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RF Reed Relays Part II

Product Training

Introduction

Purpose

- Designing and testing reed relays for switching and carrying high frequency (RF) signals and fast digital pulses

Objectives

- Show how geometrics directly determines a good RF relay
- The importance of the physical layout of test fixtures determines the test results
- We will show that the RF signals are directly affected by the conductor materials and material existing between the signal path and the relay shielding

Characteristic Impedance

- Characteristic impedance (Z) can best be used to measure the results of the reed relay's geometry and their material makeup
- For best RF performance the characteristic impedance must be consistent along the entire signal path
- Most RF circuits today are 50 Ohms (Ω)

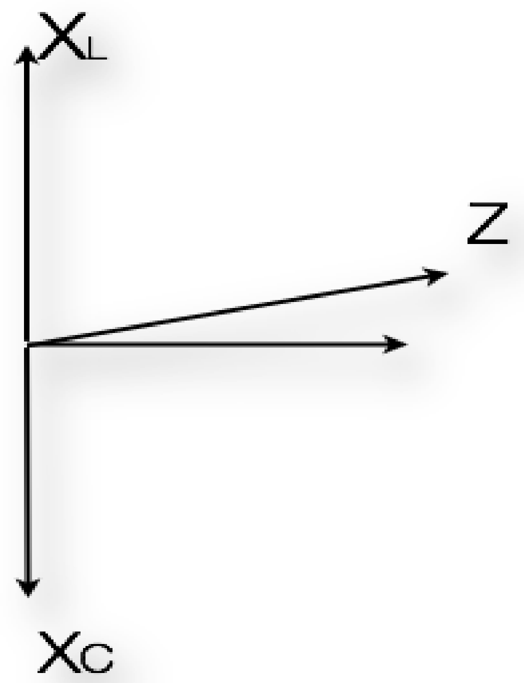
Characteristic Impedance

- How to calculate characteristic impedance
- The characteristic impedance is a vector and is composed of 3 components:
  1. Pure resistance of the circuit
  2. The capacitive reactance
  3. The inductive reactance

Characteristic Impedance

The characteristic impedance is given by the following equation:

	$Z = \sqrt{(R^2 + (X_L - X_C)^2)}$
Here:	
	$X_L = 2\pi f L$
	$X_C = 1/(2\pi f C)$
Where:	
X_L	is the inductive reactance in Ω
X_C	is the capacitive reactance in Ω
R	is the DC resistance in Ω
Z	is the impedance in Ω
f	is the frequency
L	is the Inductance
C	is the capacitance



Characteristic Impedance

- The calculation for Capacitance and inductance are:

$$C = \frac{e\,A}{d}$$

$$L = \mu_o n d A1^2$$

	C is the capacitance
Here:	
	$C = e\,A/d$
	$L = \mu_o n d A1^2$
Where:	
L	is the inductance
e	is the permittivity or dielectric constant
A	is the area of shield and blades
d	is distance between the plates
μ_o	is the permeability constant
n	is the number of turns
d	is the length of the signal line
A1	is the area of the signal line/shield

Characteristic Impedance

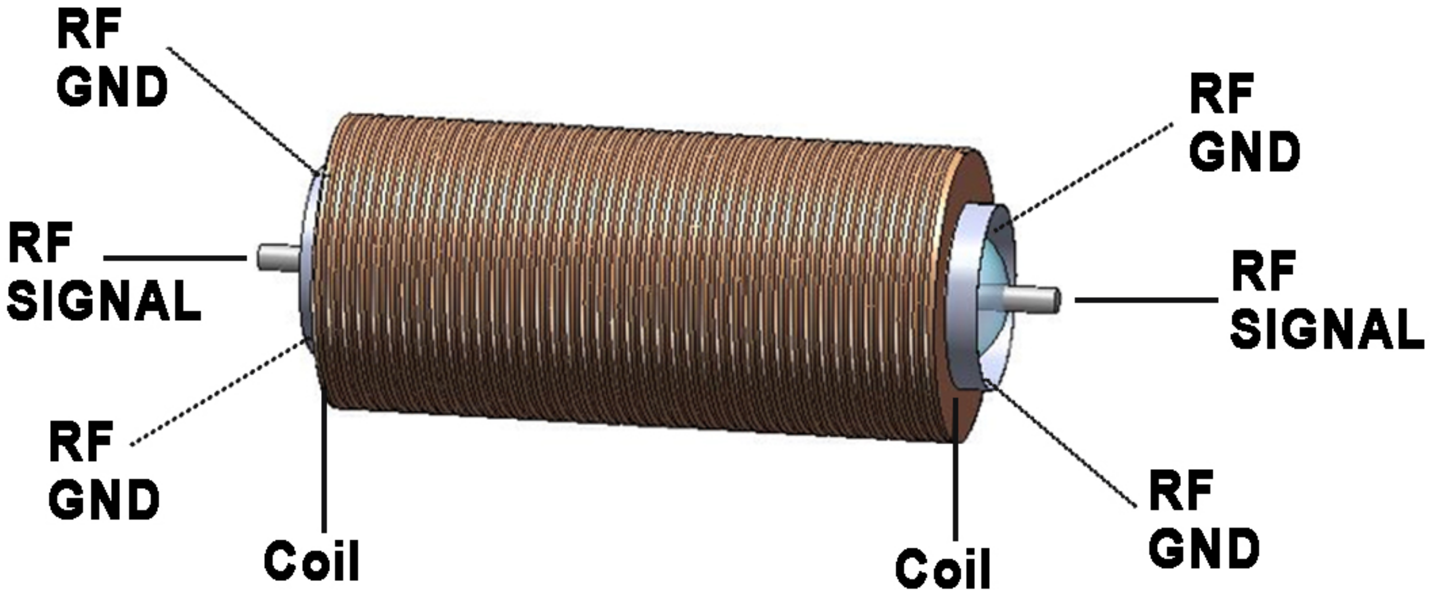
- RF looks at the distributed impedance along the signal path
- Any changes in impedance will reflect part of its signal backwards
- This results in an actual loss in signal strength

Characteristic Impedance

- The entire signal path length is critical
- The impedance is measured from the signal path to the shield
- The shield is the ground part of the signal path
- The signal path, the shield and the material between them make up the impedance

RF Relay Schematic

- The critical components that exist within each RF reed relay
  - 4 shield points
  - 2 signal leads



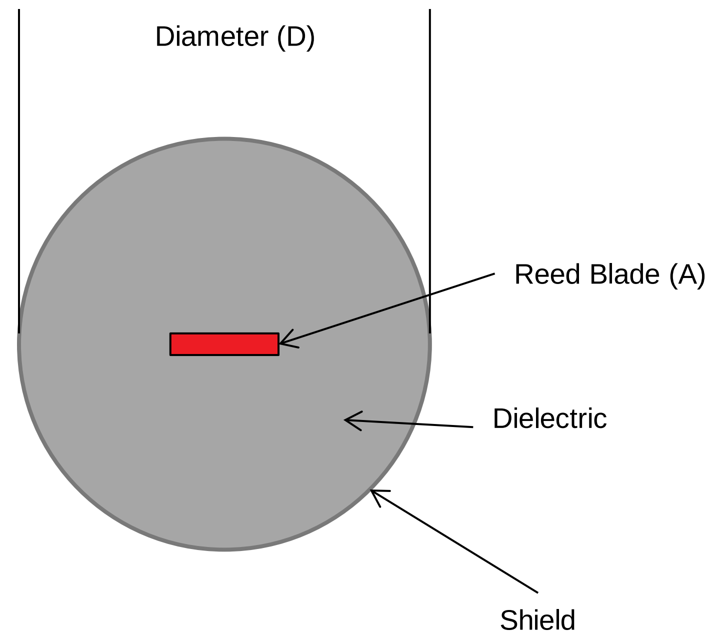
Characteristic Impedance

- We will now show you how to calculate the characteristic impedance taking in the different geometries of the reed relay
  - Calculation of the flattened section of reed blade
  - Calculation of the circular section of the reed blade
  - Calculation of the flattened leads as they exit the relay and as they are mounted on a substrate.

RF Continuous Wave Parameters

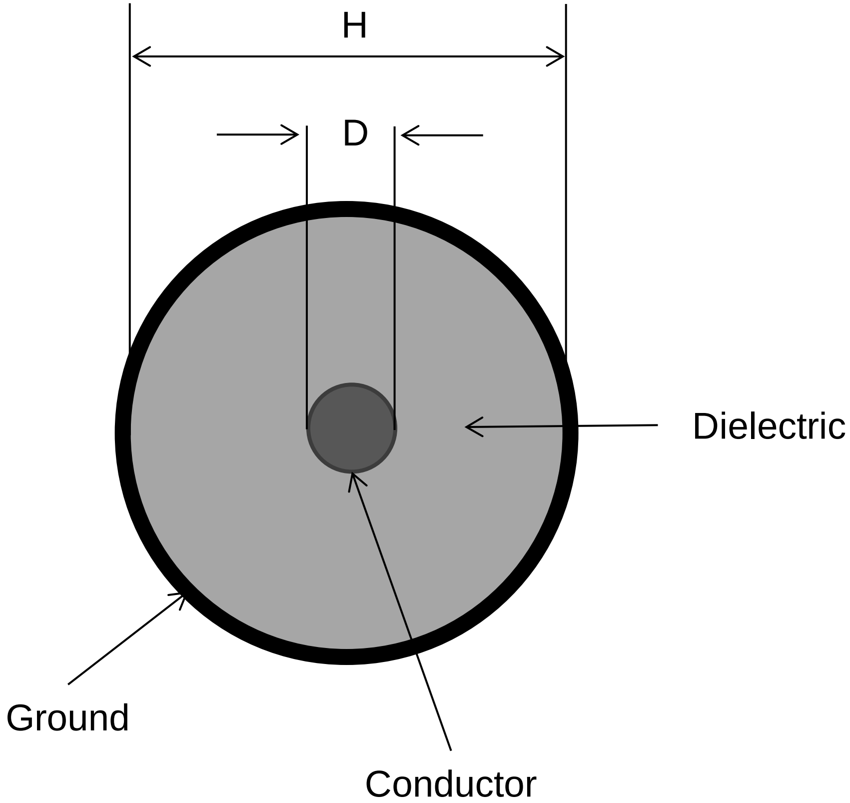
	Characteristic Impedance
Here:	
	Z = 60/(√(e)) In((D)/A)
Where:	
Z	is the impedance in Ω
e	is the dielectric constant
D	is the diameter of the shield
A	Is the cross sectional area of the reed blade
In	is the natural logarithm

Flat Reed Switch Blade



RF Continuous Wave Parameters

Character Impedance



$$Z = \frac{60}{\sqrt{E_R} + \ell_n \left(\frac{2h}{d}\right)}$$

E_R is the dielectric

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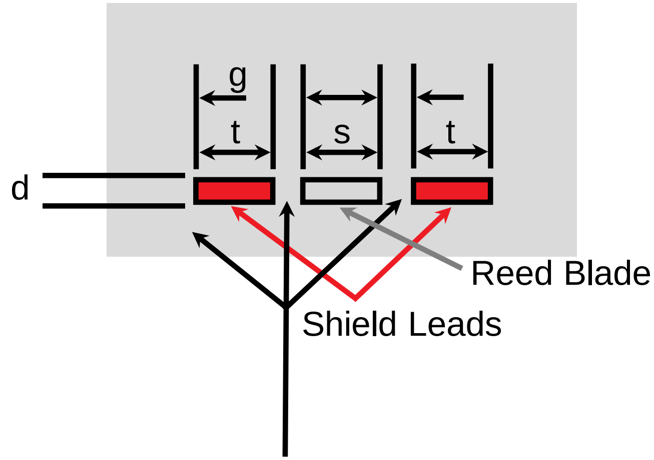
Characteristic Impedance

- Calculation of the impedance after the reed exits the shield but still within the molding enclosure

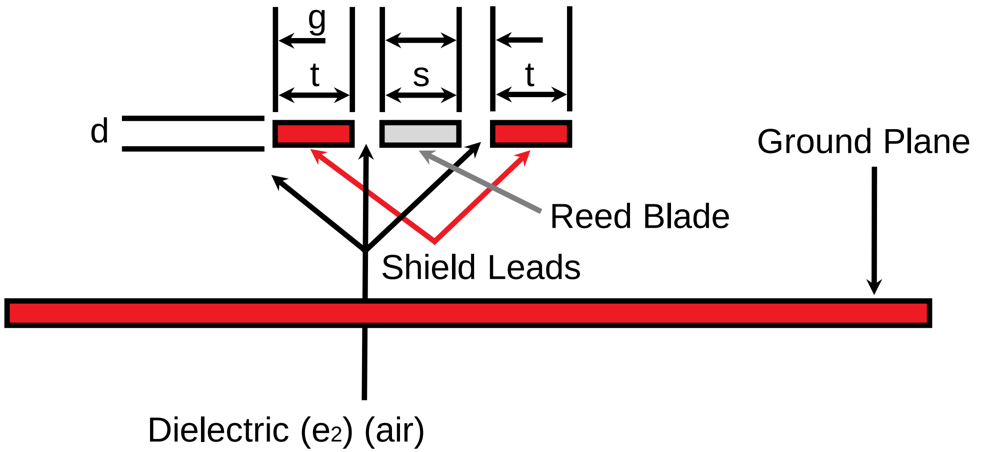


Dielectric (e1) e_1 = approximately 4.5

Z1 = ?

Characteristic Impedance

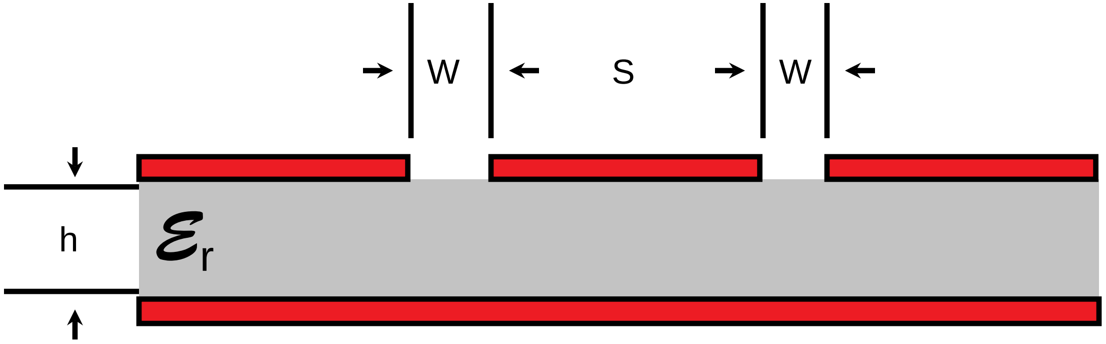
- Calculation of the impedance after the reed exits the molding enclosure into air with a ground plane under the leads



Characteristic Impedance

Where $\mathcal{E}_r$ = Relative Dielectric Constant

- W = Width of gap
- S = Width of track
- h = Thickness of dielectric



Testing the Relay

- We design the relay for RF up to, through and out the package where the leads come out
- How the leads on connected to our customer’s circuit is critical
- At the junction of our relay and the customer RF circuit (normally to a PCB) the customer must match the impedance of the relay to their circuit

Testing the Relay

- If the customer does not properly match the impedances, the RF characteristics can fall off dramatically
- This impedance matching requires a knowledgeable RF engineer that can add inductance or capacitance to the junction of the relay/PCB

Testing the Relay

- When we test our relays for RF characteristics, we make up special RF fixtures for testing the relay
- We also make up special calibration fixtures that compensate for impedance mismatching at the junction of the relay to the PCB

RF Testing

- All the testing information can be shared with our customers
- The network analyzer information can also be shared electronically with our customers.

Ways to Improve RF Performance

- Controlling the impedance path through the relay maintaining 50 ohms

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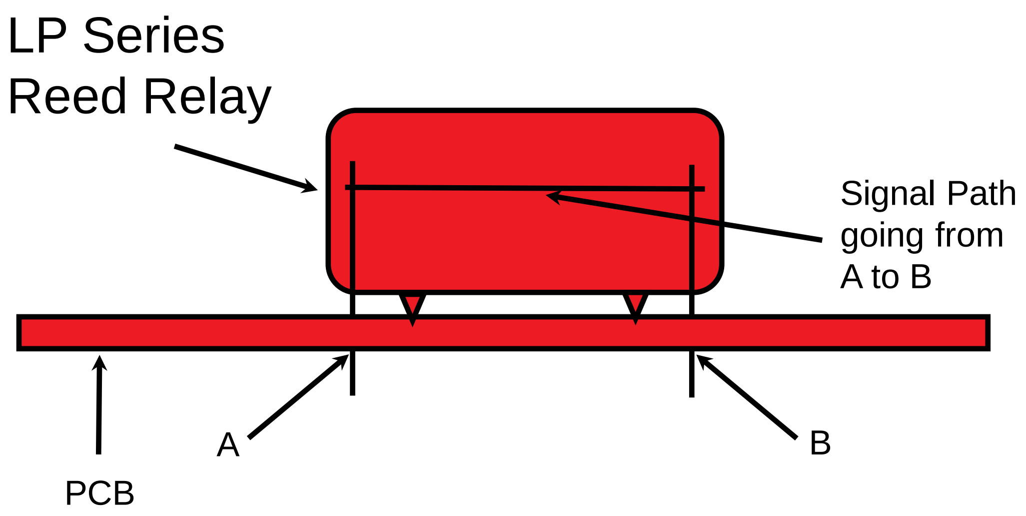
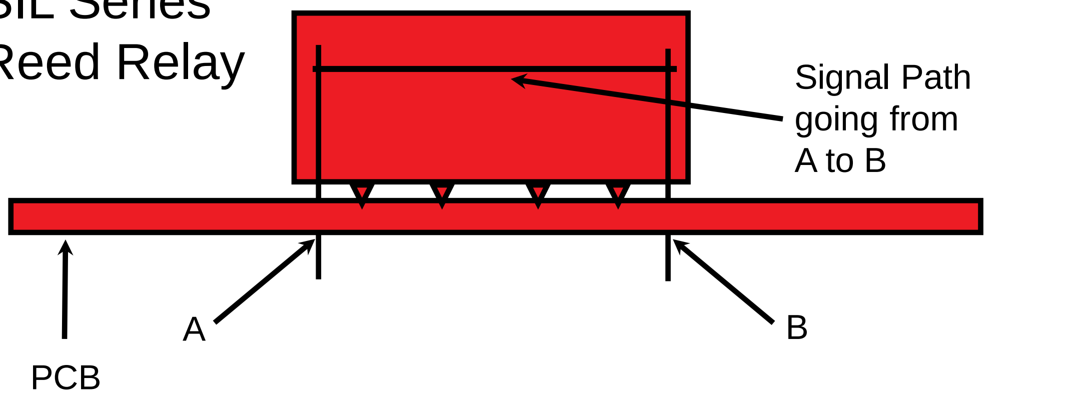
Ways to Improve RF Performance

- Shortening the signal path length by making a smaller relay (length wise)

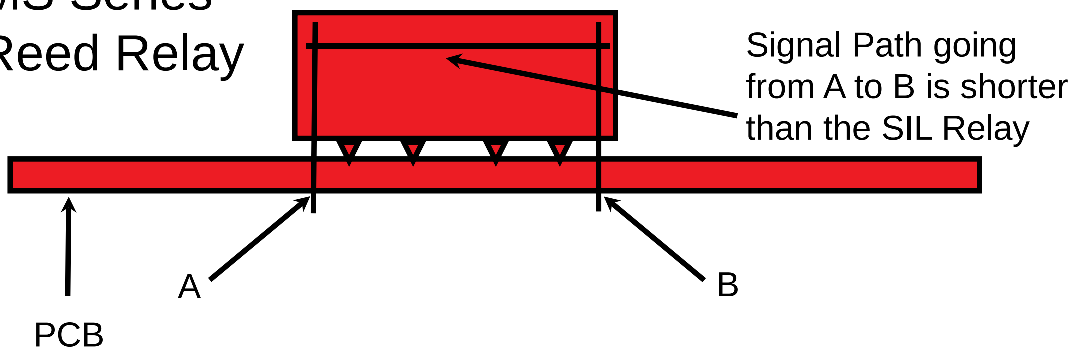


Shortening the Signal Path

SIL Series Reed Relay



MS Series Reed Relay



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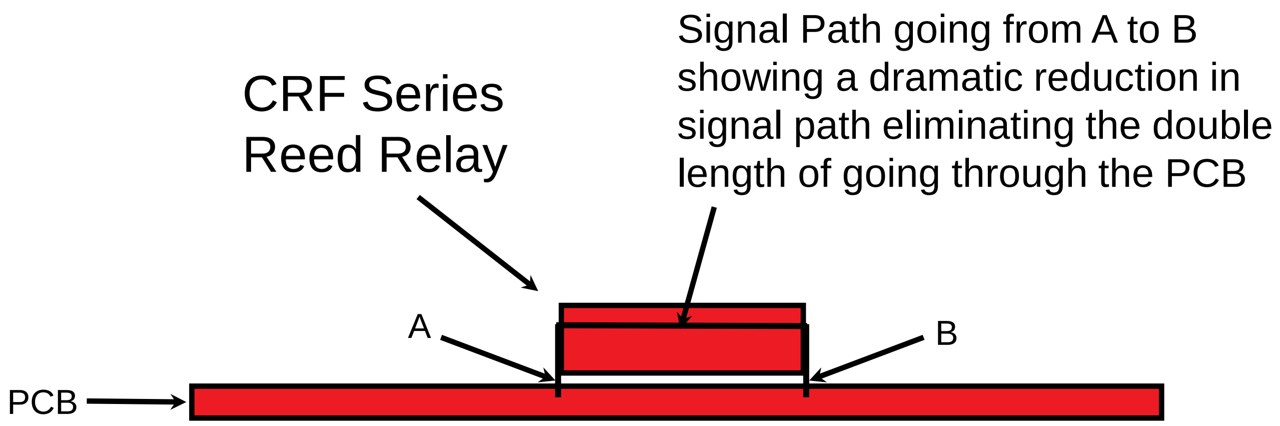
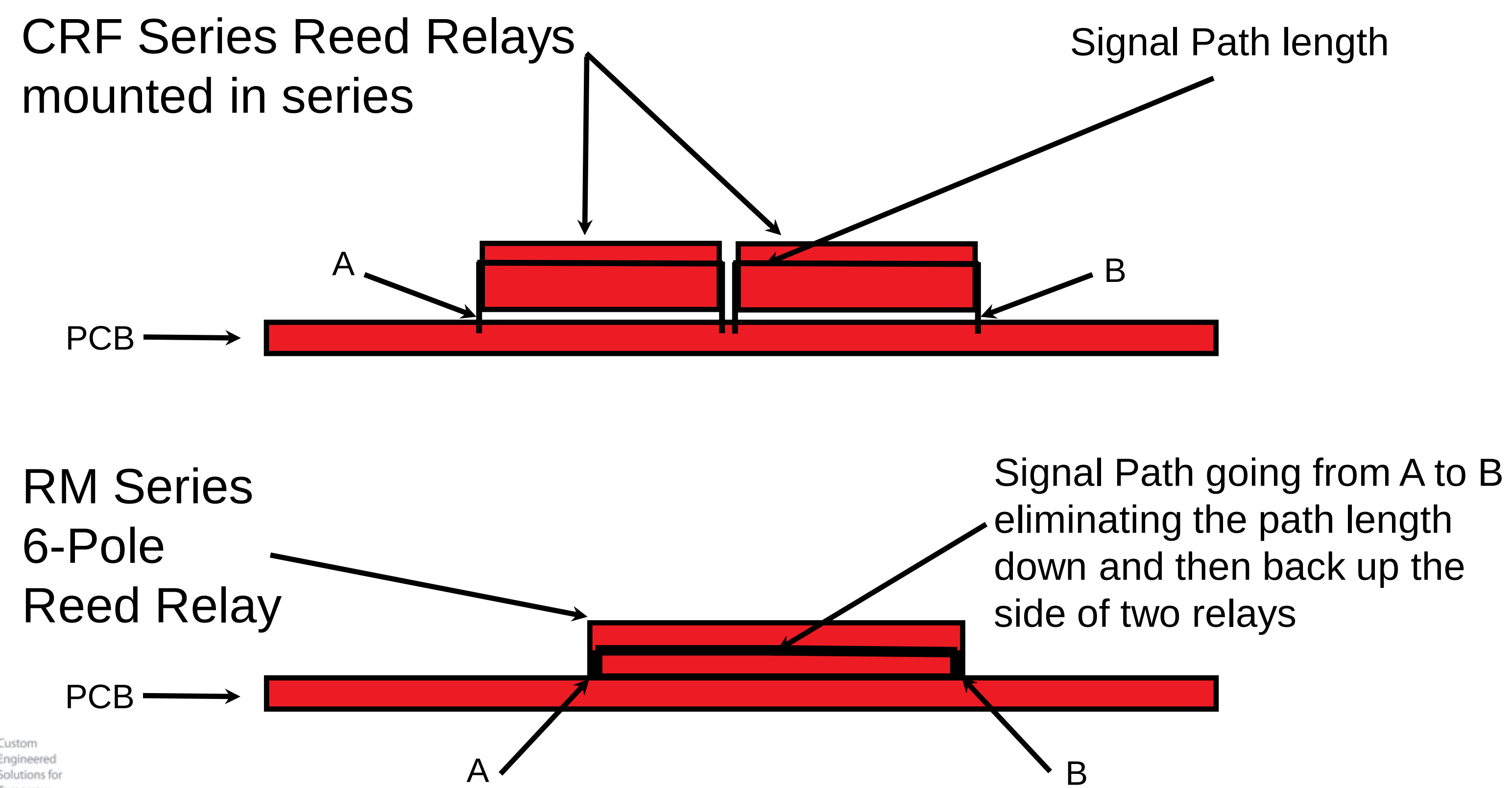
Shortening the Signal Path



Shortening the Signal Path

- An example of how the RM Series eliminates signal path



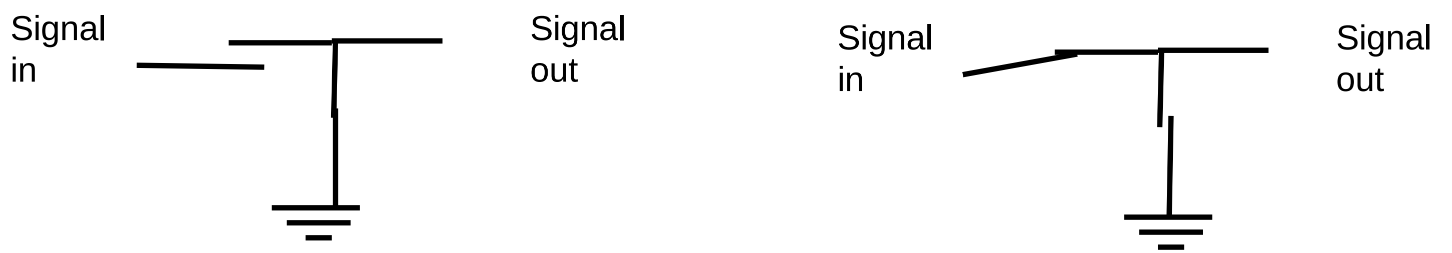
Improving Isolation

- Using higher AT switches works to a limit, where the sacrifice of increased coil power becomes too big a drain

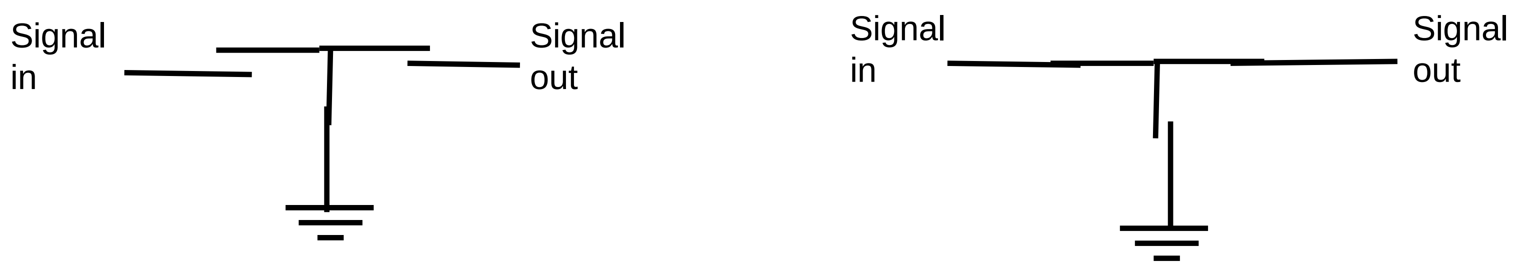
Improving Isolation

- Using a ‘T’ or 1/2 ‘T’ switching arrangement will increase isolation

1/2 T Switching



Full ‘T’ Switching



RF Parameters - Isolation

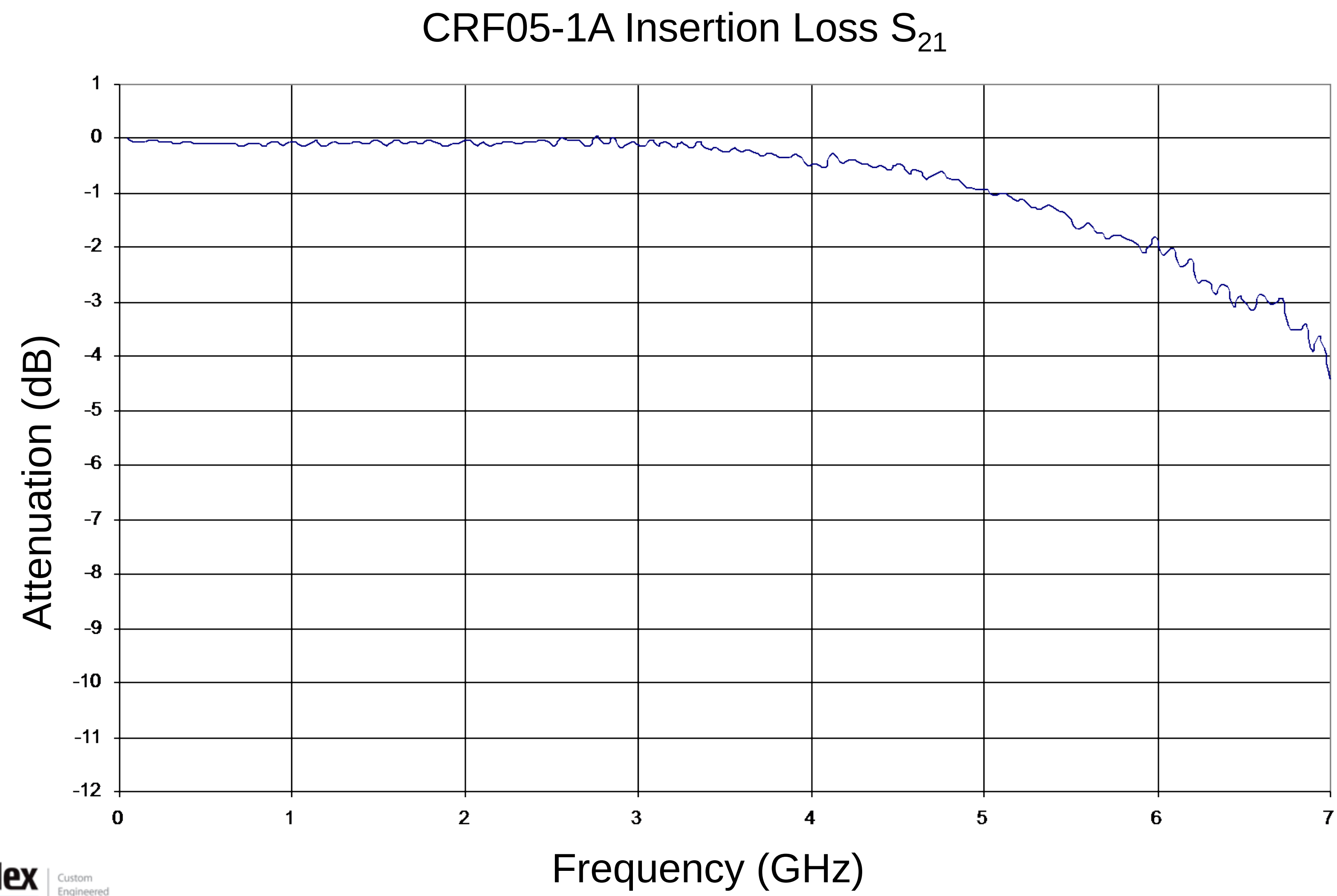
- As can be seen the ½ T and T switching will improve the isolation, but the path length has increased
- So the insertion loss and frequency response will suffer

Relays for RF Applications

- Below is a list of the Standex-Meder RF series and their frequency range

RF Relay Series	Frequency Range
LP Series	DC to 500 MHz
SIL Series	DC to 800 MHz
MS Series	DC to 1.5 GHz
CR Series	DC to 7 GHz

CRF Insertion Loss



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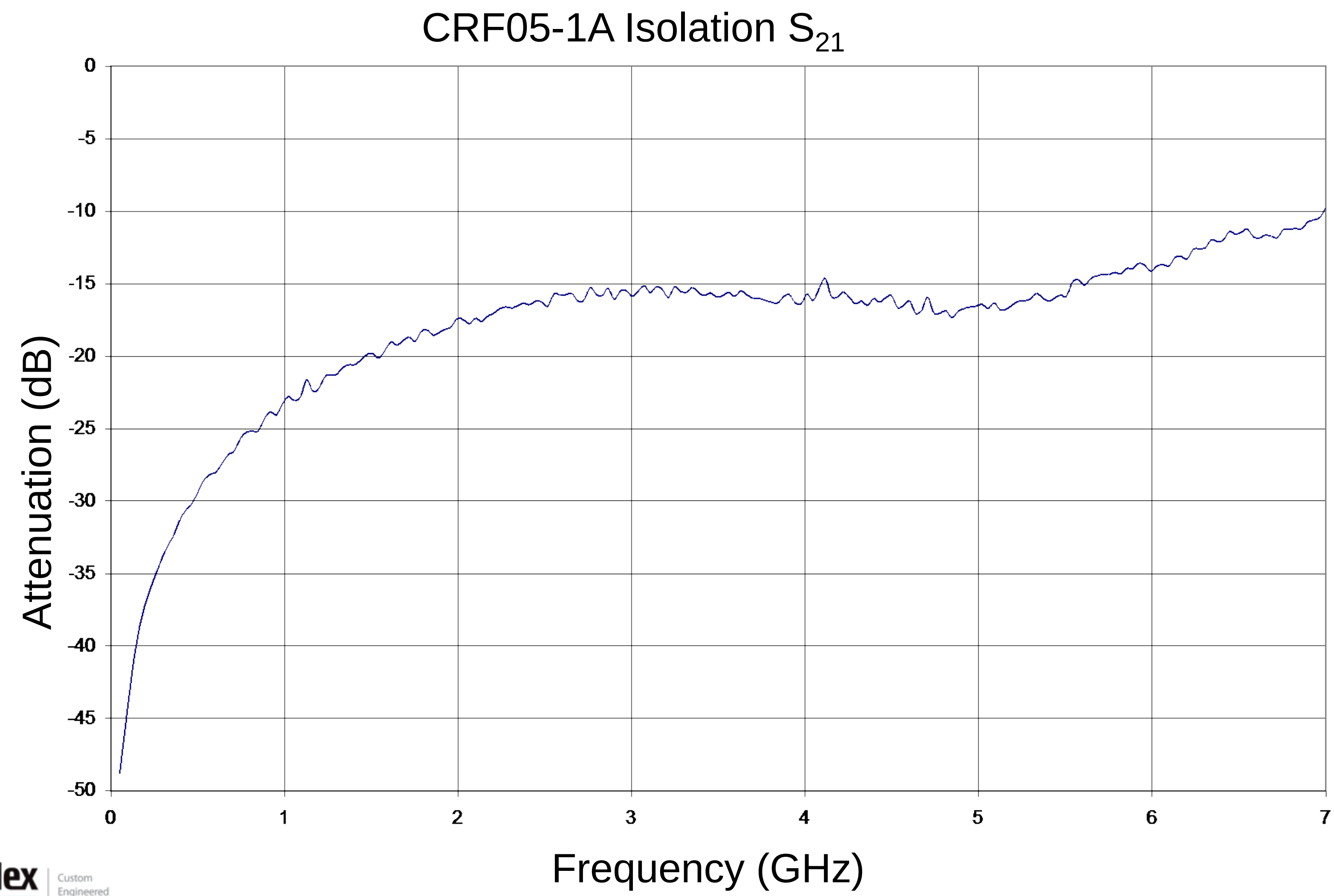
CRF Isolation



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Summary

- Reed Relays are excellent RF switching components
- The Reed Relay RF design is most dependent on its geometric and the material makeup
- Customer impedance matching entering and exiting the relay is critical for maintaining the 50Ω RF path.

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