

Design of MEM Based Triple Band Reconfigurable Antenna

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What's MEMS

- **Micro-Electro-Mechanical Systems (MEMS)** is the integration of mechanical elements, sensors, actuators, and electronics on a common silicon substrate through microfabrication technology.
- The **electronics** are fabricated using integrated circuit (IC) process sequences (e.g., CMOS, Bipolar, or BICMOS processes),
- The **micromechanical** components are fabricated using compatible "micromachining" processes that selectively etch away parts of the silicon wafer or add new structural layers to form the mechanical and electromechanical devices.

Why RF MEMS?

Switch Type	Properties					
	Insertion Loss	Isolation	Power Consumption	DC Voltage	Speed	Bandwidth
PIN/SCHOTTKY	~.15 dB	45 dB	1-5 mW per device	1-10 V	1-5 ns	Narrow/ Wide
GaAs FETs	1-2 dB	~20 dB	1-5 mW per device	1-10 V	2-10 ns	Narrow/ Wide
HBT/PIN	0.82 dB	25 dB	1-5 mW per device	1-10 V	1-5 ns	Narrow/ Wide
Best FET	0.5 dB	70 dB	5 mW	3.5 V	2 ns	Narrow/ Wide
MEMS – Sergio Shunt	0.06 dB @ 20 GHz	30 dB	~1 μ W	12-14 V	> 30 μ s	Wide (1-40 GHz)
MEMS – Scott/Jeremy(Shunt)	0.3 dB @ 30 GHz	50-60 dB	~1 μ W	~20 V	> 30 μ s	Moderate (10-40 GHz)

Advantages of RF MEMS

- High performance, low bias power consumption
- Potential low cost manufacturing into a variety of substrates

Limitations of RF MEMS

- Slower switching speed
- Potential lifetime limitations

Applications

- Reconfigurable Apertures
 - Elements
 - Ground planes
 - Array feeds/architecture
- Phase shifters
- Filters

Reconfigurable Antenna

Reconfigurable multi-band antennas are attractive for many military and commercial applications where it is required to have a single antenna that can be dynamically reconfigured to transmit or receive on multiple frequency bands. Such common-aperture antennas result in considerable savings in size, weight and cost. They find application in space-based radar, communication satellites, electronic intelligence, and aircraft and many other communications and sensing applications.

Antenna modeling

The center patch antenna was first designed based on the equations from the transmission line model (TLM) approximation. That approximation states that the operating frequency of patch antenna is given by :

$$f_r = \frac{1}{2(L + \Delta L) \sqrt{\epsilon_{r\text{eff}}} \sqrt{\mu_0 \epsilon_0}}$$

where L is the length of the antenna, and are the free space dielectric permittivity and permeability respectively, is the effective dielectric permittivity given as

$$\epsilon_{\text{eff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-1/2}$$

Where ϵ_r and h are the relative dielectric permittivity and thickness of the substrate and W is the width of the patch. Because of the fringing effects, the antenna looks larger than its physical dimensions. takes this effect in account and can be computed from:

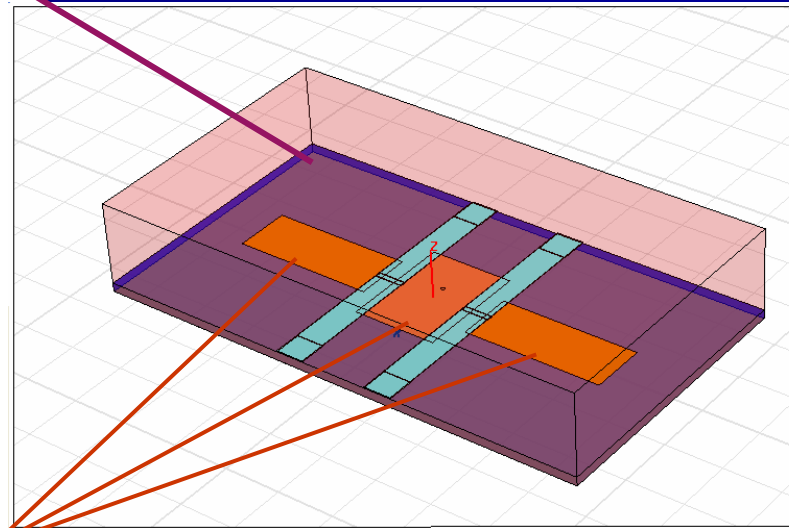
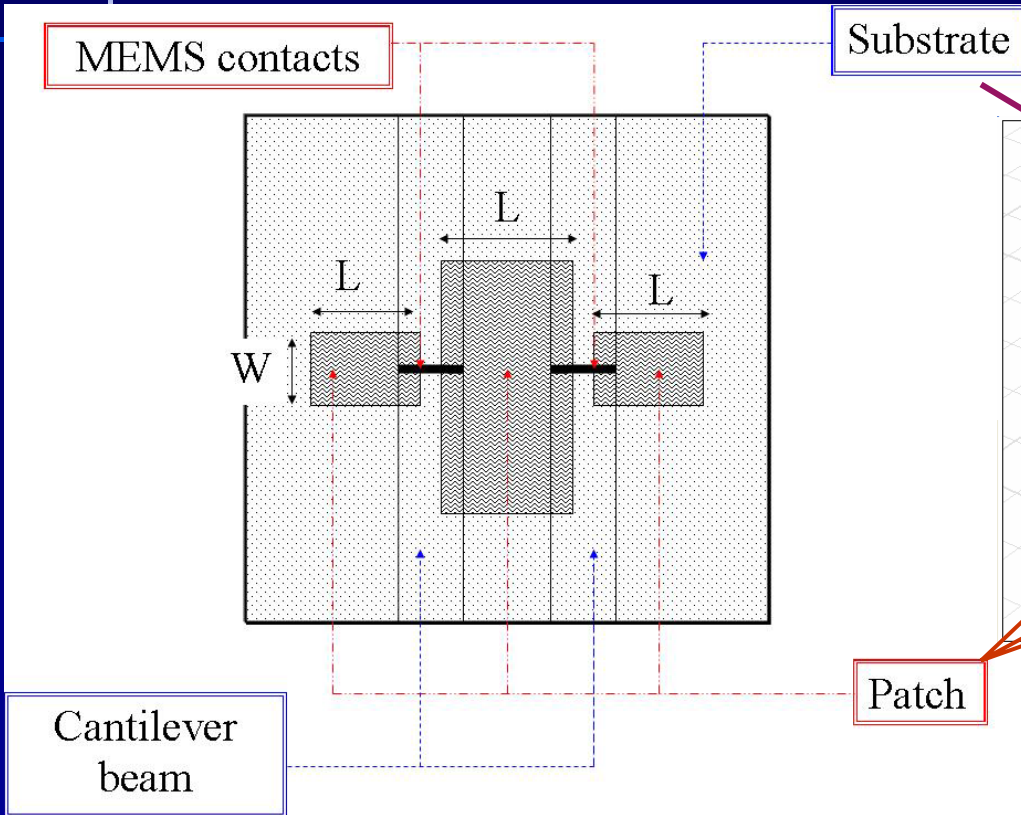
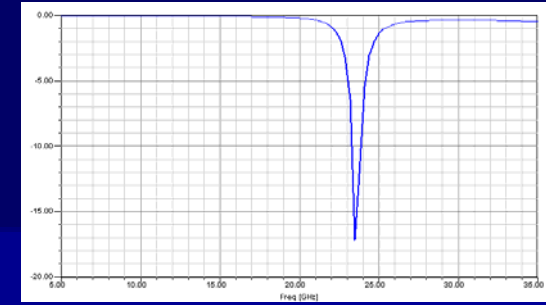
$$\Delta L = 0.412h \frac{(\epsilon_{eff} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{eff} - 0.258) \left(\frac{W}{h} + 0.8 \right)}$$

In order to facilitate its characterization, the antenna was designed to have a 50Ω input impedance as mentioned earlier. The input impedance of the antenna can be adapted by choosing the right position for the feeding point. Its value is maximum at the patch border and decreases as we move inside according to:

$$Z_{in} = Z_{max} \cos^2 \left(y \frac{\pi}{L} \right)$$

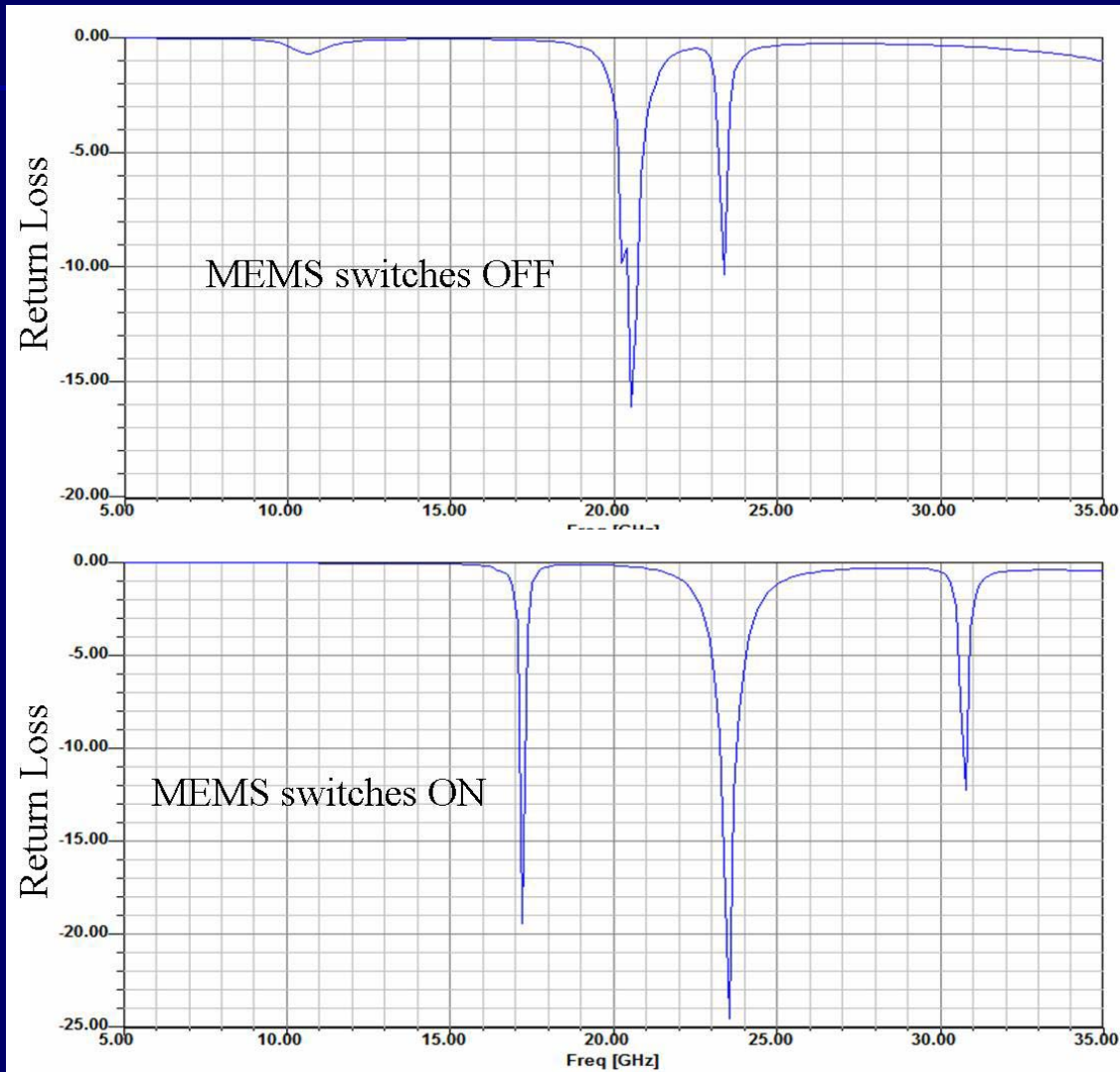
where Z_{max} is the impedance at $y=0$. Because the antenna was to be fed with a microstrip, the connection to a point inside the metal patch requires the use of wire bonding or an inset.

Reconfigurable Antenna

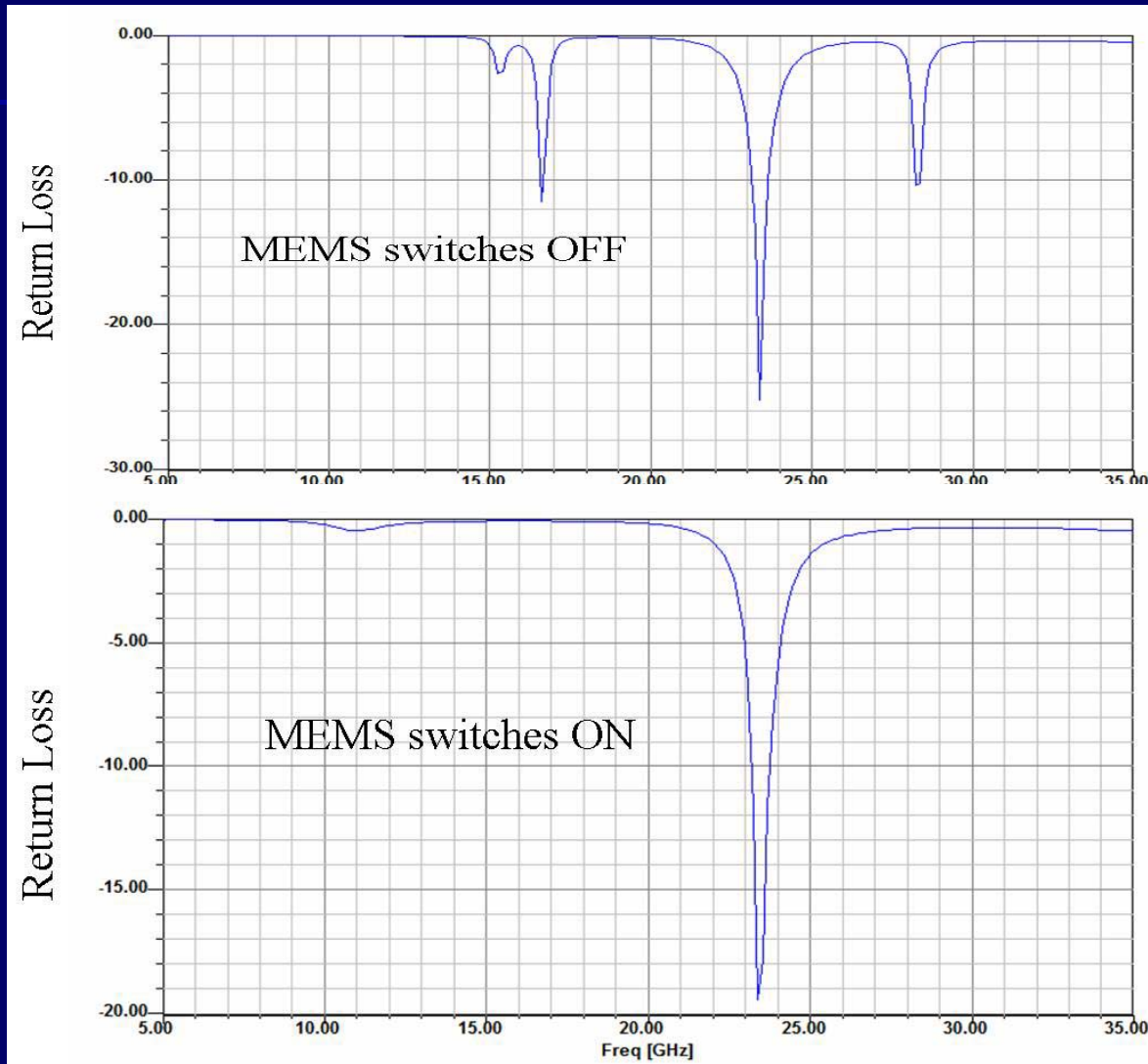


Schematic diagram of MEMS reconfigurable antenna.

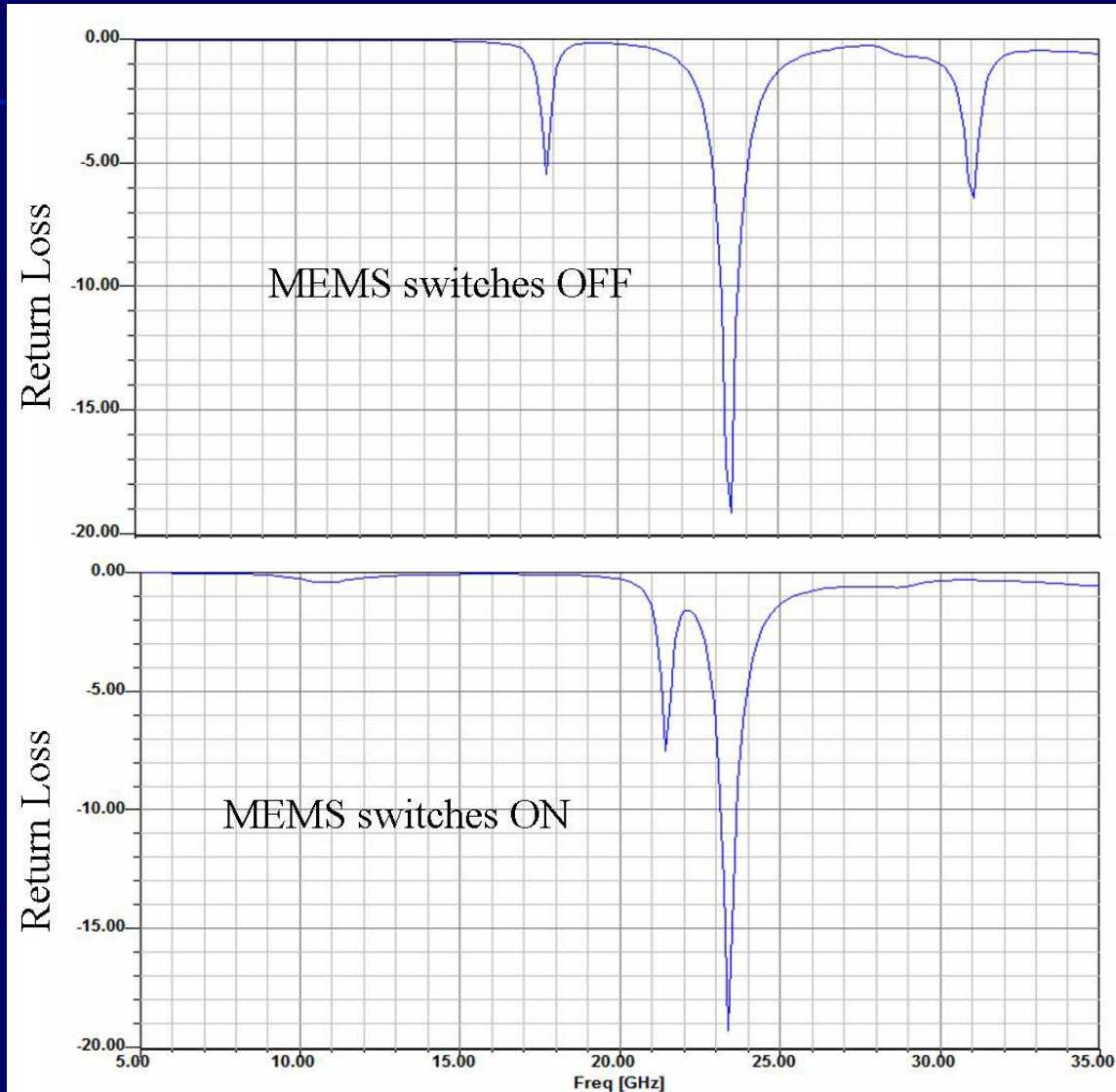
Return loss of the antenna when both the switches are either OFF or ON for wing patch dimension 5×1.22 mm.



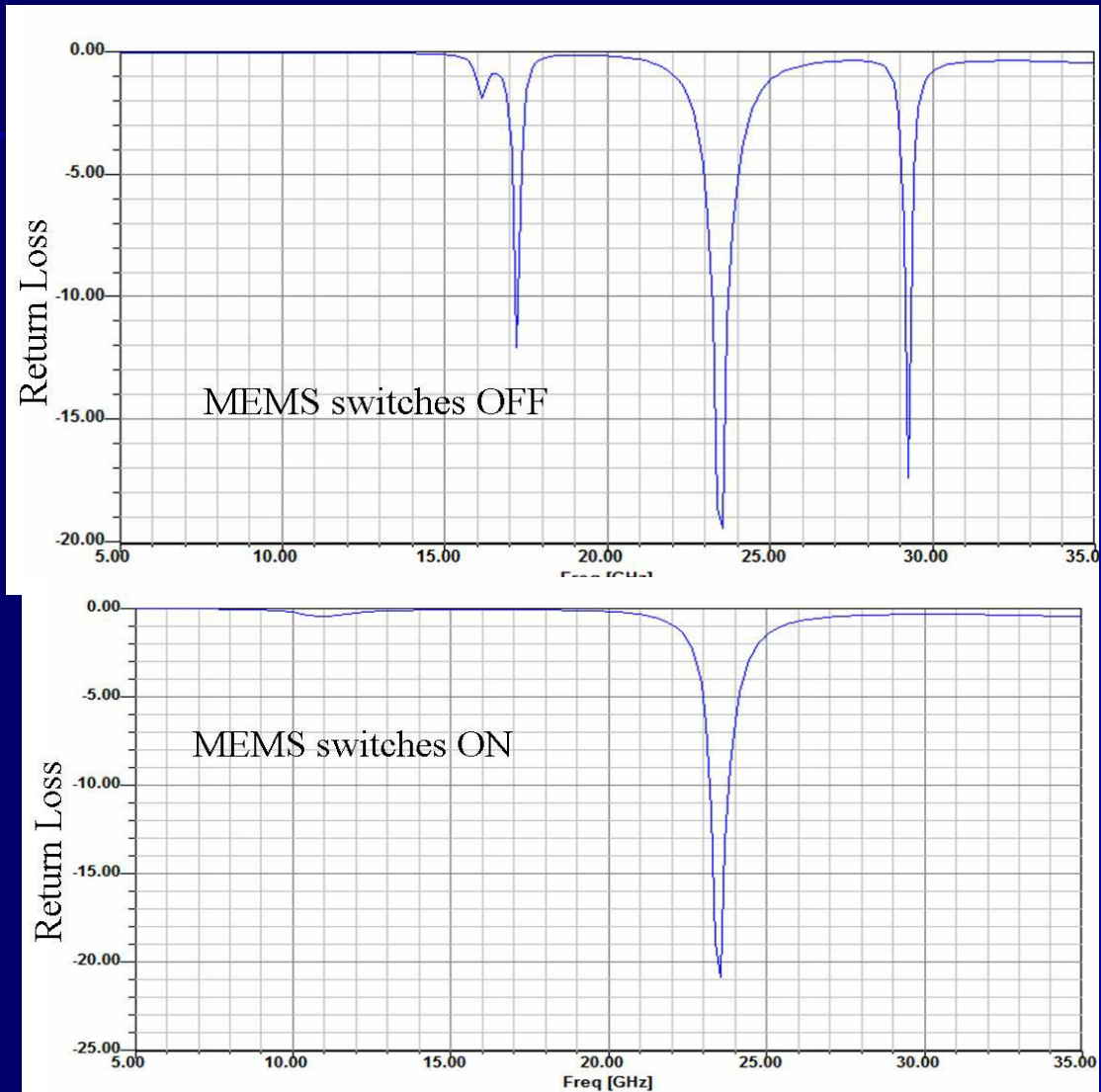
Return loss of the antenna when both the switches are either OFF or ON for wing patch dimension 5×2 mm.



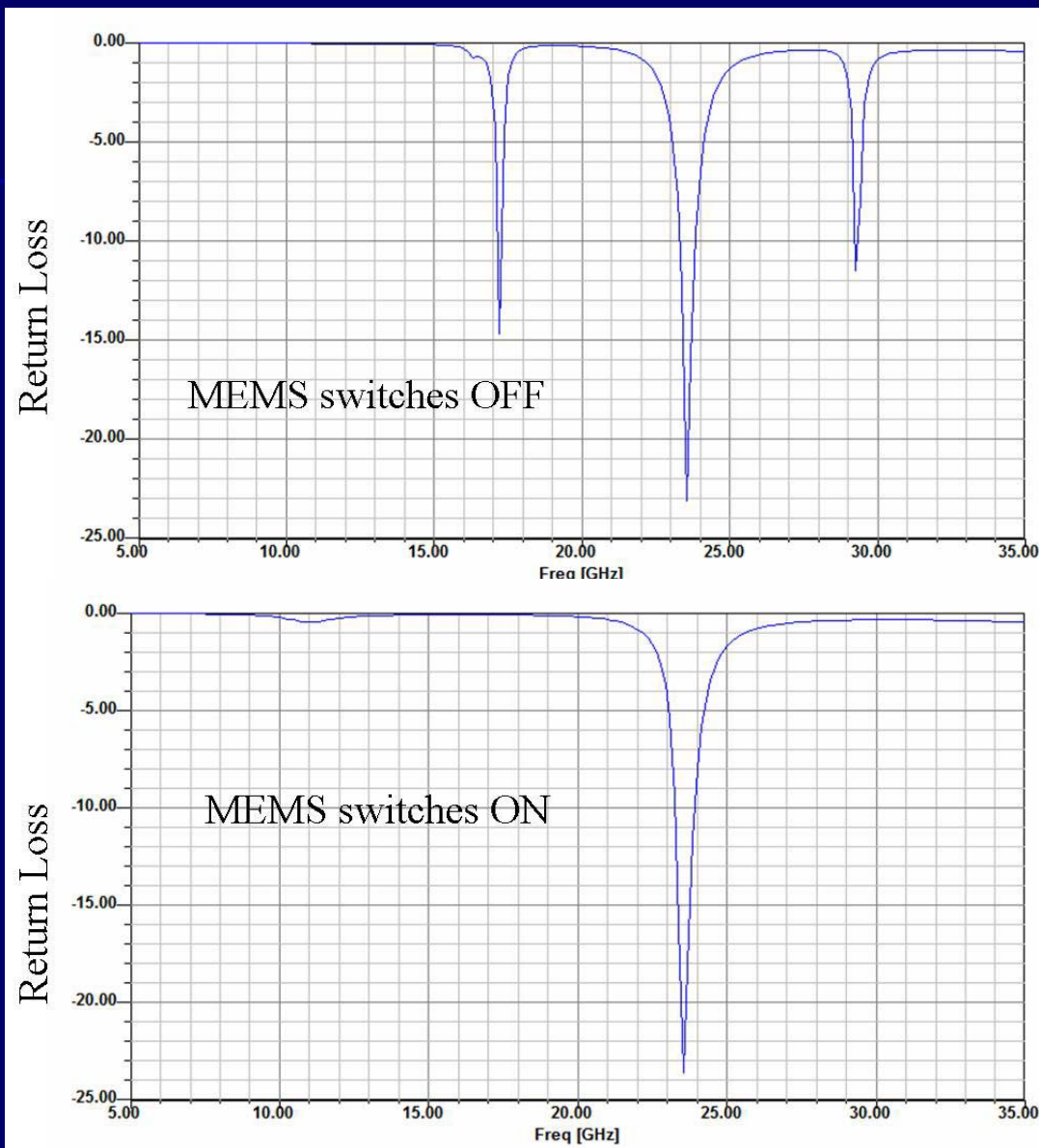
Return loss of the antenna when both the switches are either OFF or ON for wing patch dimension 5×3 mm.



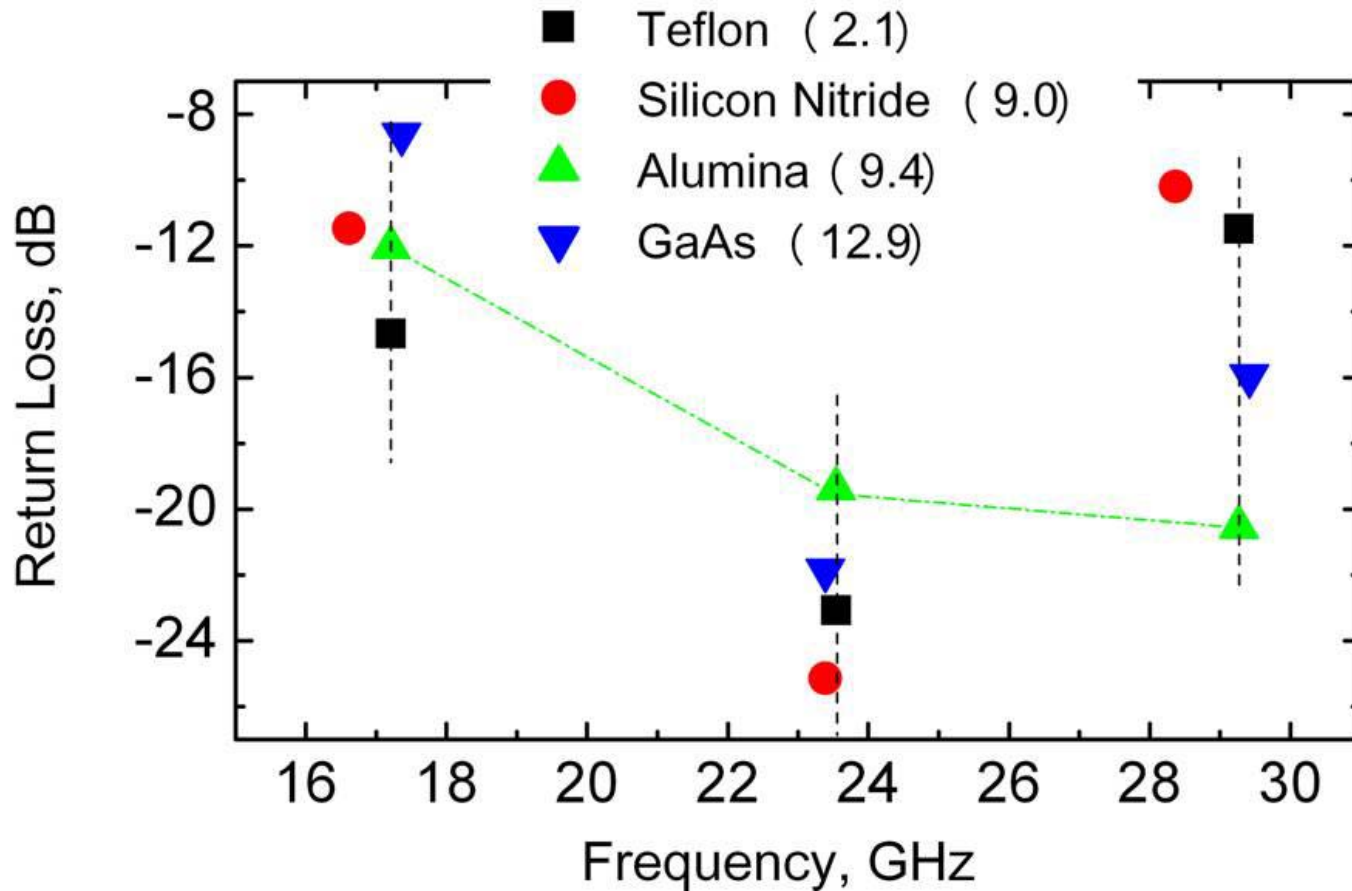
Return loss of the antenna for Alumina as MEMS bridge material (wing patch dimension 5×2 mm) when the both the switches are either OFF or ON.



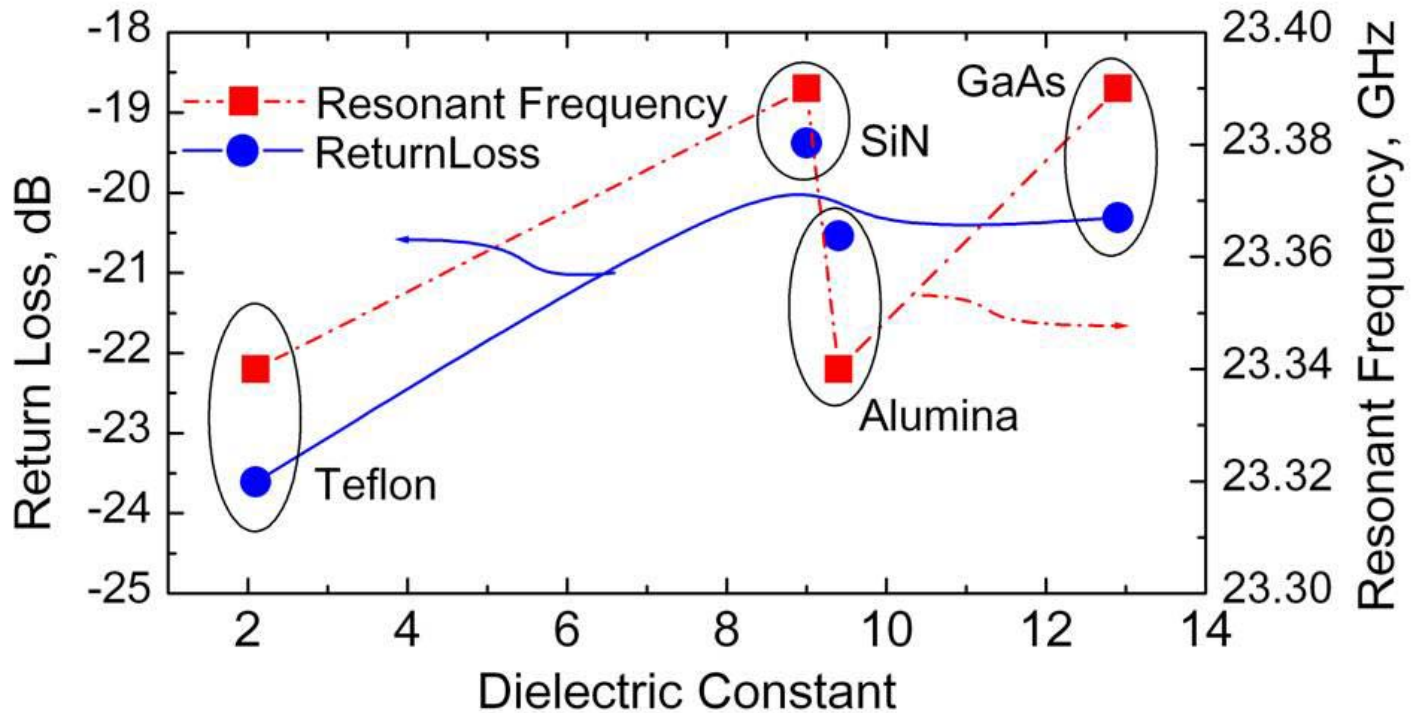
Return loss of the antenna for Teflon as MEMS bridge material (wing patch dimension 5×2 mm) when the both the switches are either OFF or ON.



Return loss of the antenna for different types of MEMS bridge materials when the switches are OFF.



Return loss and resonant of the antenna for different types of MEMS bridge materials when the switches are ON.



Conclusion

- ❑ Antenna performance has been optimized by determining the suitable material of MEMS structure.
- ❑ A reconfigurable triple-band antenna operating at 17.21, 23.54 and 29.27 GHz using MEMS switches with low insertion loss was achieved by selecting alumina for MEMS structure.
- ❑ Single resonant frequency occurred when both the MEMS switches are ON confirmed that the antenna behaves like a single patch antenna. There is not much shift in resonance frequency by changing the MEMS structure material.
- ❑ MEMS material has greatly effect the performance of the antenna in terms of insertion loss. The proposed reconfigurable antenna can be implemented in easy fabrication process steps by sandwich method.