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BiTS

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Archive

Impedance Controlled Contacts in the Test System

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Agenda

- **Controlled Impedance**
  - What is Return Loss
  - What is a Smith Chart
  - Capacitances and Inductances in Contactor System
  - Difference between Standard and Controlled Impedance Contacts
- **Controlled Impedance Affects**
  - Pitch Effects on Controlled Impedance
  - Modeled vs. Measured Comparison
- **Comparison of Technologies**
  - Impedance Changes vs. Frequency
  - Examples of Different Contacts When Testing 50 Ohm Amplifier
- **Conclusion**

What is Return Loss?

- Definition: Return Loss is the amount of power reflected back to a generator from a load that is mismatched.
- Return Loss = -20log $|\Gamma|$ where Γ is defined as

  $\Gamma = (Z_L - Z_o) / (Z_L + Z_o) = S_{11}$
- Customers usually define usable bandwidth as a Return Loss better than - 20 dB. (i.e. 1/100 of the power being reflected back to the generator.)
- VSWR = S = $(1 + |\Gamma|) / (1 - |\Gamma|)$

  $\Gamma = 0$ Perfectly matched load

  $\Gamma = 1$ Total Reflection

Courtesy of bing.com/images

What is a Smith Chart

The Smith Chart is a graphical aid to assist in solving problems with transmission lines and matching circuits. The Smith Chart can be used to display impedances and is the preferred method of displaying how RF parameters behave at one or more frequencies.[1]

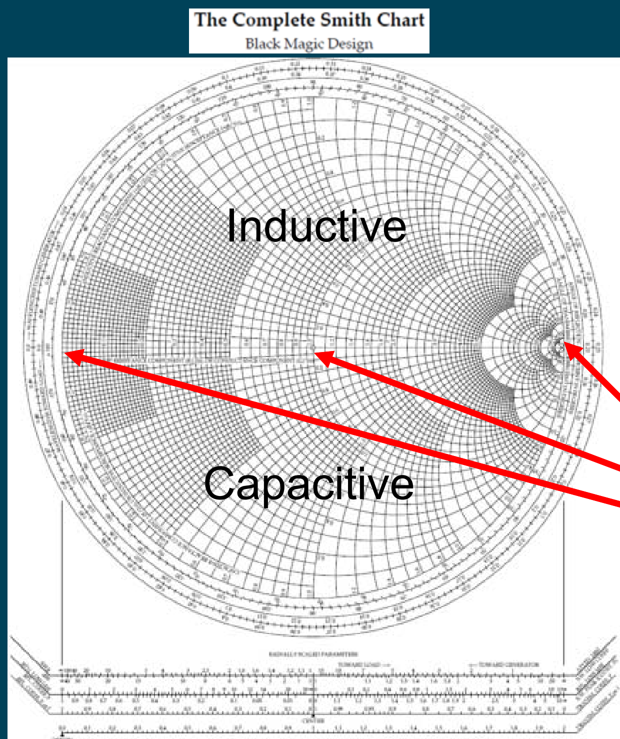
The Smith Chart can be used to visually represent:

* How capacitive or how inductive a load is across the frequency range
* How difficult the match is likely to be at various frequencies
* How well matched a particular component is [1]

Wavelength of signal (λ) = f (Frequency) / c (speed of light)

1. Wikipedia Definition

What is a Smith Chart



Element Type	Impedance (Z or z) or Reactance (X or x)	
	Real (Ω)	Normalised (No Unit)
Resistance (R)	$Z = R$	$z = \frac{R}{Z_0} = RY_0$
Inductance (L)	$Z = jX_L = j\omega L$	$z = jx_L = j\frac{\omega L}{Z_0} = j\omega LY_0$
Capacitance (C)	$Z = -jX_C = \frac{-j}{\omega C}$	$z = -jx_C = \frac{-j}{\omega CZ_0} = \frac{-jY_0}{\omega C}$

$\omega = 2 * \pi *$ Frequency

Perfect Open

Perfect 50 Ohm Match

Perfect Short

Characteristic Impedance (Z_o) = R + jωL – j/ωC

Capacitances and Inductances in Contactor System

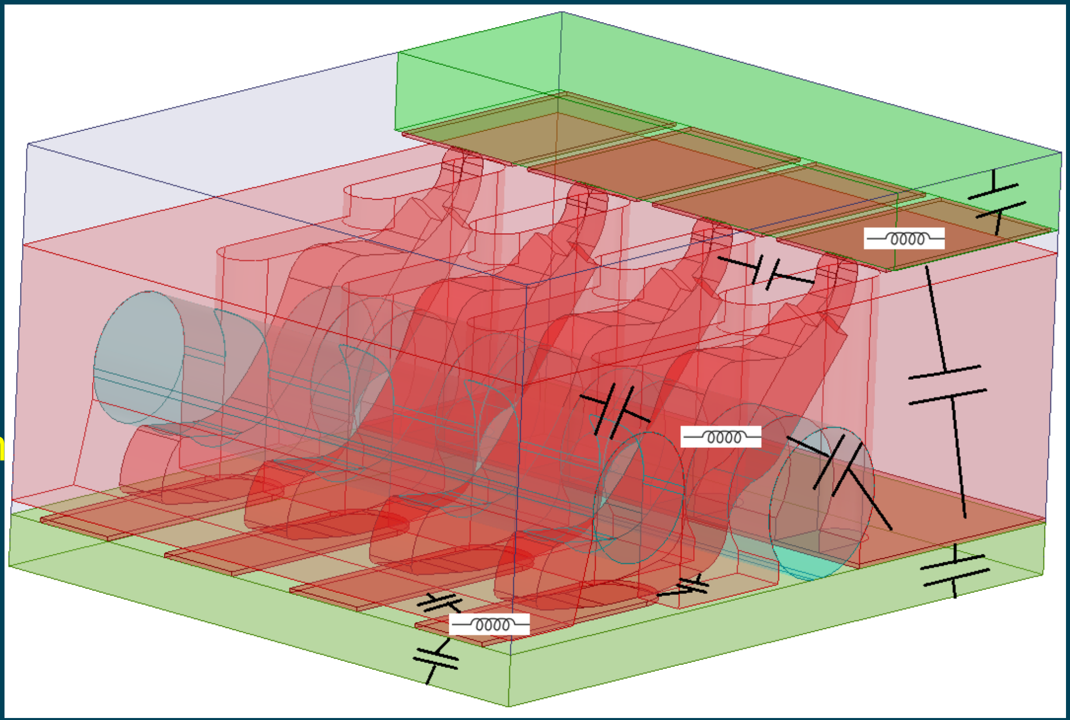
$C = \varepsilon_r * \varepsilon_o * A/D$

Where ε_r is dielectric constant between contacts

A = Surface Area of surface facing adjacent contact

D = Distance between contacts

ε_o = constant = 8.854×10^{-12} F/m



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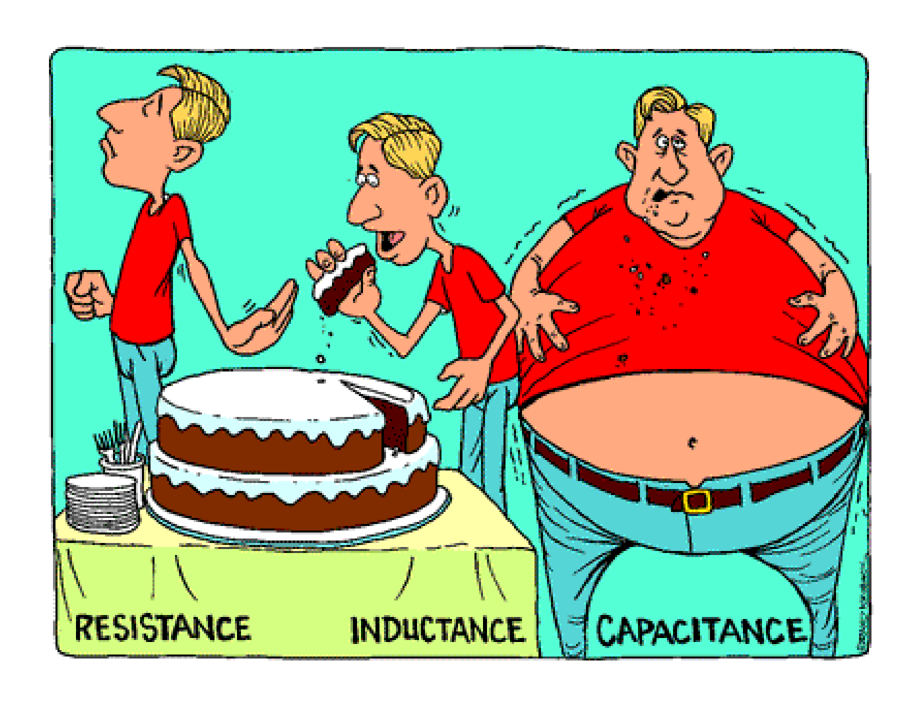
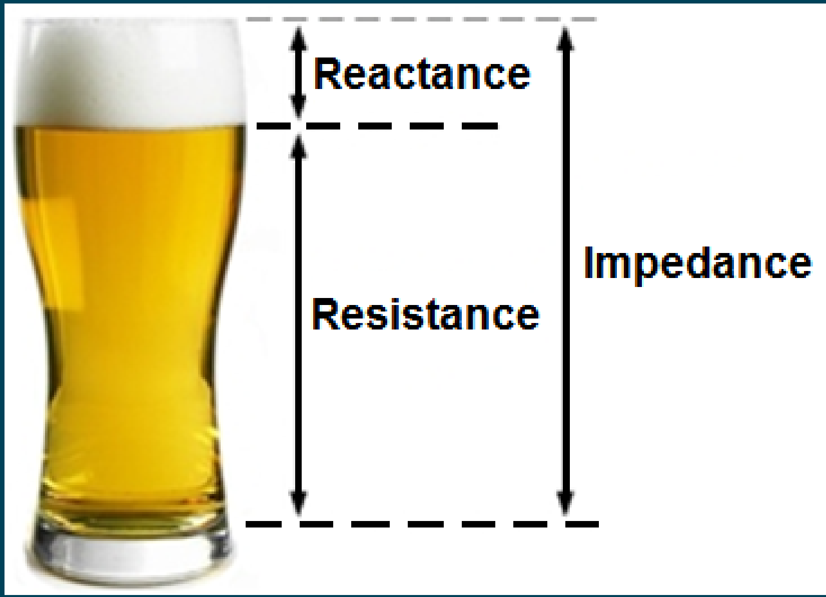
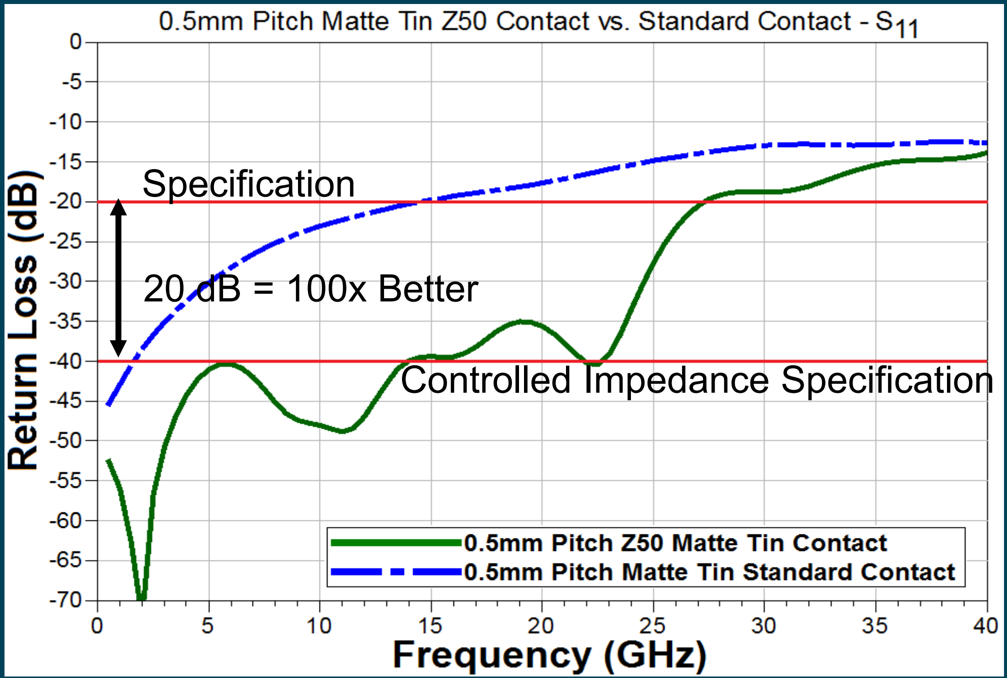
Basic Difference Between Resistance, Inductance and Capacitance





Courtesy of
bing.com/images

0.5mm Pitch Measured Data of Controlled Impedance Contact (Z50) vs. Standard Contact – S_{11}



A 10 dB Decrease in Return Loss Results in a 10X Improvement in Reflected Power

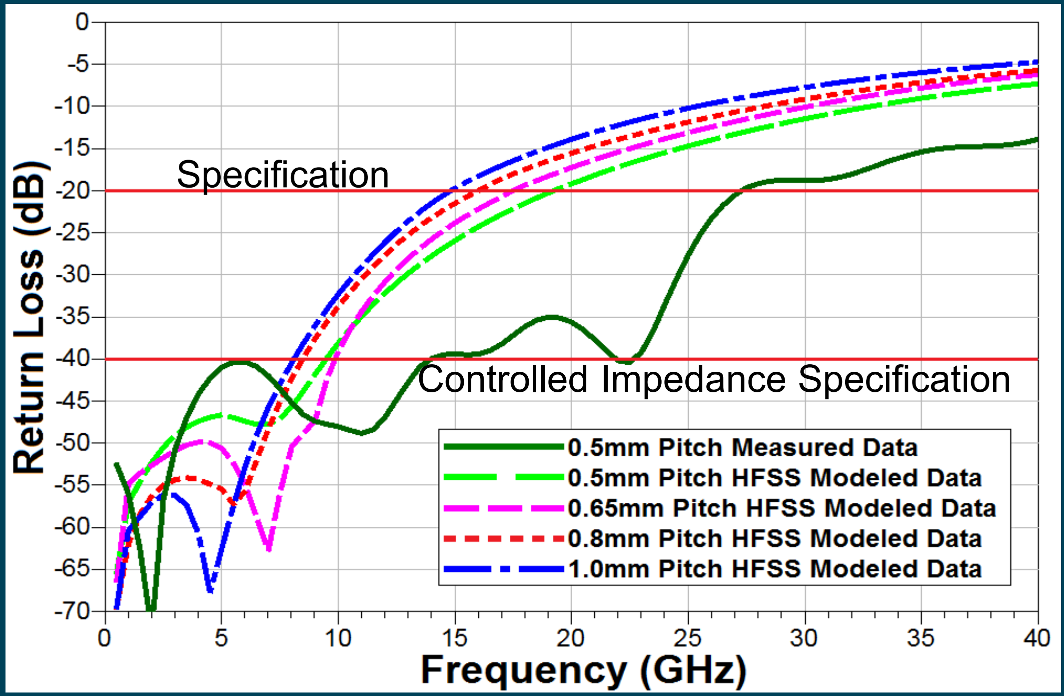
0.5mm Pitch Inductance and Capacitance Summary - Standard vs. Z50

Device Plating	BeCu	BeCu	XL-2	XL-2
	Standard	**Z50**	**Standard**	**Z50**
Description	**Specs**	**Specs**	**Specs**	**Specs**
Self Inductance	0.233 nH	0.396 nH	0.367 nH	0.418 nH
Mutual Inductance	0.143 nH	0.151 nH	0.149 nH	0.153 nH
Ground Capacitance	0.162 pF	0.141 pF	0.084 pF	0.145 pF
Mutual Capacitance	0.053 pF	0.027 pF	0.026 pF	0.029 pF

* Data is from third party test house (Updated 2/8/18)

Profile, Material, Length and Thickness Will Affect Contact Inductances and Capacitance

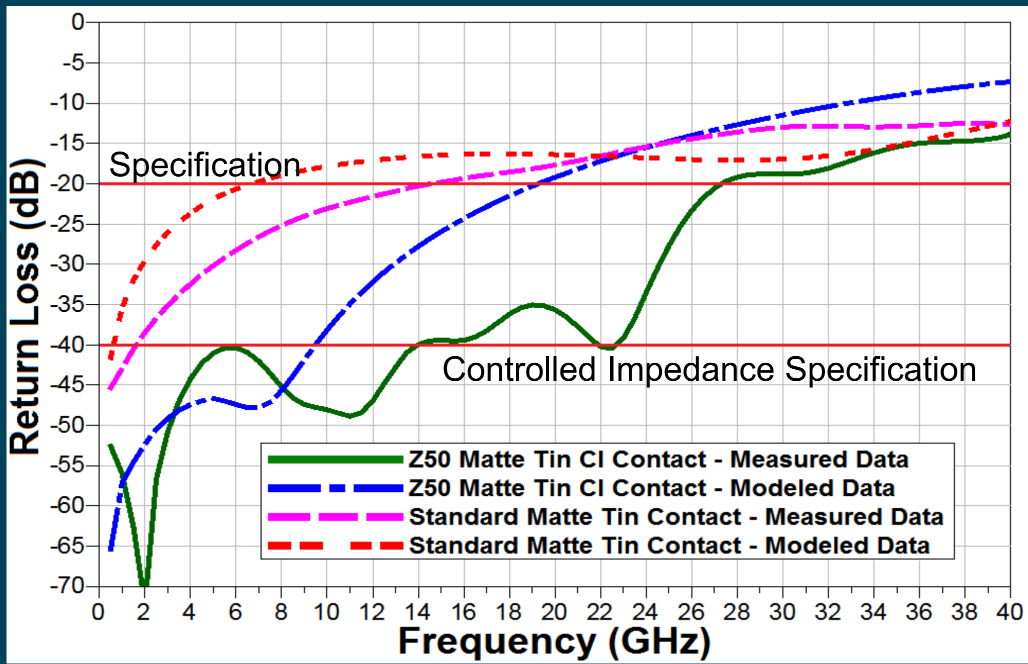
Various Pitch Controlled Impedance (Z50) Contacts Modeled HFSS Performance vs. Pitch – S_{11}



Different Pitches Result in Changes in Capacitances and Inductances of Contact

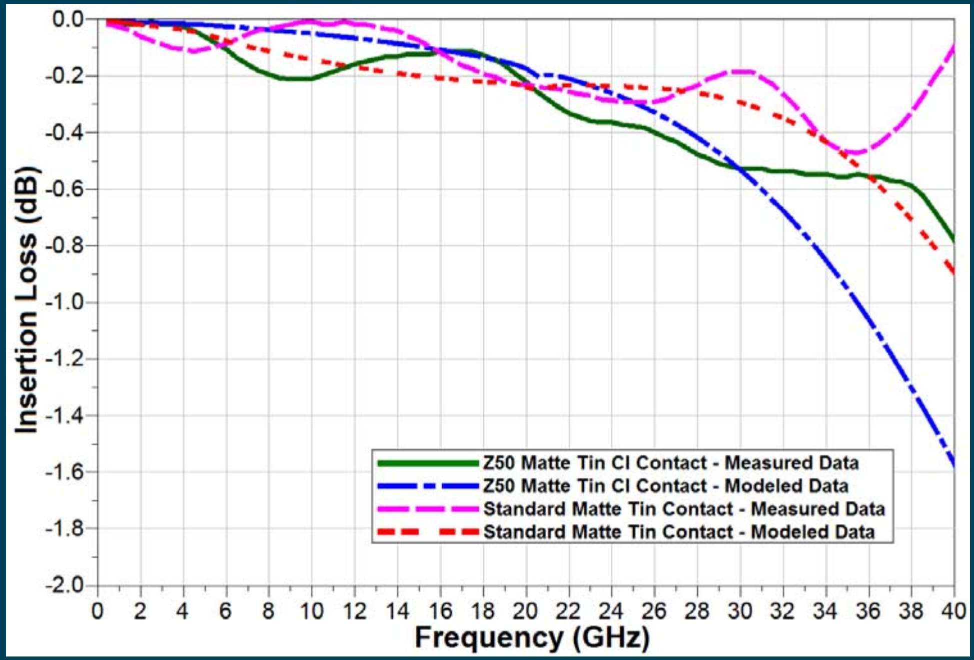
Impedance Controlling Function in the Test System 10

0.5mm Pitch Controlled Impedance (Z50) Contact vs. Standard Contact - Measured vs. Modeled – S_{11}



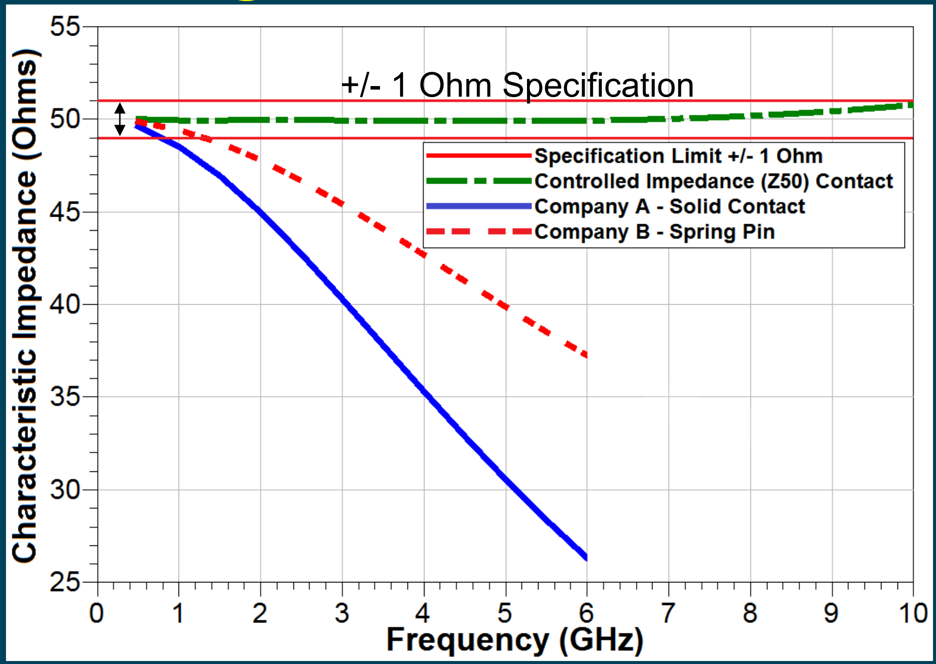
Modeled Data Includes Customer Board and Package – Measured Data Just Contactor

0.5mm Pitch Controlled Impedance (Z50) Contact vs. Standard Contact - Measured vs. Modeled – S_{21}



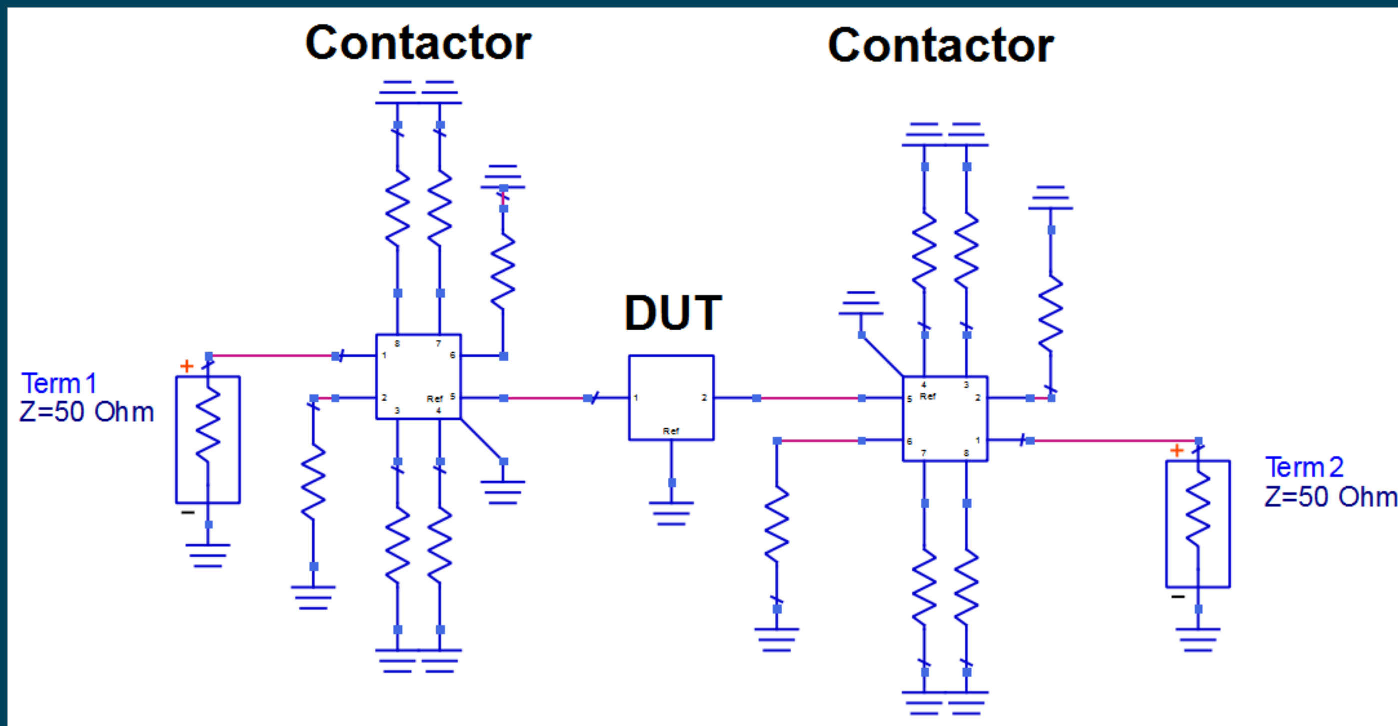
Measured Data Uses High Frequency Probes, Modeled Data Includes Interfaces

0.5mm Pitch Controlled Impedance (Z50) Contact vs. Other Technologies – Characteristic Impedance



Impedance of Three Contacts Used in Following Examples With 50 Ohm Amplifier

Case Study Using 50 Ohm RF Amplifier DUT

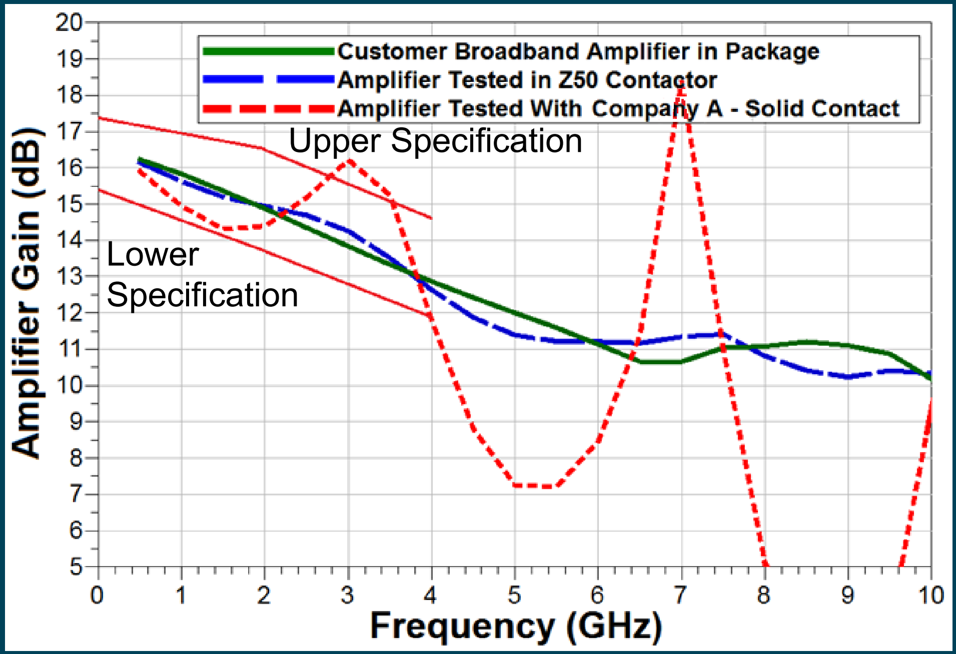


Amplifier Specifications

Amplifier Specifications							
Gain	**Min.**	**Typical**	**Max.**	**Input RL (dB)**	**Typical**	**Output RL (dB)**	**Typical**
Freq = 0.1 GHz	15.4	16.4	17.3	Freq = 0.1 GHz	30	Freq = 0.1 GHz	25
Freq = 2 GHz	13.7	14.9	16.5	Freq = 3 GHz	25	Freq = 3 GHz	16
Freq = 4 GHz	11.9	12.5	14.6	Freq = 6 GHz	22	Freq = 6 GHz	14
Noise Figure	**Typical**	**Max.**		**Saturated Output Power**		**Output Power 1dB Comp.**	
Freq = 0.1 GHz	3.2	3.7		Freq = 0.1 GHz	14 dBm	Freq = 0.1 GHz	13.1 dBm
Freq = 2 GHz	3.3	3.8		Freq = 2 GHz	13 dBm	Freq = 2 GHz	13.0 dBm
Freq = 4 GHz	3.4	4		Freq = 4 GHz	12 dBm	Freq = 4 GHz	11.0 dBm

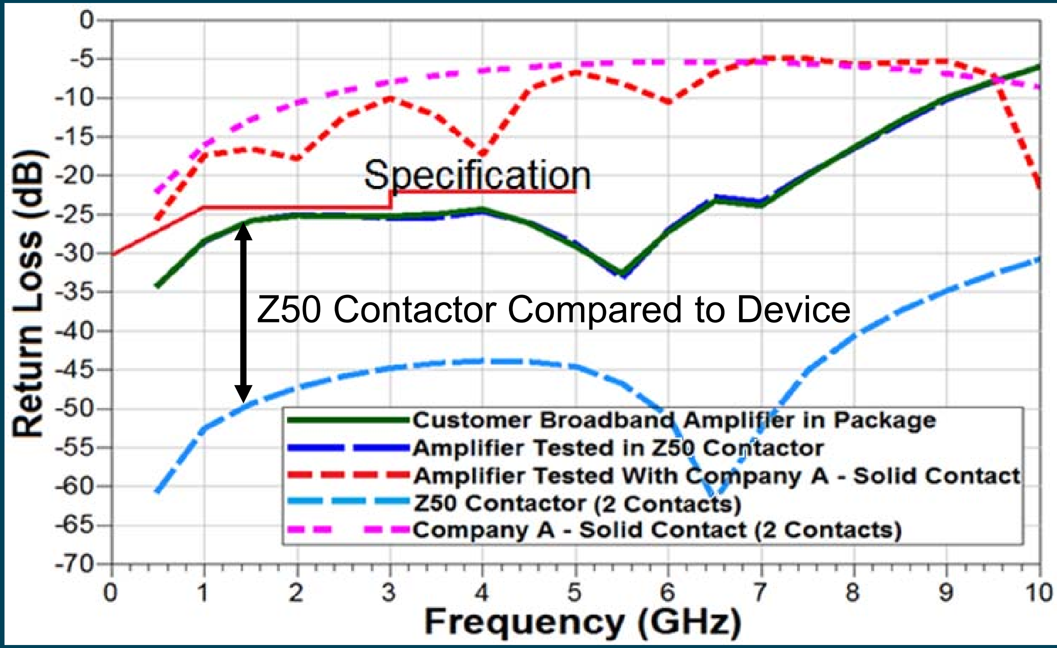
Amplifier is DC - 6 GHz internally matched to 50 Ohms, unconditionally stable, with low performance variation over temperature that can be used for Cellular, PCS, 3G base station, Fixed wireless and WLAN, or microwave radio or test equipment.

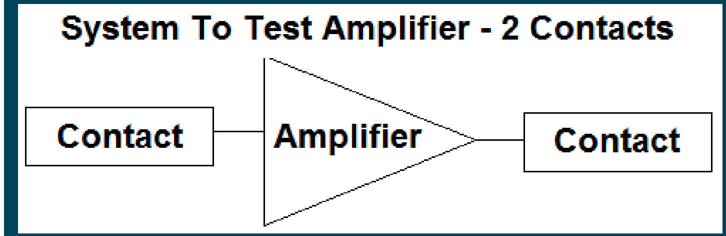
0.5mm Pitch Z50 vs. Other Solid Technology – (Amplifier vs. Amplifier in Socket) – S_{21}



Z50 Contact Tracks Actual Gain Much Better than Other Solid Technology

0.5mm Pitch Z50 vs. Other Solid Technology – (Amplifier vs. Amplifier in Socket) – S_{11}

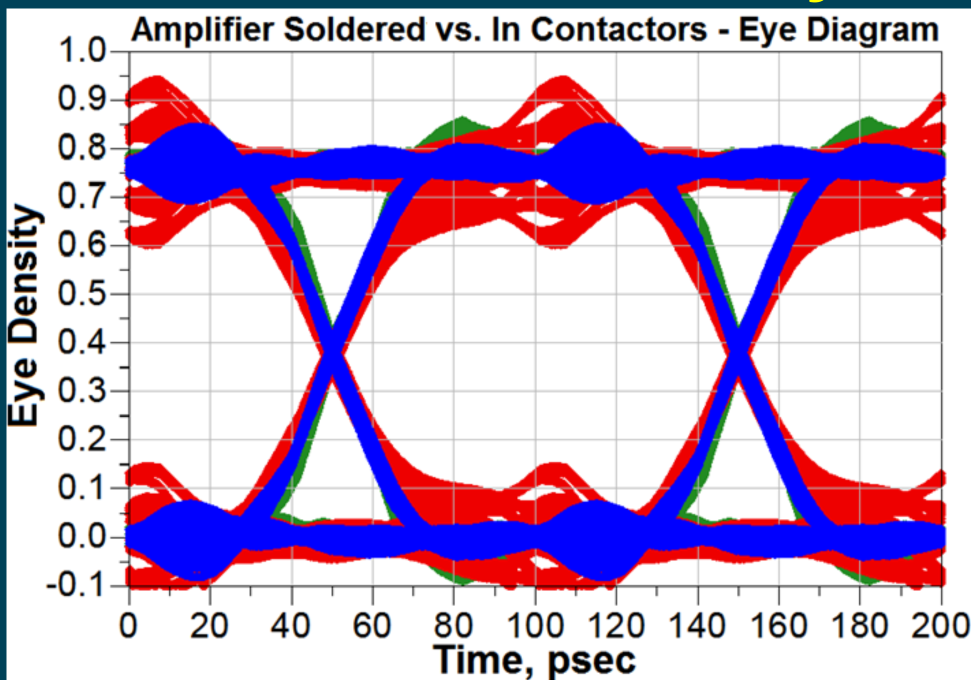




Other Solid Technology will fail every device tested because performance is worse than device being tested!

Z50 Contacts Are Needed to Test Devices When Specifications Are Tight

Amplifier System in Z50 vs. Other Solid Technology - 10 Gbits/s Eye Diagram



Green = Input + Amp

Blue = Amp + Z50

Red = Amp + Other Solid Technology

Input

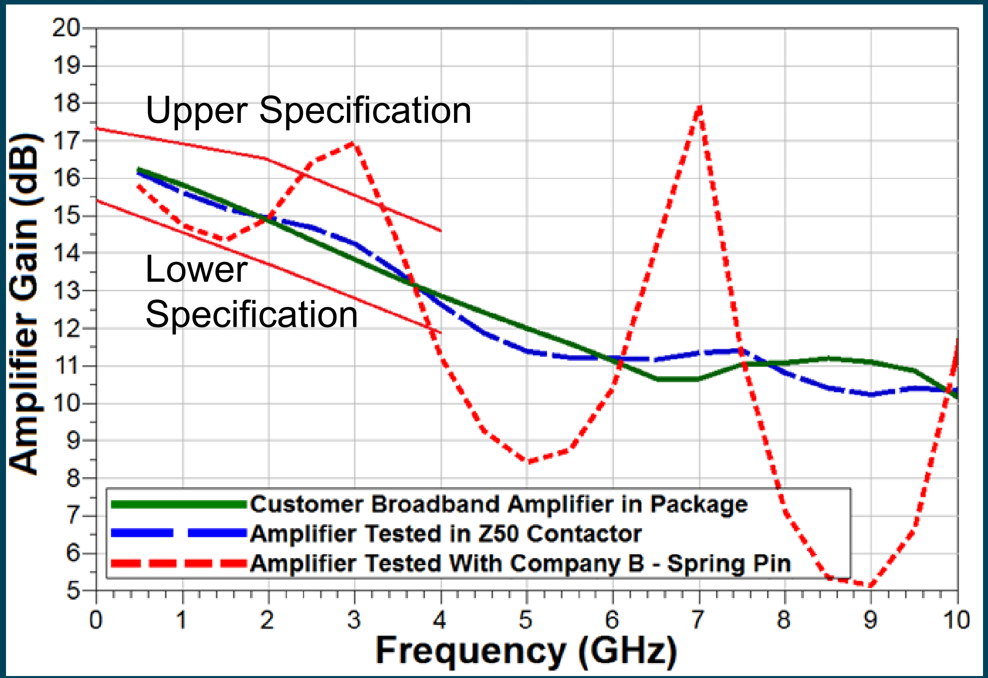
10 Gbits/sec pulse

Rise Time = 10 psec

Fall Time = 10 psec

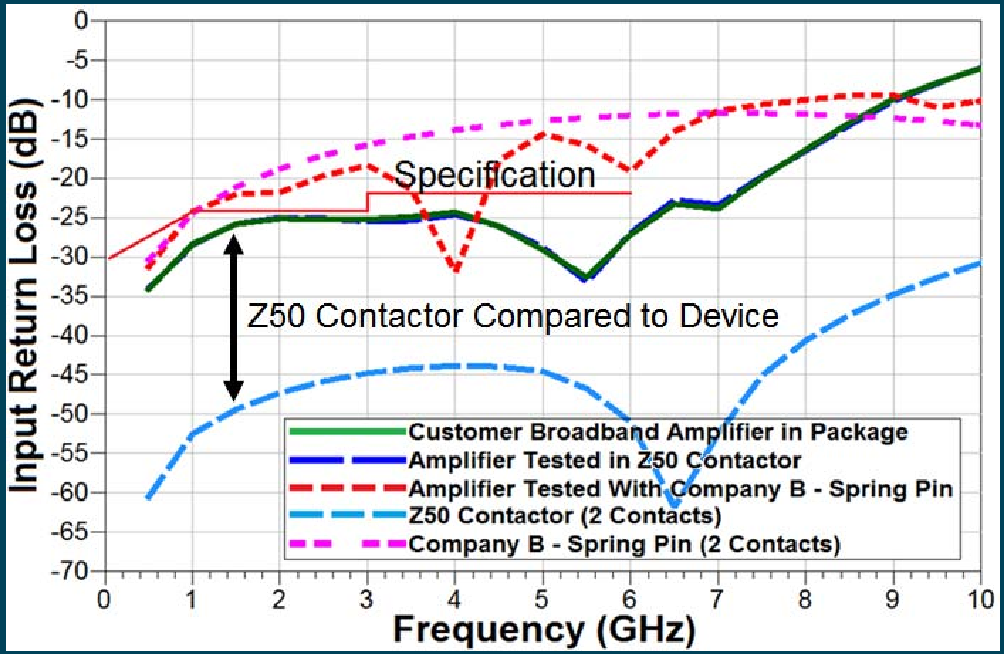
Insertion Loss Affects Closing of Eye on Top and Bottom

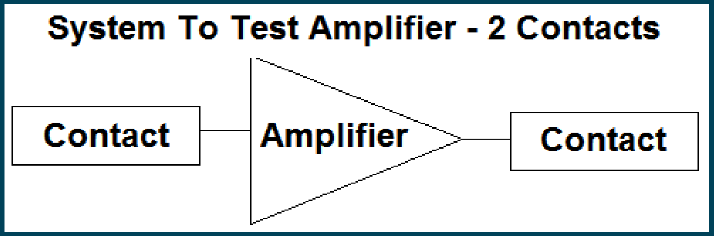
0.5mm Pitch Controlled Impedance vs. Spring Pin Design - (Amplifier vs. Amplifier in Contactor) – S_{21}



Ground Inductance of Contactor Impacts Amplifier Gain

0.5mm Pitch Z50 vs. Spring Pin Design - (Amplifier vs. Amplifier in Contactor) – S_{11}

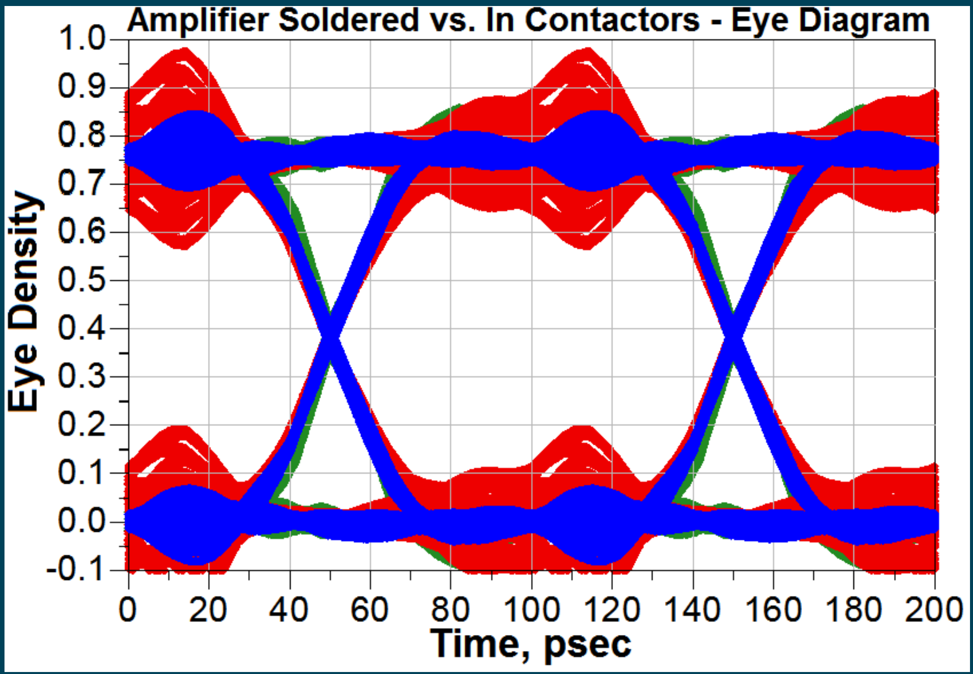




Spring Pin Technology will fail some devices and pass others depending on frequency tested which could generate more false failures!

The Better the Contactor's Performance the More Accurate the Device Test Results

Amplifier System in Z50 vs. Spring Pin Technology - 10 Gbits/s Eye Diagram



Green = Input + Amp

Blue = Amp + Z50

Red = Amp + Other Solid Technology

Input

10 Gbits/sec pulse

Rise Time = 10 psec

Fall Time = 10 psec

Jitter is more for non-solid contacts

Testing With Contactor That Out Performs Device Being Tested Results in $$$$$ Savings

Courtesy of bing.com/images

- May not need to calibrate path
- Less failures and higher yield
- Reduced false failures or false passes
- Stable results reduces need for retesting failed parts
- Controlled Impedance results in testing only device Return Loss
- Solid contact results in ability to test at higher powers or for longer times

Look No Calibration!

Conclusion

- The better the contactor's performance the more reliable the test data
- In order to get accurate results you want fixturing (including Contactor) to be 10 dB better than device being measured if possible
- If Contactor performance is superior to Device Under Test (DUT) calibration may not be necessary or could be limited
- Better Contactor performance results in fewer false failures
- Controlled Impedance Contactors only work if package and board are also 50 Ohms
- Matching will improve performance in frequency band but usually decrease performance outside of bandwidth