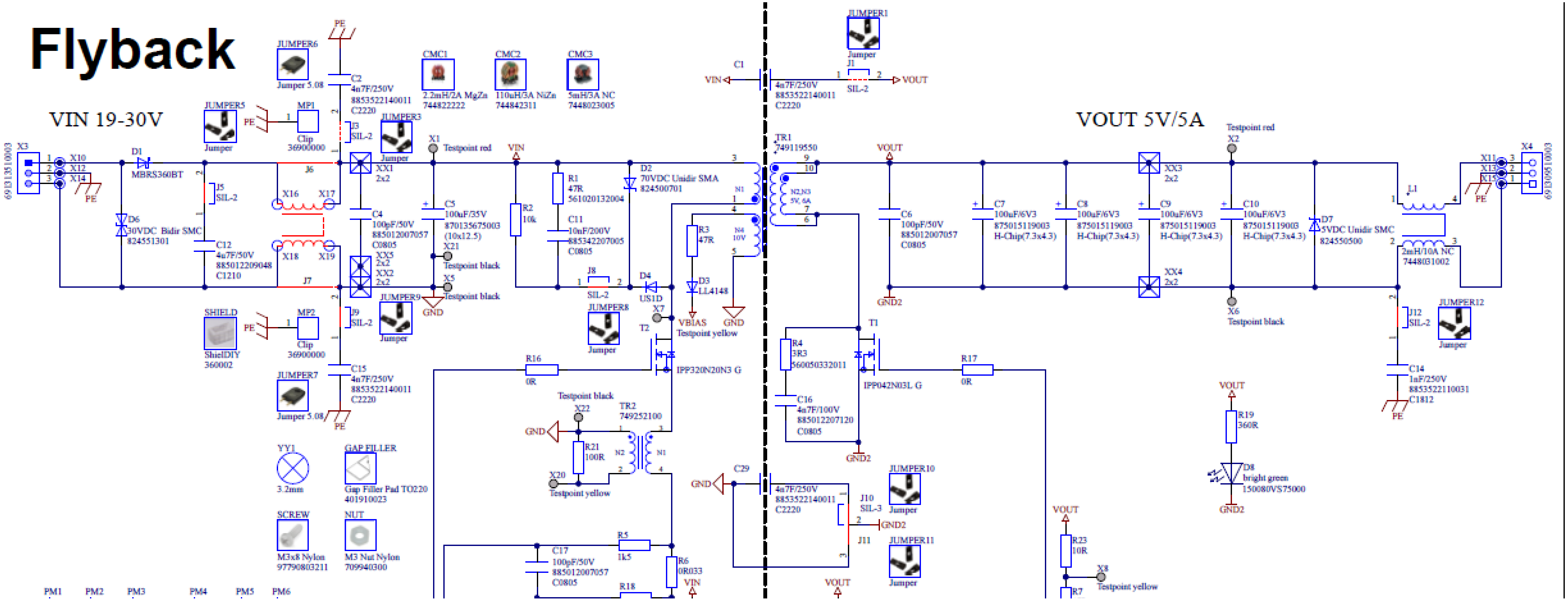
EFFICIENT EMI FILTERING OF COMMON AND DIFFERENTIAL MODE NOISE

Lorandt Fölkel M.Eng.
FAE & BDM at Würth Elektronik eiSos

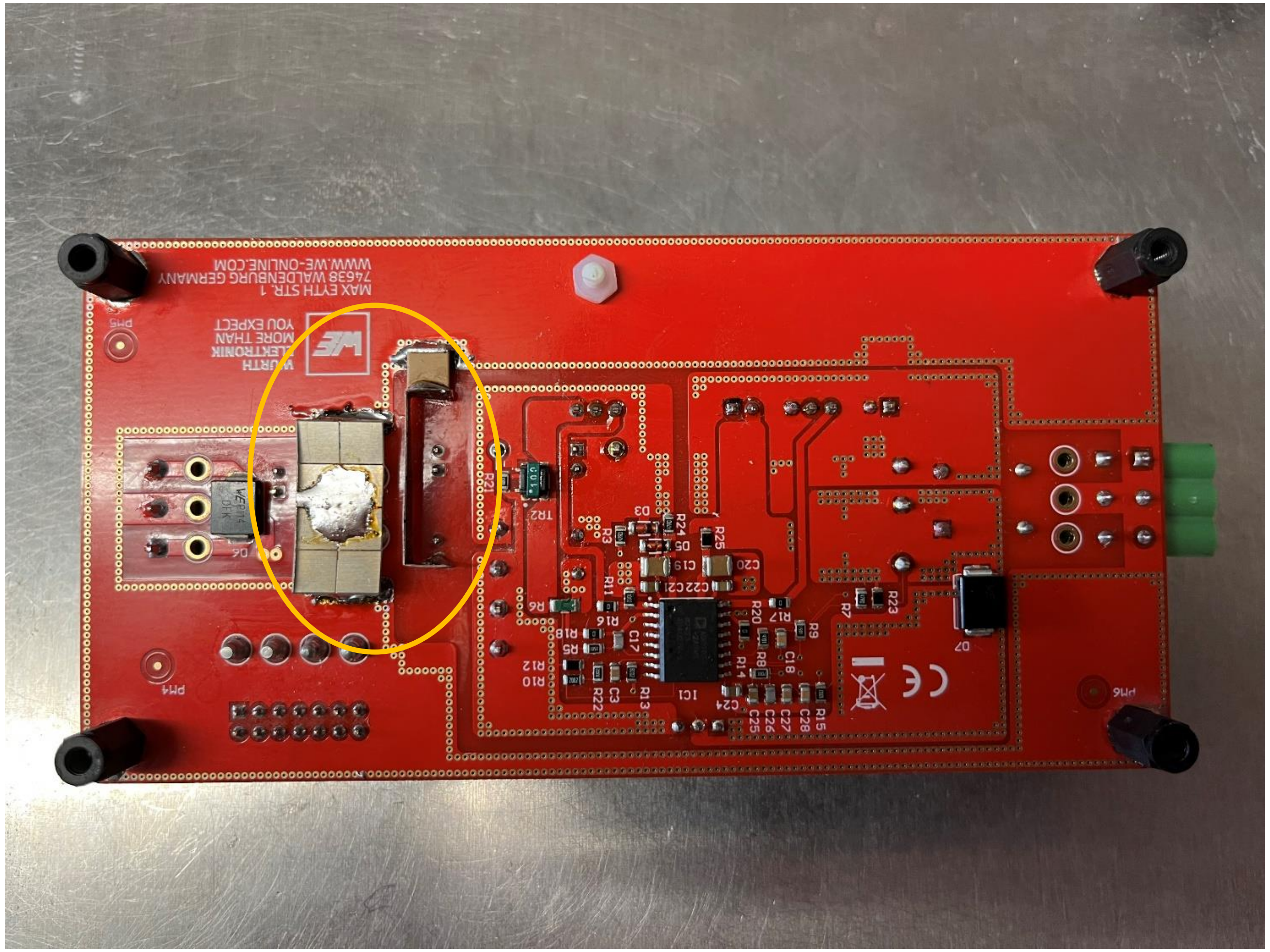
TODAY'S AGENDA

- Flyback DC/DC converter as noise source
- Design optimization
- Common mode and Differential mode filtering
- EMC Lab results

FLYBACK EMI - SCHEMATIC- V2022.1

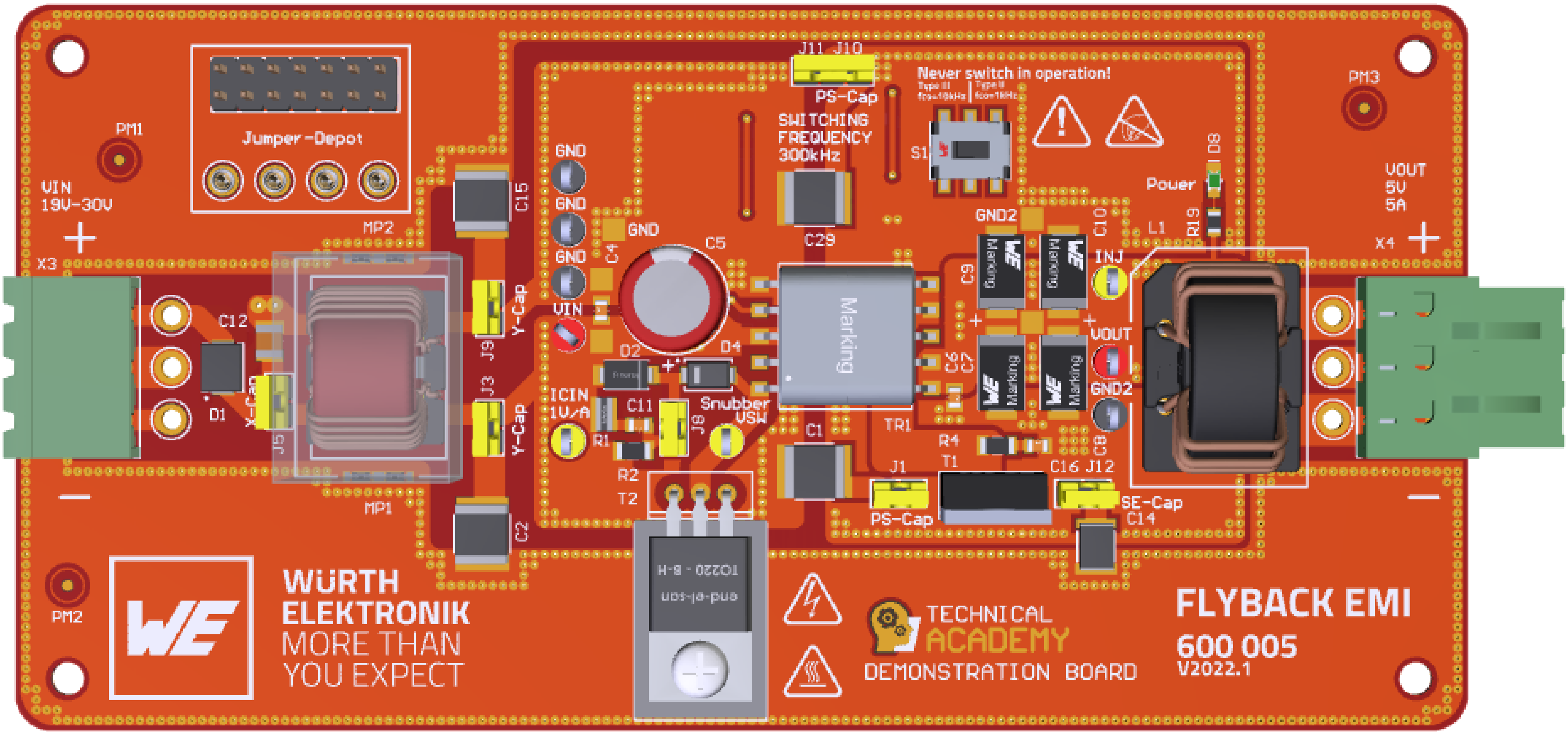


FLYBACK EMI - DEMONSTRATION BOARD - V2022.1 - MODIFICATION



FLYBACK EMI - DEMONSTRATION BOARD - V2022.1

Top



FLYBACK EMI - DEMONSTRATION BOARD - V2022.1

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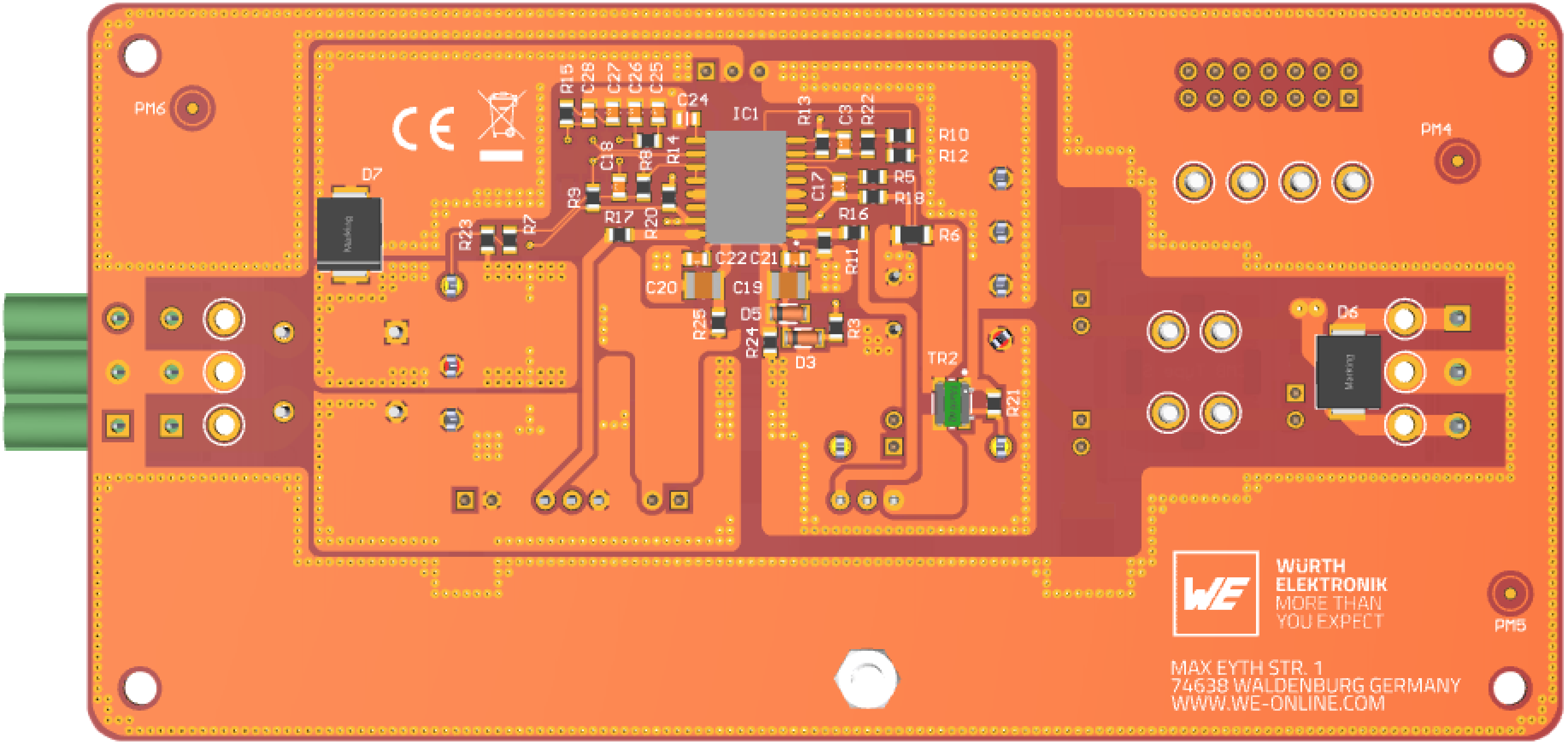
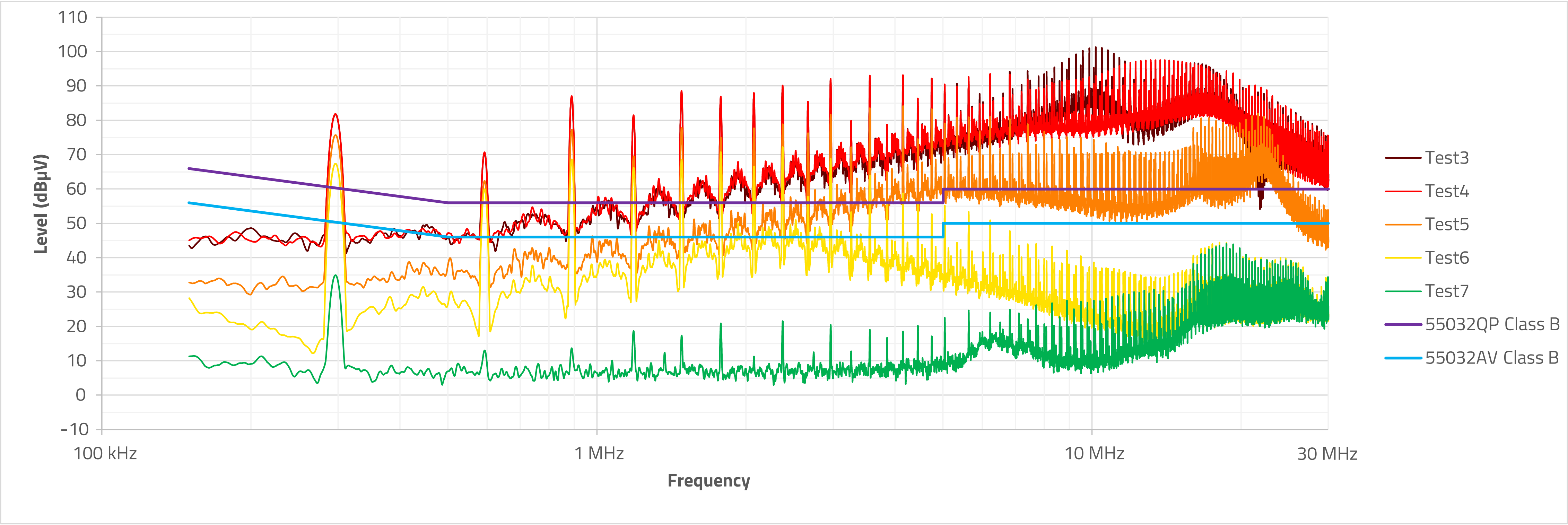
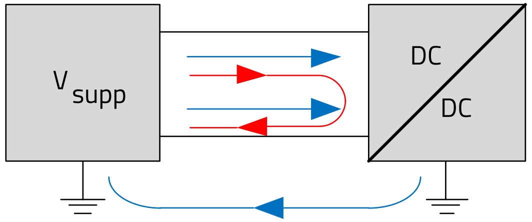


TEST#3-7: V2022.1 WITH MODIFICATION - TOTAL CONDUCTED EMISSIONS - LINE

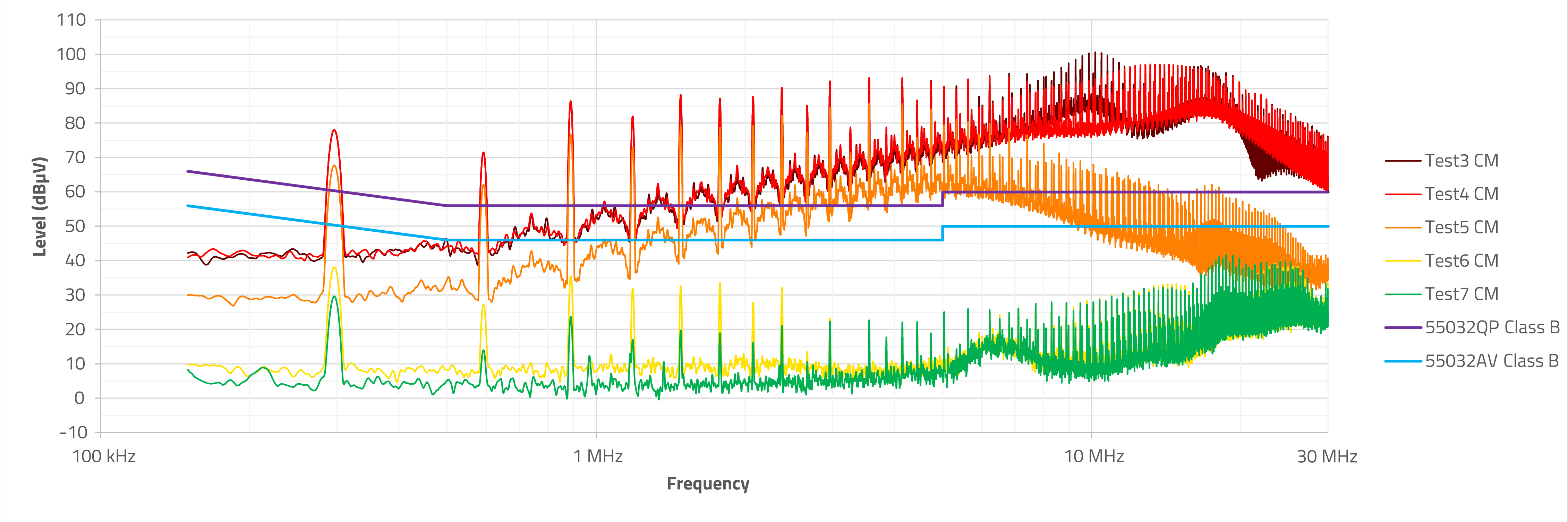


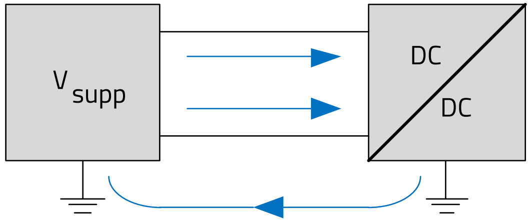


Combined

Namec	Description
Test#3	Reference (no improvement)
Test#4	Test#3 + RCD-snubber
Test#5	Test#4 + primary to secondary y-capacitors
Test#6	Test#5 + CMC and y-capacitors (CM filter)
Test#7	Test#6 + x-capacitor (DM filter)

TEST#3-7: V2022.1 WITH MODIFICATION - CONDUCTED EMISSIONS - COMMON MODE





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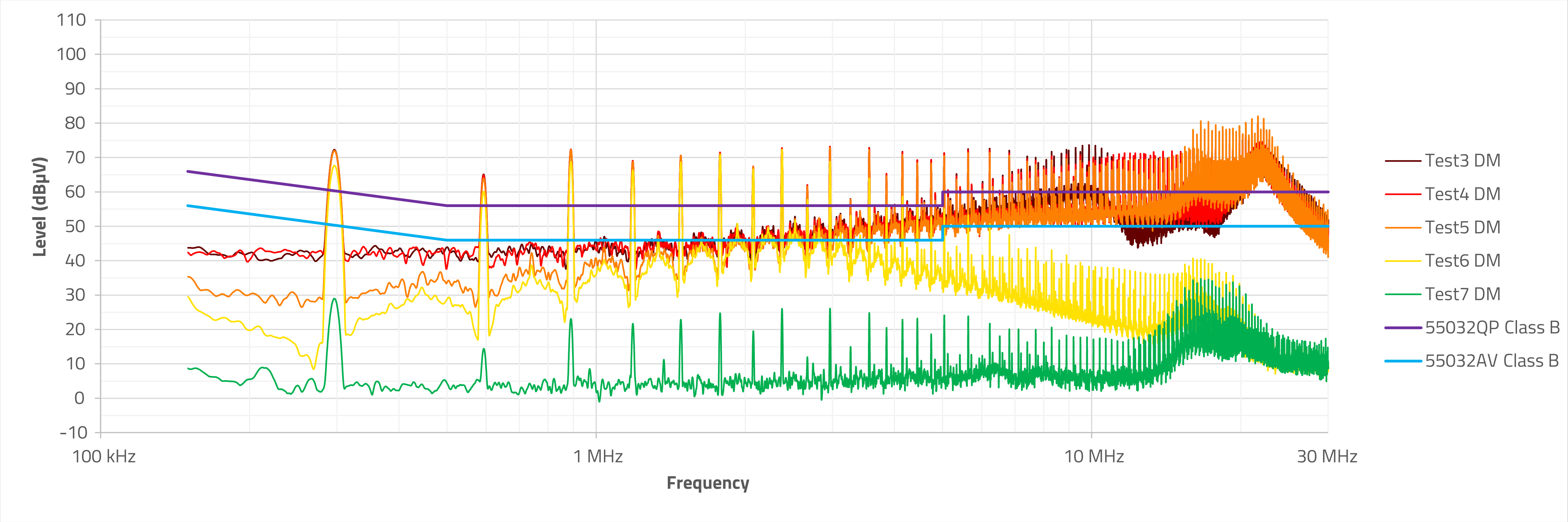
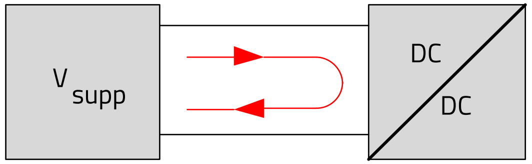
TEST#3-7: V2022.1 WITH MODIFICATION - CONDUCTED EMISSIONS - DIFFERENTIAL MODE





Differential Mode

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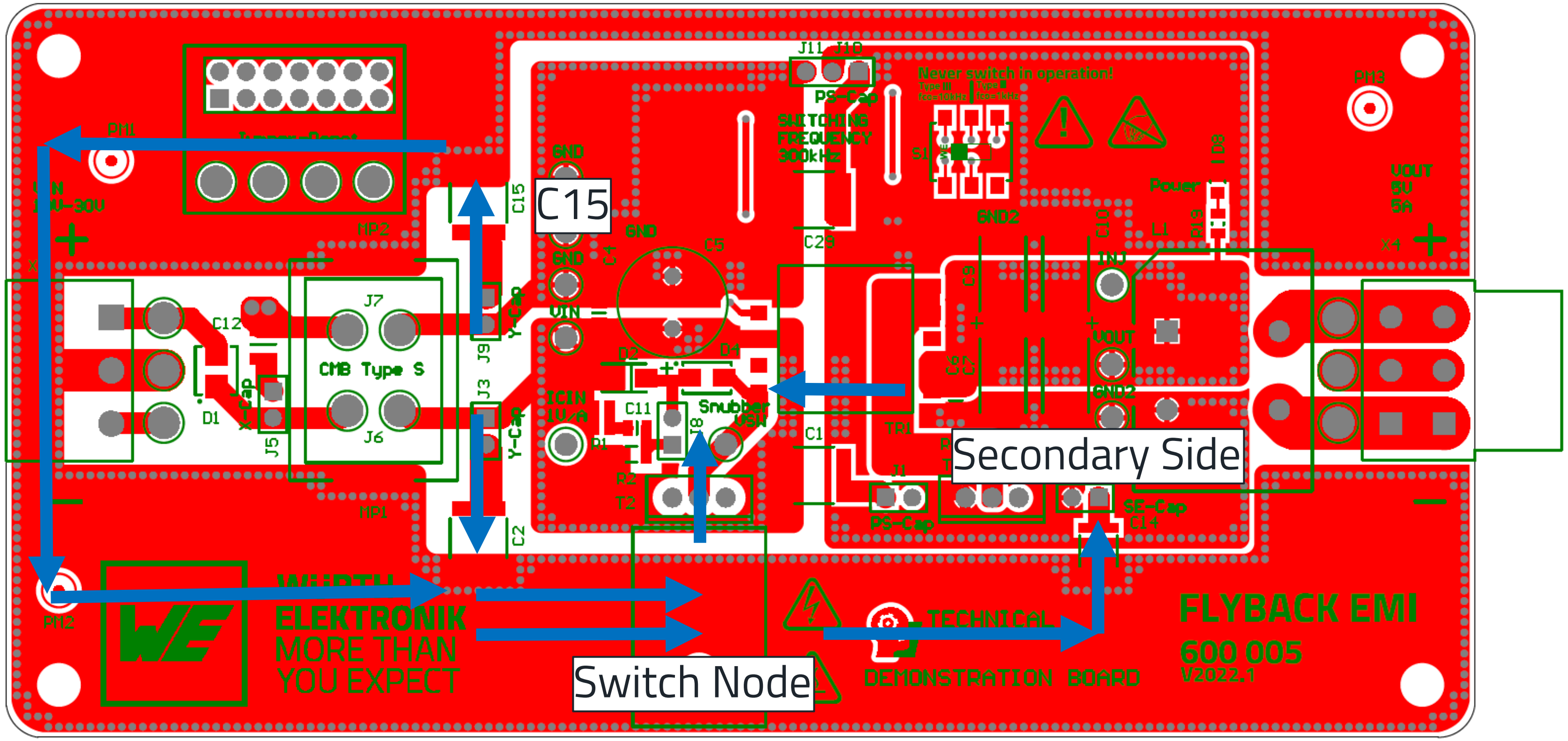
FLYBACK EMI - DEMONSTRATION BOARD - V2022.1 - MODIFICATION

Background

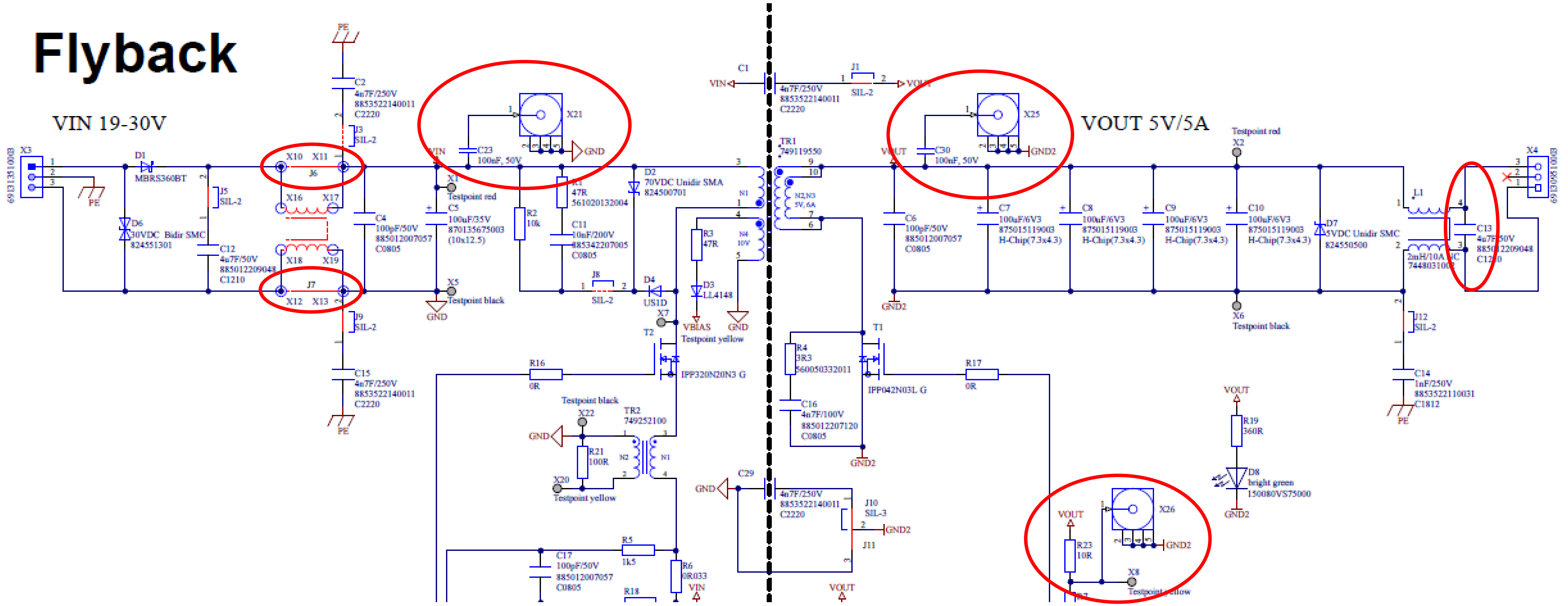


There is no short noise return path from y-capacitor C15 to CM-Noise Source (Switch node, secondary side)

CM-noise bypasses the filter and couples into the filter (parasitic loop antenna)

CM noise imbalance occurs (CM/DM conversion)

FLYBACK EMI - SCHEMATIC- V2023.1

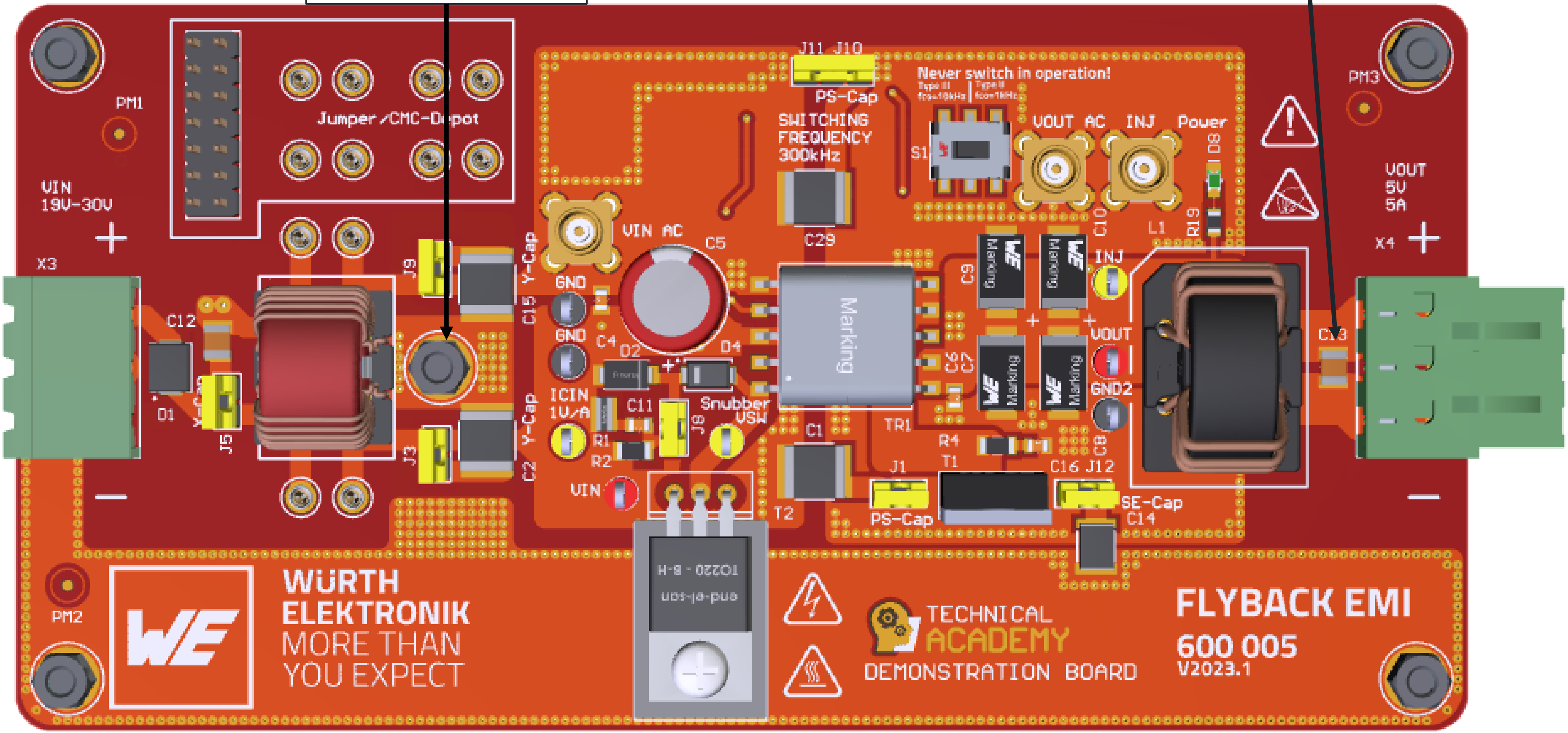


FLYBACK EMI - DEMONSTRATION BOARD - V2023.1

Top

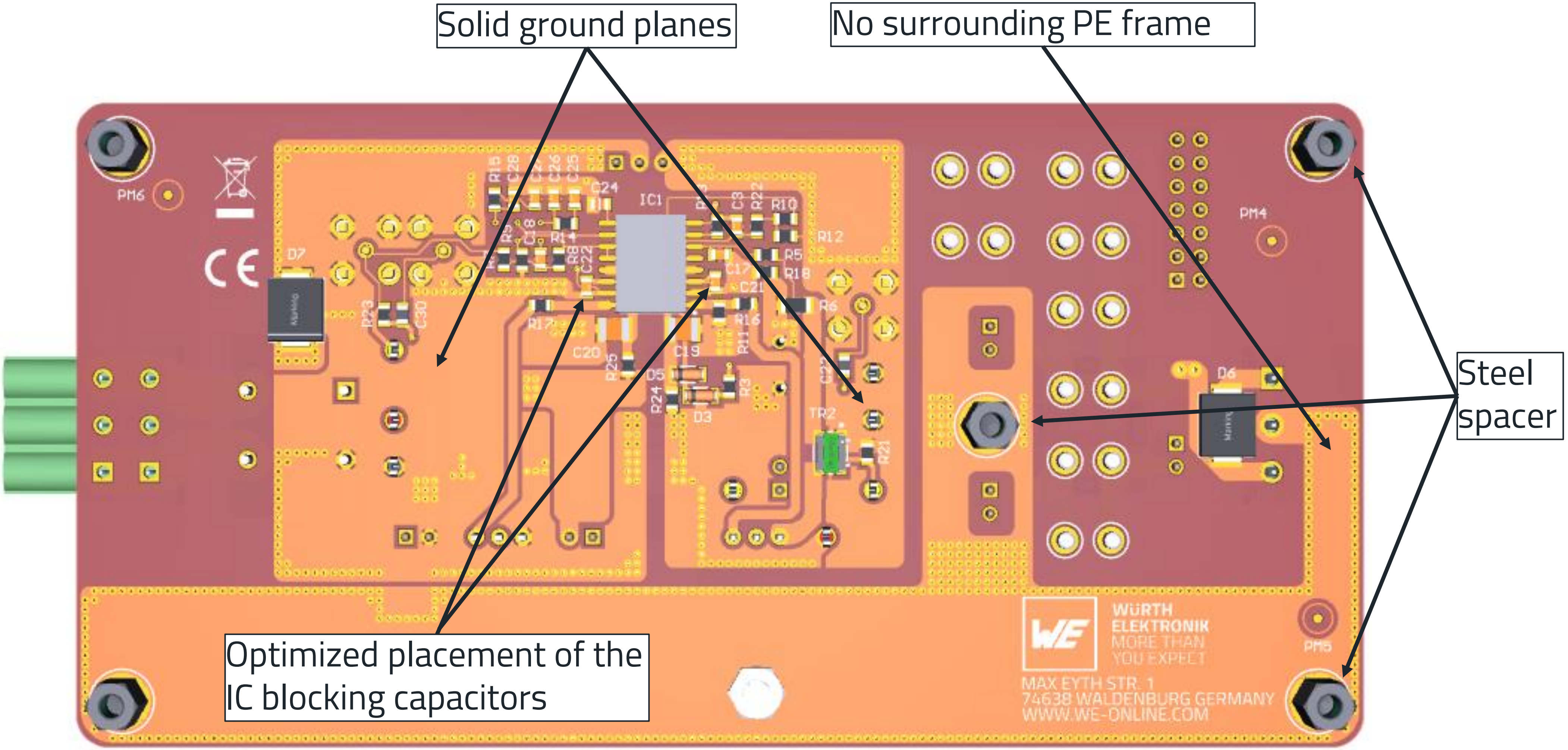
Star point connection of the Y-capacitors

Additional output filter capacitor

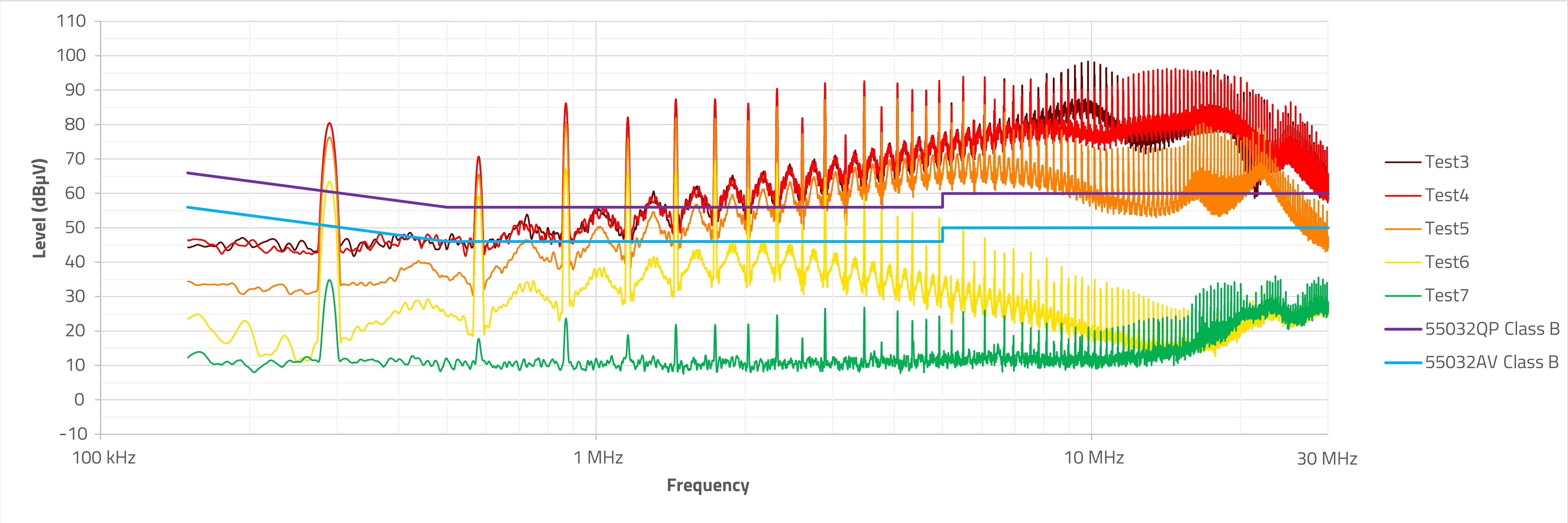


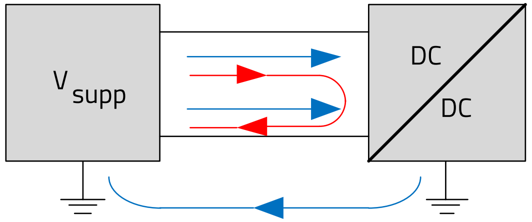
FLYBACK EMI - DEMONSTRATION BOARD - V2023.1

Bottom



TEST#3-7: V2023.1 - TOTAL CONDUCTED EMISSIONS - LINE





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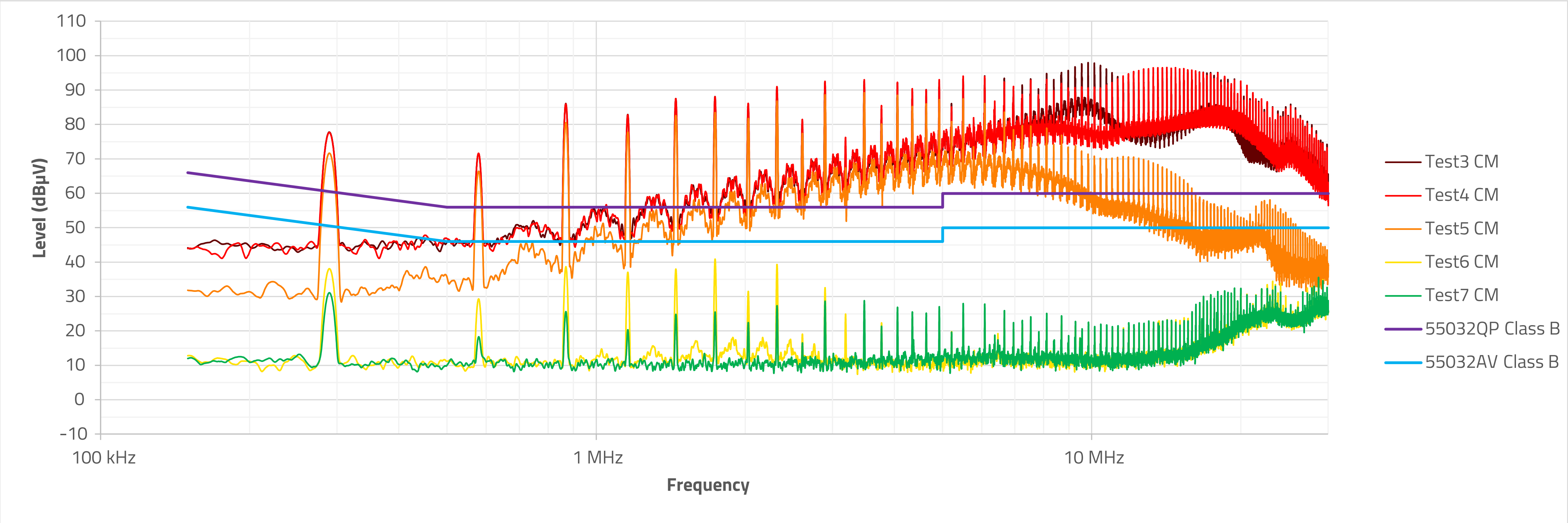
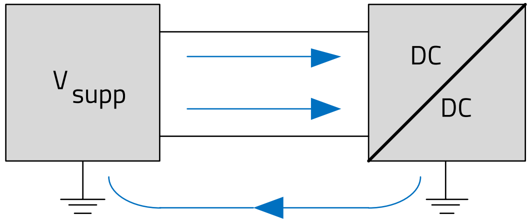
TEST#3-7: V2023.1 - CONDUCTED EMISSIONS - COMMON MODE





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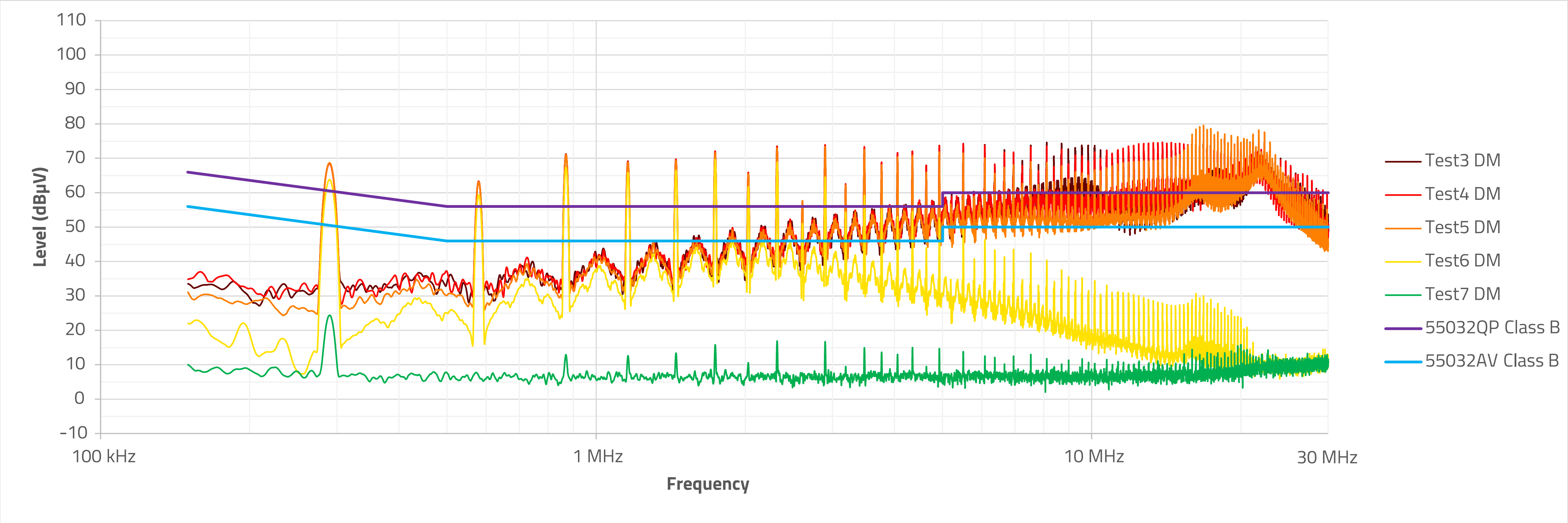
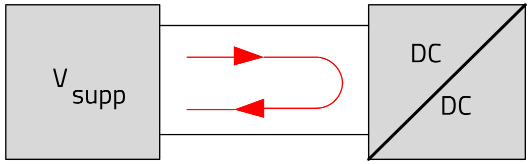
TEST#3-7: V2023.1 - CONDUCTED EMISSIONS - DIFFERENTIAL MODE





Differential Mode

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Test#5	Test#4 + primary to secondary y-capacitors
Test#6	Test#5 + CMC and y-capacitors (CM filter)
Test#7	Test#6 + x-capacitor (DM filter)

TRILOGY OF MAGNETICS

- 1. LTspice Book

  How to use and build spice models

- 2. Trilogy of Magnetics

  Design Guide for EMI Filter Design, SMPS & RF Circuits

- 3. Trilogy of Connectors

  Basic Principles and Connector Design Explanations

- 4. ABC of Power Modules

  Functionality, Structure and Handling of a Power Module

- 5. ABC of Capacitors

  Basic principles, characteristics and capacitor types

LABORATORY RACK

αRack & ΩRack

- The new rack series are modular, flexible and can be equipped individually.
- Information brochure available

αRack variants

ΩRack variants

TECHNICAL SUPPORT NEEDED?

use: #askLorandt

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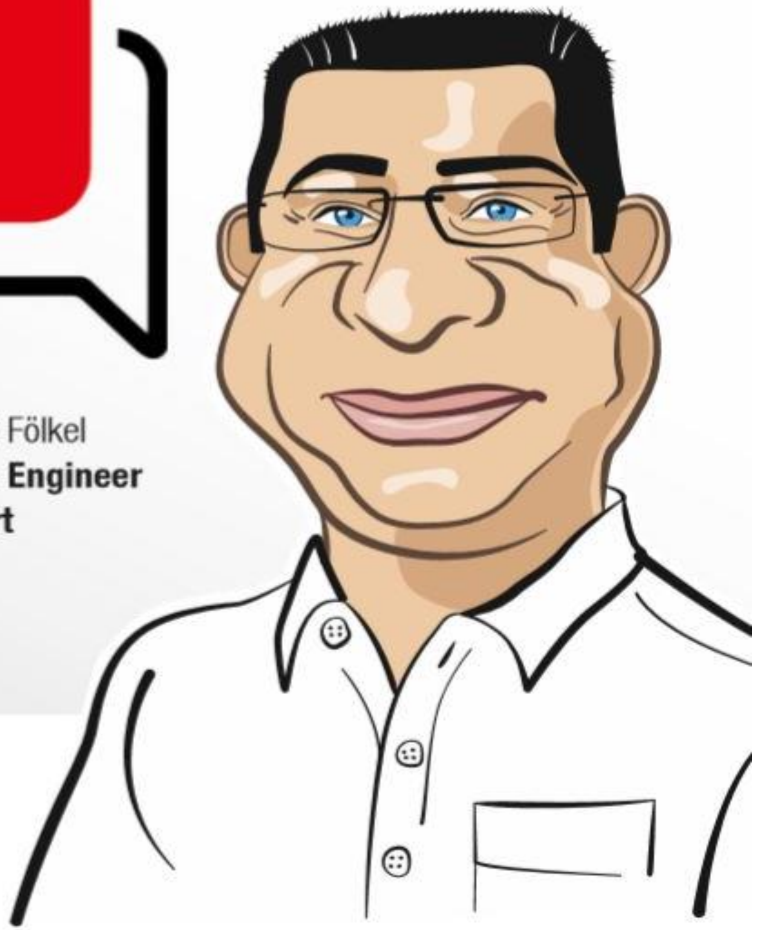
Lorandt Fölkel
Design Engineer at heart



or contact me directly:

askLorandt@we-online.com

EMI NOISE PROFILES ACROSS INDUSTRIES

Arno Distel, Dipl.-Ing.
FAE at Valens Semiconductor

TODAY'S AGENDA

- Valens Semiconductor
- EMC Noise Profiles in Automotive
- EMC Challenges in Industrial
- DSP-Based Approach to EMI
- EMC Challenges in Medical

Valens

The **High-Performance Connectivity** Company

The **Highest** Bandwidth
High-speed connectivity for a variety of applications, with no latency.

The **Longest** Reach
Unprecedented flexibility for system Design over the simplest wiring infrastructure.

The **Lowest** Error Rate
Reliable, error-free connectivity for Safety-critical systems.

17	NYSE:VLN	250	30M+	$85M	7	120	100s
Years of innovation	Trading on the New York Stock Exchange	Employees	Chipsets sold	Revenues in 2023	Global offices	Patents	Of customers

Entertainment	Digital Signage	Education	Video Conferencing	Industrial	Automotive	Medical

HDBaseT™

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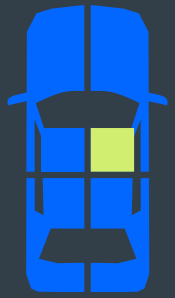
THE VARIOUS EMC PROFILES ACROSS INDUSTRIES

Industrial	Automotive	Medical

EMC CHALLENGES IN:

AUTOMOTIVE

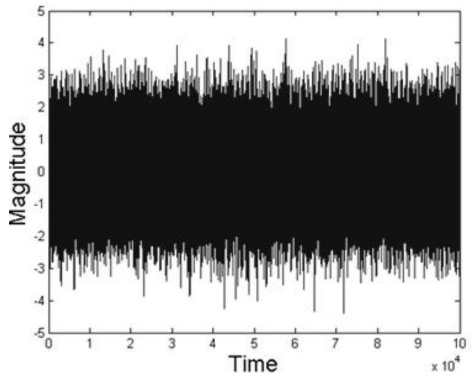


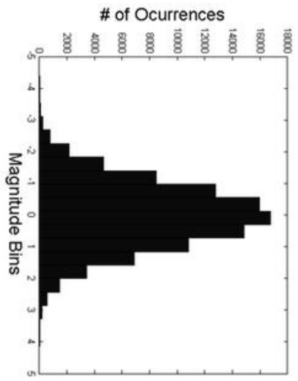
4 MAIN NOISE TYPES OF AUTOMOTIVE

Additive White Gaussian Noise (AWGN)

Continuous broadband environment noise comprising contributions from multiple independent sources, normally distributed noise peaks.

Caused by: Electrical systems within the vehicle.





4 MAIN NOISE TYPES OF AUTOMOTIVE

Transients on Line (ToL)

Large electrical transients with a short duration (up to ~200nS) but with very high amplitude.

Caused by: Electrical systems within the vehicle.

4 MAIN NOISE TYPES OF AUTOMOTIVE

Alien Crosstalk (Xtalk)

Continuous, relatively uniform, bounded broadband noise from neighboring cables (aggressors) in the harness/PCB, based on their coupling length and proximity to the “victim” cable.

Caused by: In-vehicle connectivity infrastructure.

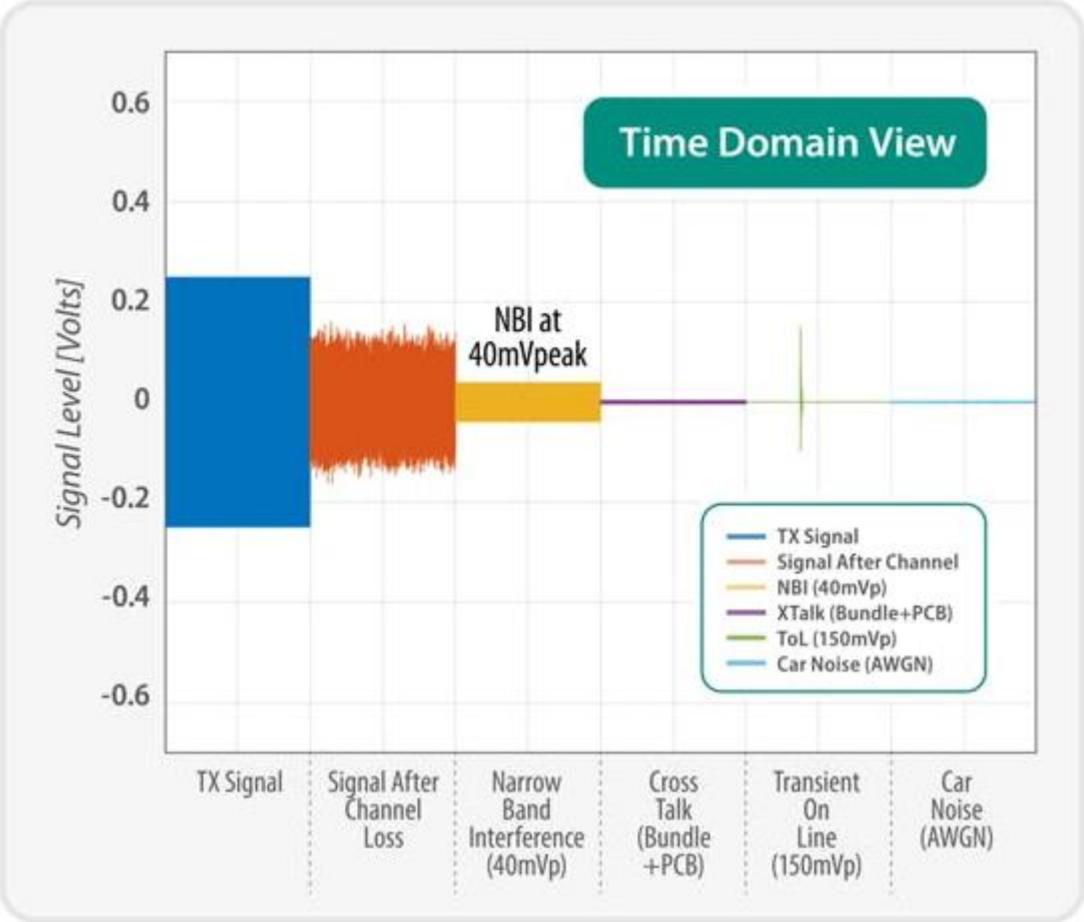
4 MAIN NOISE TYPES OF AUTOMOTIVE

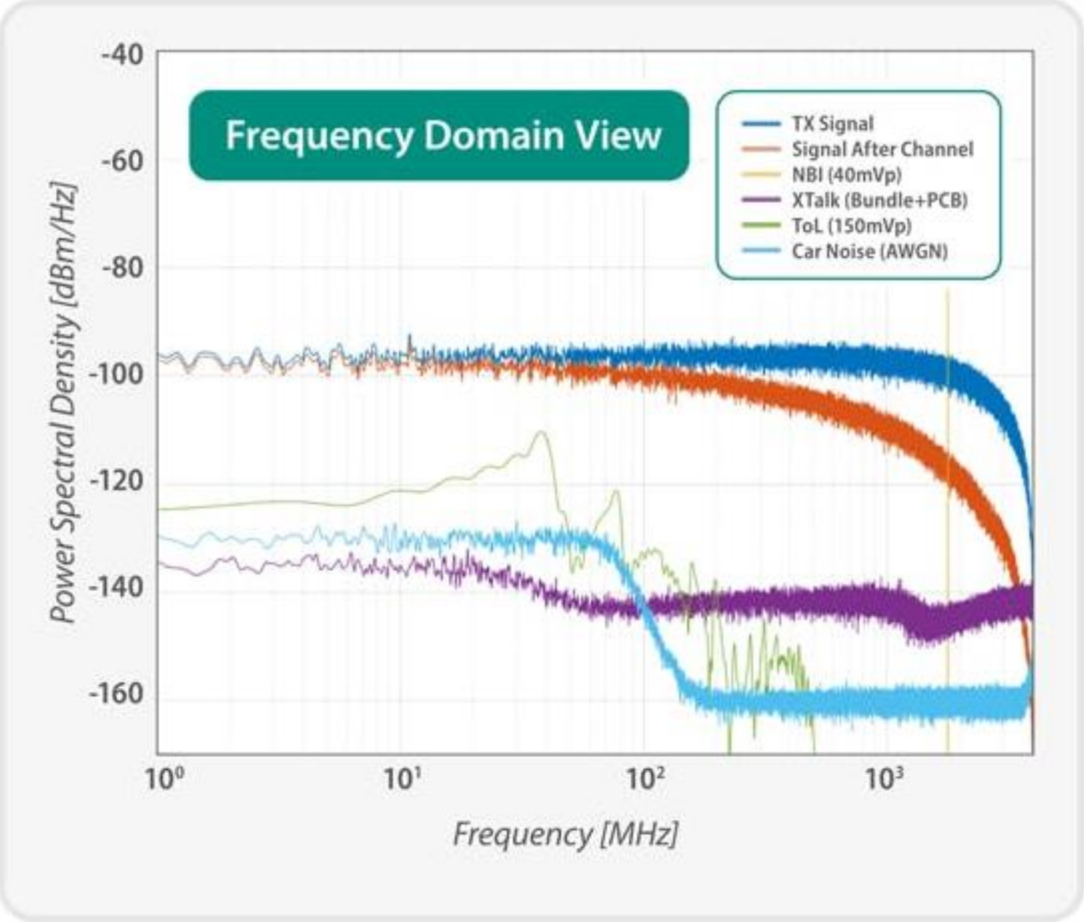
Narrow Band Interference (NBI)

Continuous narrowband noise, tested using standard EMC tests like BCI and RF Ingress. Limited peak distribution but occurring at a much higher probability.

Caused by: External-to-the-vehicle transmitters or hand-held transmitting devices in the vehicle

NOISE PROFILES IN TIME AND FREQUENCY DOMAIN





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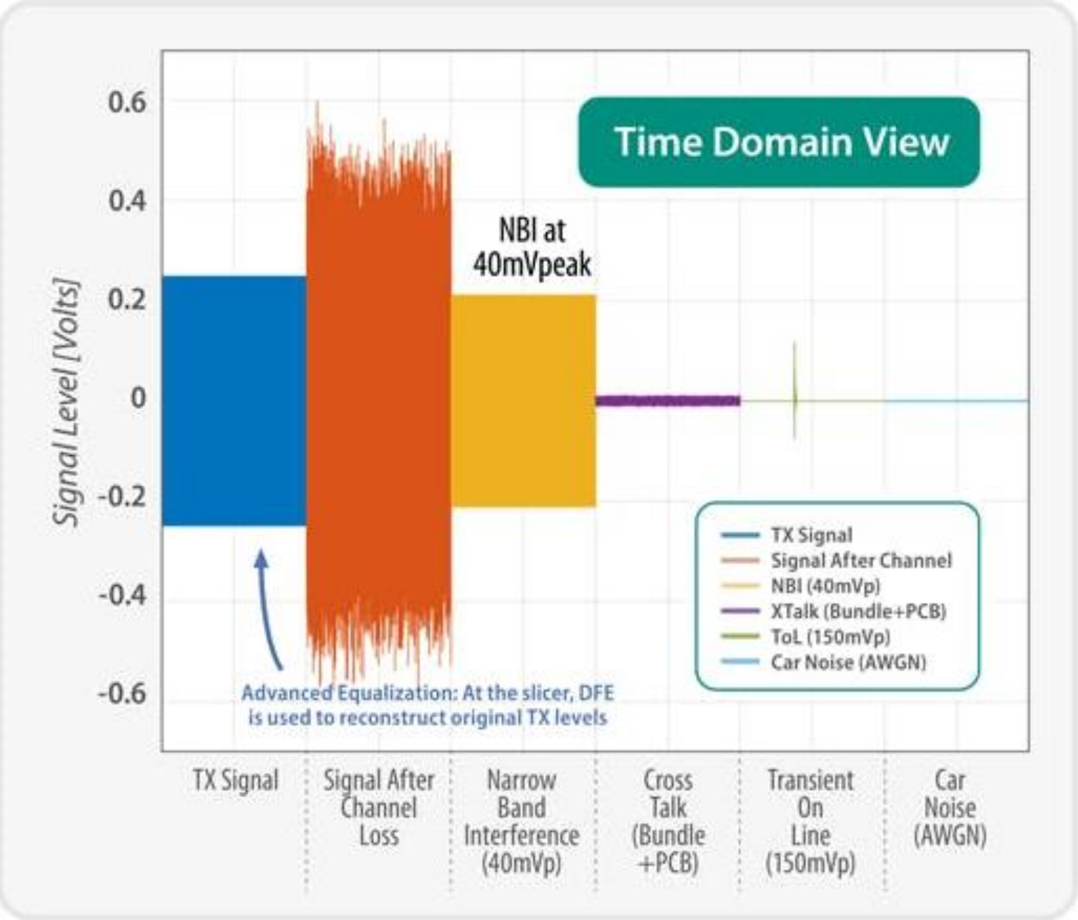
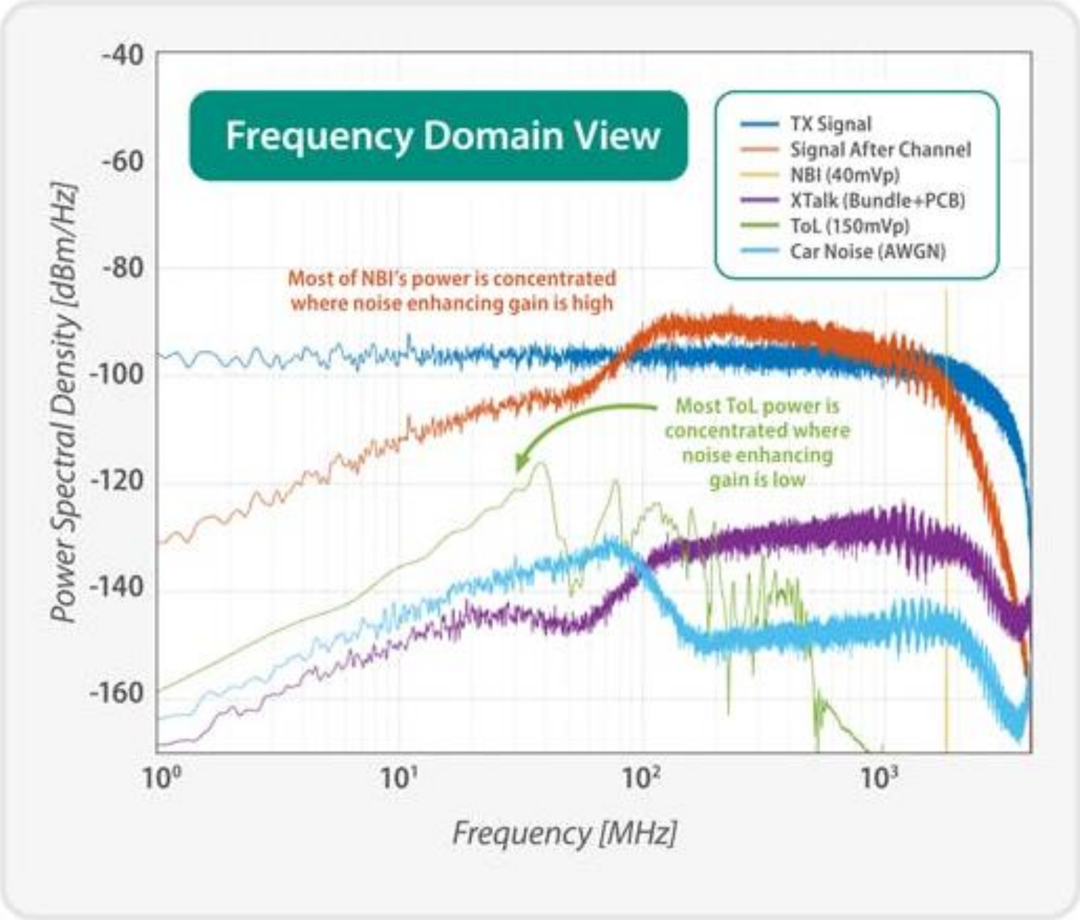




LEGACY EMI COUNTERMEASURES

- Limiting cable length
- Reducing bandwidth
- Shielded cables
- Forward error correction (FEC)

Existing solutions impose limitations on connectivity infrastructure

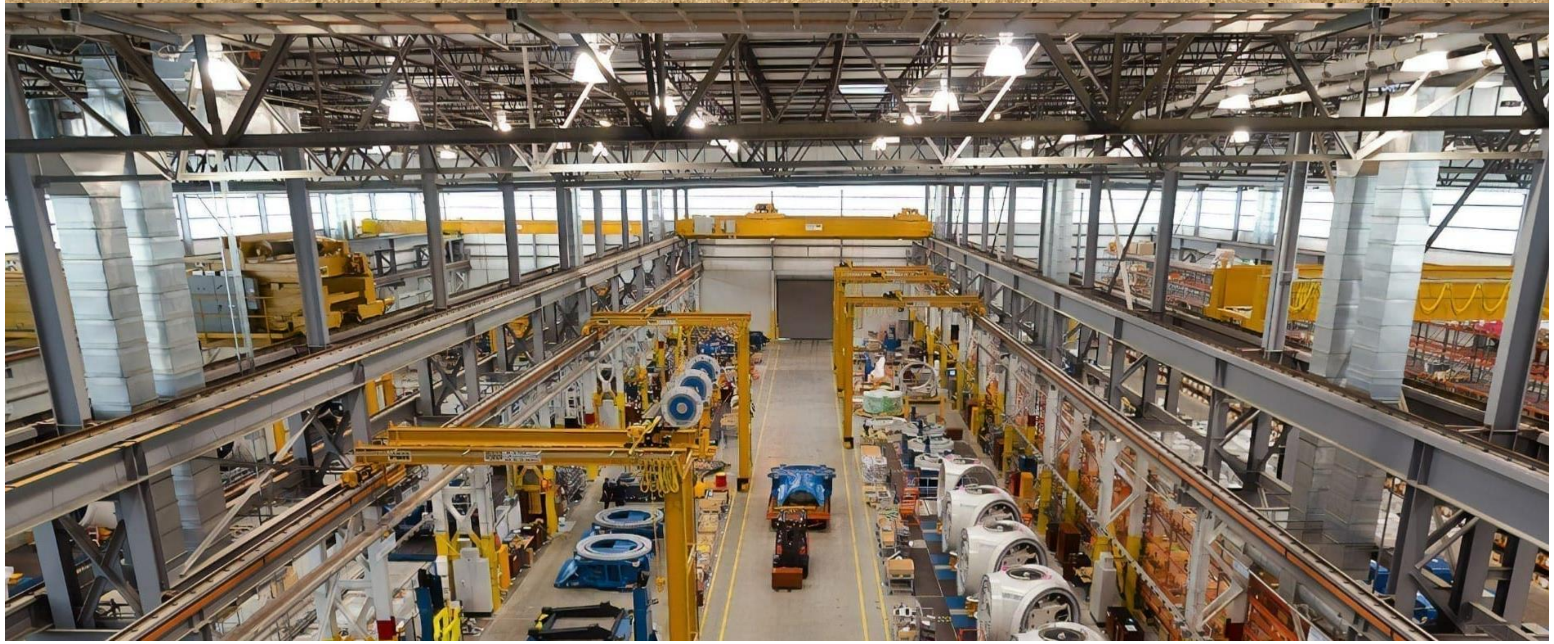
THE EFFECTS OF EMI ON AUTONOMOUS SYSTEMS

EMC CHALLENGES IN:
INDUSTRIAL

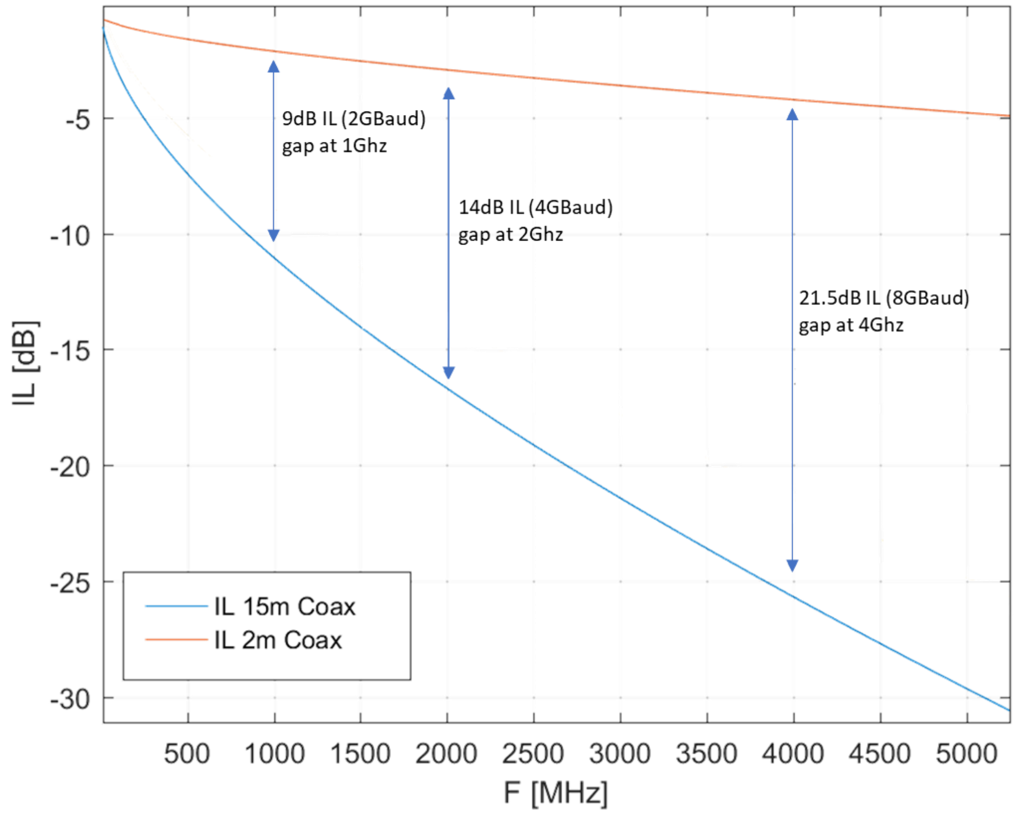
EMC CHALLENGES

Cable length

Can reach 100 meters or more in a variety of industrial applications



LONGER DISTANCES ACCELERATE CHANNEL ATTENUATION



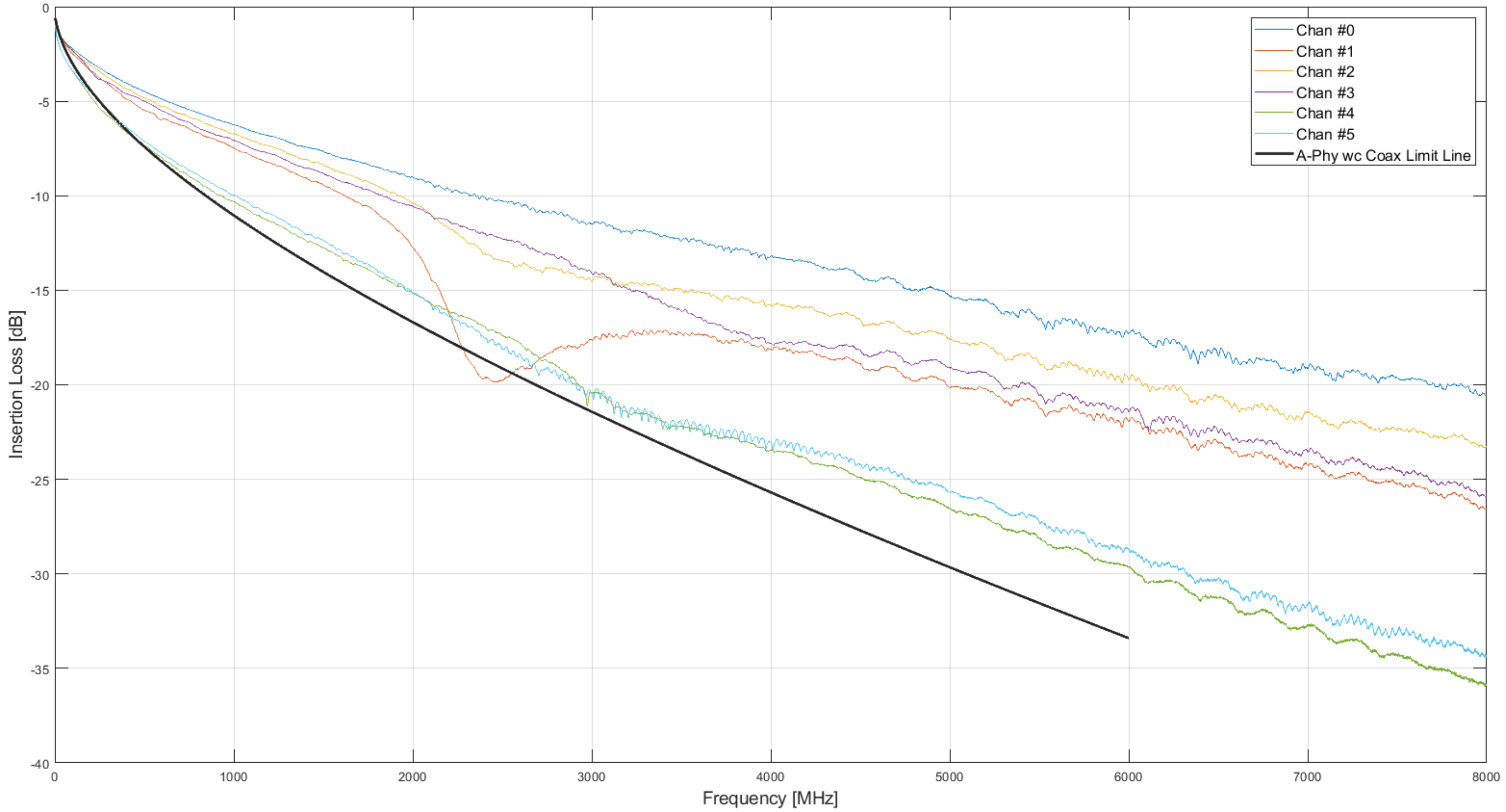
The longer the cable, the more attenuation of the channel at high frequencies.

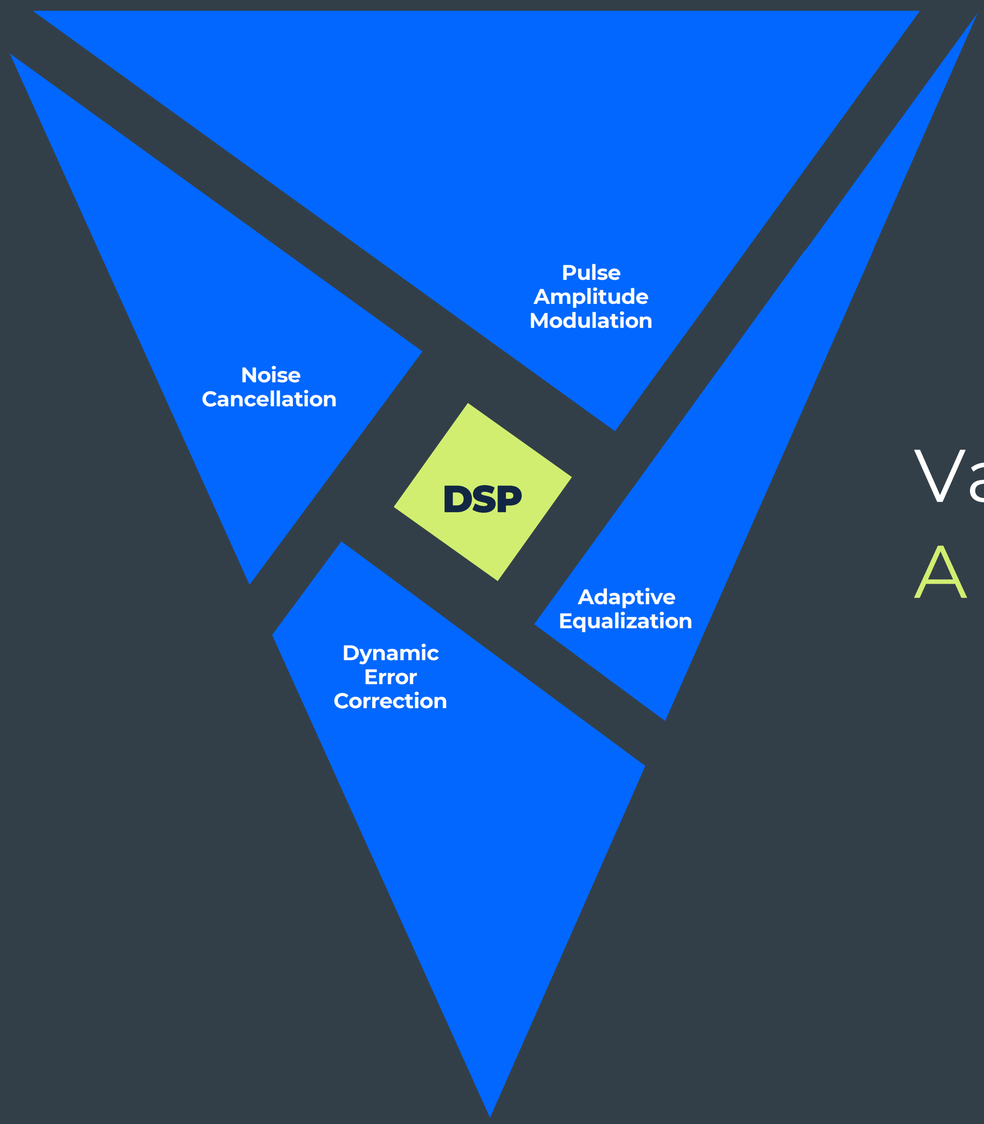
EMC CHALLENGES

Flexibility

Often requiring unshielded channels which offer higher cable flexibility

CHANNELS TESTED – CHANNEL INSERTION LOSS (IL)



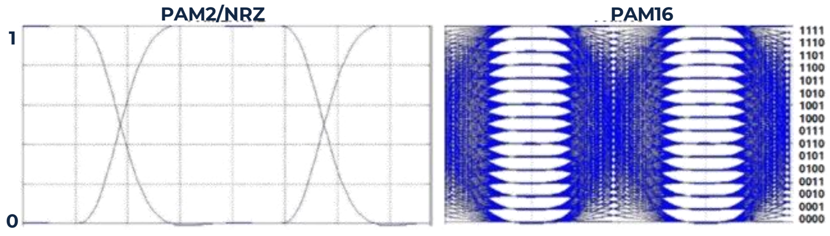


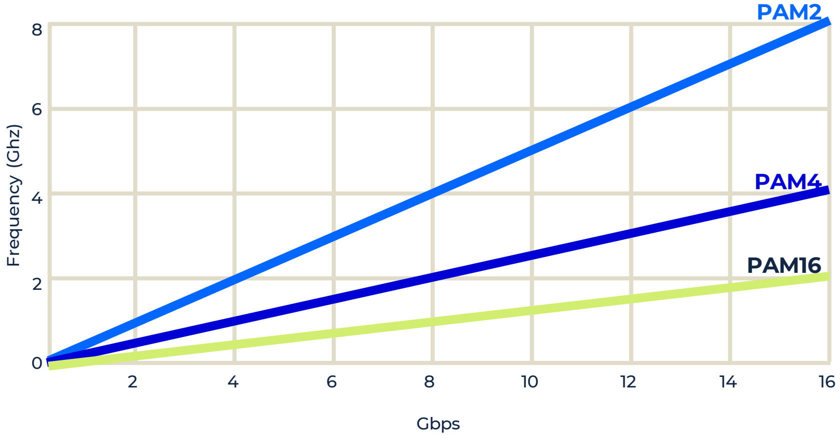
Valens' A-PHY Chipsets:
A DSP-Based Approach to EMI

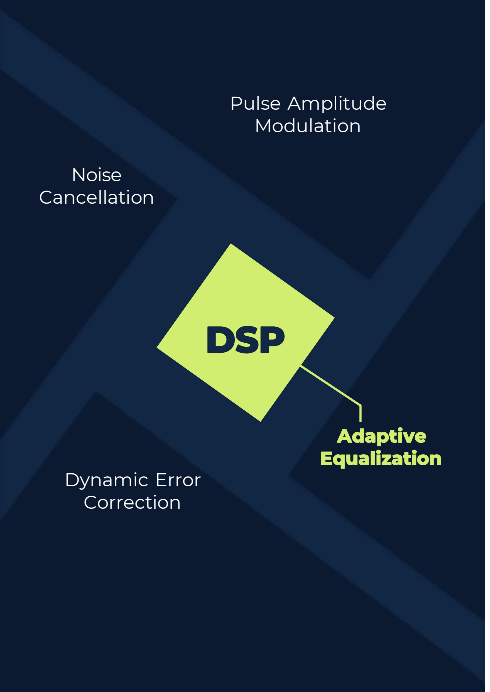
PULSE AMPLITUDE MODULATION

- Higher levels of PAM encode more bits per symbol, leading to:
  - Stream sensitive transmissions operating at different PAM levels (PAM2 for Header, PAM4 for Controls, PAM4/8/16 for payload)
  - Lower frequency on the cable
  - Lower insertion loss
  - Lower noise due to lower receiver bandwidth

Higher levels of PAM lower the required link frequency; while competing solutions use PAM2/4, MIPI A-PHY solutions reach PAM16

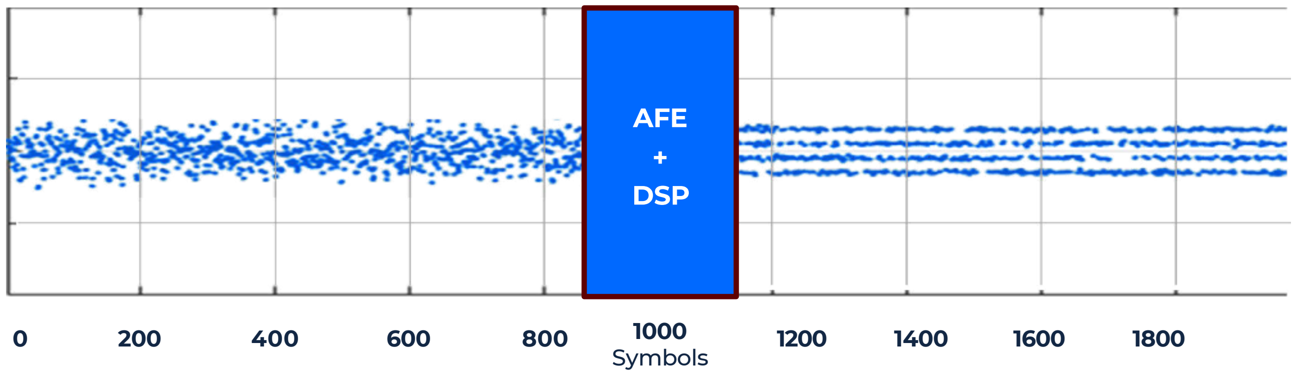






FULLY ADAPTIVE EQUALIZATION

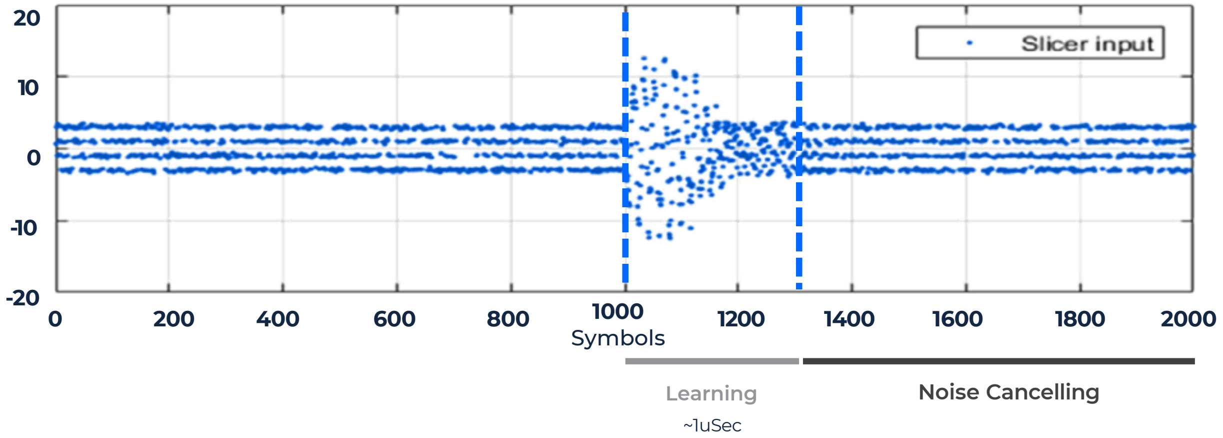
- Fully adaptive equalization tracks channel variations in real time, while competing solutions only select from pre-defined parametric/discrete filters
- Equalizes timing variations of the channel
- Compensates reflections from concatenated multi-inline cable structures



Compensates for channel insertion loss throughout the length of the cable

NOISE CANCELING FOR EMI ATTACKS

- Just-in-time noise canceller: Synchronized mechanisms that speed up canceller convergence
- Optimized for EMI attacks (NBI), including non-linear harmonic distortions



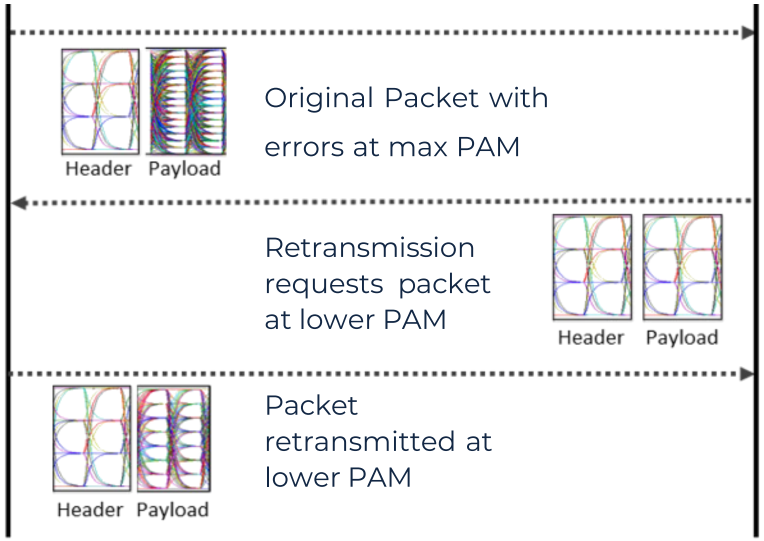
The Valens solution is fully adaptive and optimized for Narrowband Interference (NBI), while competing solutions rely mainly on shielding and application-level retransmission to deal with this noise profile

DYNAMIC ERROR CORRECTION (RTS) – OPTIMIZED FOR NBI

- Ultra-fast: occurs at the physical level (PHY)
- Dynamic modulation ensures retransmitted packets arrive uncorrupted

	FEC Forward error correction	**DMLR** Dynamically Modulated Local Retransmission
Bounded latency	✓	✓
White noise correction	✓	✓
EMI noise correction	✗	✓

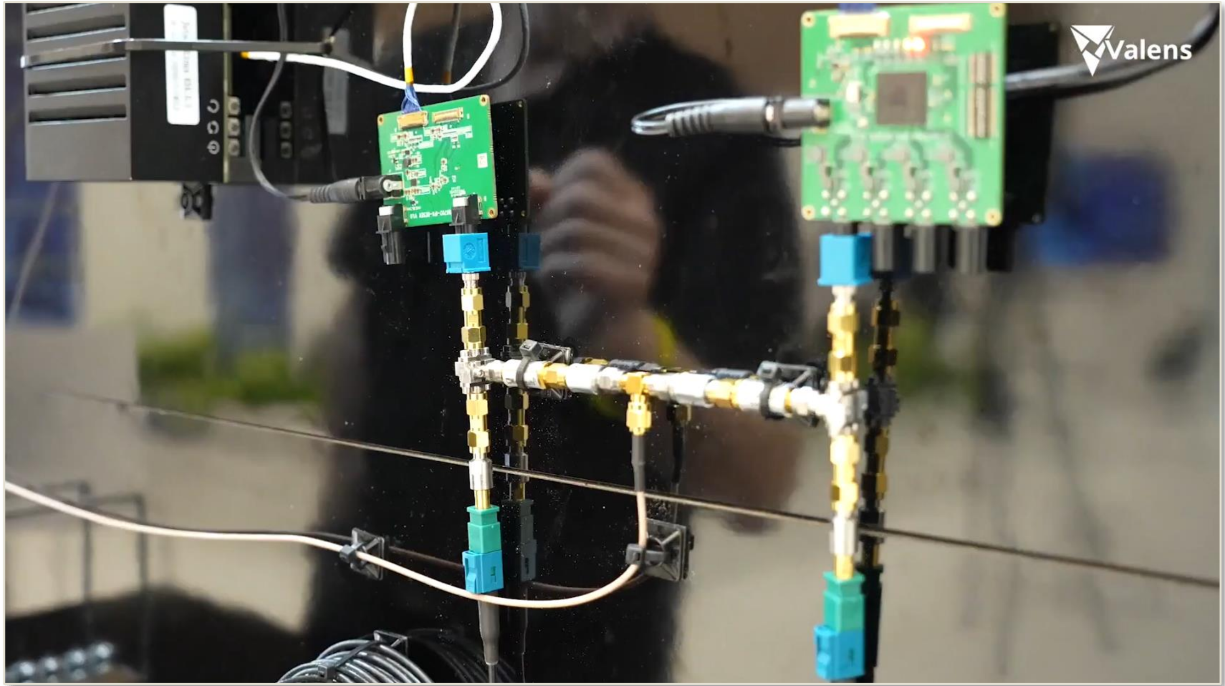
Dynamically modulated local retransmission (DMLR)



Transparent to upper layers, bounded to ~10us latency

DMLR is specifically designed to handle electromagnetic noises present in the vehicle, while FEC is extremely limited in its ability to deal with such noises

SUPERIOR TECHNOLOGY:
20X HIGHER NOISE RESILIENCE VS. COMPETITION

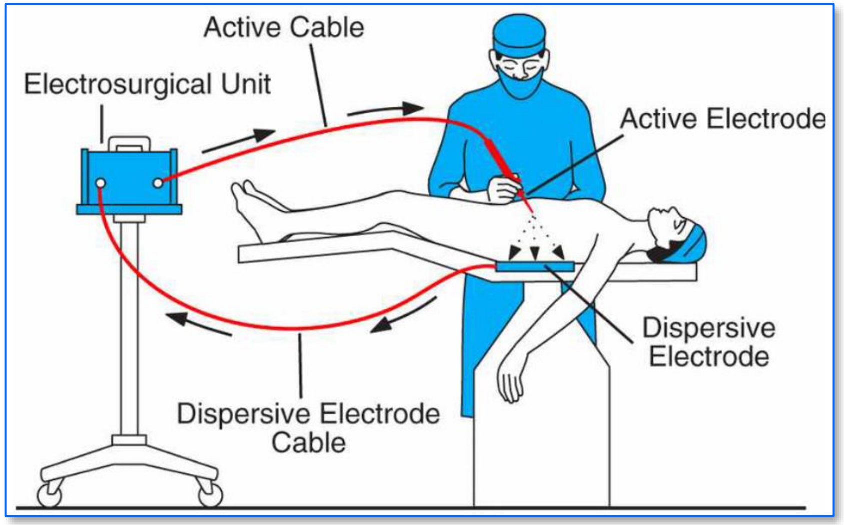


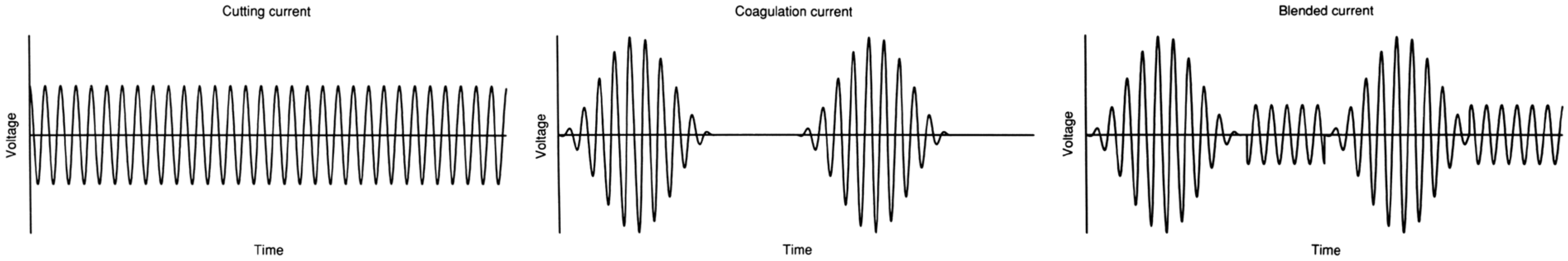
EMC CHALLENGES IN:
MEDICAL

NOISE CAUSED BY ELECTROSURGERY

Different modes use different current patterns. Modulated coag profile as worst case. Xtalk based on coupling length and proximity to the “victim” cable.

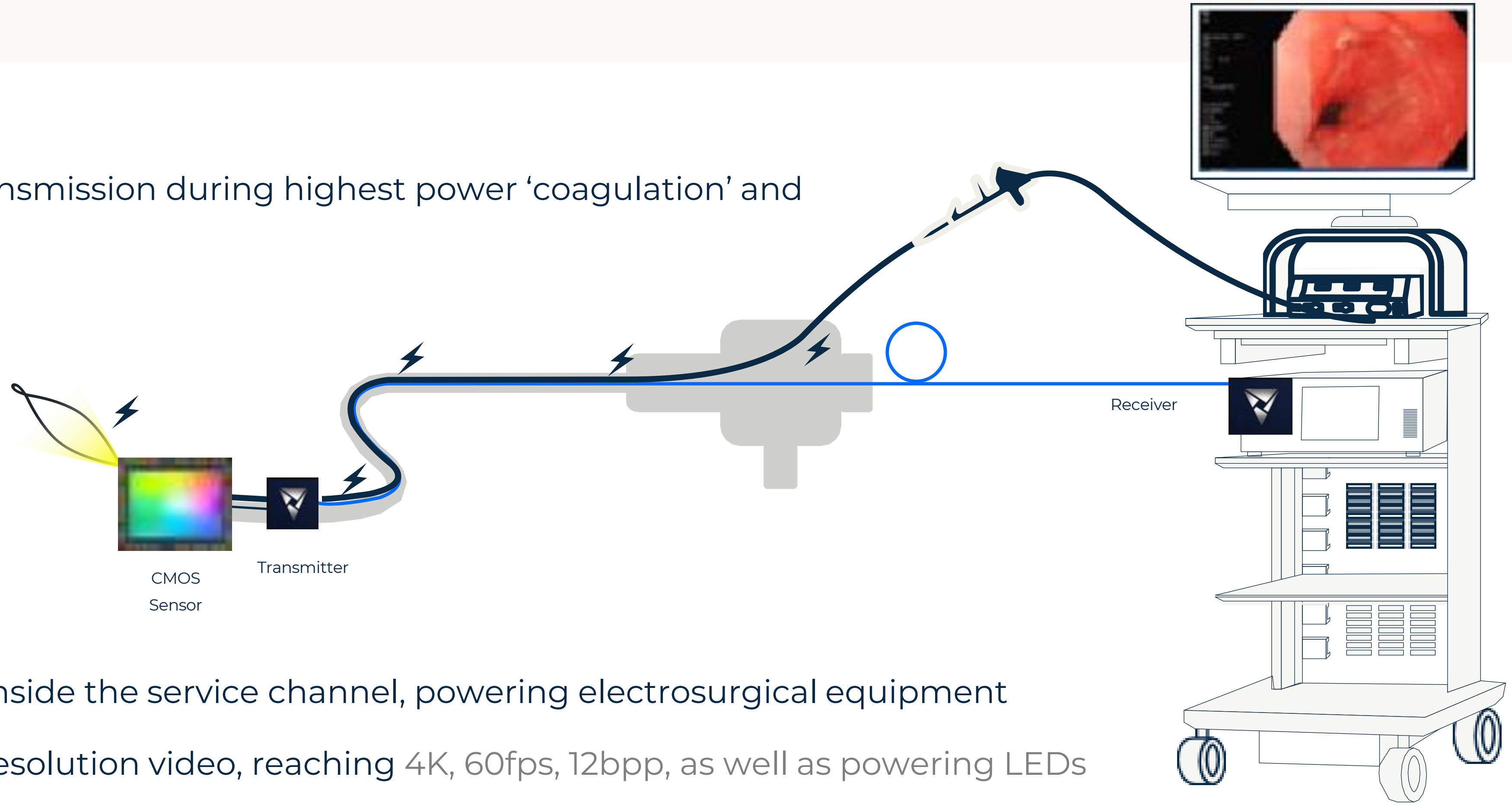
Caused by: Electrosurgical Unit operated close in vicinity to other electrical devices.





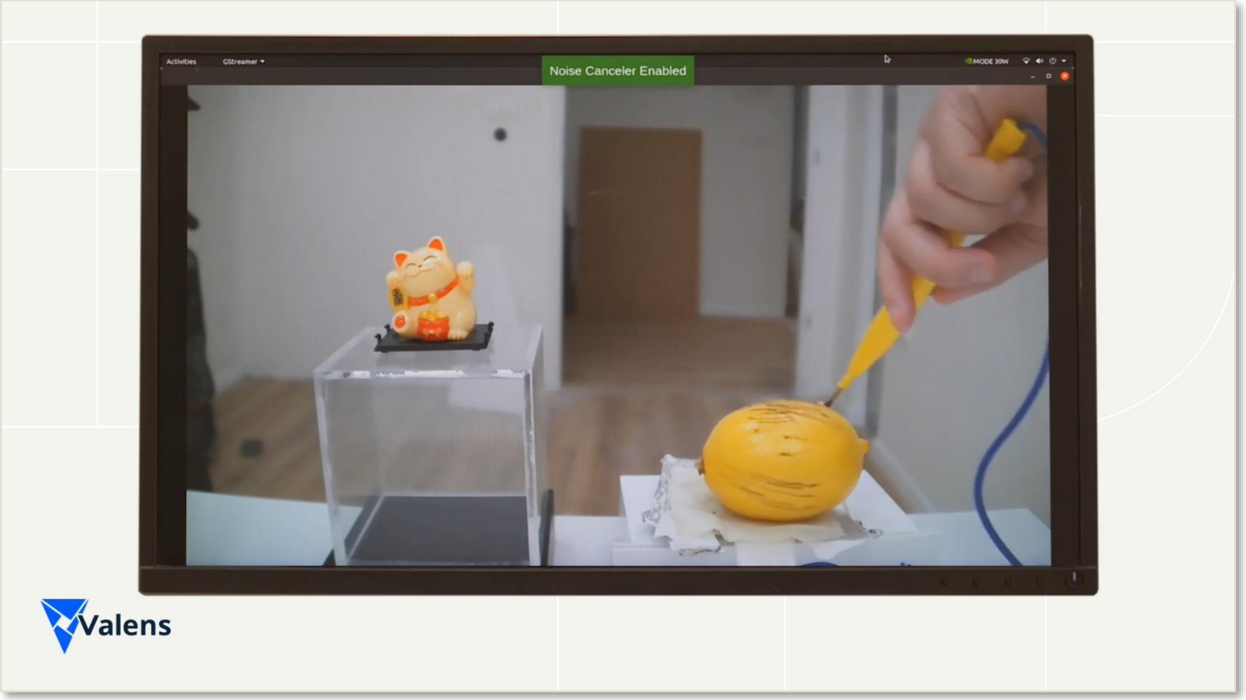
COEXISTENCE OF VIDEO AND ELECTROSURGICAL EQUIPMENT

Continuous video transmission during highest power ‘coagulation’ and ‘cut’ noise



- Cable inserted inside the service channel, powering electrosurgical equipment
- Cable for high-resolution video, reaching 4K, 60fps, 12bpp, as well as powering LEDs

ELECTROSURGICAL NOISE CANCELLATION DEMONSTRATION



Q&A

Arno Distel

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