Demo: Single Pair Ethernet Measurements

IEEE ETFA 2022 – WS10
“Enabling robust, converged networks for Industry 4.0”
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Most recent version of the presentation

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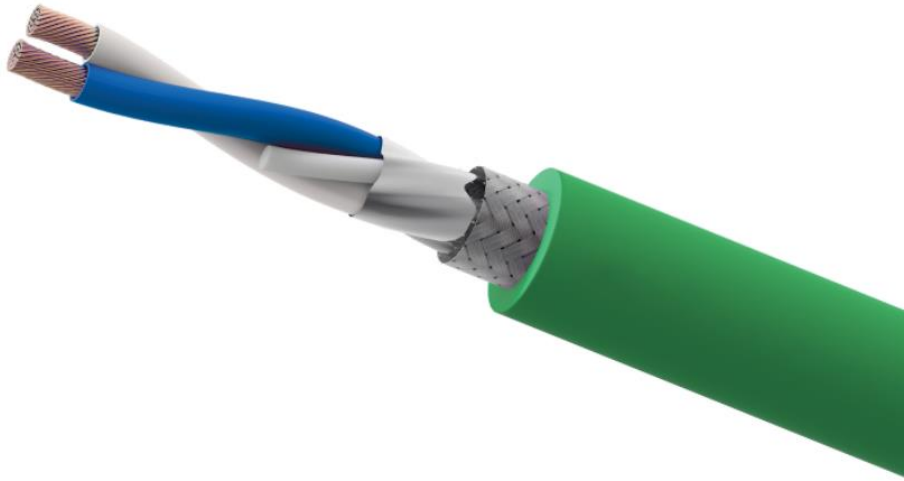
Outline

- Introduction to diagnostic tools for SPE
  - Cable testers, also for SPE
  - Signal separation and decoding
  - Logging of the frames
- AEM Cable tester
- Signals and Decoding
  - Network setup
  - Measurement setups with Rohde & Schwarz and Tektronix



Outline

- **Introduction to diagnostic tools for SPE**
  - **Cable testers, also for SPE**
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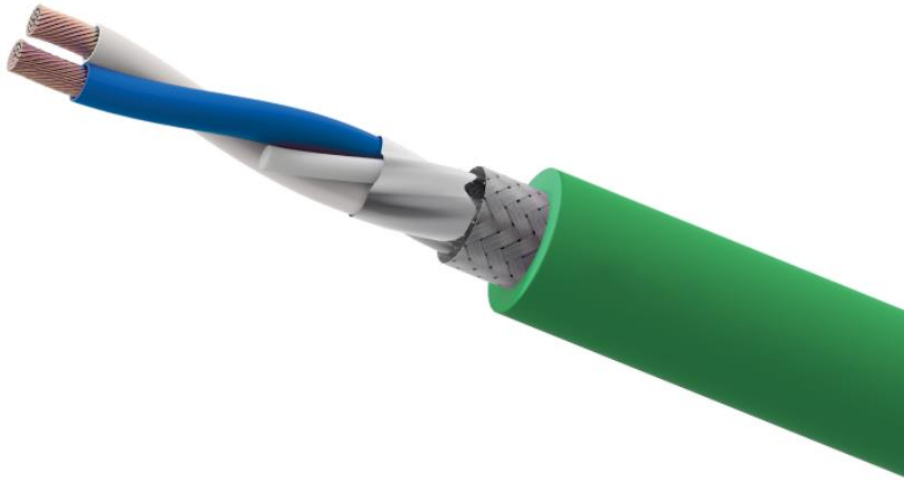


Introduction to diagnostic tools for SPE
Cable testers*, also for SPE

- AEM
  - TestPro CV100
  - IEC 63171-6 channel adapter (Harting connector)

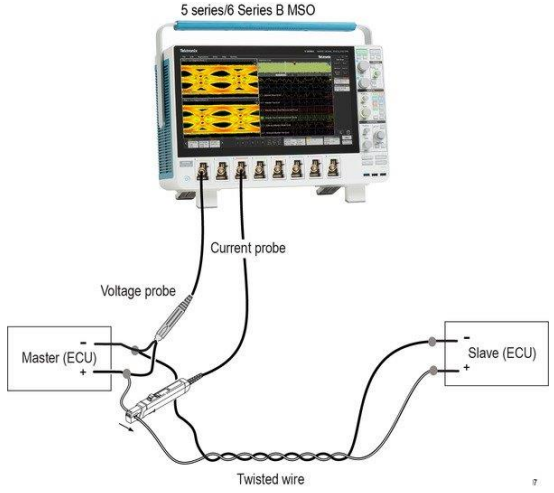
- Fluke
  - DSX-8000
  - SPE prototype adapters

- Softing
  - WireXpert 4500
  - SPE prototype adapters (IEC 63171-6)

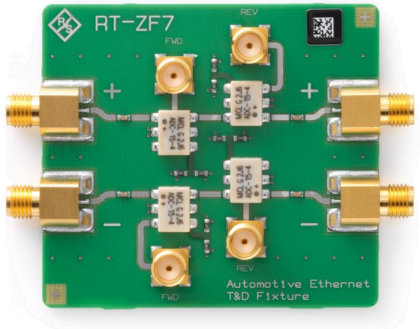
*non-exhaustive list

Introduction to diagnostic tools for SPE Signal separation and decoding*

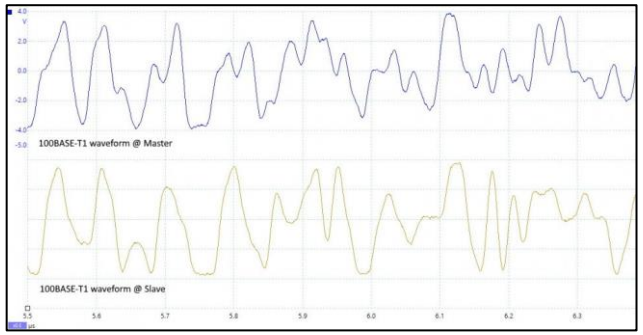
- Tektronix
  - One current and one voltage probe
  - 100BASE-T1 decoding



- Rohde & Schwarz
  - Directional coupler
  - 100/1000BASE-T1 trigger and decoding



- PicoScope
  - Two voltage probes at known distance
  - 100BASE-T1 decoding



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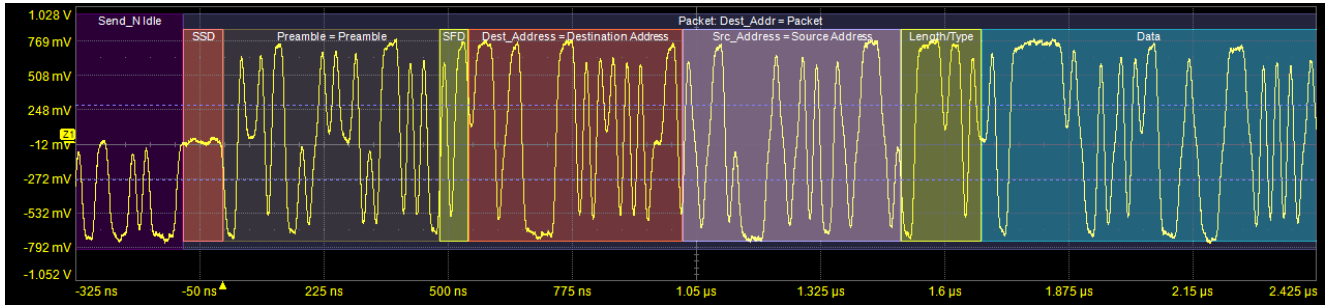
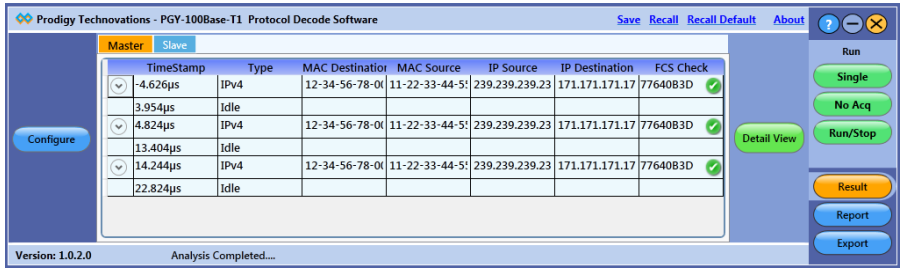
Introduction to diagnostic tools for SPE
Signal separation and decoding*

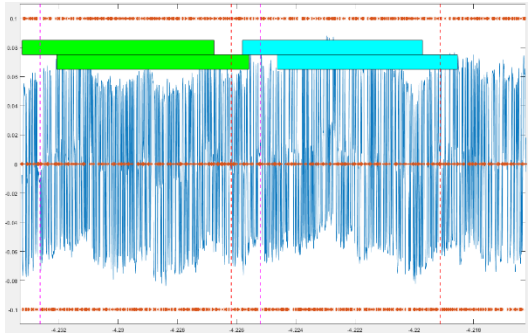
- Teledyne LeCroy
  - Directional coupler
  - 100BASE-T1 trigger and decoding



- Prodigy Technovations (software for Tektronix)
  - Directional coupler
  - 100BASE-T1 decoding
  - Has been tested the first time in Ghent, feedback was provided to the manufacturer



- MATLAB decoding (work in progress at KU Leuven)
  - Directional coupler or separated signals by Tektronix
  - 100BASE-T1 decoding



*non-exhaustive list

Introduction to diagnostic tools for SPE
Logging of the frames

Wireshark

- Measuring on 100BASE-TX links
  - Mirror ports, active taps…
- Measuring on 100BASE-T1 links
  - Active taps

Decoding oscilloscopes / software may also export loggings

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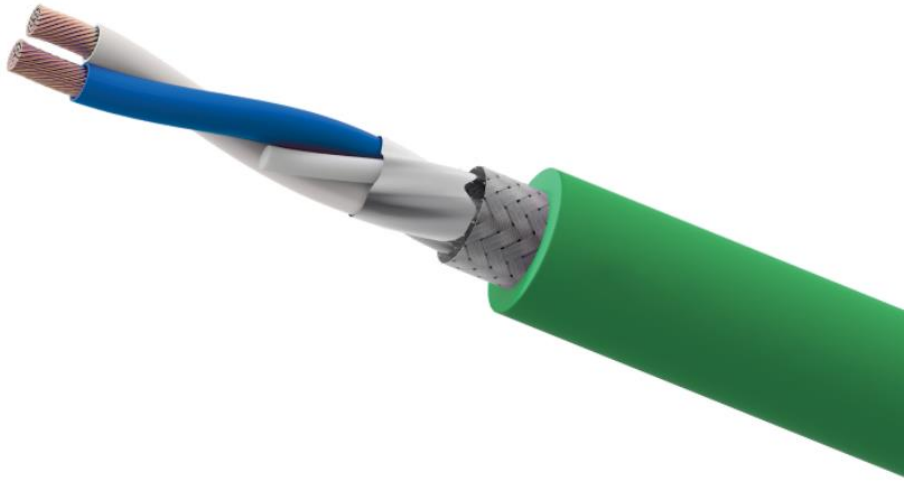
  - Network setup
  - Measurement setups with Rohde & Schwarz and Tektronix



AEM Cable tester

- TestPro CV100
  - IEC 63171-6 channel adapter (Harting connector)

AEM Cable tester

KU LEUVEN

Harting SPE 5m

Pass

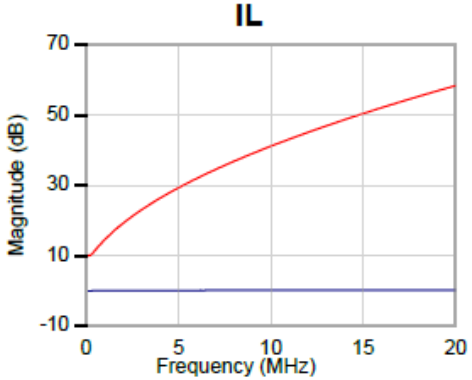
Test Time	: 22/06/2022 09:36:16
Project	: 2022-06-22 - SPE
	:
Profile	: Single Pair Ethernet
Operator	: Default
Cable Type / NVP	: SPE , 68%
Connector	: SPE

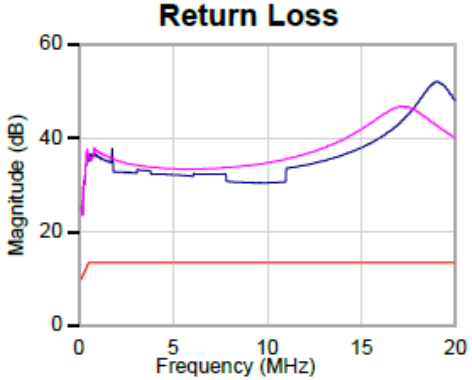
Limit	: 10BASE-T1L STP 1000m (ISO IEC 11801-9906)
Model	: TestPro CV100
Serial Number	: Main: 5400-0319, Remote: 5400-0320
Device Software	: 3.8.R1
Calibration Date	: Friday, 7 January 2022
Main Adapter	: PROBE SPE, S/N: 10004
Remote Adapter	: PROBE SPE, S/N: 10003

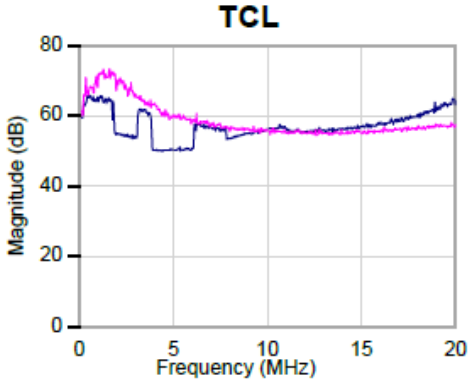
Parameter	Result	Pair	Value	Limit
Length(m)	Pass	12	3,7	1000,0
Prop Delay(ns)	Pass	12	18,0	8834,0
Delay Skew(ns)	Info	12	0,0	0,0
DC Loop Resistance(Ω)	Pass	12	0,488	47,660
Res. Unbal, wire-wire(Ω)	Info	12	0,000	0,200

RF Parameters

Parameter	Result	Main							Remote						
		Worst Margin				Worst Value			Worst Margin				Worst Value		
		Pair	Margin (dB)	Limit (dB)	Freq (MHz)	Pair	Value (dB)	Freq (MHz)	Pair	Margin (dB)	Limit (dB)	Freq (MHz)	Pair	Value (dB)	Freq (MHz)
Return Loss	Pass	12	13,1	10,7	0,18	12	23,8	0,16	12	13,0	10,7	0,18	12	23,5	0,16
IL	Pass	12	10,0	9,9	0,14	12	0,2	6,18		-	-	-		-	-
TCL	Info														
TCTL	Info														







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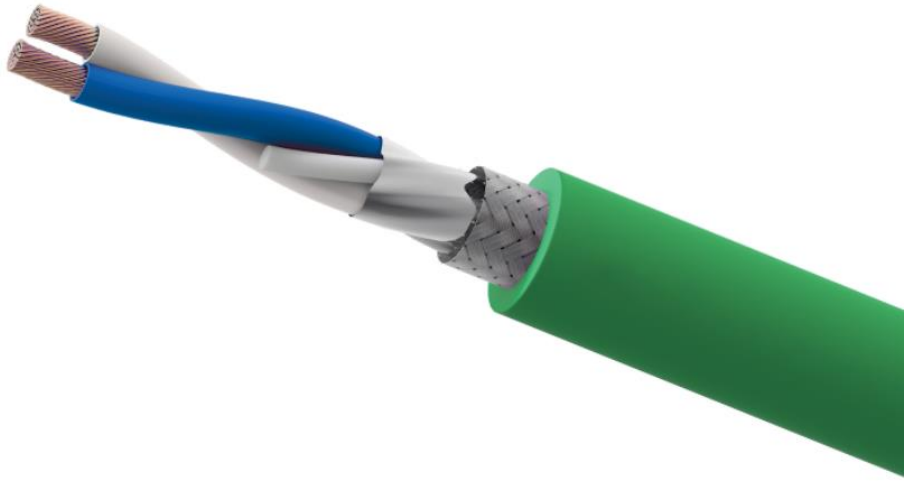
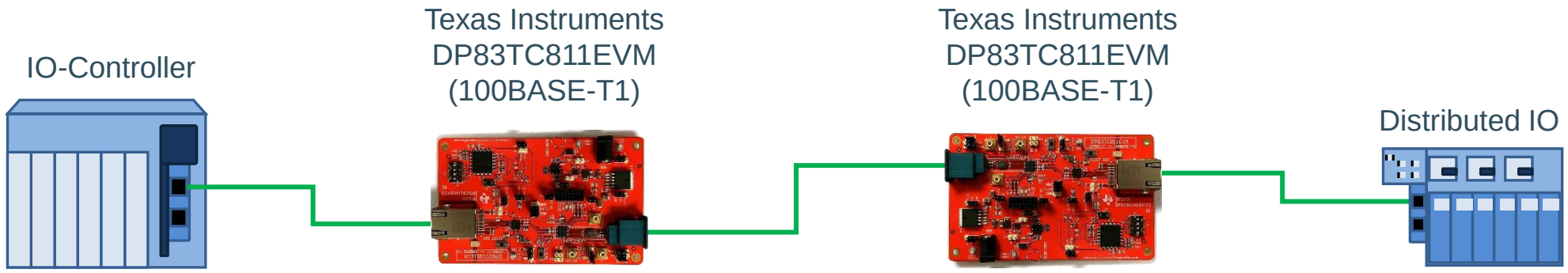
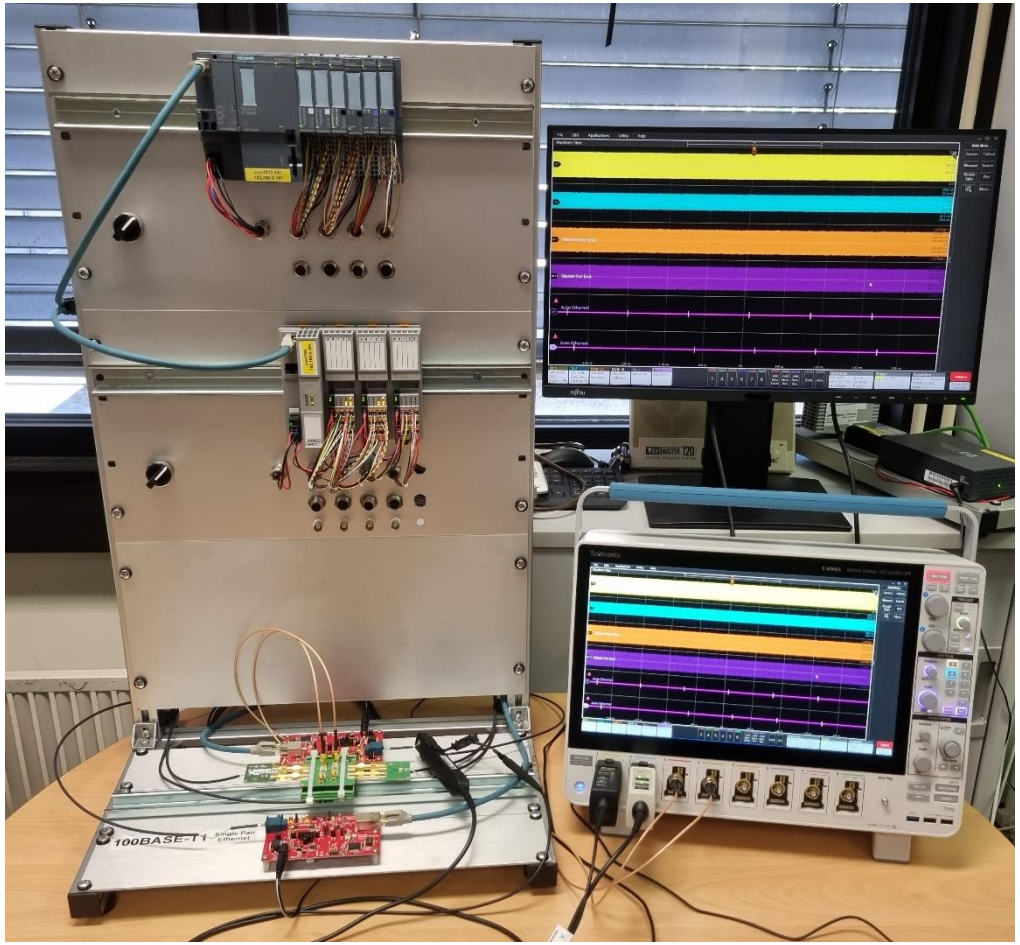
  - **Measurement setups with Rohde & Schwarz and Tektronix**

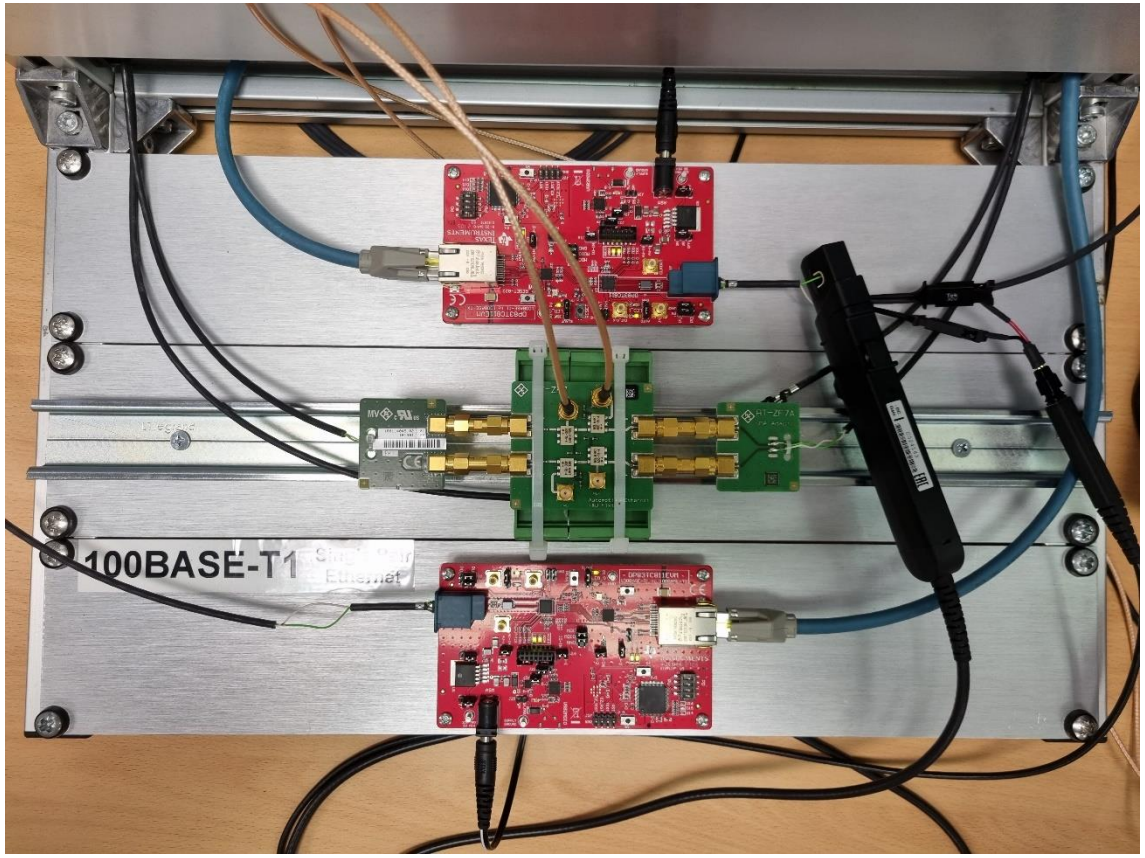


Signals and Decoding
Network setup



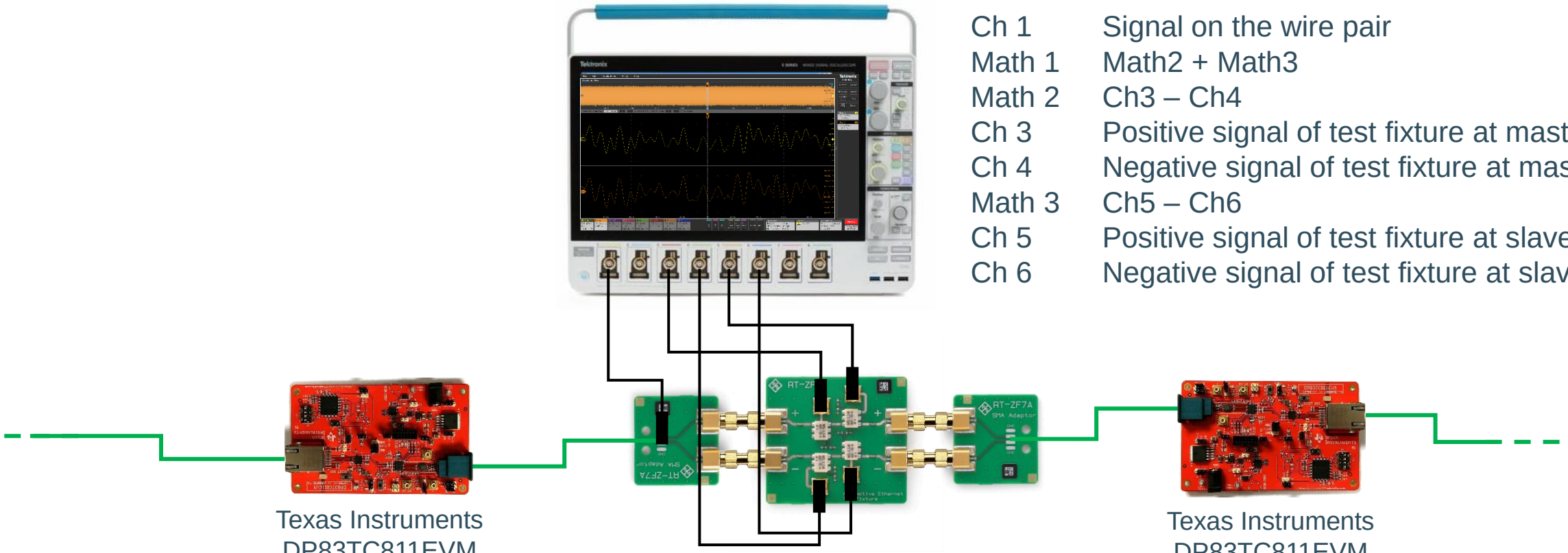
Signals and Decoding
Network setup





Signals and Decoding
Measurement setup with Rohde & Schwarz

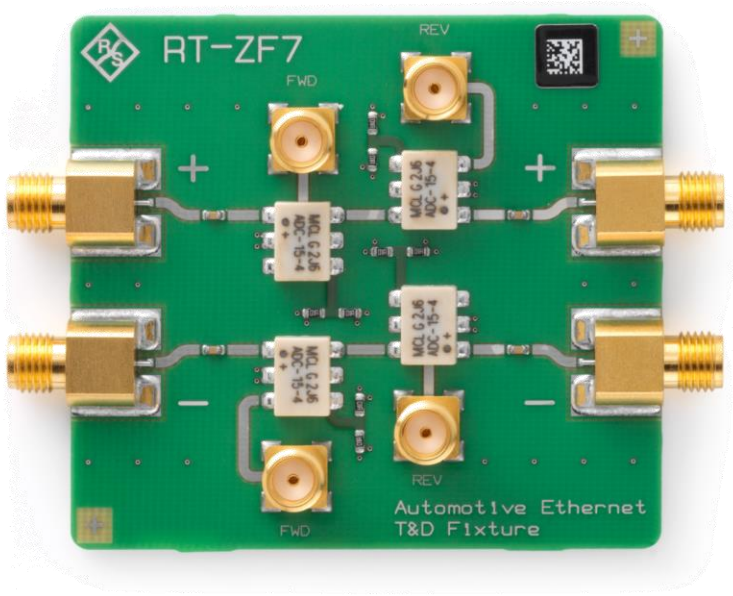
Ch 1	Signal on the wire pair
Math 1	Math2 + Math3
Math 2	Ch3 – Ch4
Ch 3	Positive signal of test fixture at master side
Ch 4	Negative signal of test fixture at master side
Math 3	Ch5 – Ch6
Ch 5	Positive signal of test fixture at slave side
Ch 6	Negative signal of test fixture at slave side



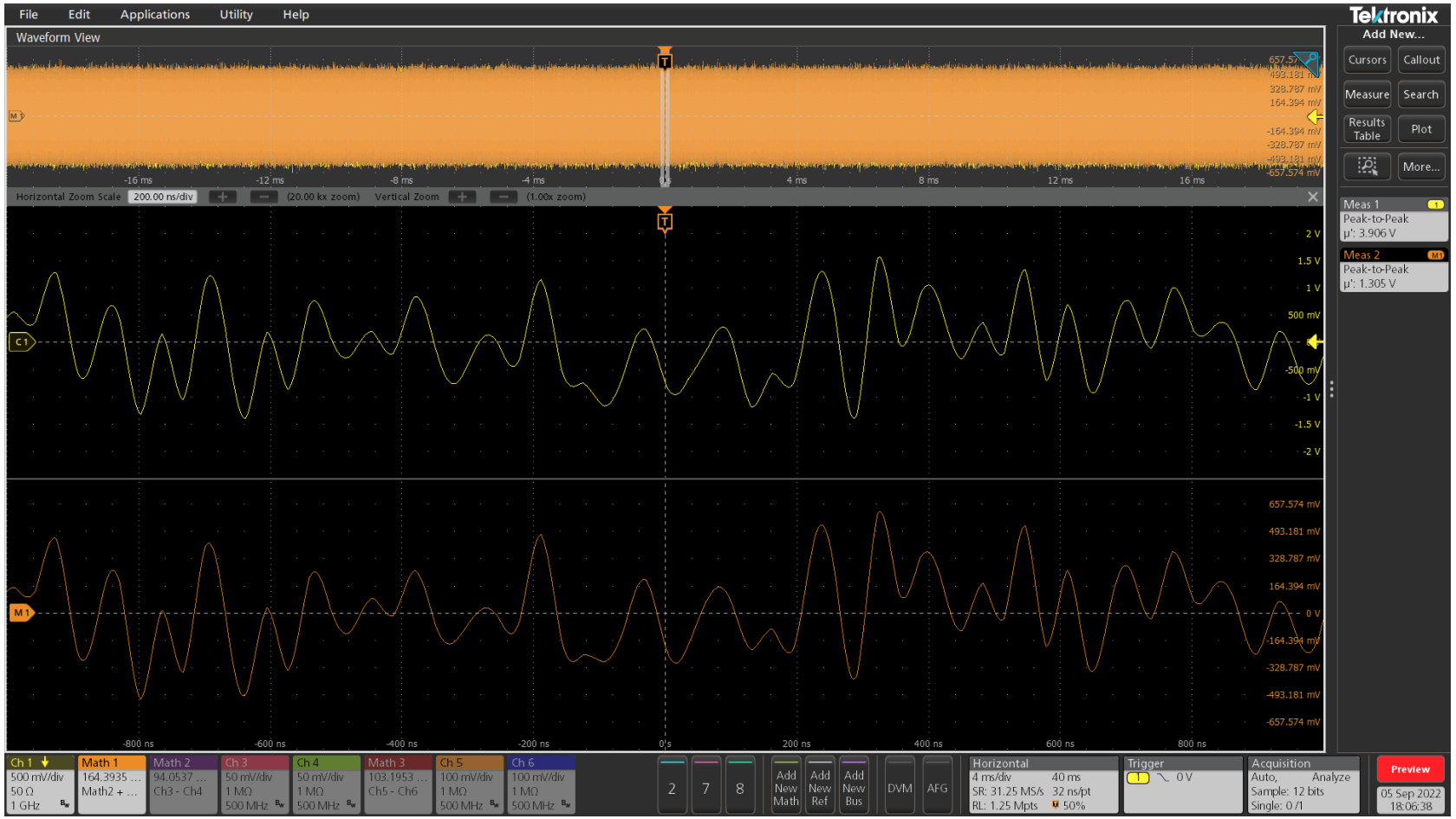
Signals and Decoding
Measurement setup with Rohde & Schwarz

Rohde & Schwarz RT-ZF7

- 100BASE-T1 and 1000BASE-T1 signal separation
- ADC-15-4+ directional couplers
  - **5 - 1000 MHz**
  - https://www.minicircuits.com/pdfs/ADC-15-4+.pdf

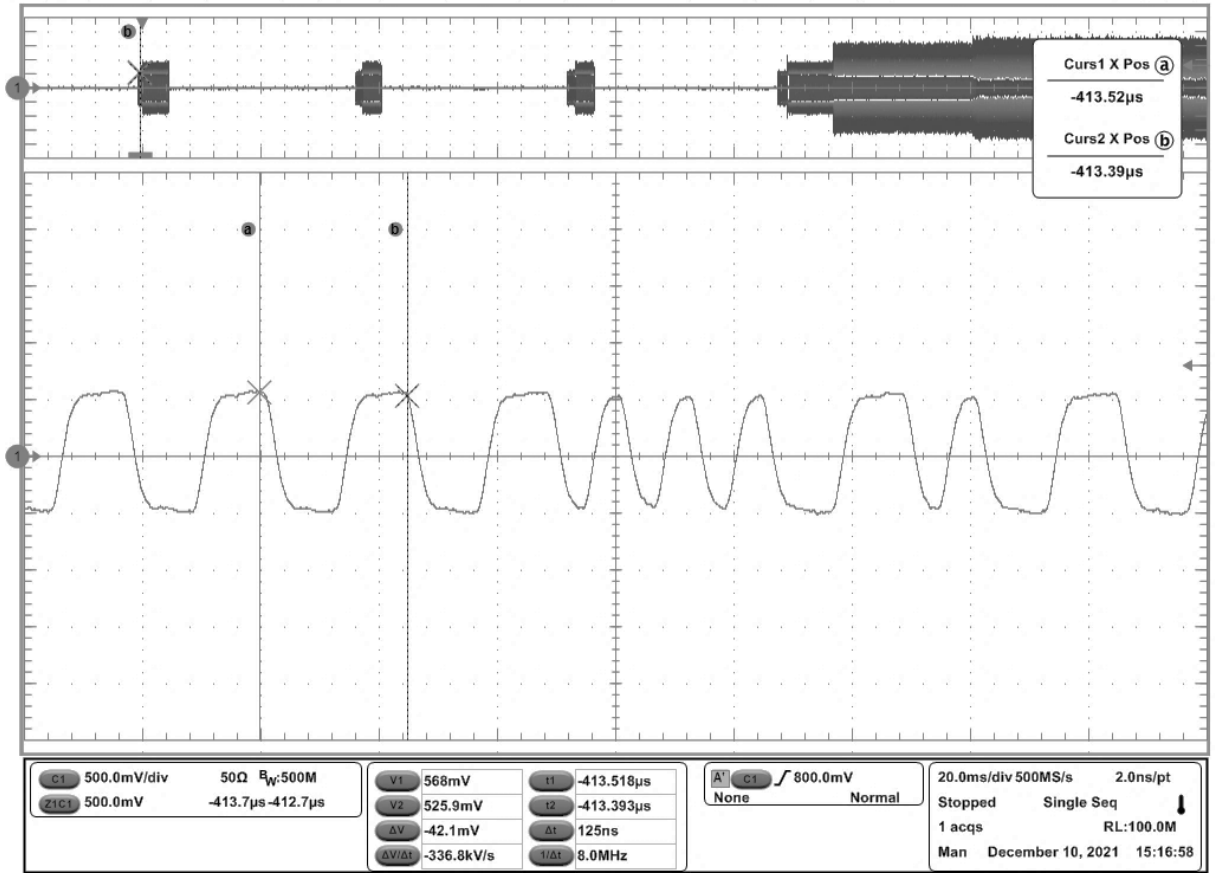


Signals and Decoding
Measurement setup with Rohde & Schwarz



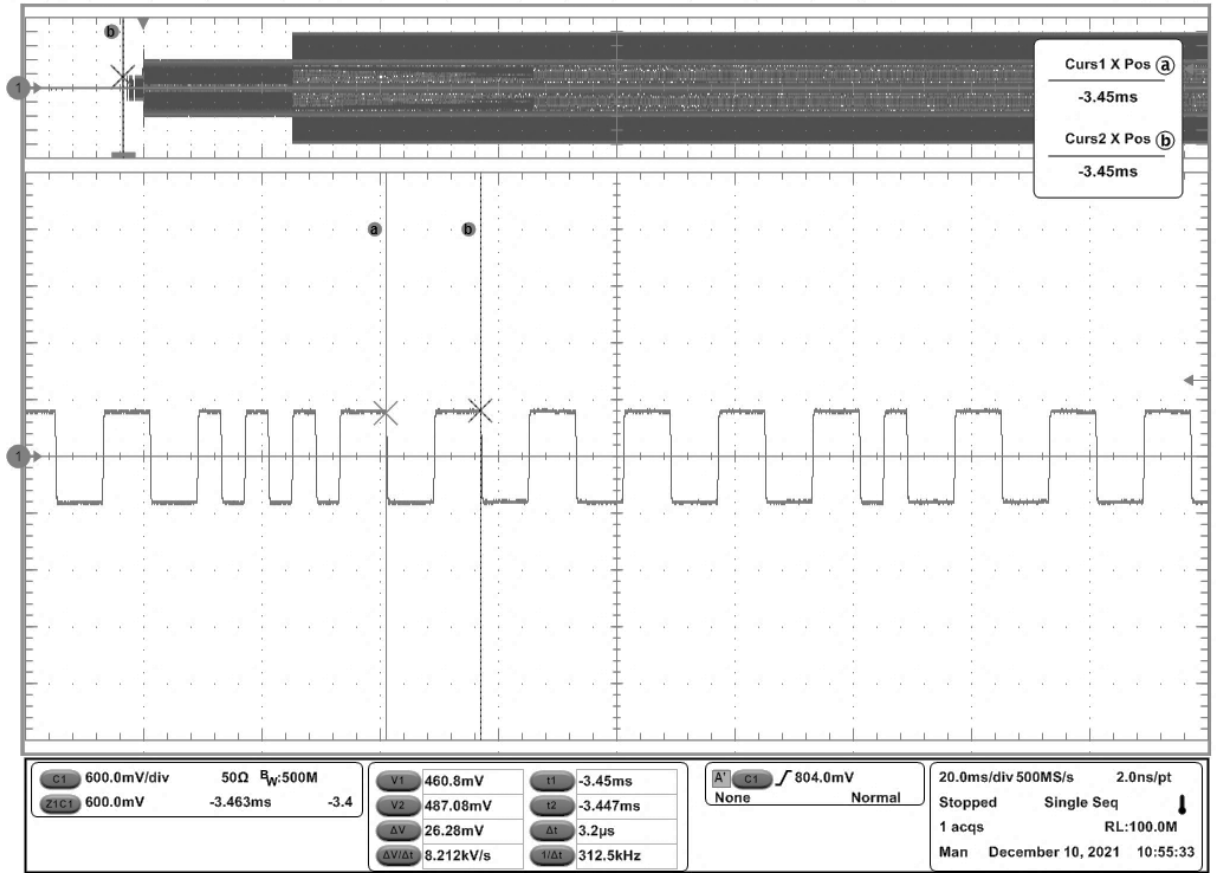
Recombined signal ~33% Peak-to-Peak of the original

100BASE-T1 negotiation
Lowest frequency 8 MHz



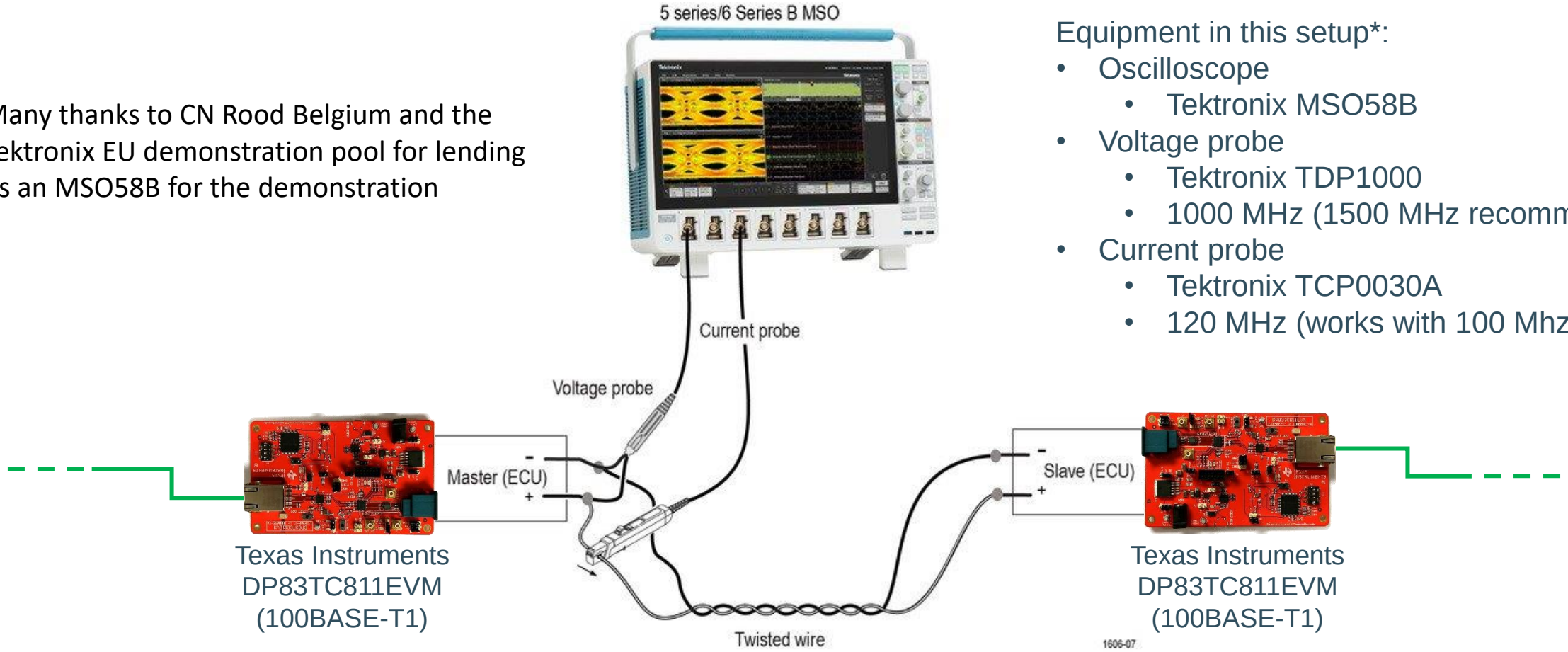
10BASE-T1L negotiation
Lowest frequency 315,5 kHz

Doesn't work with directional coupler (<< 5 MHz)



Signals and Decoding
Measurement setup with Tektronix

Many thanks to CN Rood Belgium and the Tektronix EU demonstration pool for lending us an MSO58B for the demonstration

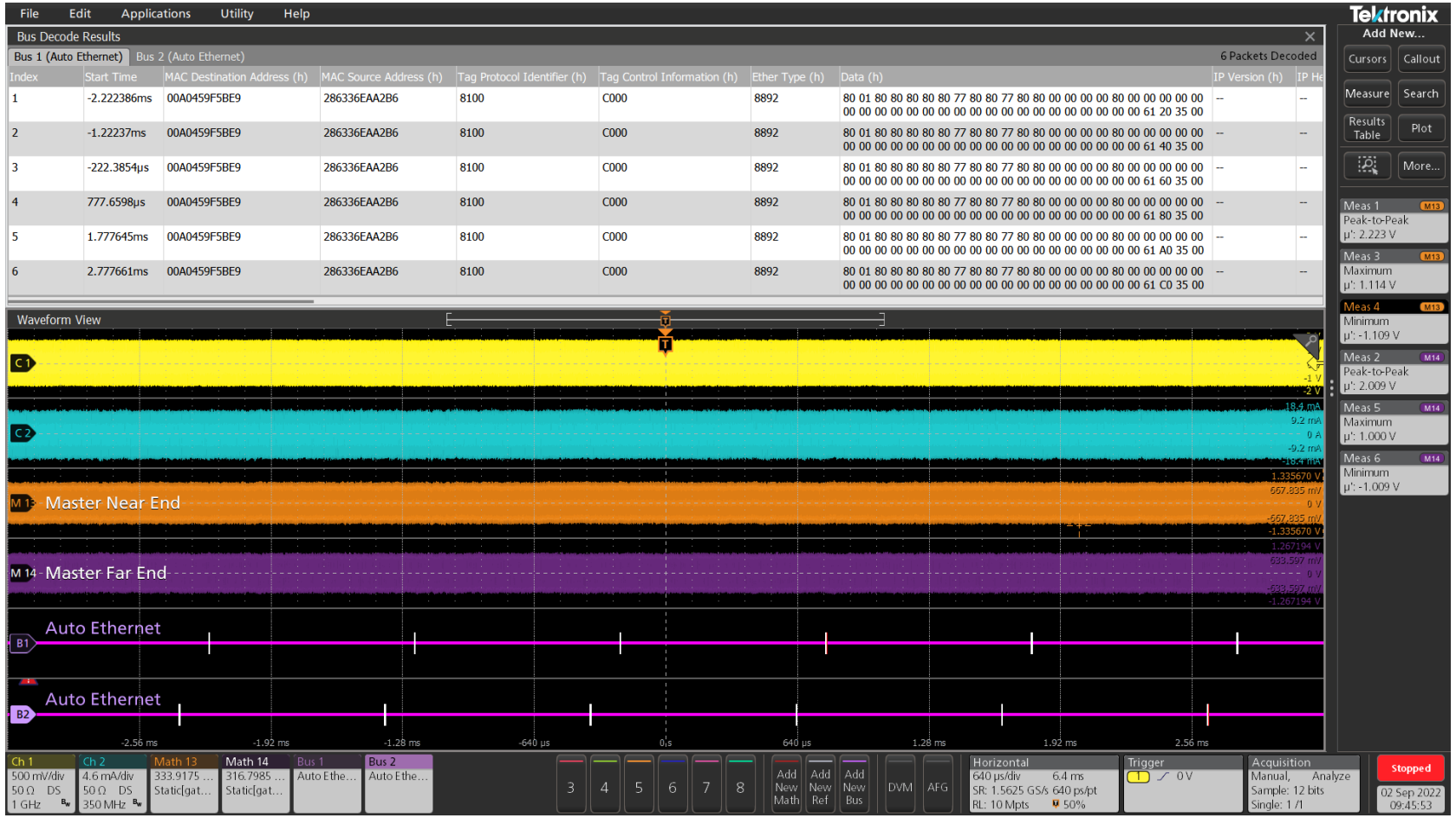


Equipment in this setup*:

- Oscilloscope
  - Tektronix MSO58B
- Voltage probe
  - Tektronix TDP1000
  - 1000 MHz (1500 MHz recommended)
- Current probe
  - Tektronix TCP0030A
  - 120 MHz (works with 100 Mhz)

*other compatible equipment available

Signals and Decoding
Measurement setup with Tektronix



File Edit Applications Utility Help

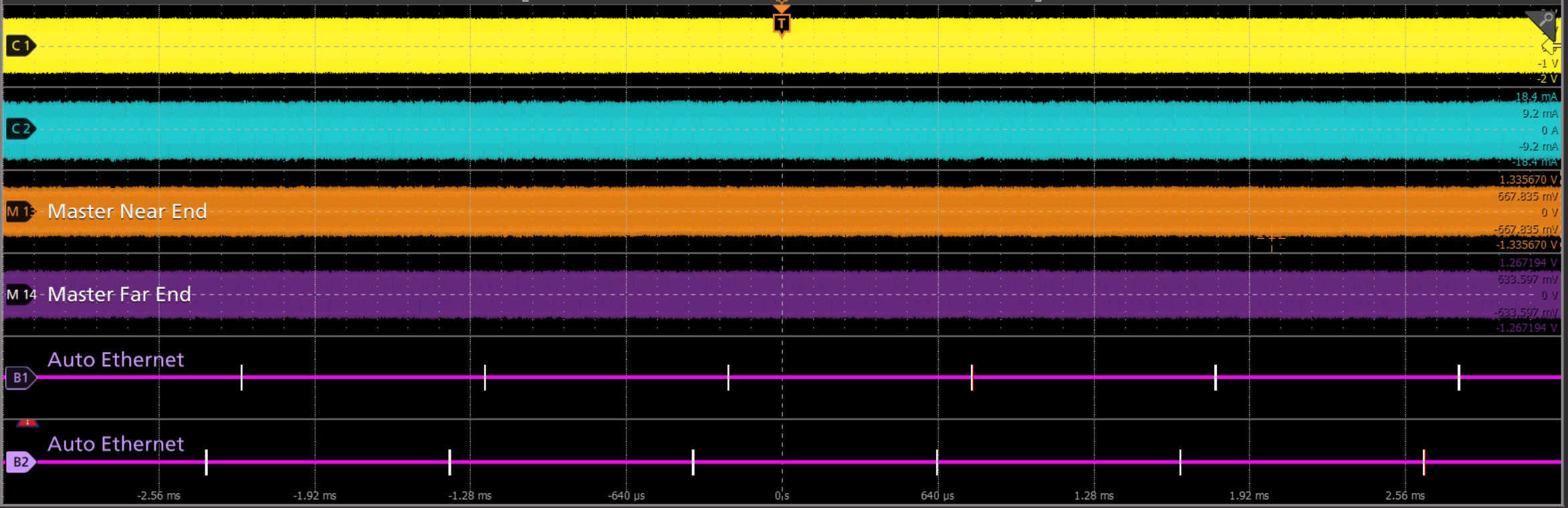
Tektronix

Bus Decode Results

Bus 1 (Auto Ethernet) | Bus 2 (Auto Ethernet) — 6 Packets Decoded

Index	Start Time	MAC Destination Address (h)	MAC Source Address (h)	Tag Protocol Identifier (h)	Tag Control Information (h)	Ether Type (h)	Data (h)	IP Version (h)	IP He
1	-2.222386ms	00A0459F5BE9	286336EAA2B6	8100	C000	8892	80 01 80 80 80 80 80 77 80 80 77 80 80 00 00 00 00 80 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 61 20 35 00	--	--
2	-1.22237ms	00A0459F5BE9	286336EAA2B6	8100	C000	8892	80 01 80 80 80 80 80 77 80 80 77 80 80 00 00 00 00 80 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 61 40 35 00	--	--
3	-222.3854µs	00A0459F5BE9	286336EAA2B6	8100	C000	8892	80 01 80 80 80 80 80 77 80 80 77 80 80 00 00 00 00 80 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 61 60 35 00	--	--
4	777.6598µs	00A0459F5BE9	286336EAA2B6	8100	C000	8892	80 01 80 80 80 80 80 77 80 80 77 80 80 00 00 00 00 80 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 61 80 35 00	--	--
5	1.777645ms	00A0459F5BE9	286336EAA2B6	8100	C000	8892	80 01 80 80 80 80 80 77 80 80 77 80 80 00 00 00 00 80 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 61 A0 35 00	--	--
6	2.777661ms	00A0459F5BE9	286336EAA2B6	8100	C000	8892	80 01 80 80 80 80 80 77 80 80 77 80 80 00 00 00 00 80 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 61 C0 35 00	--	--

Waveform View



Add New...

Cursors | Callout | Measure | Search | Results Table | Plot | More...

Meas 1 M13
Peak-to-Peak
µ': 2.223 V

Meas 3 M13
Maximum
µ': 1.114 V

Meas 4 M13
Minimum
µ': -1.109 V

Meas 2 M14
Peak-to-Peak
µ': 2.009 V

Meas 5 M14
Maximum
µ': 1.000 V

Meas 6 M14
Minimum
µ': -1.009 V

Ch 1: 500 mV/div, 50 Ω DS, 1 GHz Bw
Ch 2: 4.6 mA/div, 50 Ω DS, 350 MHz Bw
Math 13: 333.9175 ..., Static[gat...
Math 14: 316.7985 ..., Static[gat...
Bus 1: Auto Ethe...
Bus 2: Auto Ethe...

3 4 5 6 7 8 | Add New Math | Add New Ref | Add New Bus | DVM | AFG

Horizontal: 640 µs/div, 6.4 ms; SR: 1.5625 GS/s, 640 ps/pt; RL: 10 Mpts, 50%

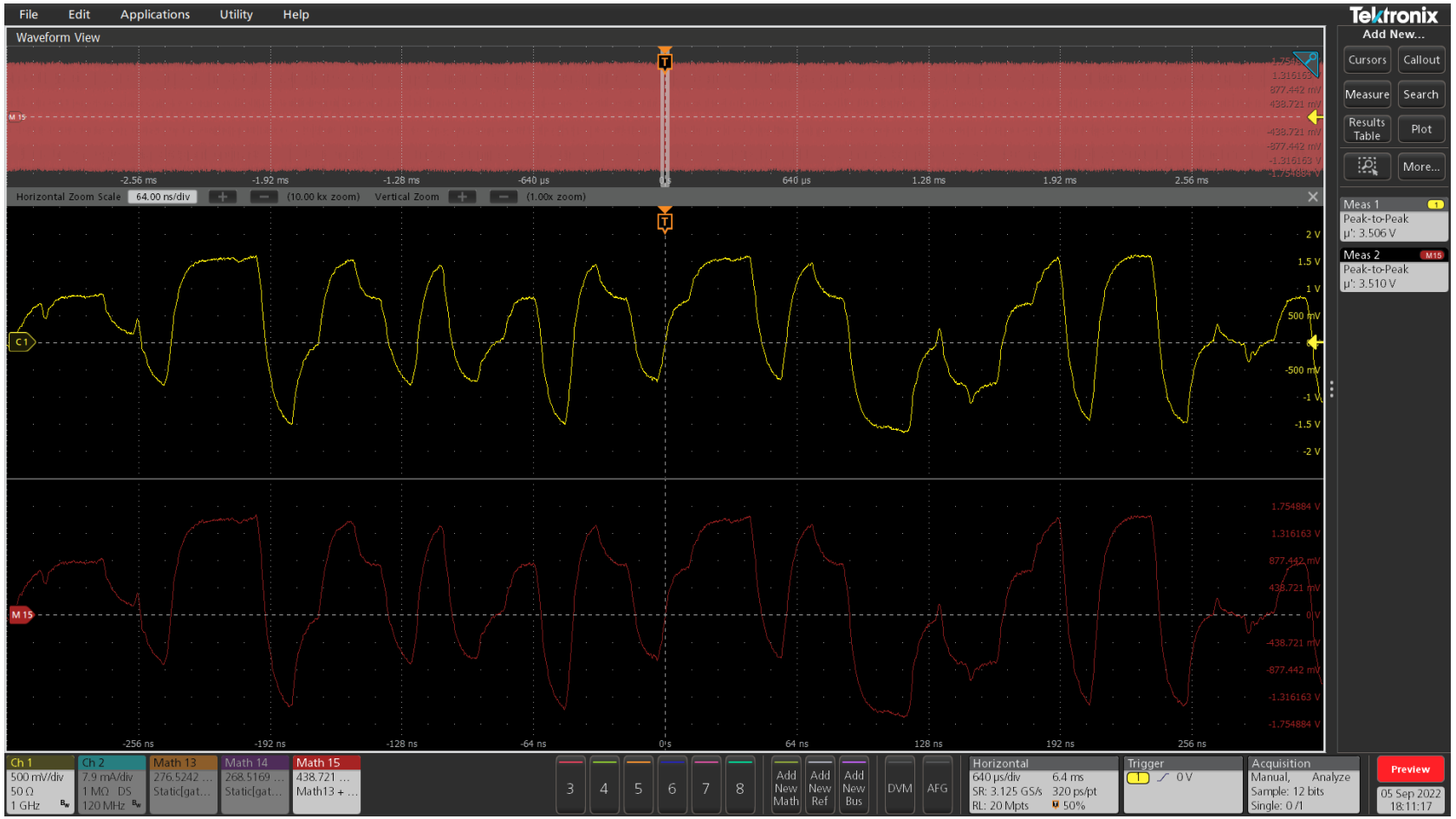
Trigger: 1, 0 V

Acquisition: Manual, Analyze; Sample: 12 bits; Single: 1 /1

Stopped

02 Sep 2022 09:45:53

Signals and Decoding
Measurement setup with Tektronix



Recombined signal ~100% Peak-to-Peak of the original

Questions?

Most recent version of the presentation