IEEE 802.3 RTPGE PHY Study Group

Passing Automotive EMC with IEEE Standard PHYs

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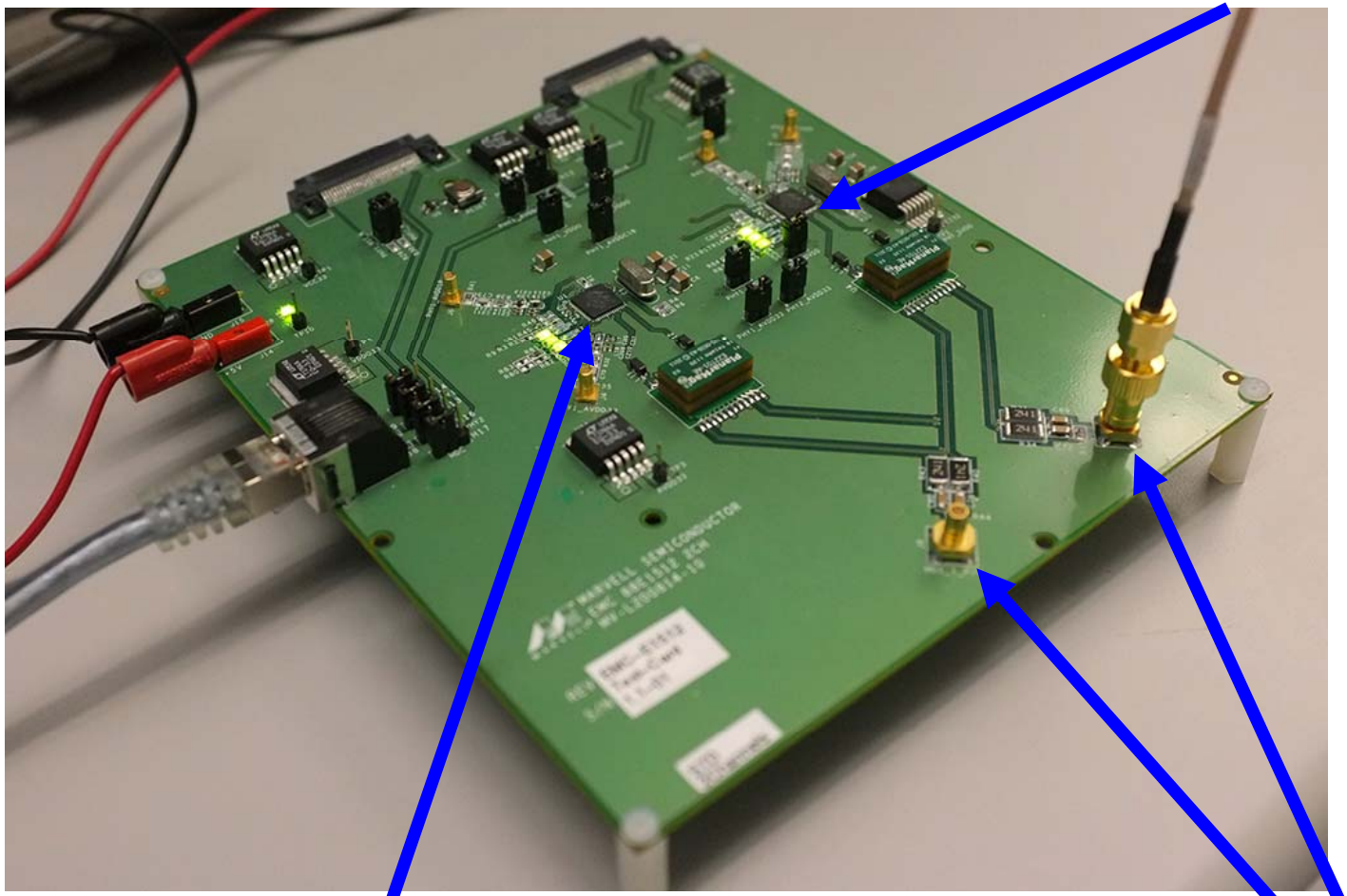
Don Pannell
Marvell Semiconductor

Introduction

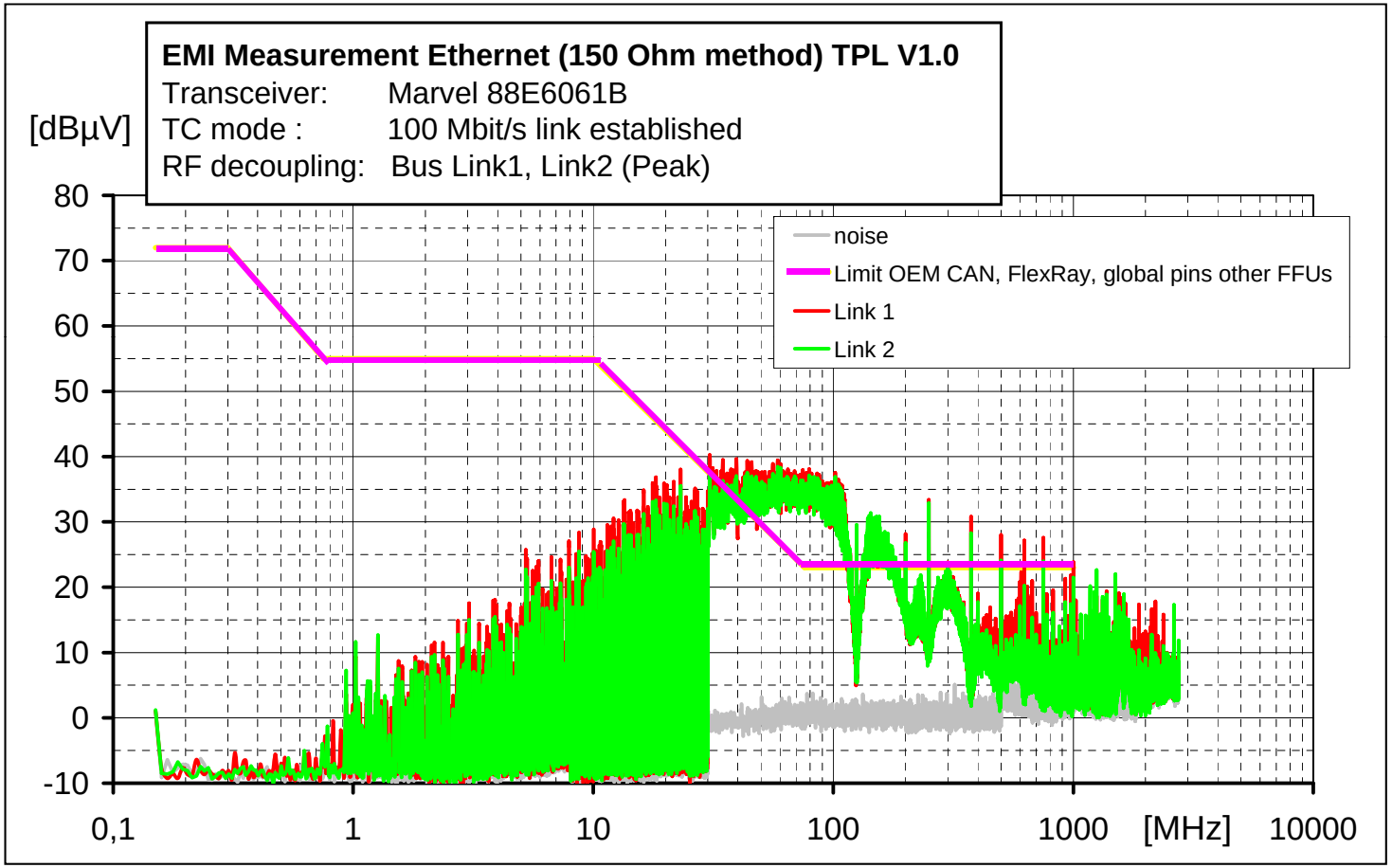
- As stated in the RTPGE Call for Interest (CFI) IEEE 802.3 100BASE-TX PHYs have been used in cars since 2008 – but they were limited to diagnostic systems because the PHYs could not pass the Automotive EMC requirements
- This is no longer true as IEEE 802.3 100BASE-TX PHYs can now pass
- I'd like to pass on what we learned as this may be helpful for the GE case
- Please refer to Michael Jones' presentation on the FTZ Tests & Setup as these were used here

Photo of the FTZ Test Board



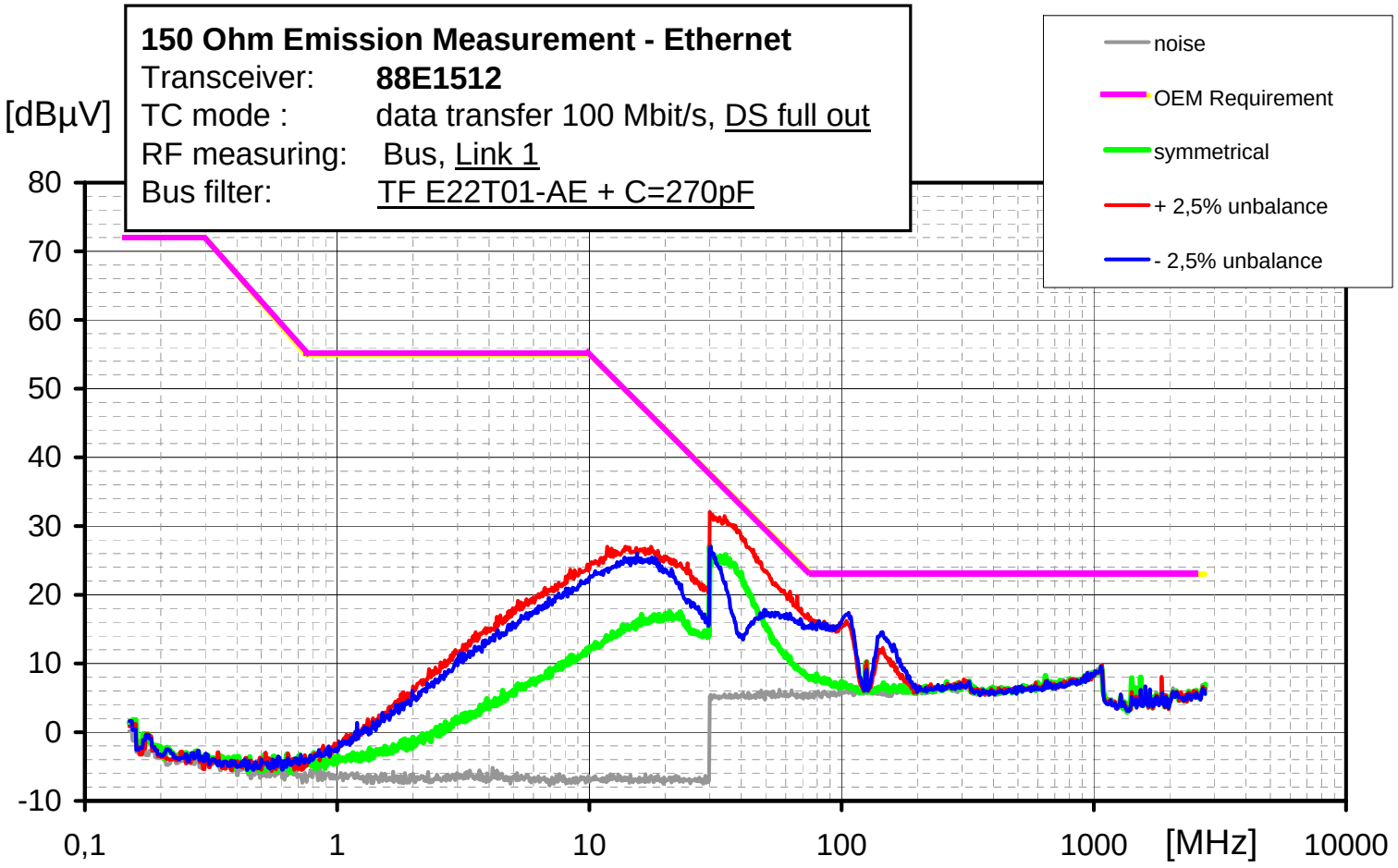
Note – All test results in this presentation have been performed by FTZ

Original Failing EMC Results from 2009



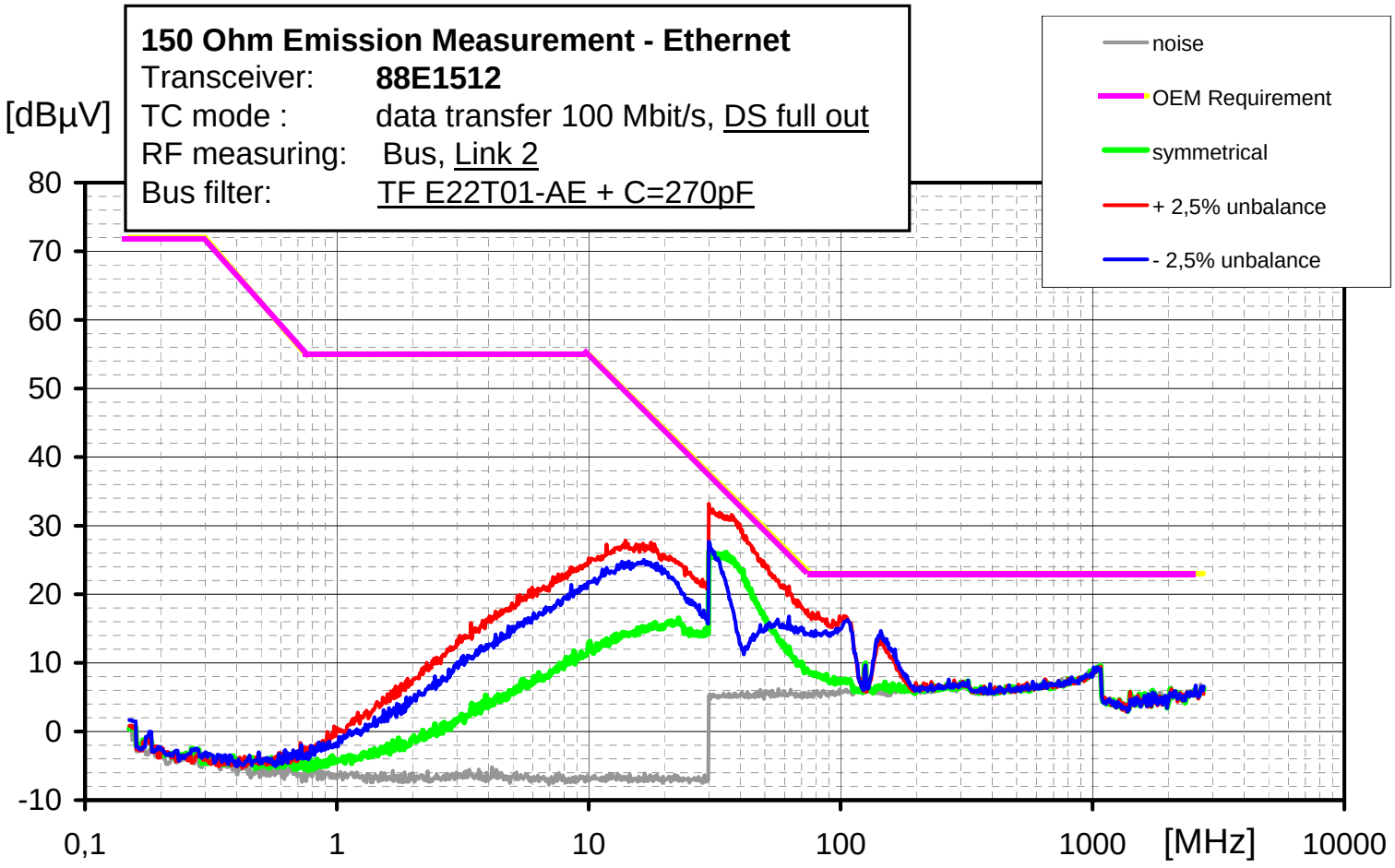
→ **This and other company's similar results is where the perception came from that IEEE Standards Based 100 Mbps PHYs cannot pass the low Automotive EMC limits**

Present Day Passing EMC Results – Link 1



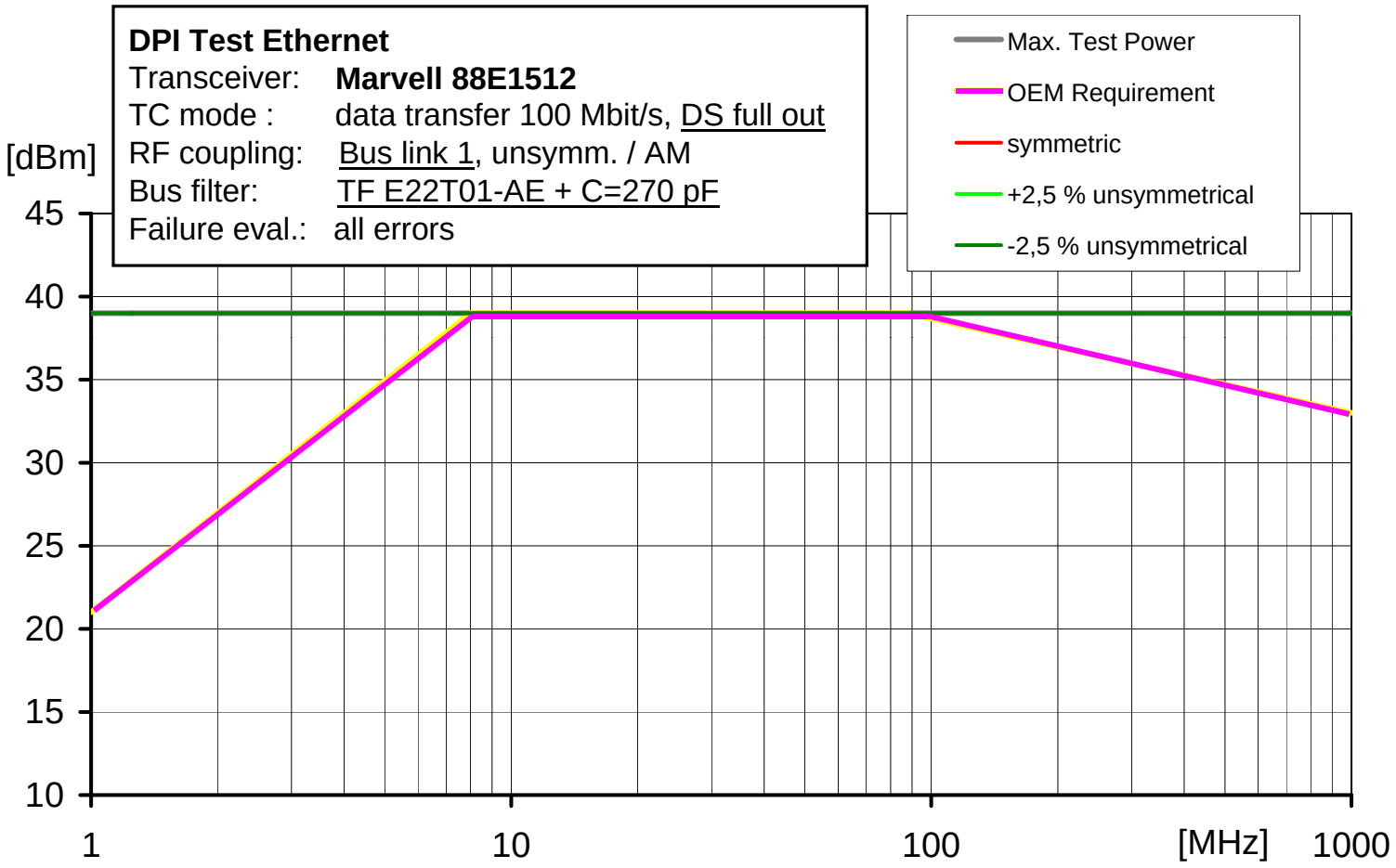
→ **IEEE Standards based 100 Mbps PHY**
→ **PHY 1's Tx is Link 1**

Present Day Passing EMC Results – Link 2



→ **IEEE Standards based 100 Mbps PHY**
→ **PHY 2's Tx is Link 2**

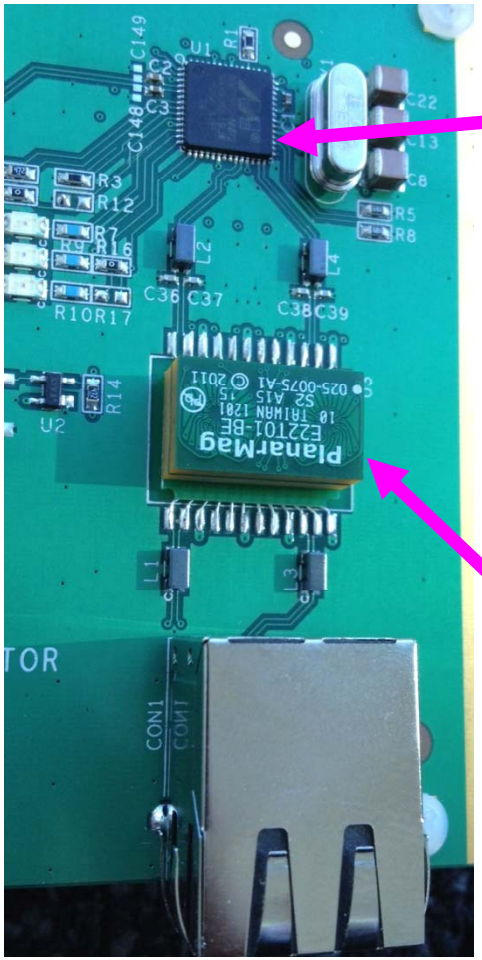
Immunity to RF Disturbances Passing Test



→ **Reducing the EMC is useless if the Receiver gets data errors under injected RF disturbances**

→ **Link 2 had identical zero error packets**

How This Was Achieved



- Improved PHY Design
  - EMC was lowered by using a Voltage mode PHY vs. a Current mode PHY design
  - Voltage mode reduces component induced noise
  - Originally done to lower our Standard PHY's power and EMC for other markets
- Improved PCB Design
  - EMC was lowered by using Planar magnetics and low pass filtering
  - Standard Ethernet Planar magnetics gives 100% yield as they are not hand wound – they are built from printed circuit boards, long term lower cost
  - Low pass filtering was done by adding a 120 pf to 270 pf cap on each Tx MDI line (2 caps total)
- ***Standard PHYs & Components***

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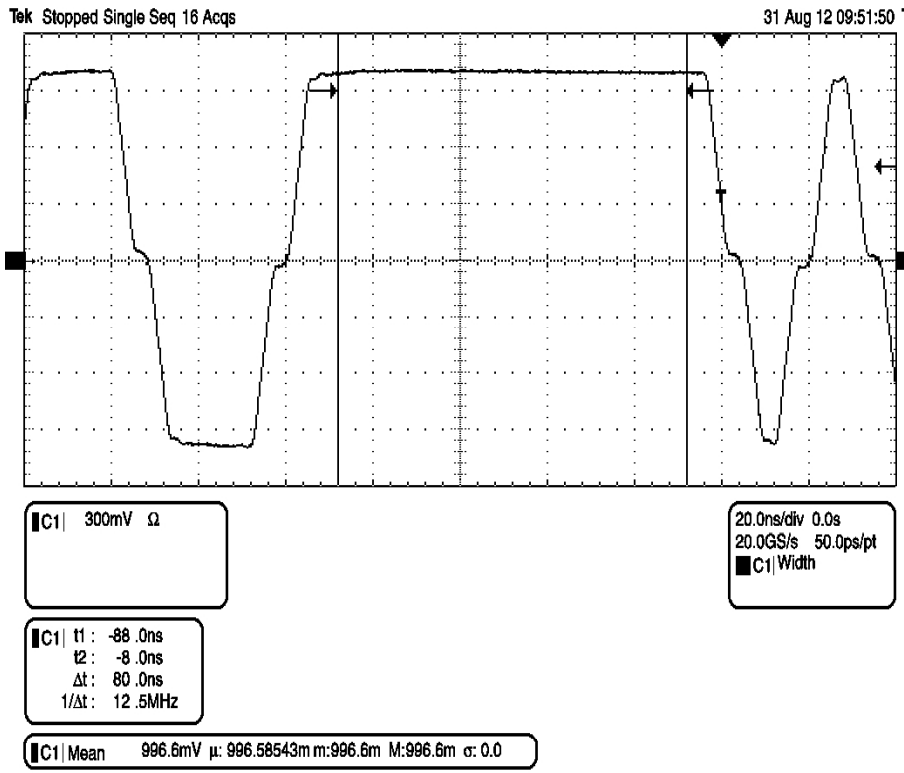
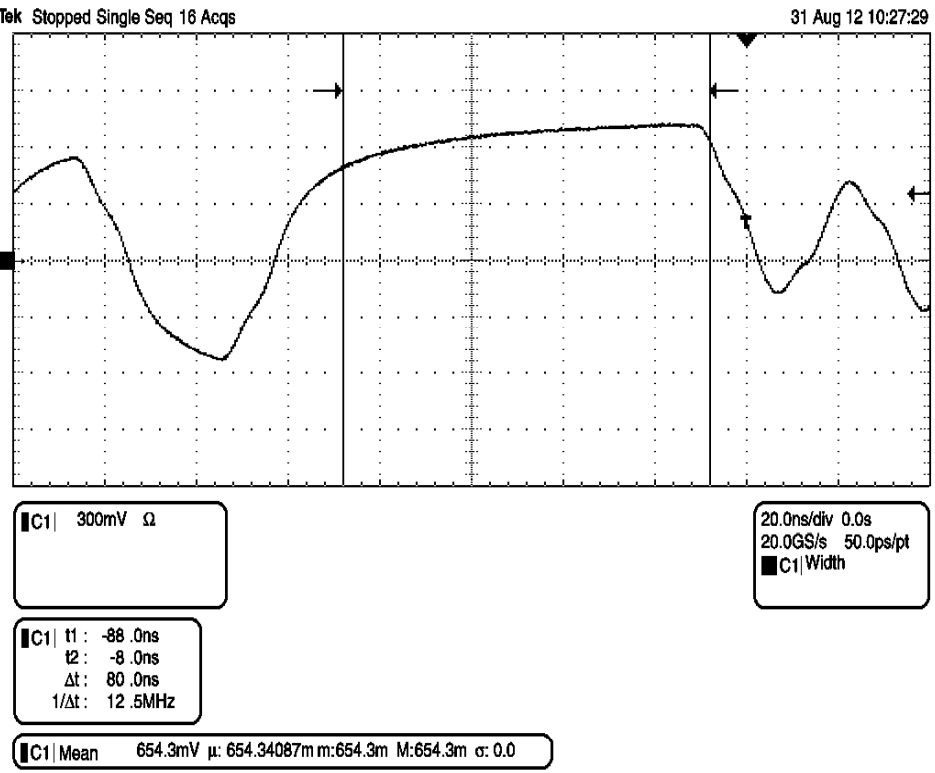
The Effects of the Low Pass Filter

Low Pass Filter Effects

- Doesn’t the addition of the Low Pass filter invalidate the IEEE 802.3 standards compliance?
  - It does for the IEEE 802.3’s intended environment of 100 meters of CAT5e meeting FCC/TUV Class B EMI
  - But automotive applications have a more stringent EMC requirement and also have a shorter reach requirement so it doesn’t have to use and doesn’t want to use the same transmit mask
  - Different applications/environments may need different transmit masks or other requirements
- It turns out the Low Pass filter approximates ‘n’ meters of cable – they both attenuate the signal

Waveform of an Unfiltered 100BASE-TX PHY



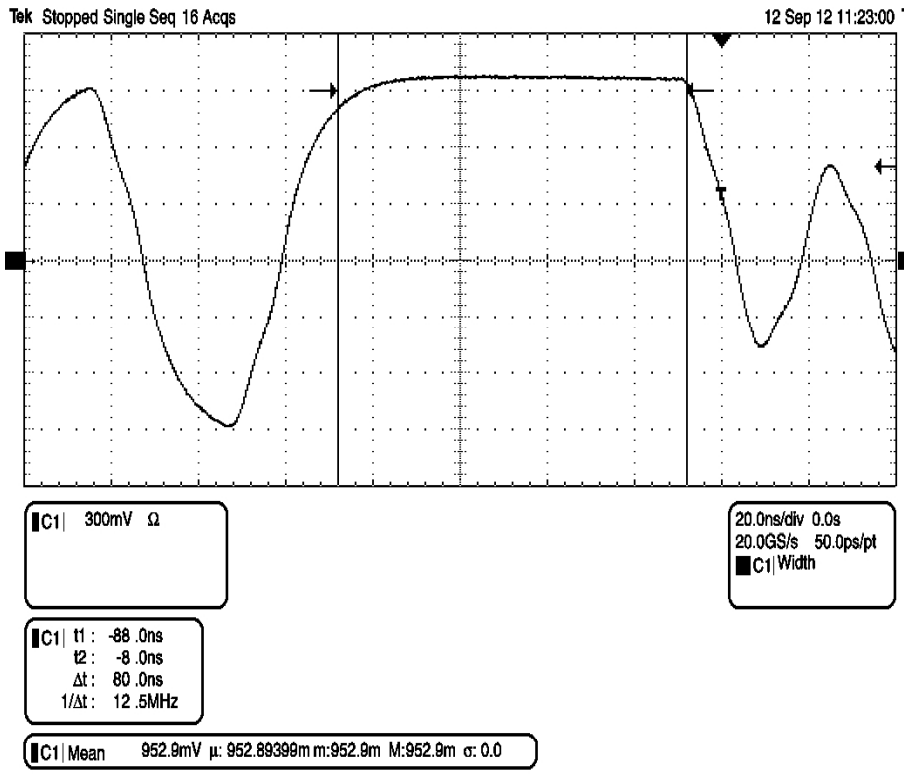


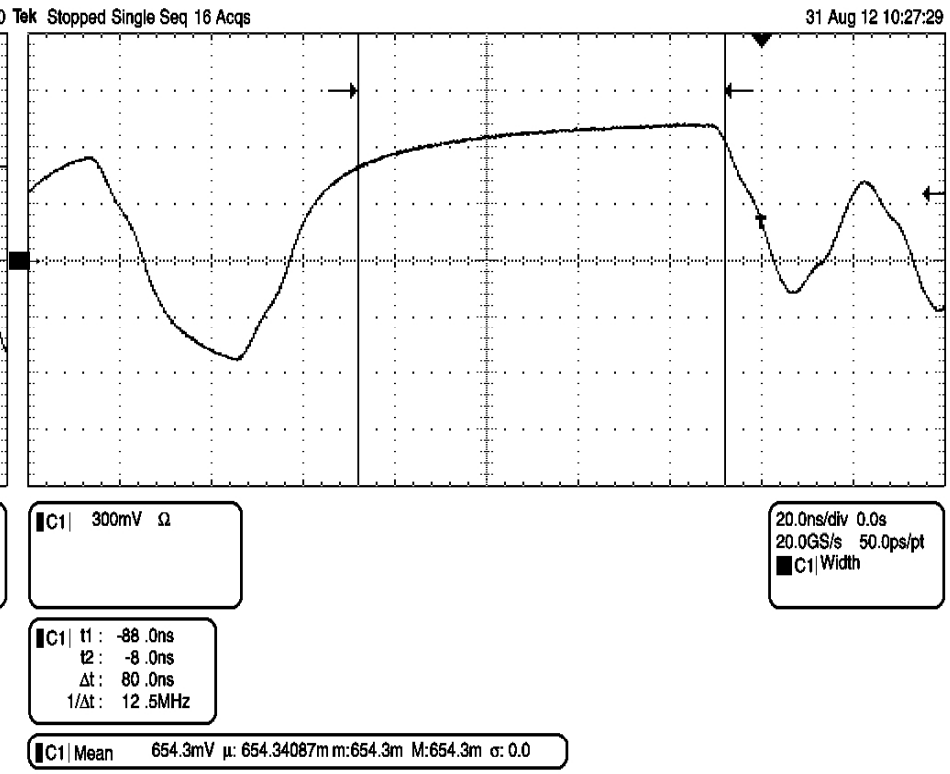
Transmit waveform for unfiltered PHY
At the Transmitter

Transmit waveform for unfiltered PHY
After 70 meters of CAT5e cable

The cable ‘filters’ the signal

Filtered w/270pf vs. Unfiltered at 70 meters



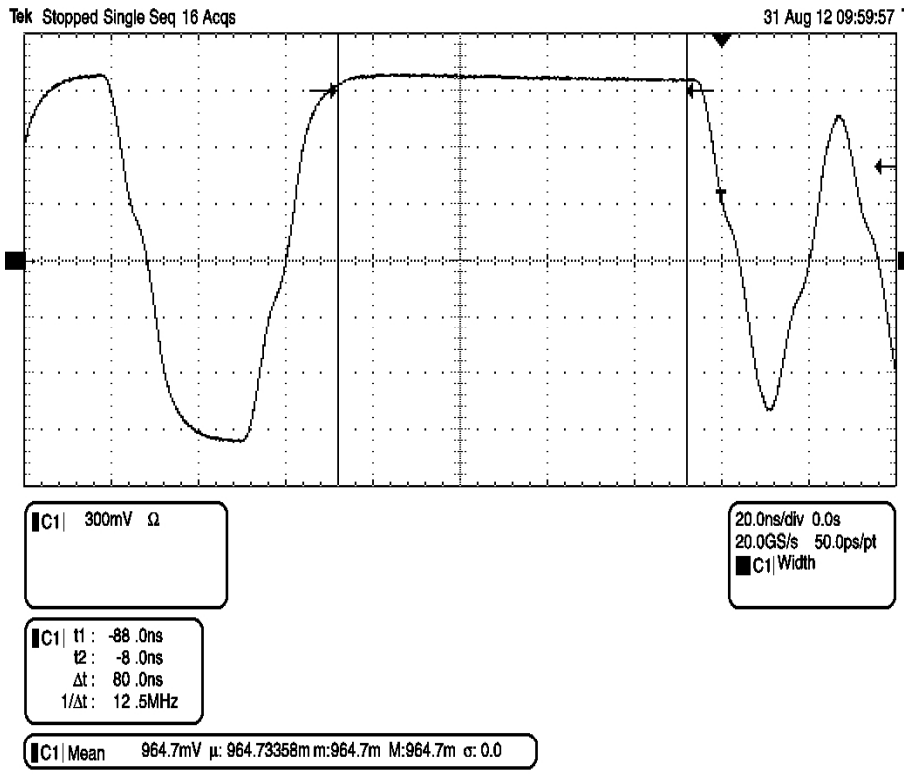


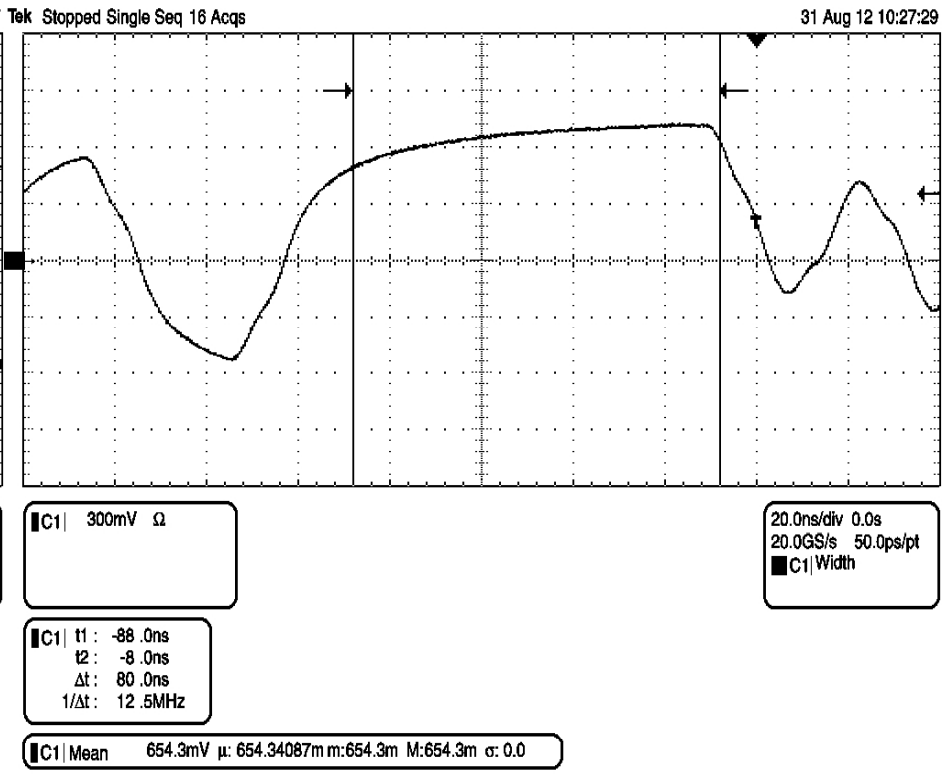
Transmit waveform for a filtered PHY
At the Transmitter – 270 pf caps

Transmit waveform for unfiltered PHY
After 70 meters of CAT5e cable

70 meters is worse than 270pf filtering

Filtered w/120pf vs. Unfiltered at 70 meters



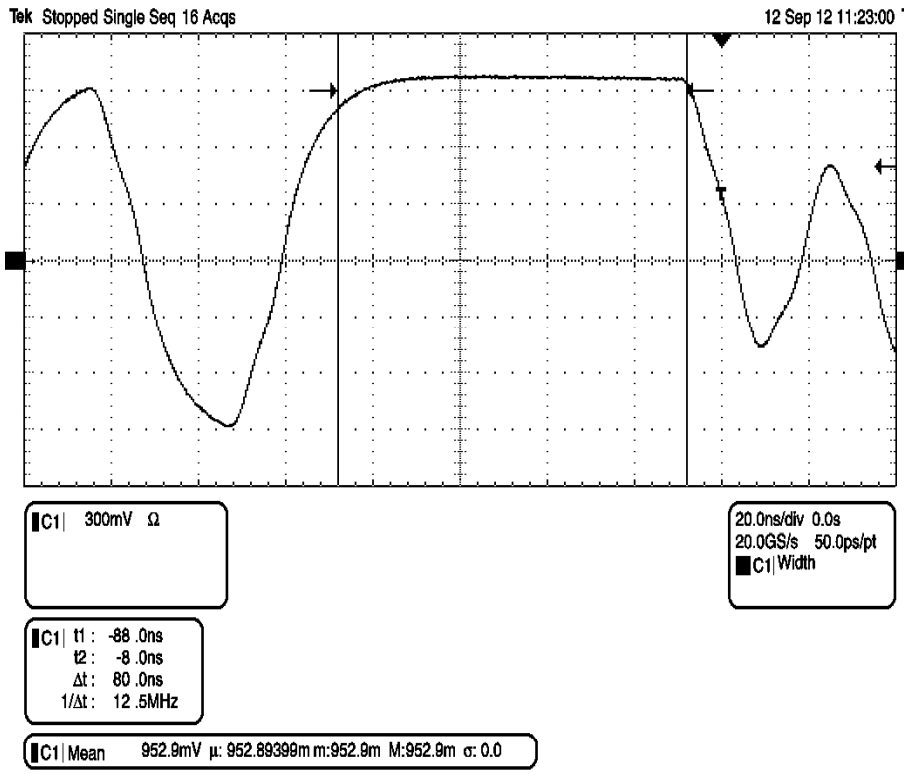


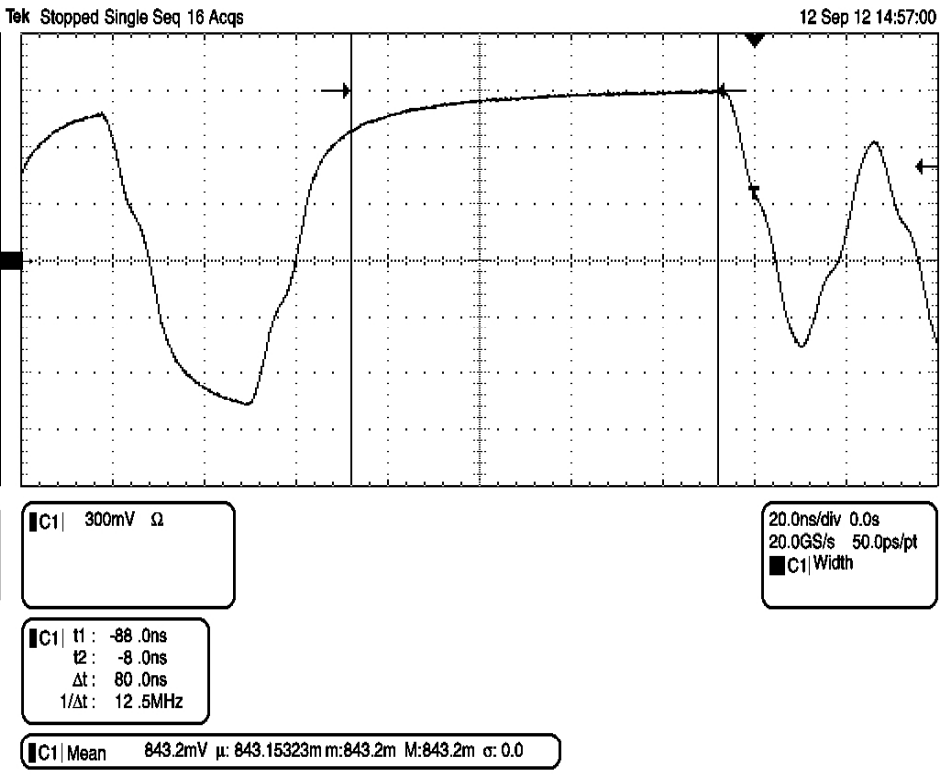
Transmit waveform for a filtered PHY
At the Transmitter – 120 pf caps

Transmit waveform for unfiltered PHY
After 70 meters of CAT5e cable

70 meters is worse than 120pf filtering

Filtered w/270pf vs. Unfiltered at 40 meters



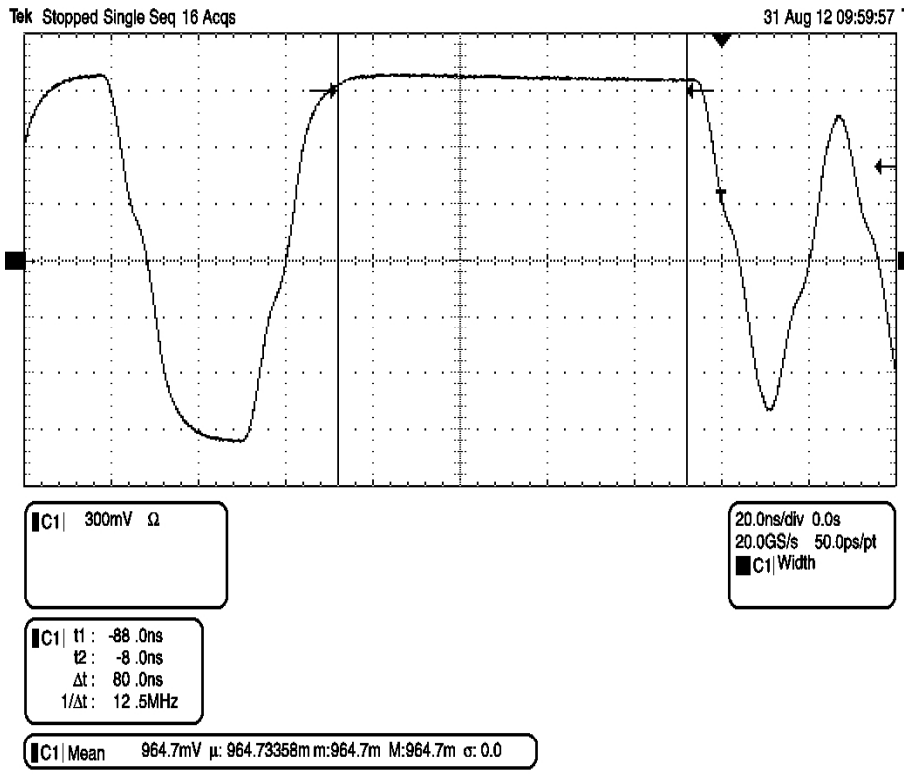


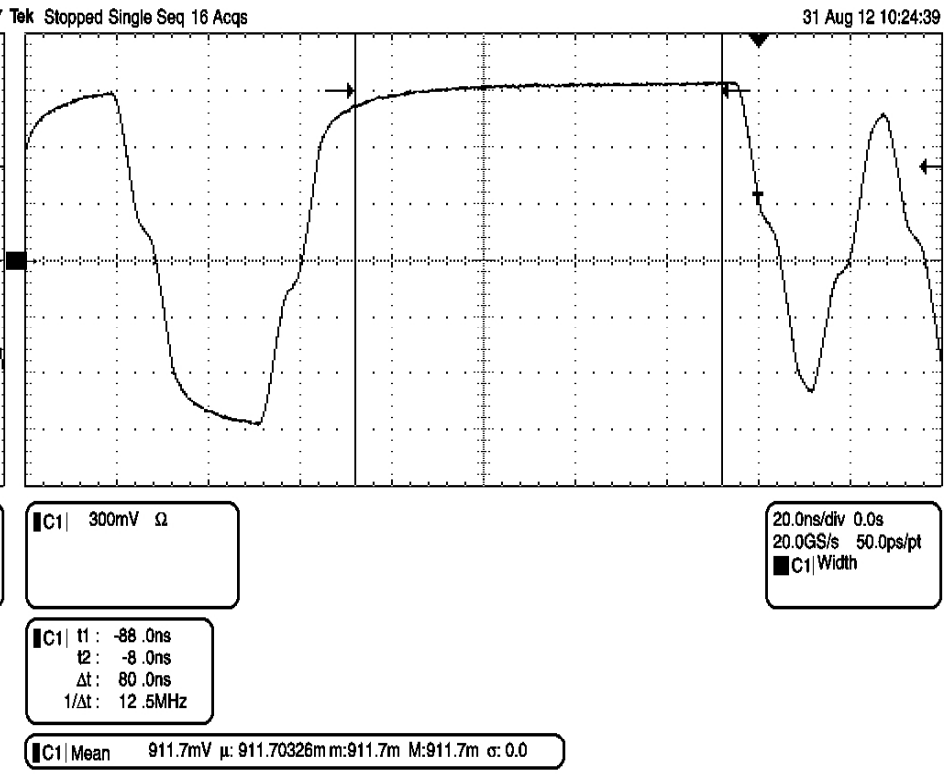
Transmit waveform for a filtered PHY
At the Transmitter – 270 pf caps

Transmit waveform for unfiltered PHY
After 40 meters of CAT5e cable

270 pf is ~= to 40 meters of cable

Filtered w/120pf vs. Unfiltered at 20 meters





Transmit waveform for a filtered PHY
At the Transmitter – 120 pf caps

Transmit waveform for unfiltered PHY
After 20 meters of CAT5e cable

120 pf is ~= to 20 meters of cable

Conclusion

- More than one company has passed the FTZ tests using similar filtering techniques and the two devices interoperated at 100 meters
- An IEEE 802.3 100BASE-TX PHY that was designed to pass FCC/TUV Class B and drive 100 meters of CAT5e cable can be filtered to pass the automotive EMC requirements and still drive 50+ meters and interoperate with other IEEE 802.3 100BASE-TX PHYs
- This may be very important information for this group

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Questions?

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