Smart Sensors, Smarter AI
Building Reliable Edge Systems

Thomas Mauer (TI), Systems Engineer, Industrial Automation, System Engineering and Marketing (SEM)

Octavian Stroe (WE), Product Definition Engineer at Würth Elektronik

Texas Instruments

Speaker Introduction



Name: Thomas Mauer

Role: System Engineer in Industrial Automation team at Texas Instruments Freising, Germany

Expertise: 25+ years of experience in processors solutions and industrial comms (real-time Ethernet, fieldbuses, industrial application)

Education: Dipl. Ing. (FH) from the University of applied Sciences in Wiesbaden, Germany



Name: Octavian Stroe

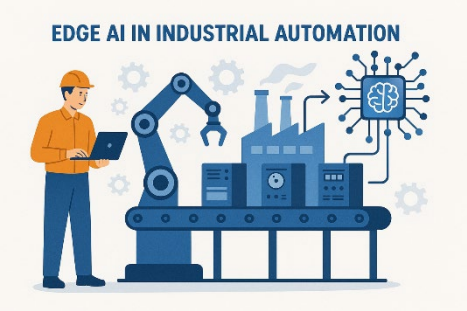
Role: Product Definition Engineer at Würth Elektronik

Expertise: Multidisciplinary engineer with deep expertise in sound engineering, audio electronics, and mechanical design

Education: Holds a degree in Sound Engineering with a specialization in audio electronics from the University of Huddersfield and a master's degree with a focus on optical compression.

Edge AI: Unlocking Real-Time at the Edge

- **Decentralized Analysis**: Perform complex analysis and processing tasks directly on the sensor node
- **Data Reduction**: Reduce data traffic from the sensor node to the gateway by only transmitting processed results
- **Real-Time Decision Making**: Run smart AI models in real-time, enabling instantaneous decision making
- **Benefits:**
  - Reduced latency and increased responsiveness
  - Decreased bandwidth usage and energy consumption
  - Improved accuracy and relevance through local processing
- **Key Features:**
  - Integration of various sensor types (image, audio, environmental)
  - Low-power computing for battery-powered devices
  - Scalability for large-scale deployments and massive data sets
  - Robust security features to protect sensitive information



Webinar overview

- Edge AI Fundamentals
- Sensor Board with Analog Front-end and Gateway Board
- Edge AI Processing and Anomaly Detection
- Digital Transmission over 10BASE-T1L with PoDL
- Würth Elektronik Products in the Edge Board and Gateway board
- EMC/EMI Measurement Process
- EMC/EMI-related Issues Found in Sensor Board Design
- Solutions and Revisions to Overcome EMC Problems
- EMC/EMI-related products from Würth Elektronik to help the design
- Conclusion / Reference Material

Application: Predictive maintenance



Unpredicted failure
- Costly (tools, material)
- Safety Concerns
- Affects Production

Why predictive maintenance?



"It costs approximately 50% more to repair a failed asset than if the problem had been addressed prior to failure" *



Machine breakdown can be unsafe leading to manpower loss, fines, audit, production stop…



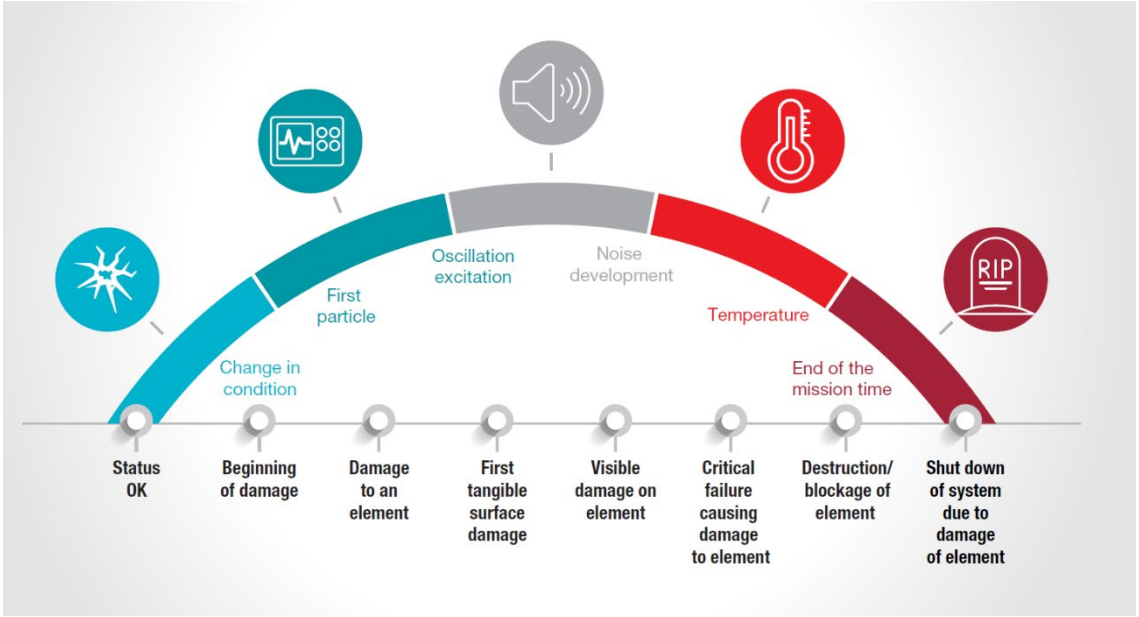
Non-invasive, retrofitting techniques reduces down time, increases availability and productivity

Maintenance	Corrective	Preventive	Predictive
	•Replace when breaks	•Replace upon schedule	•Replace when required

Industry 4.0

* Source: Emerson brief

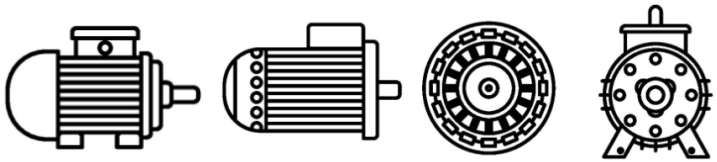
Predictive maintenance | Condition monitoring



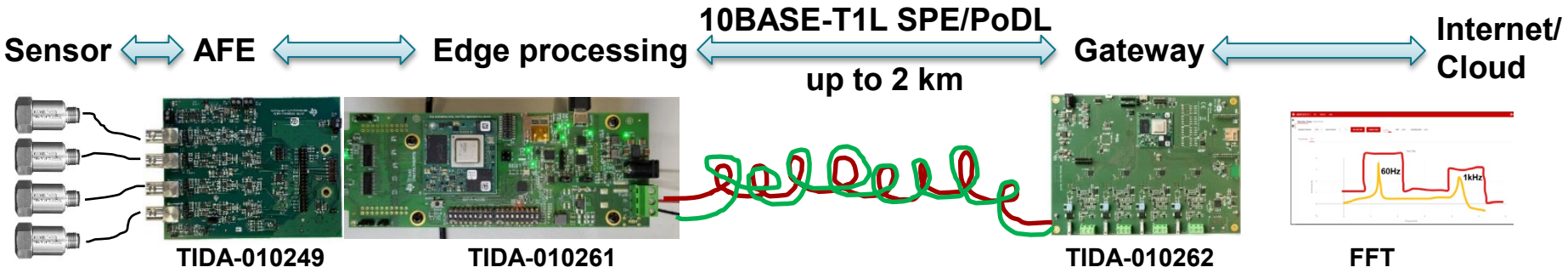
Condition monitoring

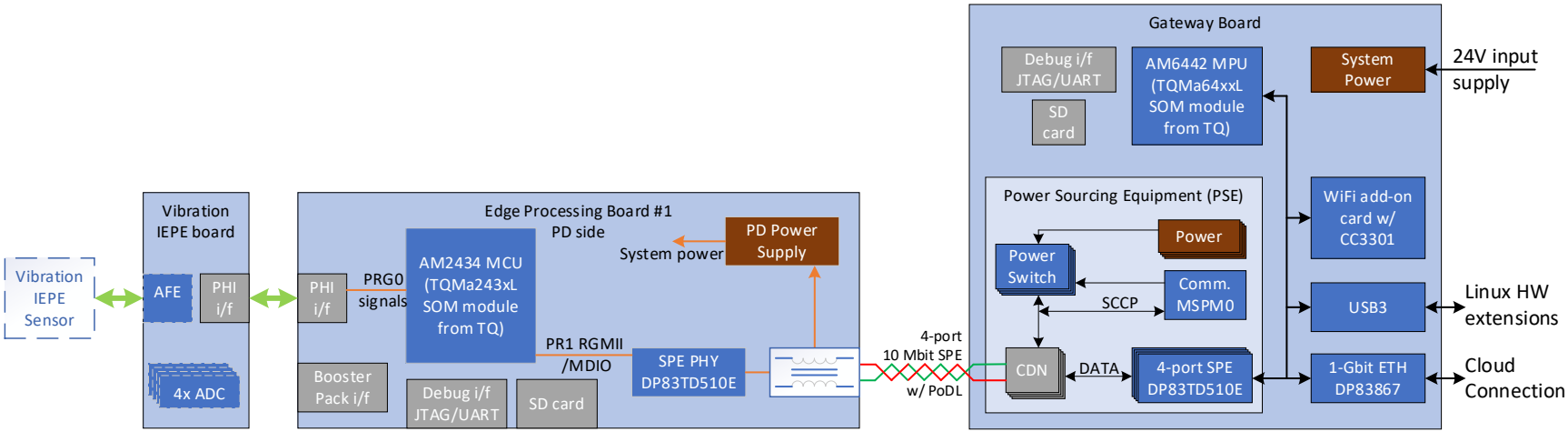
- Current
- Temperature
- Vibration

- Misalignment
- Mechanical defects
- Unbalance
- Loose fixtures



Vibration Monitoring with Edge Processing and 10BASE-T1L with PoDL Communication





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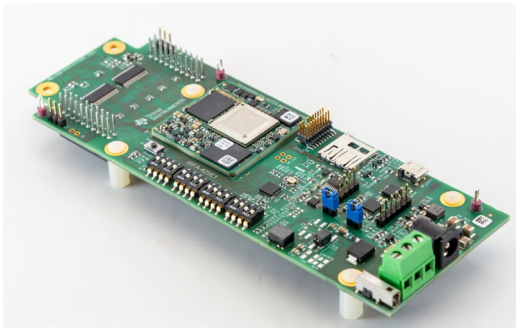
TIDA-010261: 10 BASE-T1L single pair ethernet (SPE) sensor with power over datalines (PoDL) reference design

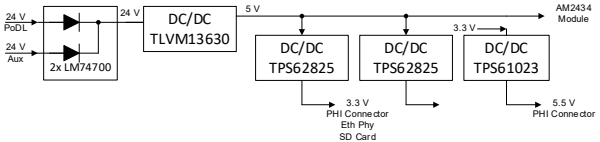
Features

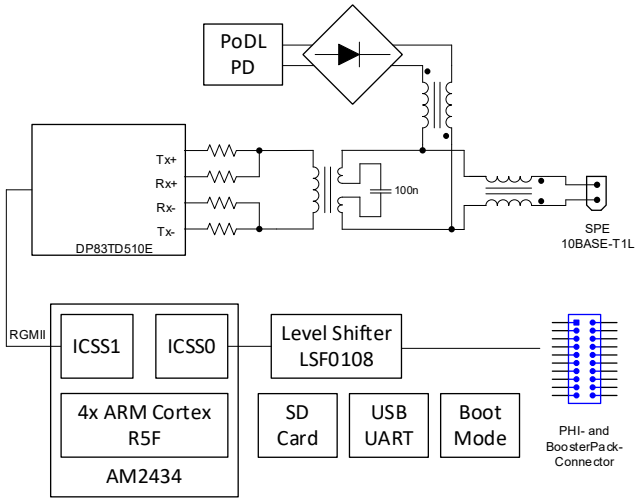
- Carrier board reference design with AM24x system on module (SOM) from 3rd party TQ Systems
- Single pair Ethernet with DP83TD510E (10 BASE-T1L)
- Power over Datalines (PoDL, 802.3cg), Powered Device (PD), Class 12, Type E
- PoDL Serial Communication Classification Protocol (SCCP) communication protocol with MSP430
- BoosterPack and PHI connector with PRU interface
- Optional 24V power supply

Benefits

- SPE and PoDL reference schematics
- FreeRTOS support
- Connects to Gateway board (TIDA-010262)
- Interface for ADC EVMs and BoosterPack
- R5F and PRU-ICSS handling data capture and Edge processing



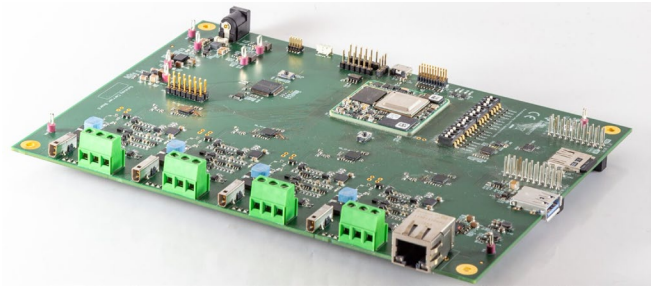




TIDA-010262: Four-port single pair ethernet with power over data line gateway reference design

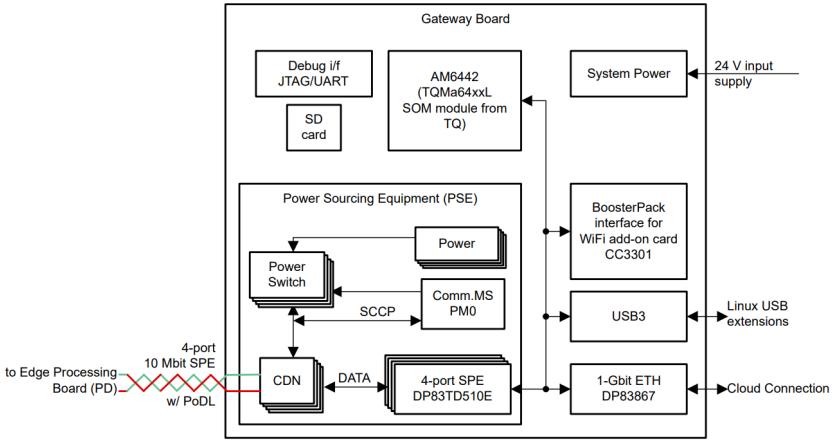
Features

- Carrier board reference design with AM64x system on module (SOM) from 3rd party TQ Systems
- Single pair Ethernet with DP83TD510E (4-port, 10Mbit)
- Power over data line (PoDL), Power Sourcing Equipment (PSE)
- PoDL SCCP communication protocol with MSPM0
- Cloud connection with 1 Gbps Ethernet with DP83867IS
- 24V power supply
- USB 3 interface
- WiFi/Bluetooth CC3301 booster pack support



Benefits

- 4-port SPE and PoDL reference schematics
- Linux support for applications (NodeRed, MQTT, Docker)
- Interfaces with Edge Processing board (TIDA-010261)
- 4-port SCCP protocol support via low-cost MSPM0



Digital Transmission over 10BASE-T1L with PoDL

Long-Range Data Transfer Made Possible

- Edge AI systems utilize the 10BASE-T1L standard, which enables data transmission over long distances (>1km) using only a single twisted pair cable. The Power over Data Line (PoDL) functionality provides power to the device(s), eliminating the need for separate wiring.

Advantages

- **Reduced Infrastructure Costs**: Lower installation and cabling costs due to single-cable deployments
- **Increased Flexibility**: Easy reconfiguration and troubleshooting with minimal disruption to the network
- **Improved Scalability**: Smoothly integrate new devices or locations without extensive setup changes

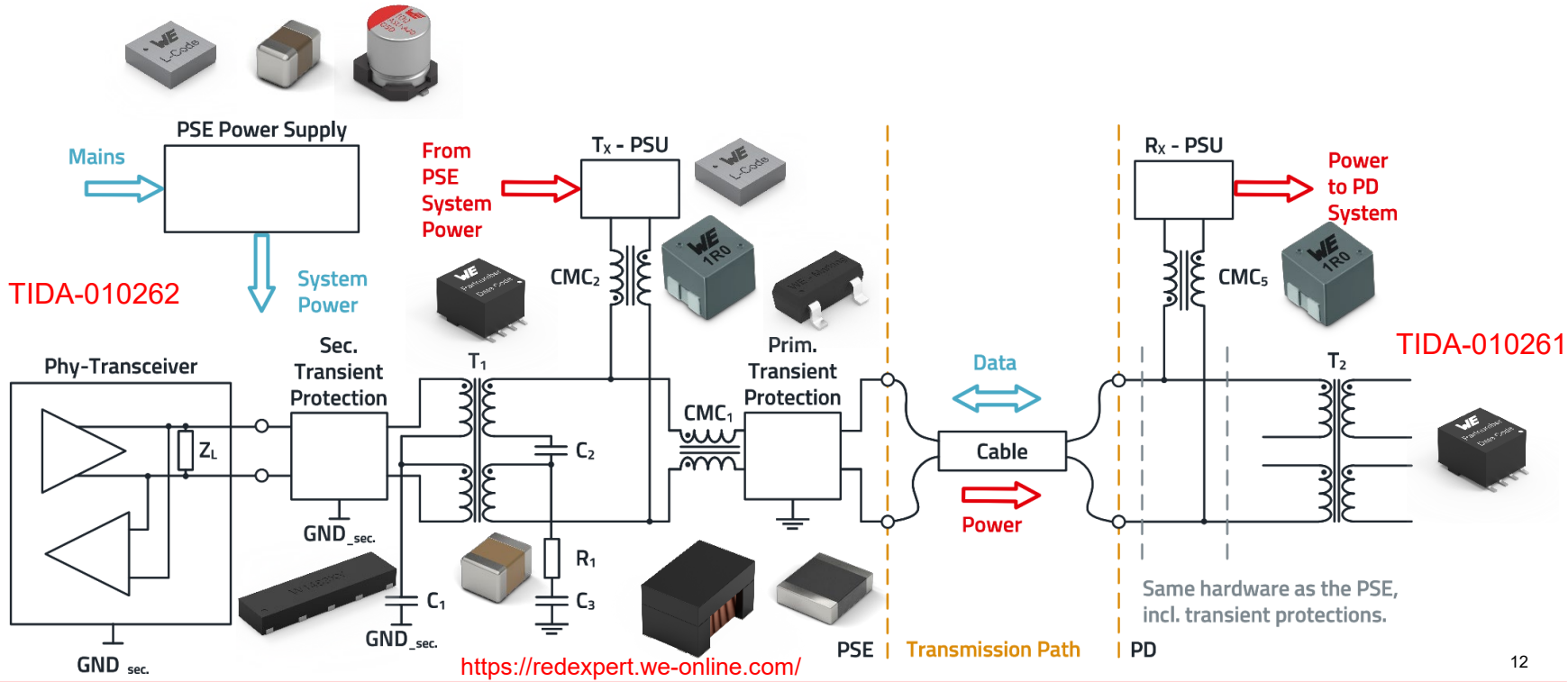
Data Processing at the Sensor Node

- Edge AI systems process data directly within the sensor node, reducing latency and minimizing transmission requirements. Only processed results are transmitted, thereby decreasing the load on communication networks.

Monitor Function: Anomaly Detection & Notifications

- The Edge AI system continuously monitors measured parameters against predefined thresholds. If anomalies or deviations occur, operators are immediately notified via alerts, enabling swift corrective action.

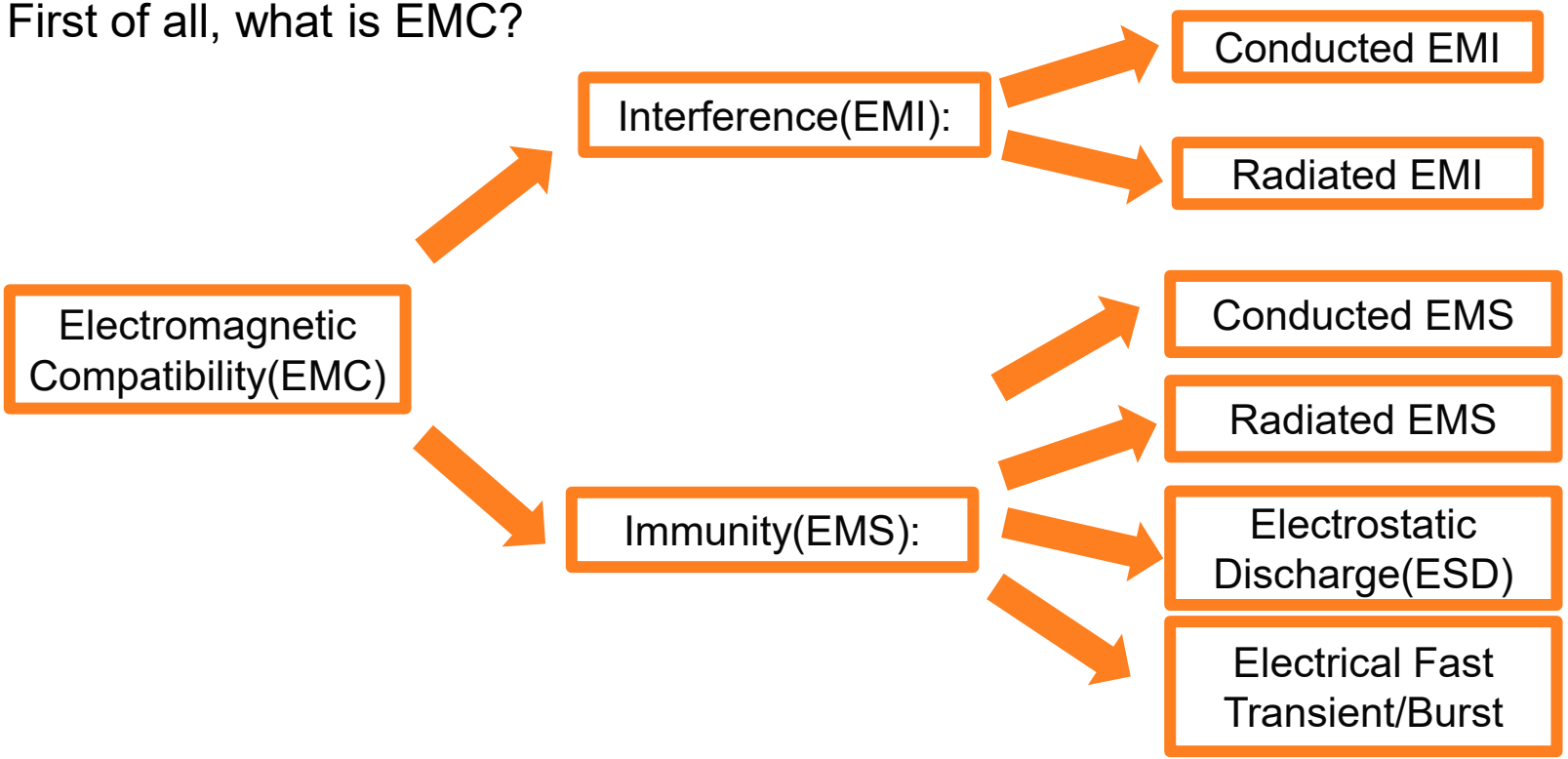
EMC/EMI-related products from Würth Elektronik to help the design



https://redexpert.we-online.com/

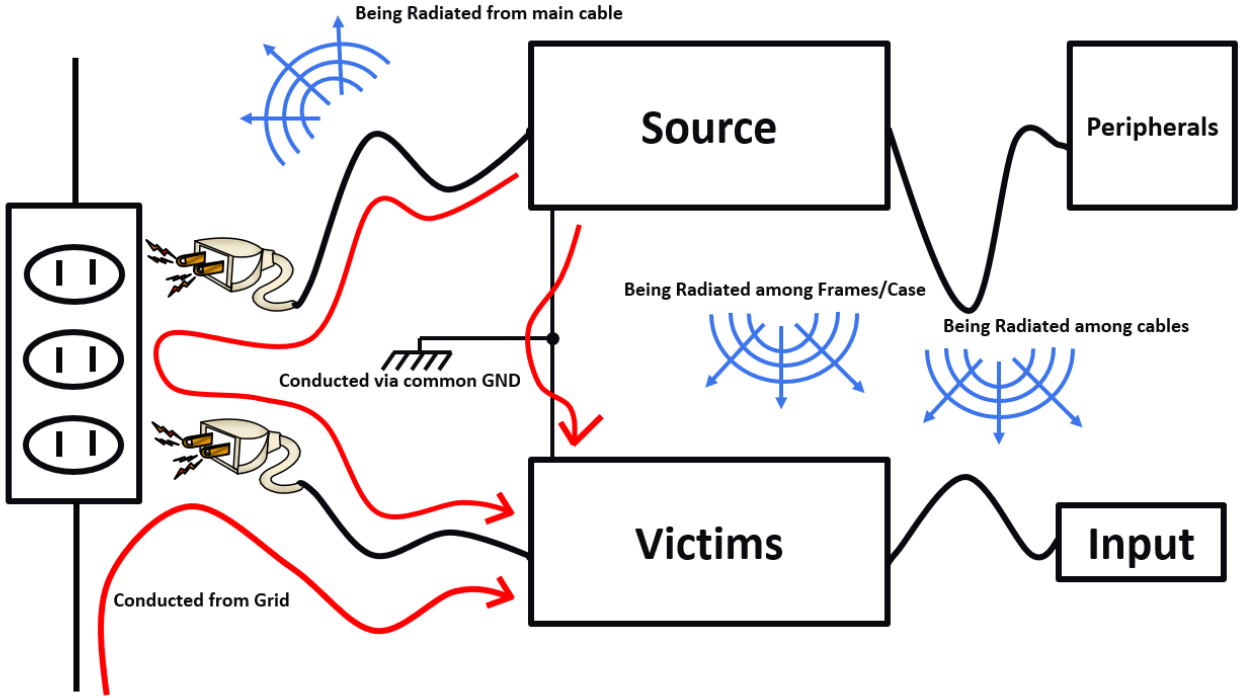
EMC/EMI Measurement Process / Trips and Tricks for EMC/EMI

- First of all, what is EMC?



EMC/EMI Measurement Process / Trips and Tricks for EMC/EMI

- If we were to visualize EMC on a system



EMC/EMI Measurement Process / Trips and Tricks for EMC/EMI

- 10Base-T1L in variable speed drivers
  - IEC 61800-3
    - IEC61000-4-x

Performance (acceptance) criterion	Description
A	Module shall continue to operate as intended. **No loss of function or performance even during the test**.
B	**Temporary degradation of performance during test** is accepted. After the test, module shall continue to operate as intended **without manual intervention.**
C	During the test, loss of functions accepted, but no destruction of hardware or software. After test, module shall continue to operate as intended automatically, **after manual restart, or power off, or power on. Not self-recoverable**.

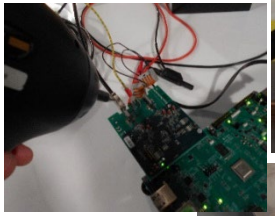
Port	Phenomenon	Basic standard	Level	Performance (acceptance) criterion
Enclosure ports	ESD	IEC61000-4-2	+/-4kV CD or 8kV AD, if CD not possible	B
	RF electromagnetic field amplitude	EC61000-4-3	80MHz to 1GHz, 10V/m, 80% AM (1MHz)	A
Power port	Fast transient Burst (EFT)	IEC61000-4-4	+/-2kV/5kHz or 100kHz (a)	B
	Surge 1,2/50us, 8/20us	IEC61000-4-5	+/-1kV (c) +/-2kV (d)	B
	Conducted RF	IEC61000-4-6	0.15-80Mhz, 10V, 80% AM (1kHz)	A
Power interface	Fast transient Burst (EFT)	IEC61000-4-4	+/-2kV/5kHz or 100kHz, capacitive clamp	B
Signal interfaces	Fast transient Burst (EFT)	IEC61000-4-4	+/-1kV/5kHz or 100kHz	B
	Conducted RF	IEC61000-4-6	0.15-80Mhz, 10V, 80% AM (1kHz)	A
Ports for process measurement control lines	Fast transient Burst (EFT)	IEC61000-4-4	+/-2kV/5kHz or 100kHz	B
	Surge 1,2/50us, 8/20us	IEC61000-4-5	+/-1kV (d),(f)	B
	Conducted RF	IEC61000-4-6	0.15-80Mhz, 10V, 80% AM (1kHz)	A

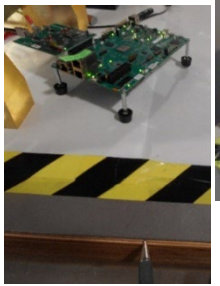
EMC/EMI Measurement Process / Trips and Tricks for EMC/EMI

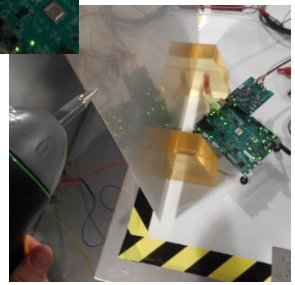
- Measurements carries out on the 10Base-T1L

IEC61000-4-2 ESD

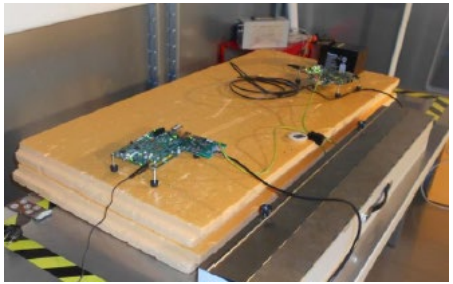
Contact and Air Discharge







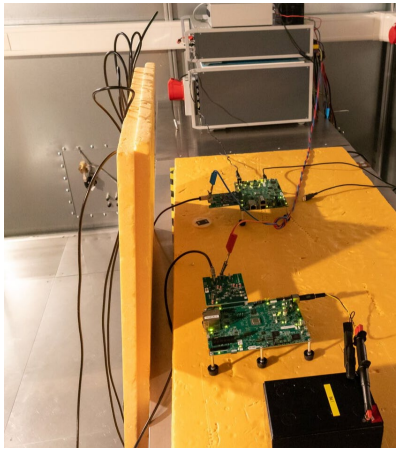
IEC61000-4-4 EFT



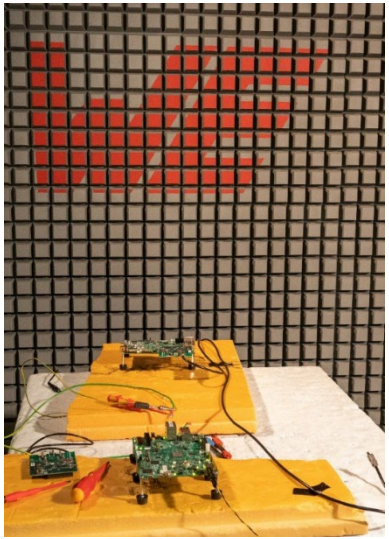
IEC61000-4-6 Conducted RF



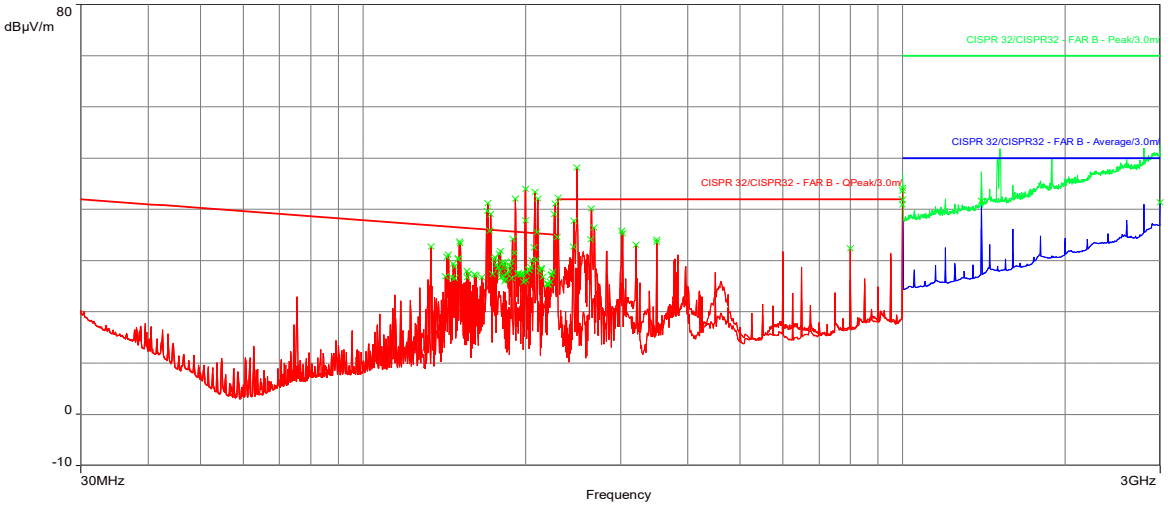
IEC61000-4-5 Surge

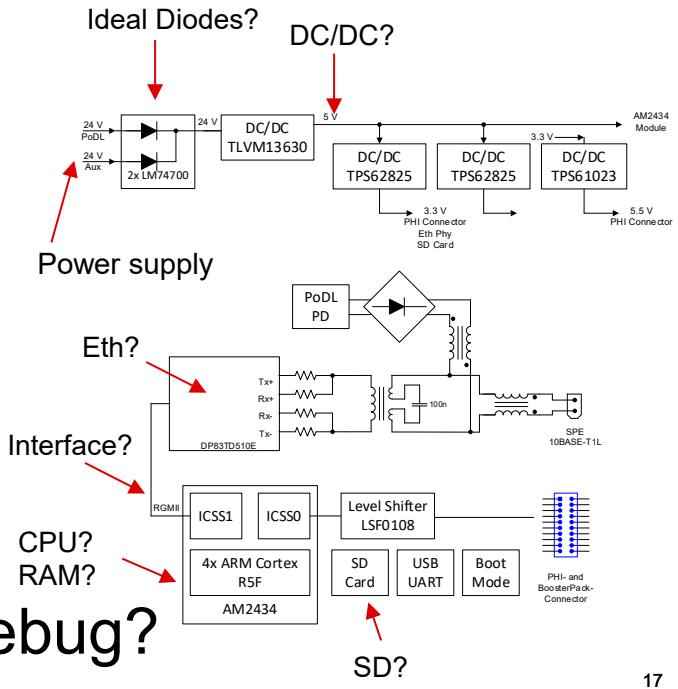


CISPR-32



EMC/EMI-related Issues Found in Sensor Board Design



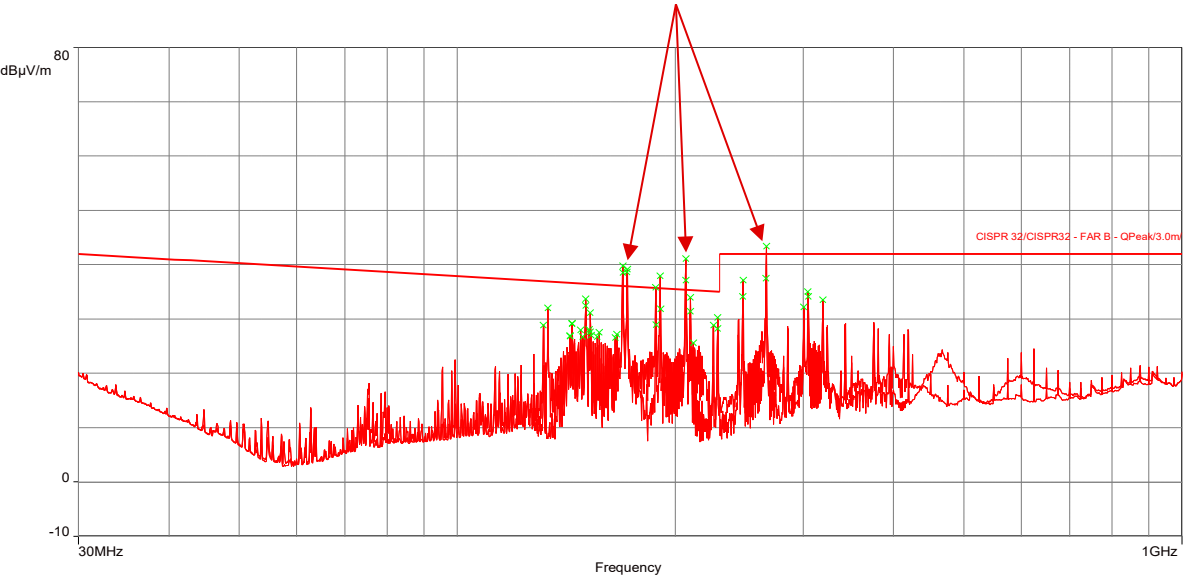


→ Fail, but how to debug?

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EMC/EMI-related Issues Found in Sensor Board Design

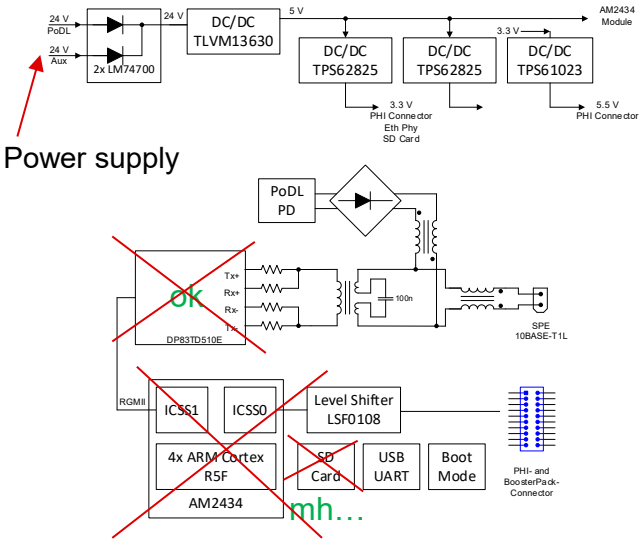
Some peaks are gone, but still a lot of noise



Looks like a problem of the power supply?

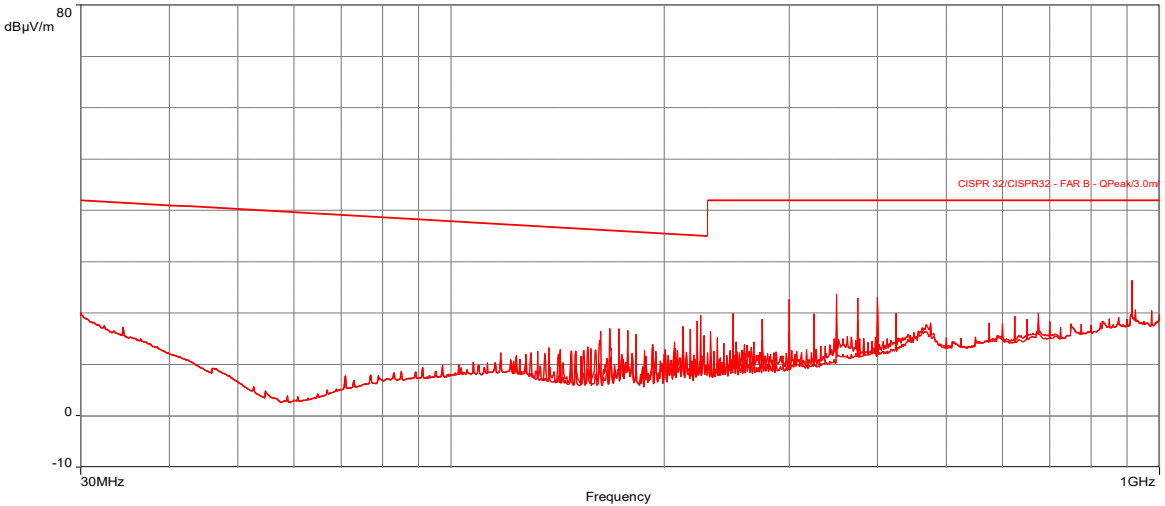
Disable SPE Phy + SD Card – no boot

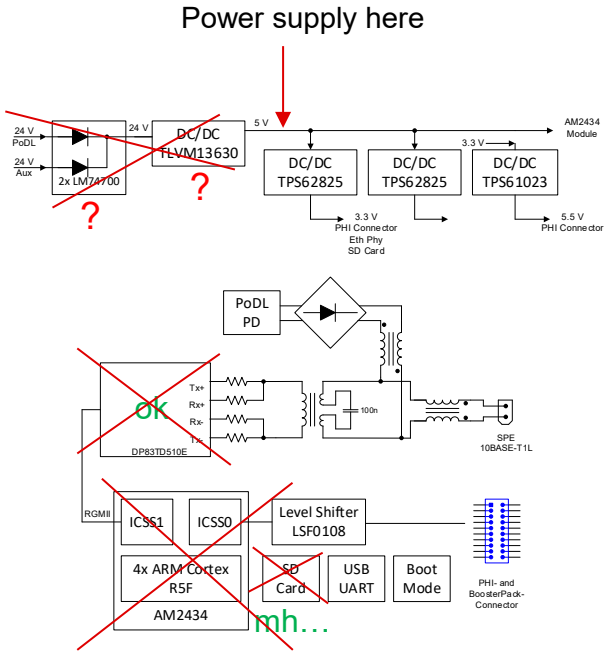
Power supply



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EMC/EMI-related Issues Found in Sensor Board Design

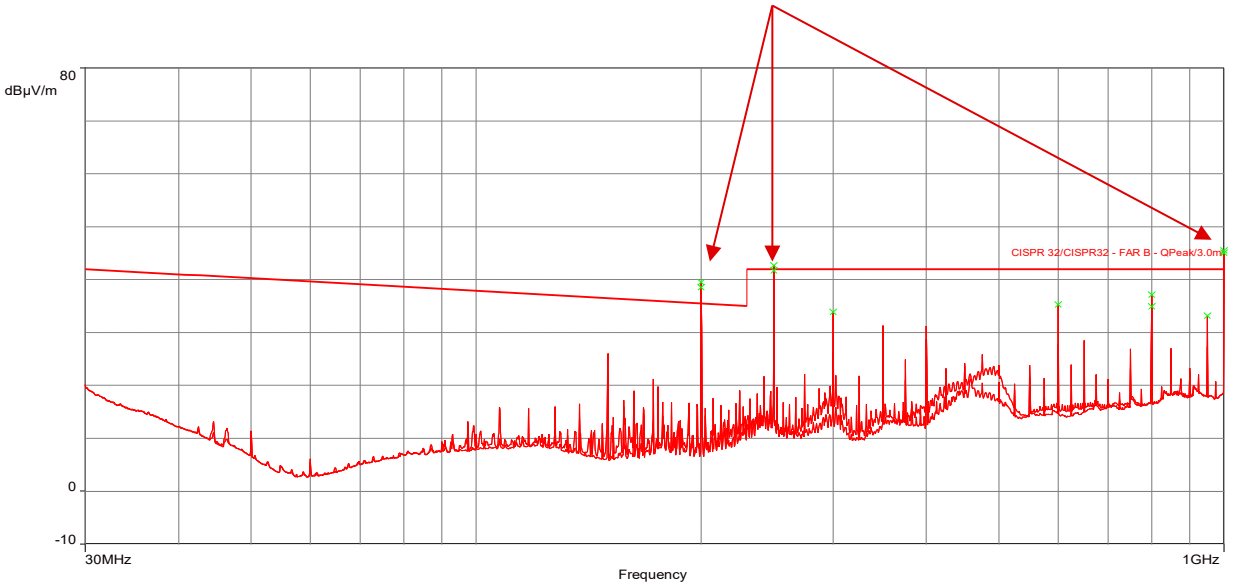




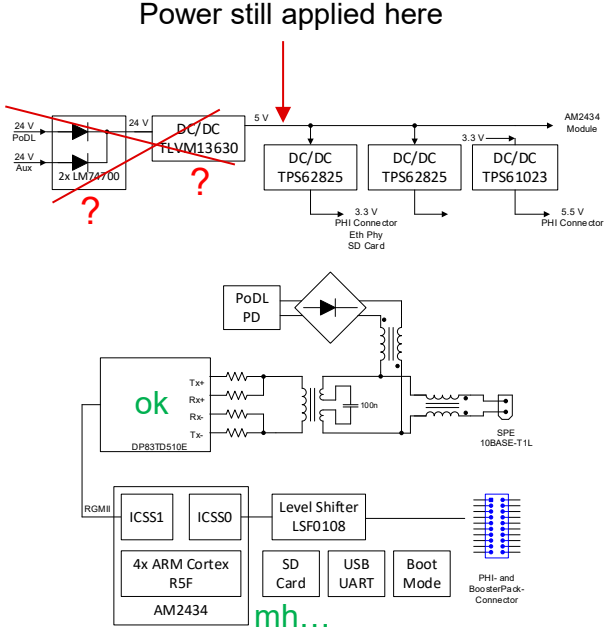
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EMC/EMI-related Issues Found in Sensor Board Design

200MHz / 250MHz / 1GHz – polarization dependent

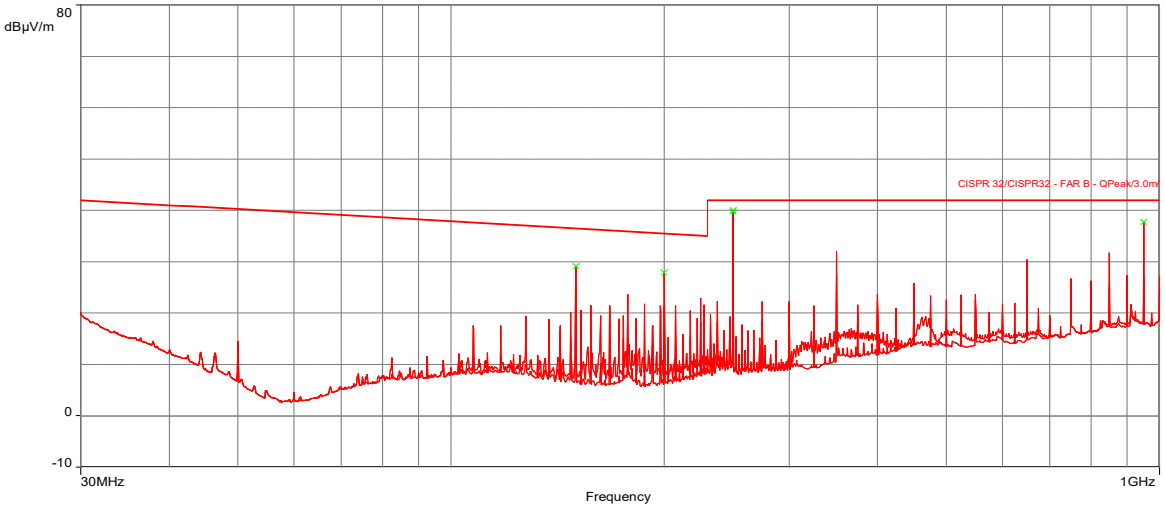


Power still applied here

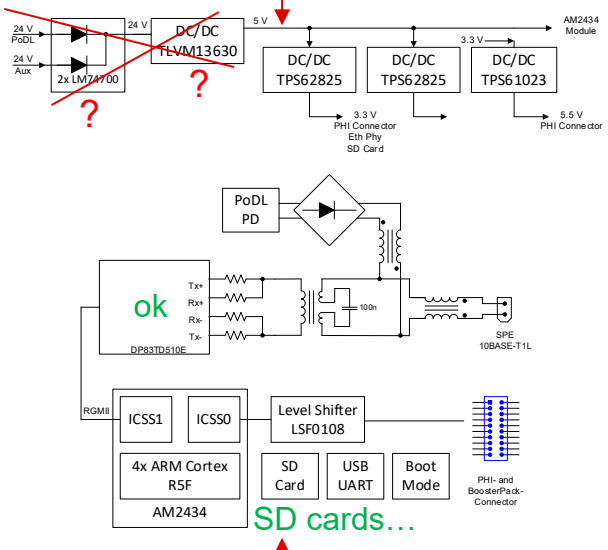


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EMC/EMI-related Issues Found in Sensor Board Design



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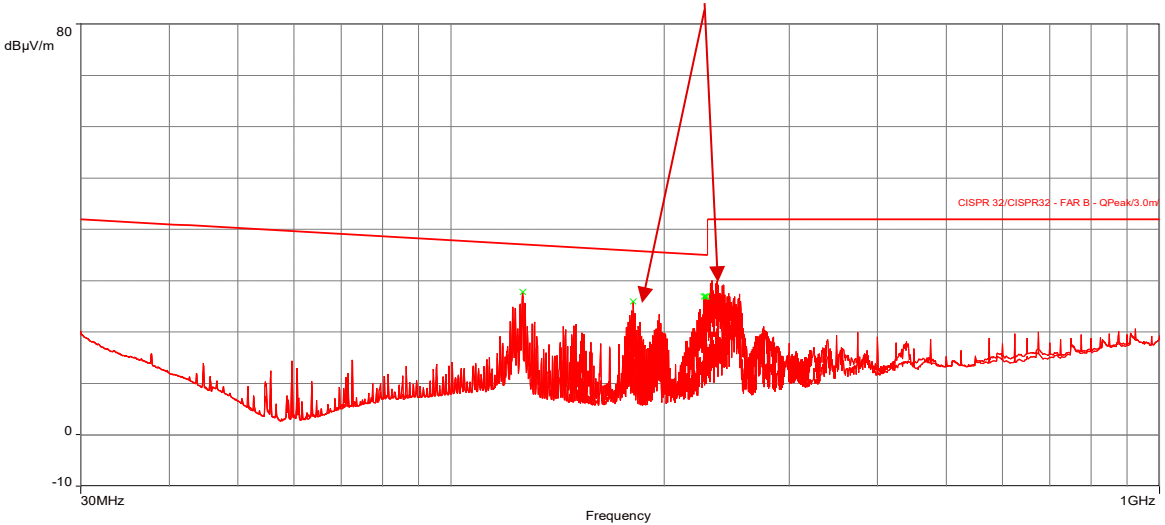


Series Termination + slower SD card

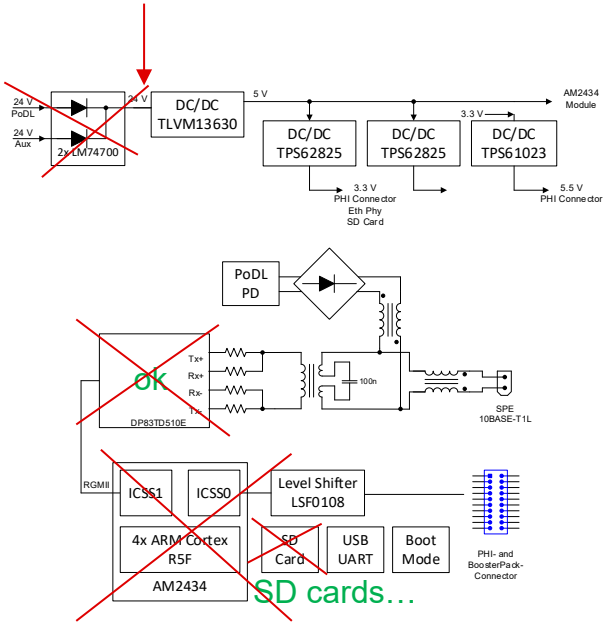
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EMC/EMI-related Issues Found in Sensor Board Design

Some noise from the DC/DC, might be coupled into cable from inductor



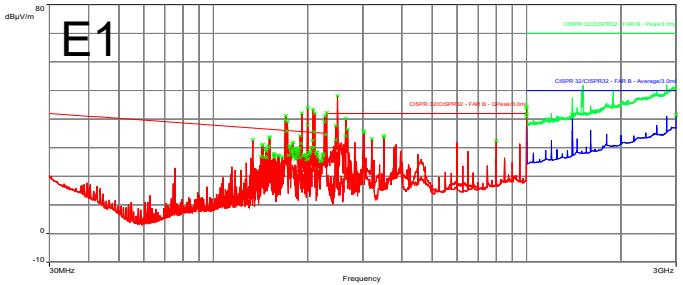
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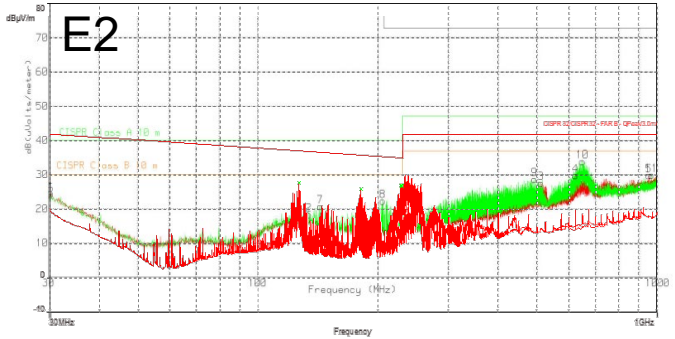


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Solutions and Revisions to Overcome EMC Problems

- Limitations observed on first sensor board (E1 of TIDA-010261) prototype.
  - CISPR32 – noise level above limits
    - Ideal diodes can be tricky; their internal charge pump generates interference that can reach up to 600 MHz. A missing input capacitor amplified this issue.
    - SD cards operate at a clock frequency of 200 MHz with a risetime of only 1 ns, necessitating matched length and impedance to minimize noise contamination.
    - For optimal performance, position the TPSM13630 part a safe distance from connectors, as the internal inductor can couple noise directly into power cables.
    - Disable all unnecessary clock outputs of PHYs to prevent unwanted interference. To further mitigate potential issues, do not connect these clocks to LEDs or pin headers





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Conclusion

- The importance of early-stage design and layout reviews to ensure optimal cost efficiency and avoid complicated product redesigns.
- Tackling EMC from an early stage with a focus on providing component provisions on the schematic that can be used in case of additional filtering needed.
- Careful understanding of how each component, especially DC/DC converters could influence the noise propagation in such a complex system.
- A lot of EMC/EMI issues can be avoided by taking care during design & layout
  - Stick to the good layout and schematic recommendations in the components datasheet
  - Take care of common rules, see EMC/EMI Compliant Design for Single Pair Ethernet (snla434)
  - Add additional parts like ferrite beads, TVS diodes, capacitors – if not needed they can easily be DNPed during test

Getting started

You can start evaluating the Edge System processing solutions leveraging the following:

Content type	Content title	Link to content or more details
Würth Elektronik EMC Labs	EMC laboratories at Würth Elektronik's Waldenburg and Munich locations in Germany	More Information
Product folder	AM243x / AM64x DP83867 / DP83826AI	AM2434 / AM6442 DP83867IR, DP83826AI
Reference design	Sensor Board Gateway Board	TIDA-010261 TIDA-010262
Technical blog content or white paper	Using Vibration Monitoring, Edge AI and SPE/PoDL for Predictive Maintenance PoDL PD and PSE Application note	Blog post PD PSE
Selection and design tools and models	MCU-PLUS Software Dev Kit (SDK) Industrial Communications SDK	MCU-PLUS-SDK-AM243X INDUSTRIAL-COMMUNICATIONS-SDK-AM243X
Development tool or evaluation kit	Code Composer Studio	CCSTUDIO
Customer training series or webinar session	AM24x academy	AM24X-ACADEMY