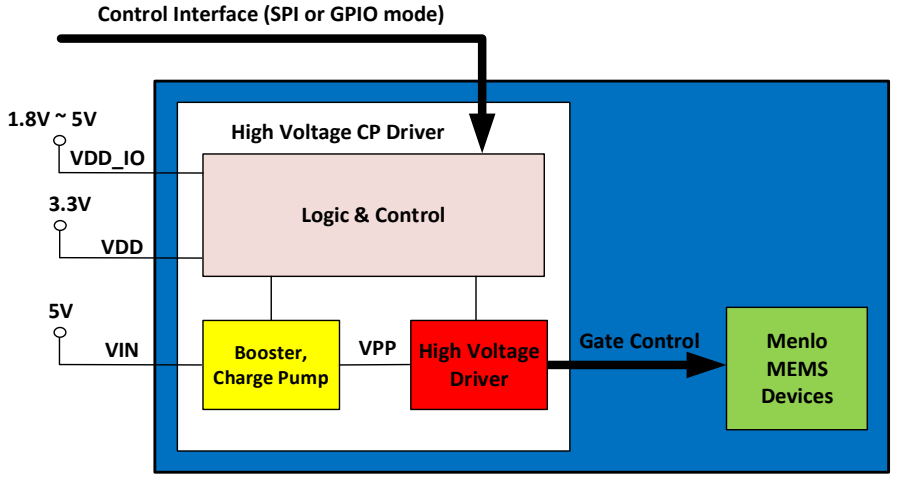
- DC to 3 GHz frequency range
- 1 A per channel on-state DC carry current, 2 A per package
- Up to 30 V per-channel on-state DC carry voltage
- ~1.0 Ω on-state resistance (per channel)
- RF power 25 W (CW) to 300 MHz, 2000 W (pulsed)
- Low on-state insertion loss 0.5 dB @ 3 GHz
- 17 dB input to output off-state isolation @ 3 GHz
- Switching + settling time 17 µs
- Integrated high-voltage driver
- Power supply 5 V (voltage booster) 3.3 V (driver)
- SPI and GPIO interface
- High reliability >3B switching cycles
- 8 mm x 8 mm LGA package

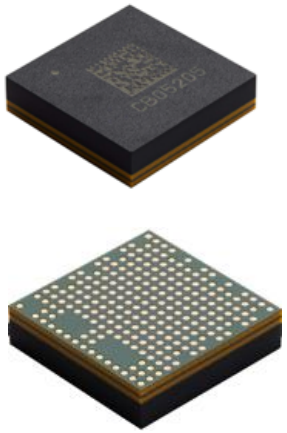
[Menlo MM1205 Datasheet (menlomicro.com)]



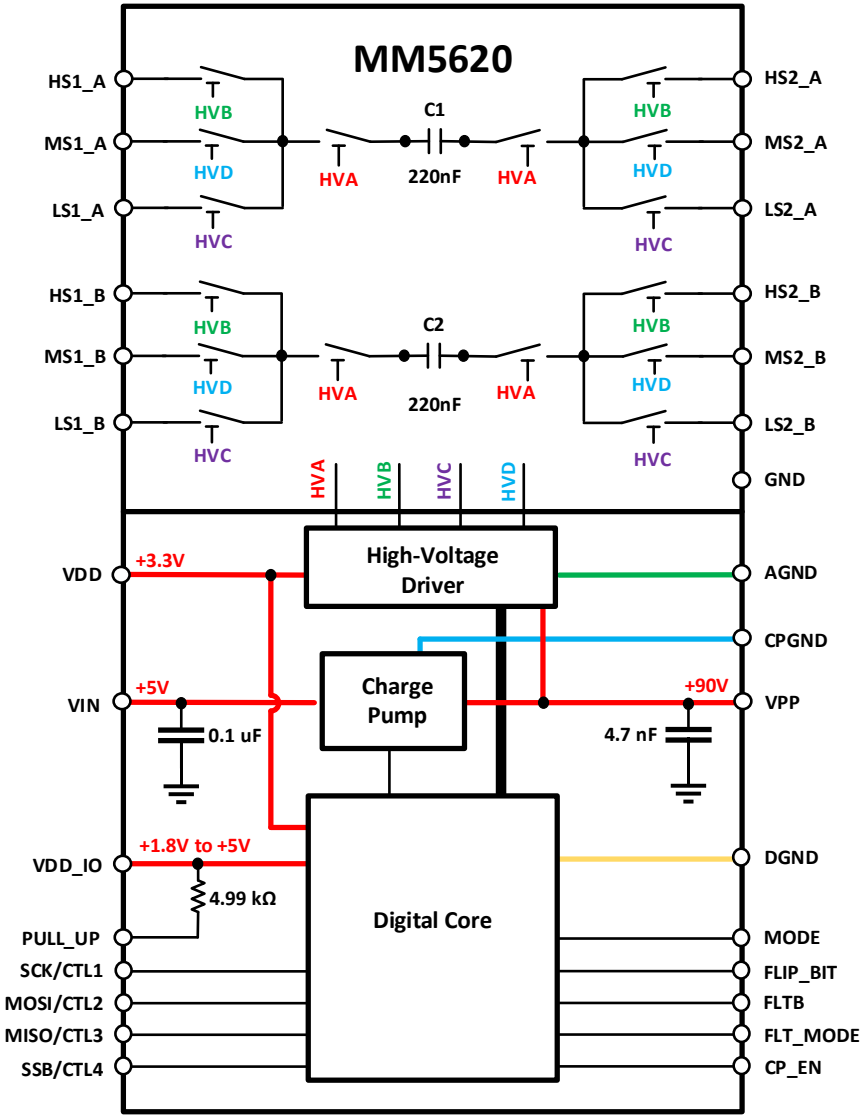


MM5620/MM5622 – 64 Gbps High-Speed Differential Switch





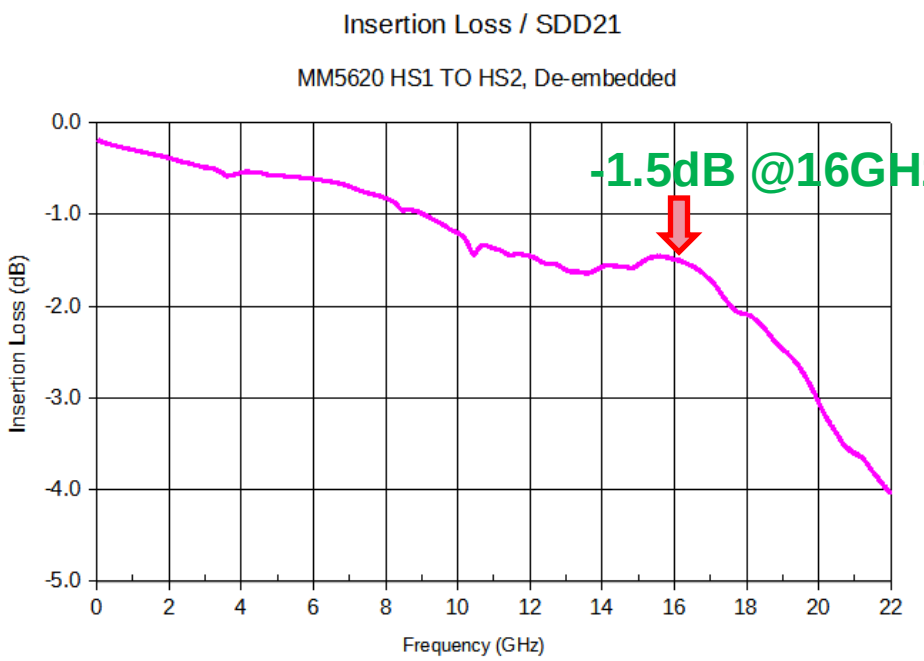
- Dual DP3T Differential Loopback Mode
- DC to 20 GHz range, support 64 Gbps
- Optimized for PCIe Gen 5 & 6, SerDes
- Built-in AC coupling capacitors (MM5620 only)
- Integrated high-voltage driver
- Power supply 5 V (voltage booster) 3.3 V (driver)
- SPI and GPIO interface
- High reliability >3B switching cycles
- 8.2 mm x 8.2 mm LGA

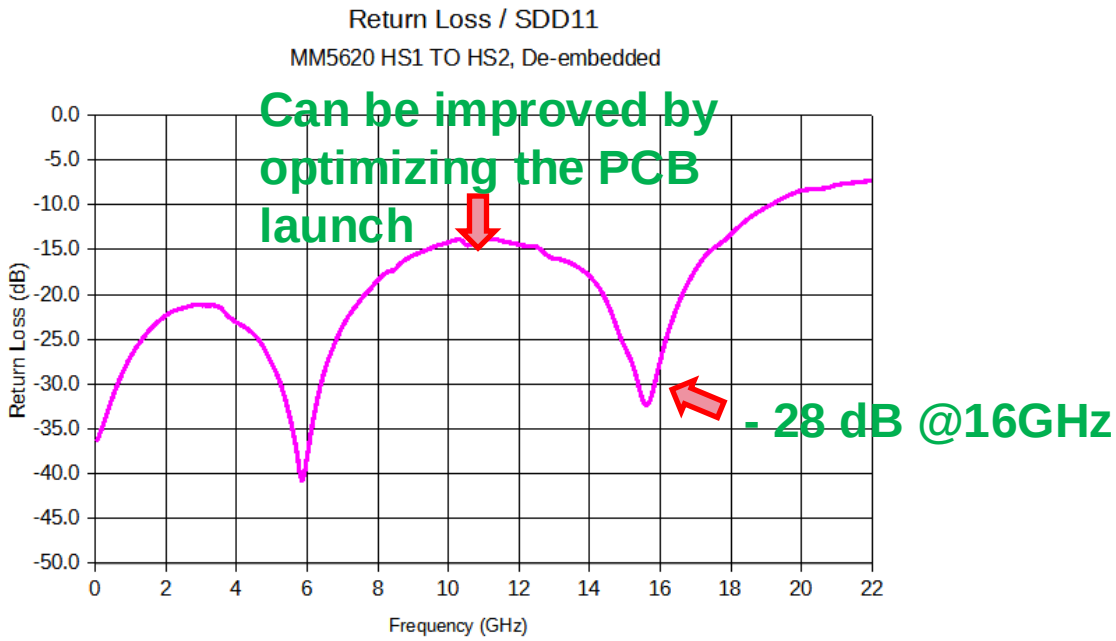


Menlo MM5620 Datasheet (menlomicro.com)

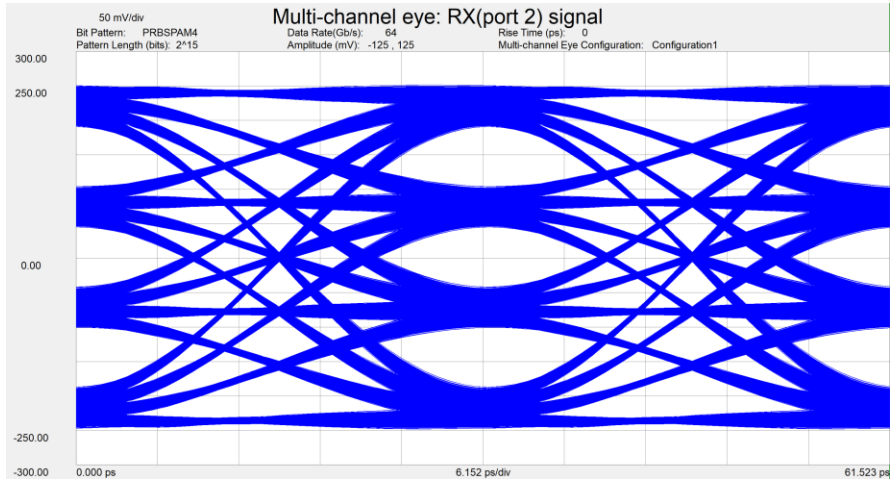
MM5620 S-Parameter Performance (HS1 to HS2 Signal Path)

Frequency Domain Analysis





Time Domain Analysis



Eye-Diagram Test Conditions

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

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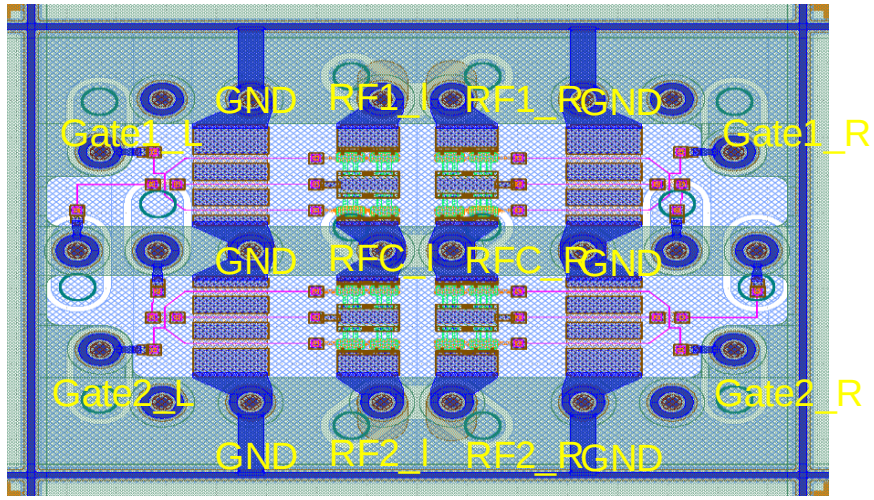
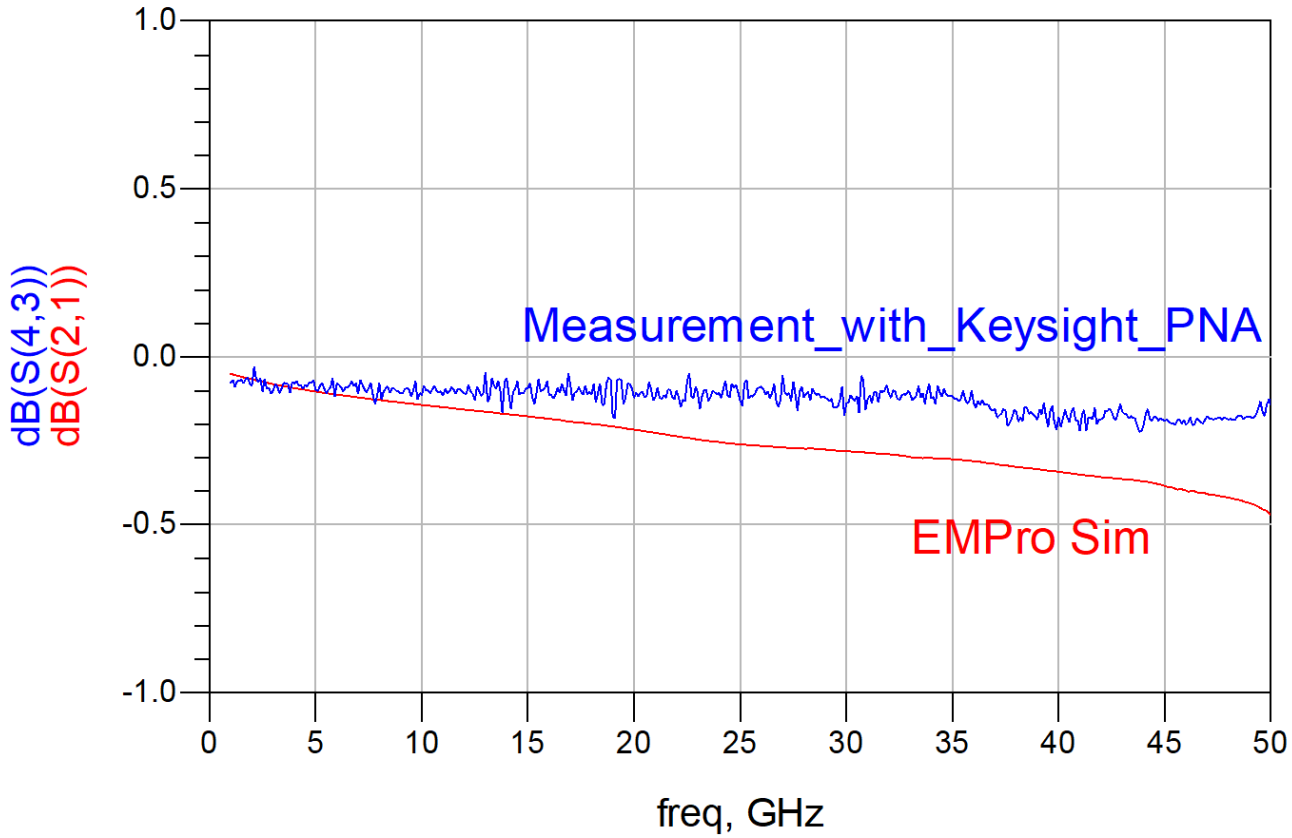
MM56xx – Next-Gen Single-Chip Differential SPDT < 10mm^2



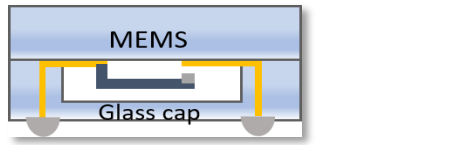
2 beam in parallel, 2 beam in series

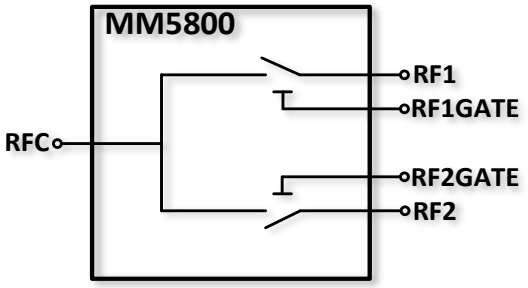
- Single DPDT (Differential)
- Target Package Size: 3.5 mm x2.8 mm
- Low-loss: <1dB @ ~60 GHz
- Low Return Loss: >15dB @ 50GHz
- High Isolation: >20 dB @ 50 GHz
- High Reliability: >3B switch cycles
- Hot-switching capable: +30dBm

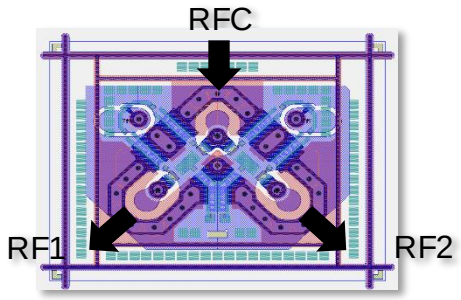


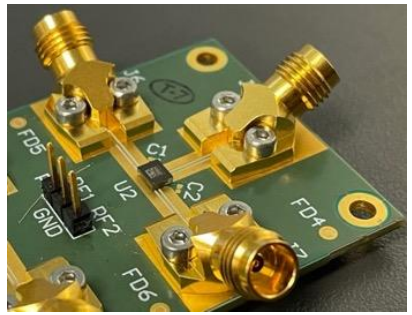
Differential Insertion Loss (Measurement vs Simulation)

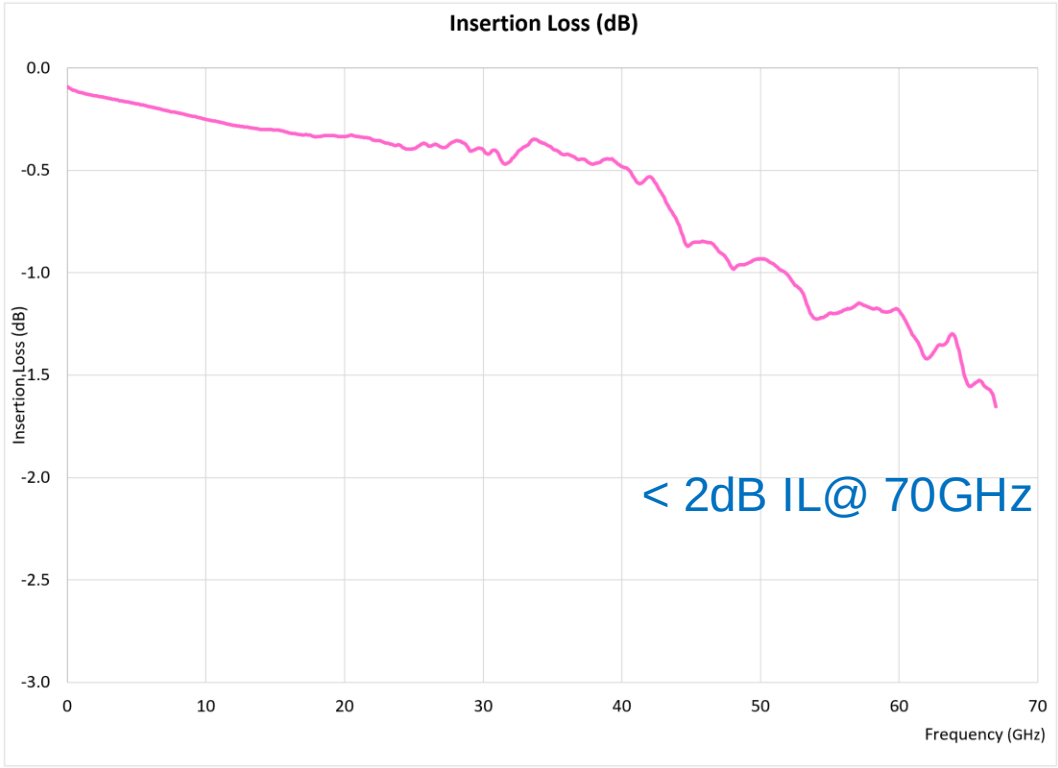
MM5800 - 70 GHz SPDT Millimeter Wave Switch





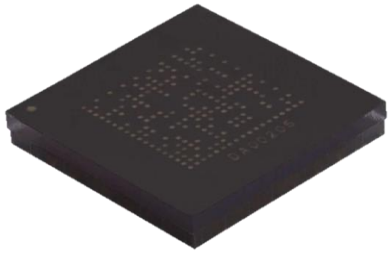


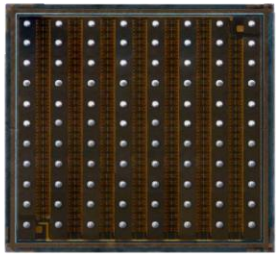


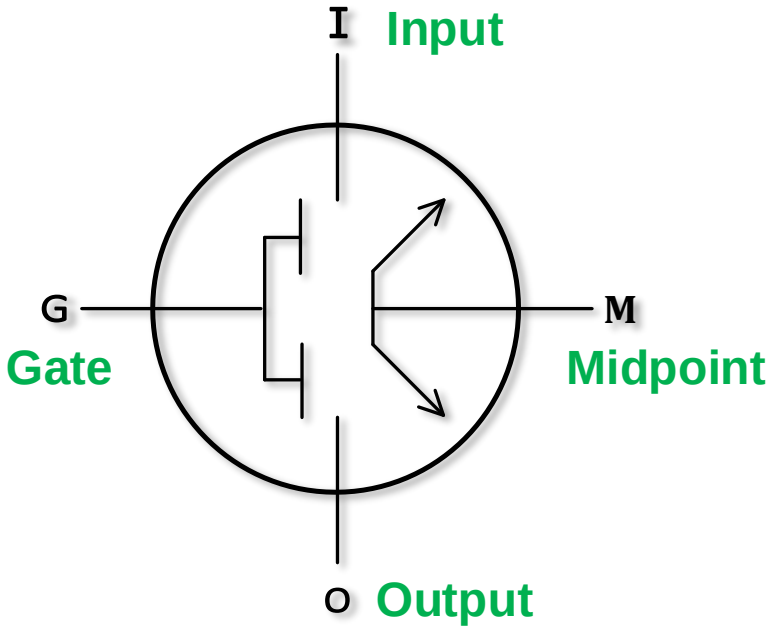


- Single SPDT: Small WL-CSP package
- Low-loss: 0.5dB @ 40 GHz
- High Isolation: 30 dB @ 40 GHz
- High Reliability: >3B switch cycles
- Hot-switching capable: +15dBm

MM9200 – 300V/10A SPST Power Switch







- Low On-State resistance: < 10 mΩ over full temp range
- Input to output off-state isolation: > 10 GΩ (typical)
- Voltage standoff (AC peak or DC): 300V
- Rated continuous current (AC or DC): 10A RMS
- Fast switching time: 10µs to open, 10µs to close
- Contact Actuation – requires 90 Vdc gate control
- High mechanical endurance: 100 million operations
- QFN and low-profile 6.5 mm x 6.0 mm WL-CSP

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

Menlo MM9200 Product Brief (menlomicro.com)

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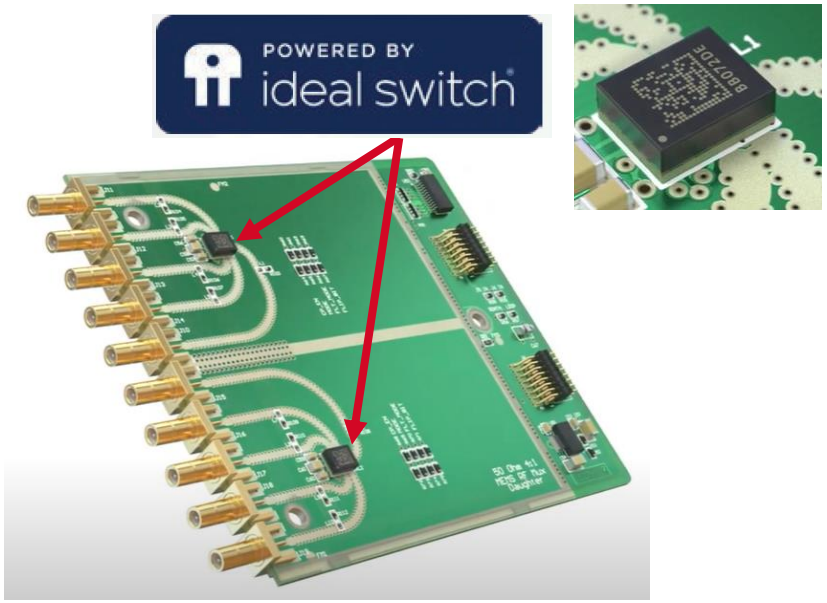
pickering

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.

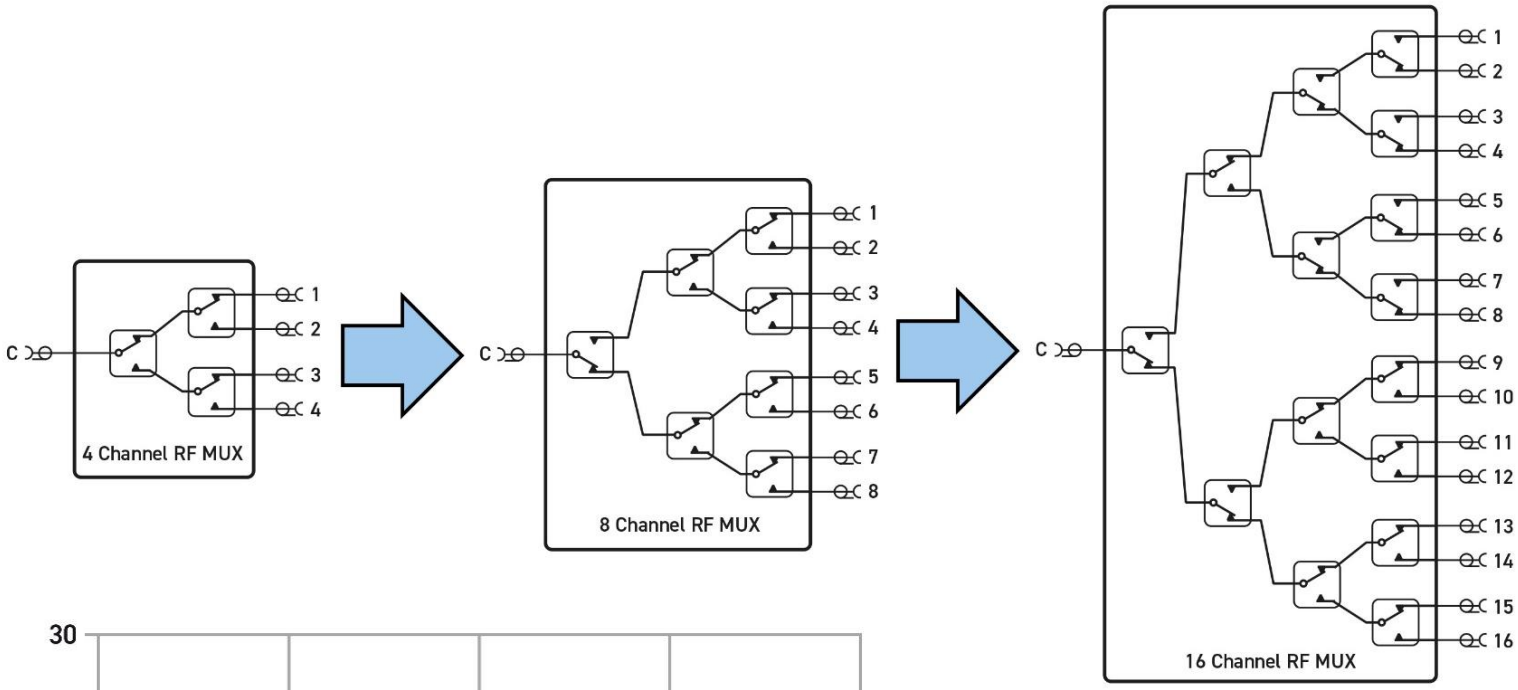
*All specifications relate to specific Pickering PXI & PXIe products.

	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.