Power supply circuits

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PA176 Architecture of Digital Systems II

Something about me ☺

Ing. Jiří Čulen, jiri.culen@mail.muni.cz   www.vfnuclear.com.

- Designer of **devices for** ionizing **radiation monitoring** on nuclear power plants, nuclear medicine and industry since 2001

- PCB design in **Altium Designer** + **Concorde Pro**
- CPLD and FPGA design in **Xilinx ISE**, **Vivado** and **Vitis**

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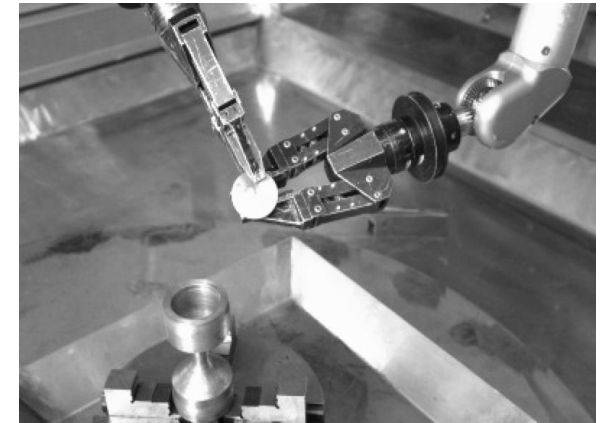# Customer Segments

Nuclear Industry

Radioactive Waste Management

Medical Industry

Environmental Monitoring

Metrology and Calibration

Dismantling and Decommissioning

# Area and process monitoring

Contamination Monitors

Power supply circuits

— Most of the components in PCBs are not implemented due to the main function, but most of it is auxiliary and supporting for main components.

— Typically, more then 50% of this auxiliary components are power supplies.
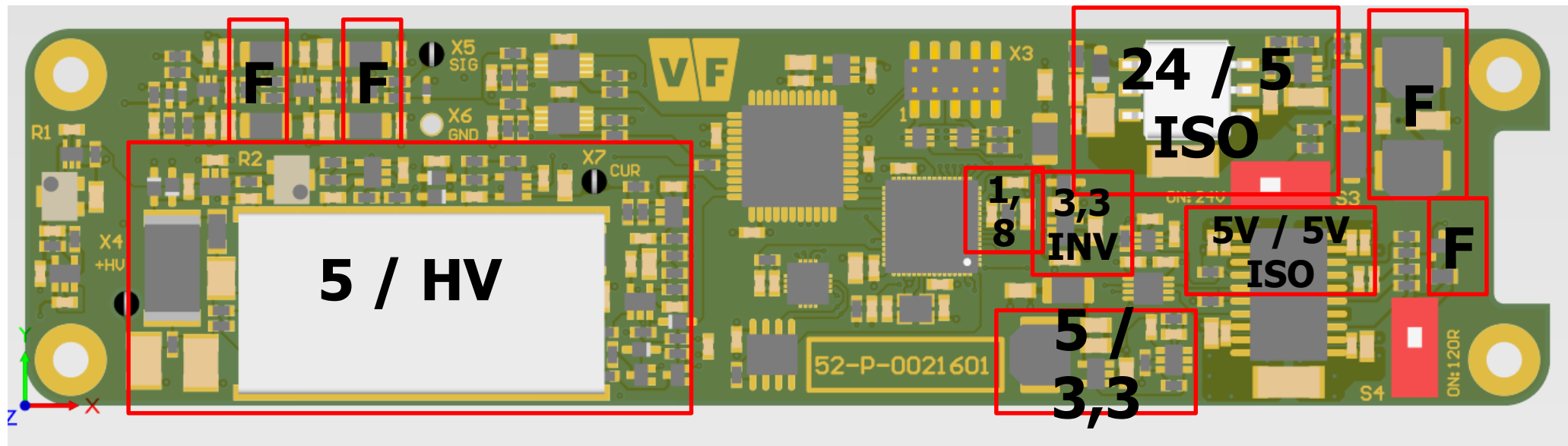
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Power supply circuits

— The typical structure of (not only) measuring instruments:

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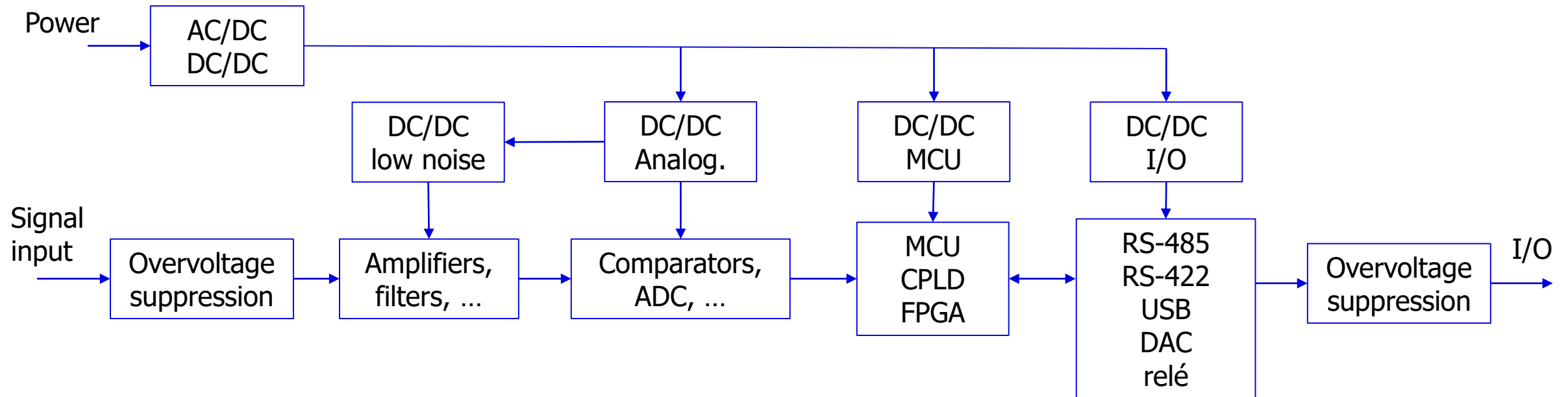
Power supply circuits

– Example of PCB for scintillation detectors:

Power supply circuits
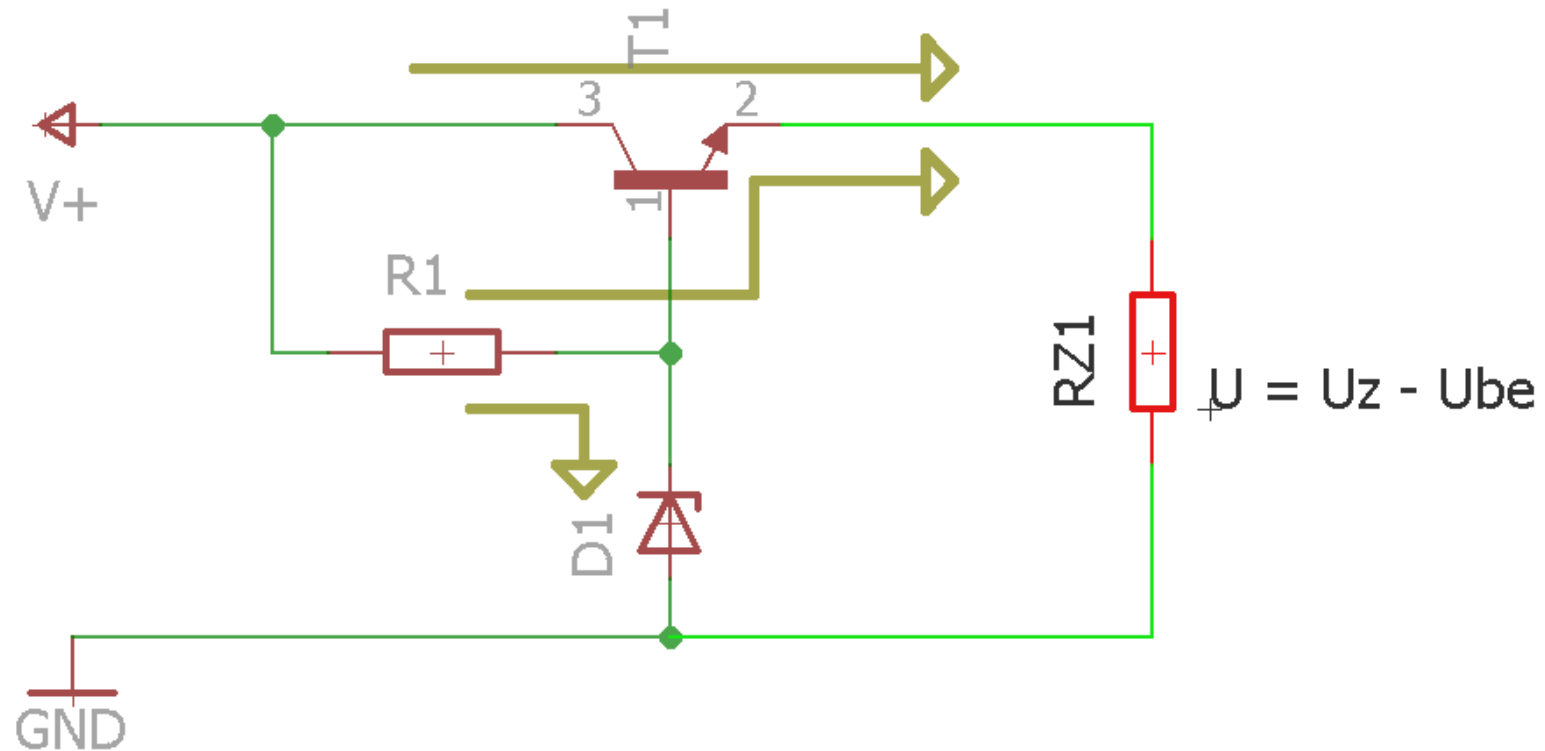
Linear Power Supply

+ low noise

- low efficiency, only for decreasing of voltage

Switching Power Supply

+ high efficiency, decreasing, increasing, inverting and galvanic isolation of voltage
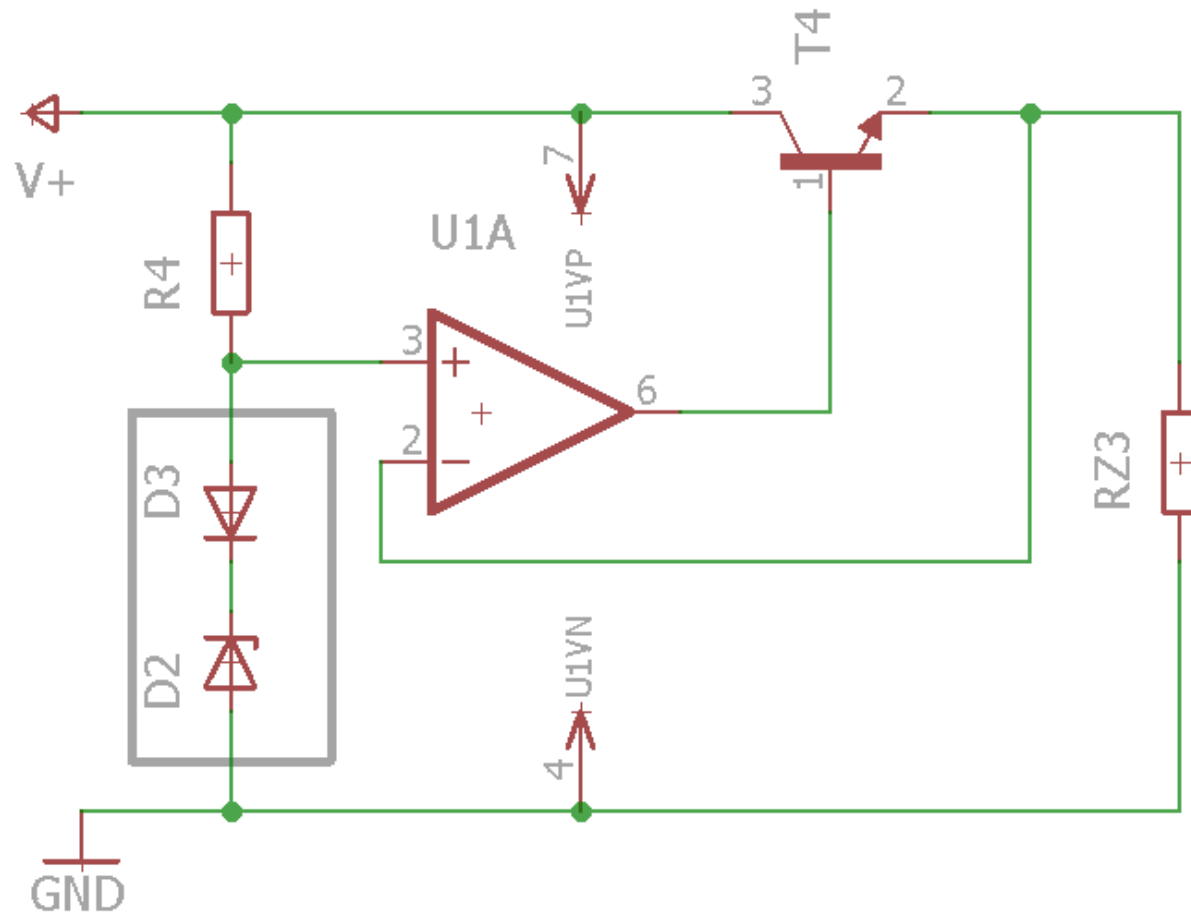
- high noise
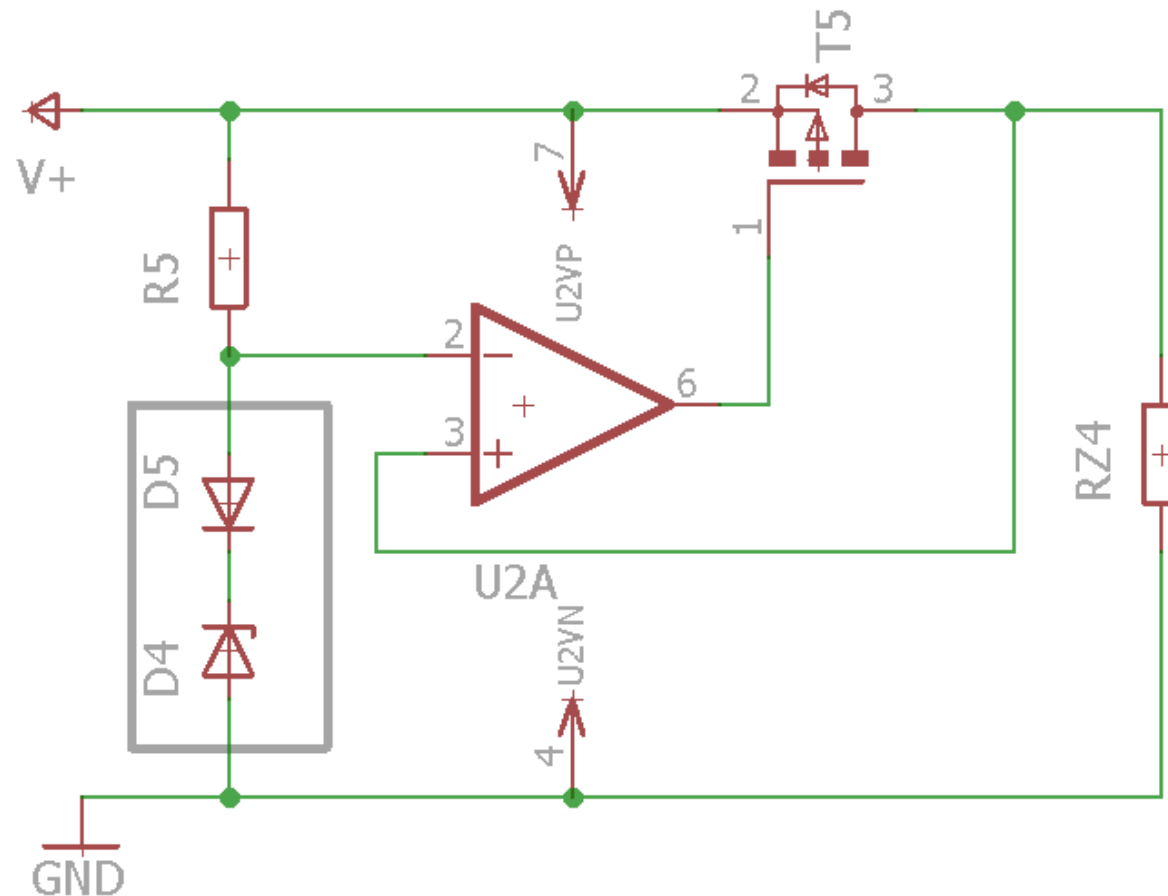
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Linear Power Supply

The basic linear voltage regulator

$$U = Uz - Ube$$

Linear Power Supply

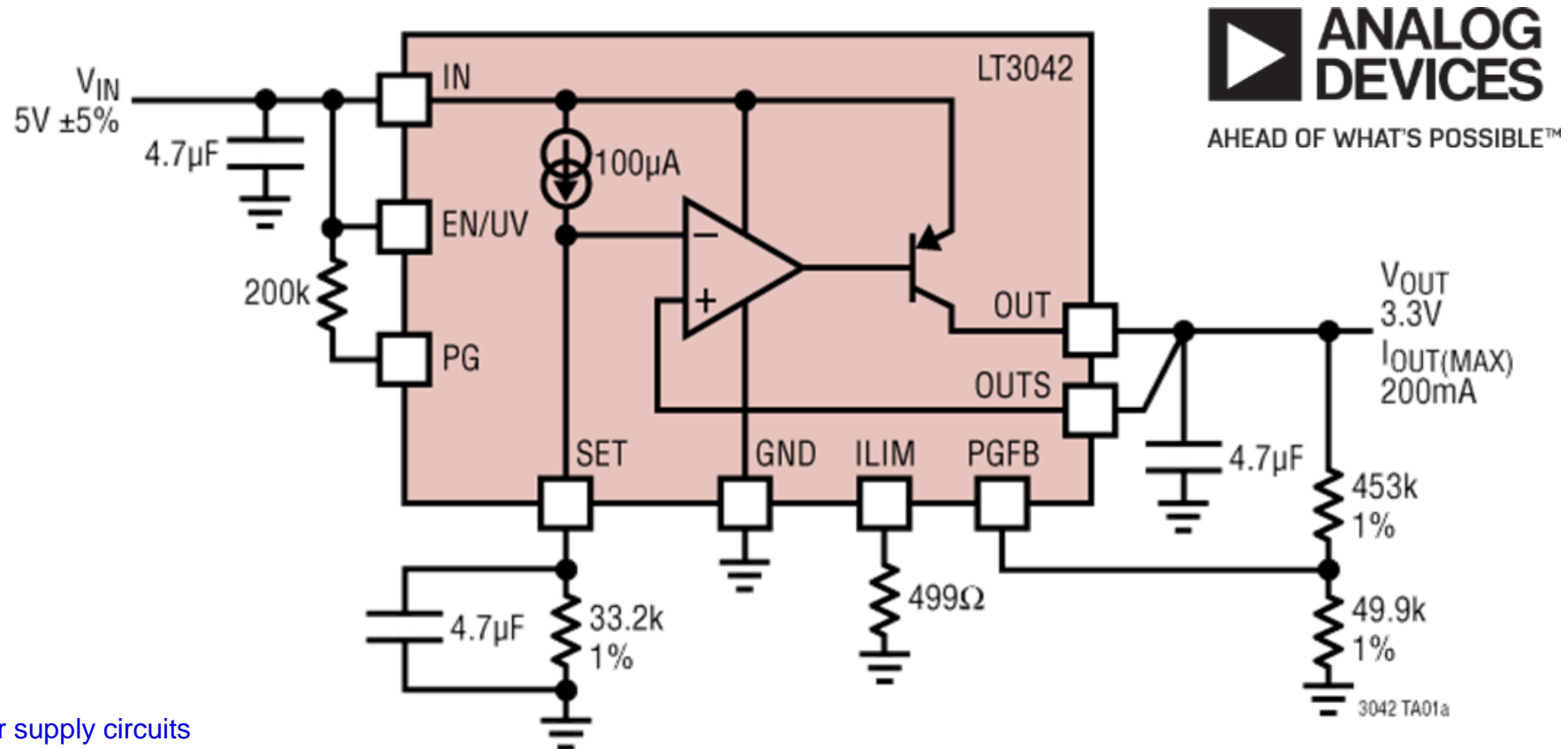Principial schematic of linear regulators – feedback loop

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Linear Power Supply

Principial schematic of linear regulators – LDO

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Linear Power Supply
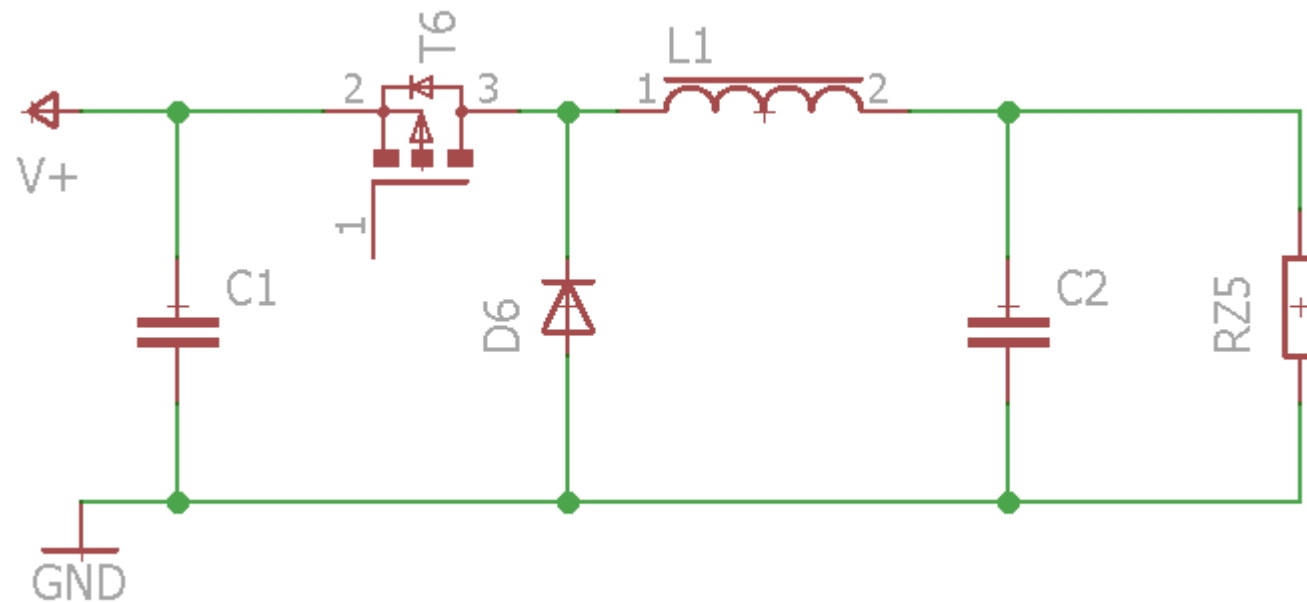
Ultralow RMS Noise: 0.8μVRMS (10Hz to 100kHz)

Switching Power Supply

- Most of switching power supply are based on accumulation of energy.
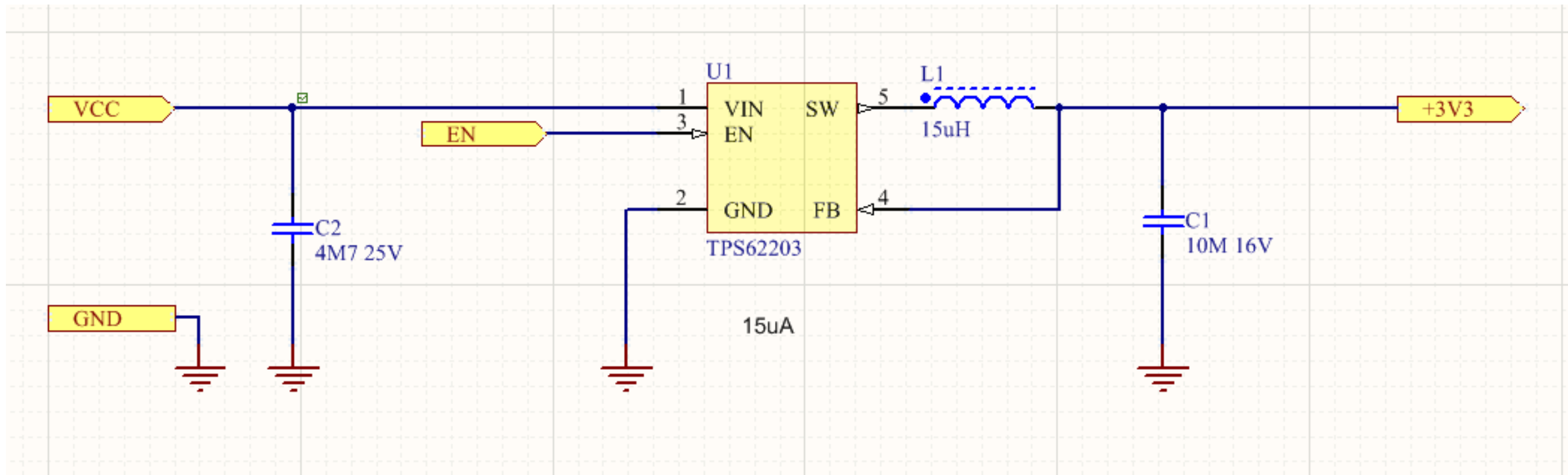- Accumulation of energy is based on magnetic field (chokes, transformers), on capacitors or on combination of both.

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Switching Power Supply
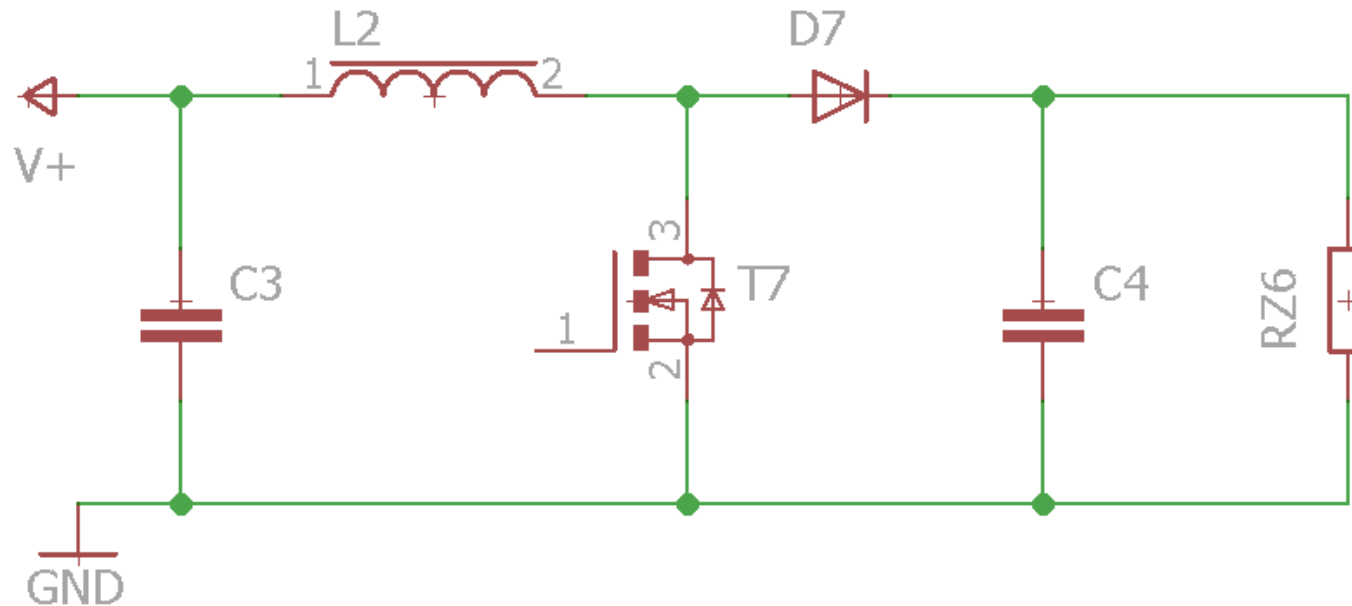
Buck (step down) topology – decreasing of voltage

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Switching Power Supply
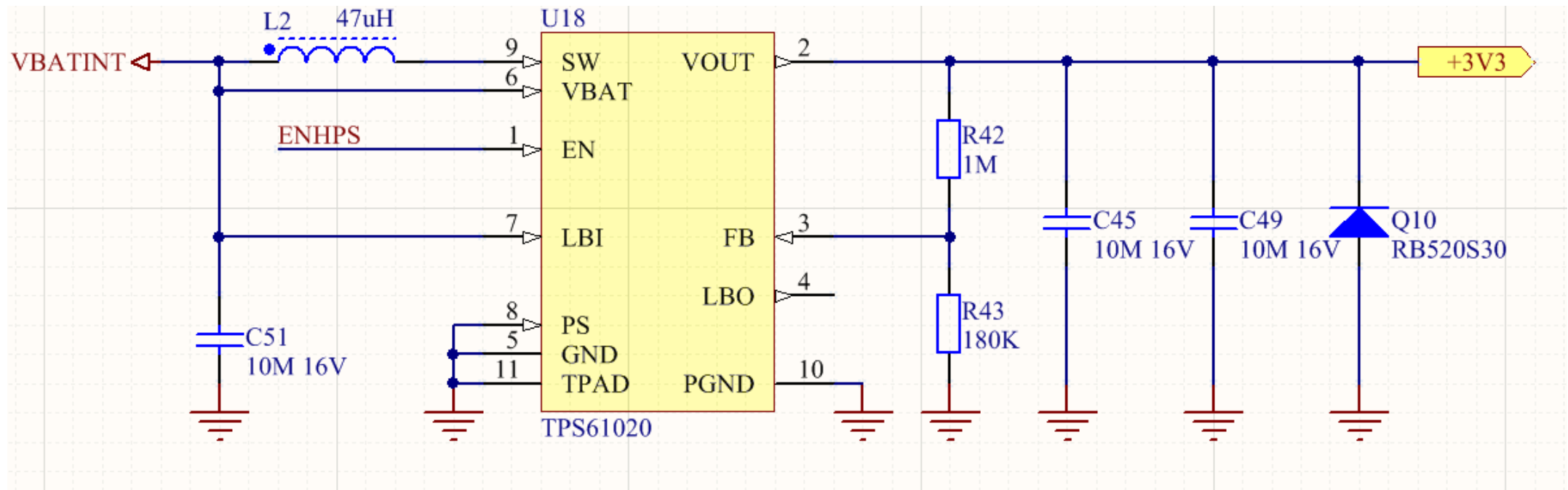
Buck (step down) topology – decreasing of voltage

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Switching Power Supply

Boost (step up) topology – increasing of voltage

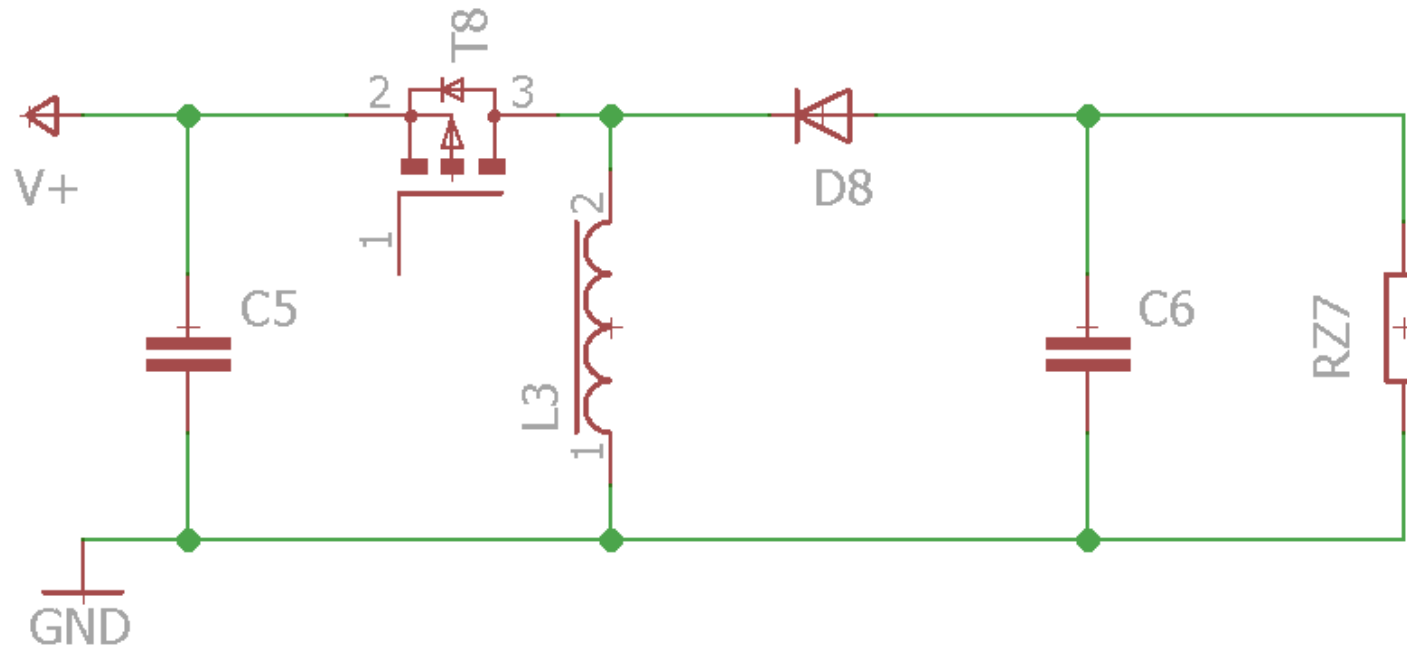The problem: Not isolating of short circuit

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Switching Power Supply
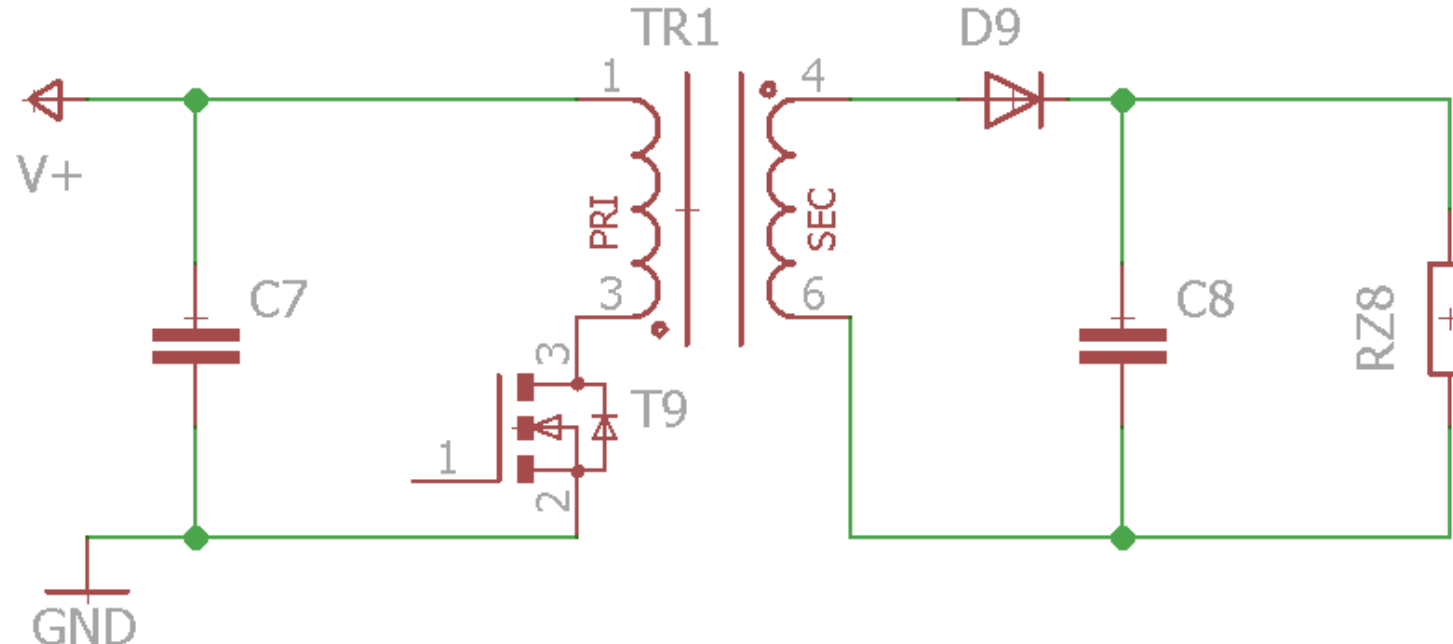
Boost (step up) topology – increasing of voltage

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Switching Power Supply

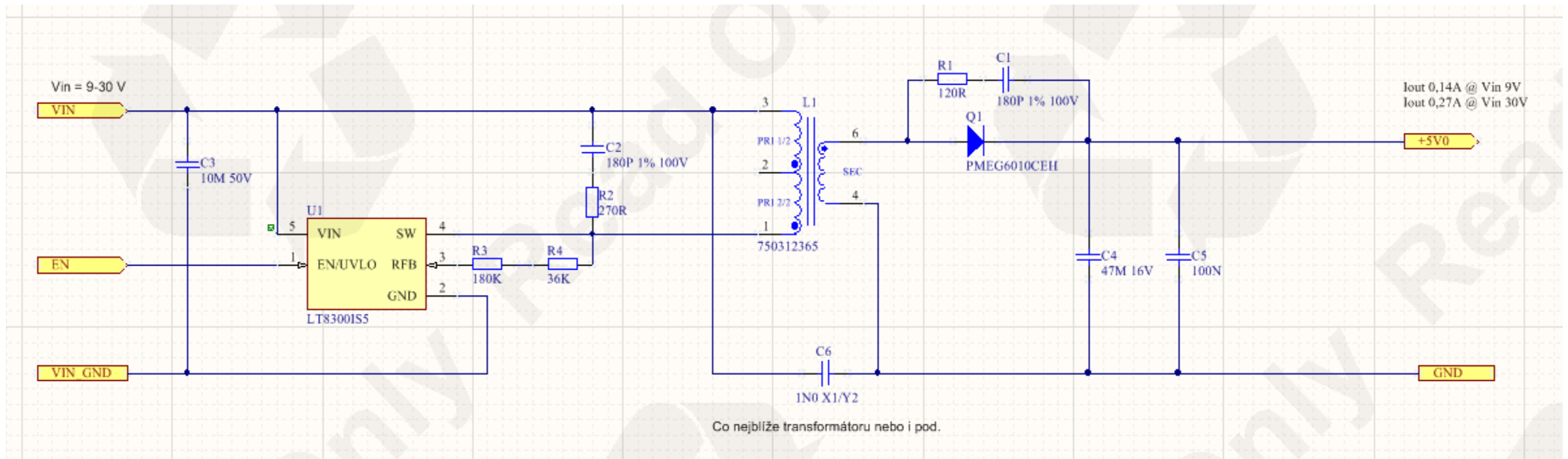Flyback (inverting) topology – inversion of voltage

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Switching Power Supply

Flyback (inverting) topology – galvanic isolation

- transformer with **air gap** (difference from pass-through DC/DC)
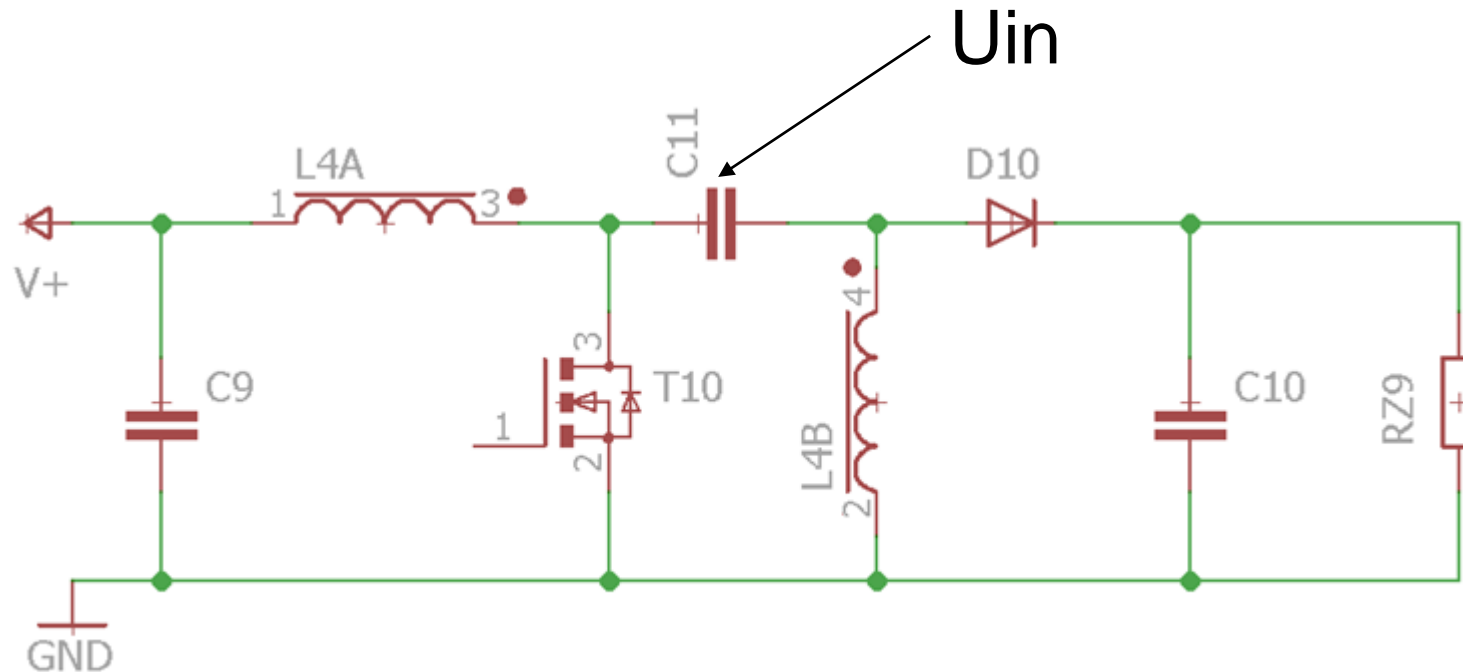
- up to approximately 200W

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Switching Power Supply
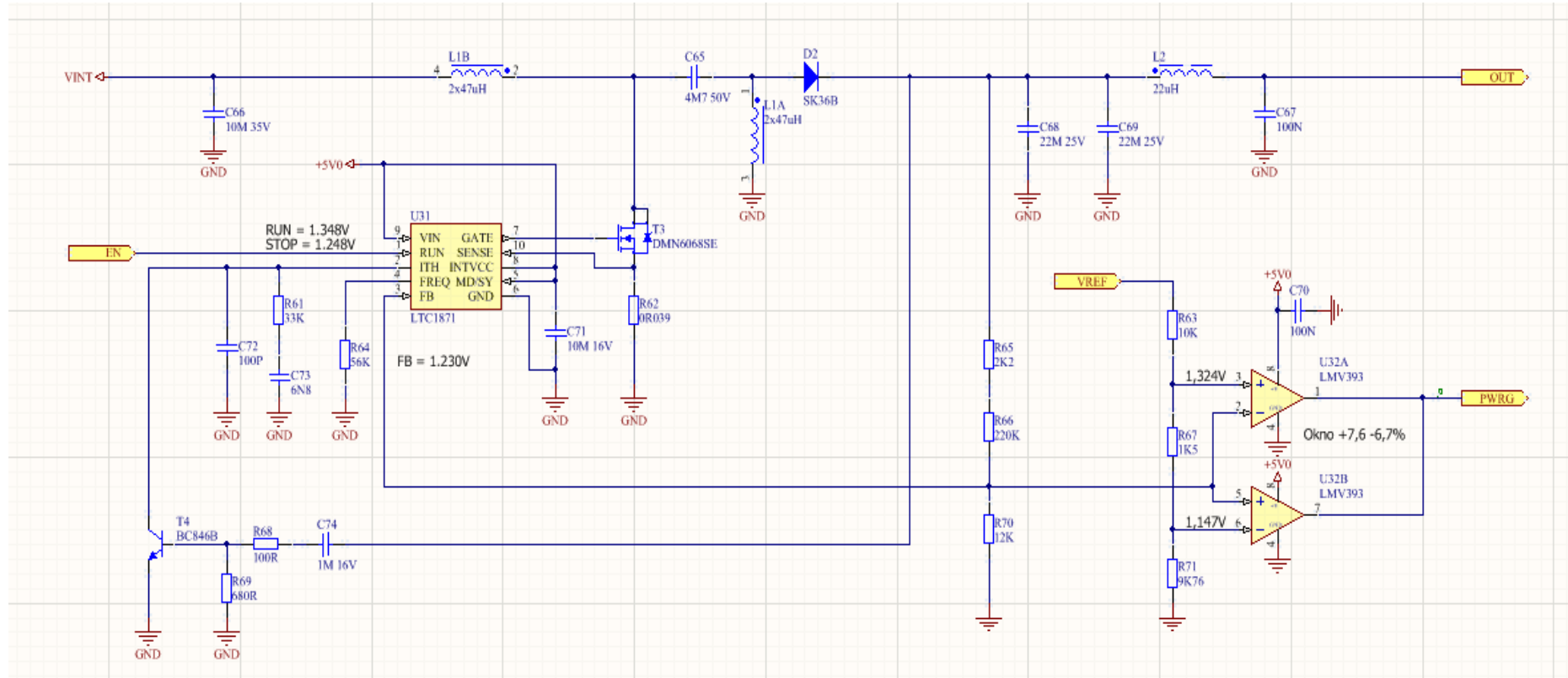
Flyback (inverting) topology – galvanic isolation

Switching Power Supply
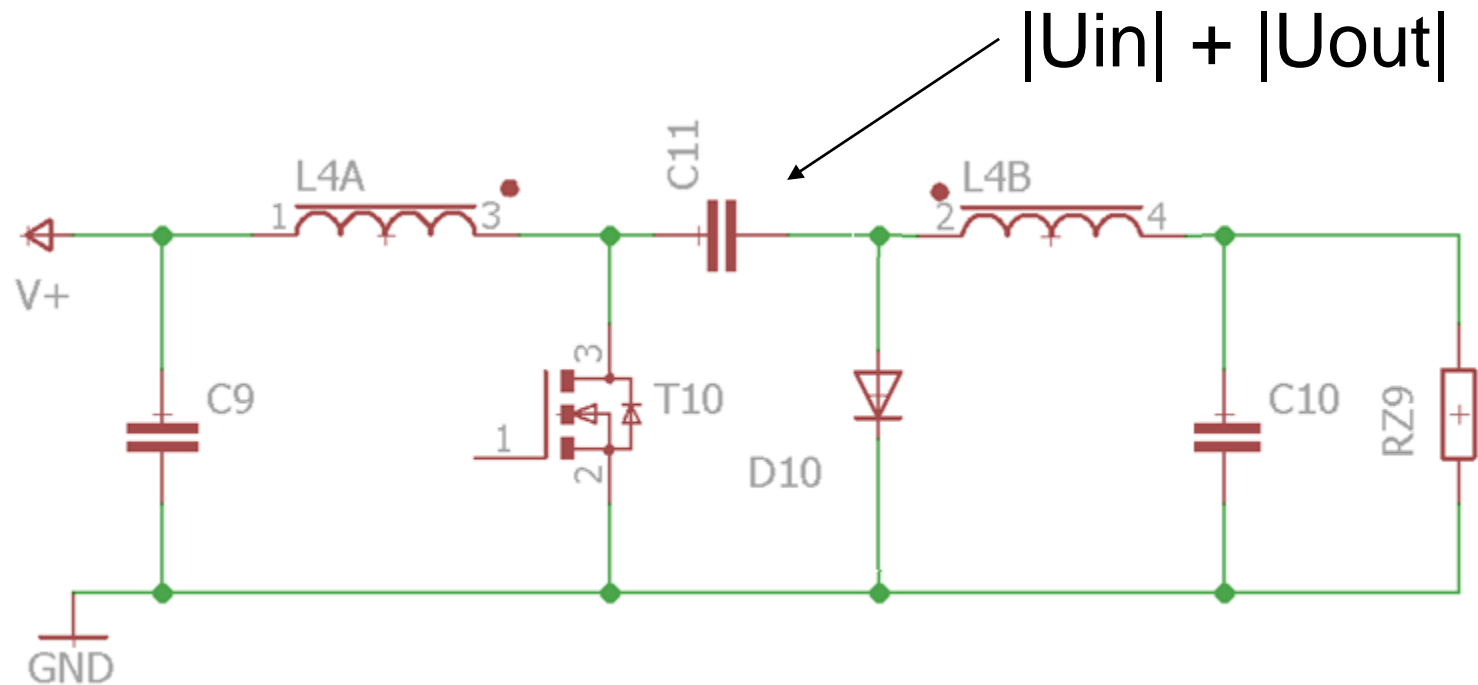
SEPIC topology – increasing/decreasing of voltage

Switching Power Supply

SEPIC topology – increasing/decreasing of voltage
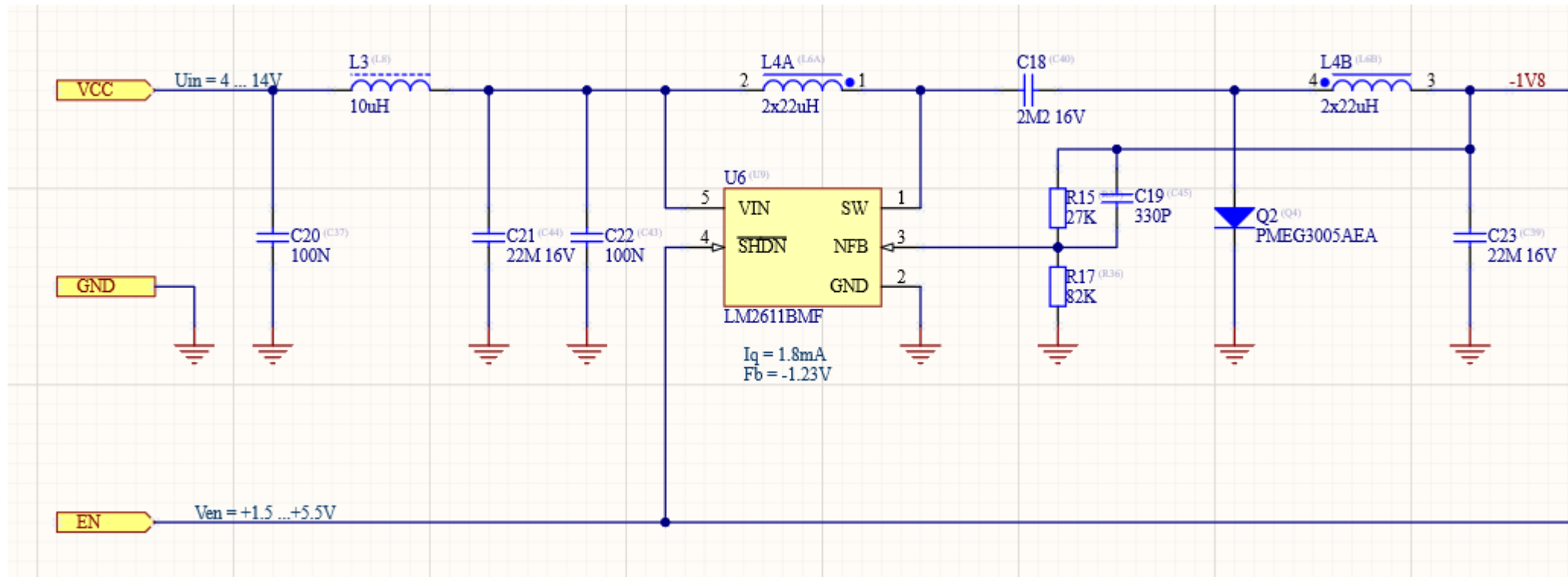
Switching Power Supply

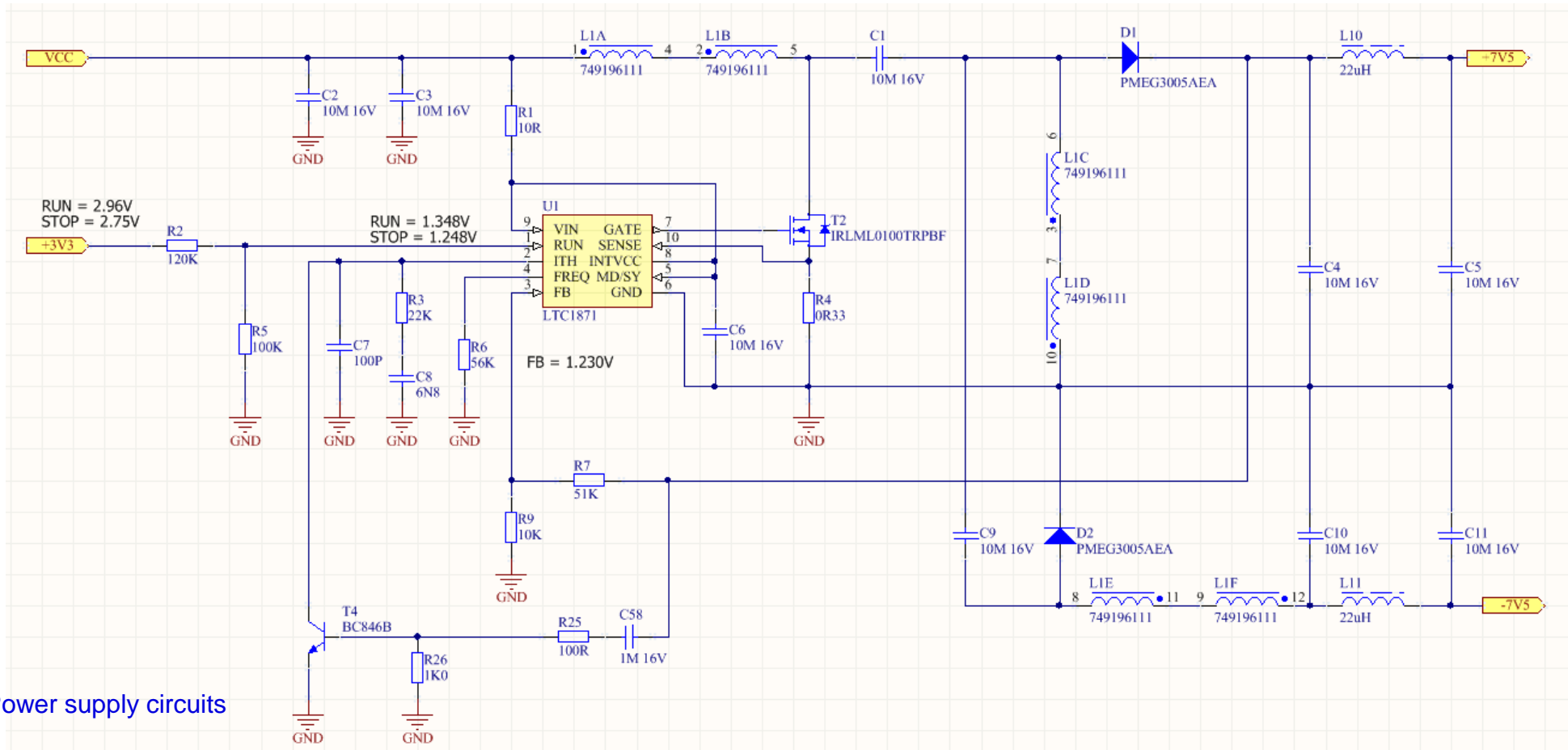ČUK topology – inversion of voltage

|Uin| + |Uout|

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Switching Power Supply

ČUK topology – inversion of voltage
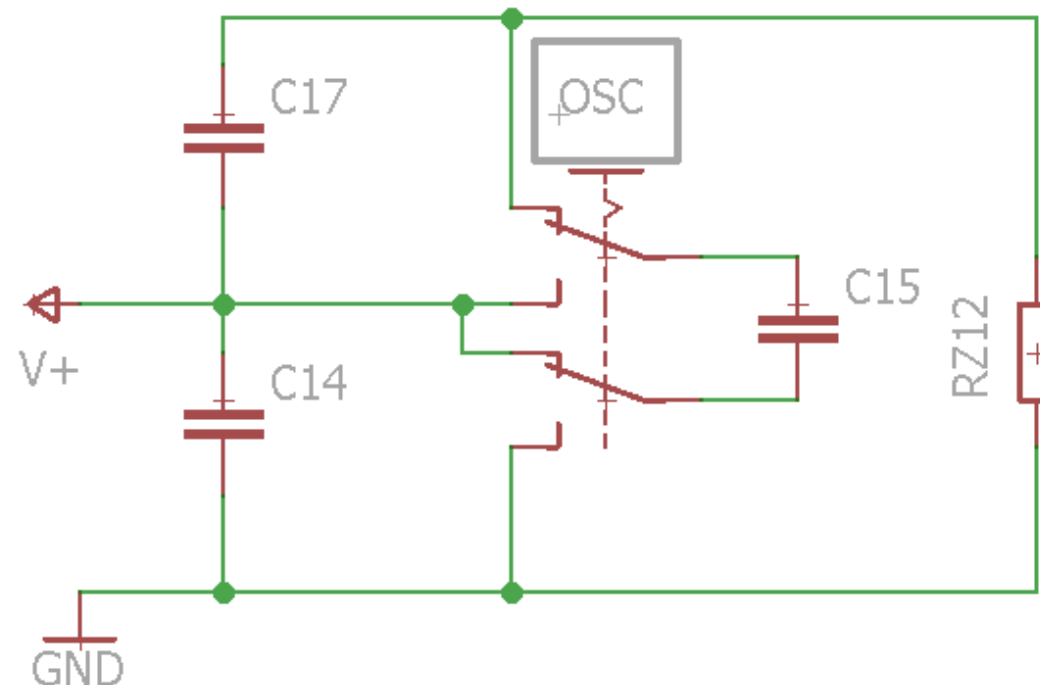
Switching Power Supply

Combination of SEPIC and ČUK topology – symmetric voltage

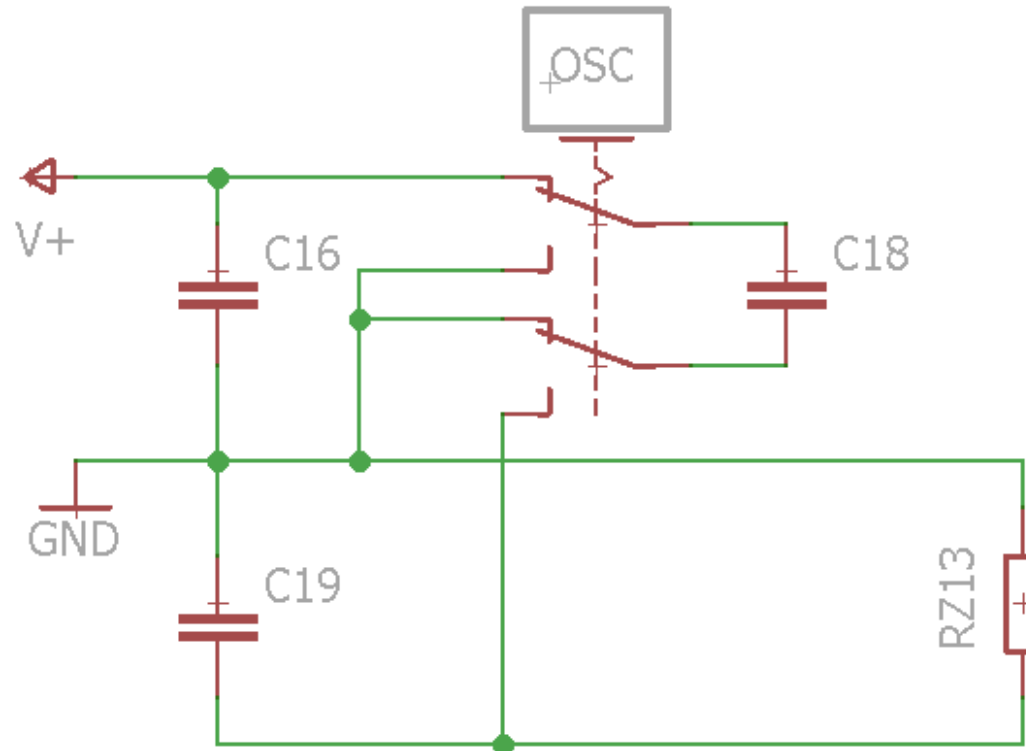# Switching Power Supply

Charge pump – voltage doubler

- Very low self consumption

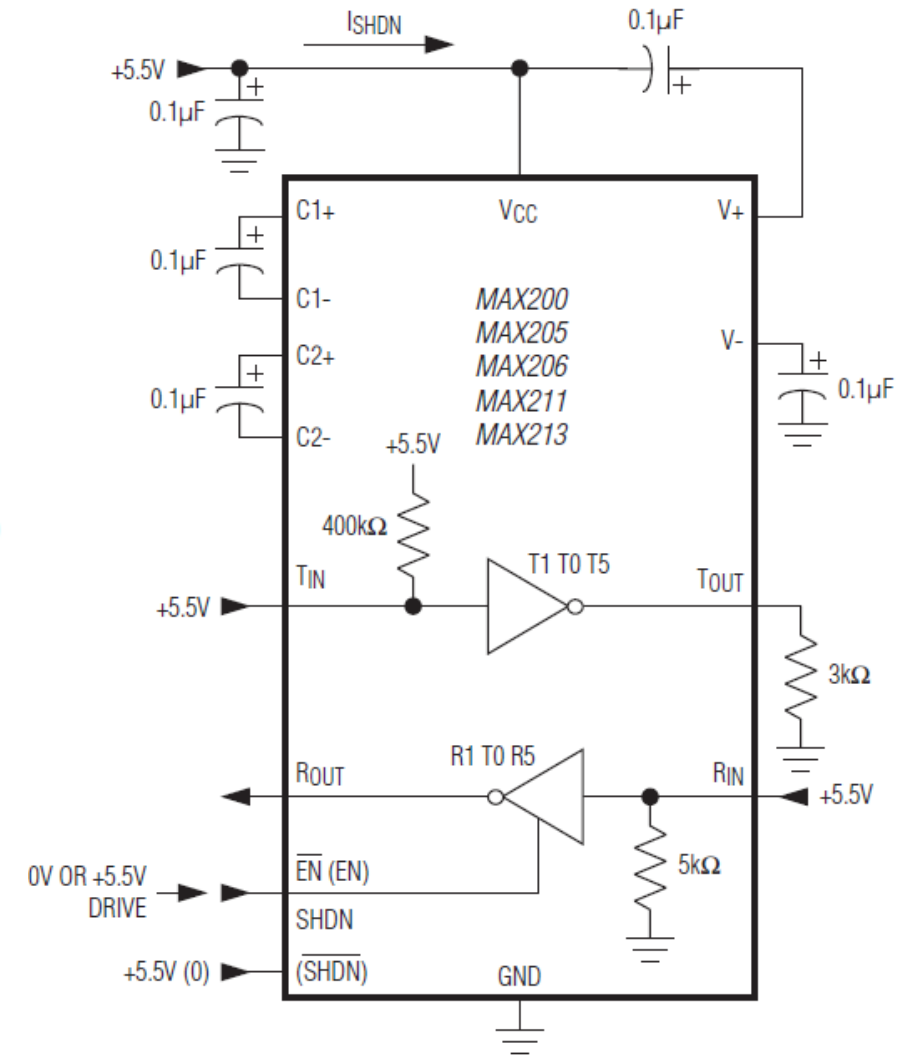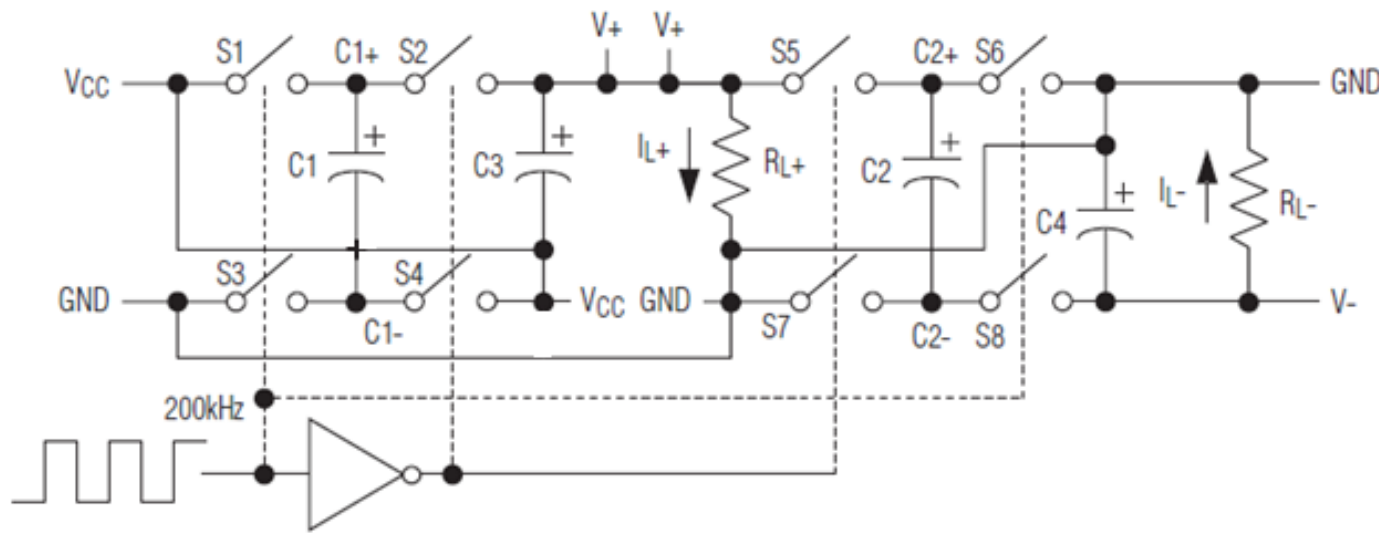- Not possible to regulate output voltage
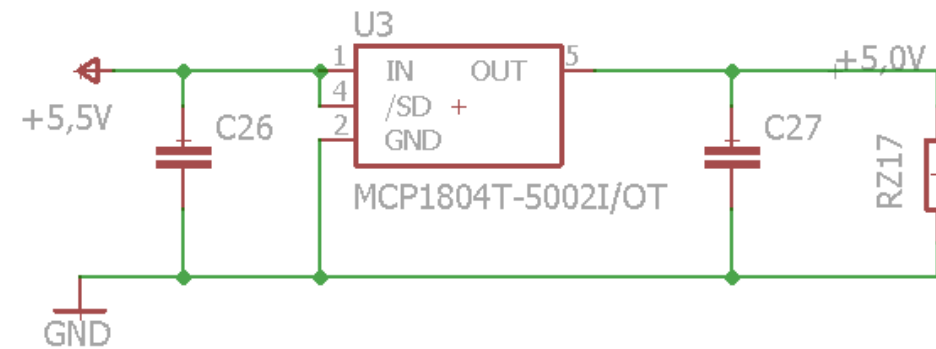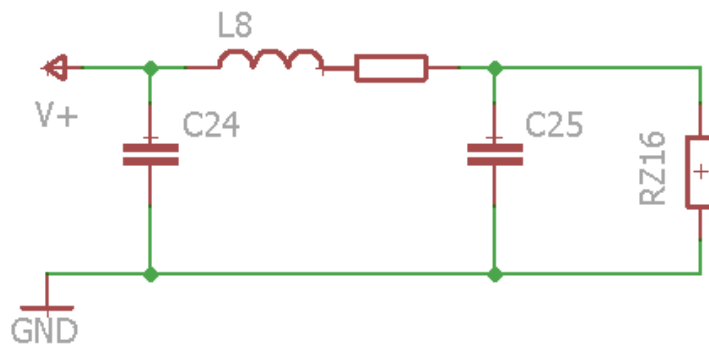
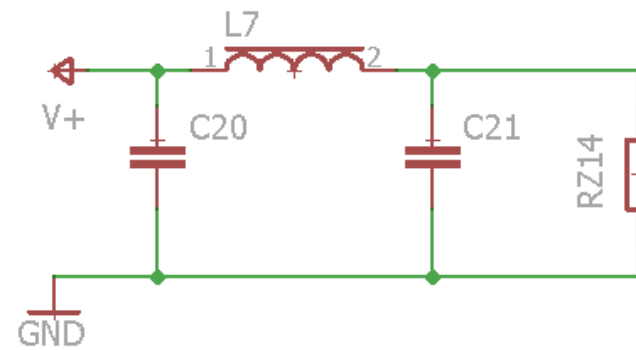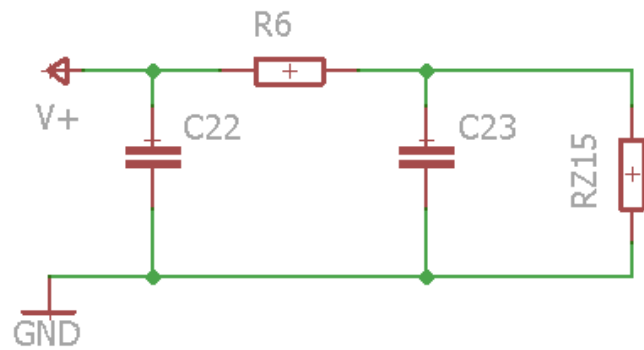MUNI
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Switching Power Supply

Charge pump – voltage invertor
- Very low self consumption
- Not possible to regulate output voltage

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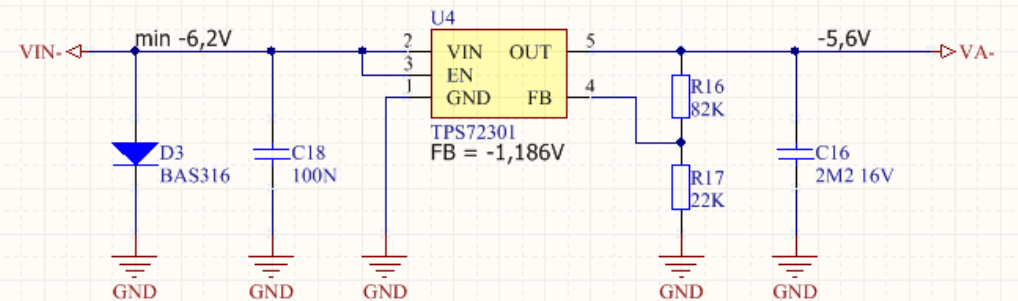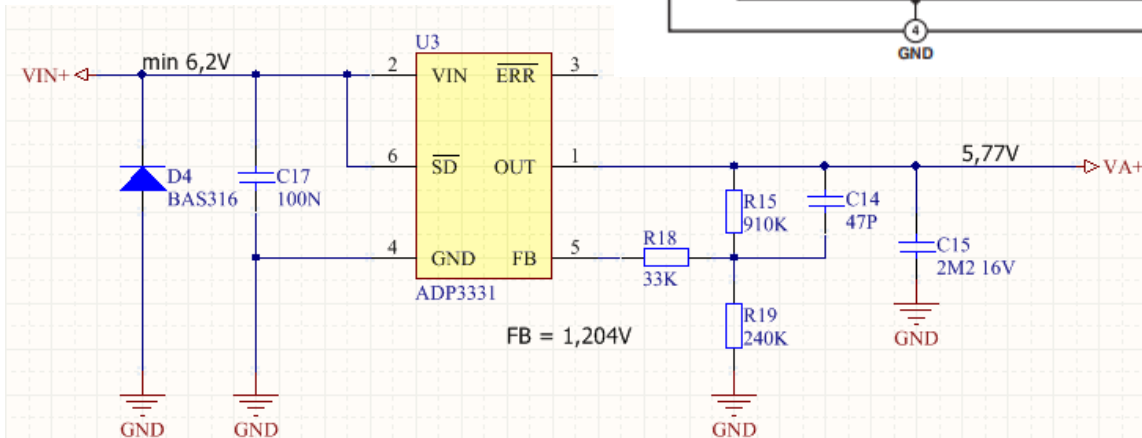# Switching Power Supply

Charge pump

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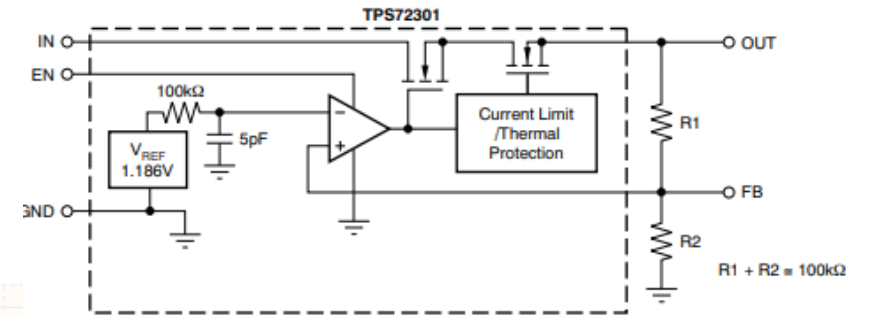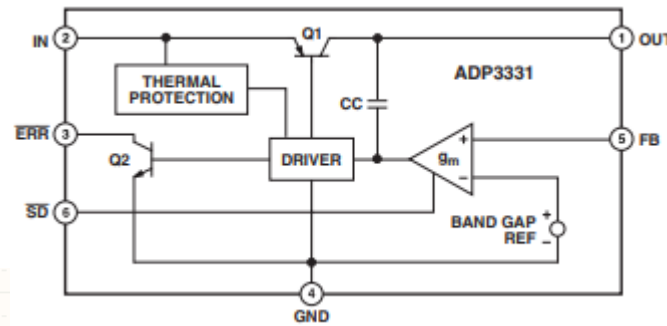# Filters for power rail

Decreasing of noise and decreasing of crosstalk's

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Filters for power rail

The best filters for low and medium frequency are linear regulators

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Starts of power supplies

It is necessary to be careful about shape, inrush current, rise times and order of voltages.

Starts of power supplies

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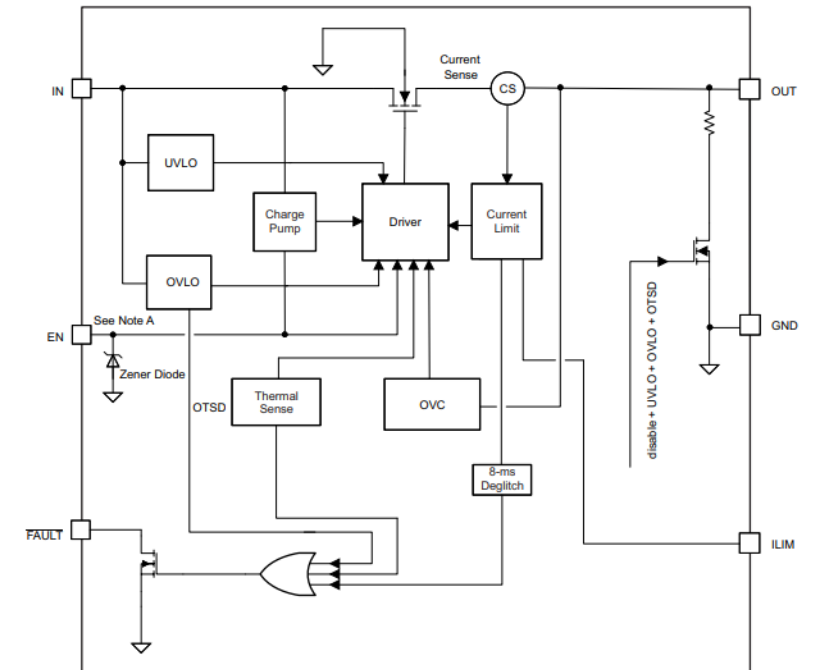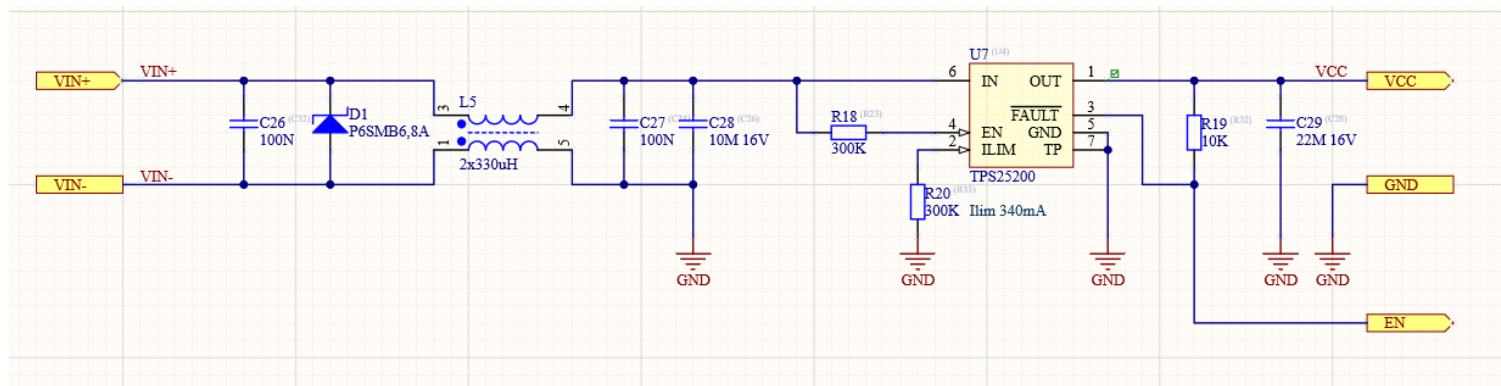
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Examples of design in the Altium Designer

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References

[1] Texas Instruments, [Power Topologies Handbook](#)

[2] Analog Devices, [LTspice simulator](#)

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Thank you for attention

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