



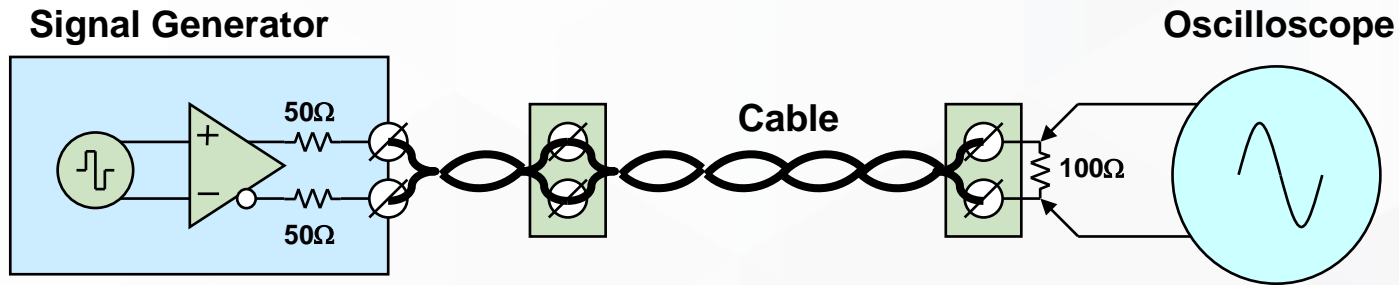
AHEAD OF WHAT'S POSSIBLE™

Cable Insertion Loss

Michal Brychta, Analog Devices
Niall Fitzgerald, Analog Devices

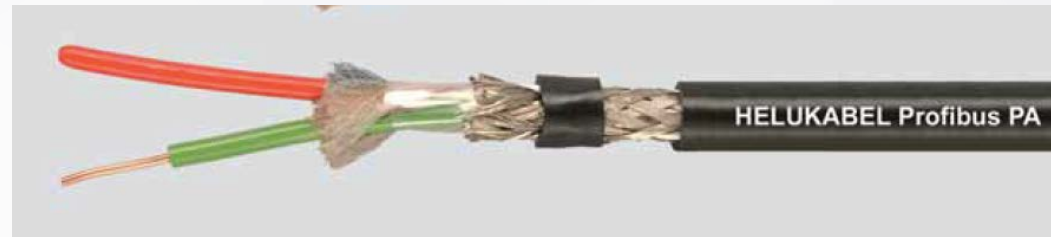
15/16 November 2023

Measurement Setup, Cable



▶ Cable:

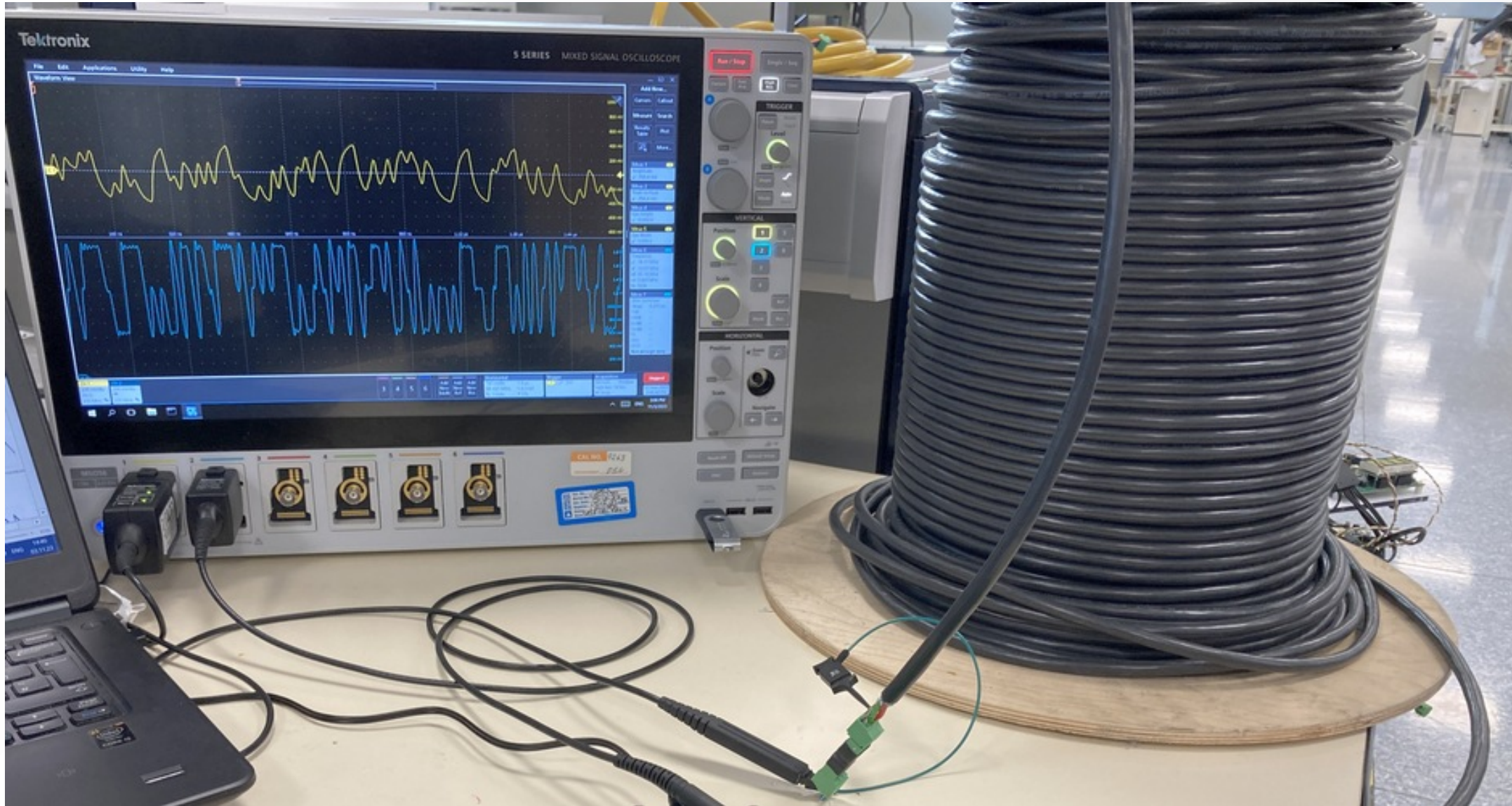
- Helukabel®, product 82836
- Cable structure: 1x2x1.0/2.55 mm (AWG 18/1)
- *Specification and picture from Halukabel® datasheet*



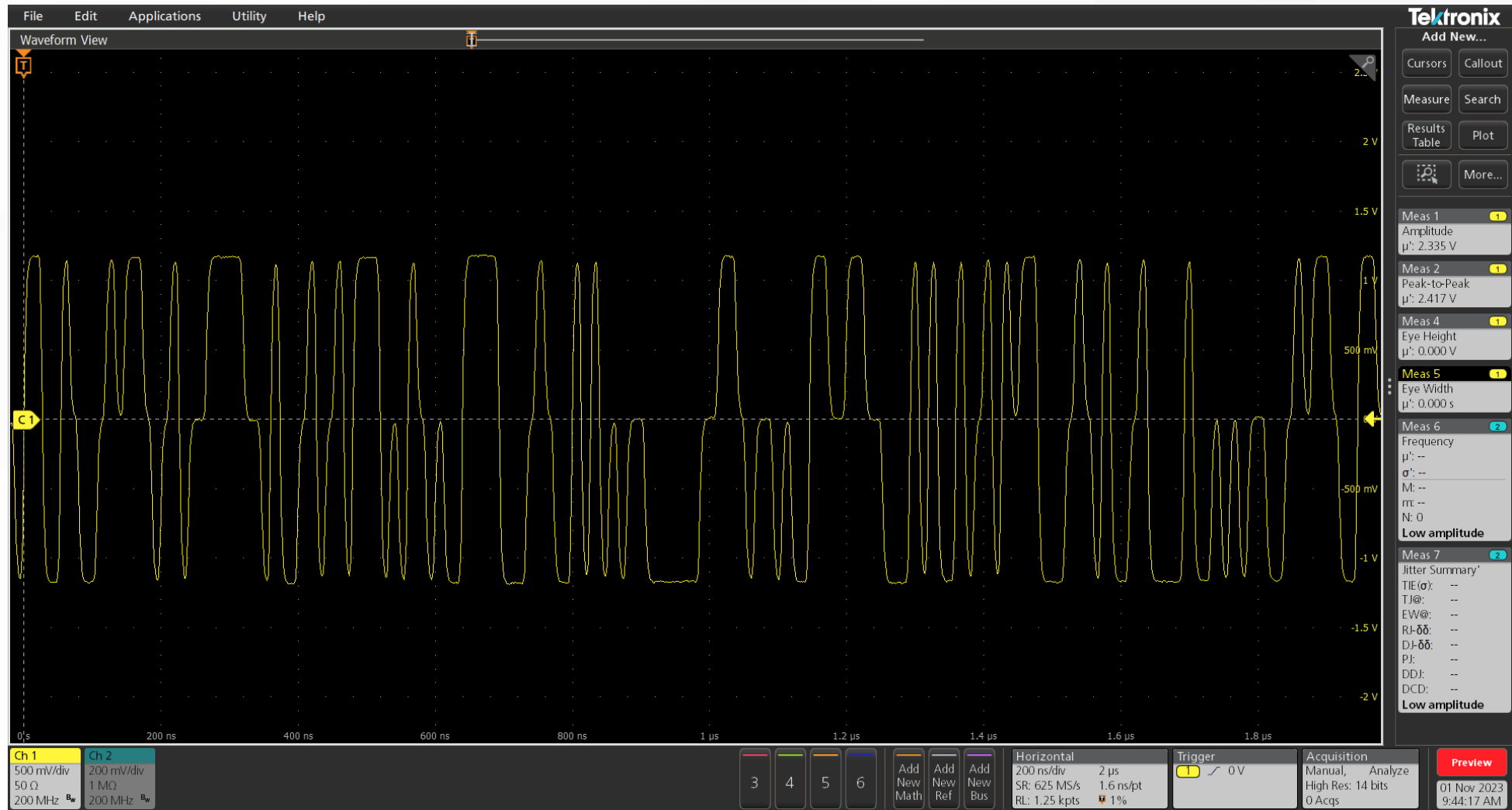
▶ 400m

- ▶ 100m + 400m with screw-terminal style, 3.81mm (0.15") pitch interconnection

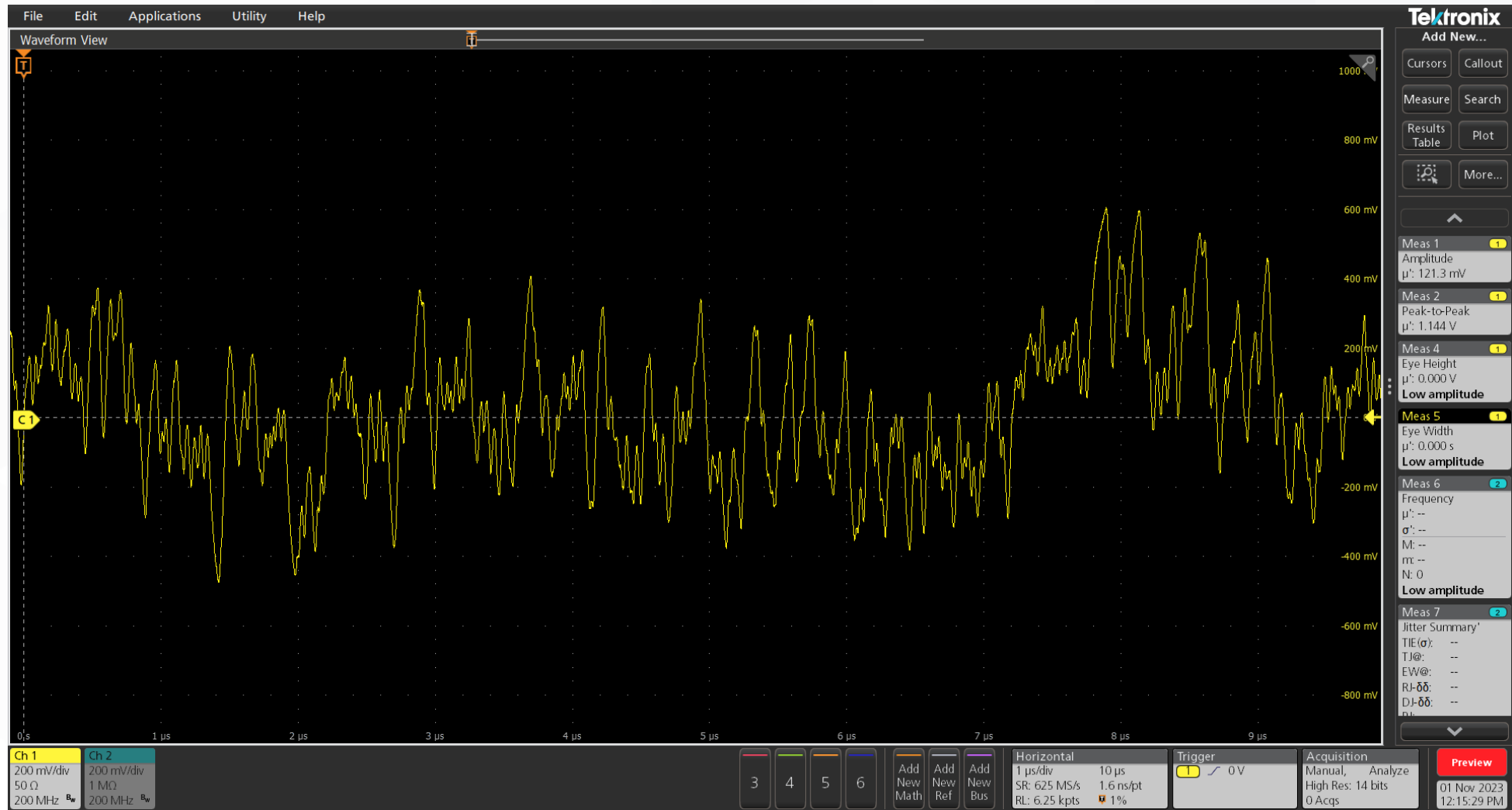
Measurement Setup, Cable



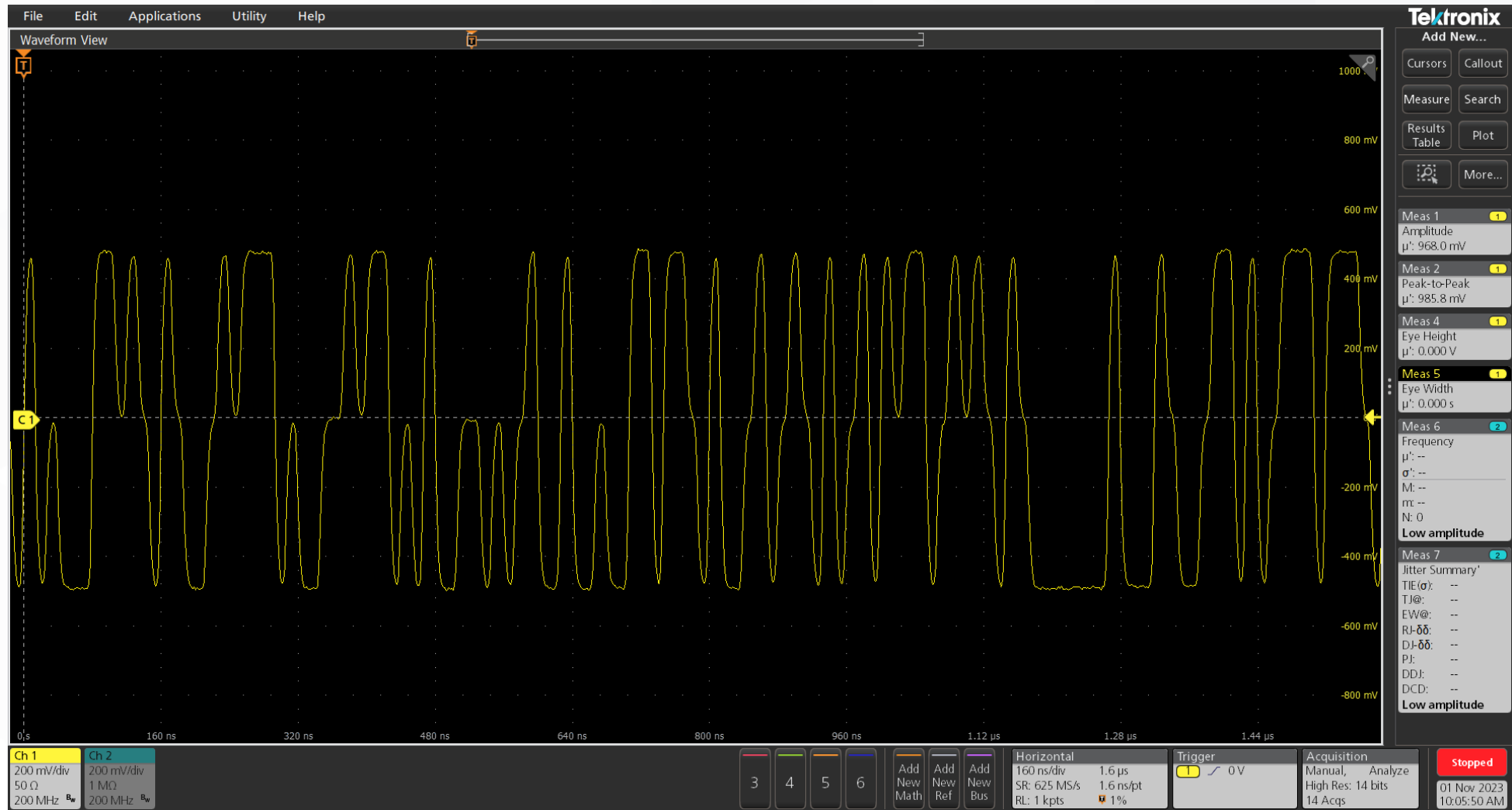
Transmit PAM3, 75Msym./sec, amplitude 2.4Vpp



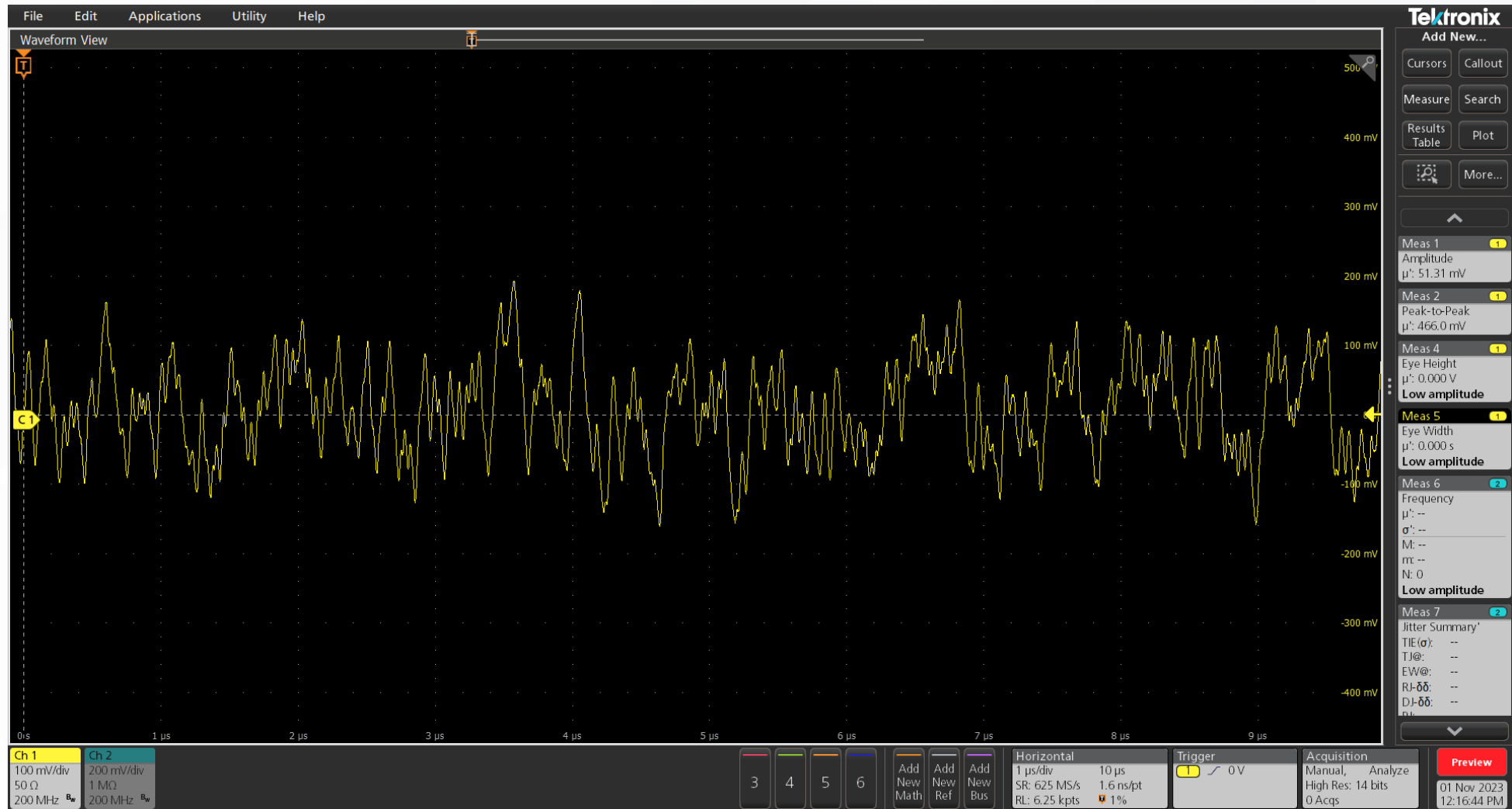
Receive signal, 100+400m cable, 2.4Vpp transmit



Transmit PAM3, 75Msym./sec, amplitude 1Vpp



Receive signal, 100m+400m cable, 1Vpp transmit

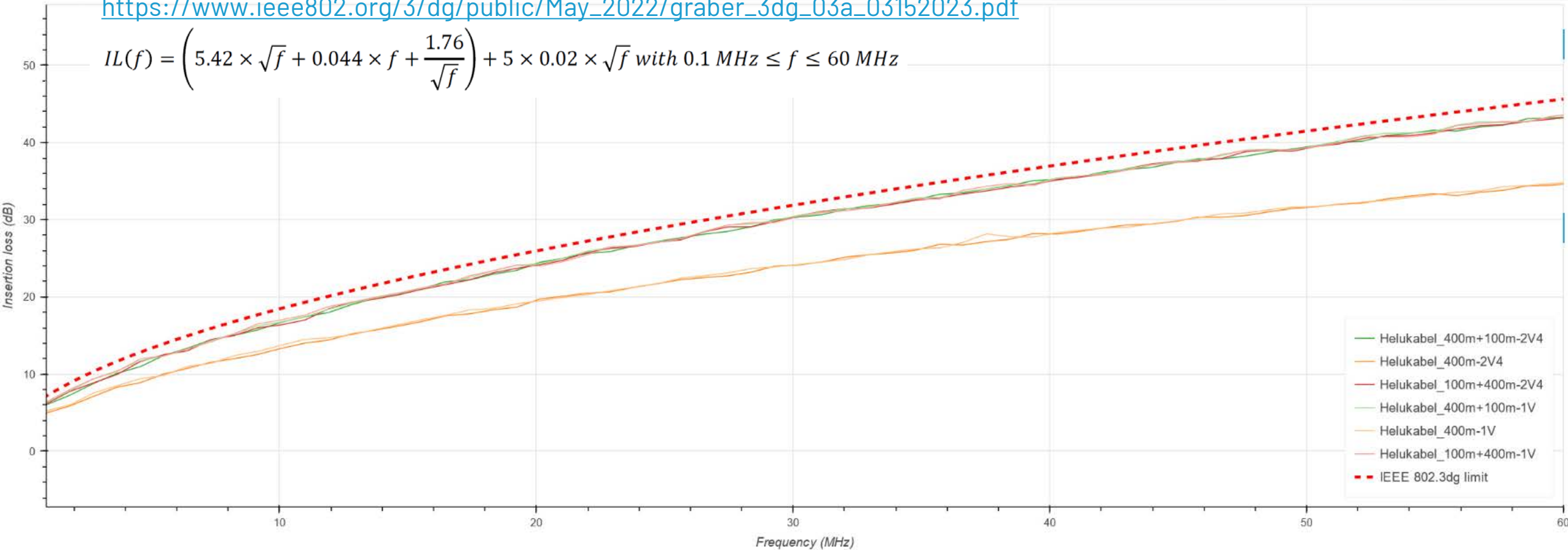


Insertion loss, calculated from oscilloscope data

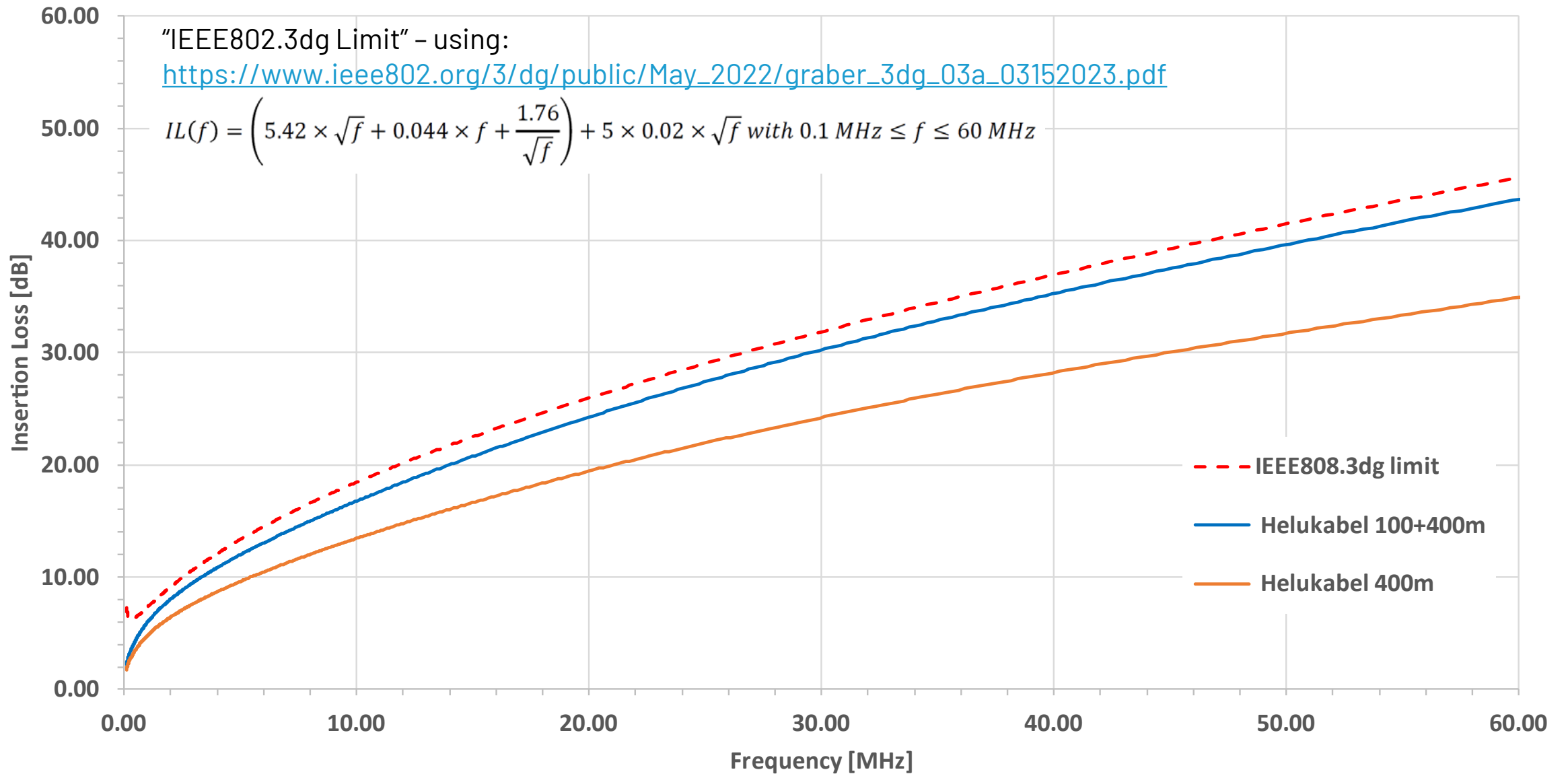
“IEEE802.3dg Limit” – using:

https://www.ieee802.org/3/dg/public/May_2022/graber_3dg_03a_03152023.pdf

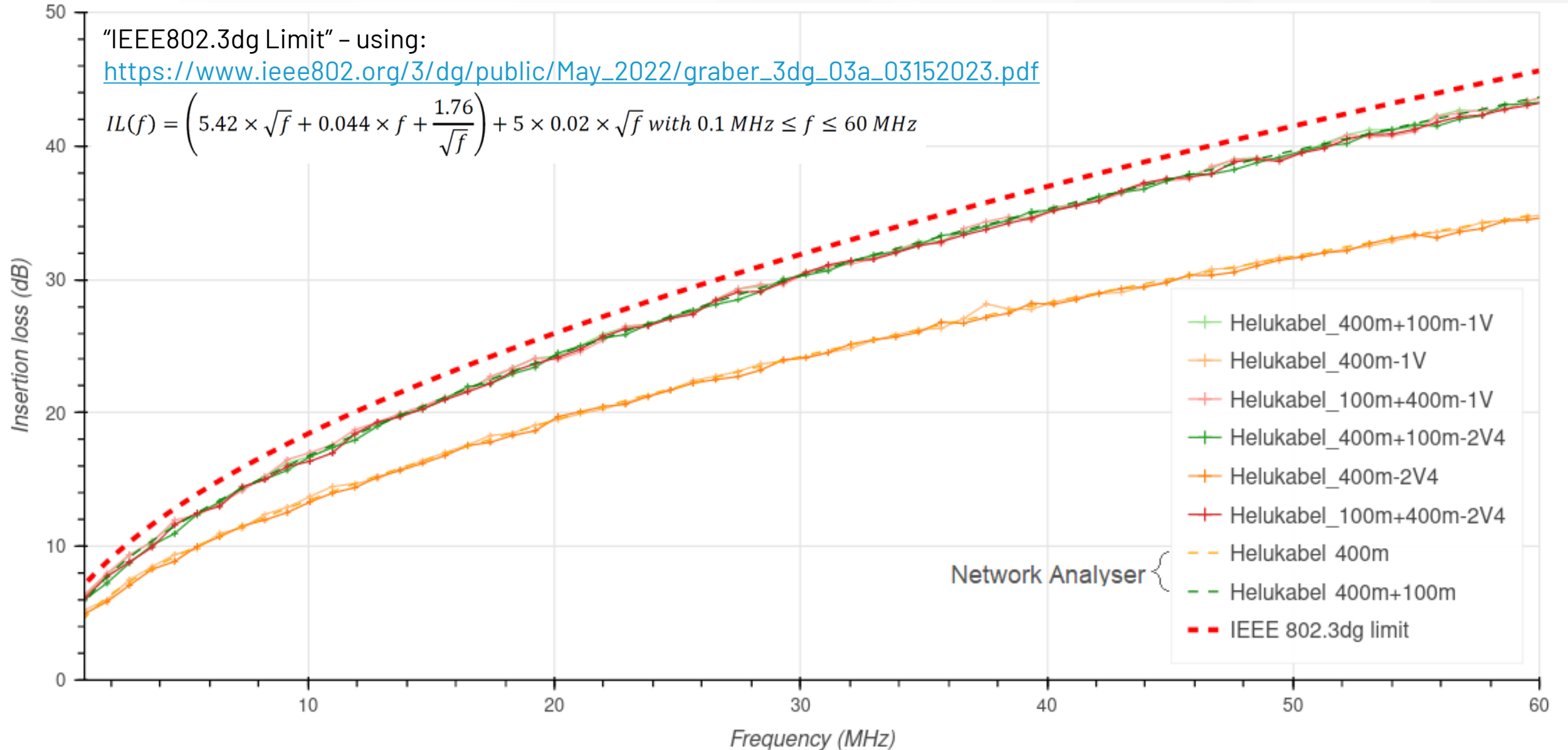
$$IL(f) = \left(5.42 \times \sqrt{f} + 0.044 \times f + \frac{1.76}{\sqrt{f}} \right) + 5 \times 0.02 \times \sqrt{f} \text{ with } 0.1 \text{ MHz} \leq f \leq 60 \text{ MHz}$$



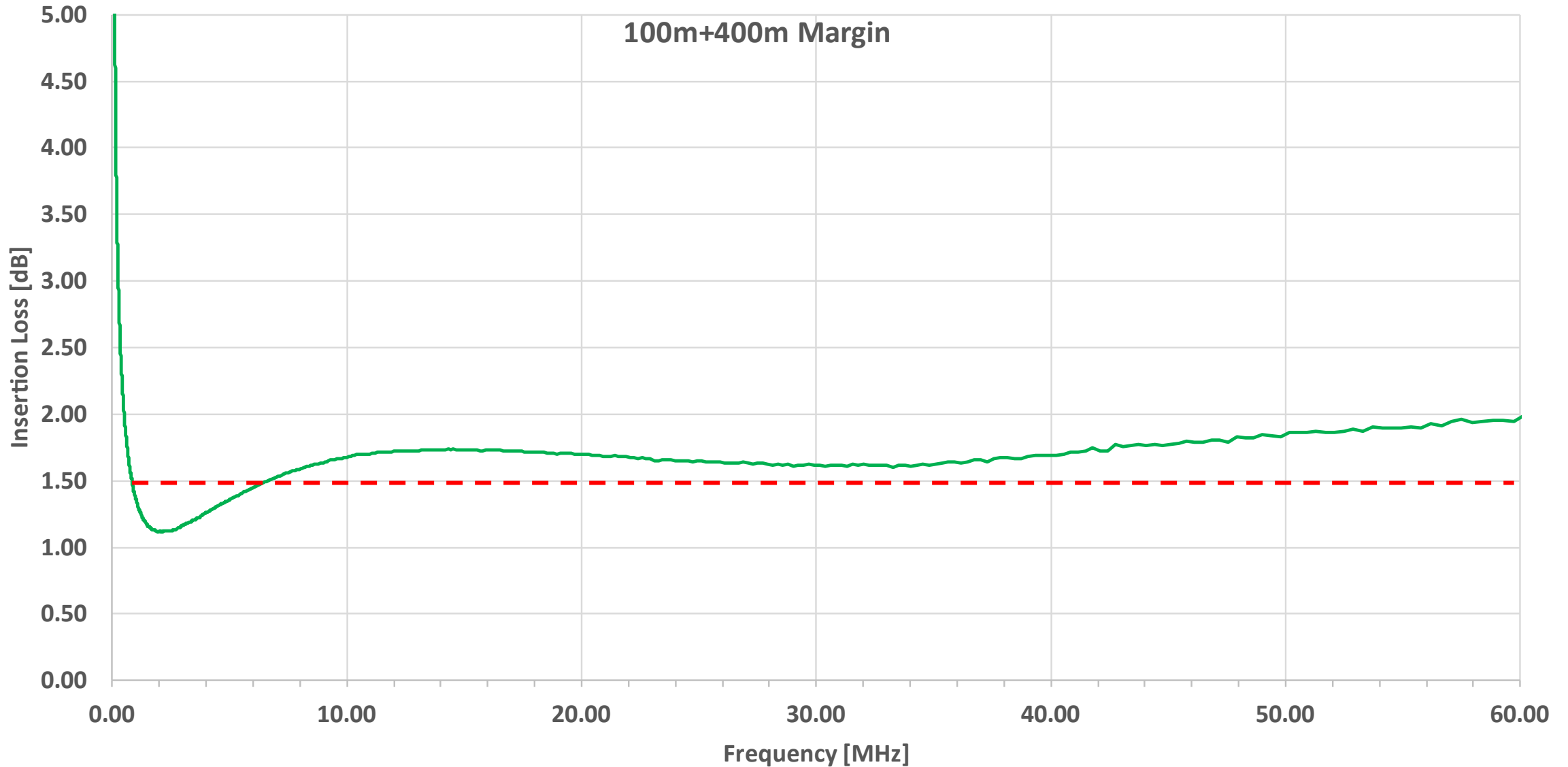
Insertion loss, measured by network analyser



Insertion loss, comparison of methods



Insertion loss margin (from network analyser data)



- ▶ Using two different methods gives very similar result
 - Close to expected real PAM 3 signal versus network analyser
 - Network analyser much easier to use, but PAM 3 easier to access
- ▶ 500m of a good AWG 18 Fieldbus type A cable
 - Very close to proposed insertion loss limit
 - Around 1.5 to 2dB margin at room temperature – Not enough...
- ▶ 400m of a good AWG 18 Fieldbus type A cable
 - Comfortably within the proposed insertion loss limit
 - 400m of AWG 18 suggested to be equivalent of 500m of AWG 16 cable
 - https://www.ieee802.org/3/dg/public/May_2022/graber_3dg_03a_03152023.pdf

Next Steps: Considering External Coupled Noise

- ▶ Signal level is only one part of SNR (Signal to Noise **Ratio**)
- ▶ Noise is the other part !

- ▶ Need to define noise character and amplitude for target applications
- ▶ Evaluate the SNR
- ▶ This may influence our modulation (PAM3 / PAM4 / PAM5) choice

Thank You

Questions?