ANALOG DEVICES

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Impulse Noise Measurements on Cables

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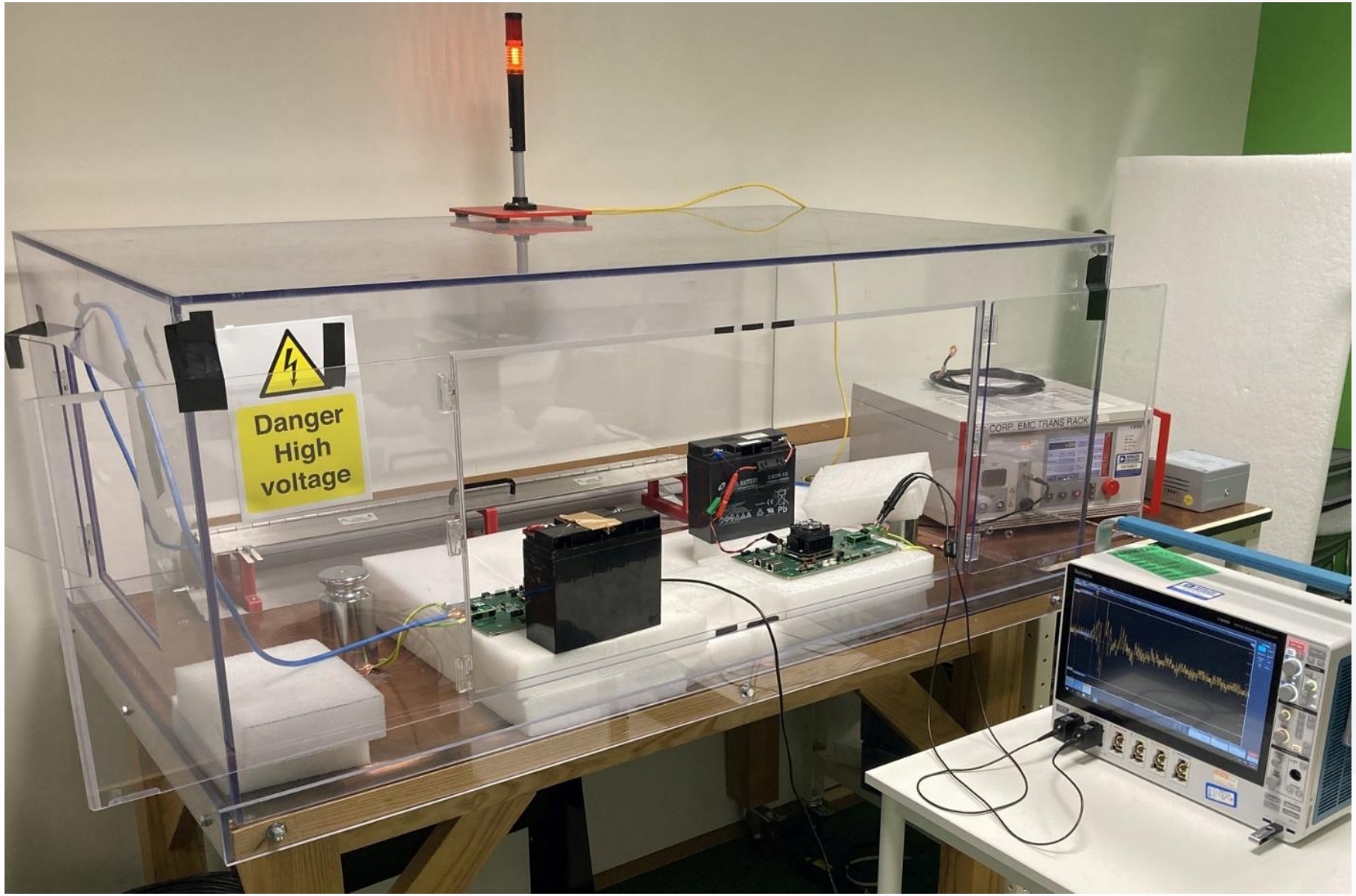
11 March 2024

Update B

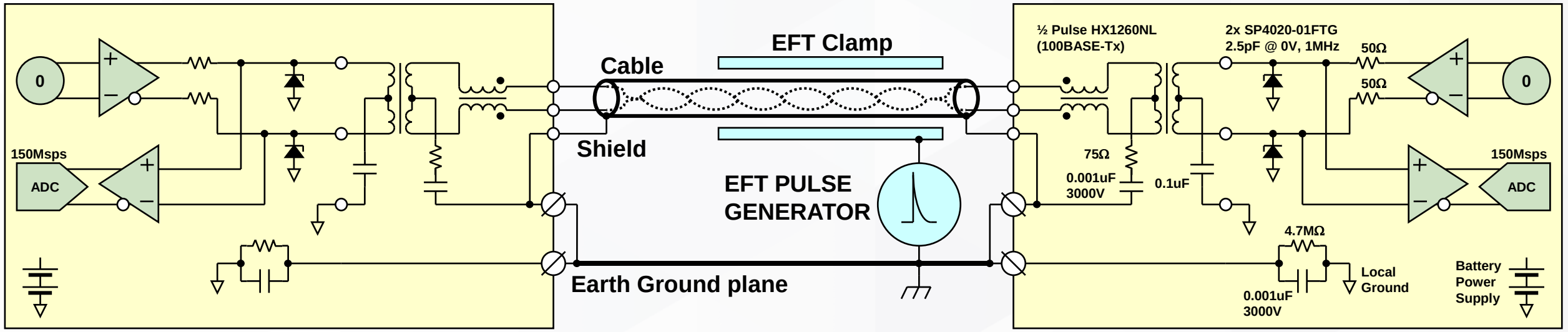
Impulse Noise Measurements on Cables

- Electrical Fast Transients (EFT) Test
  - Test setup
  - Correlation with oscilloscope
  - Some learnings
- Fieldbus APL Cable
  - 2 different cables
  - Experiments with screw terminal connectors
- CAT cables
  - Cat5 / Cat6 / Cat6A
  - Experiment with connector
- EFT noise vs. slicer thresholds
- Summary

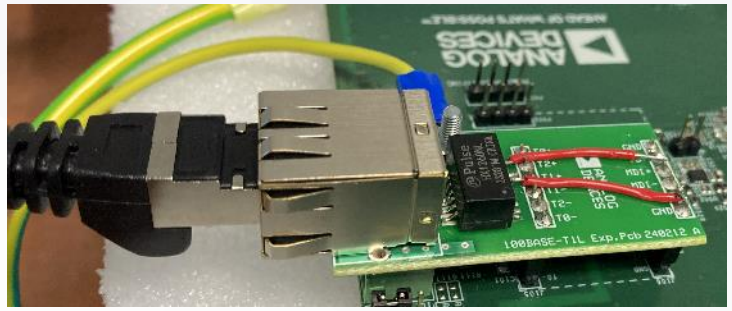
Electrical Fast Transients (EFT) Test



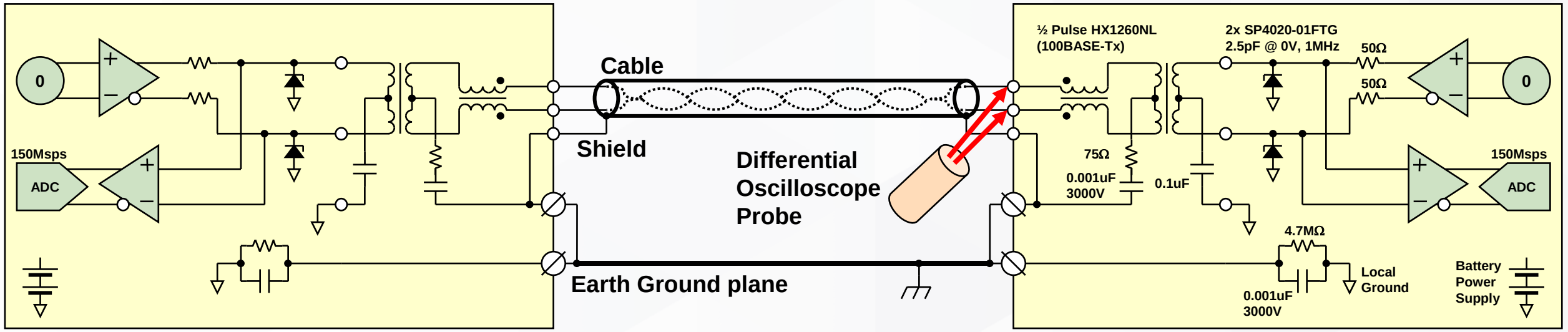
Test Setup

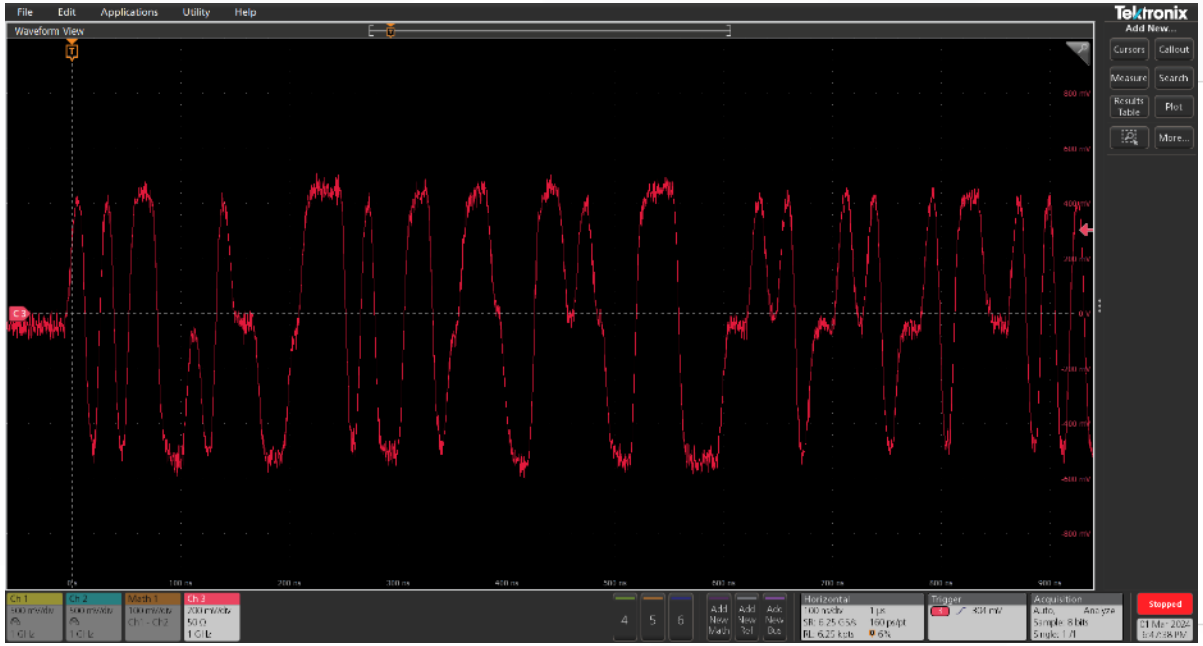


- Electrical Fast Transient (EFT) Test
- Specified in IEC61000-4-4
- Voltage 1kV
  - We used only positive pulses
- Frequency 100kHz
- Burst 750us
- Repetition 300ms

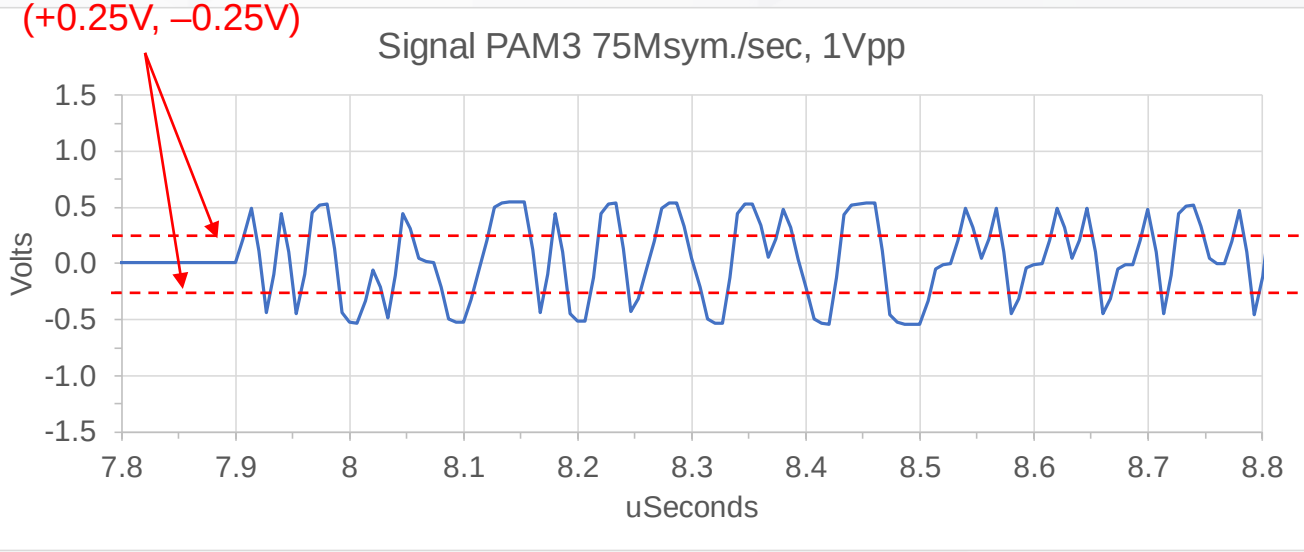


Test Setup – Check Signal - Transmit / Receive

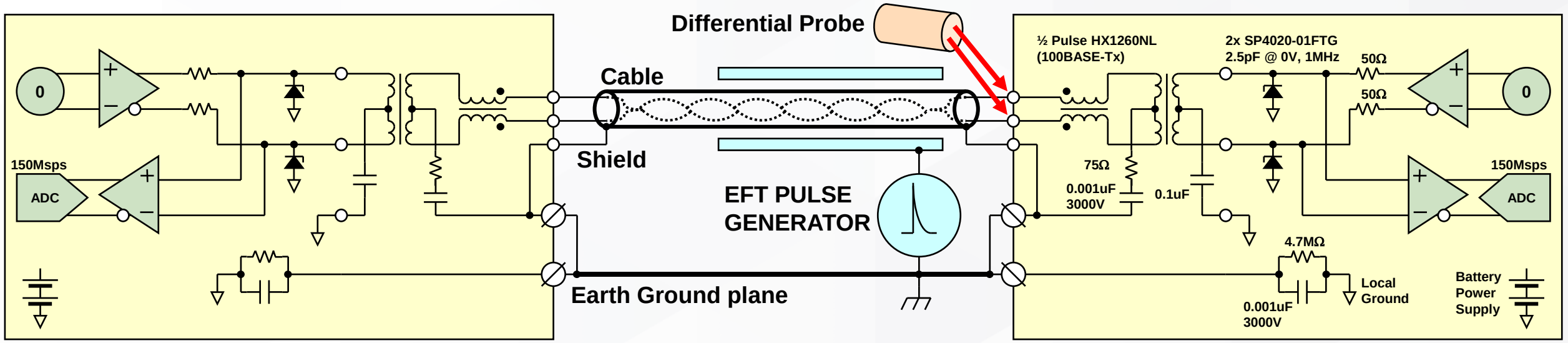


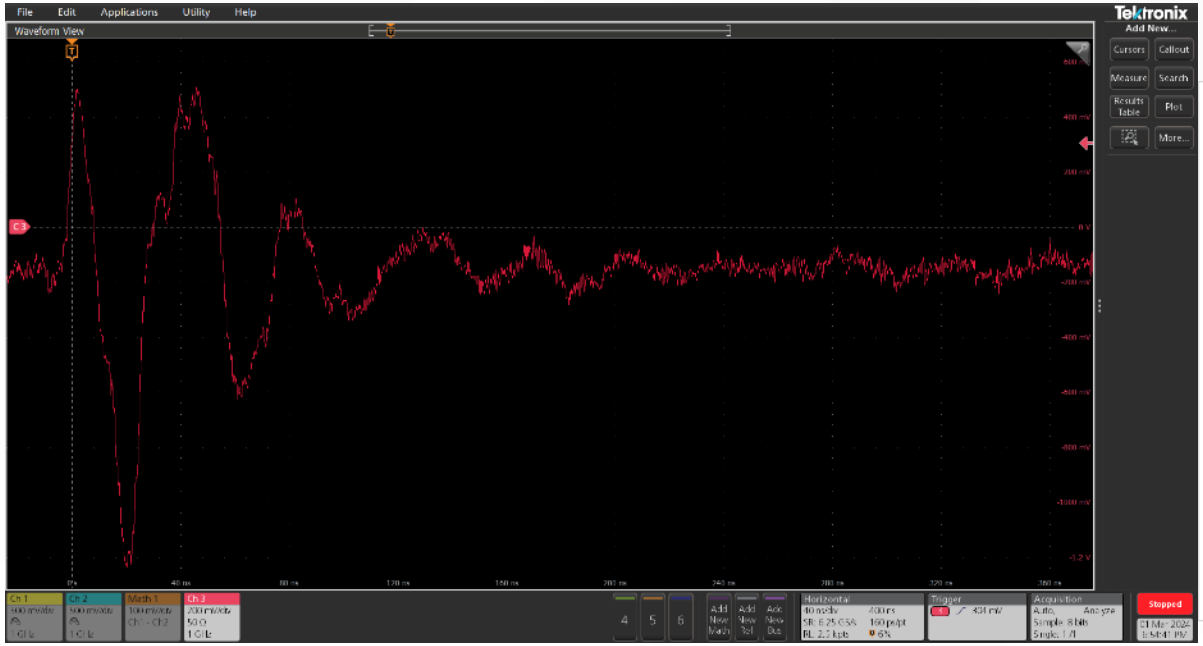


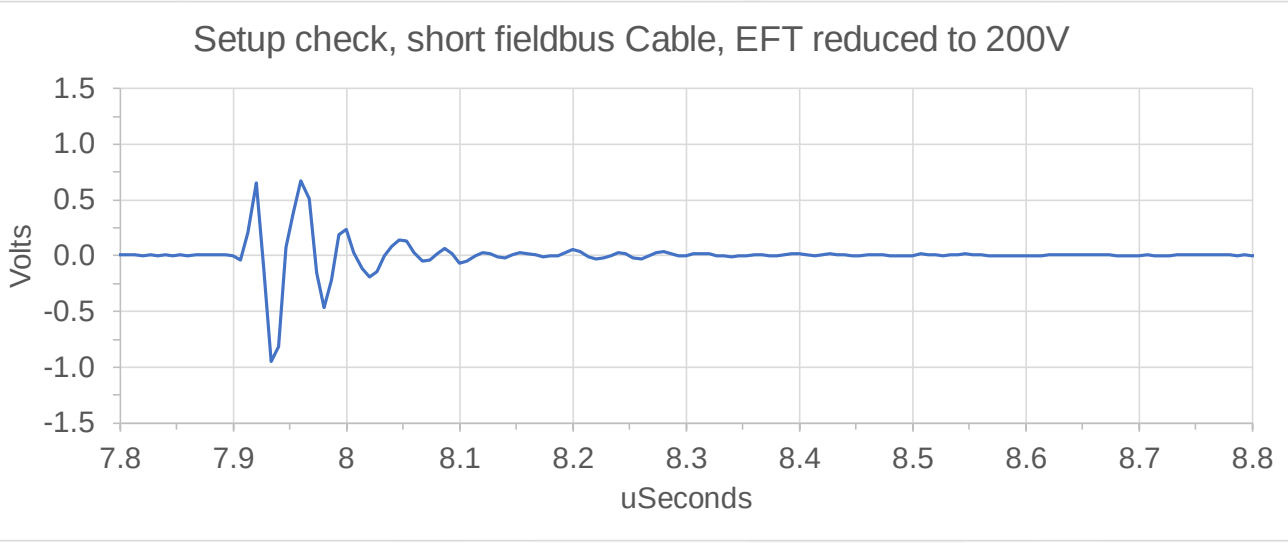
Assumed slicer thresholds at PAM3 1Vpp
(+0.25V, –0.25V)



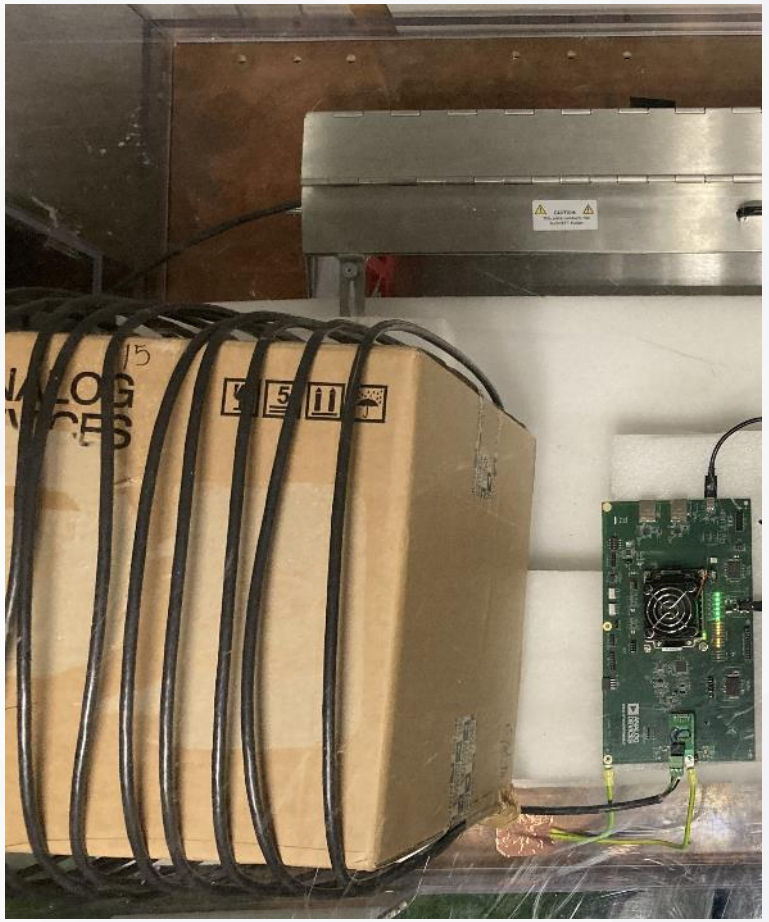
Test Setup – Check EFT (reduced to 200V)







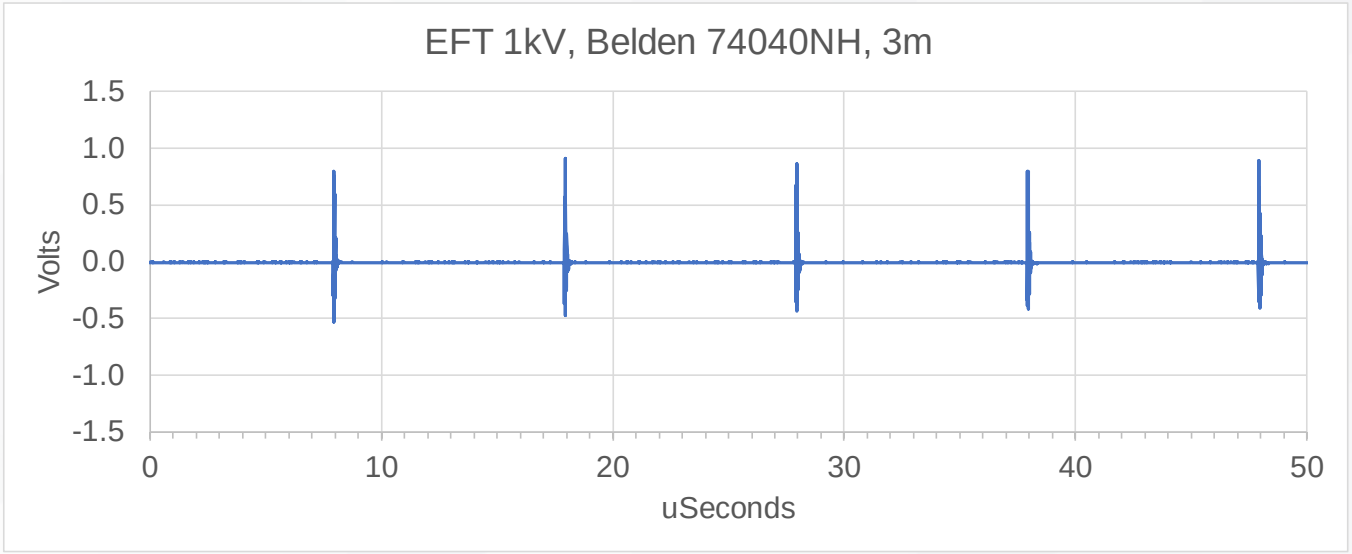
Some Common (Sense) Learnings

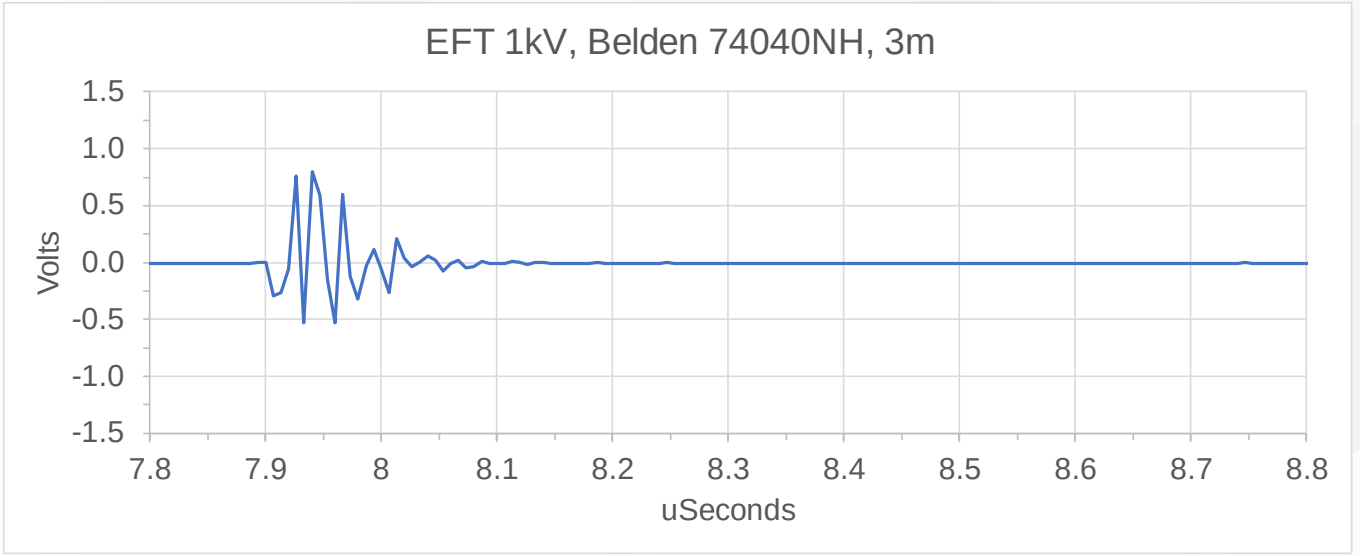


Fieldbus / APL Cable 1

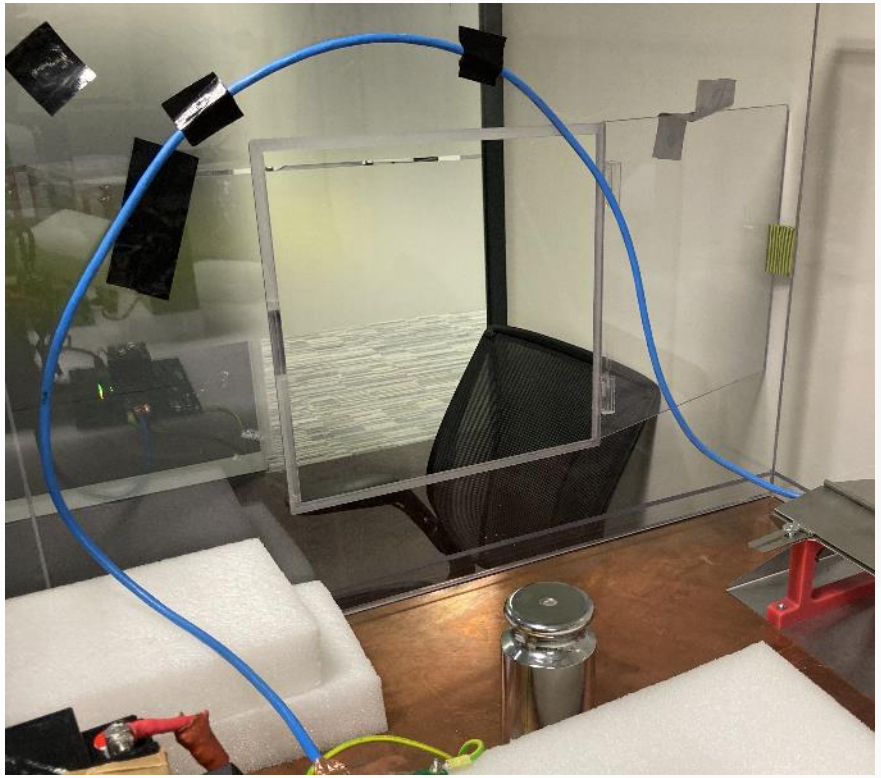
Fieldbus / APL Cable 1

- Belden 74040NH
- “DataTuff Ind SPE 1km10Mb”
- AWG18



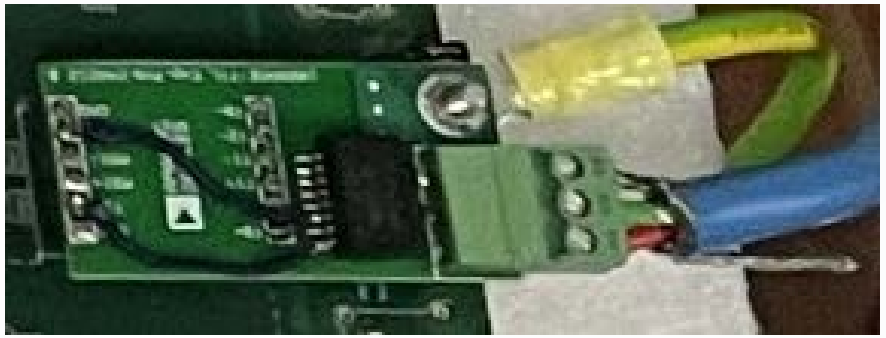


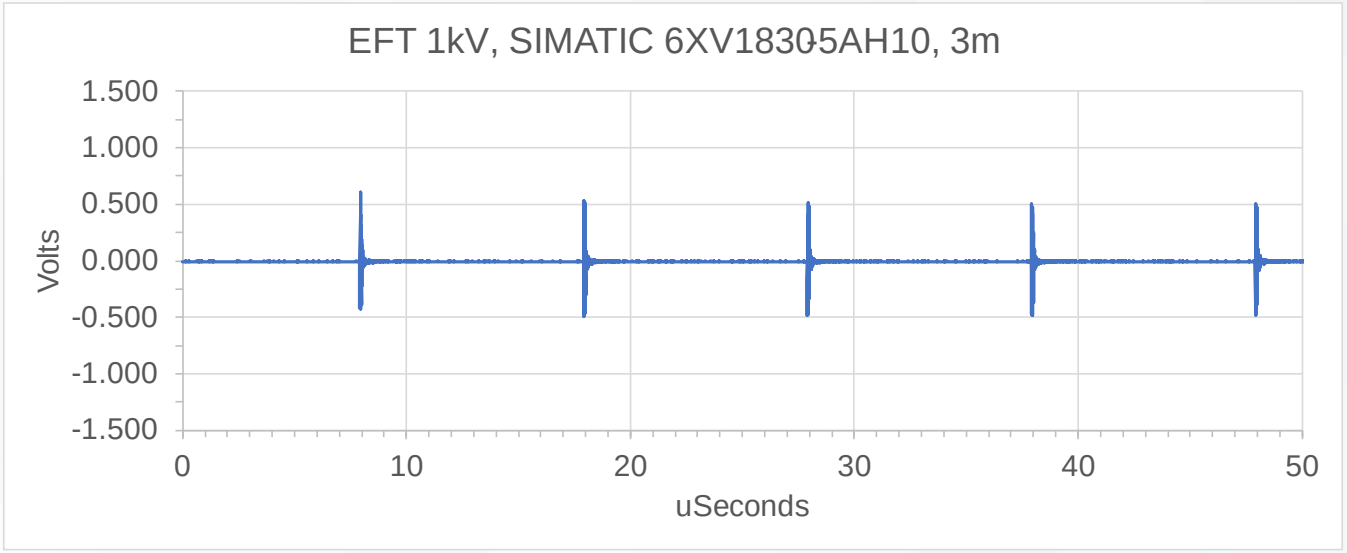
Fieldbus / APL Cable 2

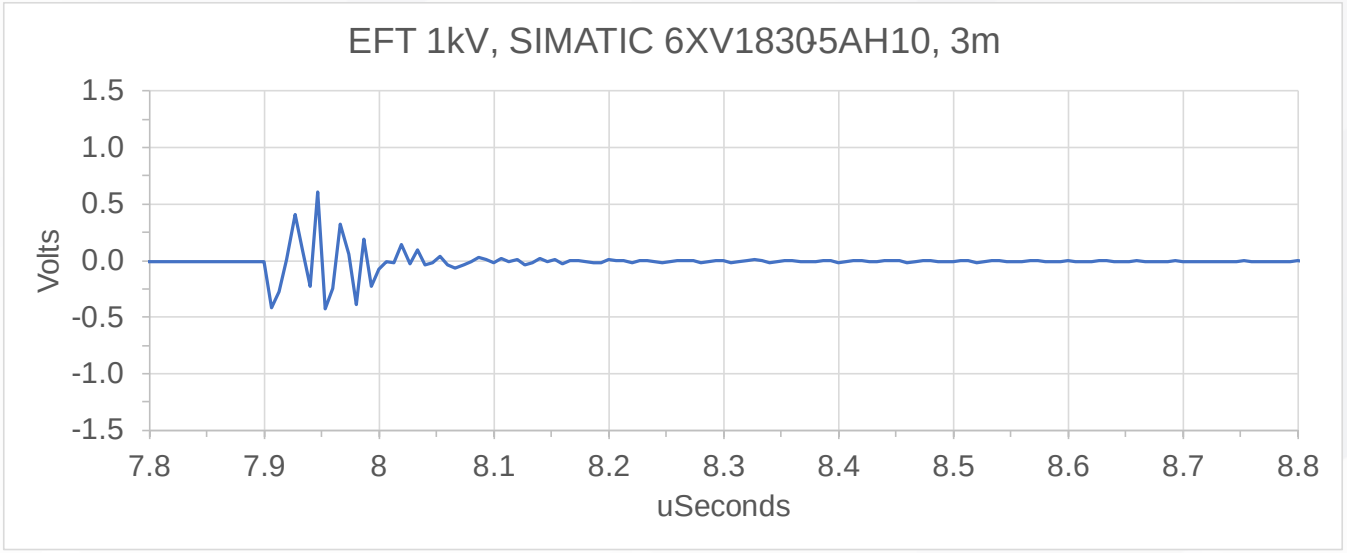


Fieldbus / APL Cable 2

- SIMATIC 6XV1830-5AH10
- “Process Cable GP/ Ethernet-APL cable”
- AWG18

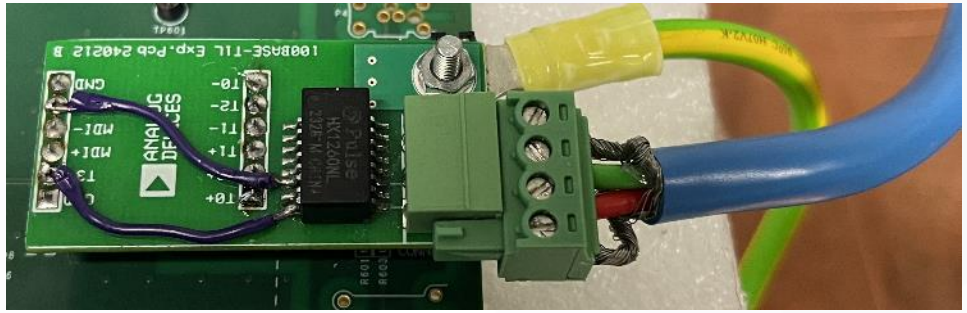


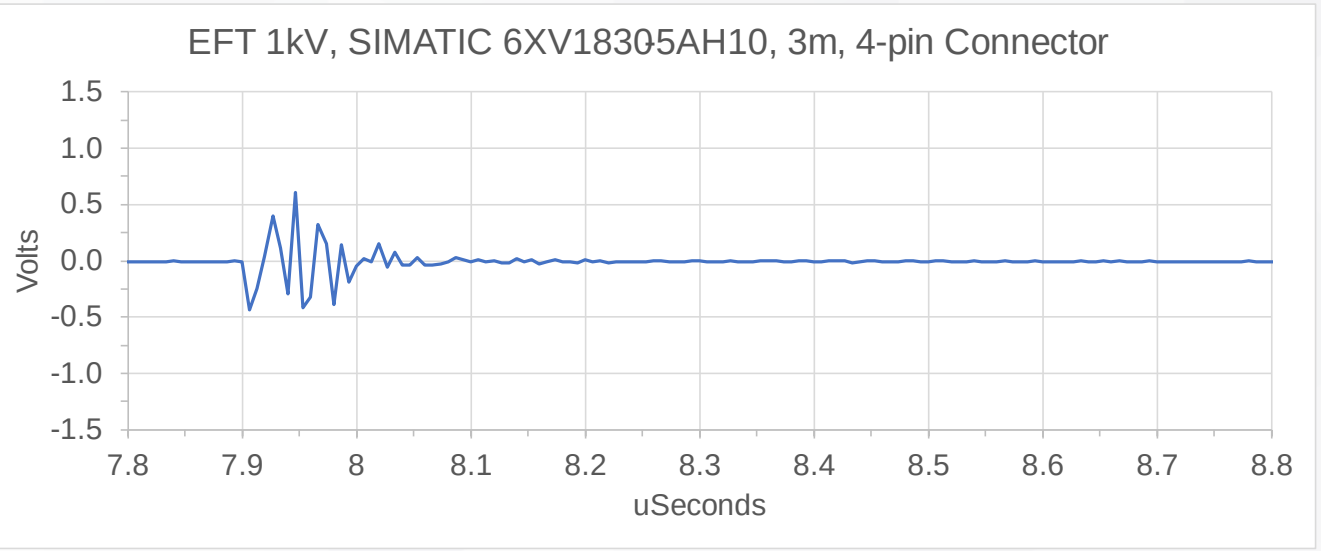




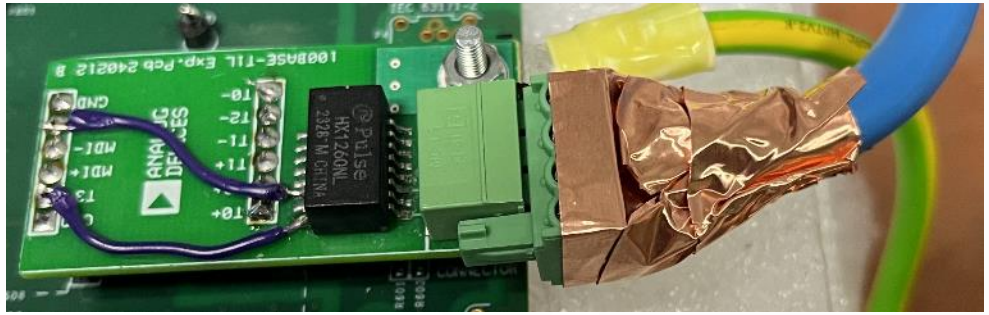
Fieldbus / APL Cable 2 – Connector Experiments

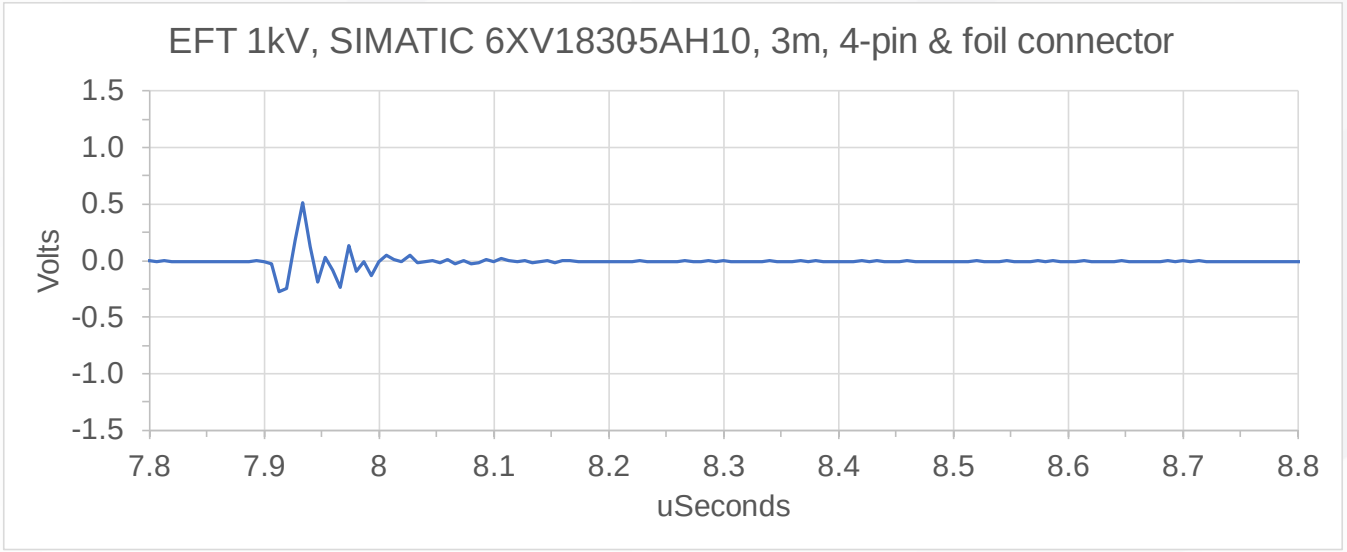
- SIMATIC 6XV1830-5AH10 (AWG18)
- 4-pin connector
  - To make parasitic coupling more balanced





- Connector wrapped in copper foil

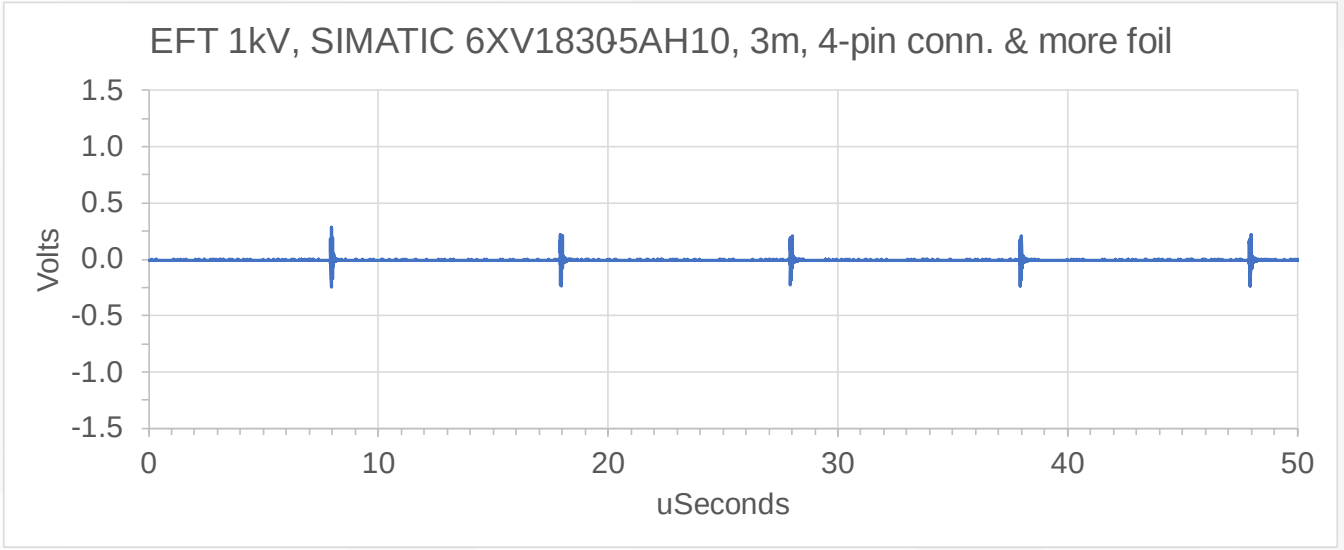


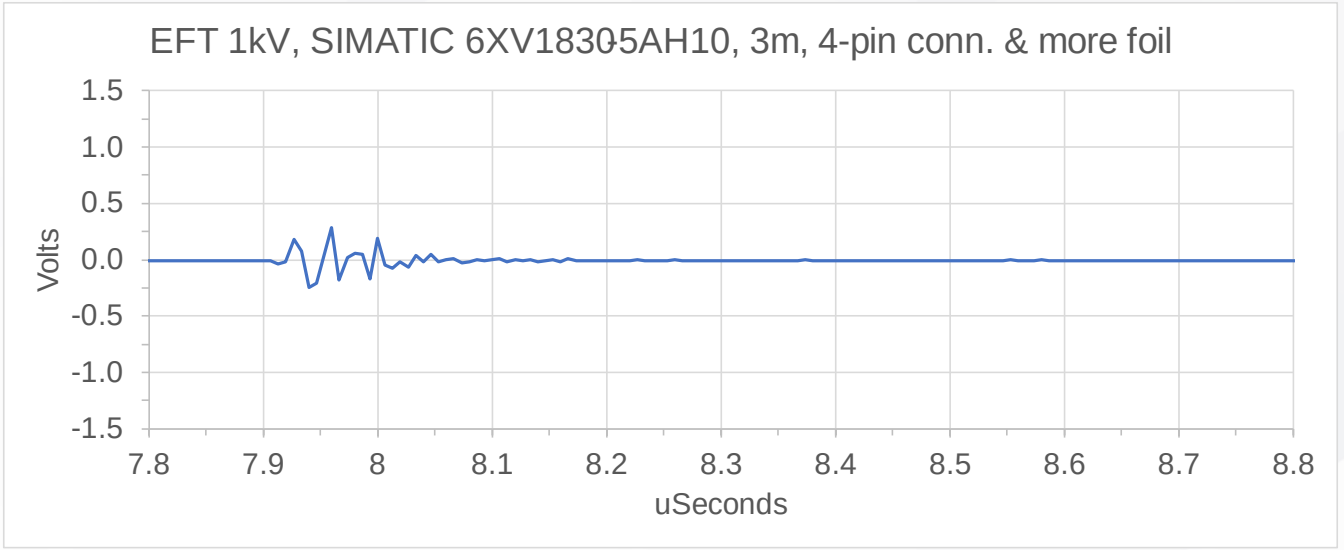


Fieldbus / APL Cable 2 – Connector Experiments

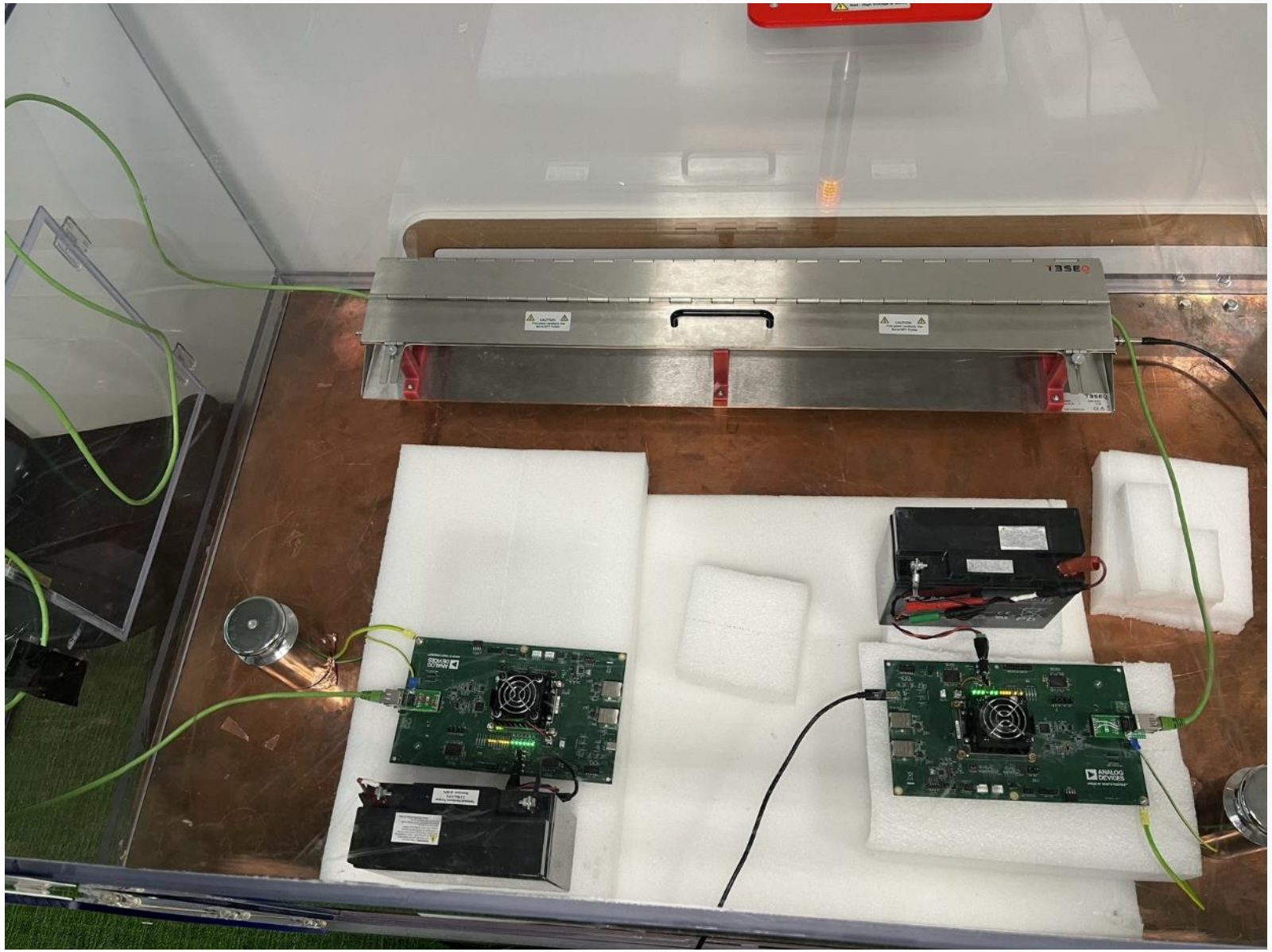
- SIMATIC 6XV1830-5AH10 (AWG18)
- 4-pin connector
- Completely wrapped in conductive copper foil, near side:

- far side:



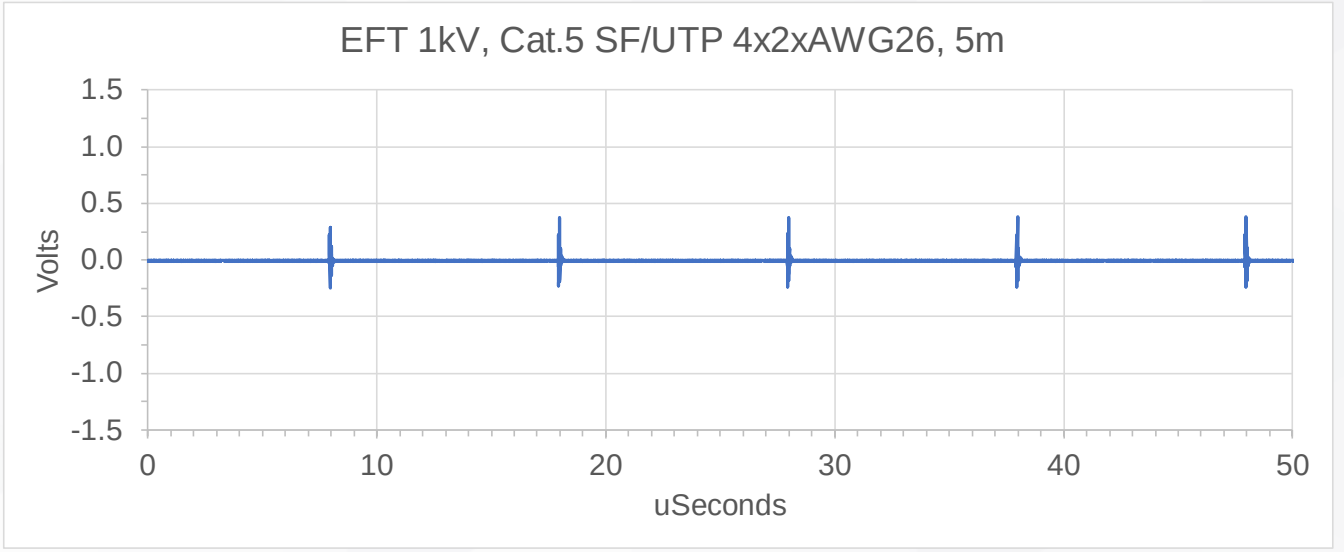


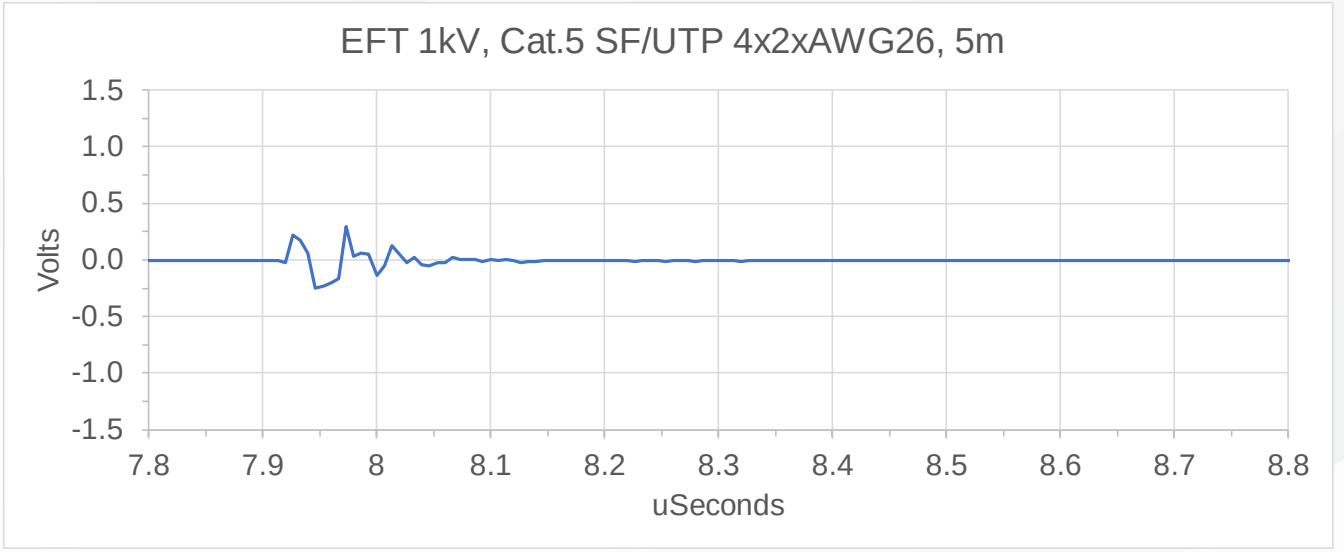
CAT5 Cable



CAT5 Cable

- (Beckhoff) ZK1090-9191-0050
- Cat.5 SF/UTP 4x2xAWG26
- Single pair used
- Unused pairs not connected, floating

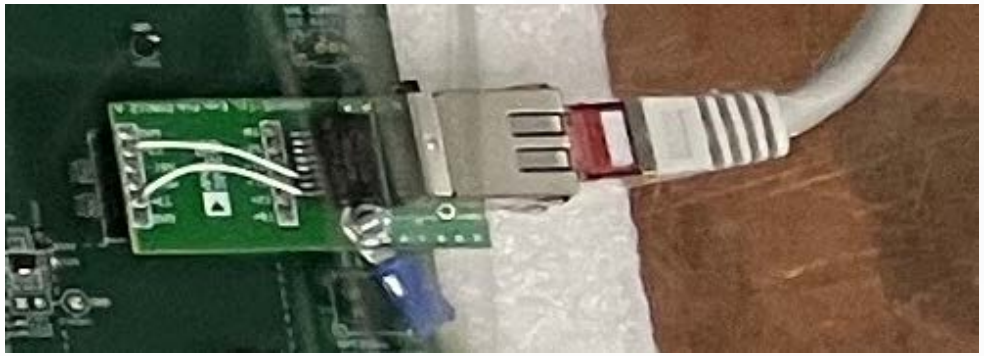


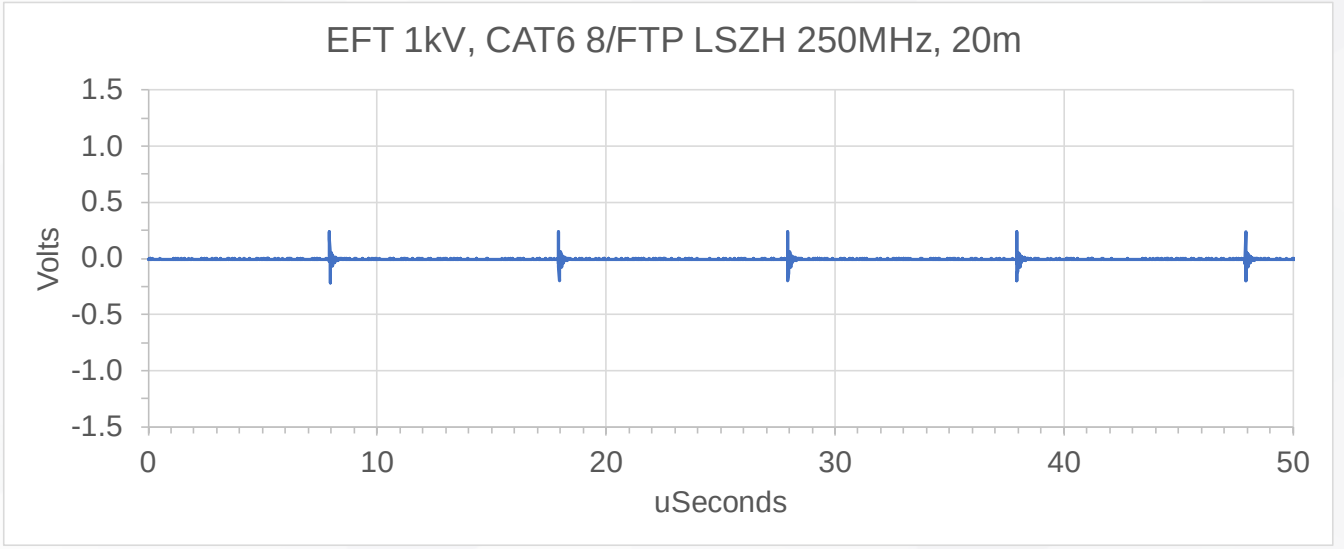


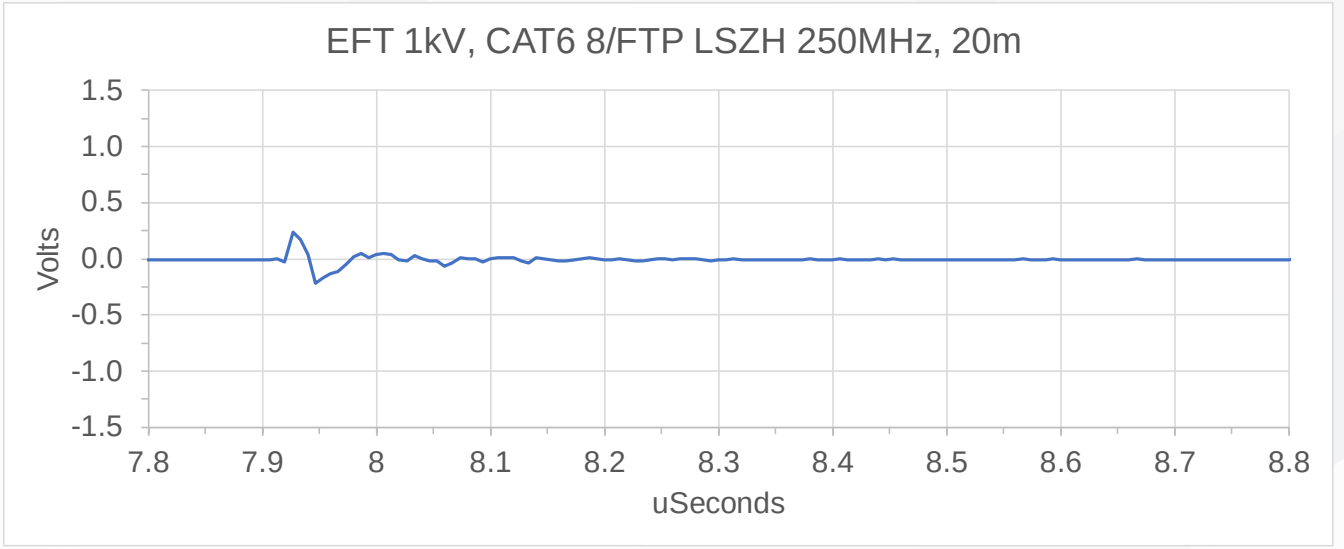
CAT6 Cable

CAT6 Cable

- (GHMT Roline)
- CAT6 8/FTP LSZH 250MHz
- Single pair used
- Unused pairs not connected, floating



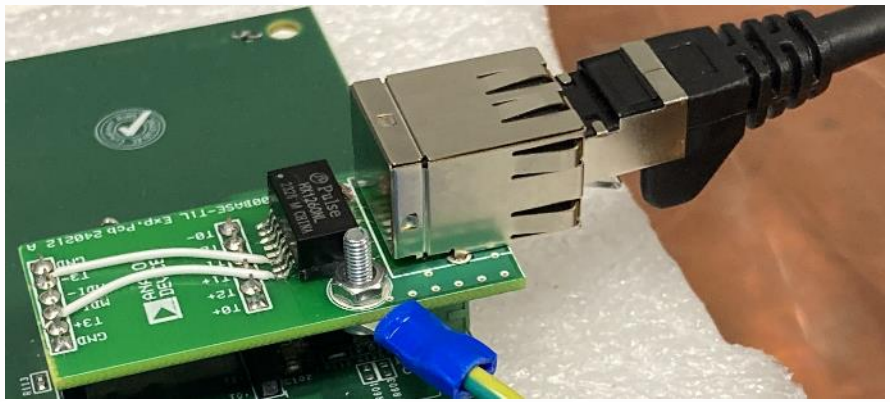


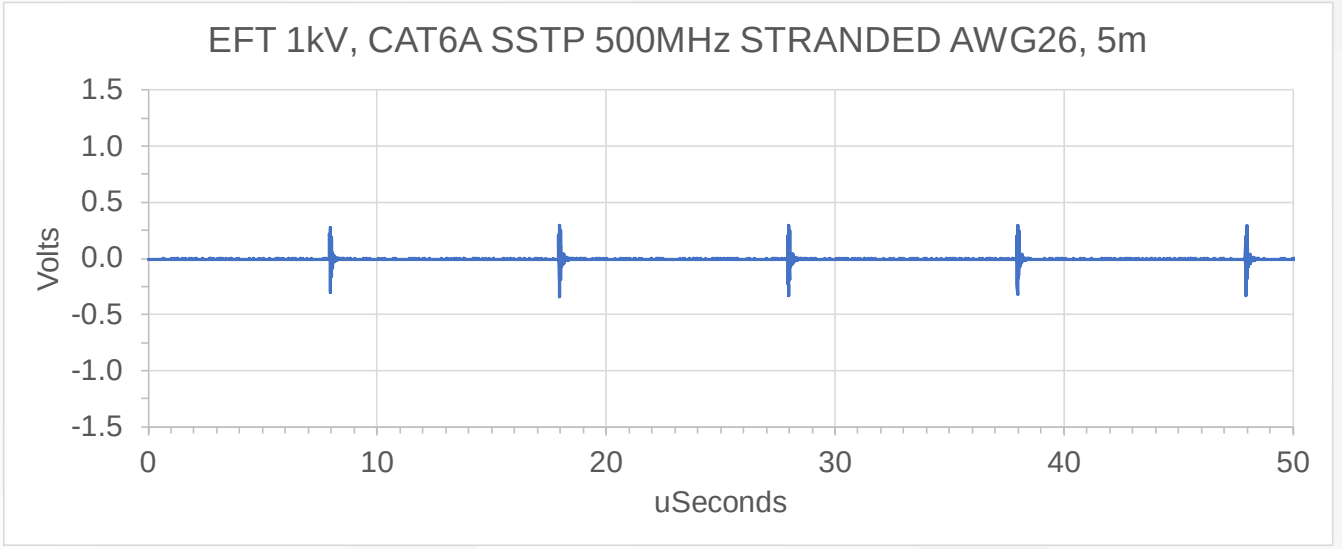


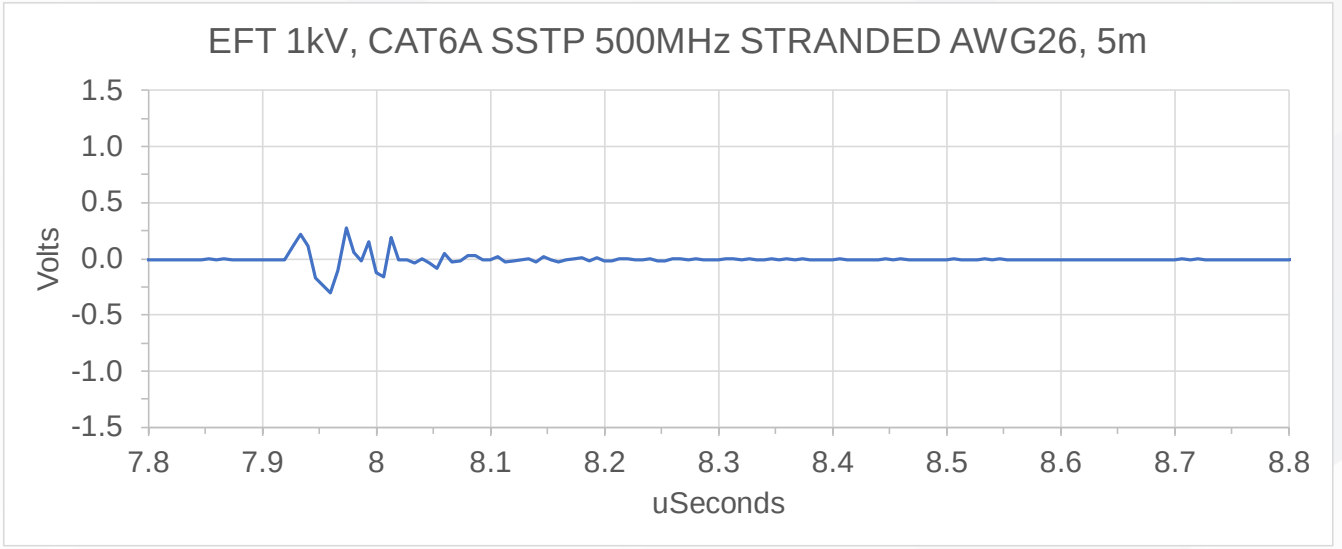
CAT6A Cable

CAT6A Cable

- (Manufacturer unknown)
- "CAT6A SSTP LSOH 500MHz 4 PAIRS STRANDED AWG26 100 ohm"
  - Each pair individually foil shielded
  - Cable stranded
- Single pair used
- Unused pairs not connected, floating

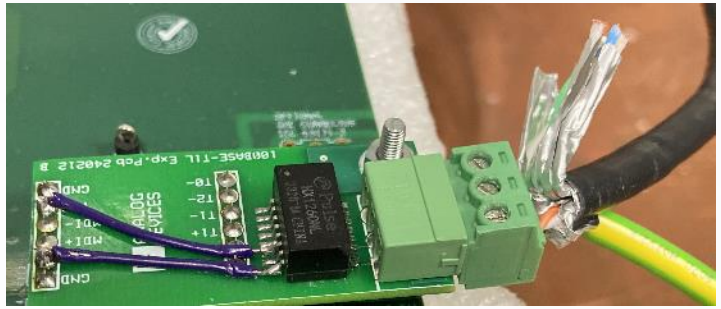




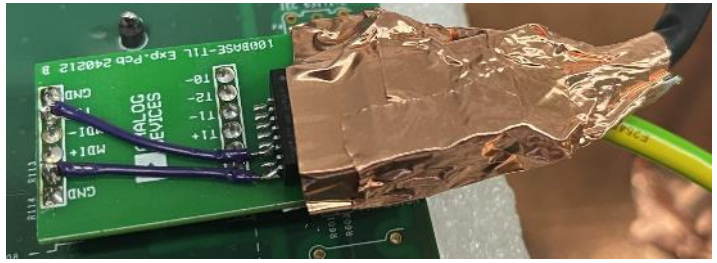


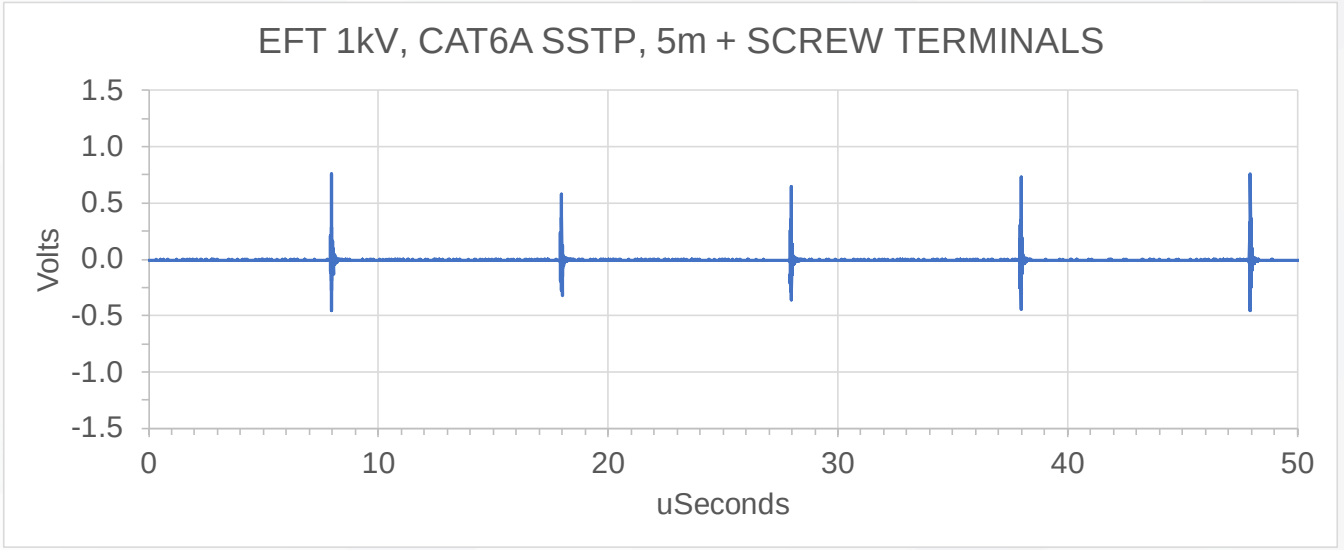
CAT6A Cable – Connector Experiment

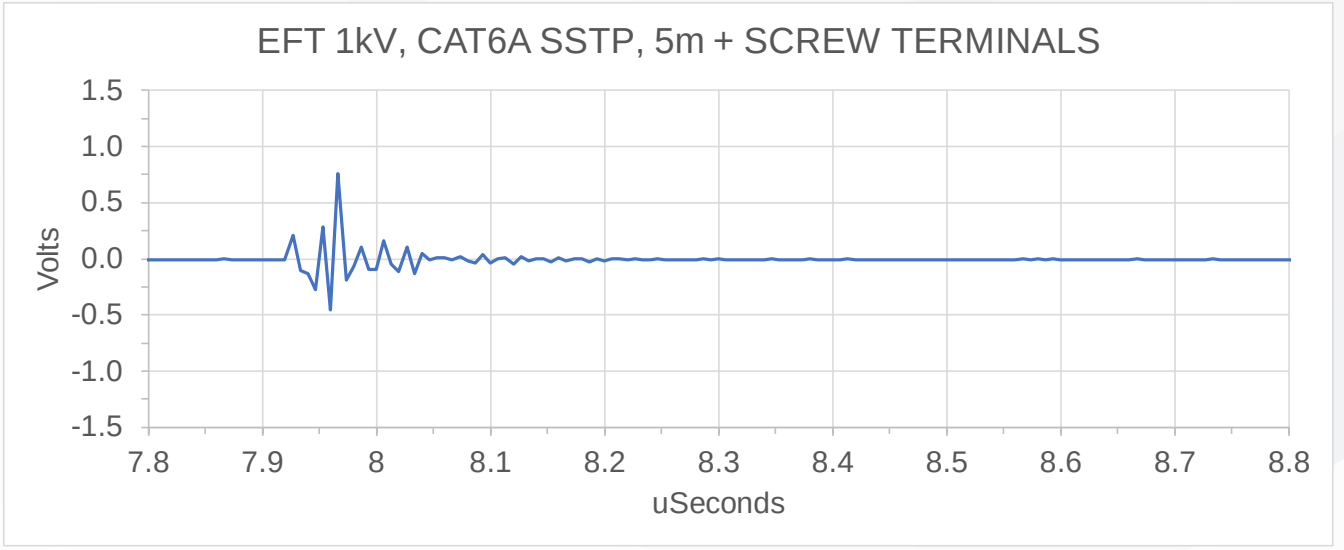
- (Manufacturer unknown)
- "CAT6A SSTP LSOH 500MHz 4 PAIRS STRANDED AWG26 100 ohm"
- Single pair used
- Unused pairs not connected, floating
- Connectors changed to screw terminals



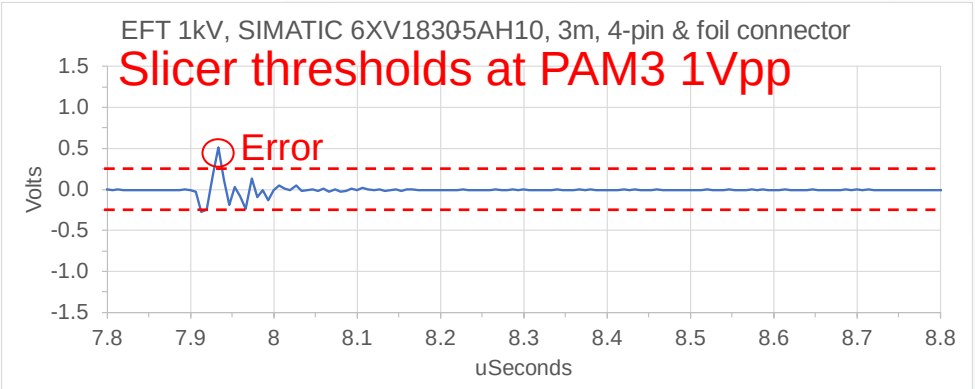
- And completely wrapped in conductive copper foil…

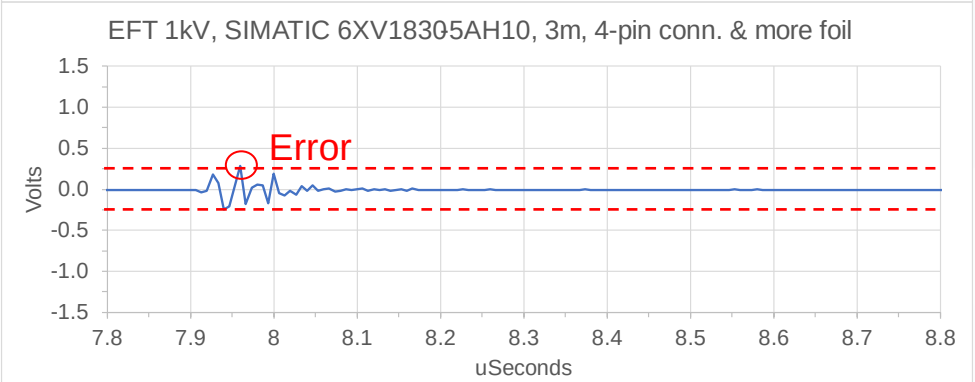


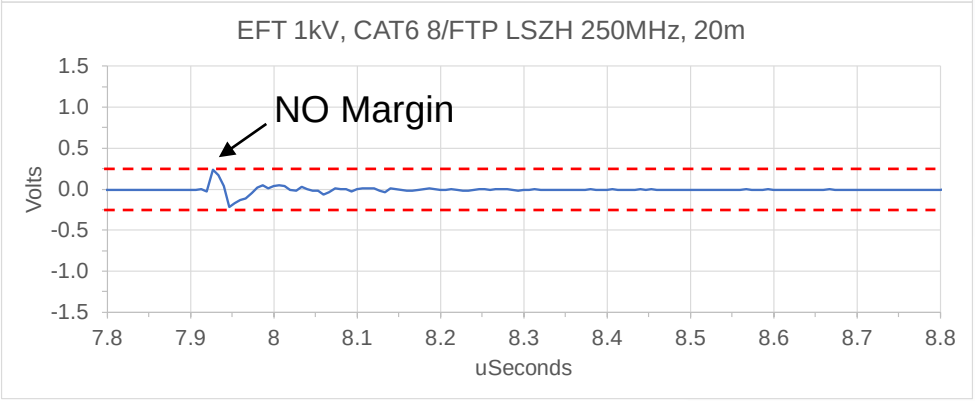


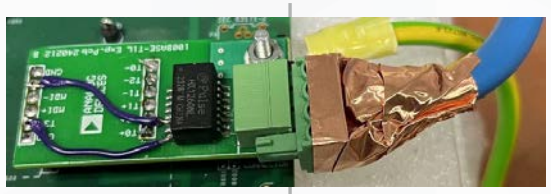


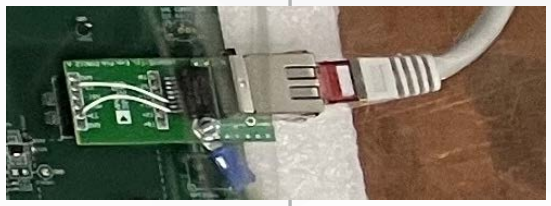
EFT Noise vs. Slicer Thresholds

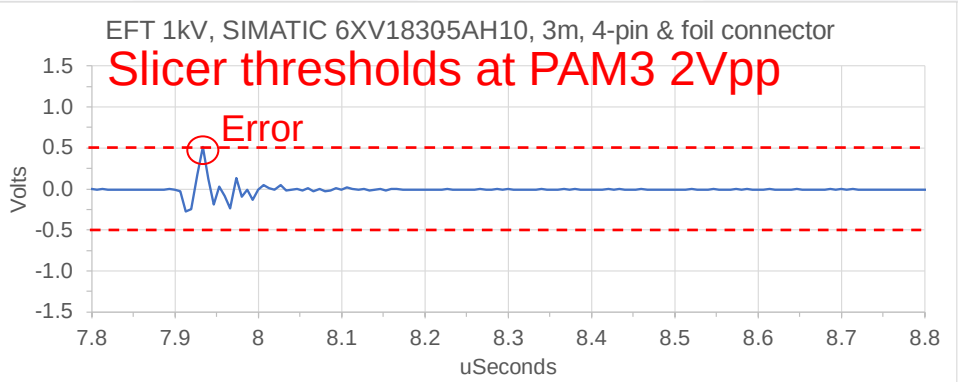


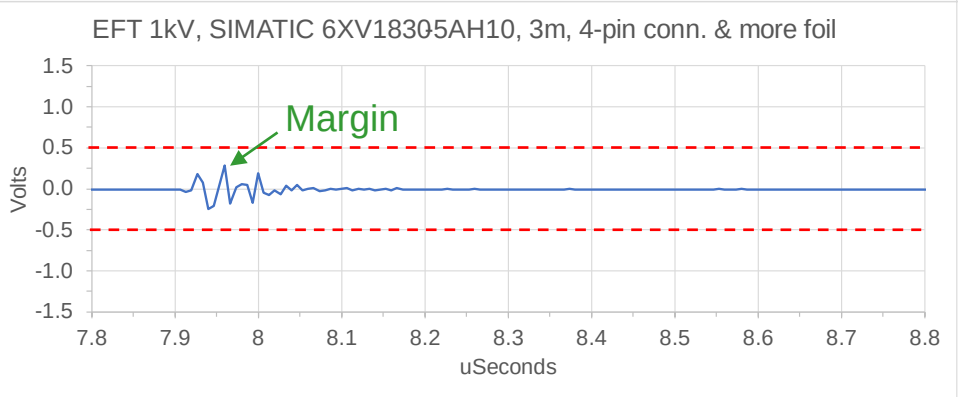


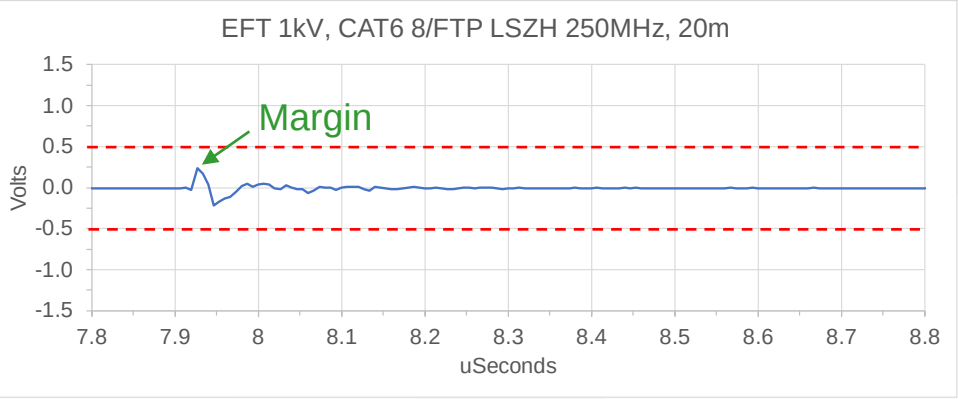




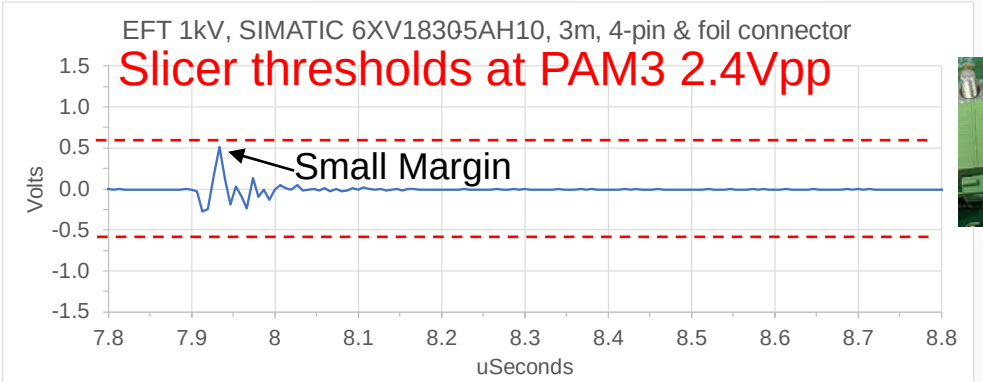


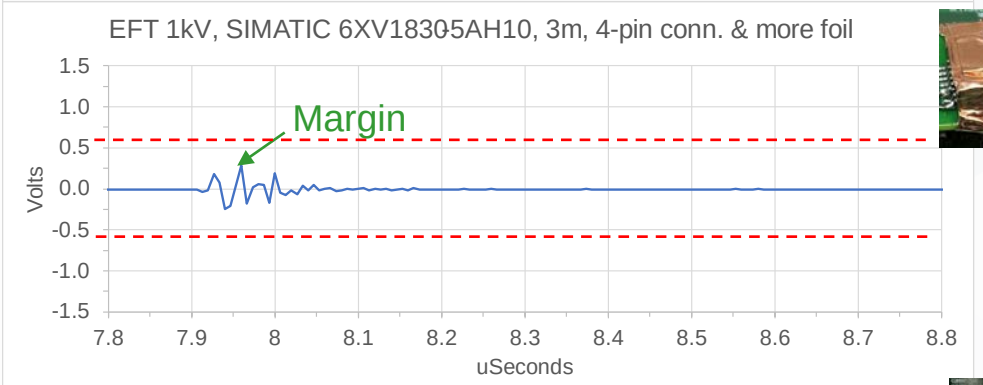


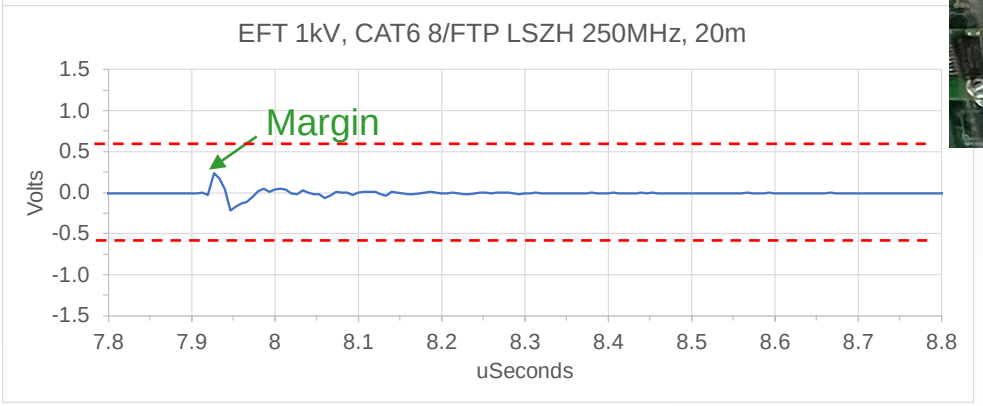


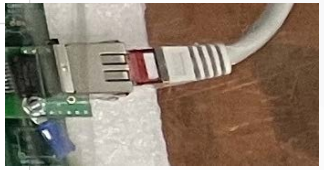


EFT Noise vs. Slicer Thresholds









- The slicer error margin depends on number of levels to be detected / distance between levels
  - Different between PAM3 / PAM4 / PAM5
  - Examples here for PAM3
- The slicer error margins depend on signal amplitude
  - Higher signal amplitude = better SNR

    However:
  - Need to consider signal levels vs. power supplies
    - TX 2.4Vpp @ (3.3V ±5%) works on 10BASE-T1L
    - 2.4Vpp may be more challenging at higher speed
  - Need to consider other EMC, specifically emissions

Summary

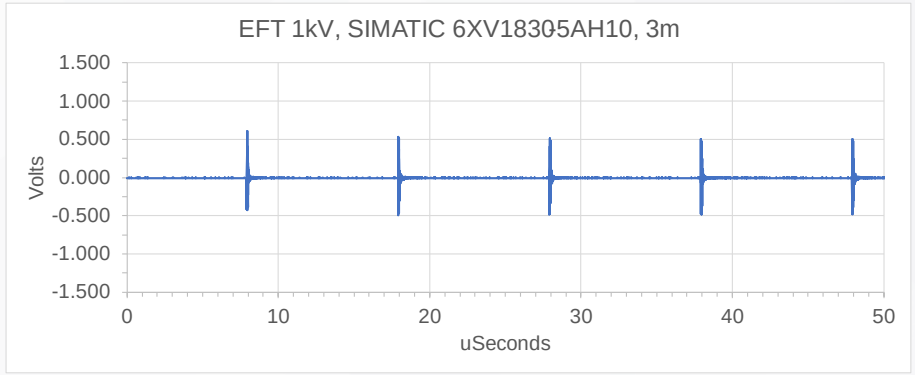
- Electrical Fast Transients (EFT)
- Measured with data acquisition system
- Several cables – all shielded

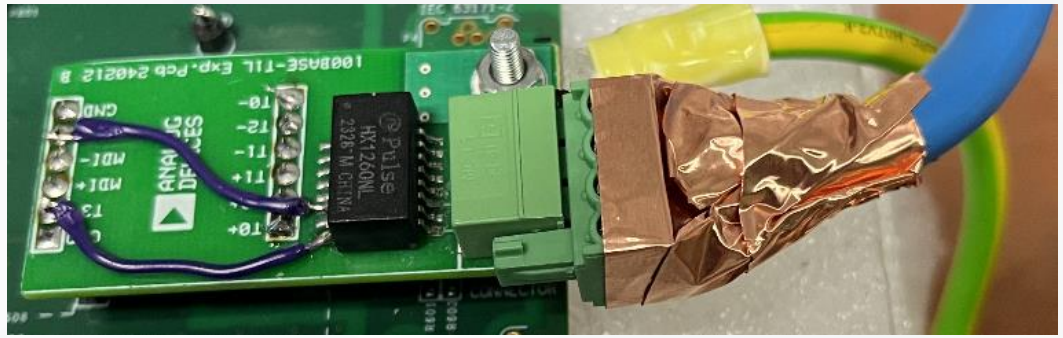
- Screw terminal connectors challenging

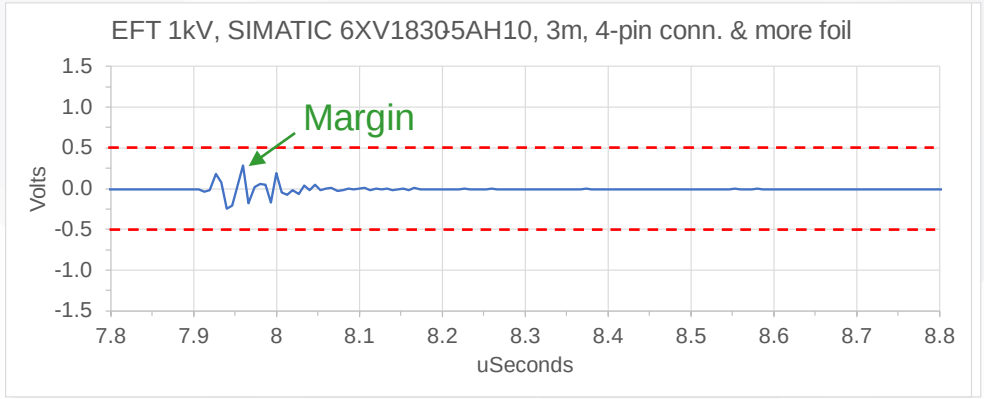
- Margin of coupled EFT versus slicer errors
  - Depends on the noise coupling
  - Depends on signal modulation & amplitude

- EFT is not the only noise in the system
  - Addition to Crosstalk, Gaussian noise..
  - Looking for more real noise measurements
    - Motor drive?
    - Other ideas / applications / sources?

- More insides from cable vendors?
- More insides from connector vendors?







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Thank You

Questions?