DESIGNING QI2 WIRELESS POWER SYSTEMS: PRACTICAL DEVELOPMENT AND EMC OPTIMIZATION

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WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

CONTENTS

- Building a Qi2 transmitter from scratch
- Introducing the WE Qi2 TX coil and tips for effective Integration
- Measurement and reduction of conducted and radiated interference through systematic filter design

COMPONENTS OF A QI2 SYSTEM

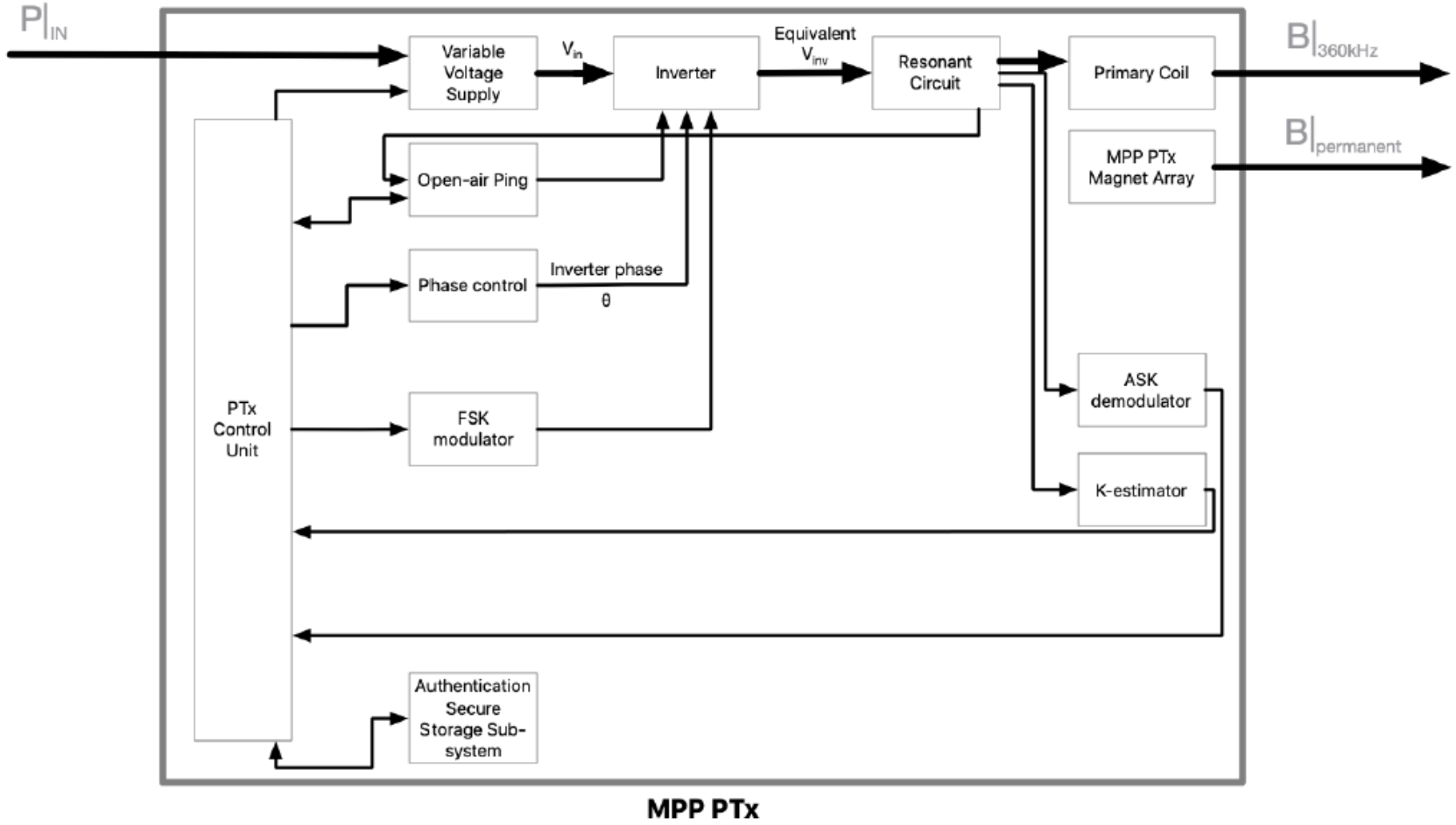
- Input power supply (e.g., USB Type-C PD or DC adapter): Provides the energy for the entire system.
- EMC filter (e.g., LC filter or ferrites): Ensures compliance with electromagnetic compatibility and filters out unwanted interference.
- Buck-boost converter: Converts the input voltage into the desired supply voltage for the power electronics and regulates it depending on the load requirements.
- Power full-bridge/inverter: Generates the high-frequency AC signal for the transmission coil using MOSFETs and drivers.
- Qi2 transmitter coil (magnet structure according to MPP): Inductively transmits energy to the receiver, typically with a magnet system for localization and efficiency enhancement.
- Wireless charging controller IC (e.g., Infineon WLC1115): Controls the entire power delivery, control loops, signal demodulation, communication, as well as protection mechanisms and interfaces (IC includes FSK modulator, Foreign Object Detection (FOD), overvoltage protection, Q-factor detection, and temperature monitoring).

COMPONENTS OF A QI2 SYSTEM

- Trust/Security IC (e.g., Optiga Trust Charge IC from Infineon): Authenticates the sender according to Qi2 security requirements and protects against tampering.
- ASK Demodulator and Signal Processing: Decodes data communication from the receiver and processes feedback signals for regulated power transfer.
- Sensors & Protection (e.g., current/voltage/temperature sensors, FOD): Monitors critical system parameters and protects against fault conditions.
- Communication Interfaces (I2C, UART, USB-PD): Enable external connection and control, especially for authentication and data transfer.

QI 2 STANDARD TX SETUP

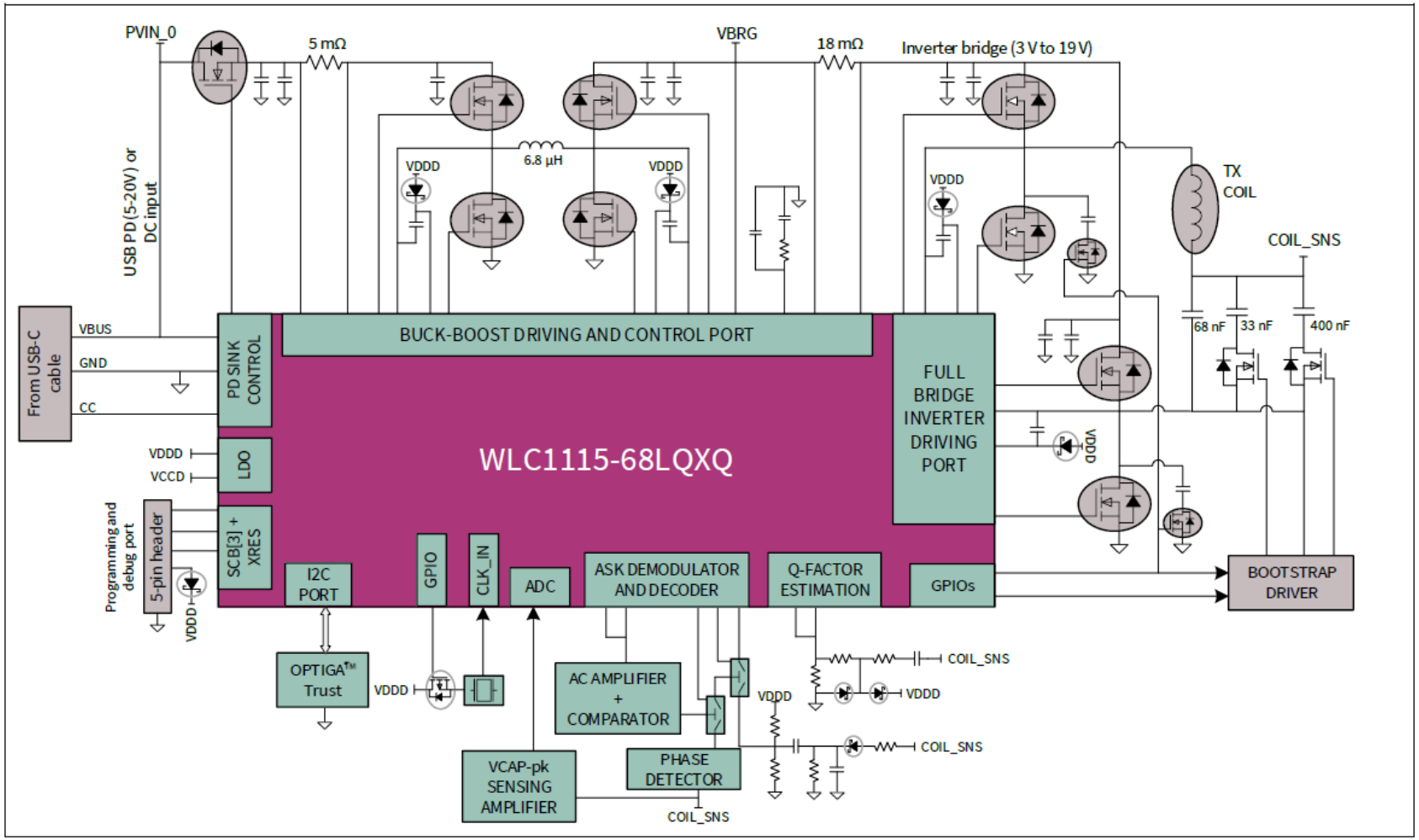
Function diagram, Source: WPC Qi 2 specifications



QI 2 TX KEY COMPONENTS

Qi 2 transmitter design, based on the Infineon WLC1115 Qi 2 IC

- Buck boost converter
- Full bridge inverter
- Q-factor estimation circuit
- LC resonant tank
- ASK demodulator



BUCK-BOOST CONVERTER

V_{IN} = 5V, 9V, 15V, 20V (USB-C PD)

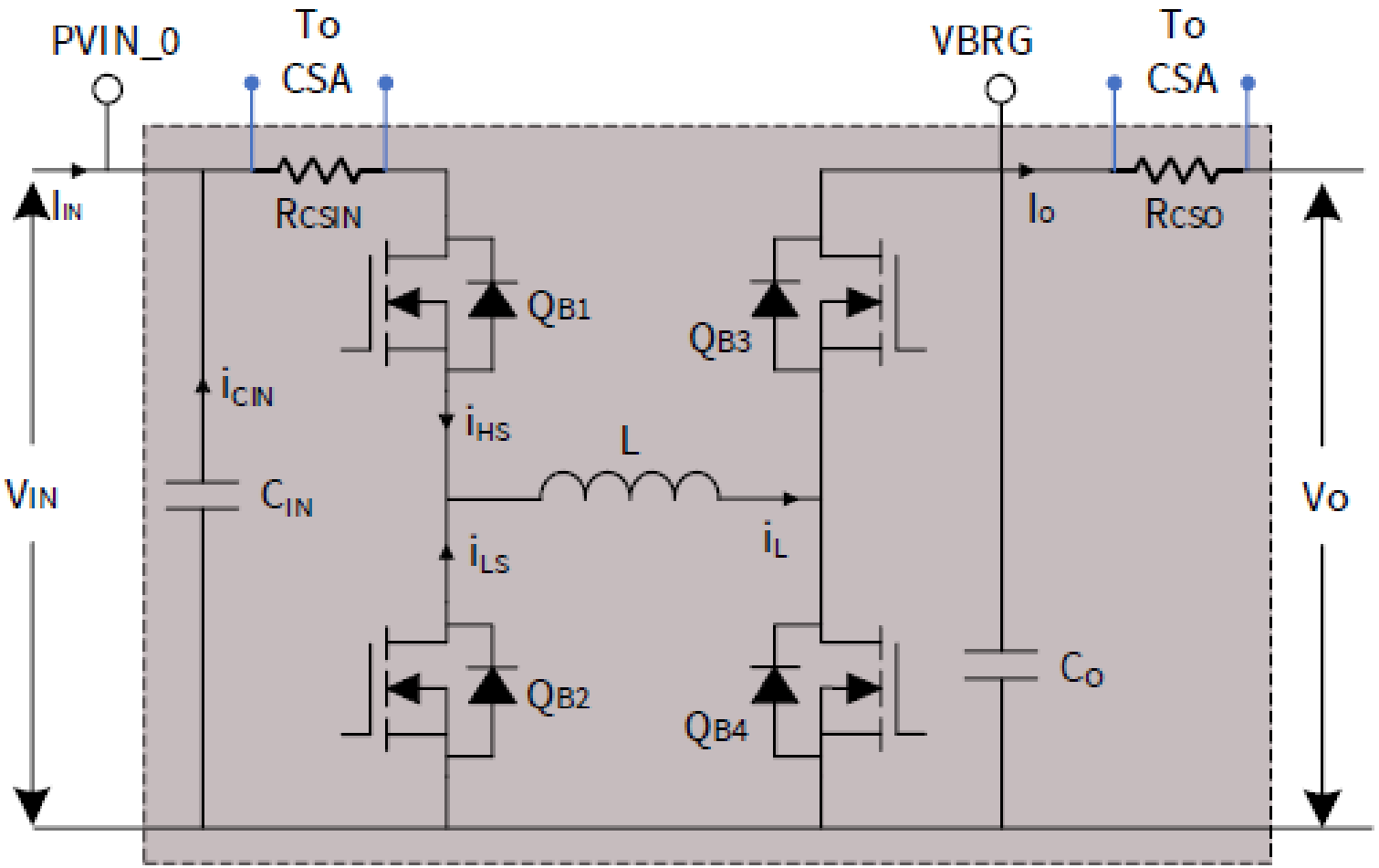
V_O = 3V - 24 V

- Buck mode:

V_{IN} >> V_O: Boost leg deactivated by keeping Q_{B3} always on and Q_{B4} always off

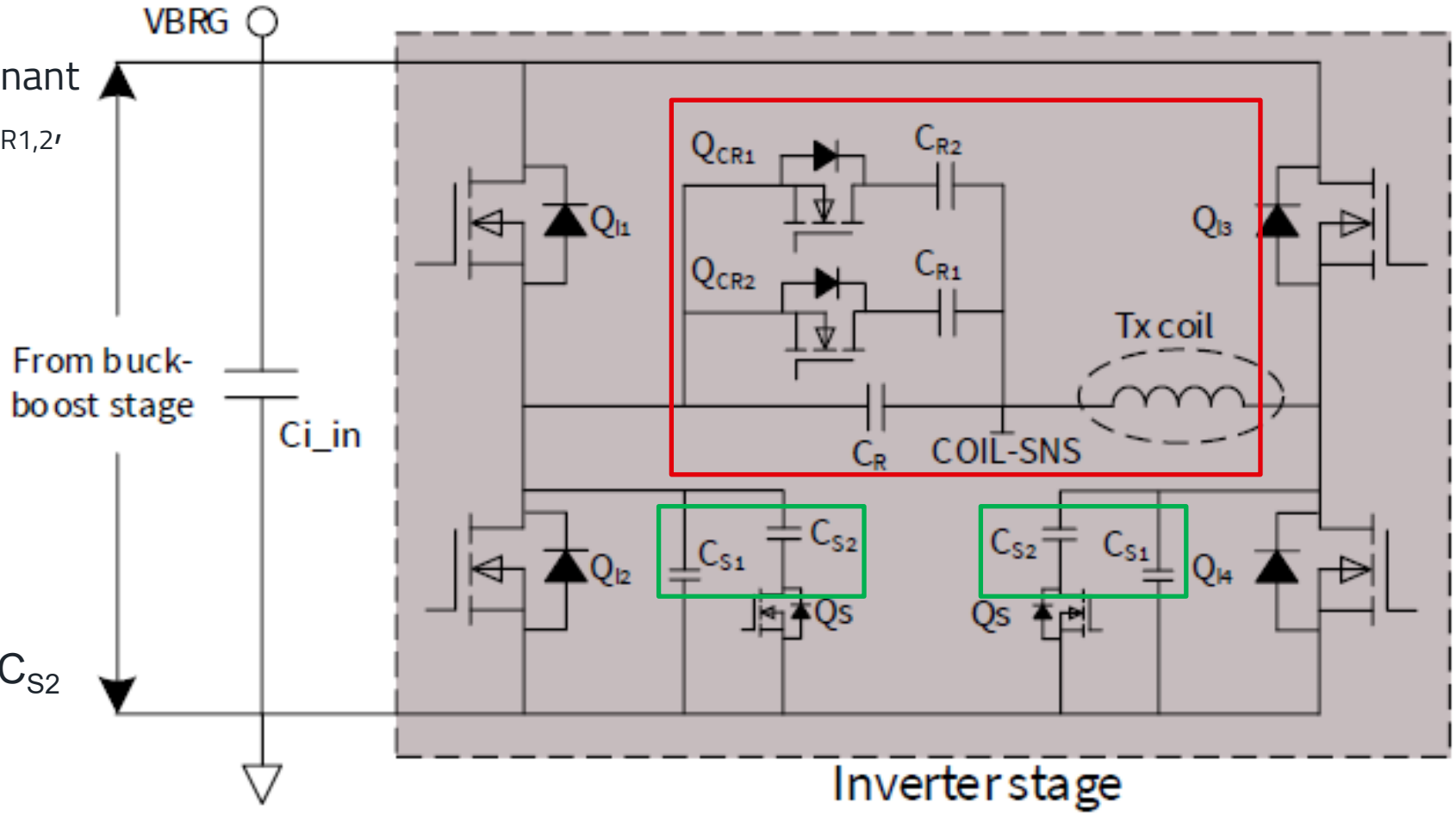
- Boost mode:

V_{IN} << V_O: Buck leg deactivated by keeping Q_{B1} always on and Q_{B2} always off



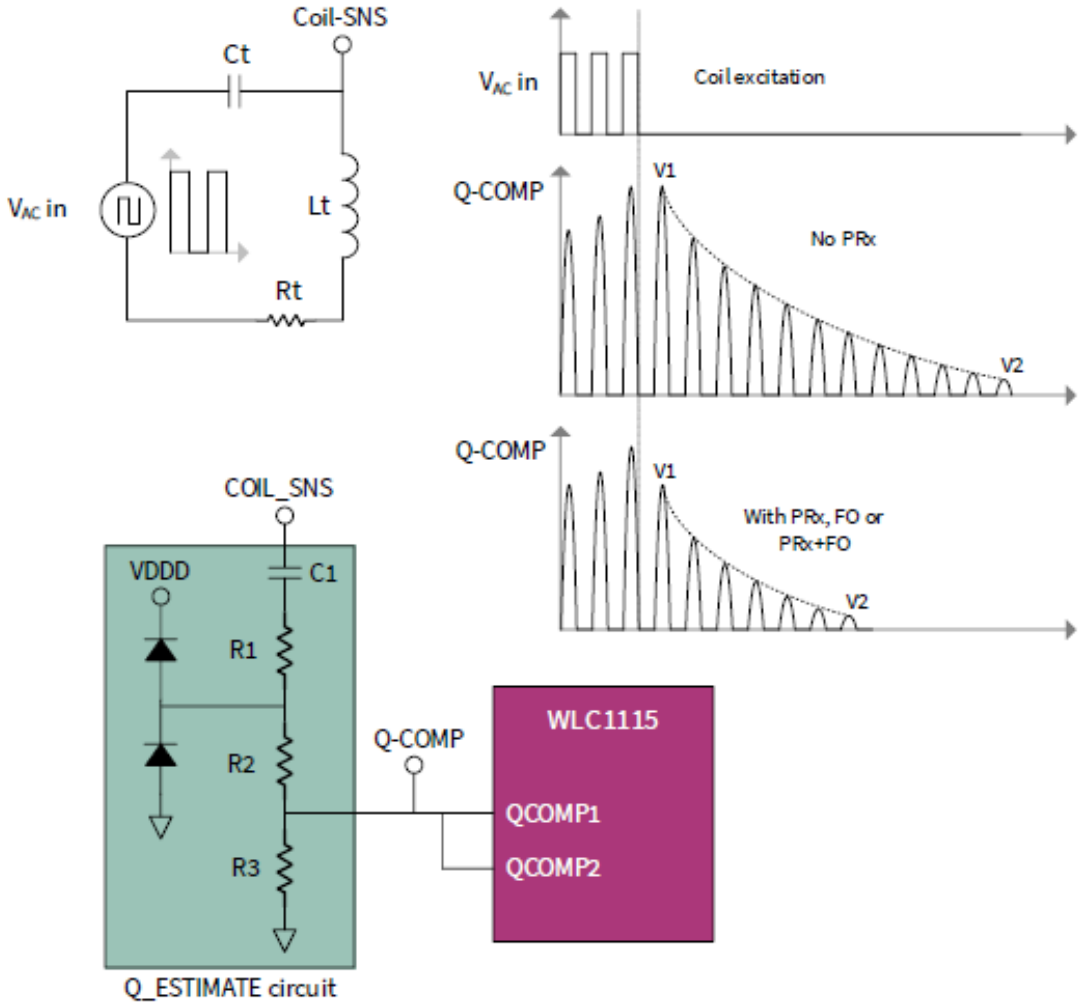
INVERTER

Full-bridge inverter with LC resonant tank (resonant tank capacitors $C_{R1,2}$, switching MOSFETs $Q_{CR1,2}$ and WPT coil)



Snubber capacitances C_{S1} und C_{S2} to reduce dV/dt during MOSFET-switching

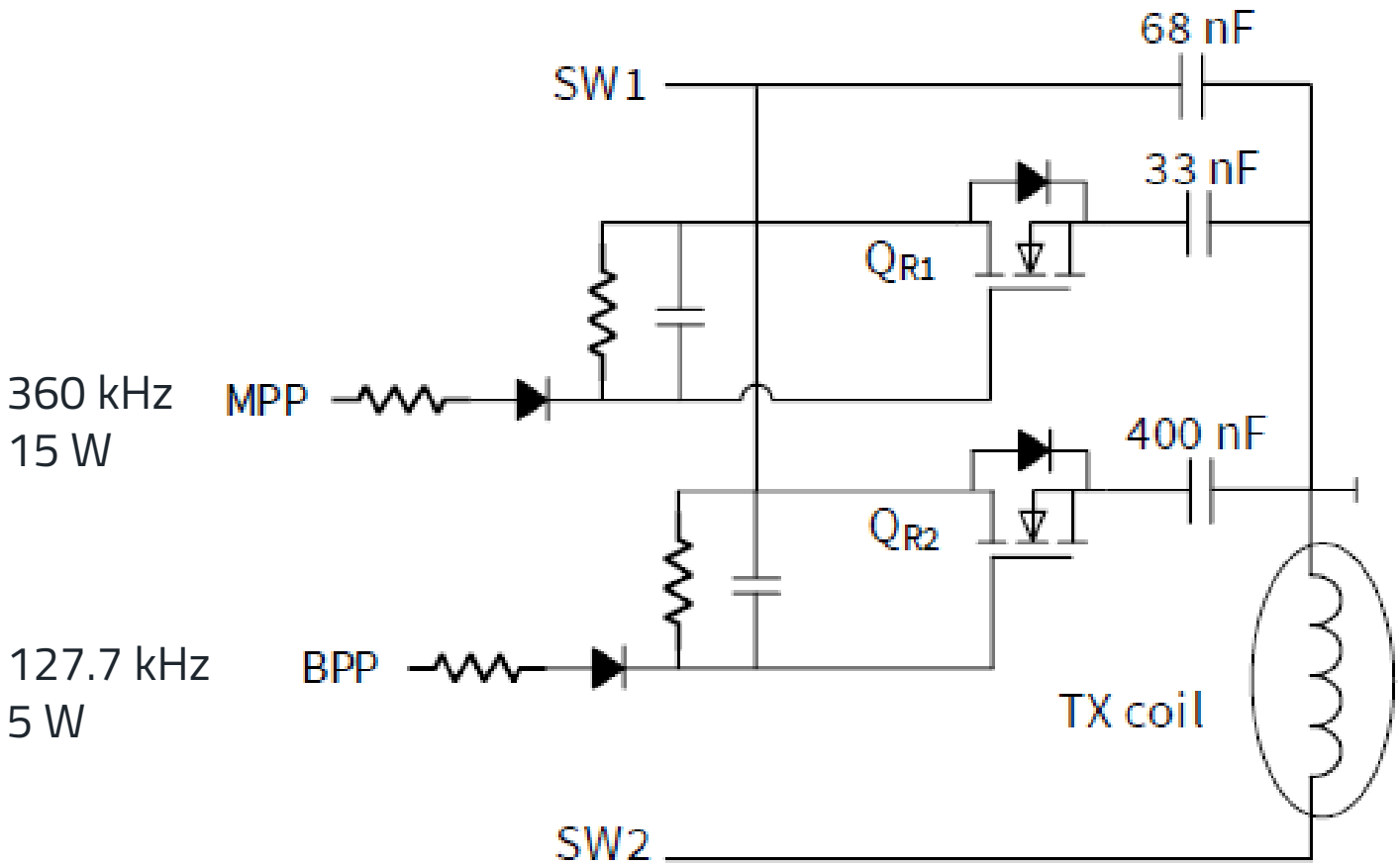
Q-FACTOR ESTIMATION CIRCUIT



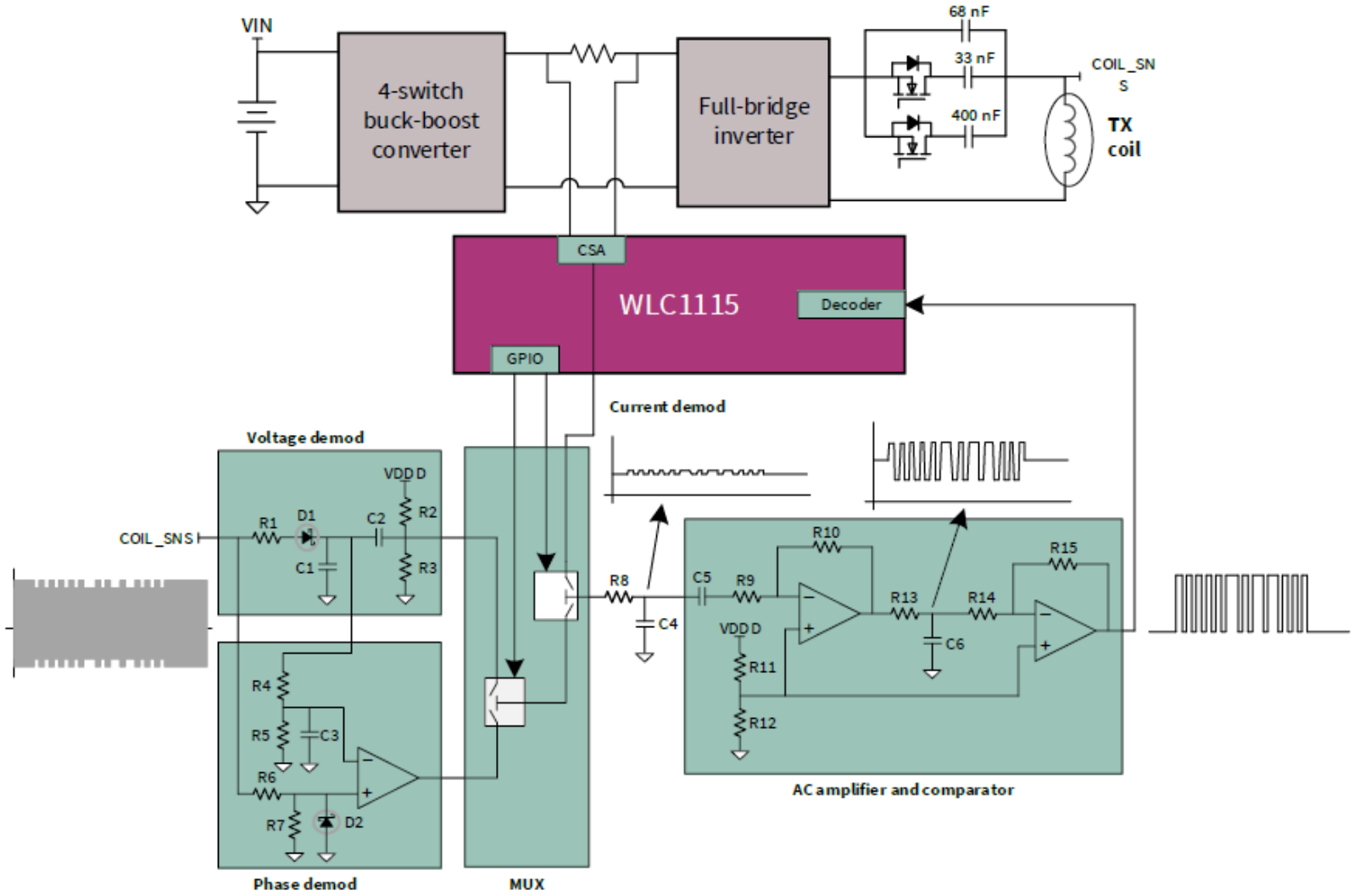
$$Q = \frac{\pi\,(t_2 - t_1)\,F_r}{\ln\left(\frac{V_1}{V_2}\right)} = \frac{\pi\,N}{\ln\left(\frac{V_1}{V_2}\right)}$$

LC RESONANT TANK

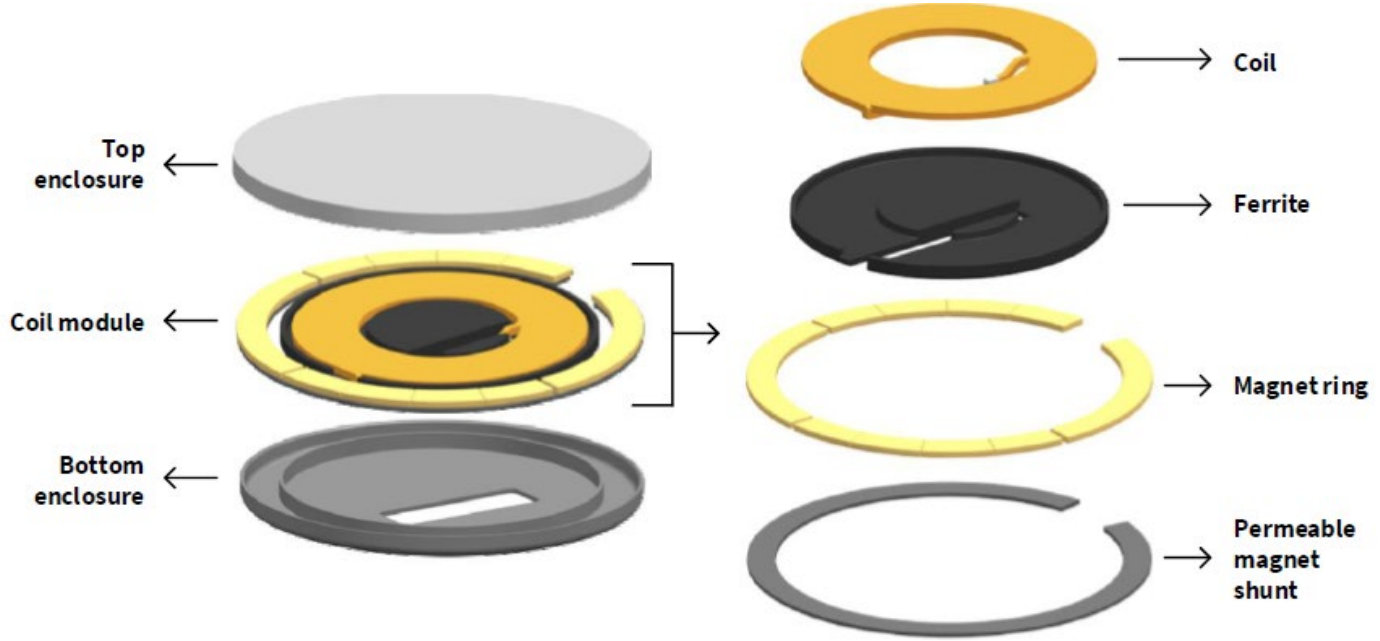
Resonant capacitors selection

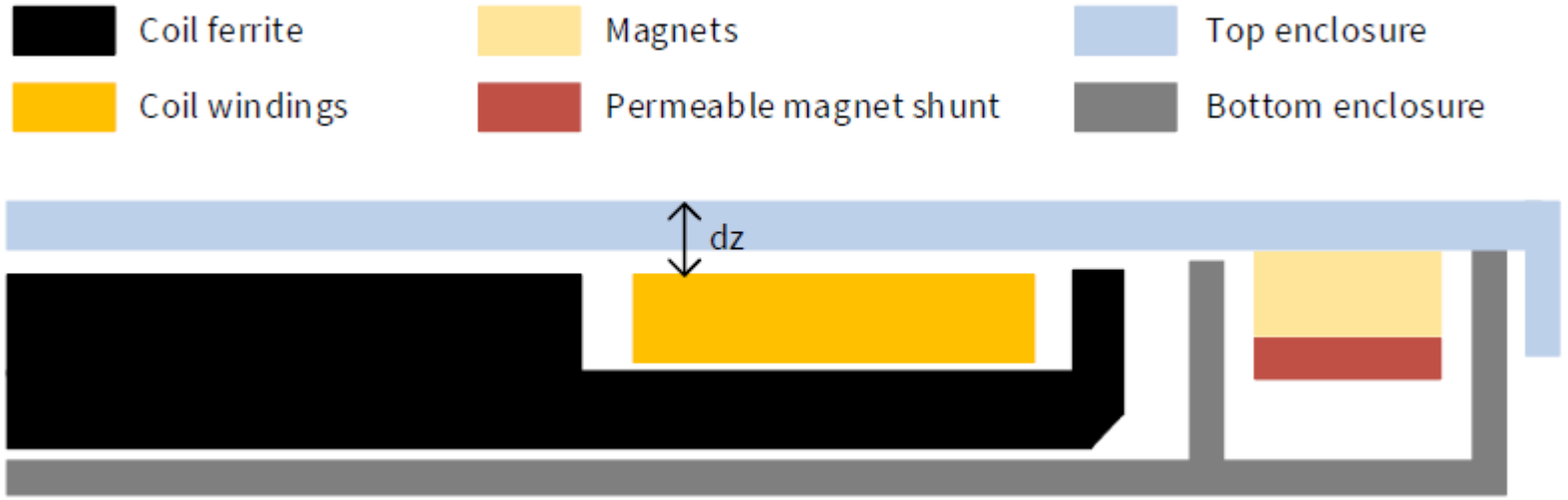


ASK DEMODULATION CIRCUIT

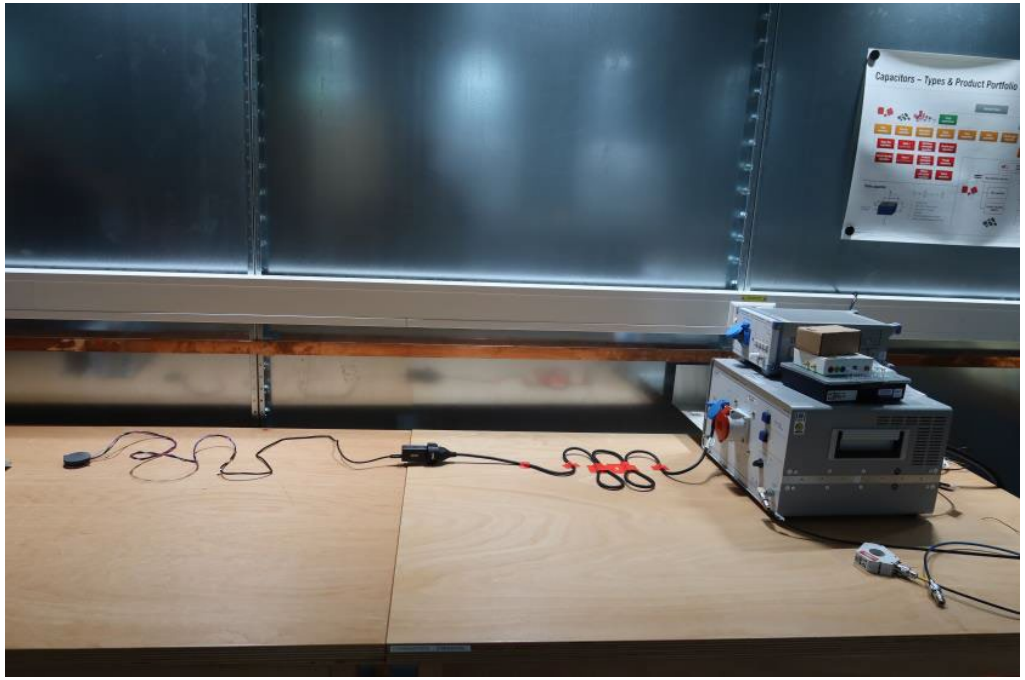


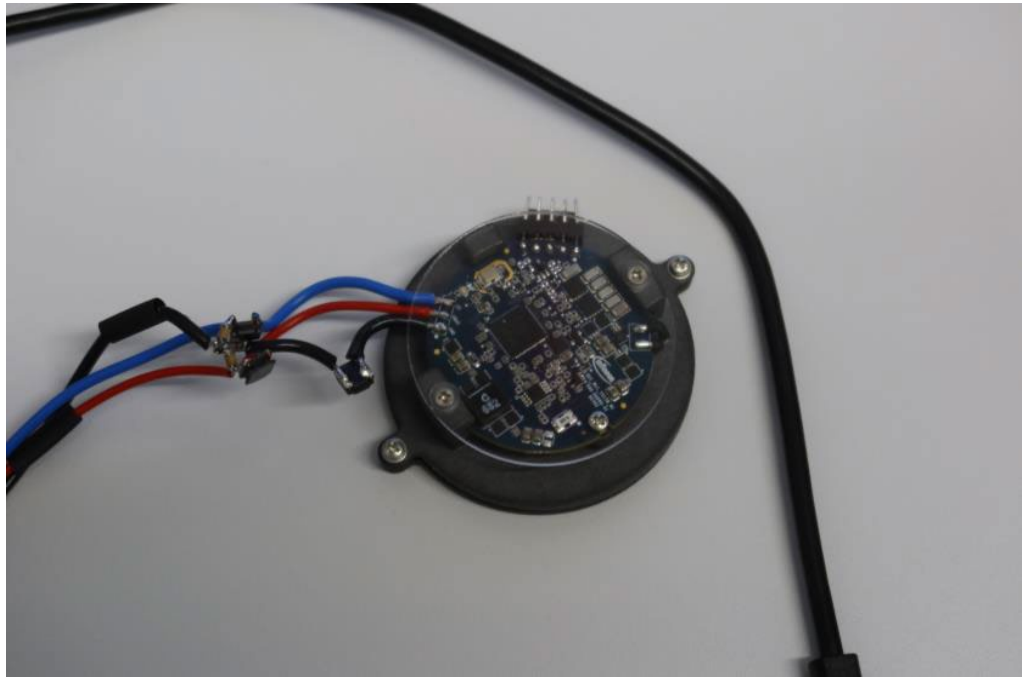
WE QI 2 TX MPP COIL





FILTERDESIGN



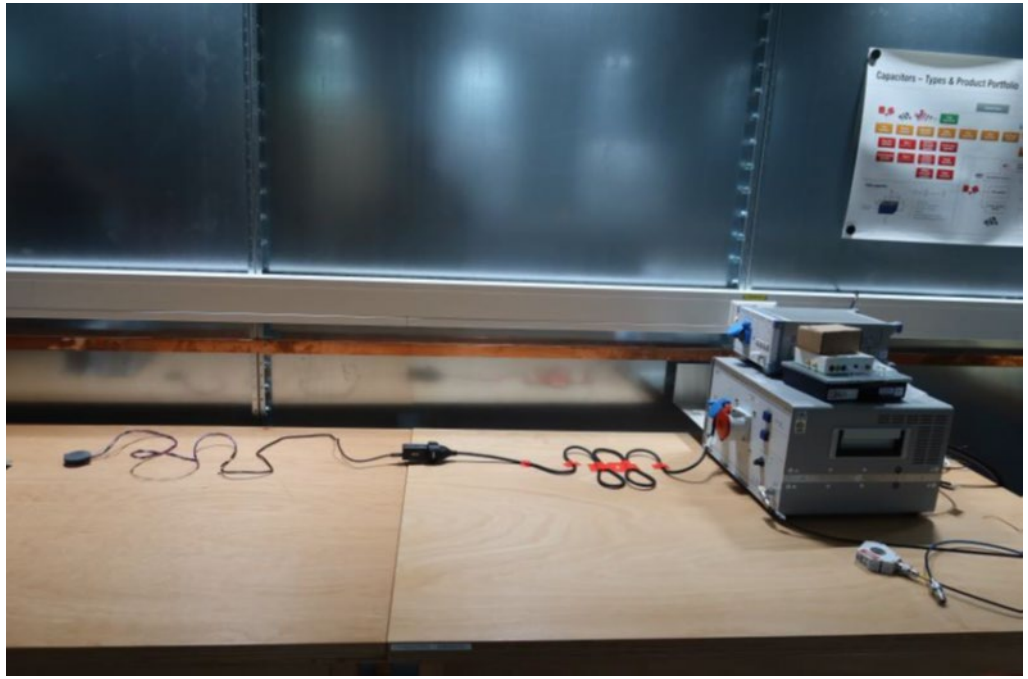


FILTERDESIGN

Measurement and reduction of conducted and radiated interference through targeted filter design

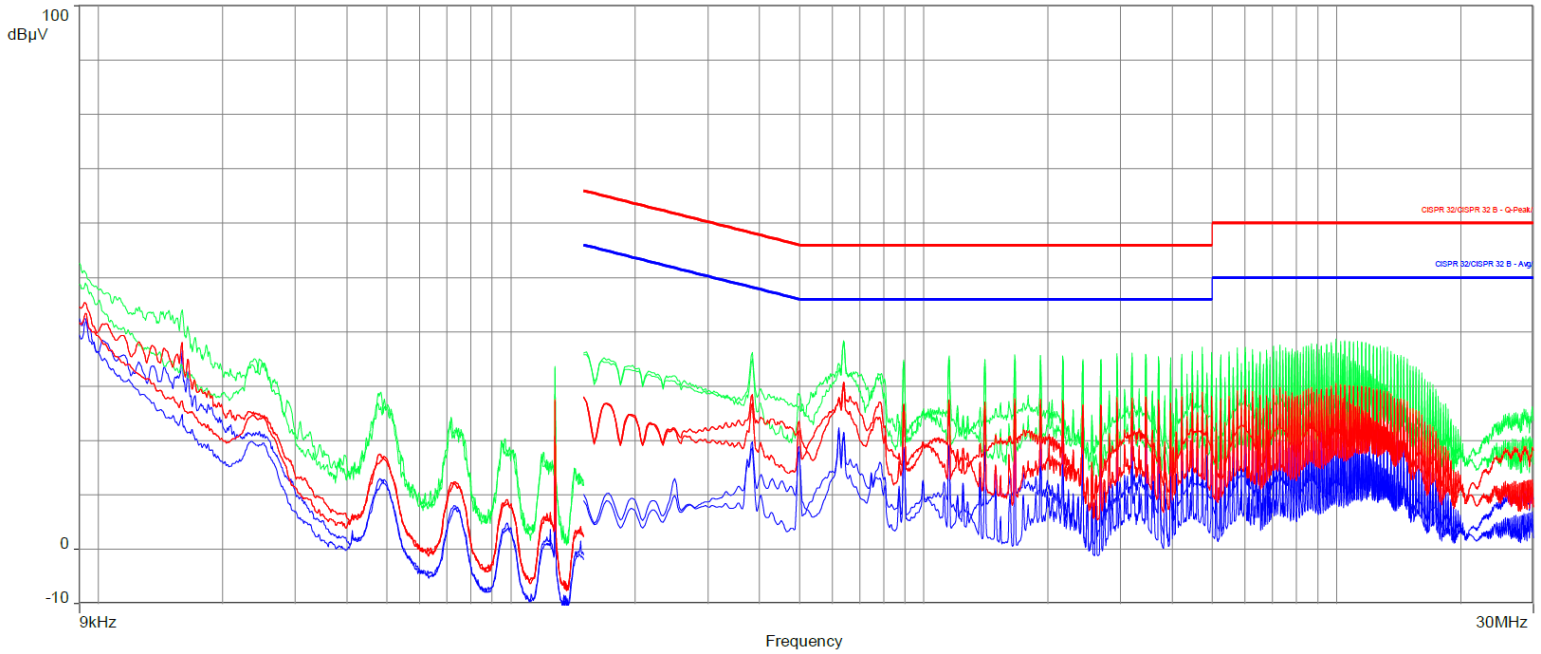
- EMC test according to CISPR 16-2-1
- Limit lines from CISPR 32 class B
- Conducted emissions

- Mains power supply wich is part of the equipment
- USB Type-C cable with three lines
  - VCC
  - GND
  - CC



FILTERDESIGN

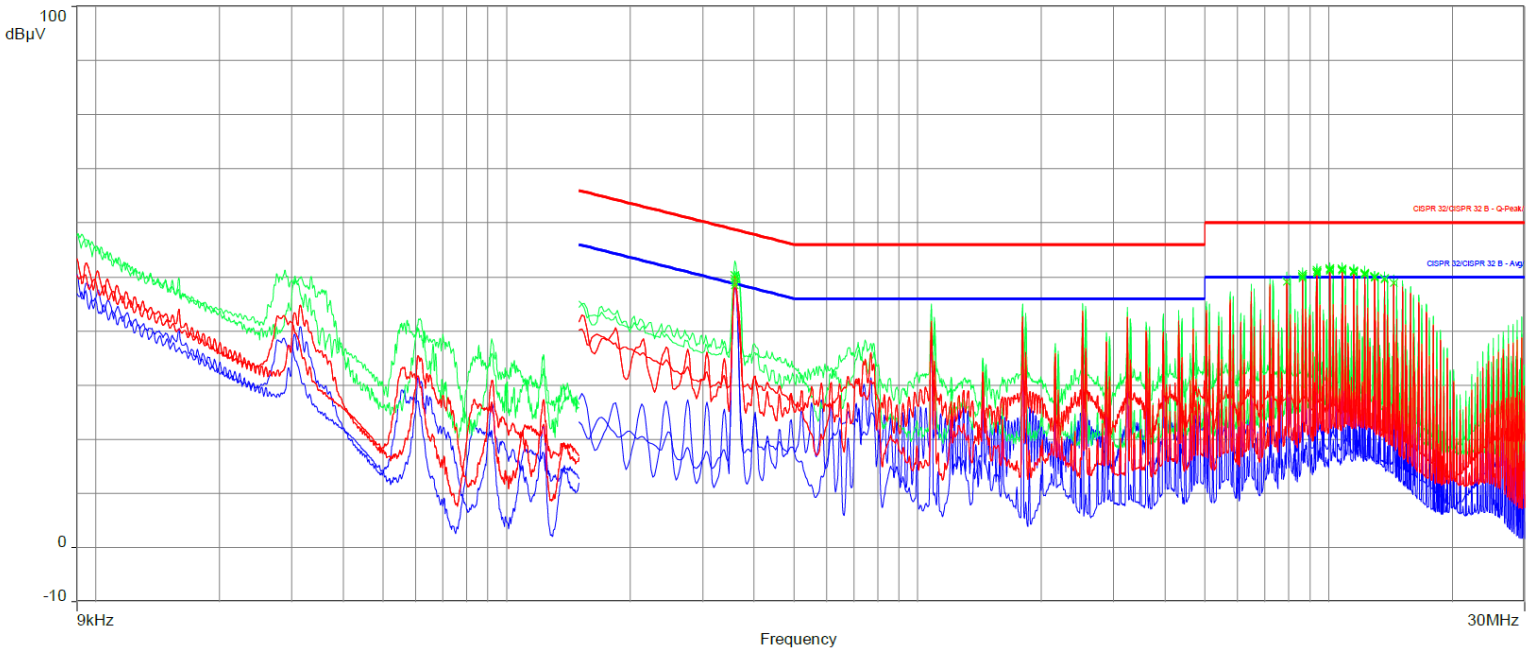
Measurement and reduction of conducted and radiated interference through targeted filter design



- CISPR 32, conducted voltage emission, class B
- Global graph (both L1 and N)
- New in standard: measurement from 9kHz to 150kHz
- Standby mode
- Pass

FILTERDESIGN

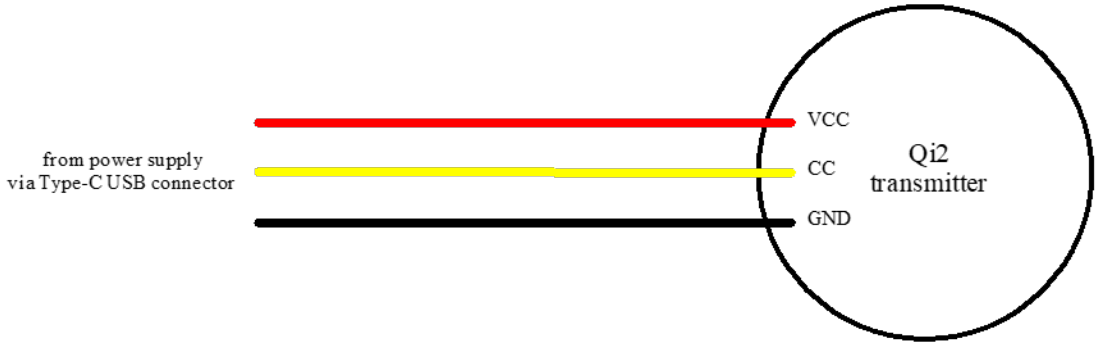
Measurement and reduction of conducted and radiated interference through targeted filter design

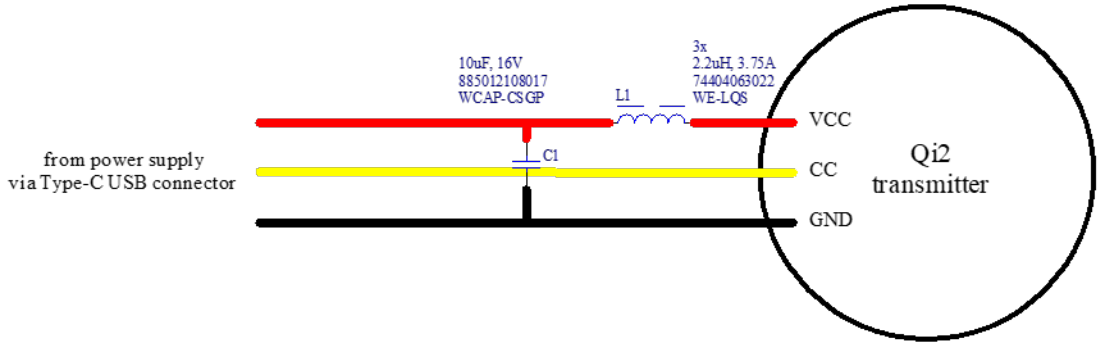


- Charging Mode with mobil phone, 80% charging level of battery
- Fail at some frequencies (AVG)

FILTERDESIGN

Measurement and reduction of conducted and radiated interference through targeted filter design





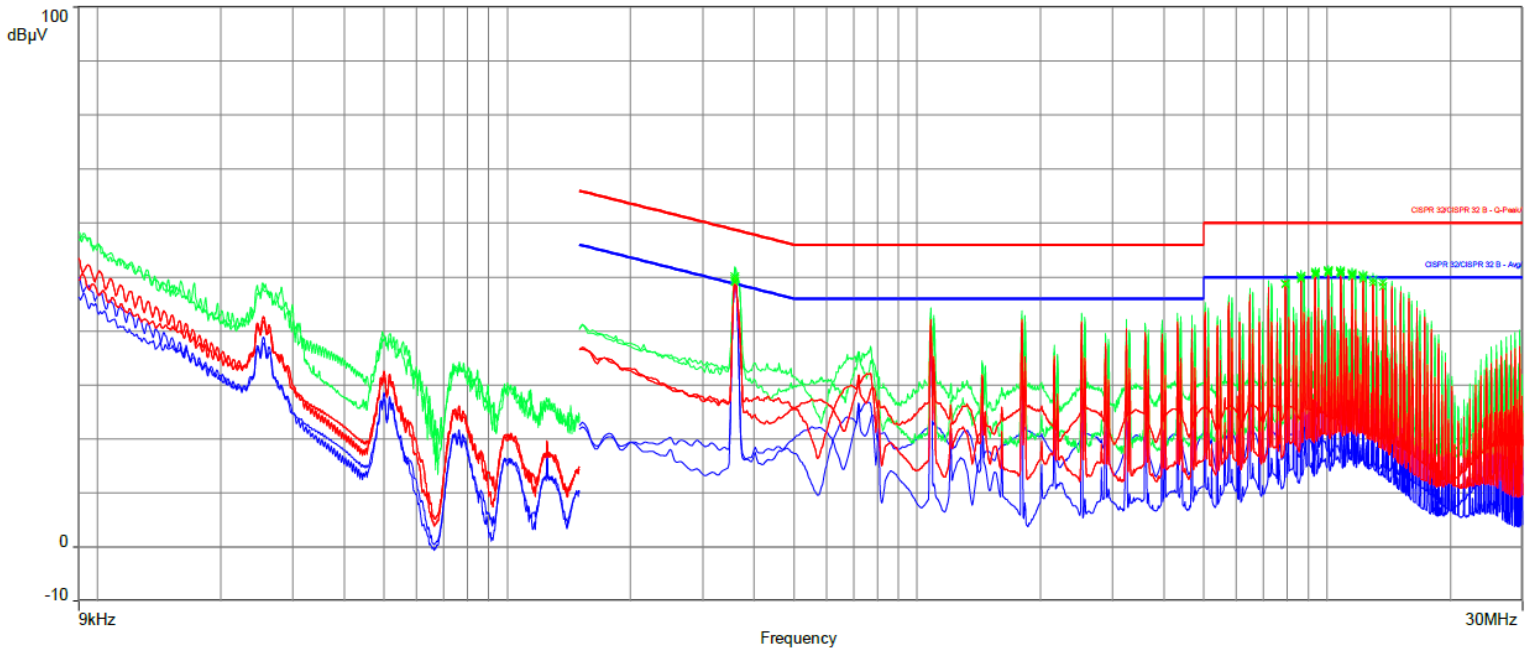
- Filter for VCC-line to reduce the base frequency
- LC-filter close to the eval board

- L1: 2.2µH inductor
- C1: 10µF capacitor

- Filtering at 360kHz with apr. 40dB

FILTERDESIGN

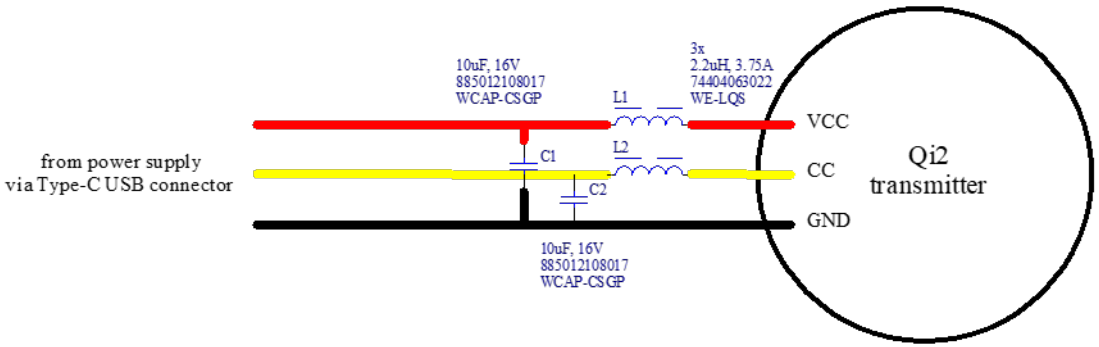
Measurement and reduction of conducted and radiated interference through targeted filter design



- Charging Mode with mobil phone, 80% charging level of battery
- LC-Filter to positive supply line close to the eval-board
- Fails again

FILTERDESIGN

Measurement and reduction of conducted and radiated interference through targeted filter design

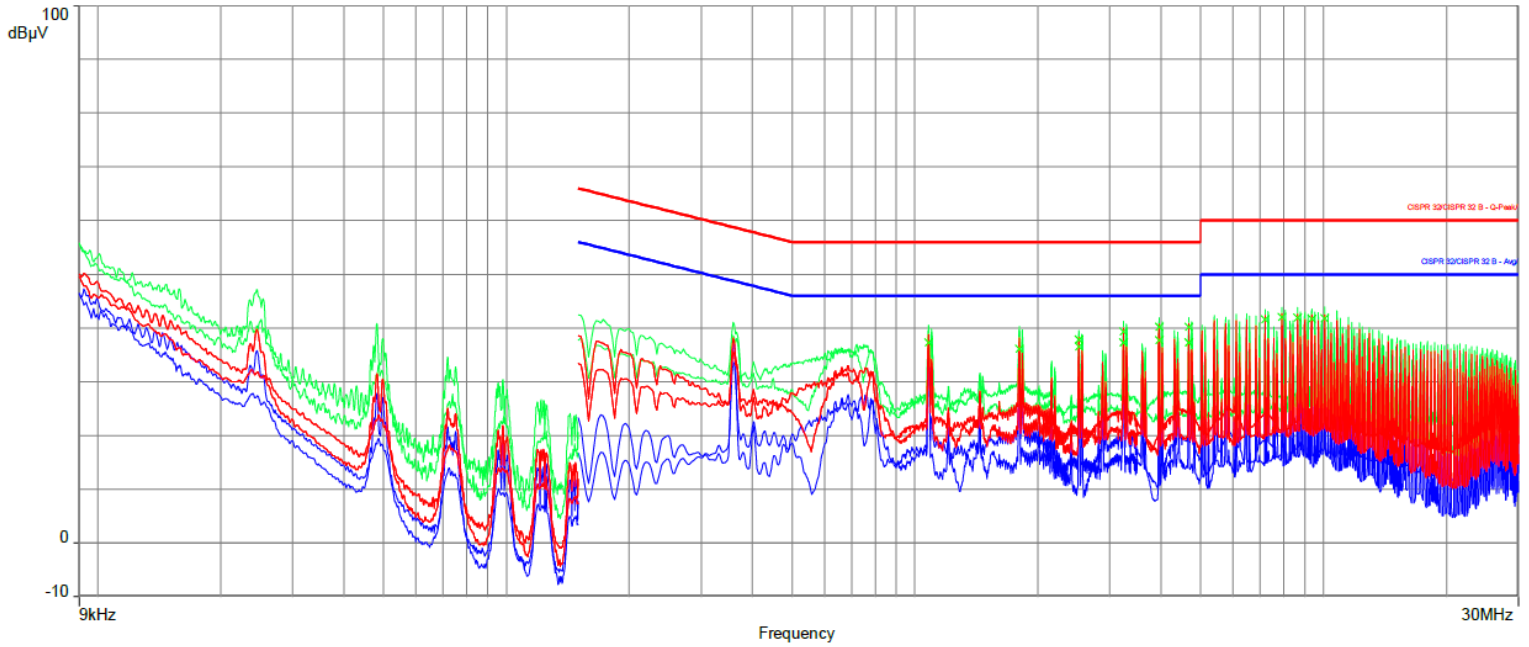


- L1, L2: 2.2µH inductor
- C1, C2: 10µF capacitor

- Filtering both lines because of coupling effects to CC-line

FILTERDESIGN

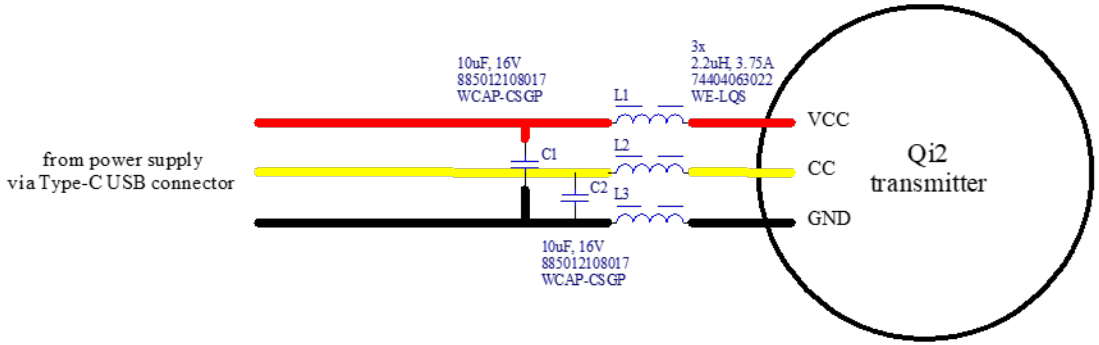
Measurement and reduction of conducted and radiated interference through targeted filter design

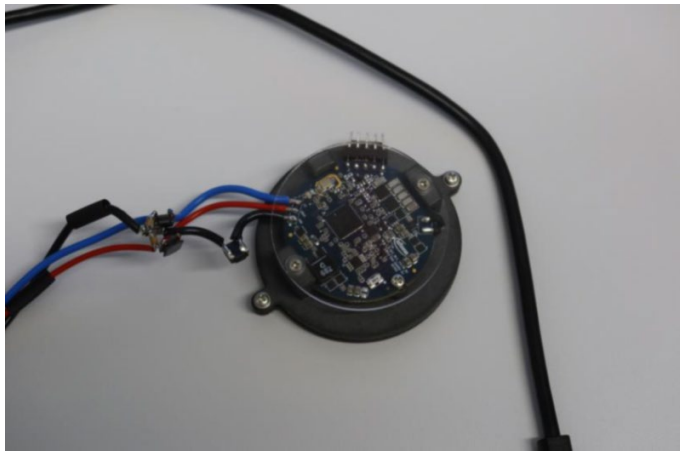


- Charging Mode with Mobil Phone, 80% charging level of battery
- LC-Filter to positive supply line close to the eval-board
- LC-Filter to CC-Line close to the eval-board
- Pass (but tight to limit)

FILTERDESIGN

Measurement and reduction of conducted and radiated interference through targeted filter design





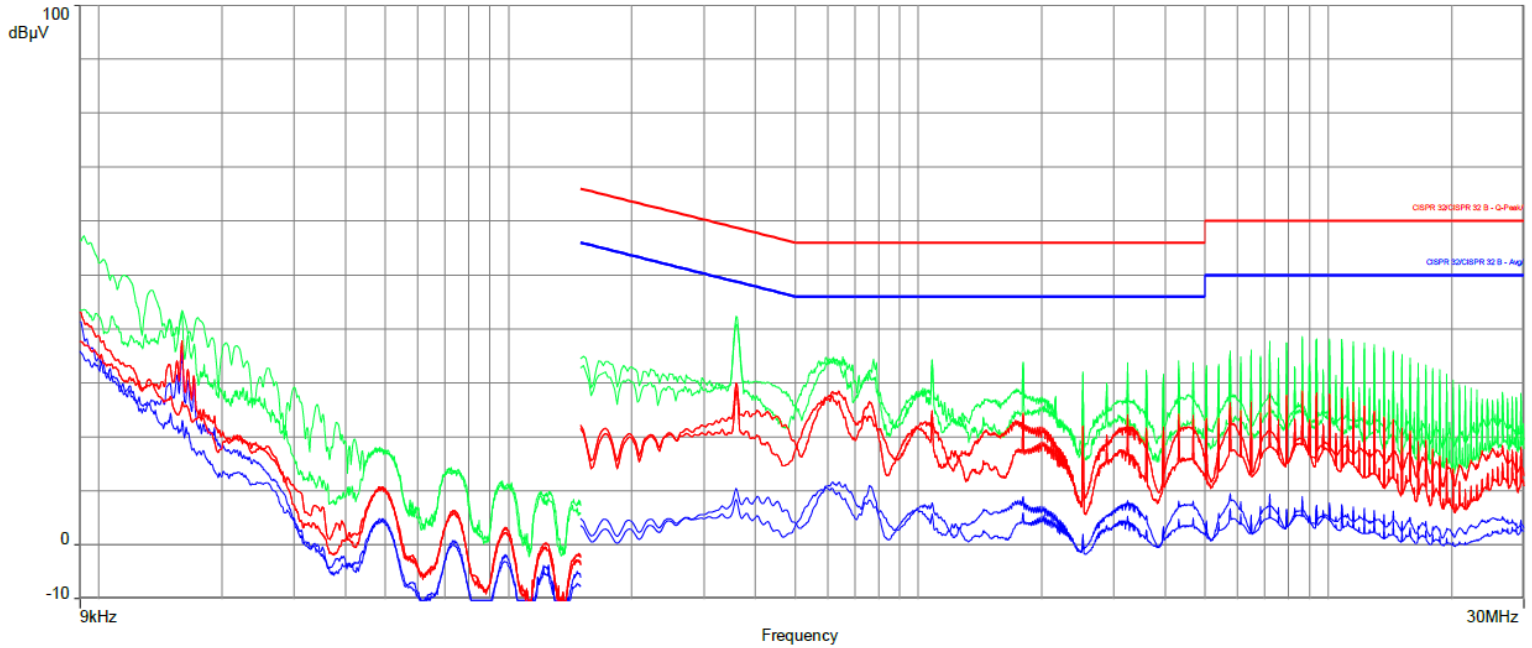
- L1, L2, L3: 2.2µH inductor
- C1, C2: 10µF capacitor

- Filtering both lines because of coupling effects to CC-line

- Block also GND-line

FILTERDESIGN

Measurement and reduction of conducted and radiated interference through targeted filter design



- Charging Mode with Mobil Phone, 80% charging level of battery
- LC-Filter to positive supply line close to the eval-board
- LC-Filter to CC-Line close to the eval-board
- L into GND-line
- Pass

FILTERDESIGN

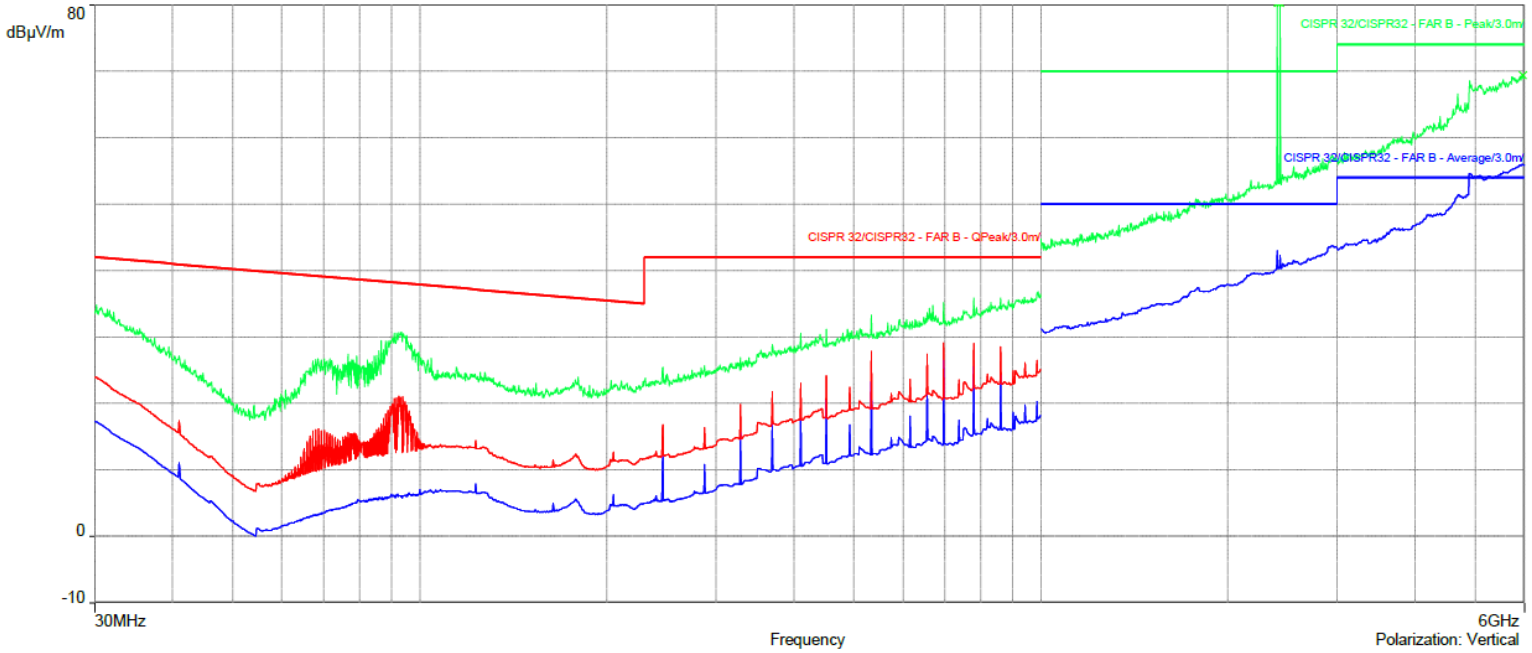
Measurement and reduction of conducted and radiated interference through targeted filter design

- EMC test according to CISPR 16-2-3
- Limit lines from CISPR 32 FAR
- Radiated emissions

- First measurement with modified device from conducted emissions test

FILTERDESIGN

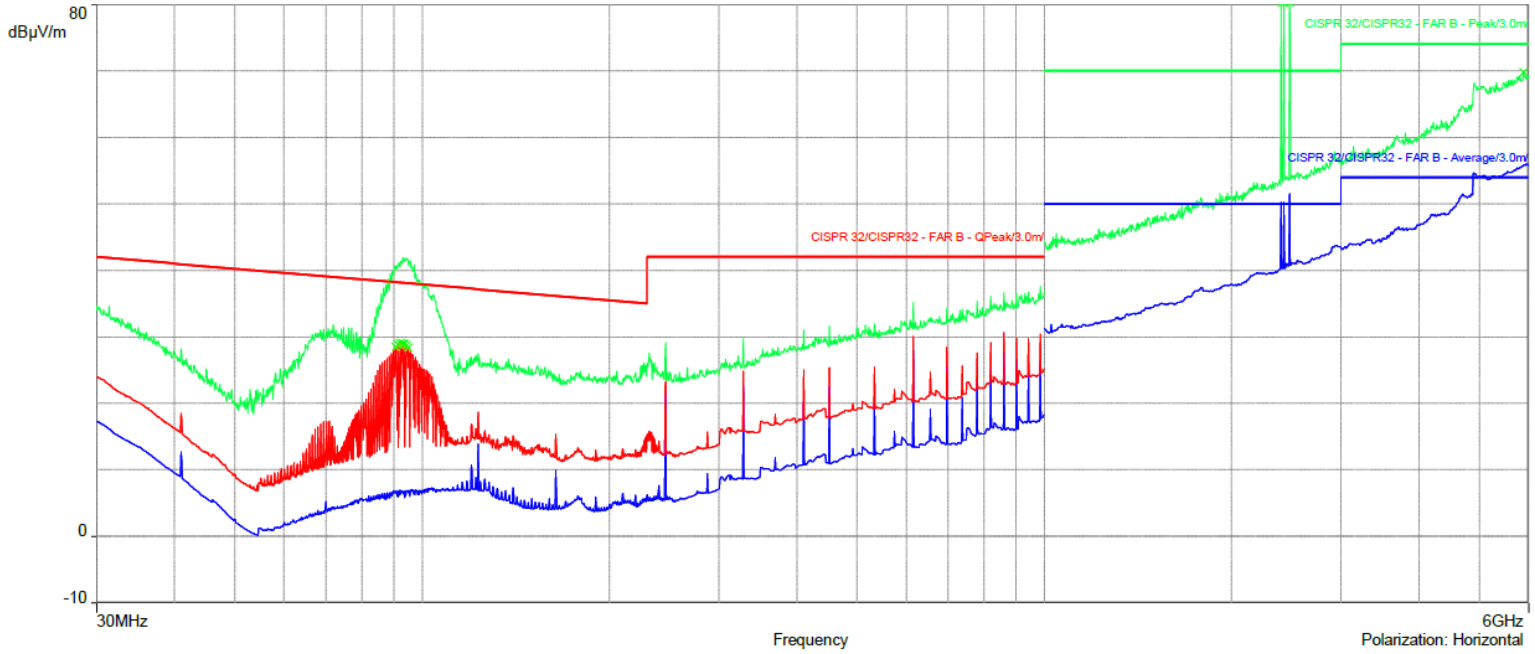
Measurement and reduction of conducted and radiated interference through targeted filter design



- Charging with filter (identical to conducted best case)
- Vertical
- Pass

FILTERDESIGN

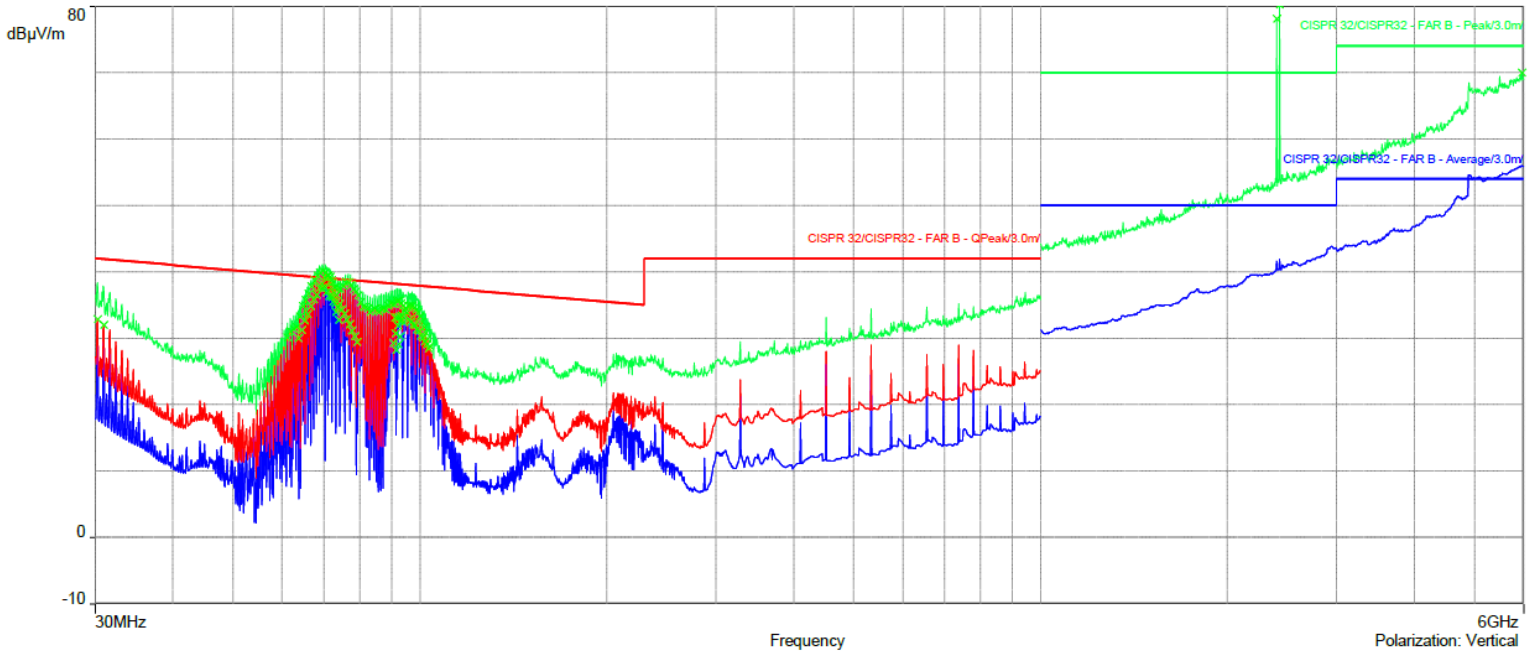
Measurement and reduction of conducted and radiated interference through targeted filter design



- Charging with filter (identical to conducted best case)
- Horizontal
- Pass

FILTERDESIGN

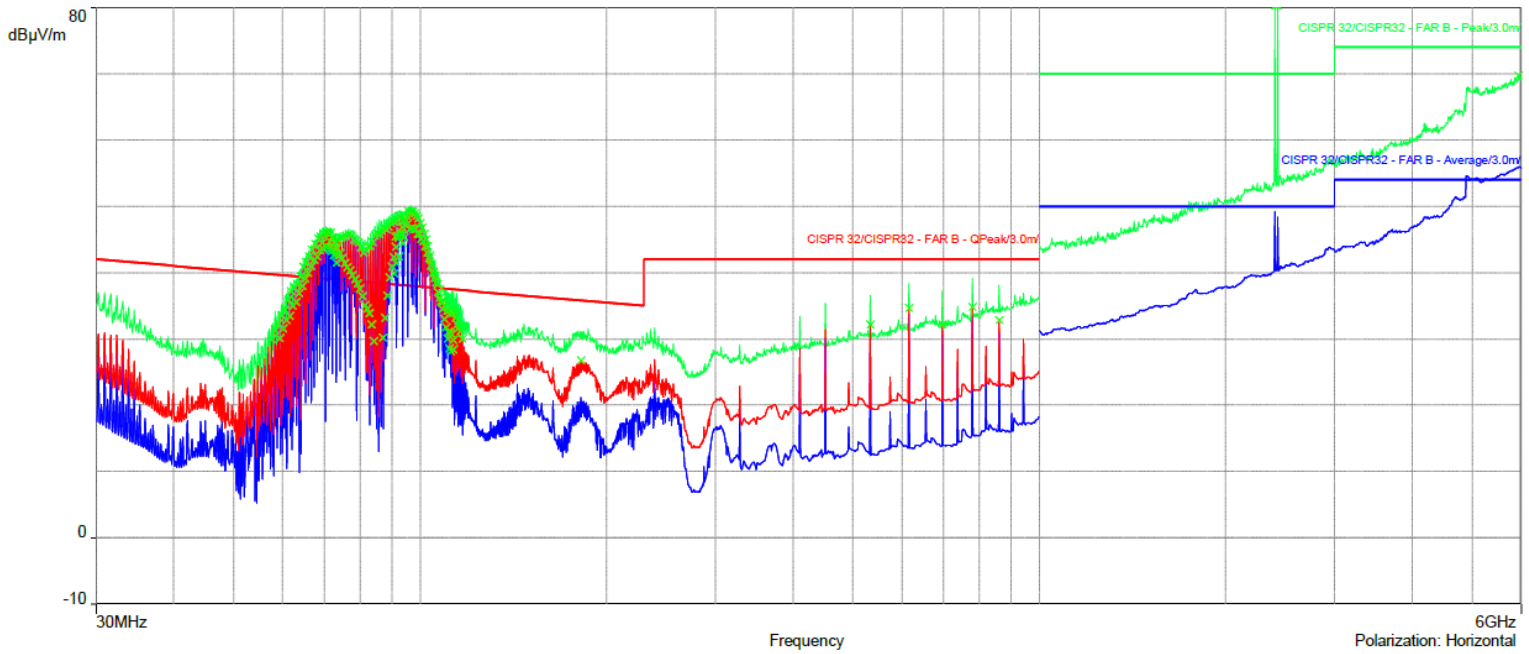
Measurement and reduction of conducted and radiated interference through targeted filter design



- Charging w/o filter
- Vertikal
- Fail

FILTERDESIGN

Measurement and reduction of conducted and radiated interference through targeted filter design



- Charging w/o filter
- Horizontal
- Fail

THANKS FOR YOUR ATTENTION

QUESTIONS?

contact: wirelesspower@we-online.com