Forward Error Correction need in 10BASE-T1M

Wojciech Koczwara • Forward Error Correction need in 10BASE-T1M • 05/15/23

Rockwell Automation

Forward Error Correction need in 10BASE-T1M

In response to 802.3da objectives:

8. Support operation in the noise environments for building, industrial, and transportation applications

4. Support interoperability with Clause 147 multidrop

11. Support addition and removal of a node or set of nodes to a continuously operating powered mixing segment

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Forward Error Correction need in 10BASE-T1M

Prior art:

FEC for 802.3da (Gergely Huszak, George Zimmerman)

Drive noise measurements (David Brandt)

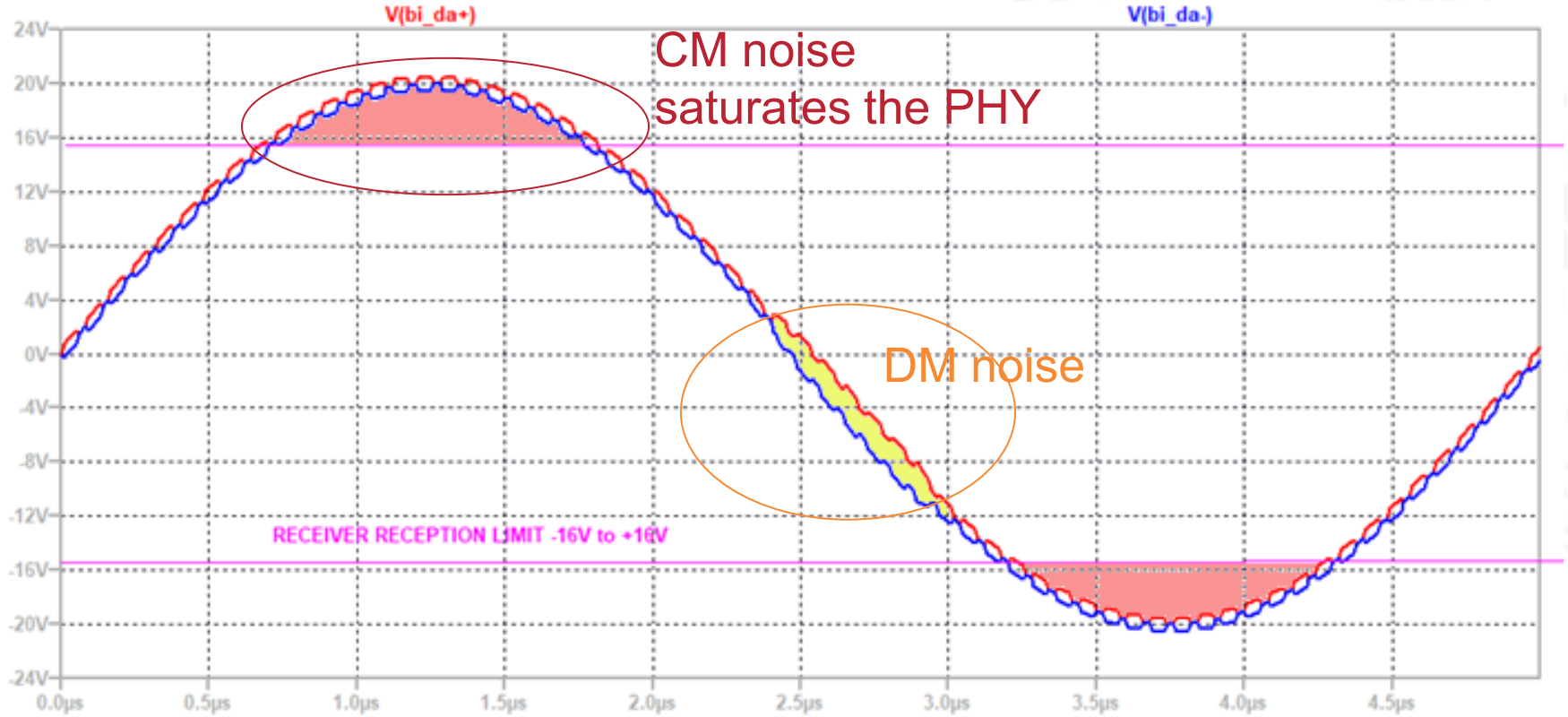
Agenda

1. Multidrop noise problems
2. Noise immunity vs power routing
3. EFT test noise
4. Real-world motor drive noise
5. Conclusion

Noise problems in multidrop

Due to required high impedance receivers, they are prone to both DM and CM noise

1. **Differential mode noise needs to stay well under 1Vpp to assure proper reception of 1Vpp signal**
2. **Common Mode noise on the link can saturate a high impedance receiver, causing data misinterpretation already at +/-16V**

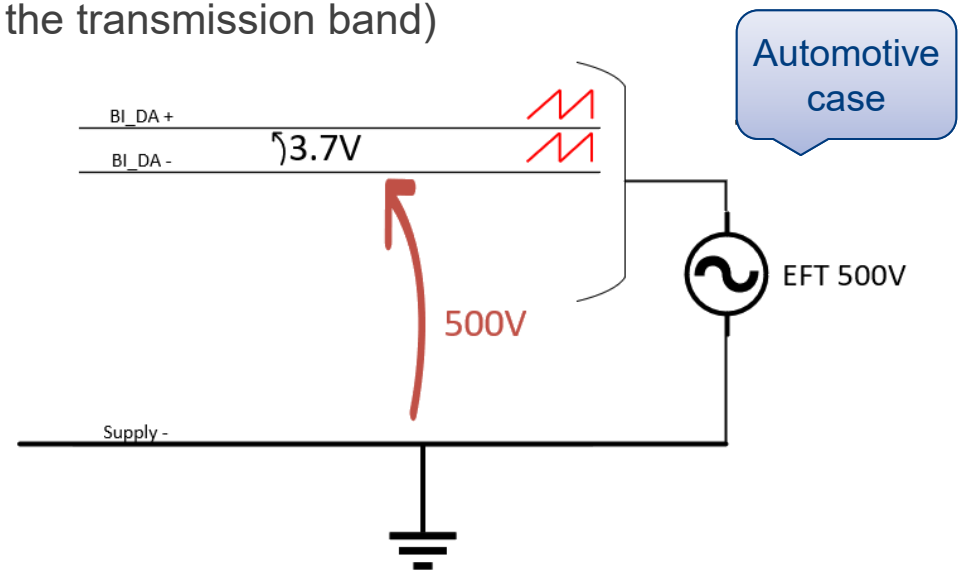


Common Mode noise immunity vs power routing

T1S PHY refers to its local GND pin. Two approaches can be followed:

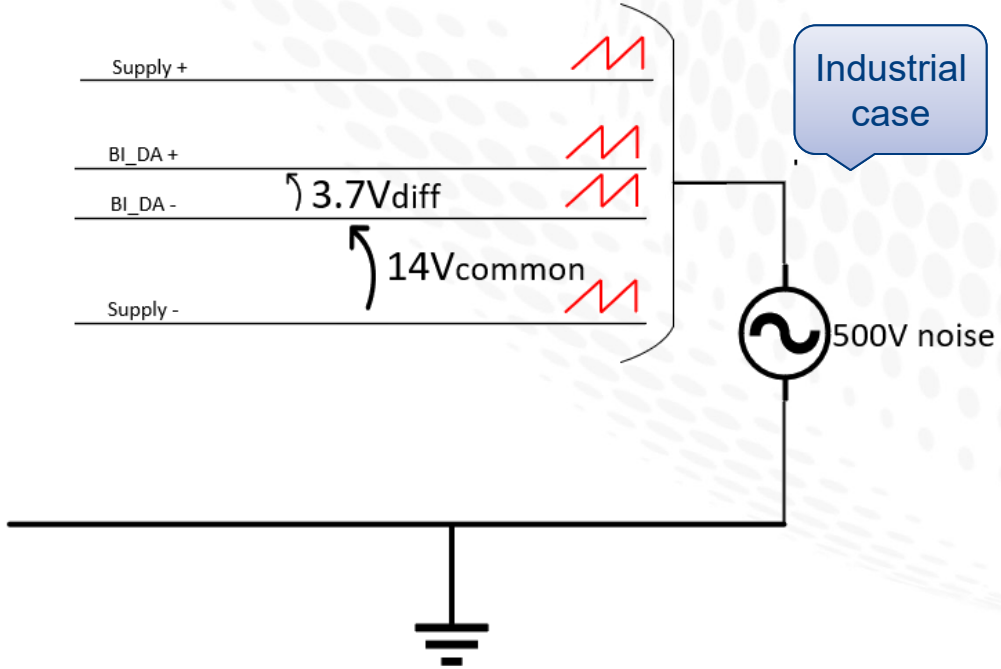
Single pair routing, separate power:

- the noise couples between PHY GND and SPE
- Large CM noise (e.g. 500Vpp), Common Mode Choke is likely required (caveat: resonance in the transmission band)



Composite routing with power (including PoDL):

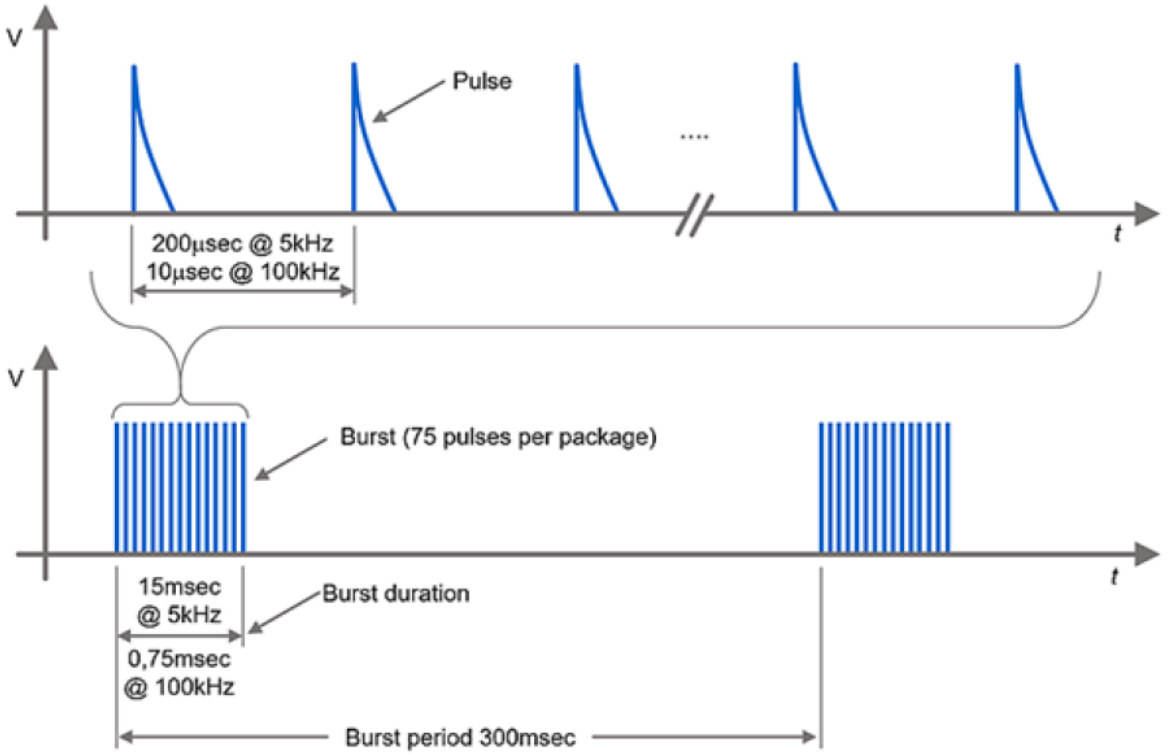
- the noise couples to both PHY GND and SPE
- the PHY sees only the difference in coupling between GND and SPE

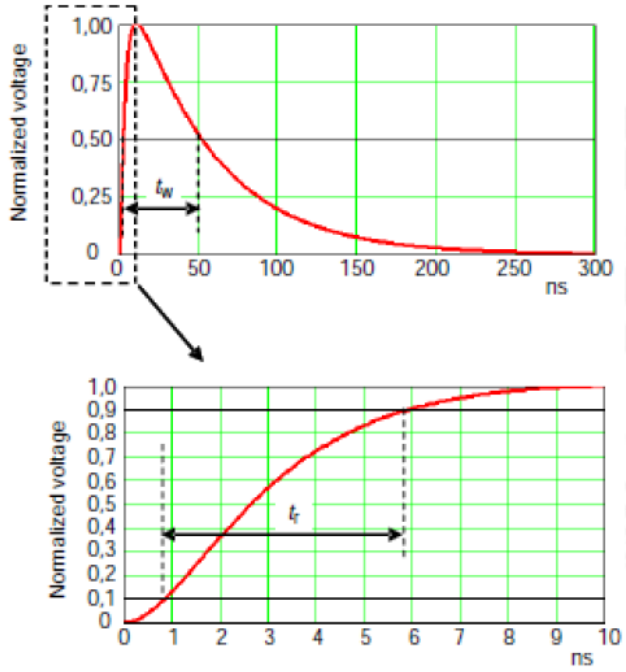


EFT (IEC61000-4-4) test

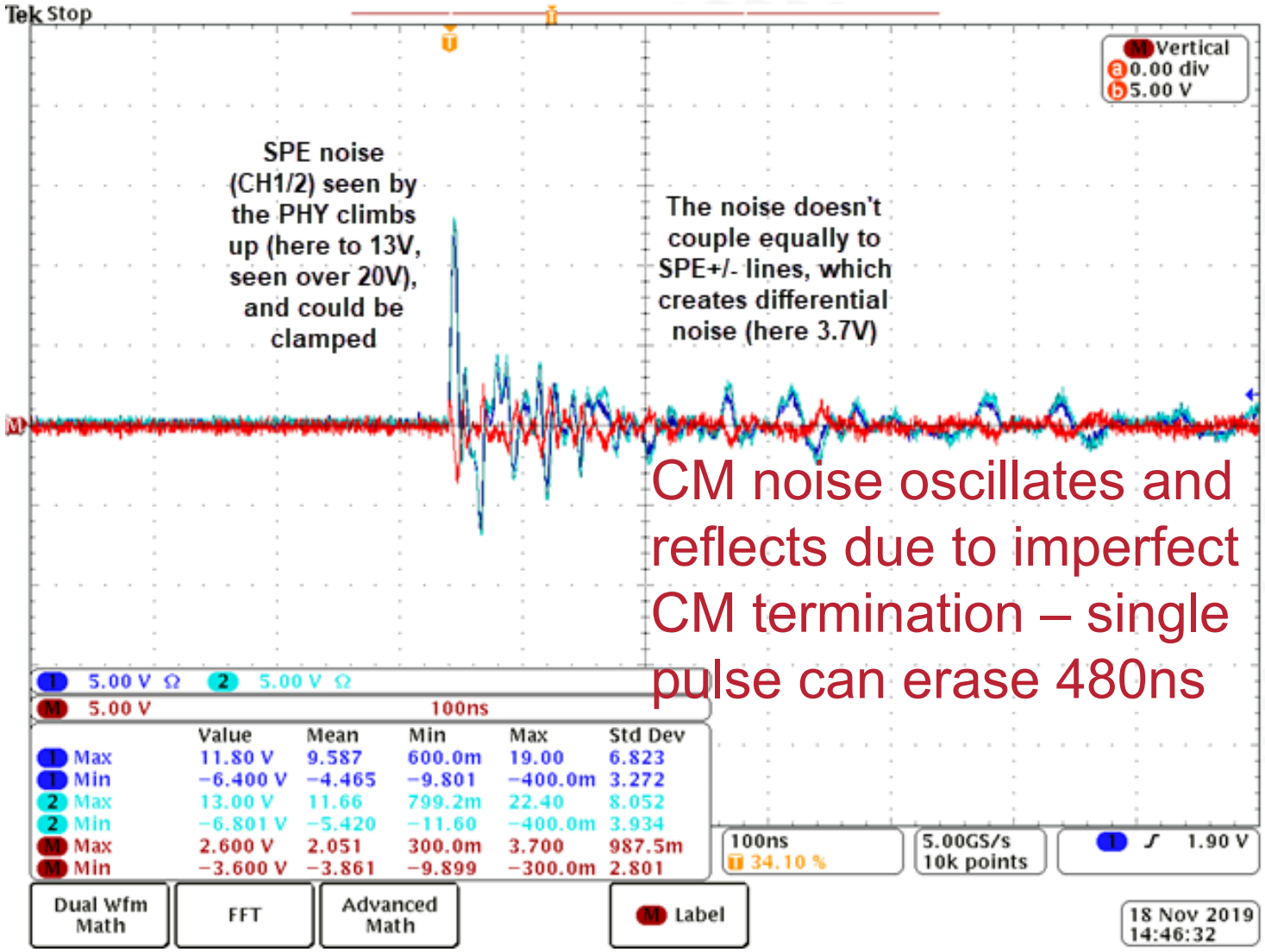
Electrical Fast Transients (burst transients) are common mode disturbances coming from an arc when mechanical contact is open due to a switching process.

Similar disturbances could be observed from motor drivers and other load switching signals, if their cables bundled together with SPE cables.



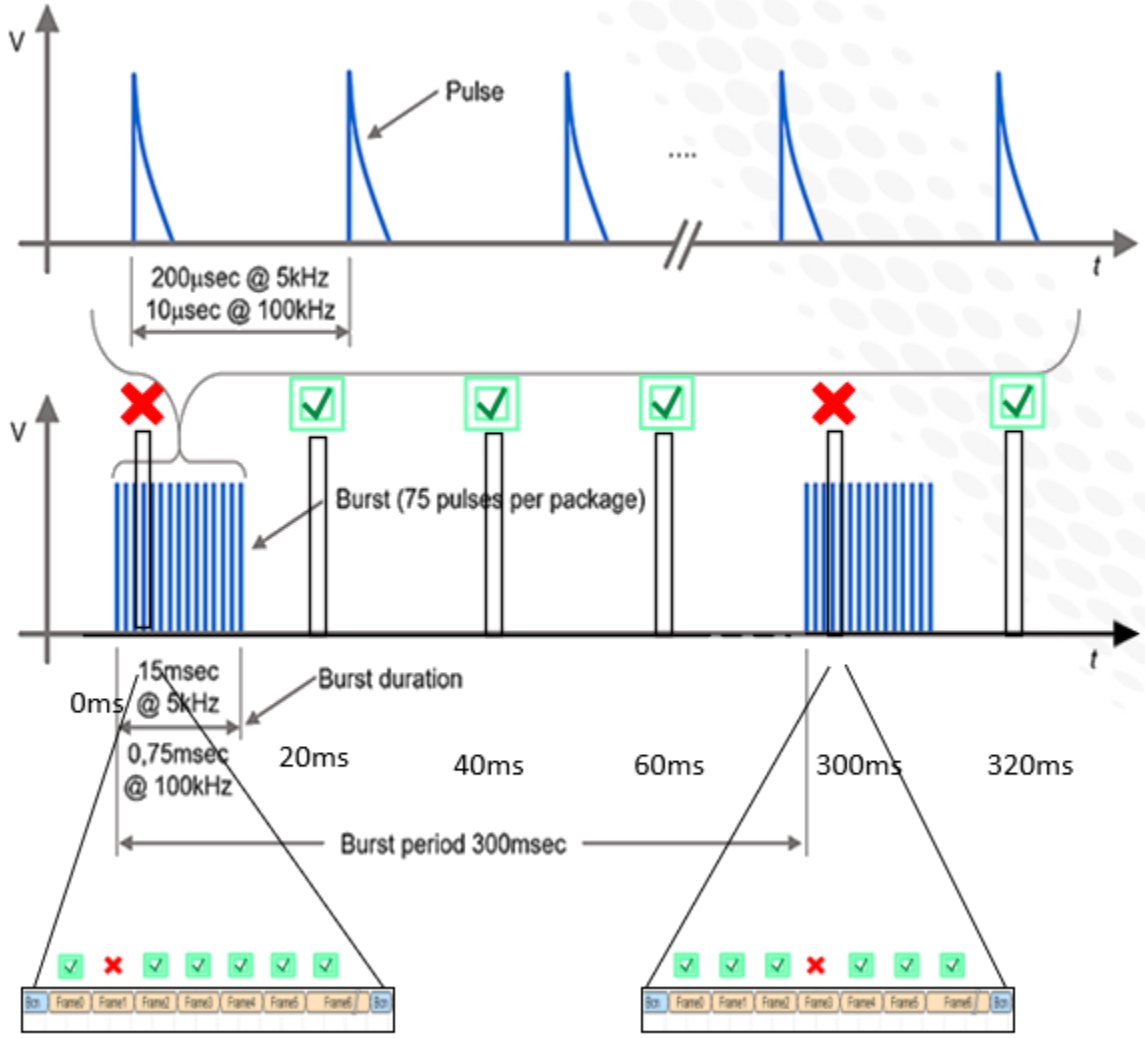


What happens during EFT testing



Mitigation by transmission protocol

Repeating the frames helps maintaining communication during EFT test

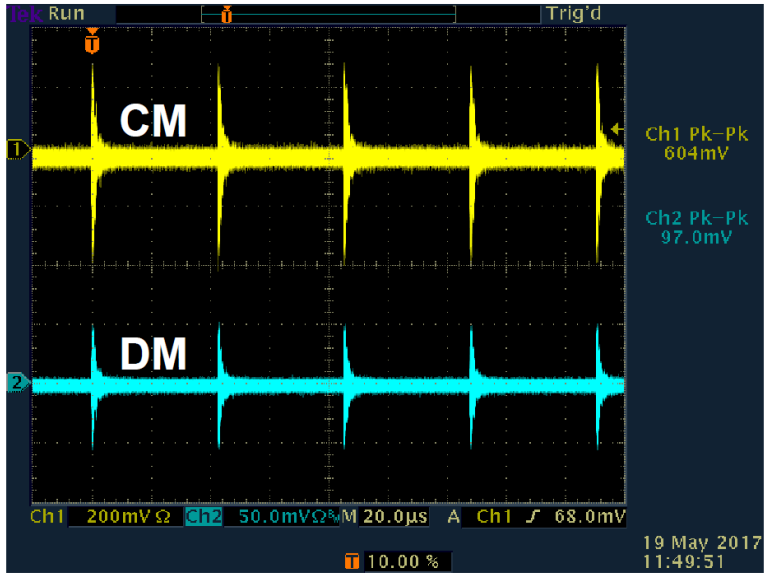


Real world motor drive cable in proximity

Shielded communication cable results, separate power routing

CM noise needs scaling x100-500 for unshielded communication with separate power routing

Setup: Adjacent cables, Isolated GNDs, 0 Hz
Measurements: Drive end

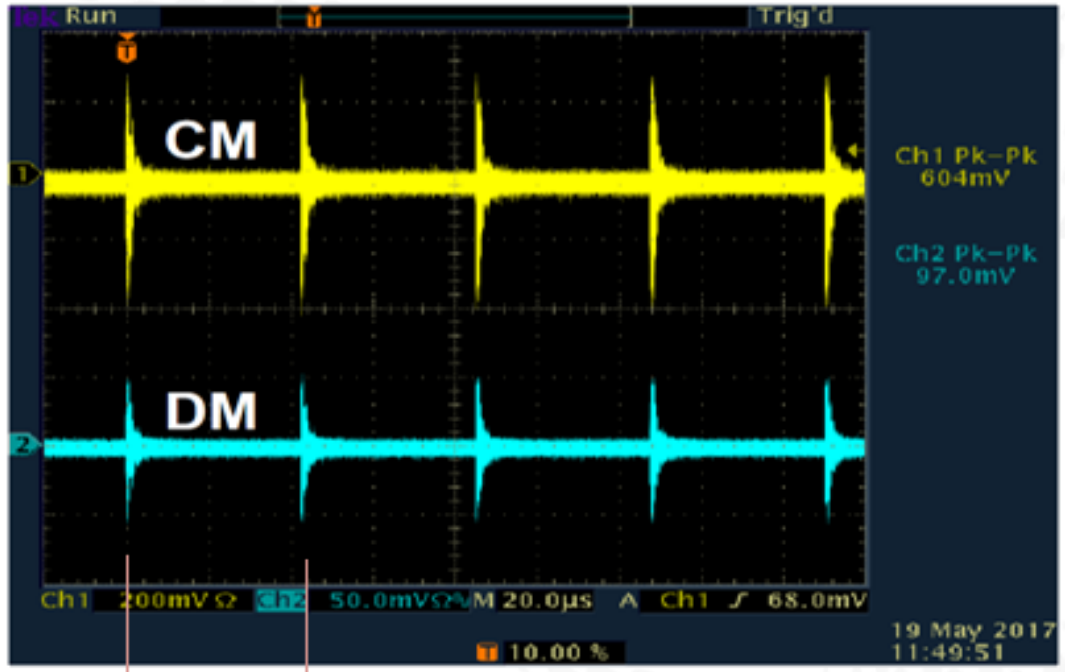


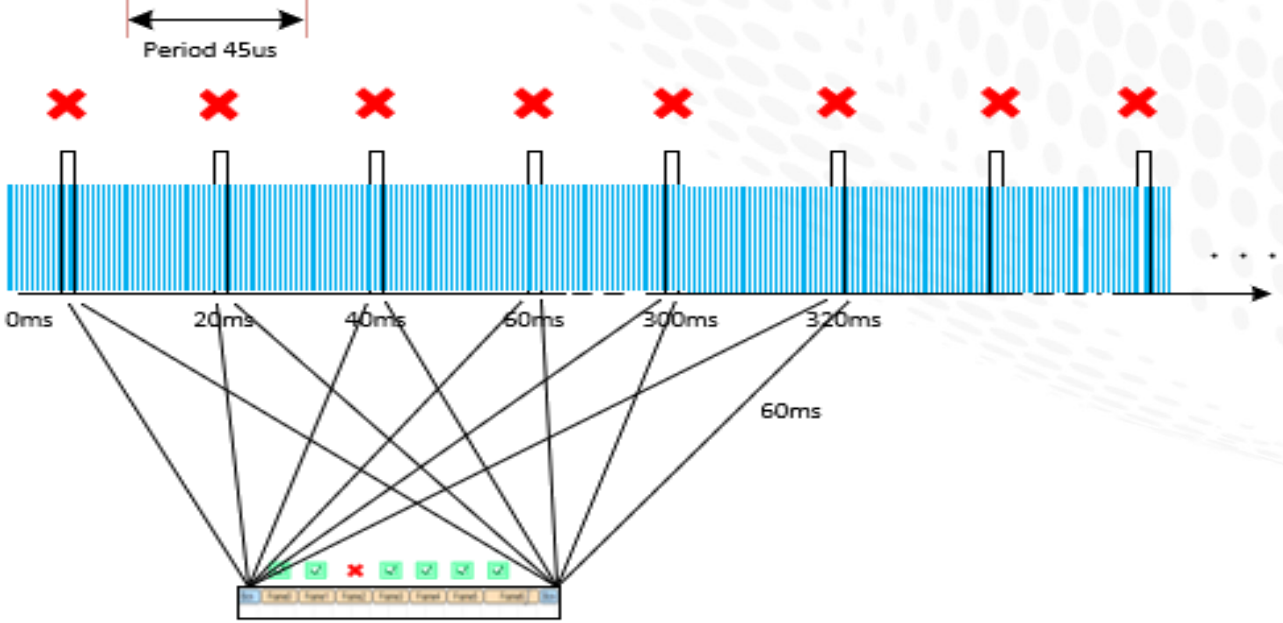
- ~6x voltage reduction
- ~24 kHz

Noise pulse occurs every 45us and causes both differential and common mode noise

Protocol mitigation?

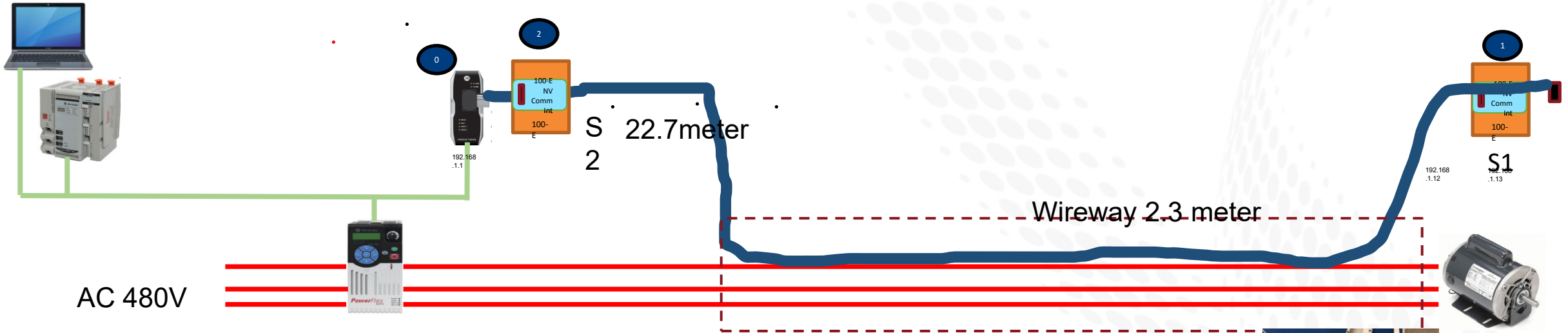
Not feasible





Protocol mitigation?

Not feasible even with **composite power routing**



(1)Ramp motor 0-60HZ

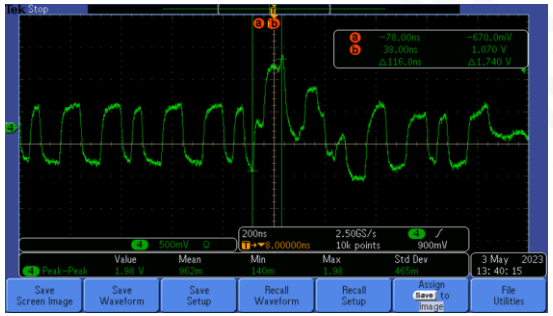
a. BER test, Node 1 sending packet, node 2 receiving packets. Fail

b. BER test, Node 2 sending packet, node 1 receiving packets. Fail

(2) Jogging the motor at zero speed

a. BER test, Node 1 sending packet, node 2 receiving packets. OK

b. BER test, Node 2 sending packet, node 1 receiving packets. Fail



Conclusion

Recommend to implement Forward Error Correction to allow operation in the noise environments. Without FEC, impulse noise immunity is hard to maintain

- The EFT test destroys communication but can be mitigated by frame repetition between pulse bursts

- **But the real world drive noise is repetitive and doesn’t allow for any standard Ethernet frame to pass undisturbed**

- Special care should be taken when power is delivered separately to the circuit

Thank you!
Questions?

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