48V Open DC Grid Interface

Martin Jäger

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Open DC grid overview

AC grid

48 VDC

Direct battery supply possible

Distributed renewable energy sources

Lower voltage appliances

48 V appliances

Distributed storage (DC coupled)

Communication for high level energy management
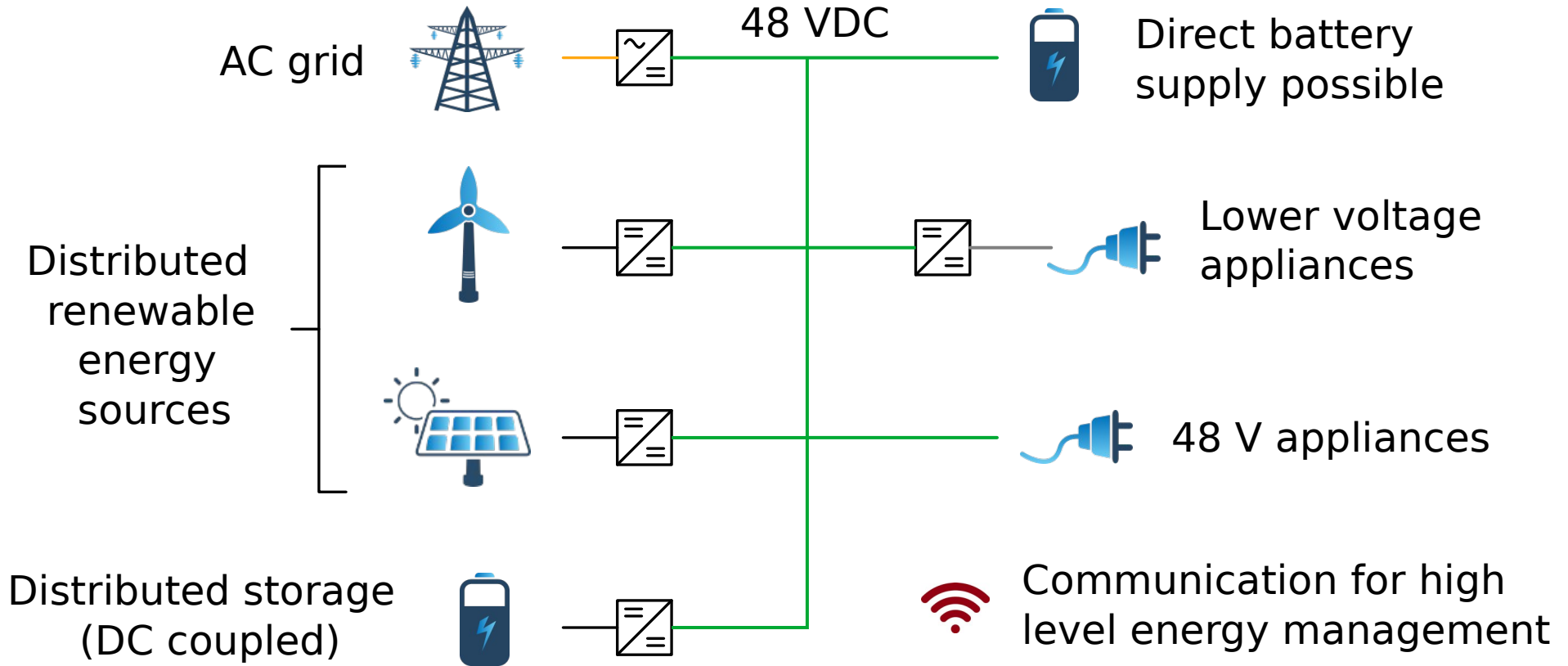
Grid control basics: Water analogy
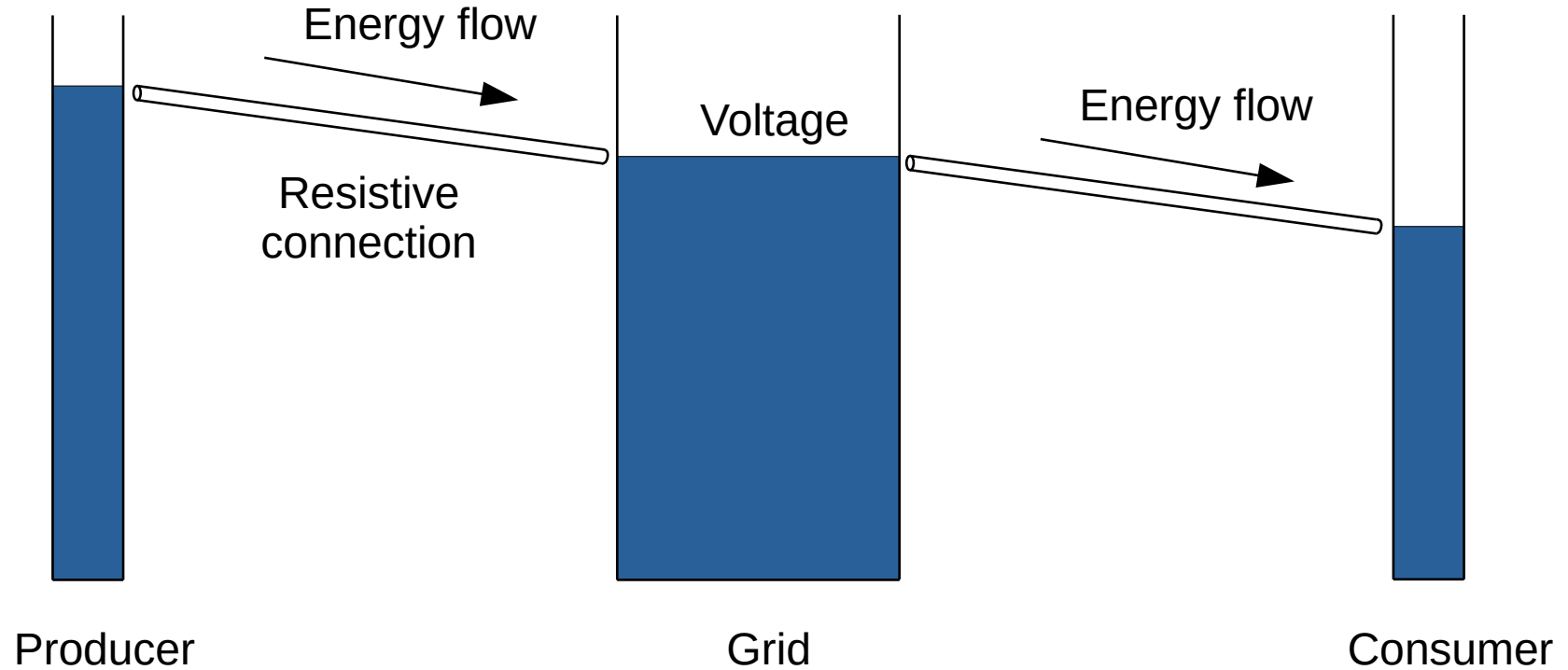
Voltage Levels according to ISO/DIS 21780

| Protection Against Electrical Shock | 60V - $U_{48shprotect}$ |
Overvoltage	58V - U_{48r}
	54V - $U_{48max,high,limited}$
Limited Operation	52V - $U_{48max,unlimited}$
	48V - U_{48n}
Unlimited Operation	
	36V - $U_{48min,unlimited}$
Limited Operation	
	24V - $U_{48min,low,limited}$
Undervoltage	
	20V - $U_{48stoprotect}$
Storage Protection	
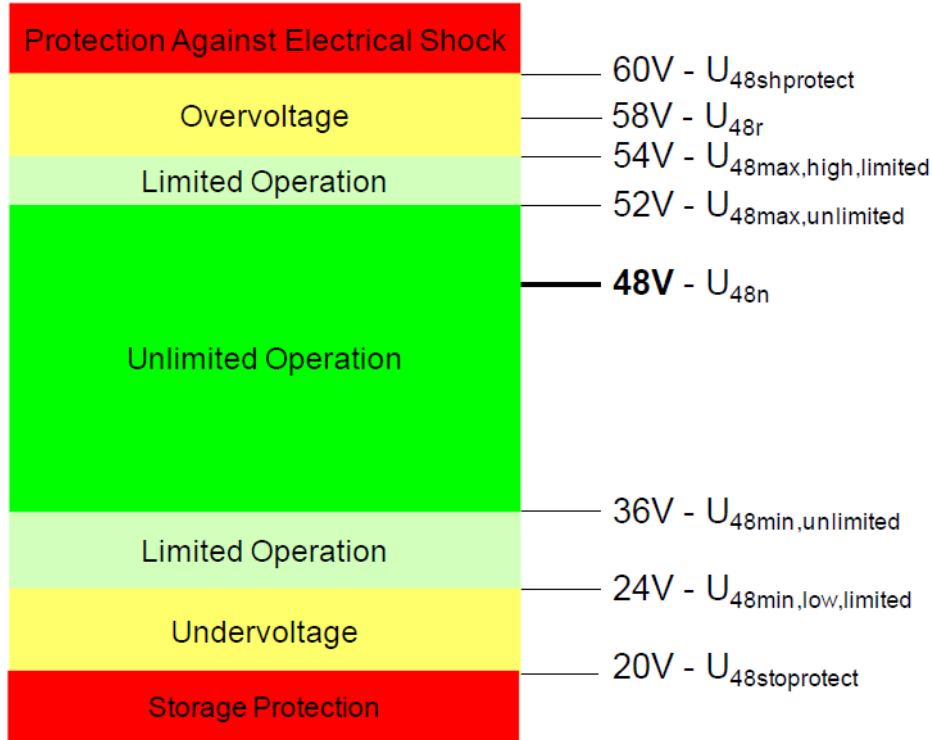
- **IEEE P2030.10:**
  - Stay below 52V if possible, but voltage up to 58V is allowed
  - Minimum supply voltage of 36V at the consumer (source voltage must be higher)
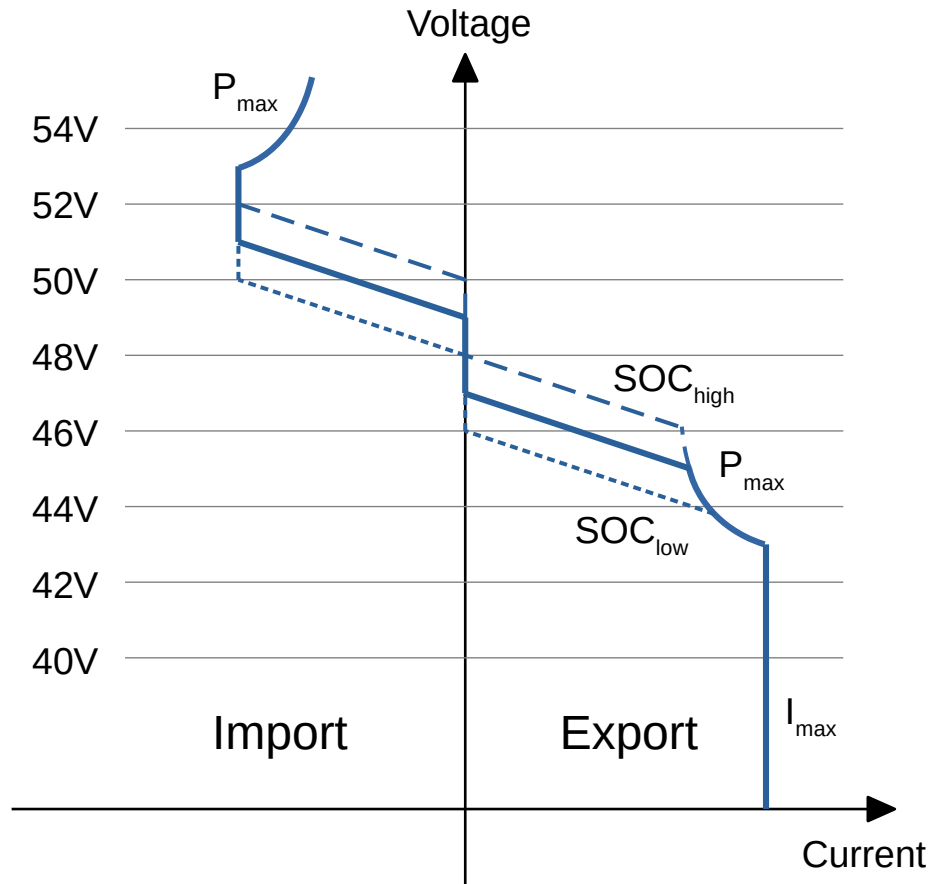
- **Selected Range for ODG Pilot**
  - Target voltage of renewable energy generators: 54V
  - Lowest voltage for loads: 40V
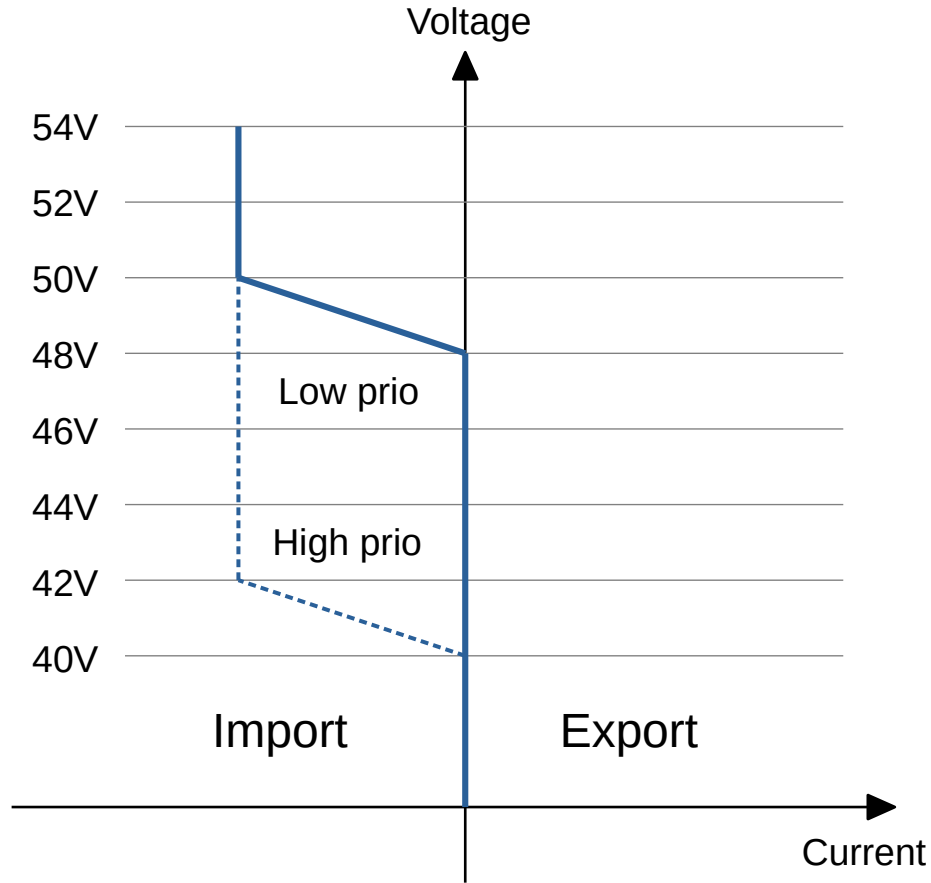
Renewable Energy Source
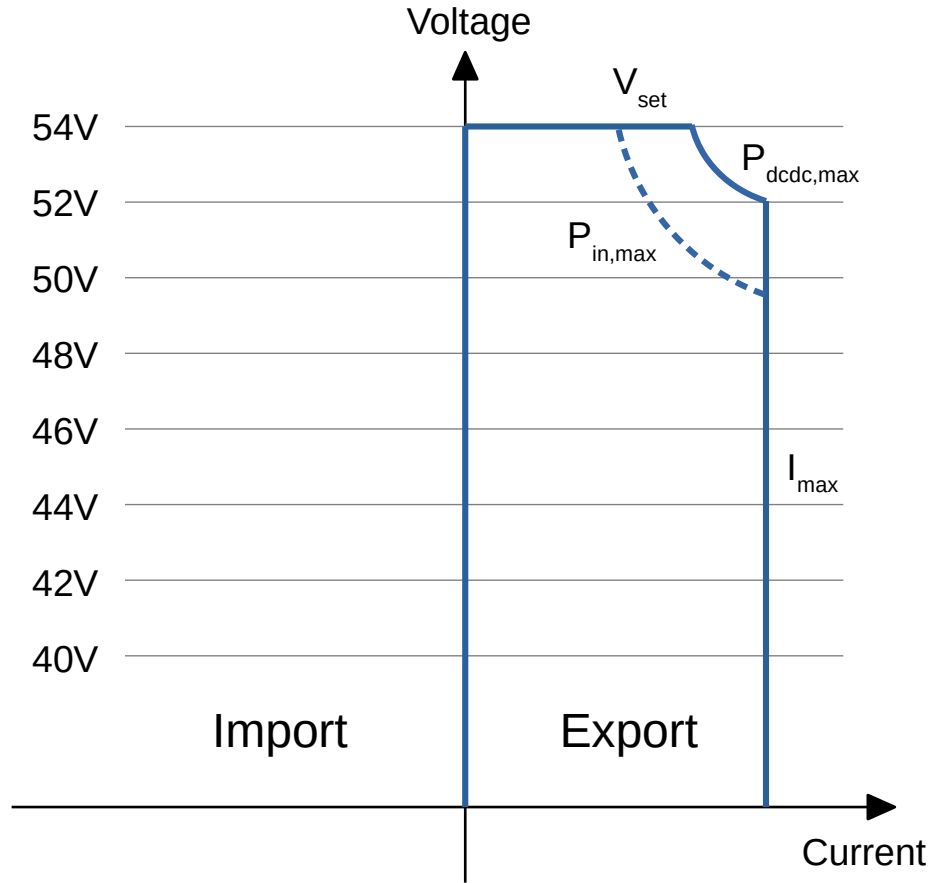
- Always try to generate maximum grid voltage until maximum power / current is reached

Energy Storage System

- SOC determines nominal voltage
  - Low batteries are charged first and discharged last

- Hysteresis to prevent energy transfer between batteries

- Droop resistance defined by maximum device current
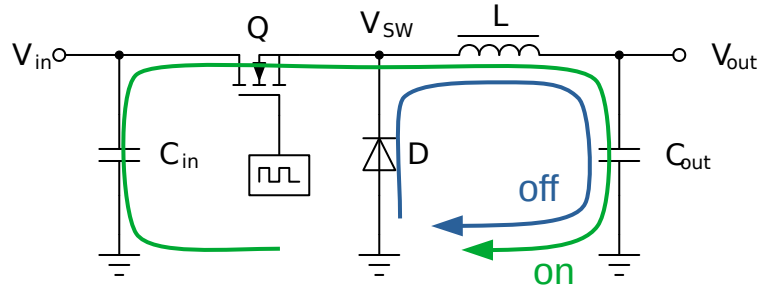
Smart Loads

- Load shedding determined by grid voltage

- Ideally, a load would ramp down its power slowly instead of shutting off immediately.

- Hysteresis needed between on and off thresholds

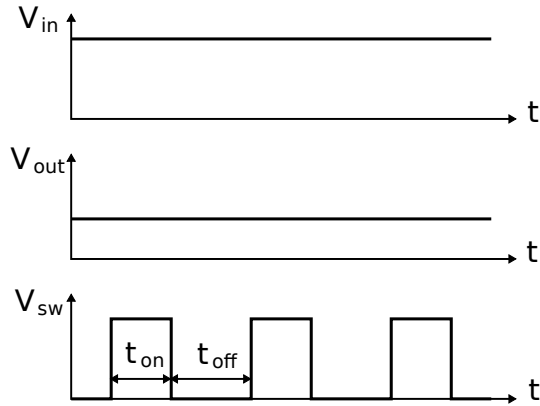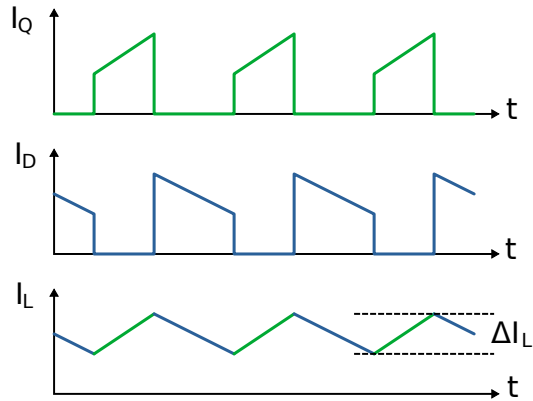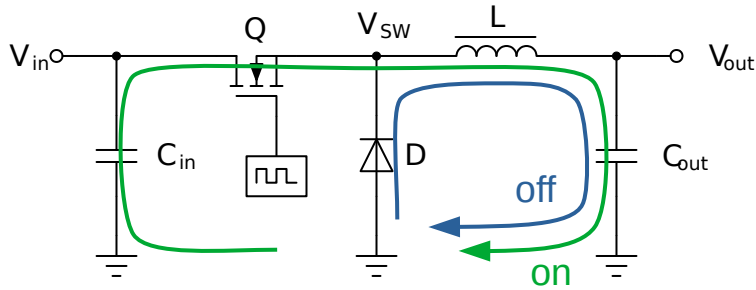# Example: Renewable energy source (left) and battery (right)
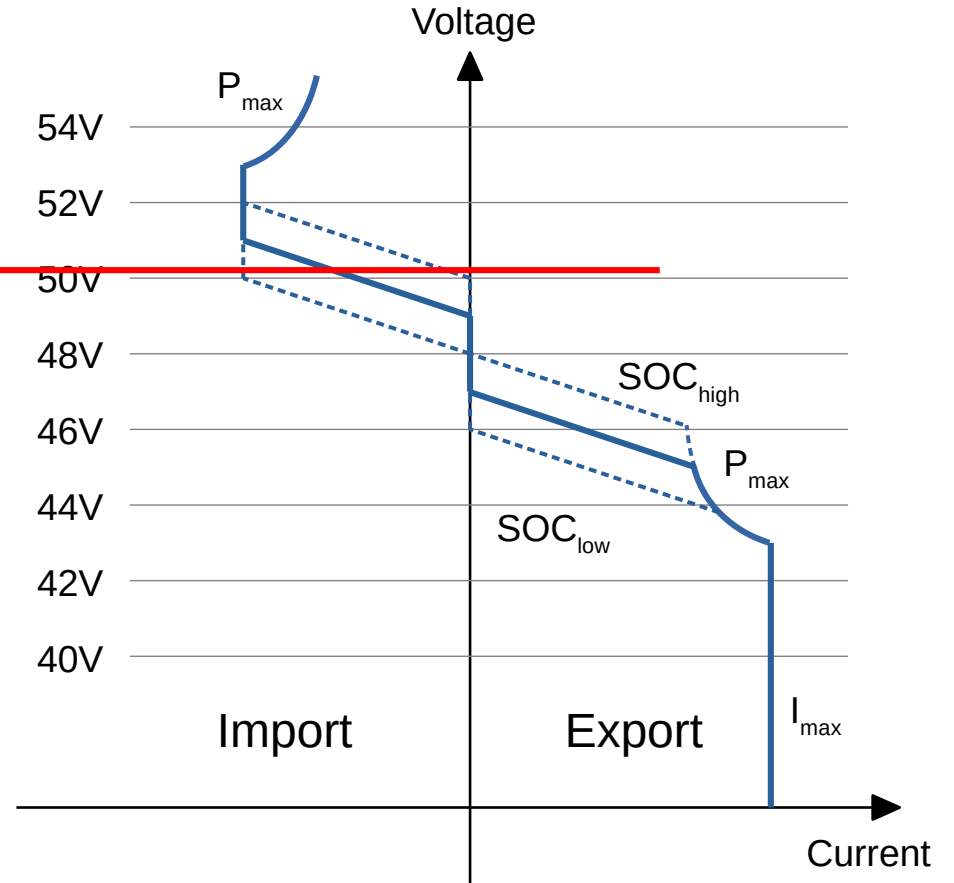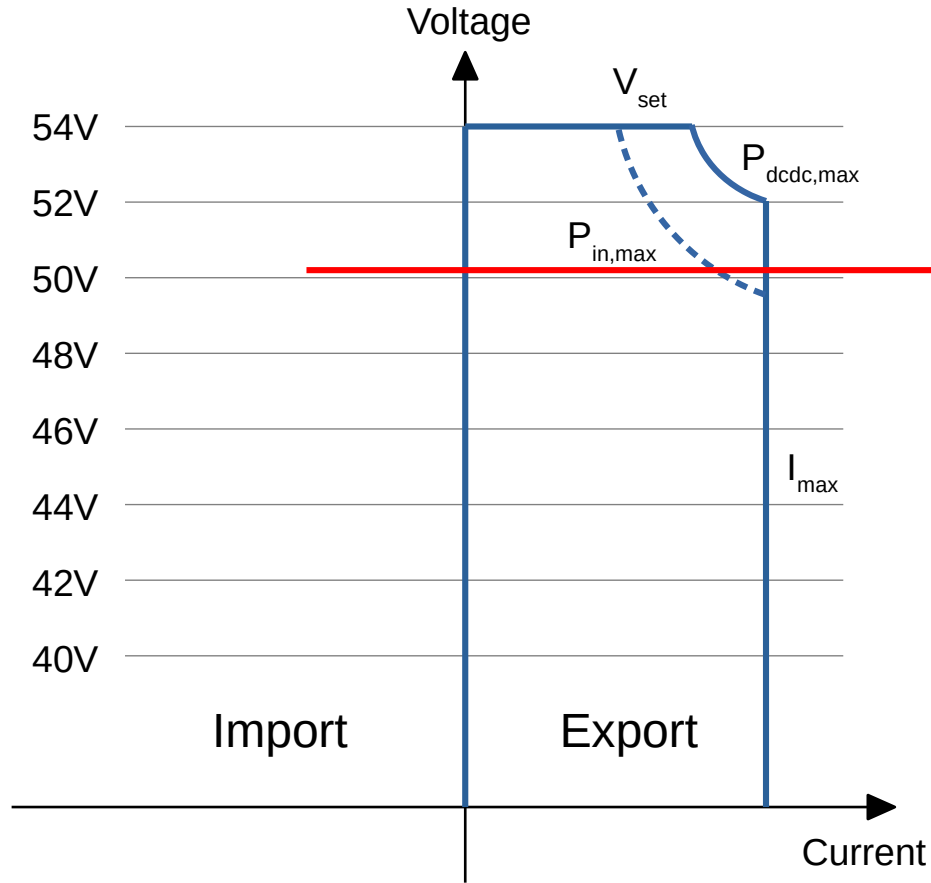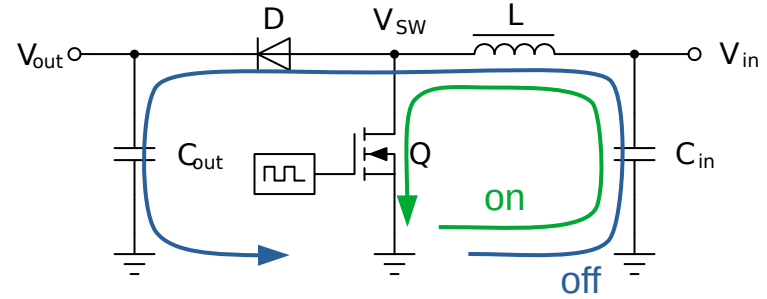
Backup

DC/DC buck converter basics

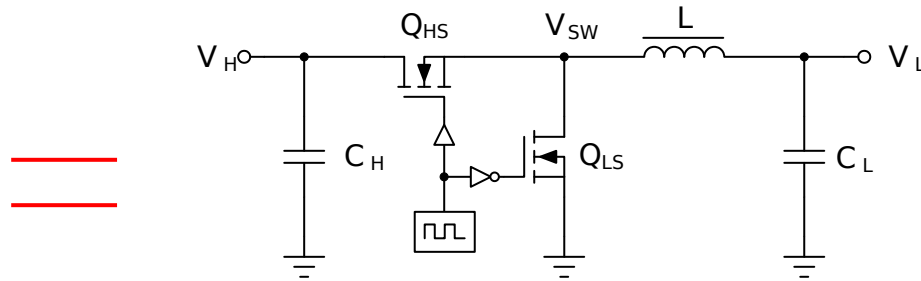$$D = \frac{t_{on}}{t_{on} + t_{off}} = \frac{V_{out}}{V_{in}}$$

Bi-directional DC/DC converter

Buck converter

Boost converter

Synchronous converter