IEEE 802.3dg Task Force

EFT Pulse Measurements

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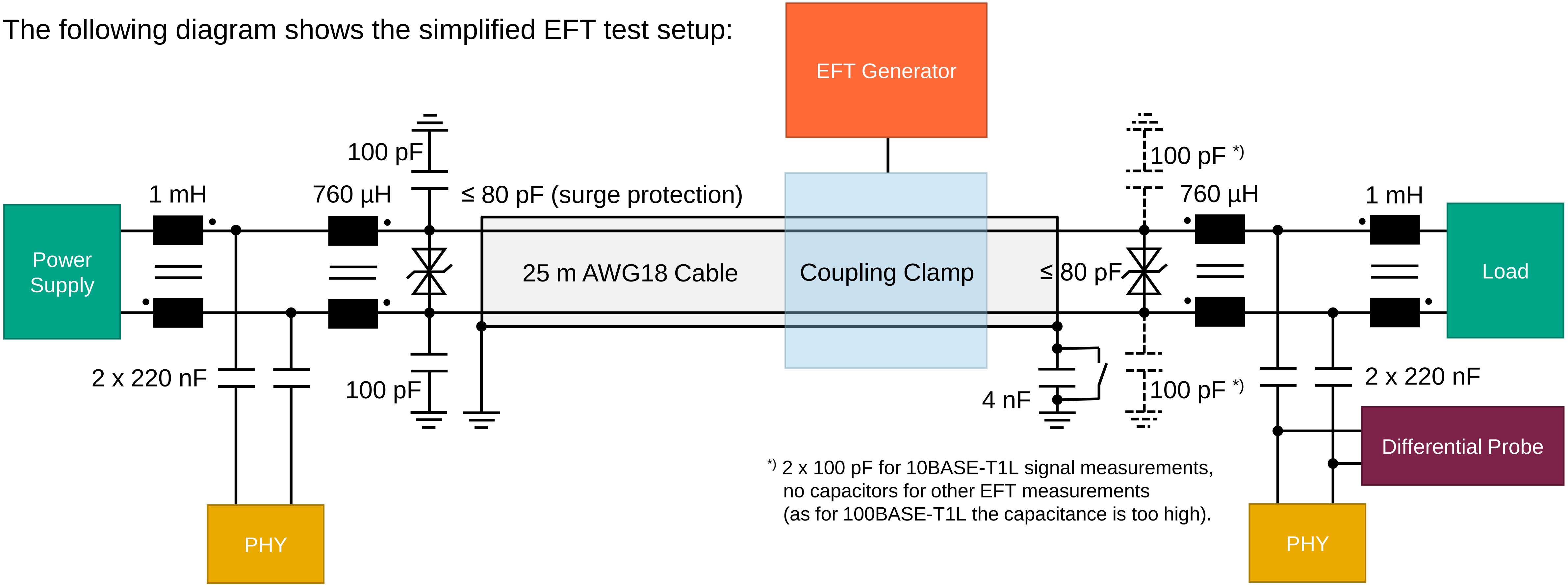
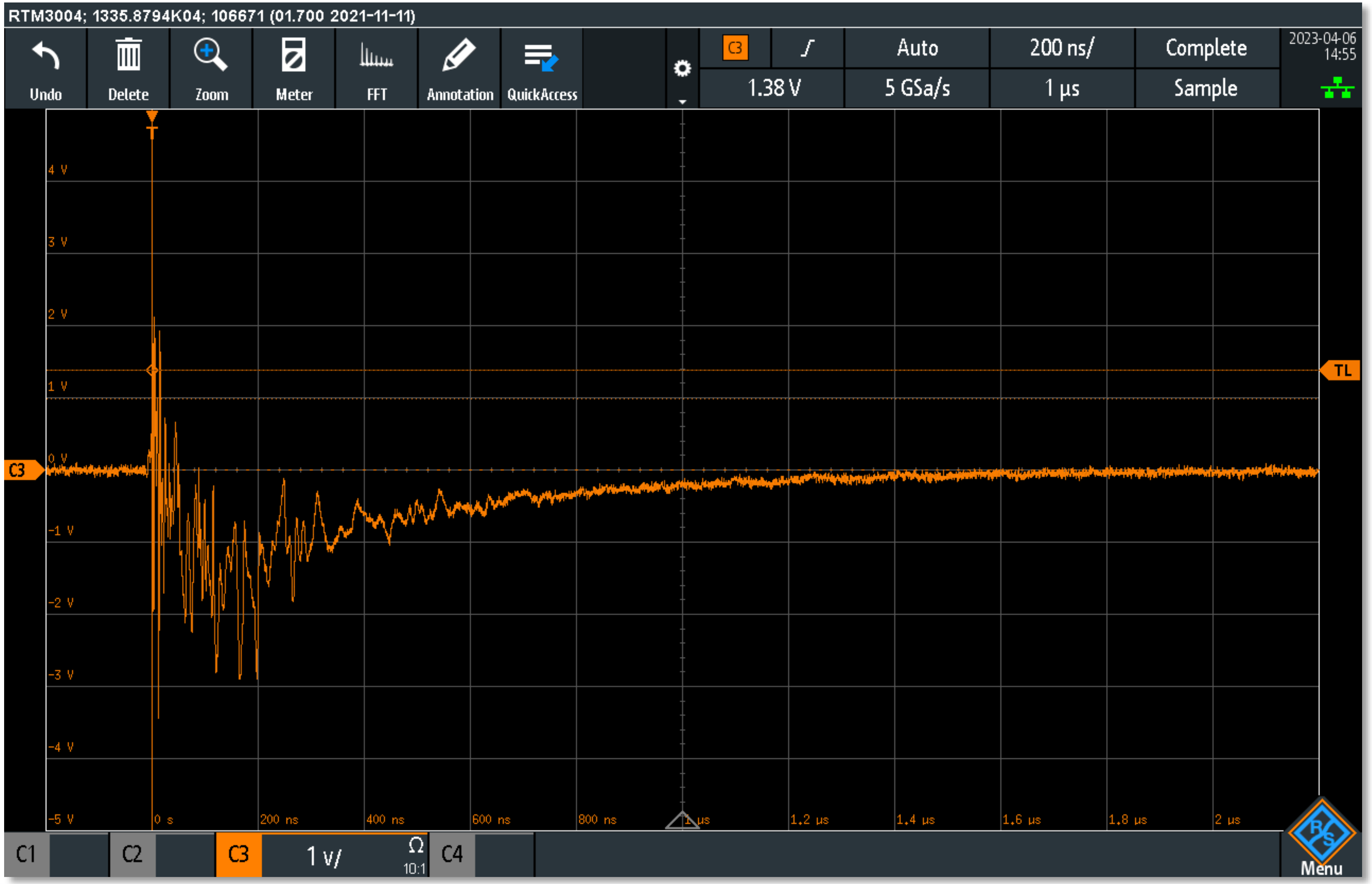
Test Setup

- The following diagram shows the simplified EFT test setup:



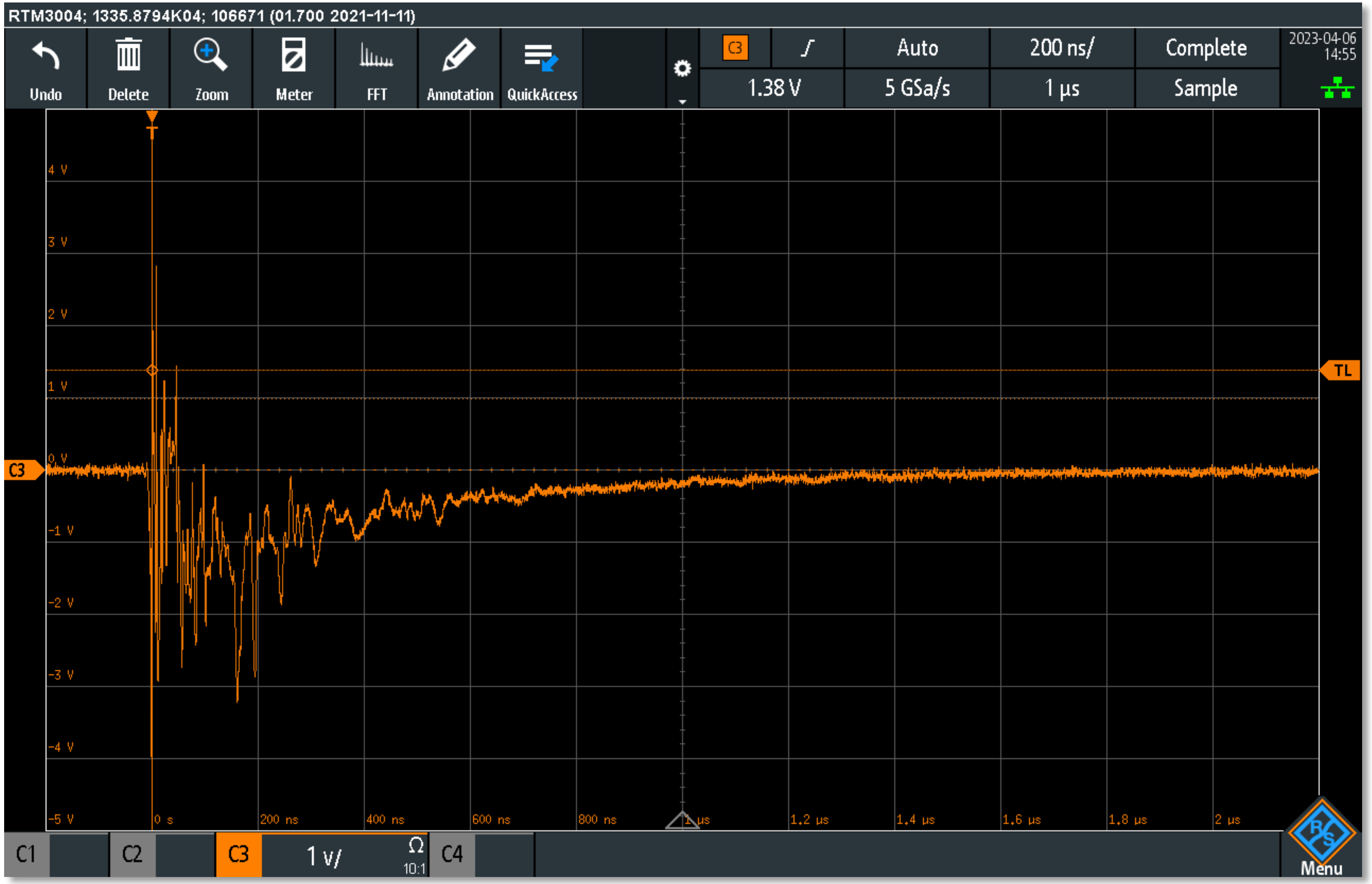
- The EFT signal is coupled onto a 25 m long shielded AWG18 cable using a capacitive coupling clamp.
- The signal is measured at the PHY (after the coupling capacitors) using a 200 MHz differential probe.
- The PHY is set to „mute“, which keeps the internal driver active, but disables the transmit signal.

25 m cable, shield cap. coupled, 5 kHz Burst, pos. 1.1 kV



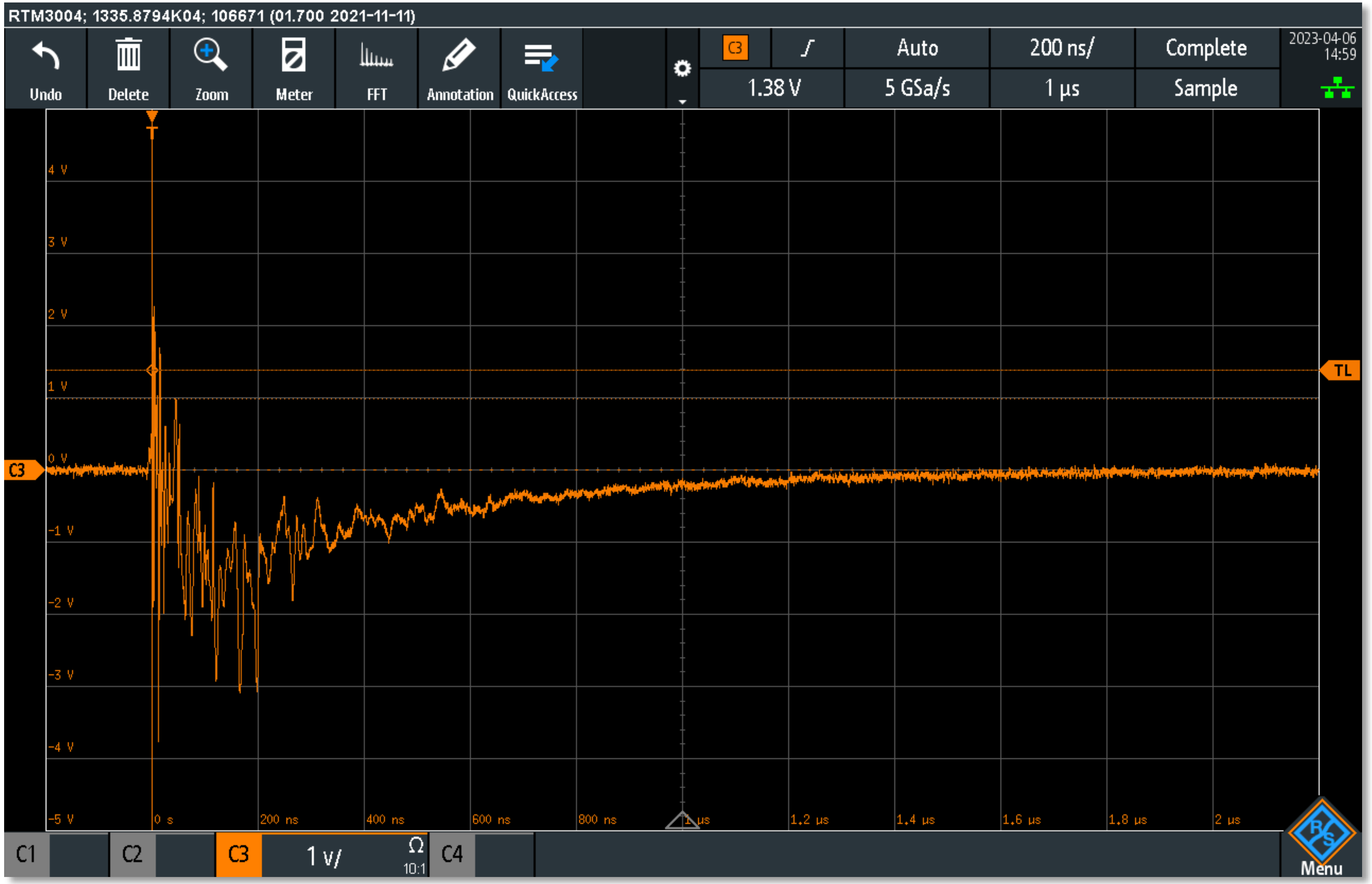
No 100 pF from +/- to GND before CMC.

25 m cable, shield cap. coupled, 5 kHz Burst, neg. 1.1 kV



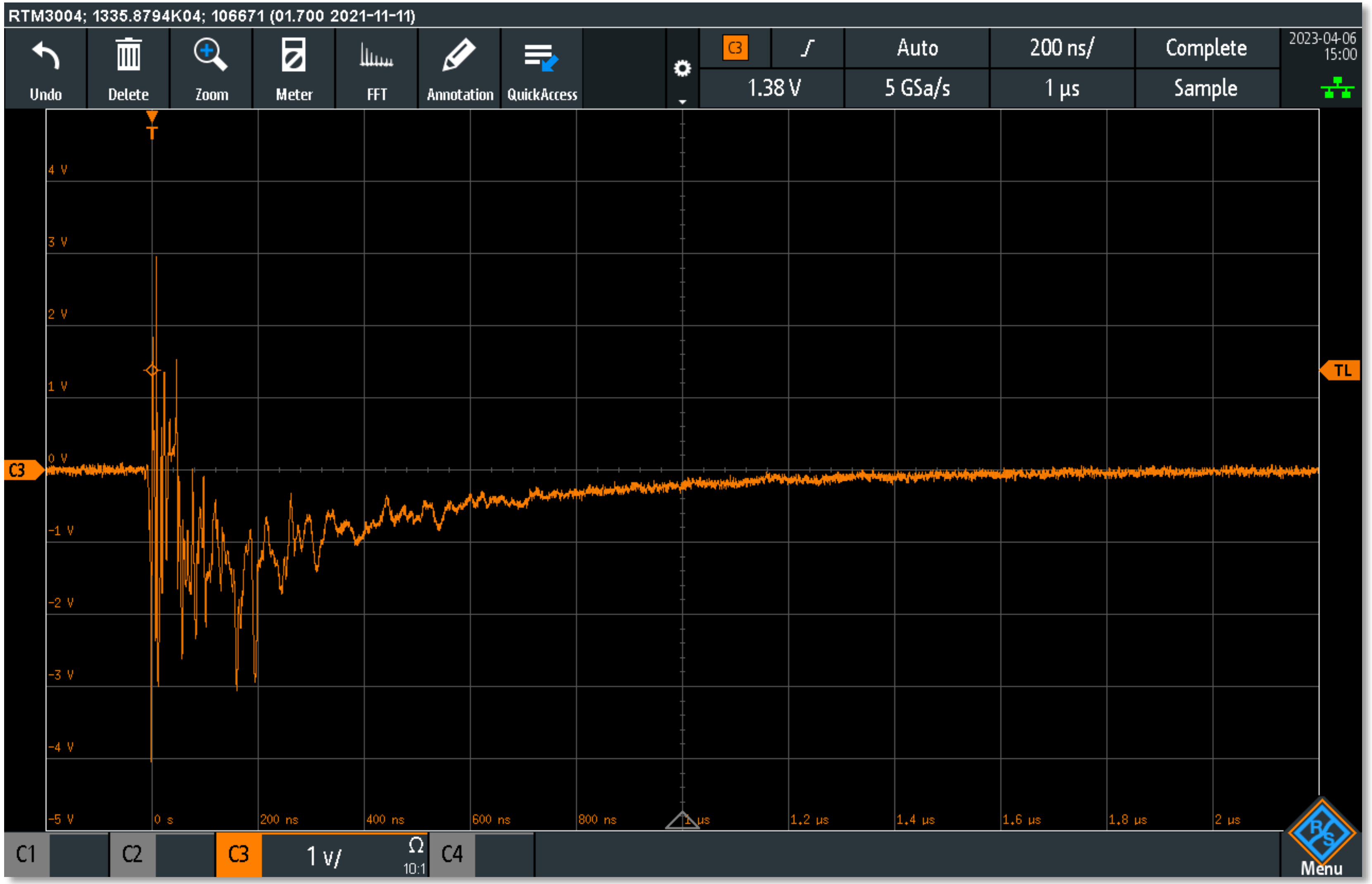
No 100 pF from +/- to GND before CMC.

25 m cable, shield direct coupled, 5 kHz Burst, pos. 1.1 kV



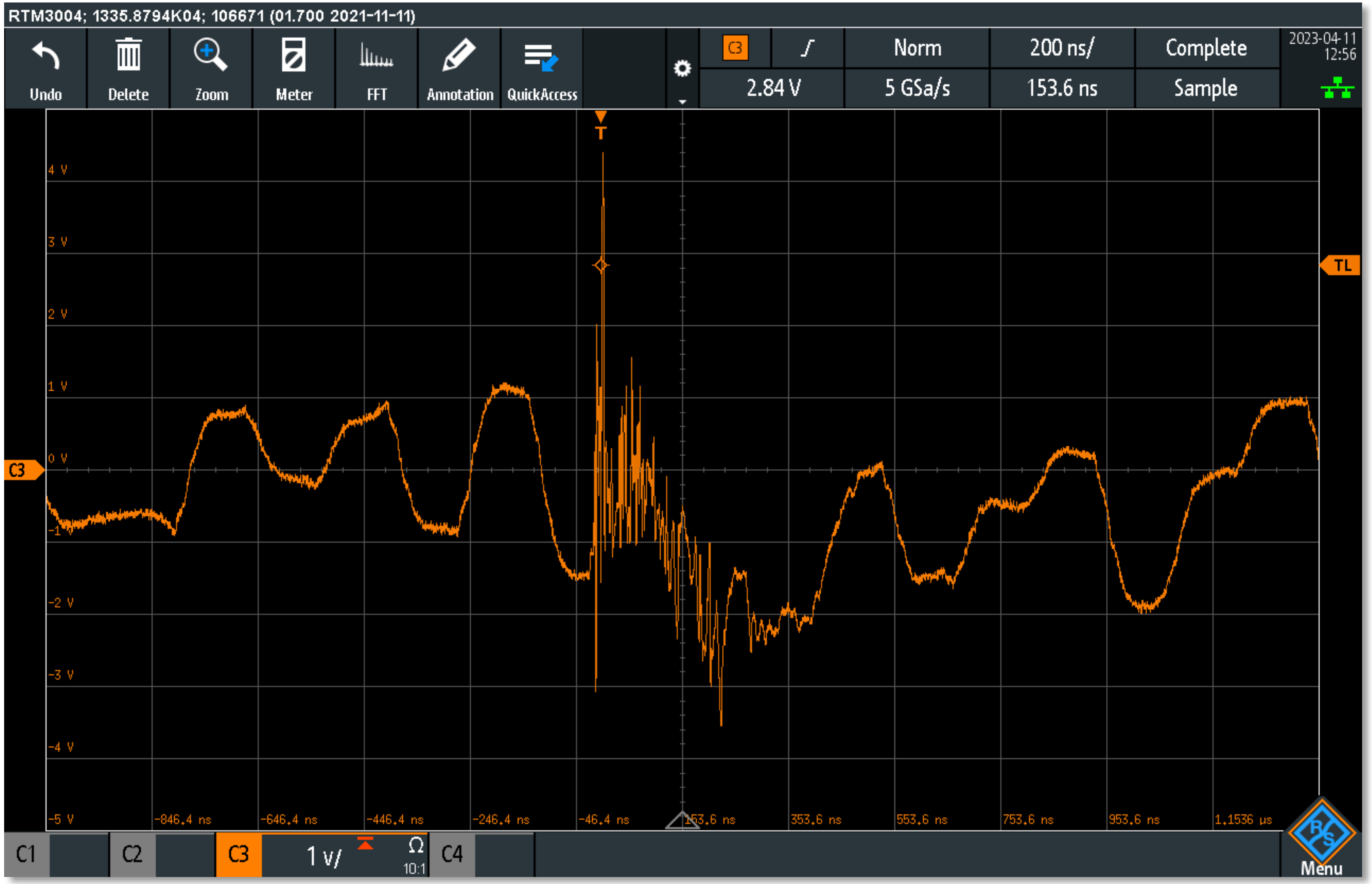
No 100 pF from +/- to GND before CMC.

25 m cable, shield direct coupled, 5 kHz Burst, neg. 1.1 kV



No 100 pF from +/- to GND before CMC.

600 m cable, 100 kHz Burst, pos. 1.1 kV



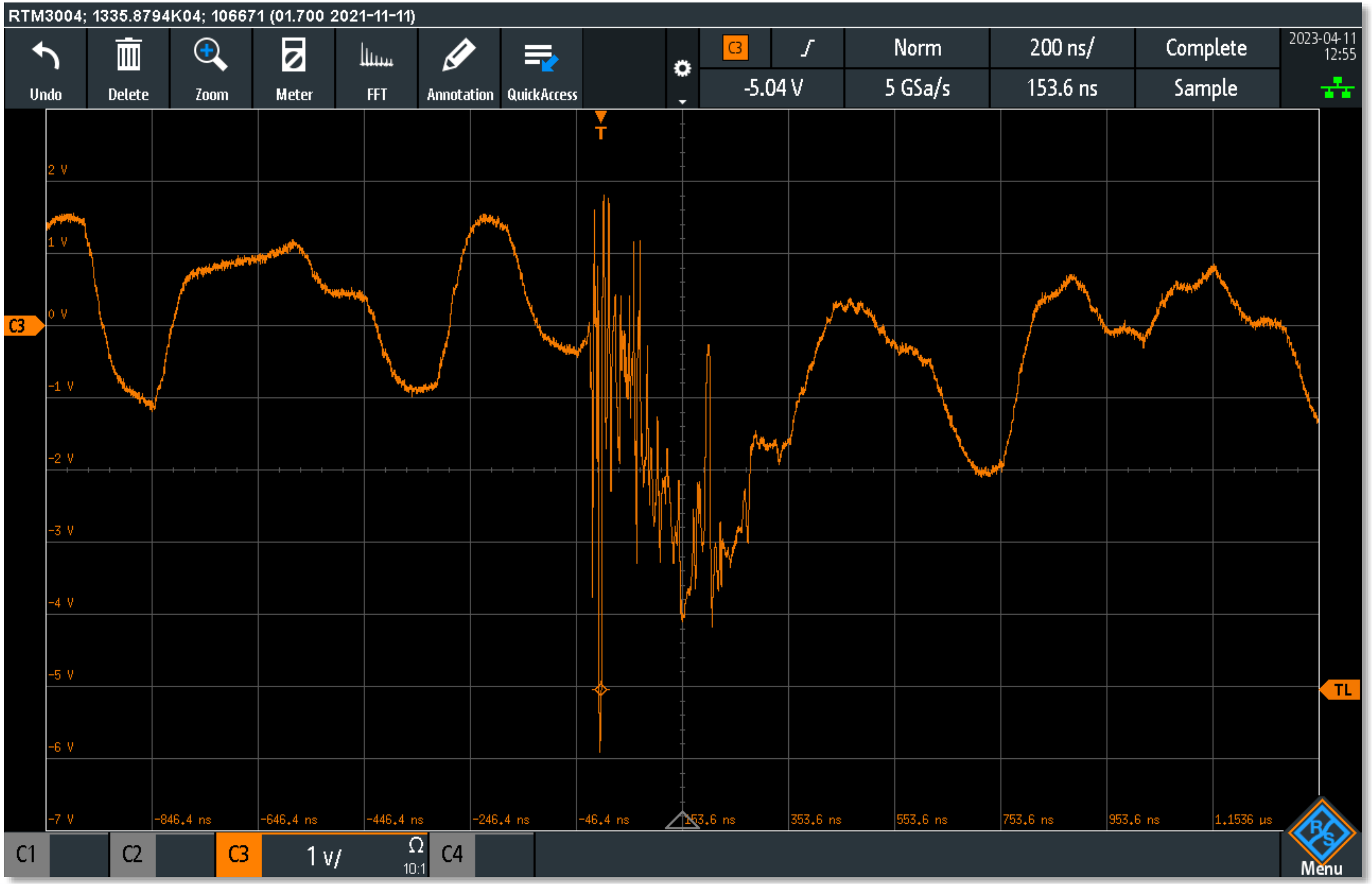
10BASE-T1L signal.

2 x 100 pF from +/- to GND before CMC.

No telegram errors.

Max. slicer error 0.43.

600 m cable, 100 kHz Burst, neg. 1.1 kV



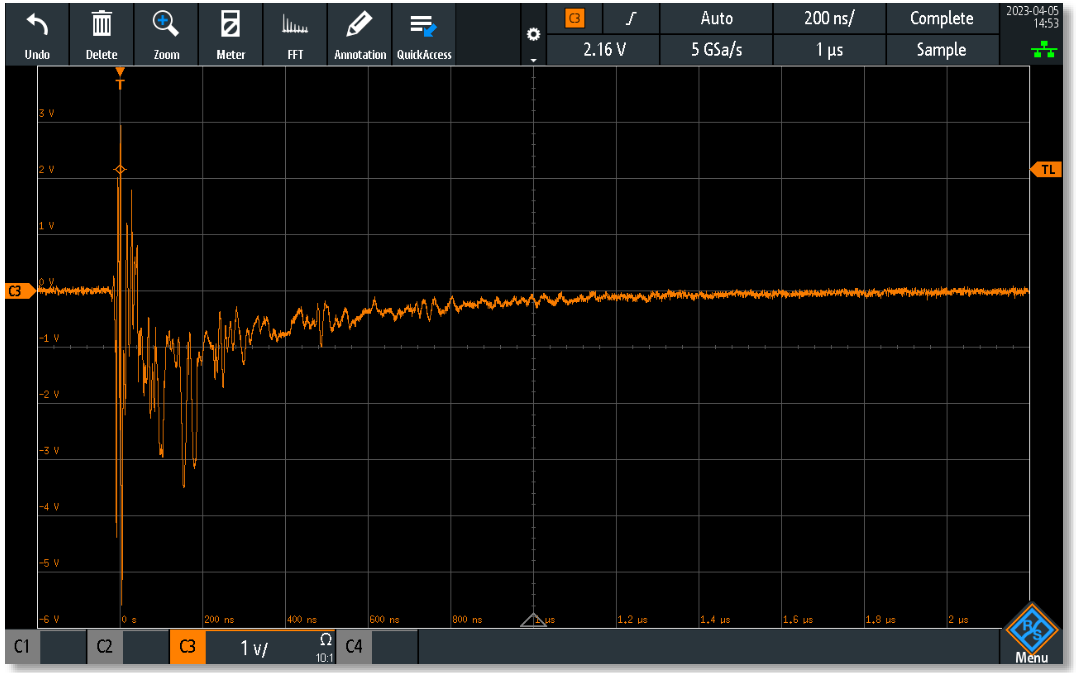
10BASE-T1L signal.

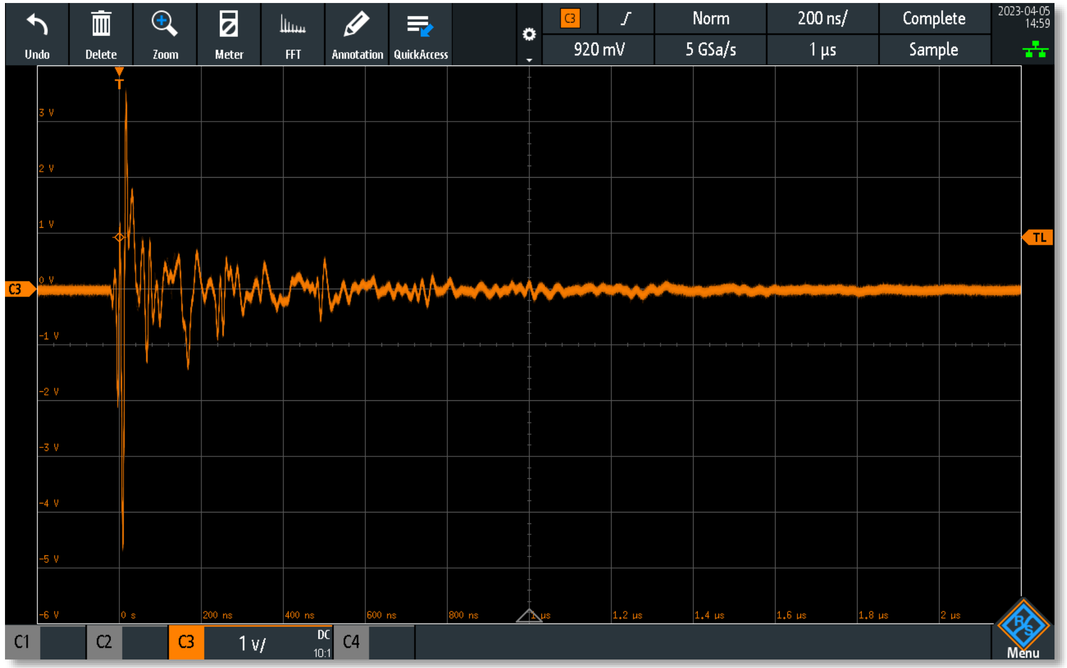
2 x 100 pF from +/- to GND before CMC.

No telegram errors.

Max. slicer error 0.44.

Differential Probe Influence on Measurements





- The differential probe and the oscilloscope are also influenced by the EFT disturbance (mainly depending on CMRR).
- Comparing the used differential probe for the previous measurements (**left** screen shot, 200 MHz BW, ± 20 V differential, ± 60 V common mode) to a second differential probe (**right** screen shot, 100 MHz BW, ± 70 V differential, ± 700 V common mode), it can be seen, that the used probe is creating some „low frequency“ offset voltage after an EFT impulse is applied.
- The second probe does not show this behavior, but shows higher noise and provides a lower bandwidth.
- The scope supply has been isolated using a separate isolation transformer to reduce capacitive coupling to ground.

Summary

- The measurements show that a single EFT pulse (50 ns ± 30 % pulse width) does not influence the communication signal only during this short time duration, but also adds ringing to the system.
- This ringing is decaying within a time duration of about **500 ns** (600 ns to be on the safe side).

- For **10BASE-T1L** this is in the range of 4 to 5 symbol times (due to the 4B3T coding up to 3 triple ternary code groups could be affected, which is equivalent to 12 consecutive bits).
- As the ringing after an EFT pulse is having a high frequency (typ. ≥ 50 MHz) compared to the 10BASE-T1L signal frequency (3.75 MHz Nyquist frequency, typ. 8 MHz low pass filter cut-off frequency), the ringing is reduced by the PHY input filters.
- For an AWG18 cable length of up to 600 m applying 1.1 kV EFT pulses, no bit errors occur in the used test setup.

- For a **100BASE-T1L** PHY a ringing of 500 ns to 600 ns is already equivalent to 50 to 60 bit times (and depending on the used line coding some more bits could also be affected).
- Additionally the signal frequency for 100BASE-T1L will be much closer to the ringing frequency, which will make a low pass filter at the input of the PHY less effective (it could potentially help to go to a higher PAM-level than PAM-3 and cut-off close to Nyquist frequency).
- As many bits can be affected during an EFT pulse, the efficiency of a FEC coding is likely limited or would lead to high latencies due to a large block size.

Thank you!