

# **EXAMINATION OF SPECTRAL LIMITATIONS IN HFC PLANTS**

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# SUPPORTERS

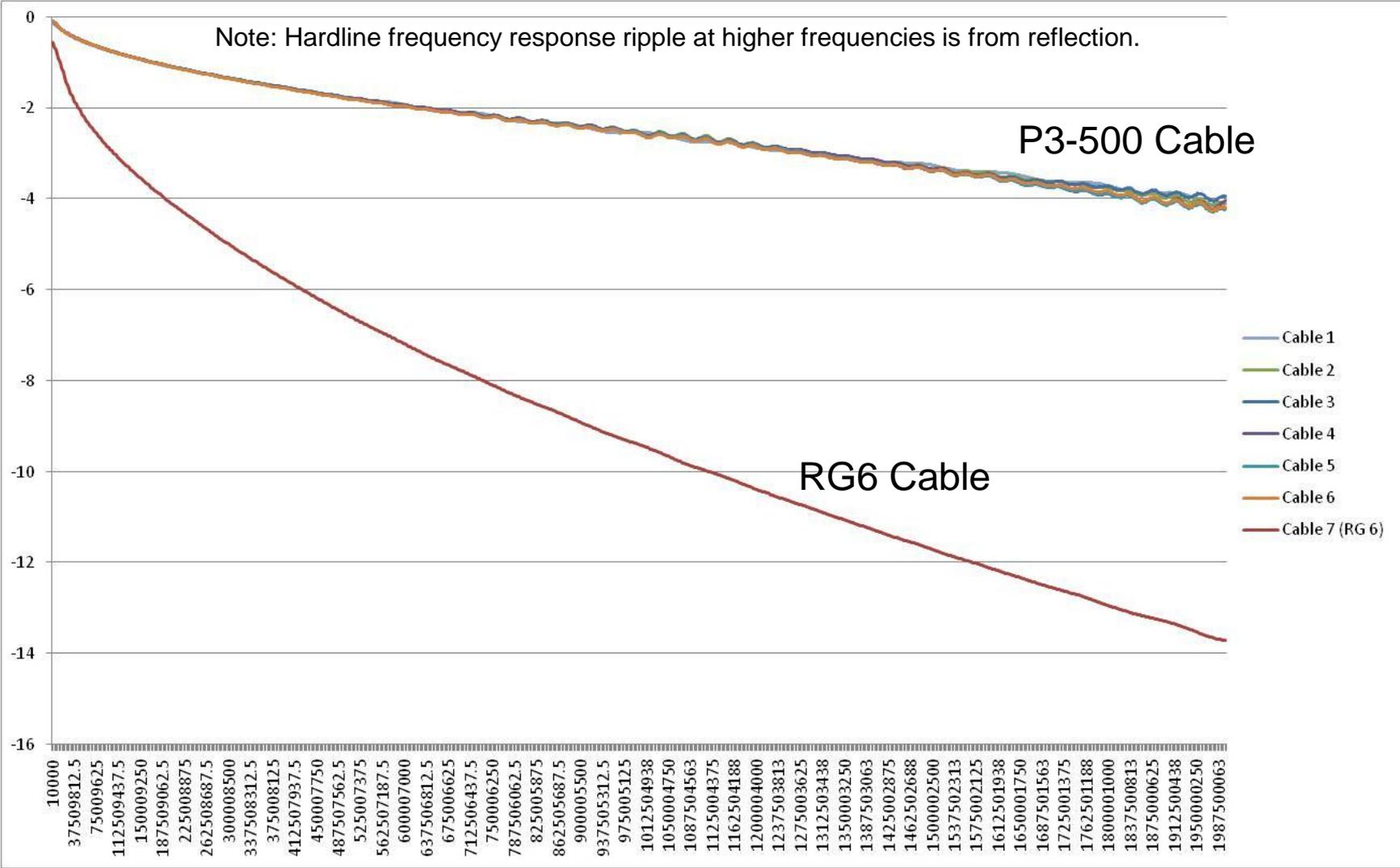
- **Alberto Campos, CableLabs**
- **Robert L. Howald, Motorola**

# OBJECTIVES

- **Characterize two types of 1 GHz multi-taps up to 1600 MHz using S-parameters.**
- **Compare and validate simulation of a Node + 0 plant model against actual measured losses.**
- **Demonstrate the channel response characteristics and effects on spectrally efficient, high capacity modulation.**

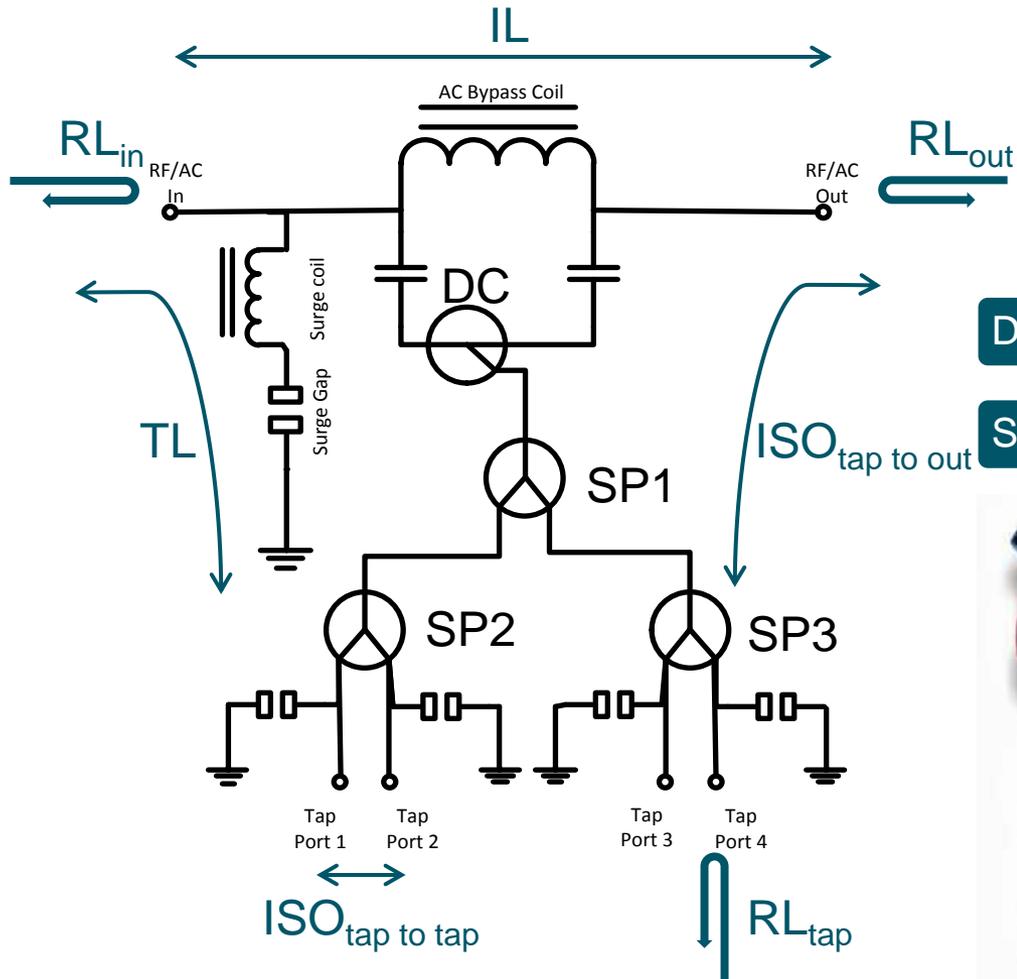
# **COAXIAL CABLE MEASURED DATA**

# TEST RESULTS - CABLE LOSS



# 4-PORT MULTI-TAP MEASURED DATA

# TYPICAL 4-WAY MULTI-TAP DIAGRAM

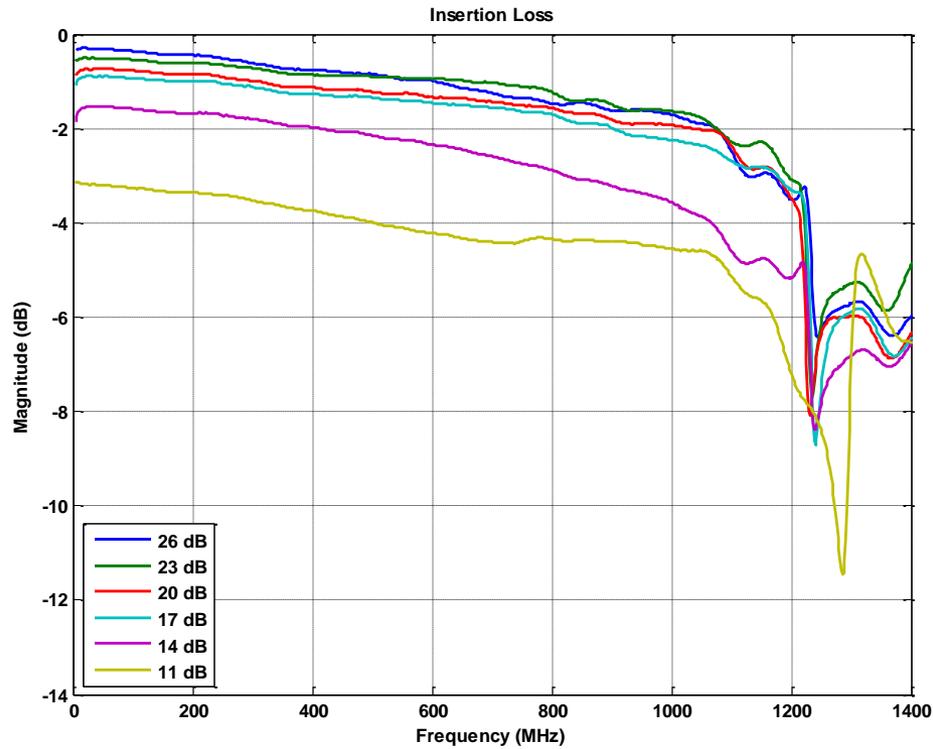


DC: 0, 3, 6, 9, 12, 15, 18, 21, 24, 27 dB

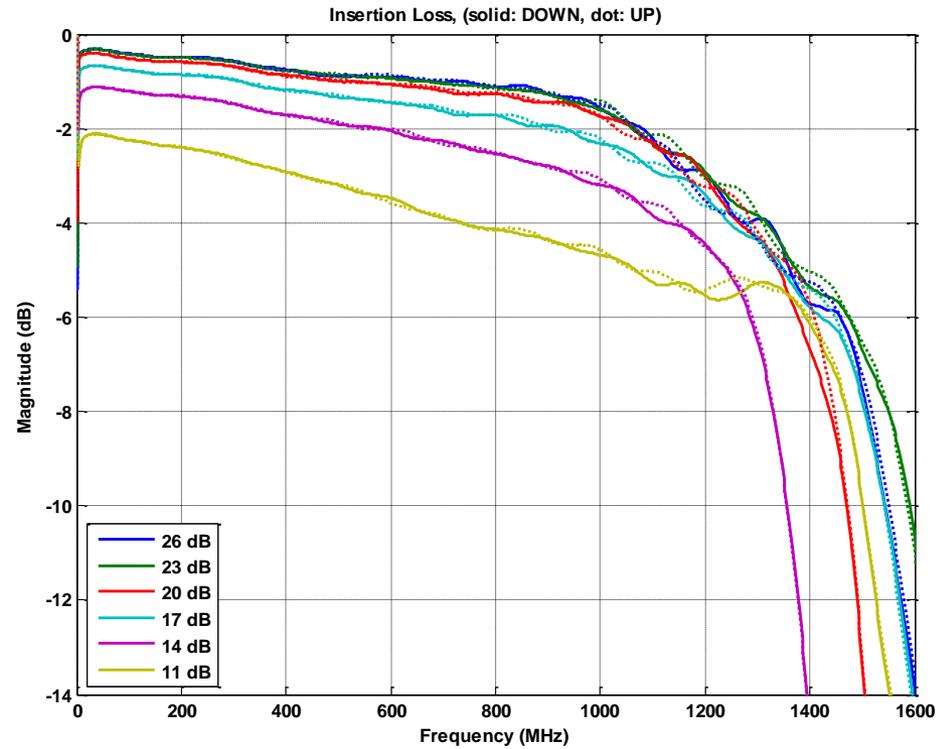
SPx: 4 dB



# INPUT TO OUTPUT INSERTION LOSS

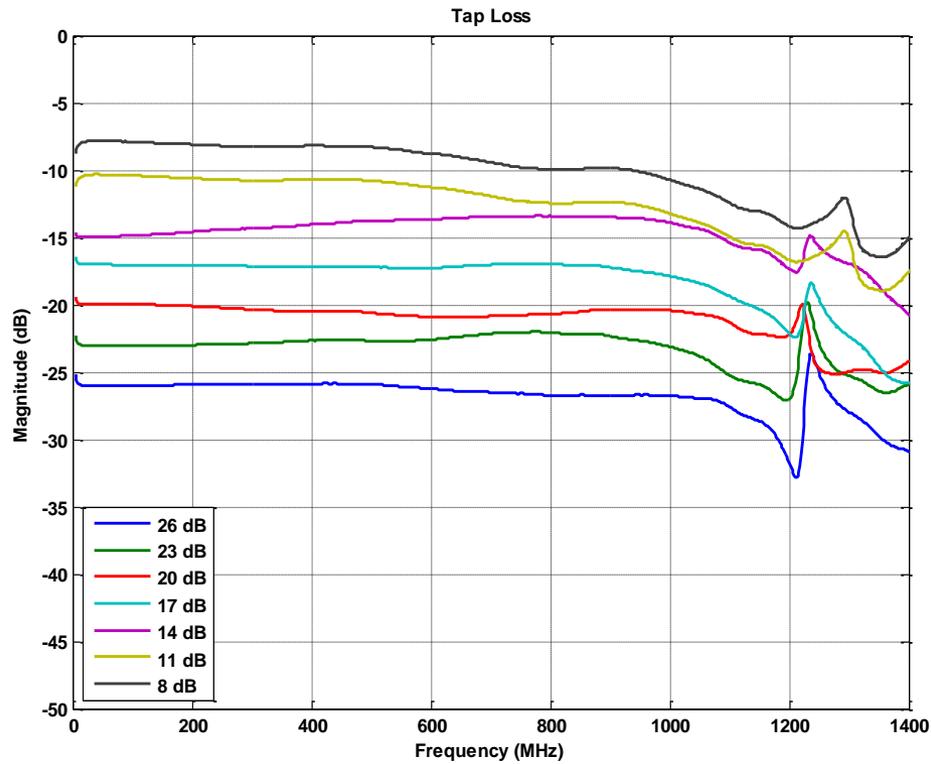


Type A

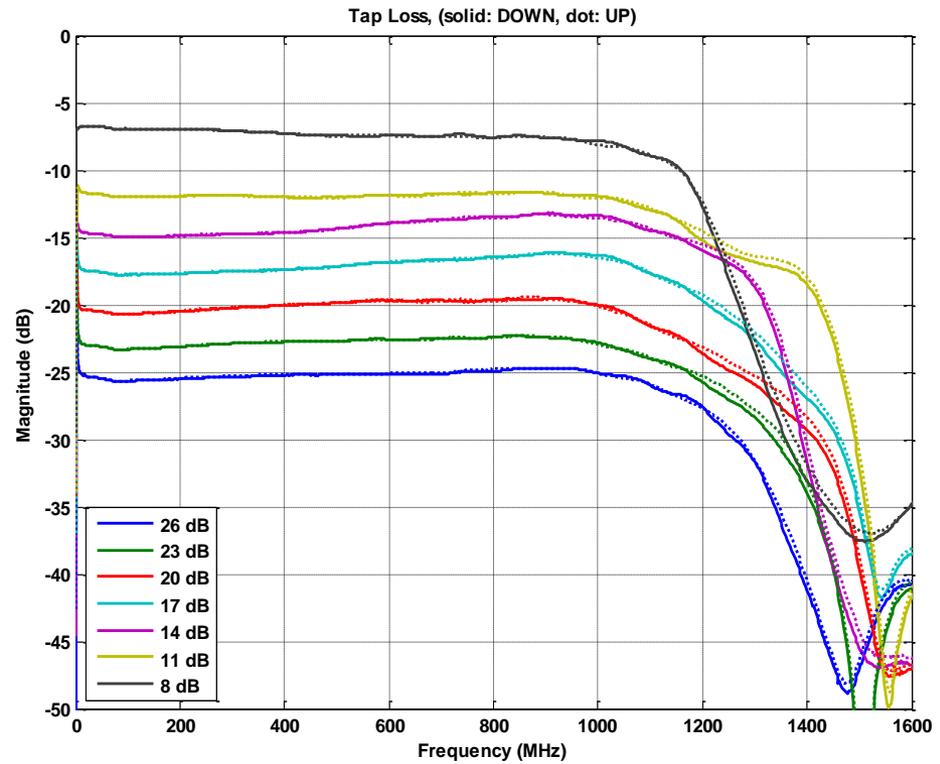


Type B

# TAP LOSS

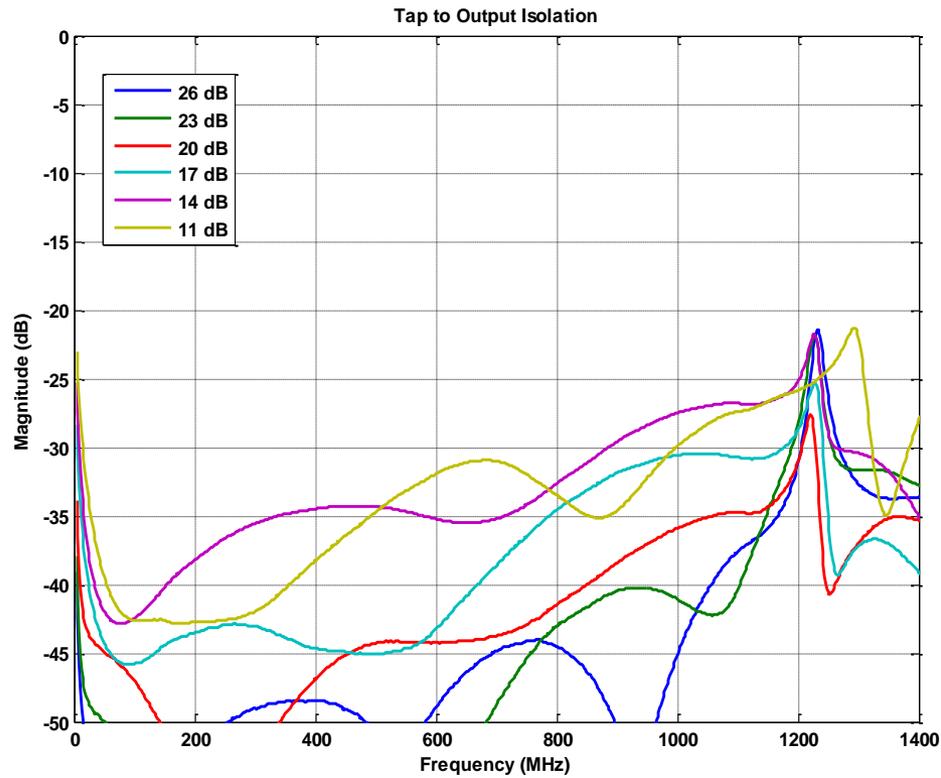


Type A

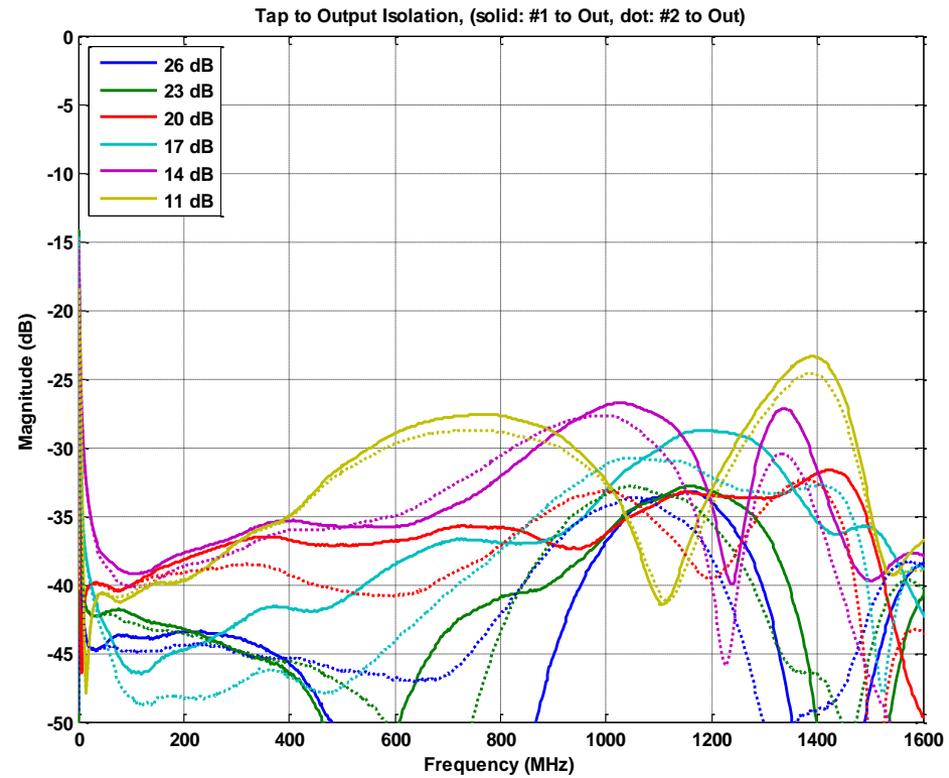


Type B

# TAP TO OUTPUT ISOLATION



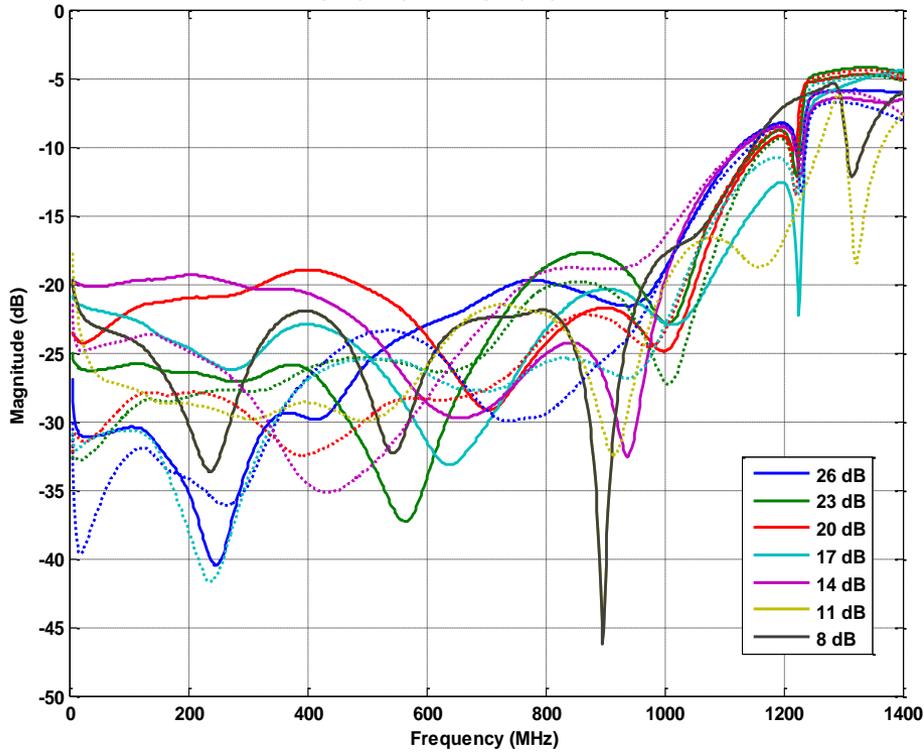
Type A



Type B

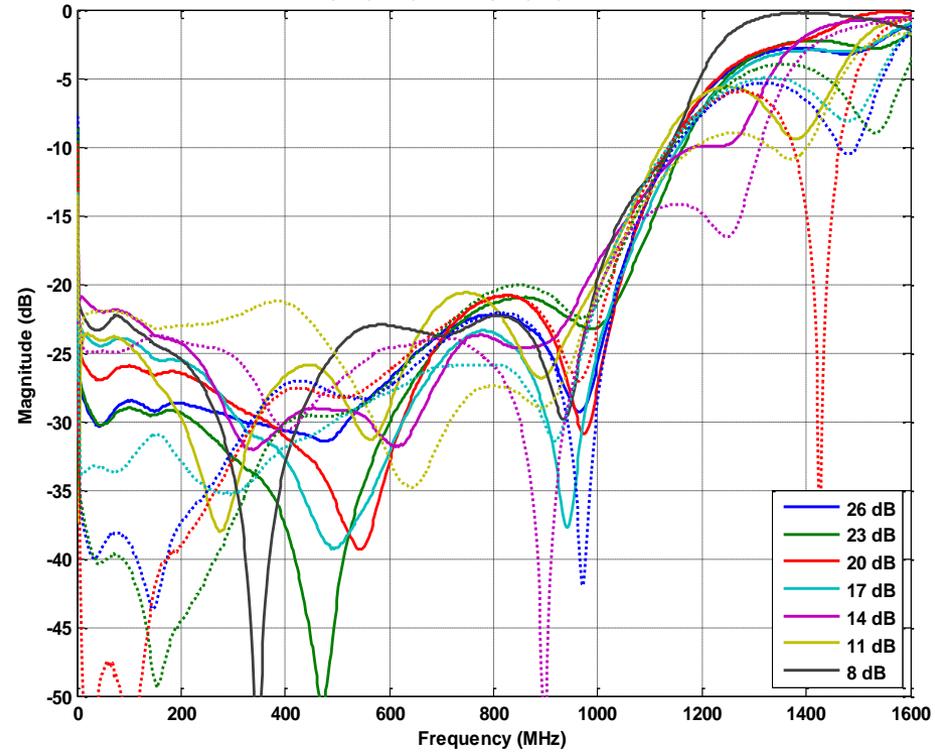
# INPUT AND OUTPUT RETURN LOSS

Input (solid) and Output (dot) Return Loss



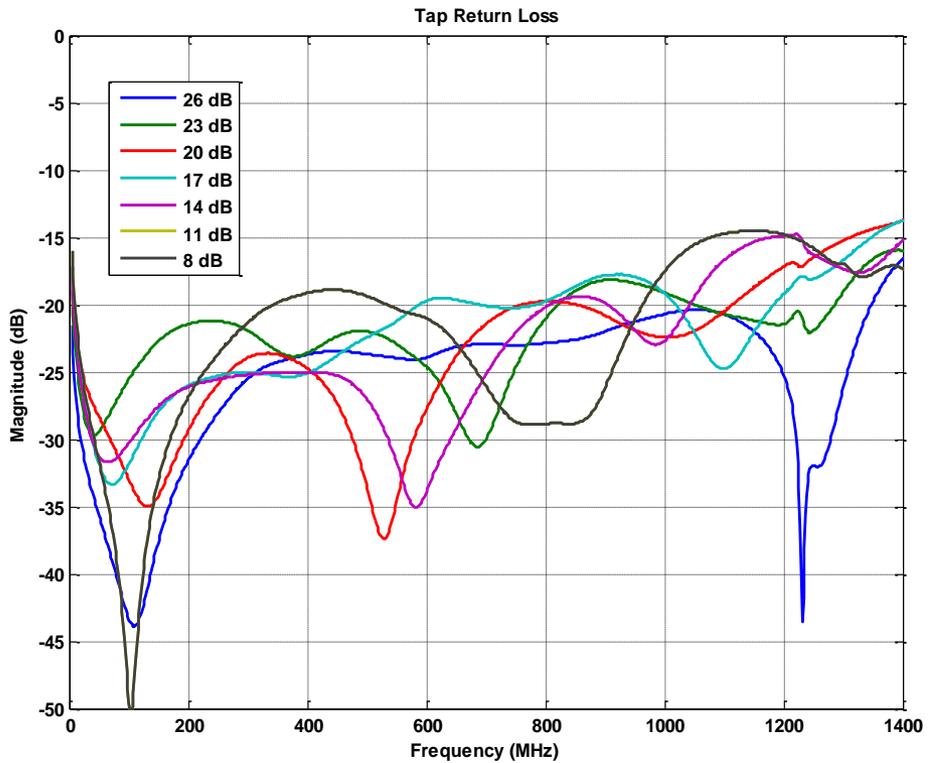
Type A

Input (solid) and output (dot) Return Loss

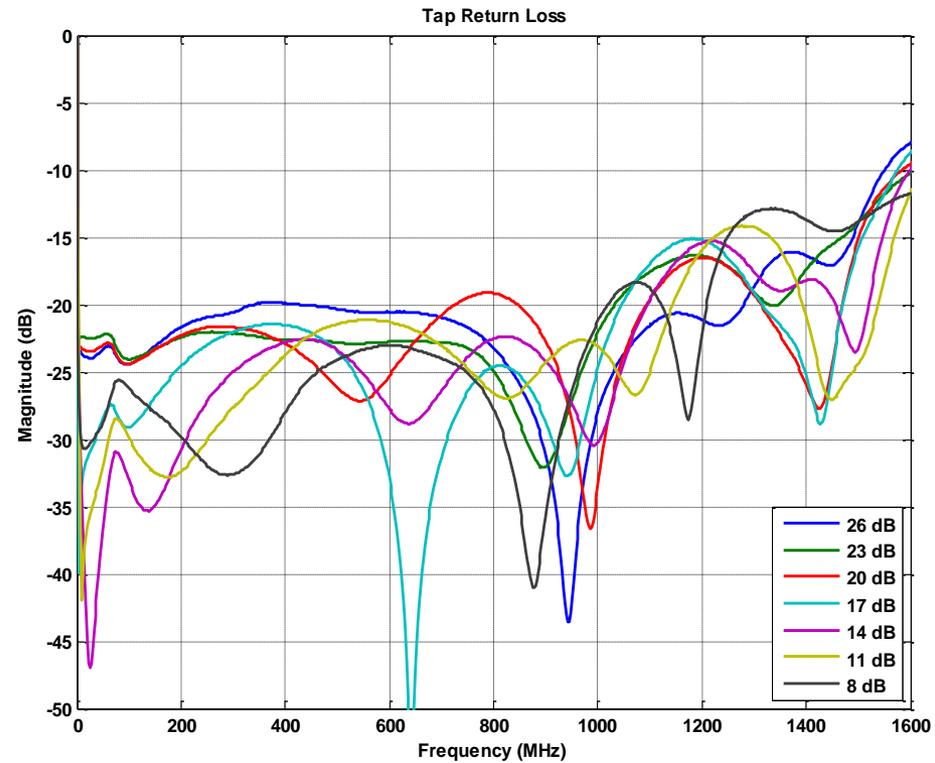


Type B

# TAP RETURN LOSS



Type A



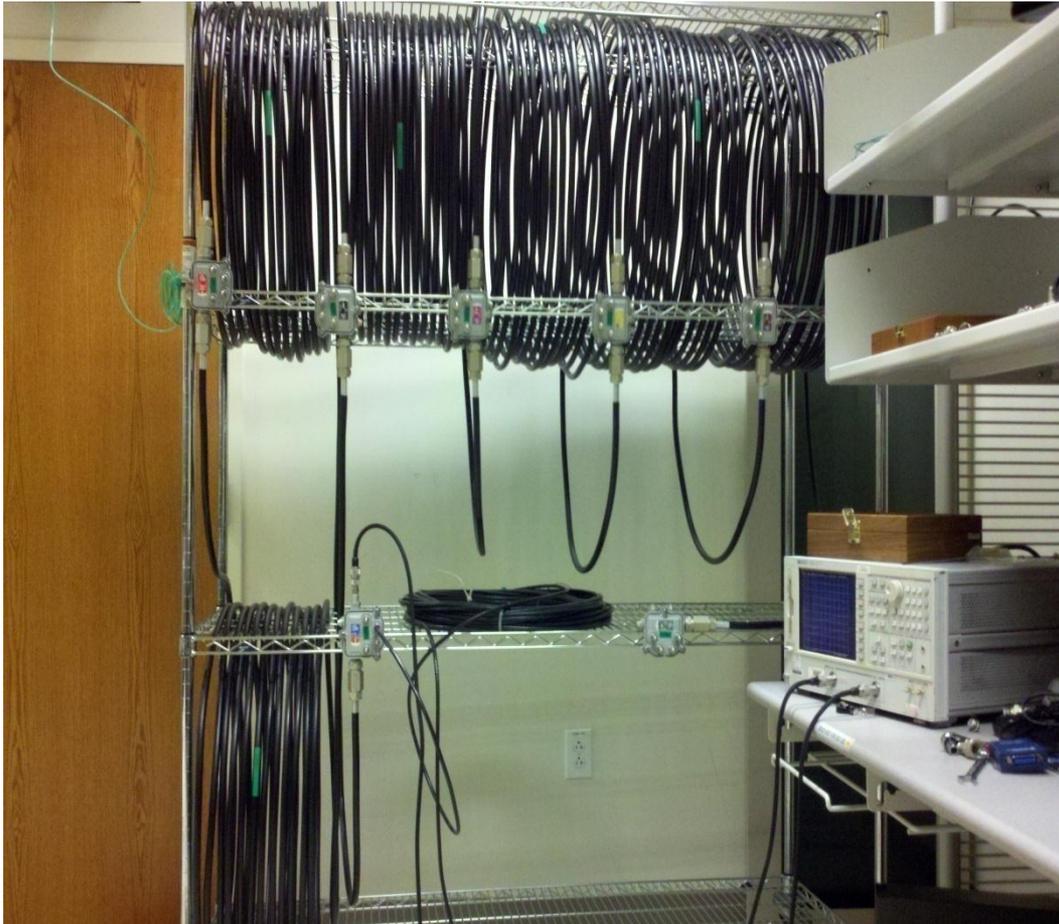
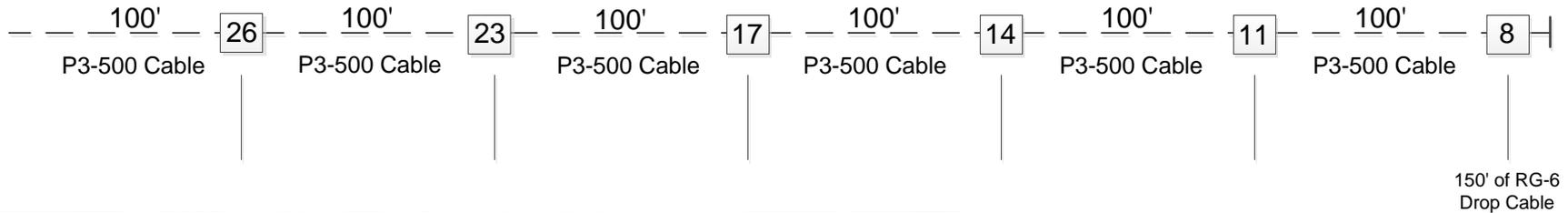
Type B

# SUMMARY: MULTI-TAP MEASURED DATA

- **Multi-tap insertion loss and return loss is optimal from 15 to 1000 MHz. Between 5 to 15 MHz, the performance is slightly degraded.**
- **Multi-tap insertion loss and return loss progressively degrade between 1.0 to 1.2 GHz.**
- **Above 1.2 GHz, the power passing choke self resonance introduces deep nulls in the magnitude response.**

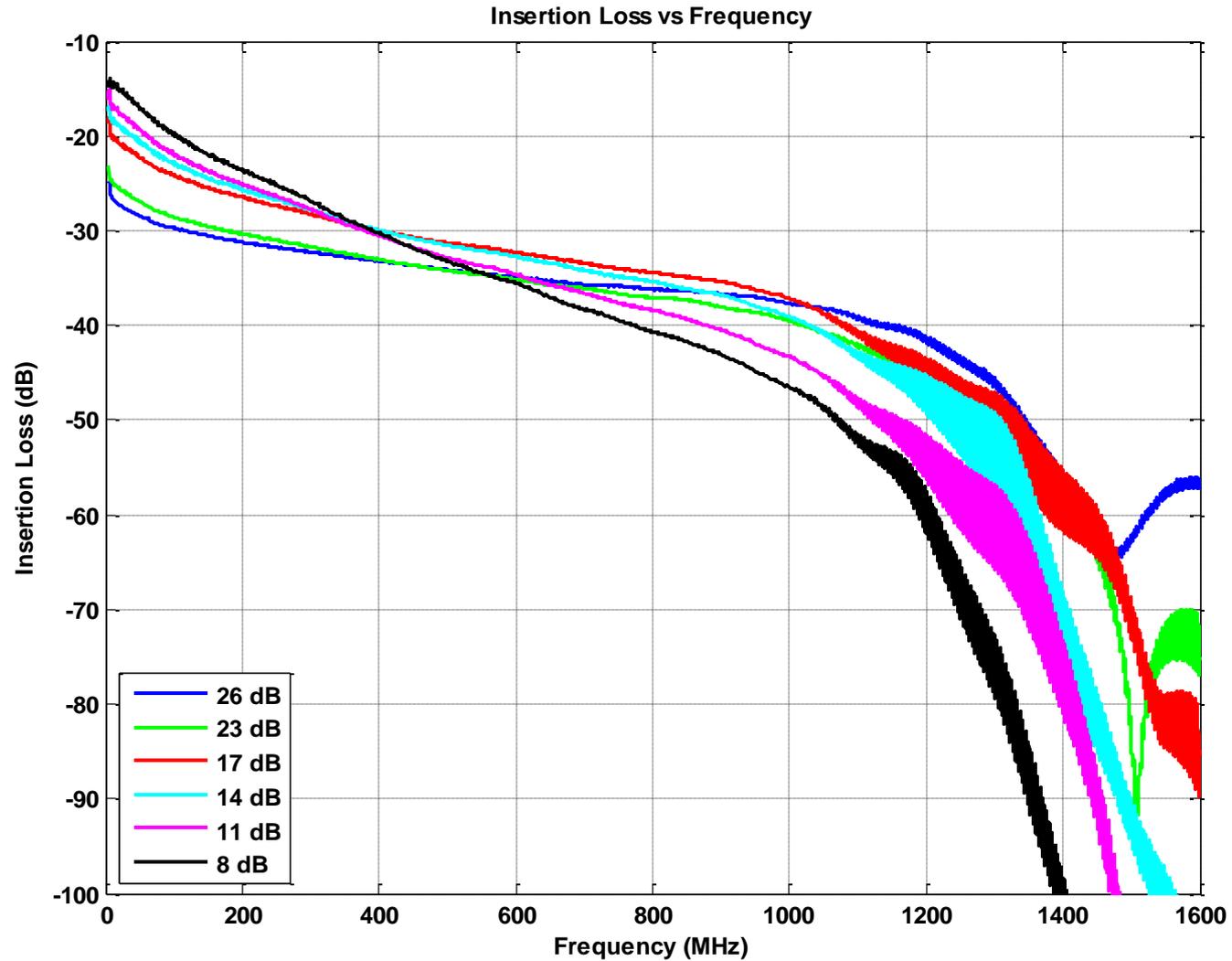
# **SIMULATED NODE + 0 PLANT RESPONSE VS. ACTUAL PLANT MEASUREMENTS**

# TEST EQUIPMENT AND MATERIALS



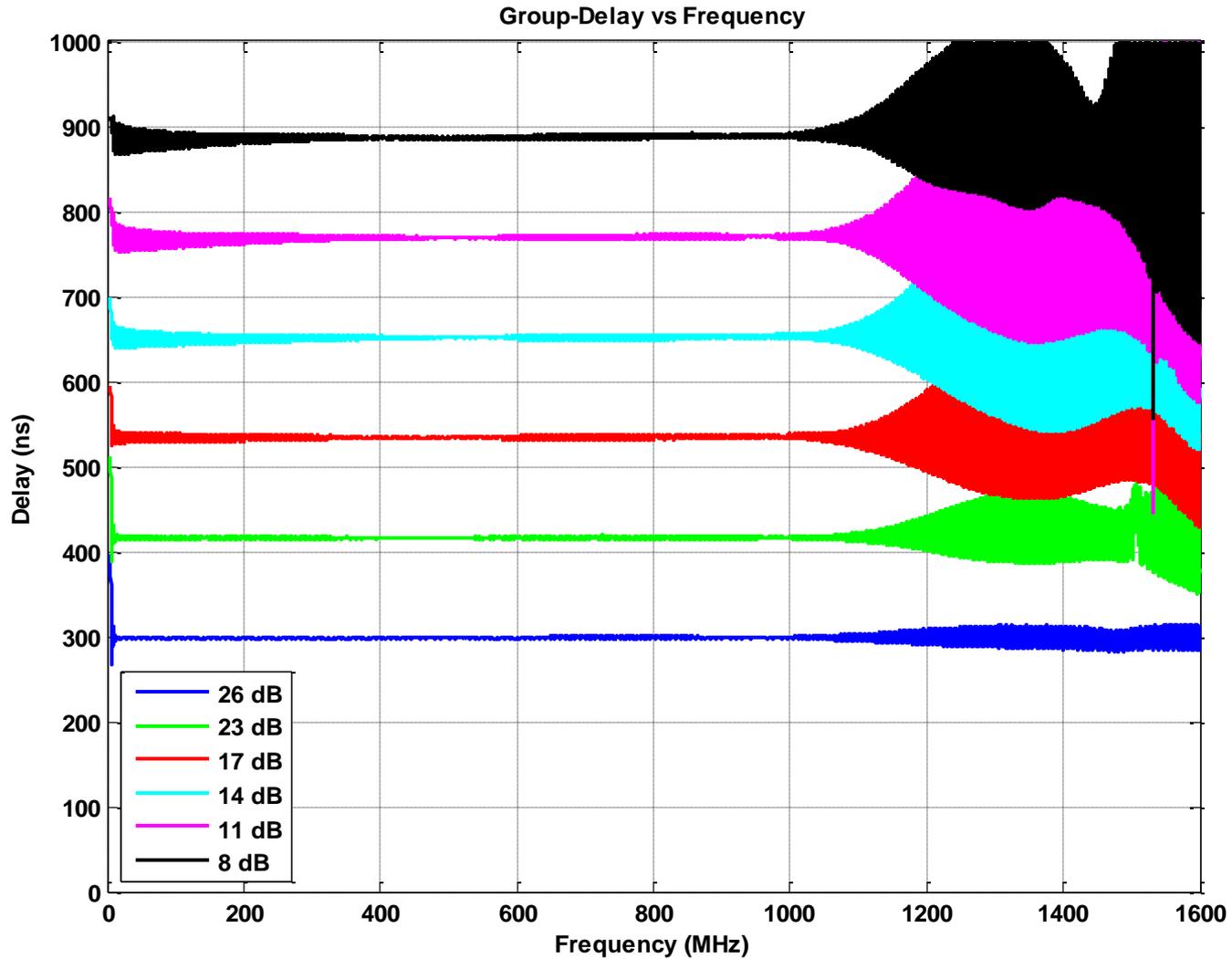
- **Test Equipment :**  
**8753 Agilent Network Analyzer**
- **Hard Line Cable :**  
**CommScope P3-500-JCA cable**
- **Drop Cable :**  
**CommScope RG-6 F6SSV Super Shield drop cable**
- **Taps :**  
**1 GHz 4-port taps**

# SIMULATION RESULTS



Note: Simulation is from 1 to 1600 MHz, step size of 0.1 MHz

# SIMULATION RESULTS



# PLANT MEASUREMENTS VS. SIMULATION

MHz	26 dB Meas	Sim	23 dB Meas	Sim	17 dB Meas	Sim	14 dB Meas	Sim	11 dB Meas	Sim	8 dB Meas	Sim
50	-26.42	-28.39	-26.40	-26.85	-21.96	-22.15	-20.40	-20.57	-19.06	-19.27	-16.60	-16.86
1000	-38.33	-37.64	-40.02	-39.47	-38.41	-37.08	-40.03	-38.98	-44.50	-43.30	-46.74	-46.49
1140	-39.27	-39.95	-42.87	-43.38	-44.03	-42.39	-45.94	-45.05	-52.34	-50.40	-54.10	-54.24

# **SUMMARY OF SIMULATED PLANT RESPONSE AND ACTUAL PLANT MEASUREMENTS**

- **Plant measurements and simulations results are in close agreement provided the S-parameters of the plant passives are available in the frequency range of interest.**
- **Loss, amplitude variation and group-delay variation increase significantly from 1000 to 1150 MHz. This may prevent the use of higher order modulation above 1 GHz.**
- **Loss, amplitude variation and group-delay variation increase abruptly and return loss decreases abruptly above 1150 MHz.**
- **Such huge degradations in current plant technology frequency response prevent the efficient use of frequencies above 1150 MHz.**

# CONCLUSIONS

- **Node+0 plant with 1 GHz passive may have 100 to 200 MHz of additional usable bandwidth.**
- **Echoes in the cable plant are relatively “mild” in the frequency range of 15 to 1000 MHz due to low variation in the amplitude and group delay response.**
- **Response between 1.0 to 1.2 GHz shows higher losses and larger amplitude variation and group-delay variation with increased echo amplitude due to the degraded return loss and tap isolation.**
- **Operation above 1000 MHz has lower spectral efficiency due to such higher loss, degraded frequency response and increased echo amplitude.**
- **Above 1.2 GHz, the plant is likely unusable due to deep notches in the amplitude response from the self resonance of the power passing choke in the multi-taps.**

**THANK YOU**