# Defining a Minimum Channel Floor from Material Constraints

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This presentation will outline the minimum channel performance based on P802.3ap adopted material characteristics, as well as a summary of the effects of lengths and materials on the channel performance.

# Defining Loss – Where to Start: Focus on Material and Conductor

- Define a method to analyze loss without 2D and 3D simulation tools.  Use equations from Bogatin and Cohn as starting points.
- Keep Characteristic Impedance constant while changing trace width and dielectric spacing.
- Verify accuracy to ADS and HFSS toolsets.
- Limit the algebraic equation model to dielectric and conductor loss, while leaving surface roughness, ripple, connector, and cross talk losses for future updates.
- This method allows for apples to apples comparison of geometries and material types.

# An Algebraic Calculation: Accurate Loss Curves Dk_Df_IL

| Material/Design Characteristics | |
|---|---|
| Simple/Detailed | |
| Char. Imp. (Ohm) | |
| Length (inch) | 40 |
| Trace Width (mil) | 8 |
| Cu Thickness (mil) | 0.67 |
| Diel. Thickness (mil) | 17 |

| Freq | Dk | Df |
|---|---|---|
| 1.00E+08 | 3.6 | 0.0092 |
| 1.00E+09 | 3.52 | 0.0115 |
| 2.00E+09 | 3.49 | 0.0108 |
| 5.00E+09 | 3.46 | 0.011 |
| 1.00E+10 | 3.44 | 0.0112 |
| 2.00E+10 | 3.43 | 0.0114 |

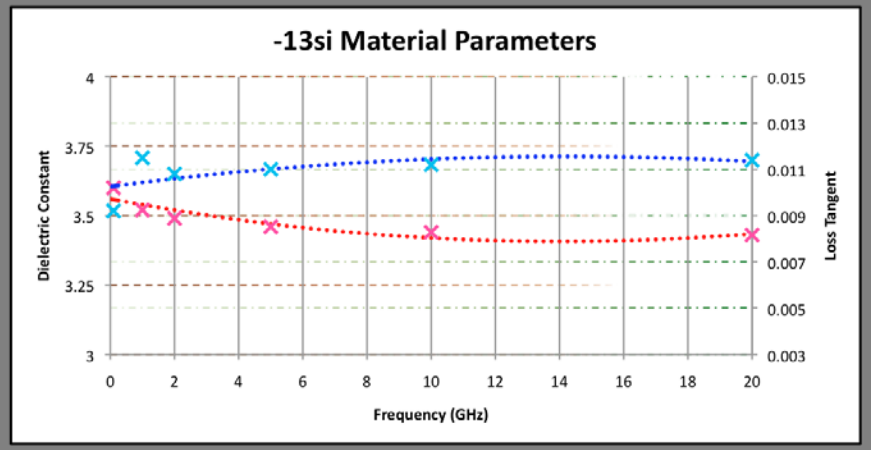
CHANGE PARAMETERS

Loss at 6GHz: 20.18 dB
Loss at 12.5GHz: 37.11 dB
Loss at 14GHz: 40.83 dB

Dk fit to Second Order Equation: c2 7.82196E-22, c1 -2.19424E-11, b 3.560238783

Df fit to Second Order Equation: c2 -6.48072E-24, c1 1.84045E-13, b 0.010253792

| Frequency (GHz) | Zo | $A_{total}$ |
|---|---|---|
| 0.01 | 50.14402 | 0.360709 |
| 0.05 | 50.15019 | 0.896001 |
| 0.1 | 50.15788 | 1.319538 |
| 0.15 | 50.16555 | 1.665403 |
| 0.2 | 50.17319 | 1.971107 |
| 0.25 | 50.18081 | 2.25118 |
| 0.5 | 50.21853 | 3.44795 |
| 0.75 | 50.25565 | 4.47334 |
| 1 | 50.29216 | 5.411257 |
| 1.25 | 50.32805 | 6.29418 |
| 1.5 | 50.36331 | 7.138736 |
| 1.75 | 50.39796 | 7.954776 |
| 2 | 50.43197 | 8.748696 |
| 2.25 | 50.46535 | 9.524913 |
| 2.5 | 50.4981 | 10.28663 |
| 2.75 | 50.5302 | 11.03623 |
| 3 | 50.56166 | 11.77557 |
| 3.25 | 50.59247 | 12.50609 |
| 3.5 | 50.62263 | 13.22896 |
| 3.75 | 50.65213 | 13.94512 |
| 4 | 50.68097 | 14.65534 |
| 4.25 | 50.70915 | 15.36028 |
| 4.5 | 50.73667 | 16.06046 |
| 4.75 | 50.76351 | 16.75635 |
| 5 | 50.78968 | 17.44832 |
| 5.25 | 50.81518 | 18.13672 |



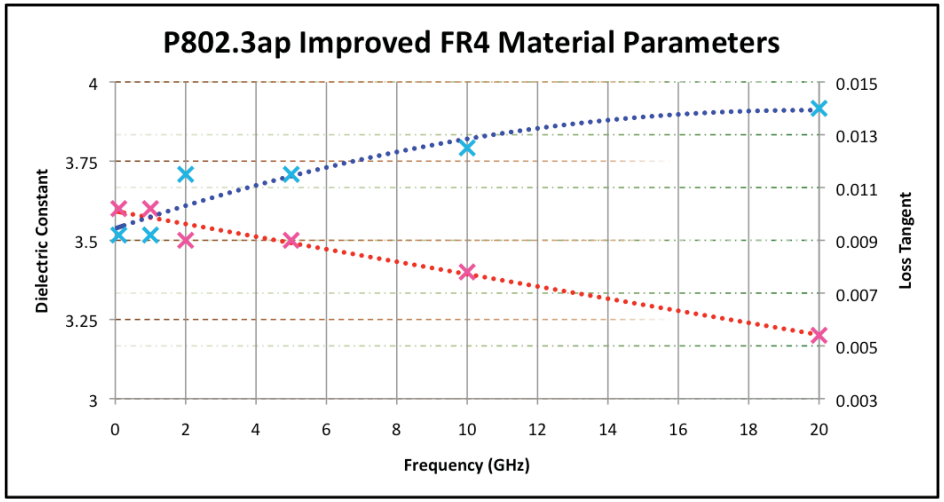
# Remember

- The following data DOES NOT INCLUDE:
  - Surface Roughness
  - Ripple
  - Connector
  - Cross Talk

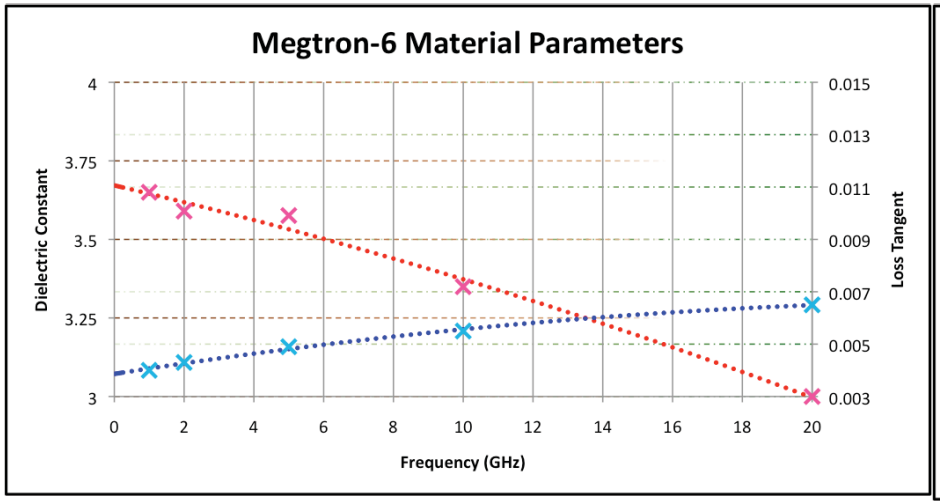
# Validation:
# Comparing Algebra to Calculus

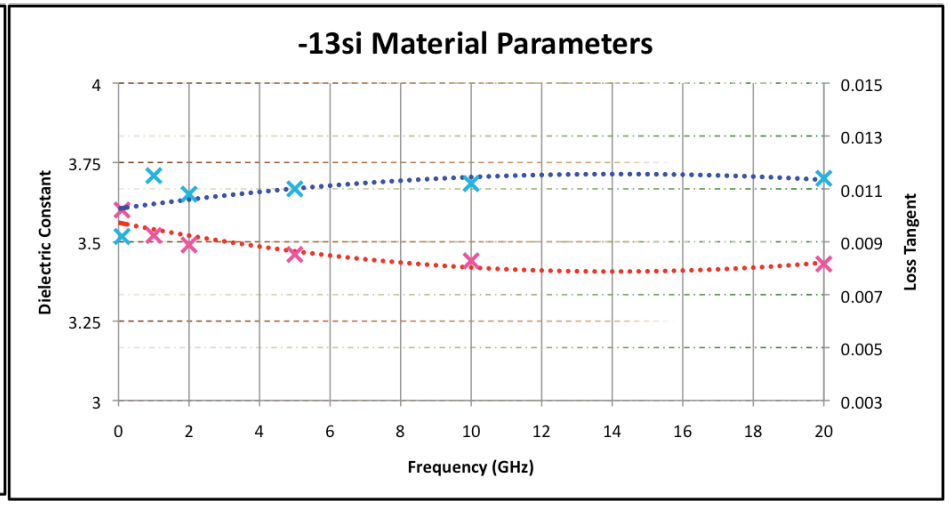
| **30in 8mil track 17mil spacing, 1/2oz cu** | | | | |
|---|---|---|---|---|
| | | | | |
| Impr FR-4 | Algebraic | | ADS / HFSS | |
| Freq | Zc in Ohms | Loss in dB | Zc in Ohms | Loss in dB |
| 6GHz | 50.8 | 15.6 | 51.2 | 14.6 |
| 14GHz | 52 | 33.7 | 52.2 | 32.2 |
| | | | | |
| Meg6 | Algebraic | | ADS / HFSS | |
| Freq | Zc in Ohms | Loss in dB | Zc in Ohms | Loss in dB |
| 6GHz | 50.6 | 10.5 | 50.9 | 9.4 |
| 14GHz | 52.6 | 20.3 | 52.9 | 18.6 |
| | | | | |
| | | | | |
| **40in 8mil track 17mil spacing, 1/2oz cu** | | | | |
| | | | | |
| Impr FR-4 | Algebraic | | ADS / HFSS | |
| Freq | Zc in Ohms | Loss in dB | Zc in Ohms | Loss in dB |
| 6GHz | 50.8 | 20.9 | 51.2 | 19.5 |
| 14GHz | 52 | 45 | 52.2 | 42.9 |
| | | | | |
| Meg6 | Algebraic | | ADS / HFSS | |
| Freq | Zc in Ohms | Loss in dB | Zc in Ohms | Loss in dB |
| 6GHz | 50.6 | 13.9 | 50.9 | 12.5 |
| 14GHz | 52.6 | 26.9 | 52.9 | 24.8 |

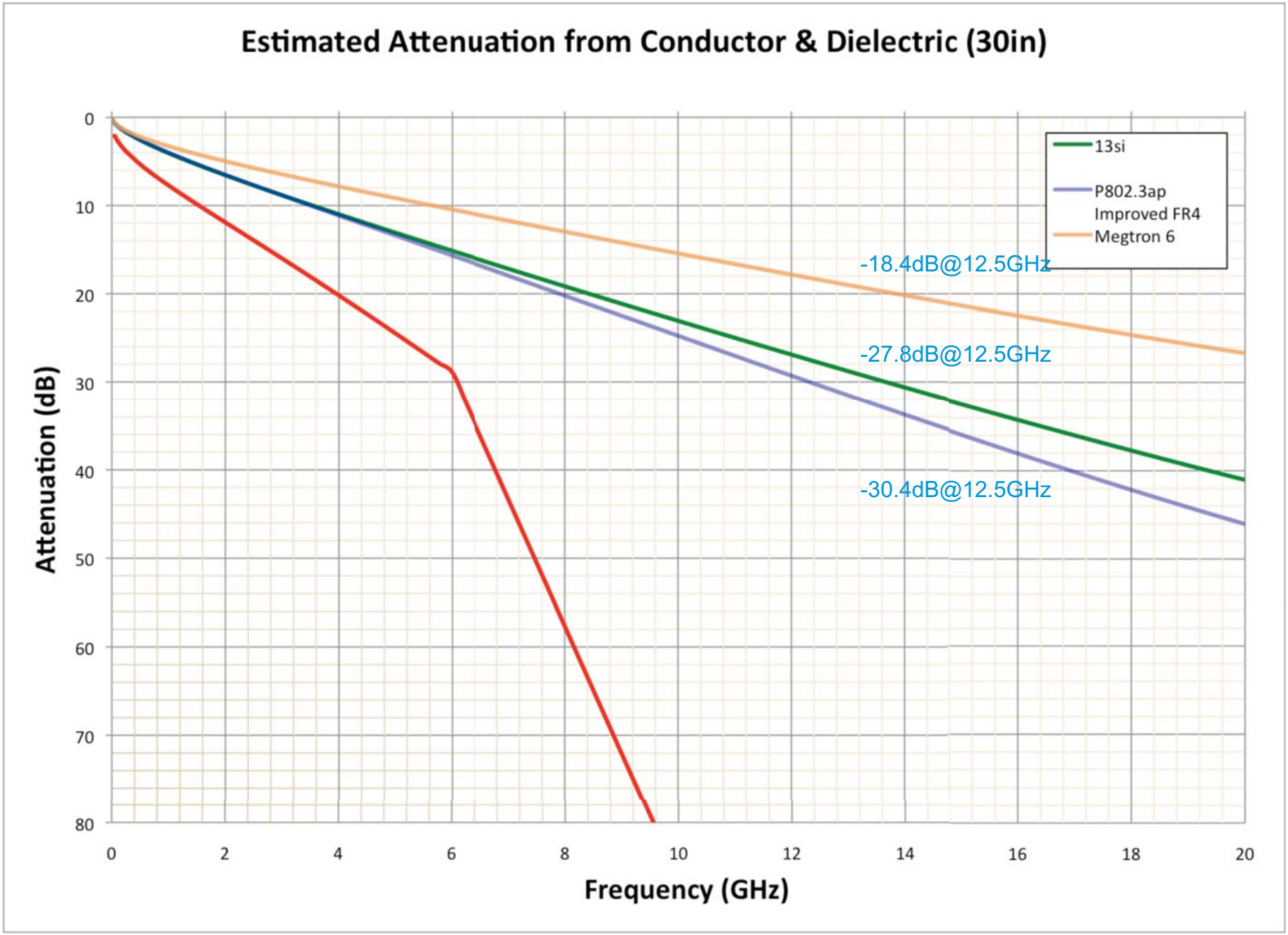
# DK and DF Material Plots

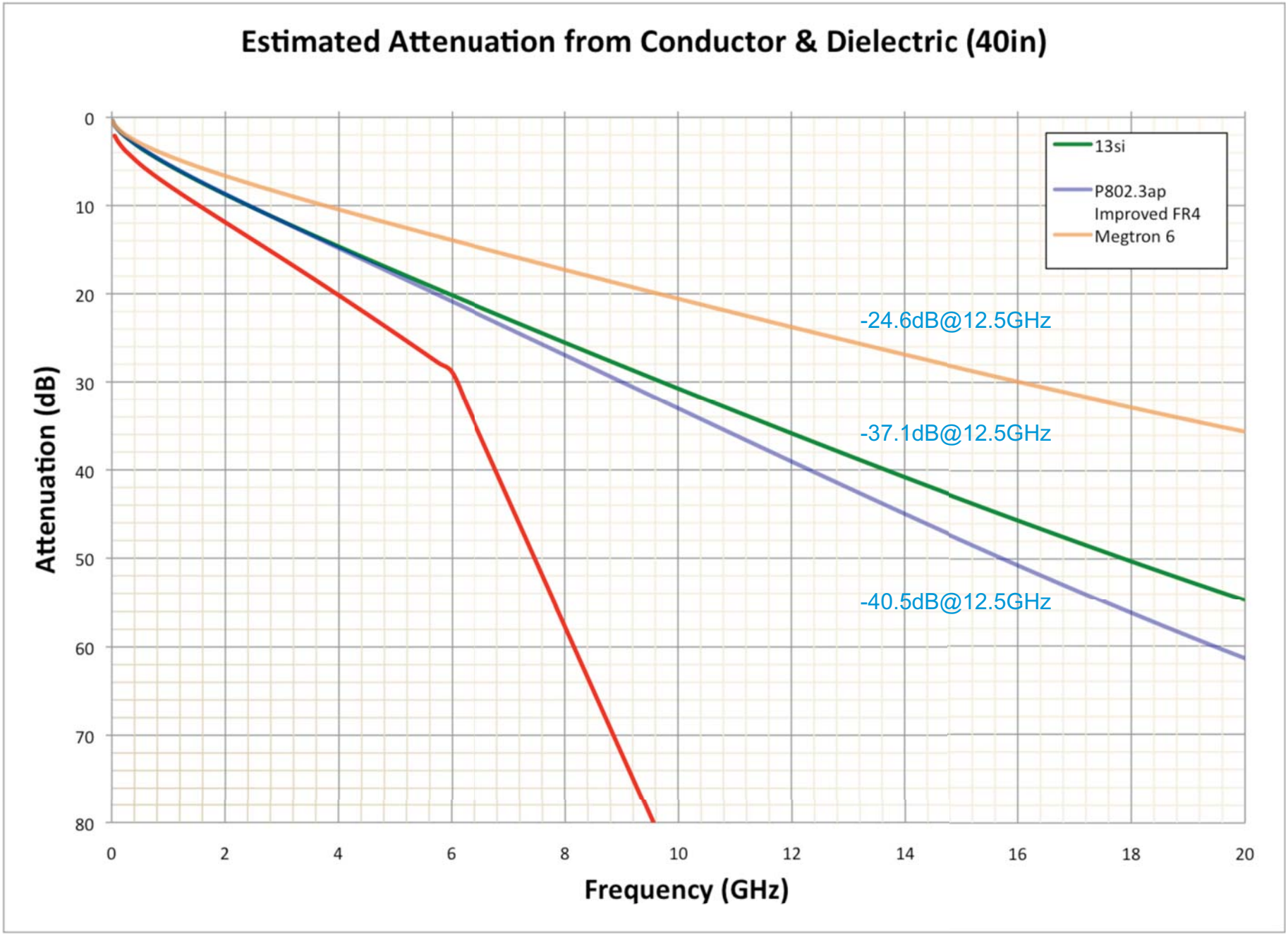



Blue line is Df
Red line is Dk




Estimated Attenuation from Conductor & Dielectric (30in)
Attenuation (dB)
0
10
20
30
40
50
60
70
80
0
2
4
6
8
10
12
14
16
18
20
Frequency (GHz)
13si
P802.3ap Improved FR4
Megtron 6
-18.4dB@12.5GHz
-27.8dB@12.5GHz
-30.4dB@12.5GHz


Estimated Attenuation from Conductor & Dielectric (40in)
Attenuation (dB)
0
10
20
30
40
50
60
70
80
0
2
4
6
8
10
12
14
16
18
20
Frequency (GHz)
13si
P802.3ap
Improved FR4
Megtron 6
-24.6dB@12.5GHz
-37.1dB@12.5GHz
-40.5dB@12.5GHz

# Summary

- Assuming a range of 5dB to 10dB for:
  - Surface Roughness
  - Ripple
  - Connector
  - Cross Talk
- A 40 inch trace on -13si material at 12.5GHz has a loss of 47dB.
- This approach at stage one of the tool provides a fair and balanced assessment of conductor losses in a material without unpredictable contributing factors of design considerations.
- Should the tool prove useful to IEEE802.3 projects, the equations and calculator can be presented to the group.