



# DESIGN FOR EMC – BOOST CONVERTER DESIGN AND MEASUREMENT

Mohamed AlAlami

Senior Field Application Engineer

Robert Schillinger

Field Application Engineer

**WÜRTH ELEKTRONIK** MORE THAN YOU EXPECT

# NOISE PROPAGATION

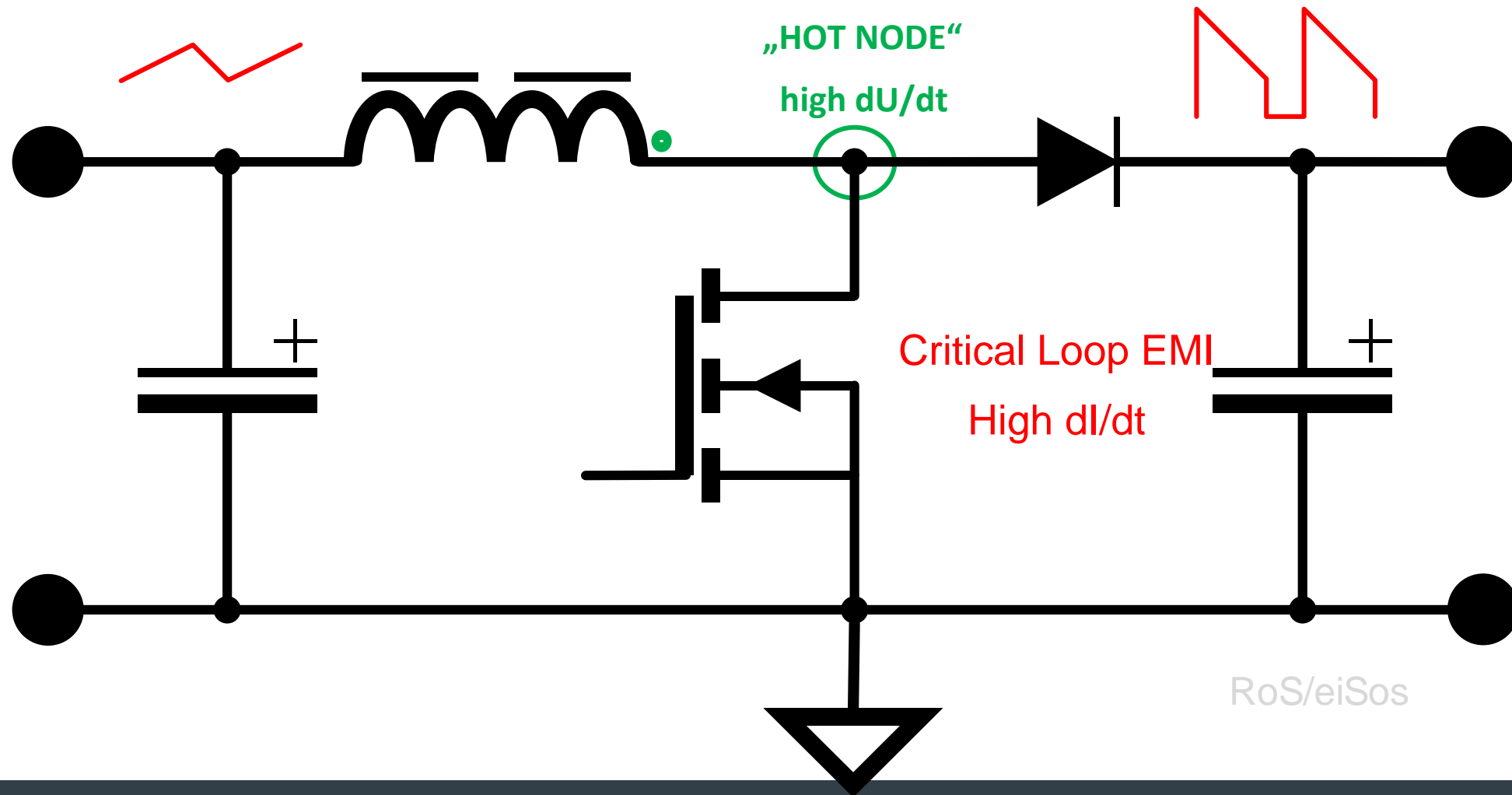
# NOISE PROPAGATION

## CM & DM Noise Currents

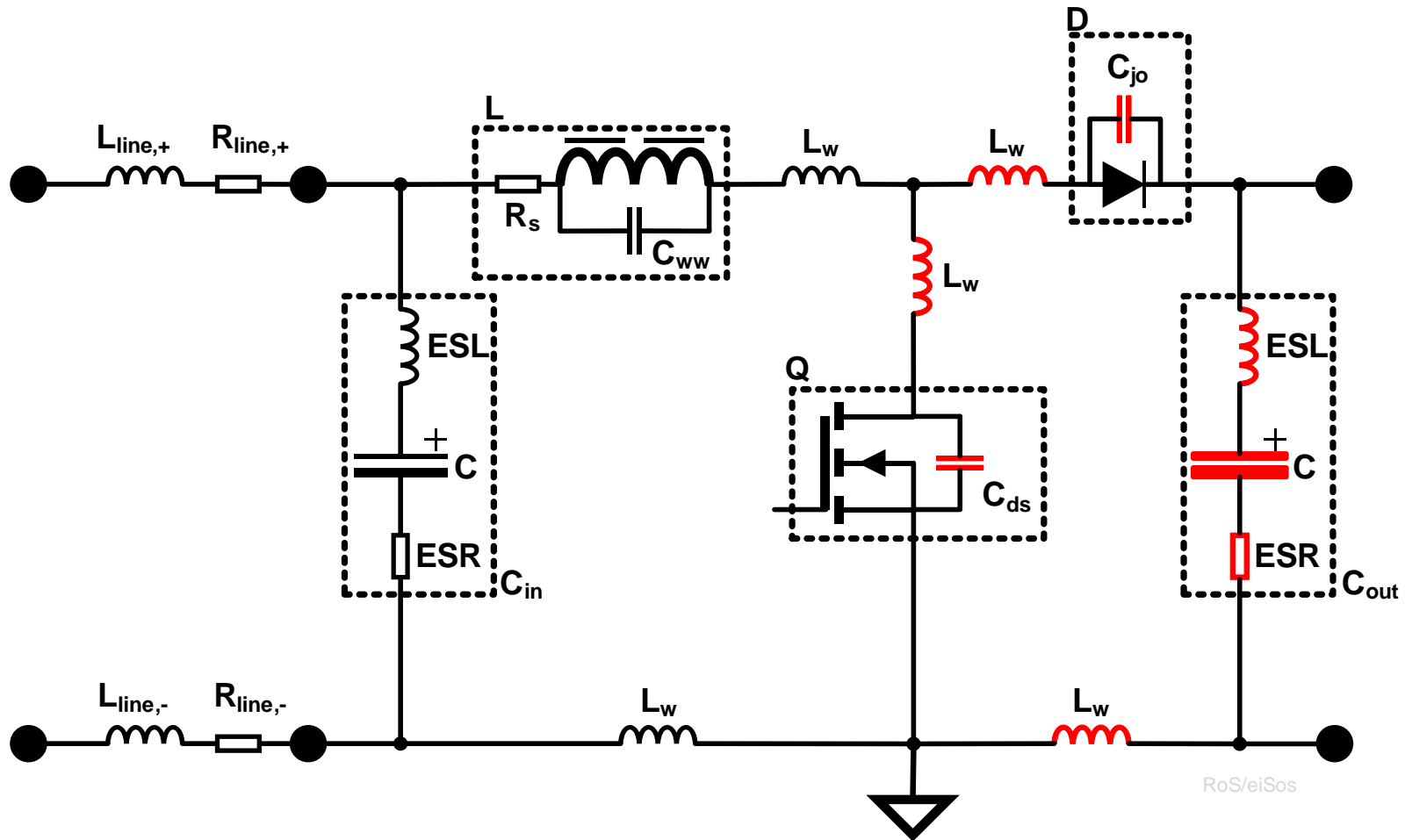
- Differential mode current (DM)
  - Current path as in the schematic
  - Easier to understand the noise paths
  - High currents,  $di/dt$  and  $dv/dt$
  - Conducted EMI problems
- Common mode current (CM)
  - Current path unexpectedly
  - Return current path very big
  - Relative low currents (some  $\mu A$ )
  - Radiated EMI problems

# BOOST CONVERTER NOISE SOURCES

# Boost Converter Noise Sources



# Parasitic Boost Model

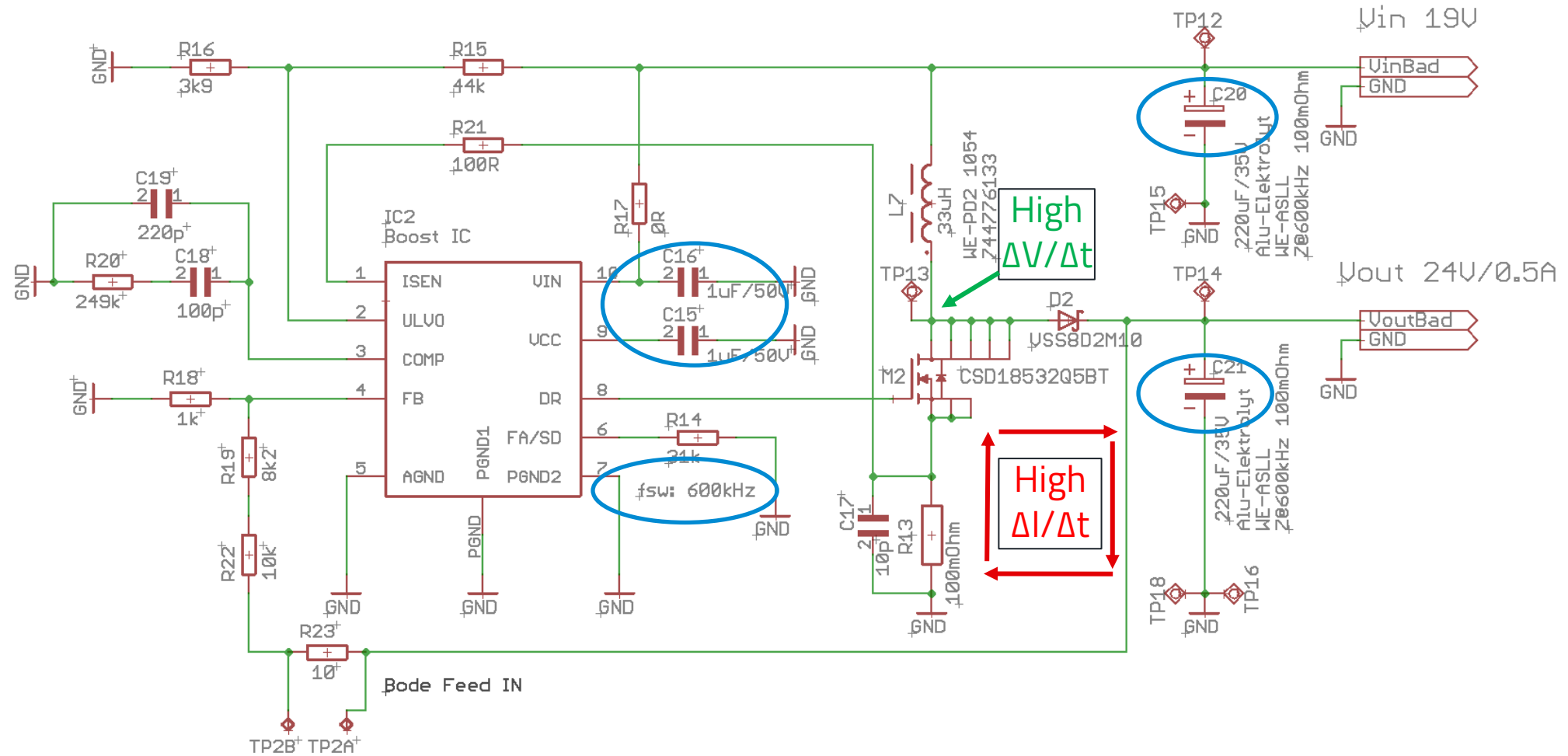


# PRACTICAL BOOST EXAMPLE

**BAD Design Practice**

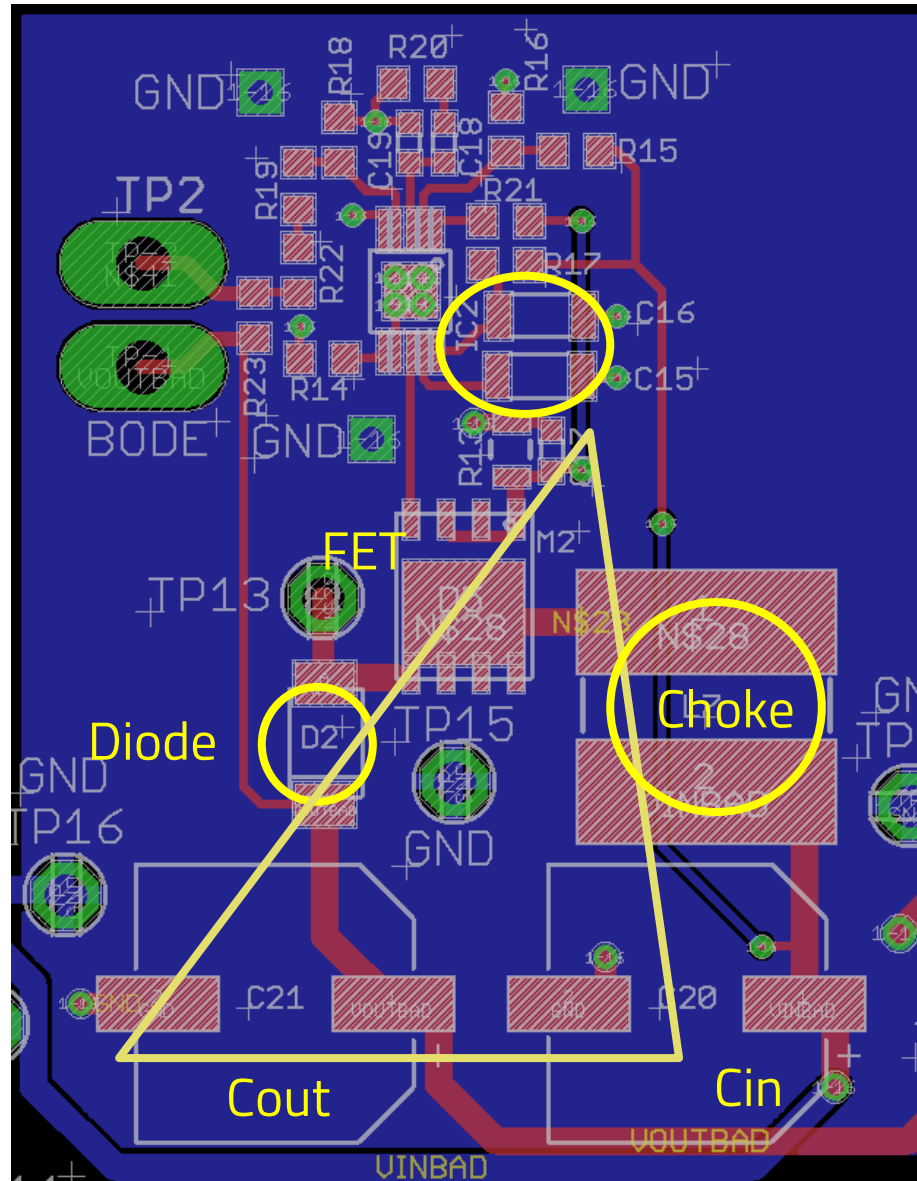
# Schematic Bad Design

19V → 24V/0,5A

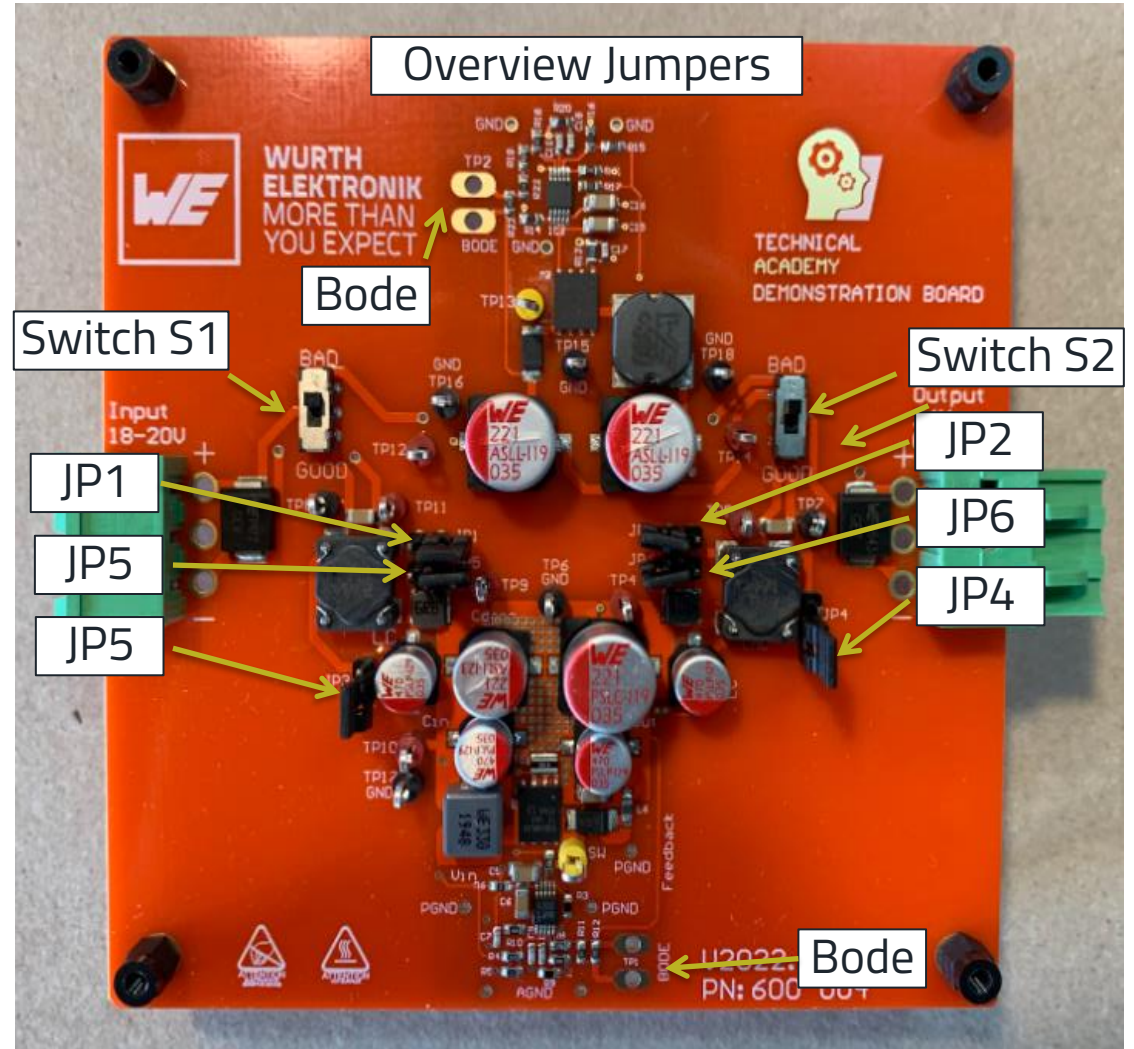
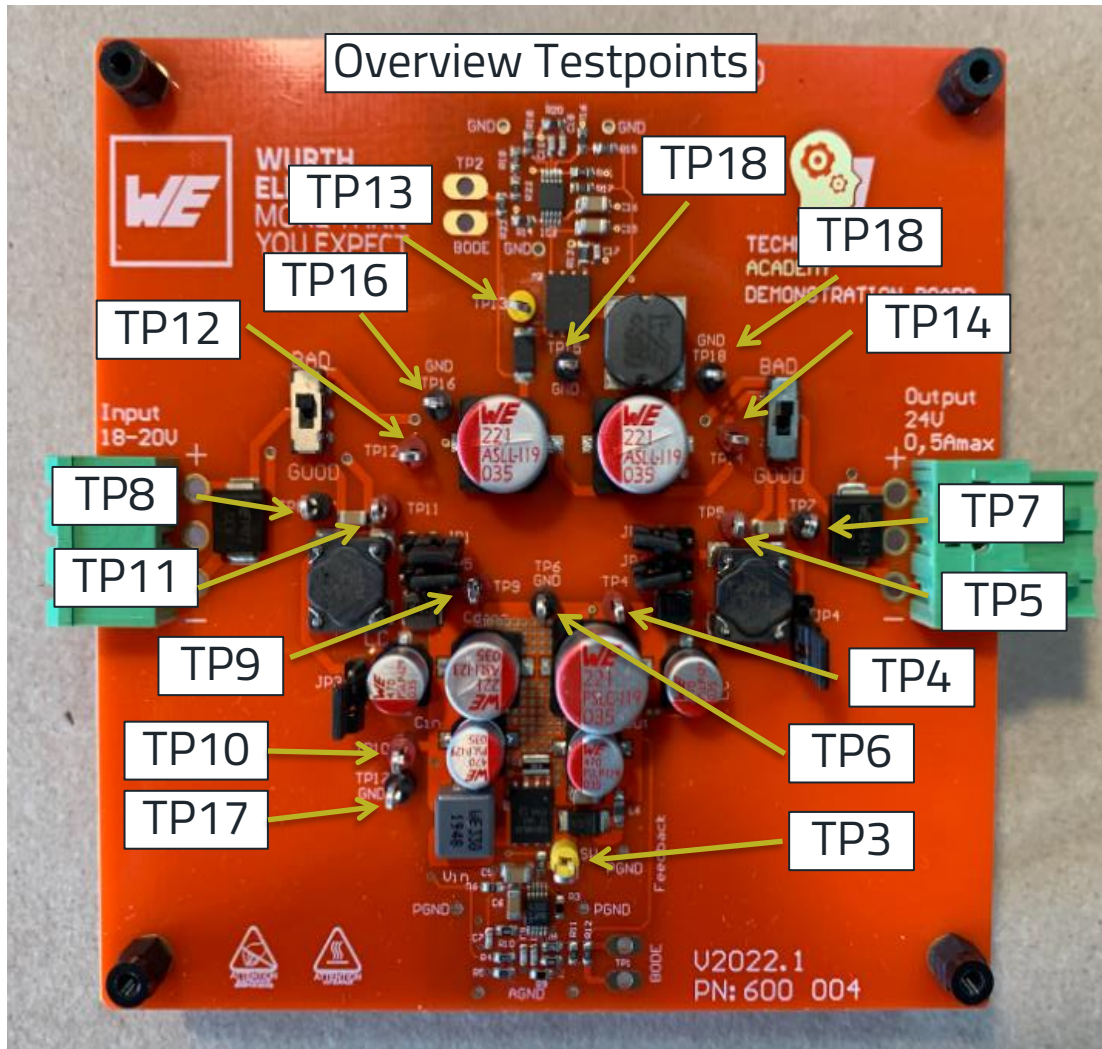




# PCB Layout Bad Design

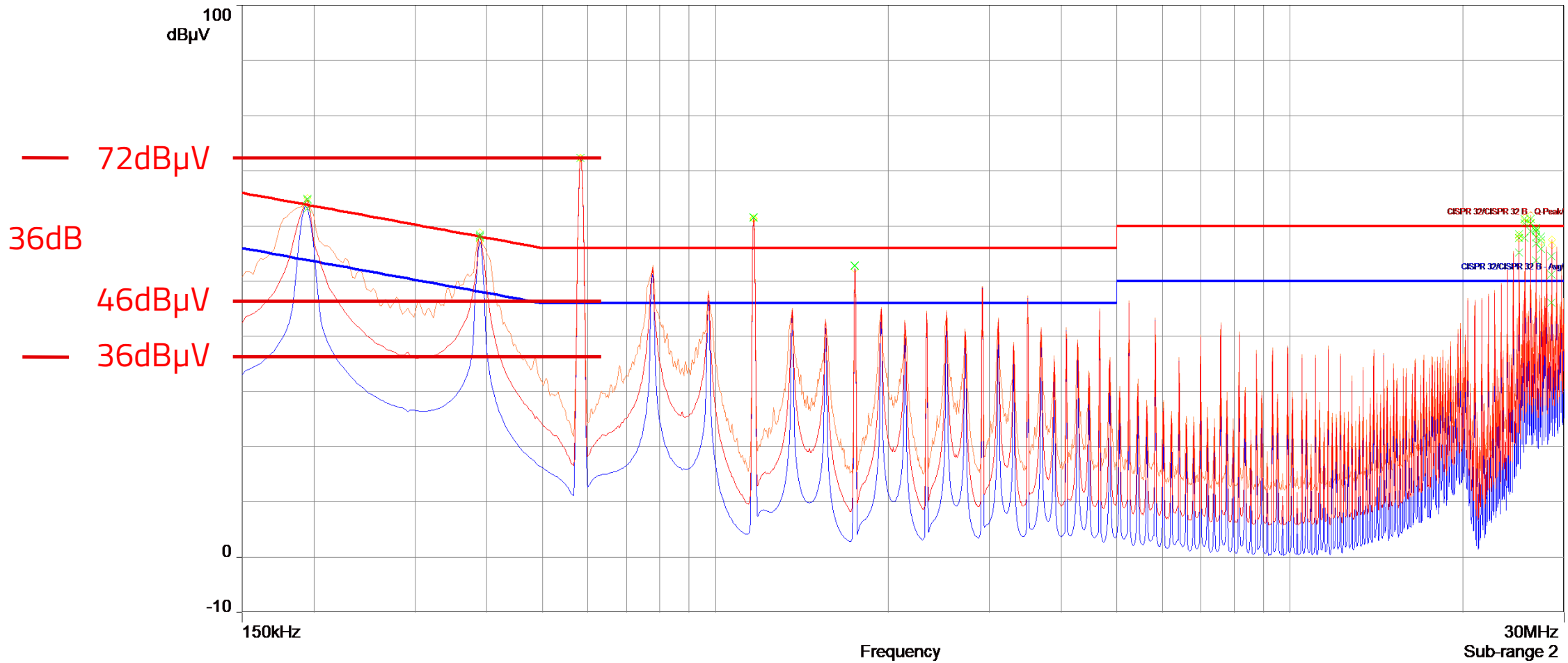


# PCB Overview



# Bad Design Practice: EMC Test Lab

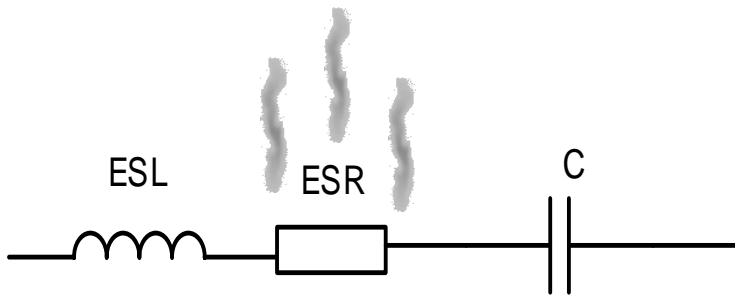
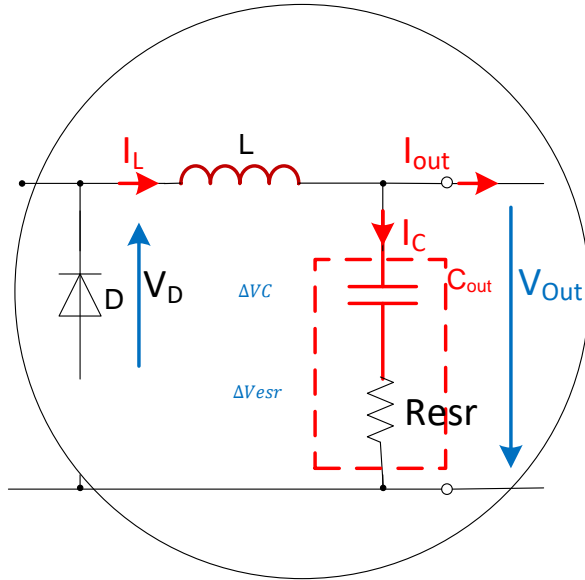
CISPR32 Conducted Emission – input w/o Filtering



# IMPROVEMENT OF NOISE REJECTION/REDUCTION

# 1. Selection of Different Capacitors

## Ripple current



- Aluminum Electrolytic Capacitors
  - Ripple current can be critical, shortening of lifetime, and
  - For too high ripple explosive failure -> blown vent and electrolyte leakage
- Ceramic Capacitors
  - Lowest ESR /mostly have no ripple current limitation
- Film capacitors
  - Low ESR, but ripple current can cause damage

# 1. Selection of Different Capacitors:

## Polymer Vs Electrolytic - Comparison

### ■ Aluminum- Electrolytic-Capacitor

- higher voltage ratings available
- is currently cheaper ( same capacity and voltage rating)



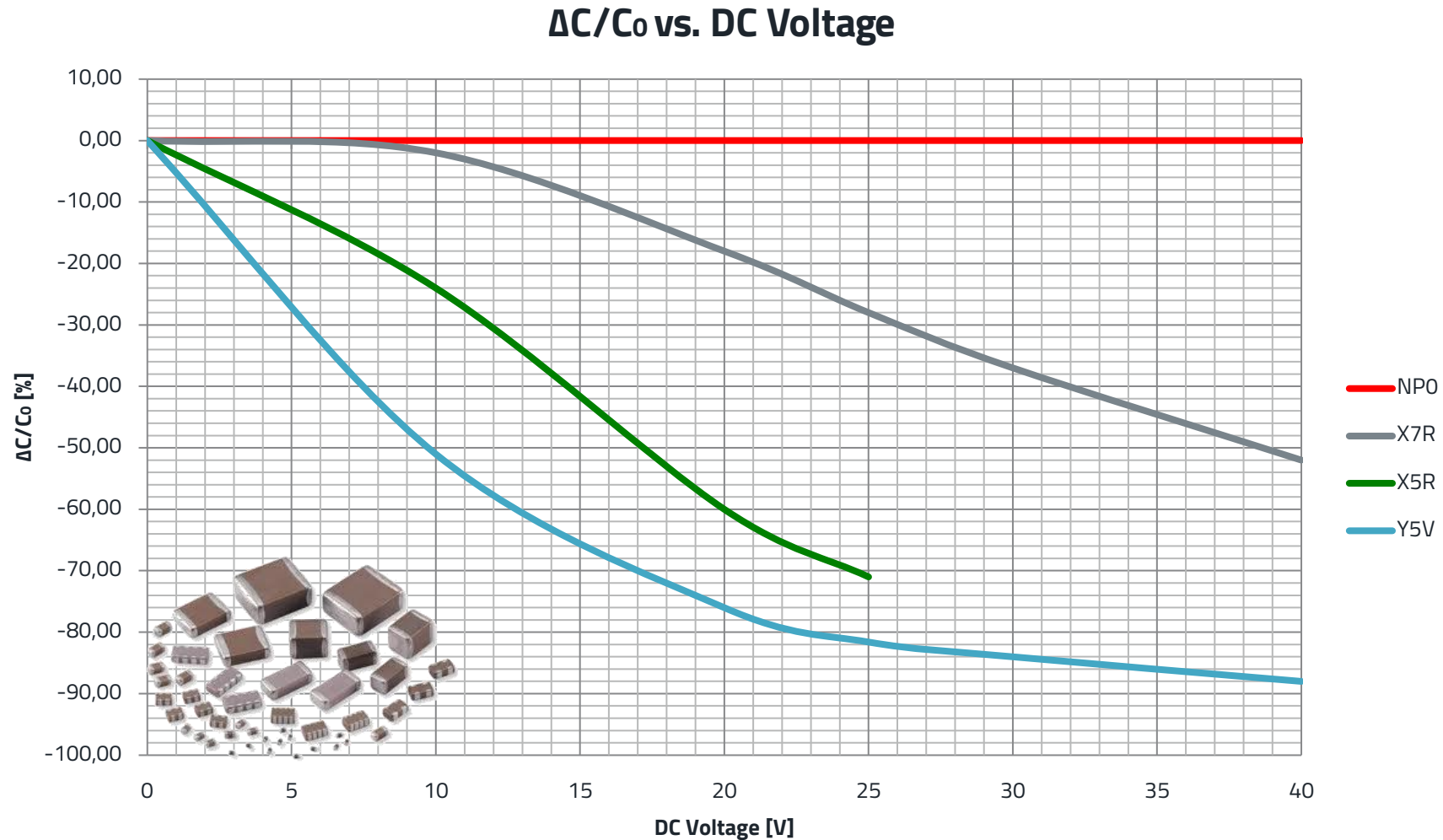
### ■ Polymer- Electrolytic-Capacitor:

- smaller ESR as an Alu-Cap >> higher allowed ripple current
- No dry-out behavior like Alu-Cap (solid electrolytic)
- higher expected lifetime / load life



# 1. Selection of Different Capacitors

## MLCC Voltage Dependence



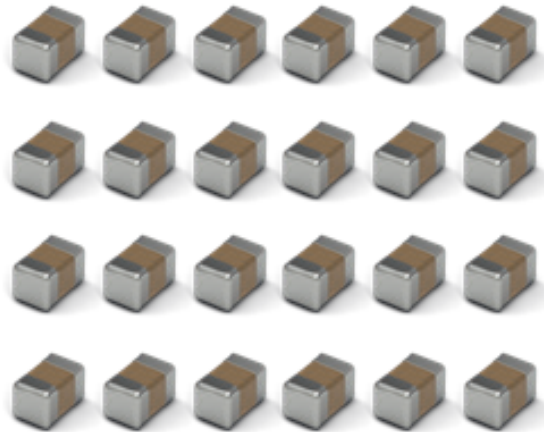
# 1. Selection of Different Capacitors

## False Economy

### Save Space on your PCB

#### 24 x MLCCs

- P/N: 885012107006  
with 47  $\mu\text{F}$
- 24 x 47  $\mu\text{F}$  = 1128  $\mu\text{F}$
- $V_R = 6.3 V_{DC}$
- Size 0805  $\rightarrow$  2 x 1.25 mm
- **C @ 6  $V_{DC}$  = 216  $\mu\text{F}$   
due to DC-Bias**
- **A = 255 mm<sup>2</sup>**



#### 1 x H-Chip Aluminum Polymer Capacitor

- P/N: 875015119006  
with 220  $\mu\text{F}$
- 1 x 220  $\mu\text{F}$  = 220  $\mu\text{F}$
- $V_R = 6.3 V_{DC}$
- Size 2917  $\rightarrow$  7.3 x 4.3 mm
- **C @ 6  $V_{DC}$  = 220  $\mu\text{F}$**
- **A = 44 mm<sup>2</sup>**



# 1. Selection of Different Capacitors

## Different input capacitors

WÜRTH ELEKTRONIK RED EXPERT Aluminum Electrolytic / Aluminum Polymer Capacitors

Filters: Order Code ⇒ 865060557008, 865080553014, 875105645005 Not Internal 3 items

Order Code	Series	Technology	Series Description	C	To...	V <sub>R</sub>	DF	ESR @600 kHz	I@20°C @1 k...	Specifi
865060557008	WCAP-ASLL	Alum. Electrolytic	SMT - Low Imp. & Long Life +105°C	220 µF	±20%	35.0 V	< 14 %	93.4 mΩ	596 mA	670
865080553014	WCAP-ASLI	Alum. Electrolytic	SMT - Low Impedance +105°C	220 µF	±20%	35.0 V	< 14 %	129 mΩ	507 mA	570
875105645005	WCAP-PSLP	Alum. Polymer	SMT - Low Profile	47.0 µF	±20%	35.0 V	< 12 %	13.3 mΩ	480 mA	1.0

865060557008 WCAP-ASLL 220 µF - 35.0 V  
865080553014 WCAP-ASLI 220 µF - 35.0 V  
875105645005 WCAP-PSLP 47.0 µF - 35.0 V

Click and type or drop an Order Code here

ADD MORE

Show Panel: Z vs. F ESR vs. F Imp vs. F Imp vs. T

ESR / Frequency

Frequency (Hz)	Blue Curve ESR (mΩ)	Orange Curve ESR (mΩ)	Green Curve ESR (mΩ)
100 Hz	~200	~100	~100
1 kHz	~100	~100	~100
10 kHz	~100	~100	~100
100 kHz	~100	~100	~10
1 MHz	~100	~100	~10
10 MHz	~100	~100	~10
100 MHz	~200	~100	~100

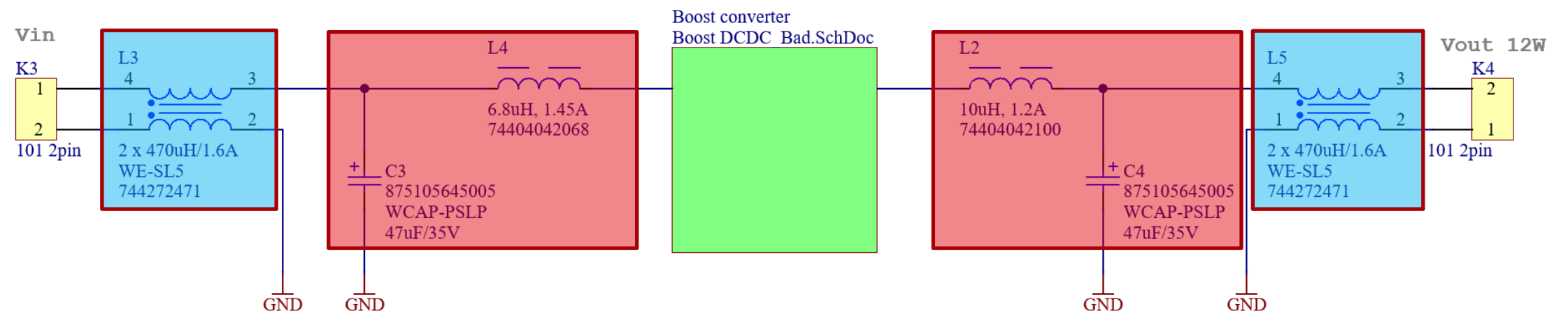
# 1. Selection of Different Capacitors

Measurement of input capacitors



# 2. Filtering of Input and Output

## CM and DM Filtering

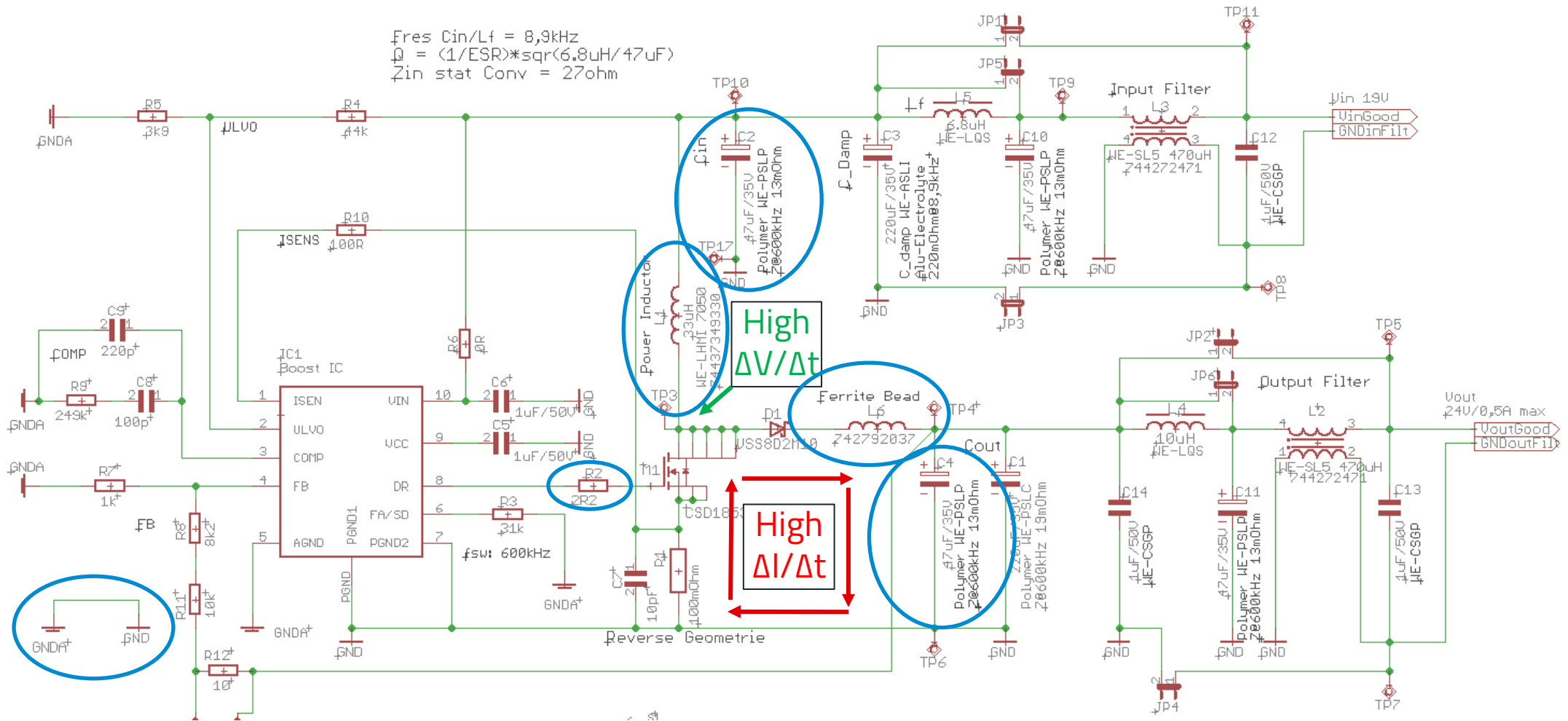


# PRACTICAL BOOST EXAMPLE

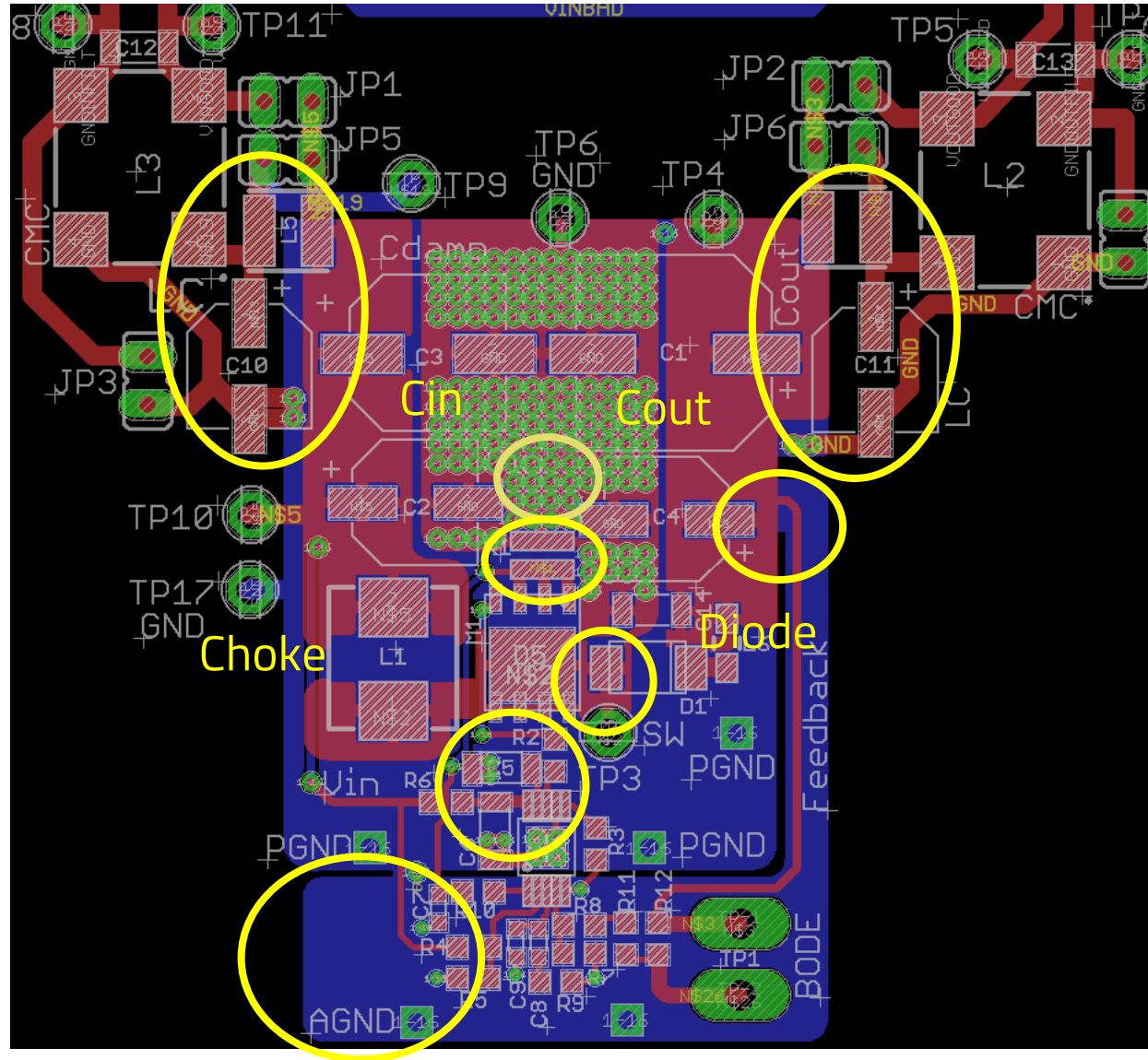
Good Design Practice

# Schematic Good Design

19V → 24V/0,5A

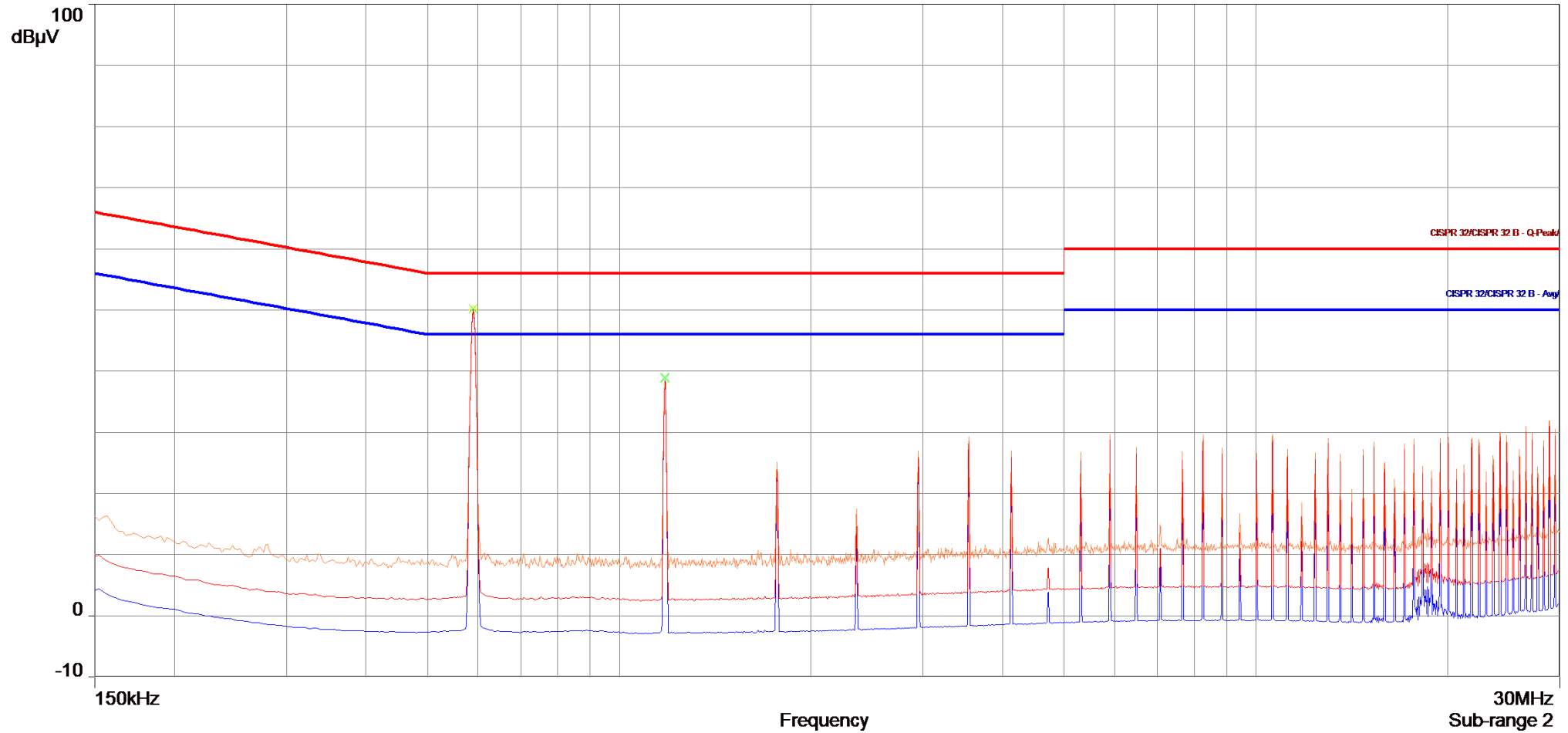


# PCB Layout Good Design



# Good Design Practice: EMC Test Lab

## CISPR32 Conducted Emission – input w/o Filtering



# Good Design Practice: EMC Test Lab

## CISPR32 Conducted Emission – input with Filtering

