HVD 450 – eMobility Testing / New Energy

Safe and wear-free Discharging of High Voltage DC Links up to 2000V

mütec Instruments

Agenda

1. General Introduction
2. Technical details
3. Application examples
4. Plug- & Play System offering
5. Backup

General Introduction

Safe and wear-free Discharging of High Voltage DC Links up to 2000V

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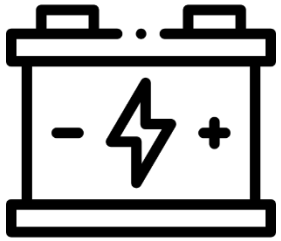
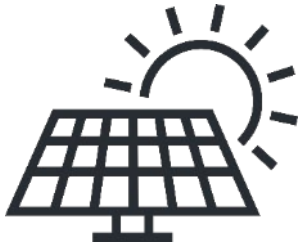
Wear-free and safe alternative to mechanical contactors

- SiC-based solid state contactor
- Wear-free switching and discharging of intermediate circuits (max. 2000 VDC, 10A)
- Integrated current and voltage monitoring
- Robust and intelligent replacement for discharging contactors
- Control Input 5…30VDC
- Adjustable discharging time constant
- **Available as complete system (19“ rack, incl. Resistors, SIL2 monitoring, temperature sensors)**

In coorperation with

1500 V DC Links are coming in style



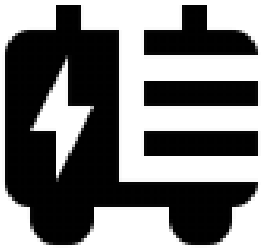


DC Power Supply
(Battery, Solar)

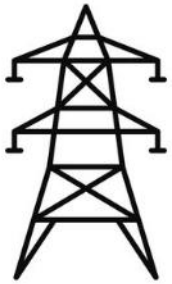
DC ->AC

DC ->DC

AC ->DC

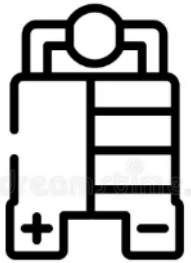


AC Load
(e-Motor)



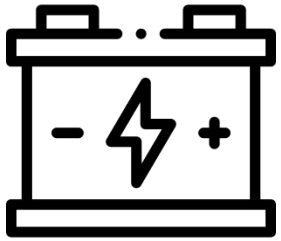
AC Power Supply
(Grid, Wind, Generator)

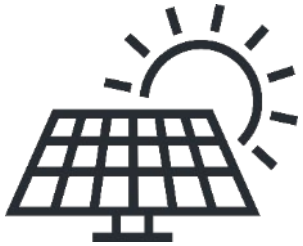
Power Electronics
(Inverter, Rectifier)



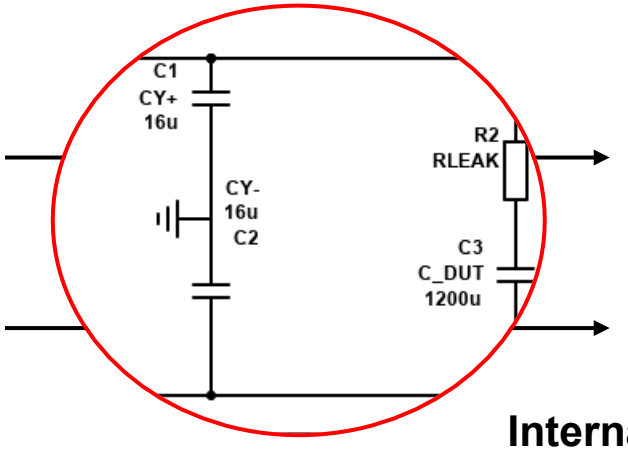
DC Load
(Electrolyser)

1500 V DC Links are coming in style

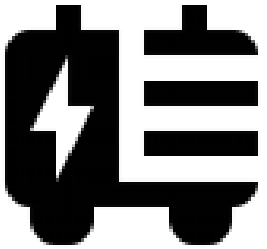




DC Power Supply
(Battery, Solar)



Internal Capacities that can be charged at 1500V ALTHOUGH the supply is disconnected
-> Major Safety Risk!



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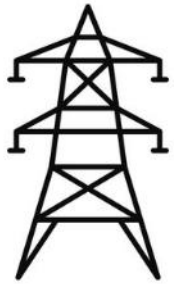

AC Power Supply
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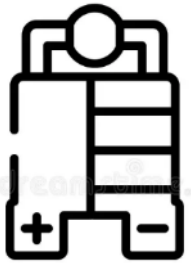
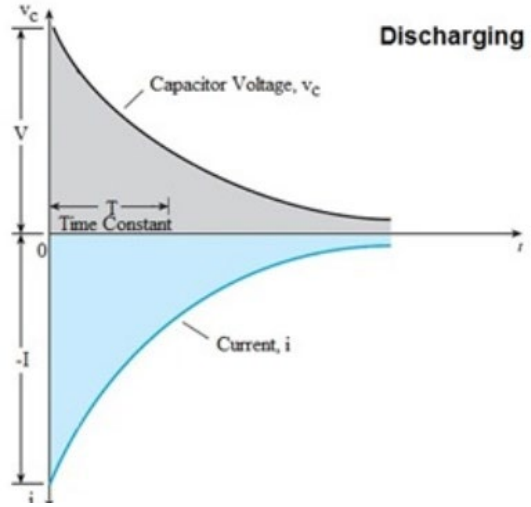


DC Load
(Electrolyser)

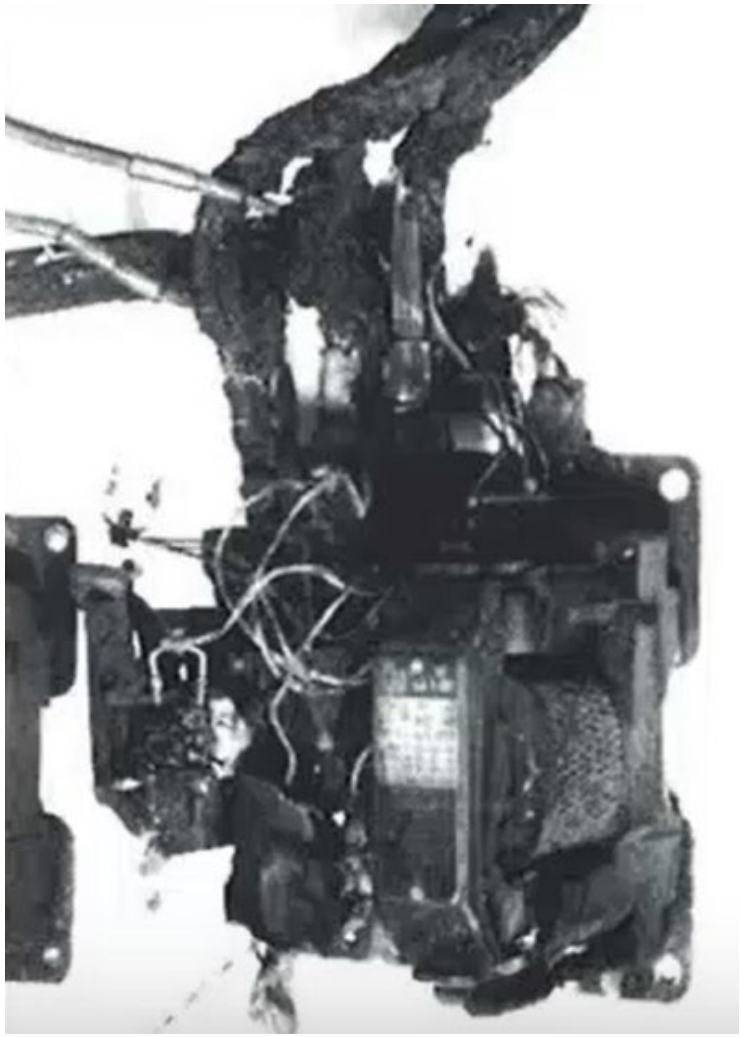
Each time you disconnect the load, the capacitors need to be discharged

- The capacities need to be discharged for handling, during production, testing or in case of emergency stops
- Conventionally, resistive loads in combination with **mechanical contactors / switches** are used to convert electrical to thermal energy
- This means:
  - High current and voltage peak
  - Mechanical & electrical wear and tear
  - Thermal stress



→ In high-voltage applications mechanical contactors have a very limited lifetime!

Replace mechanical contactors against wear-free HVD 450



Damaged mechanical contactor

Replace with

High Voltage HVD 450

HVD 450 – Introducing the first intelligent, wear-free HV contactor

Wear-Free:

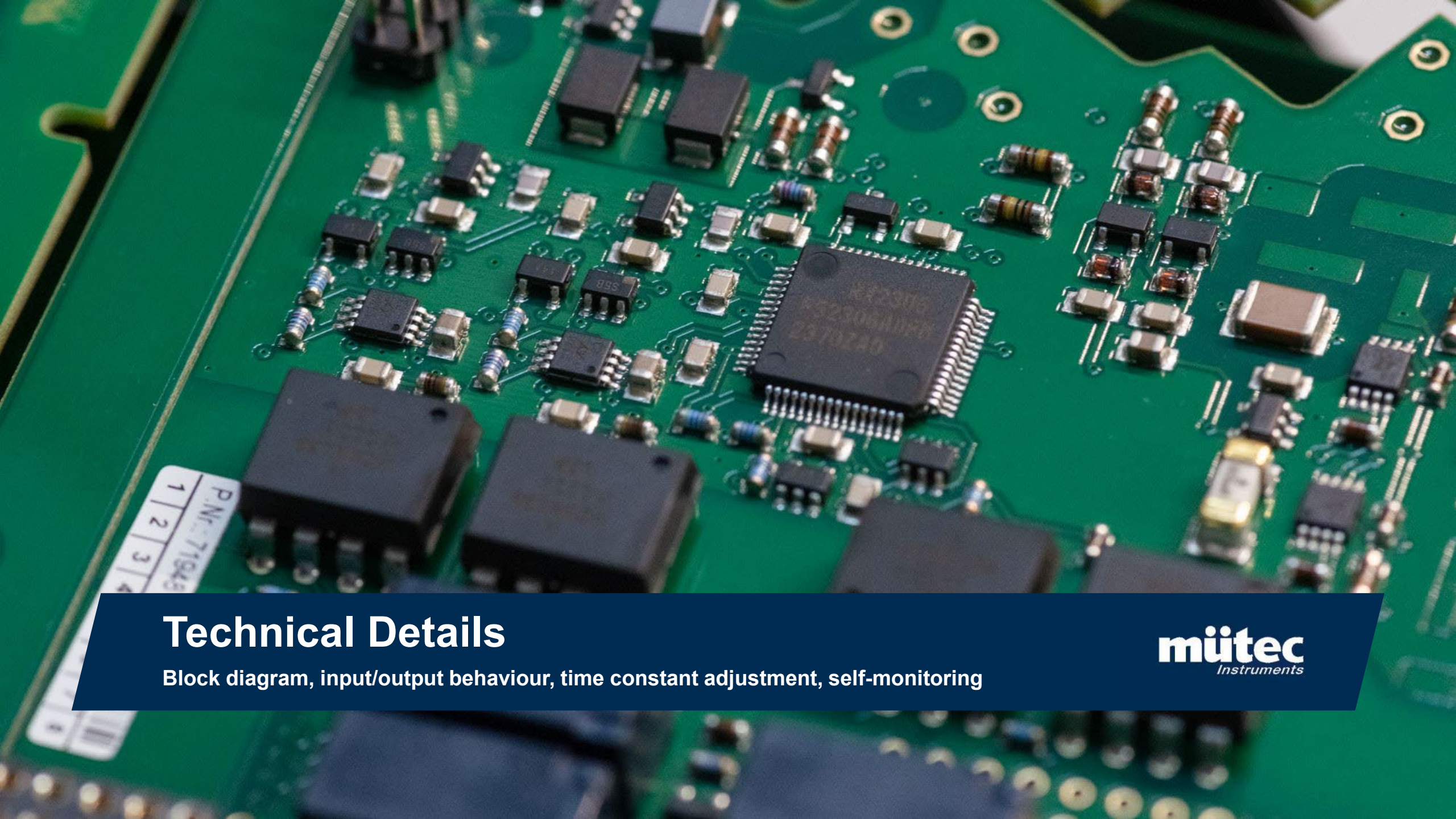
- Using special semiconductors, the HVD 450 can switch high voltages without any mechanical and electrical wear-down

Intelligent:

- The HVD 450 is equipped with internal safety routines as voltage / current monitoring and interfaces to the safety PLC to increase the reliability and safety

Flexible:

- HVDs can be tuned to different discharging time constants
- Up to 1500 VDC and 8A
- Multiple HVD 450 can be run in parallel, e.g. to discharge large power banks, e.g. 5 pc.* 8A = 40A



Technical Details

Block diagram, input/output behaviour, time constant adjustment, self-monitoring

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Block diagram

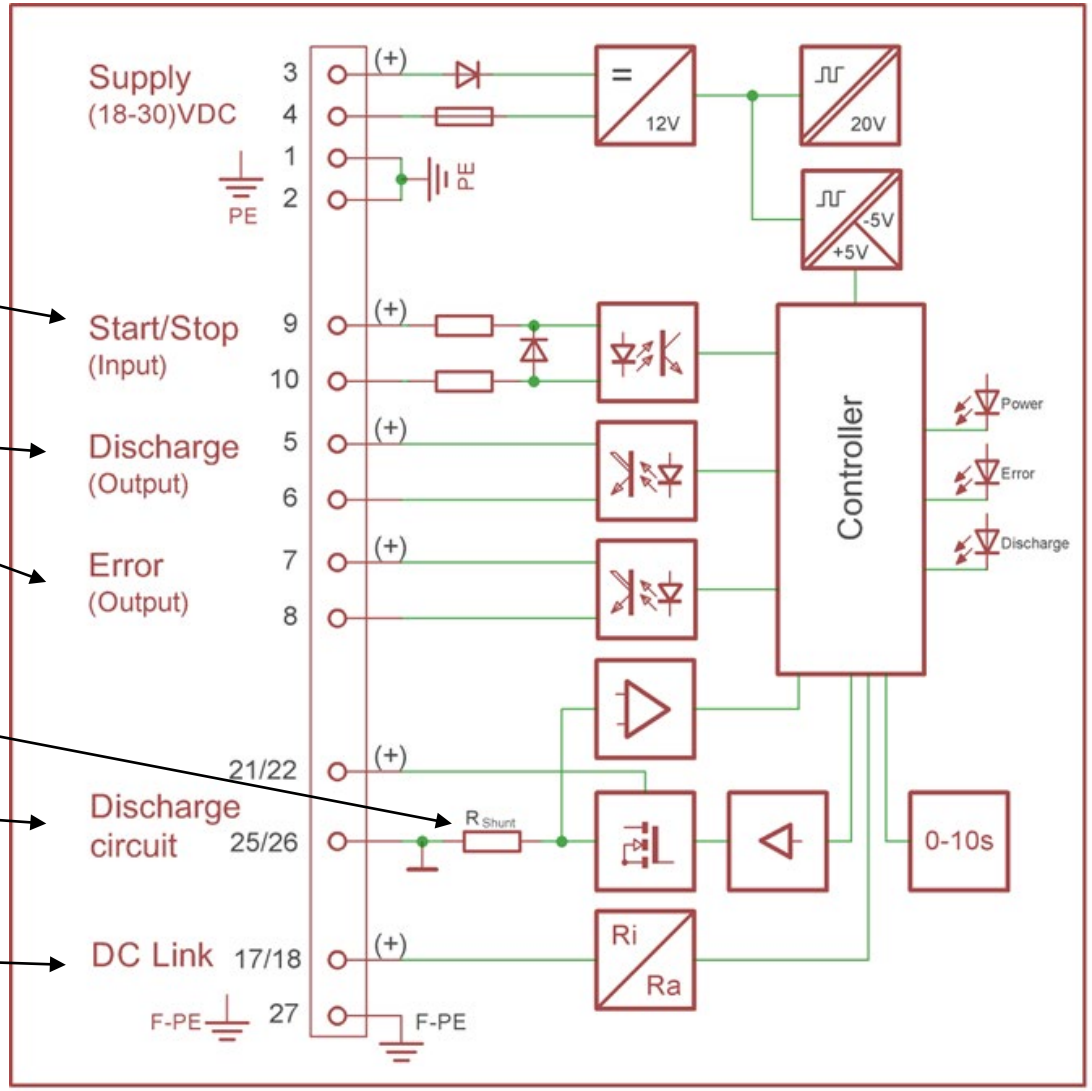
Control signal from SPS
- *level controlled, high=discharge*

Digital status out (2 bit status coding)
- *Off, Ready, Discharging, Cooldown, Error*

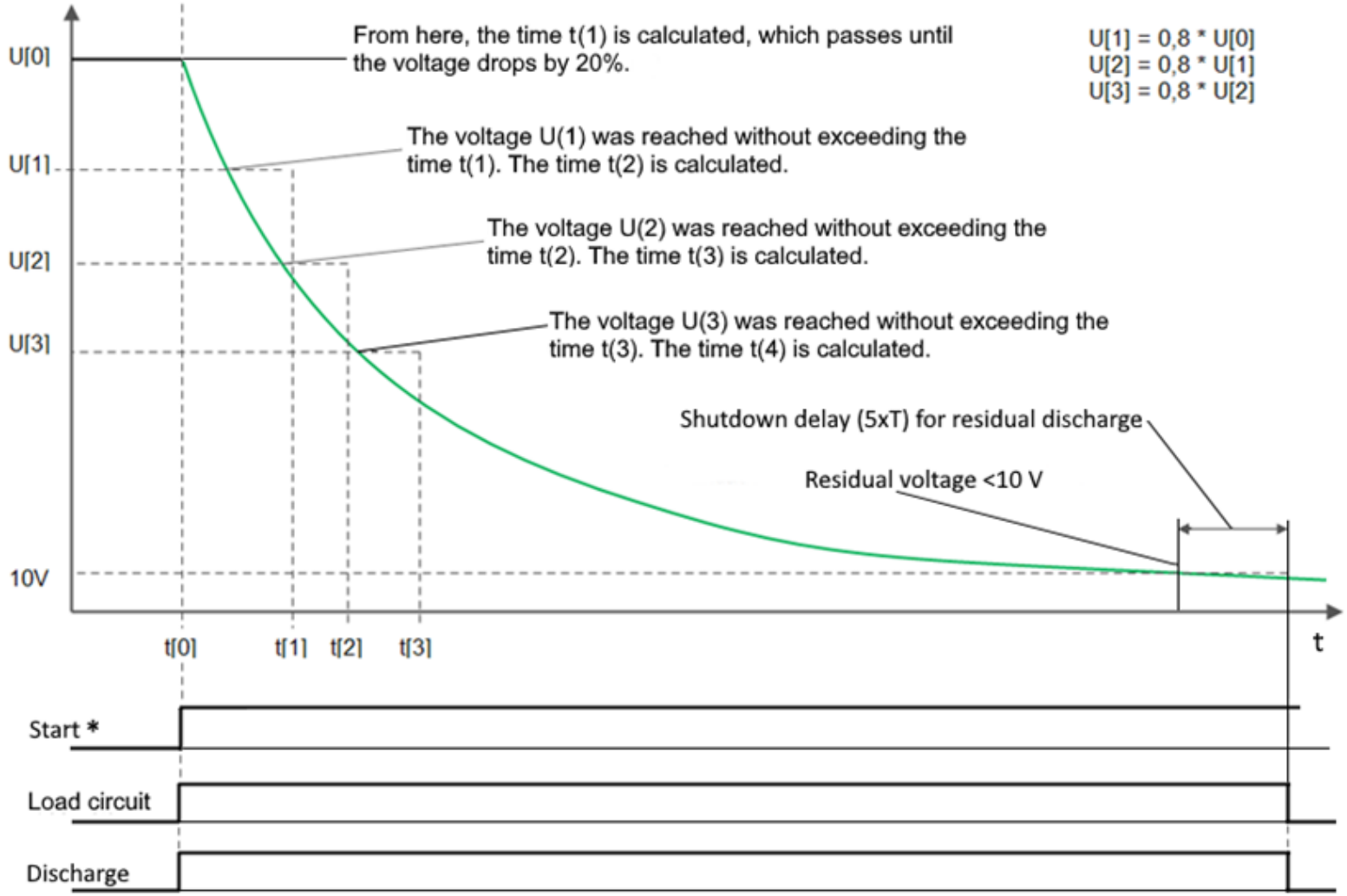
Discharge current monitoring

Connection to load resistance

DC-Link voltage monitoring

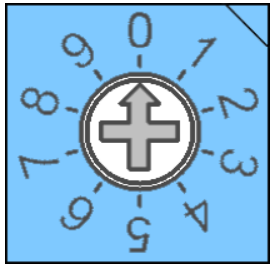


Example of a „normal“ discharge process



Setting the discharge time constant

- To monitor the discharge process, the time constant "τ" must be set in the HVD 450 using a 7-position coding switch
- The selected time constant of the coding switch must be greater than $\tau = R_{ext} \times C$
- The position mus be set prior to delivery



Coding switch positions

Example (using C = 470 µF, Rext = 330 Ω)

τ = C x Rext = 470 µF x 330 Ω = **155ms**

⇨ **at least coding switch position 1 (200ms) must be selected!**

Position	Time constant
0	100 ms
1	200 ms
2	500 ms
3	1 s
4	2 s
5	5s
6 - 9	10s

Several Safety Features to ensure safe operation

Measurement

A measurement interval of 100µs is used to measure the discharge voltage. The measurements are averaged within a time window of 1ms. This means that every millisecond a new measured value is available.

Accuracy

With a reference voltage of 5V and a voltage divider of 426:1, 1 bit of the 12-bit ADC at 2000V corresponds to a value of 520mV. Error assumption: 5 % of the measurand + 5 digit base error (5 x 520mV = 2.6V)

Discharge Trigger

The discharging process is started with a high signal at the start input, but can be be terminated again during the discharge by a low signal

Discharge Process

The time constant τ (= R x C) for the discharge is set to e.g. 20ms. After reaching the minimum voltage of 10 V, the discharge time is automatically extended by another 5τ. This can be used to ensure that the voltage that would otherwise build up again due to a residual charge in the capacitor is
does not exceed the value of 10 V.

Voltage Monitoring

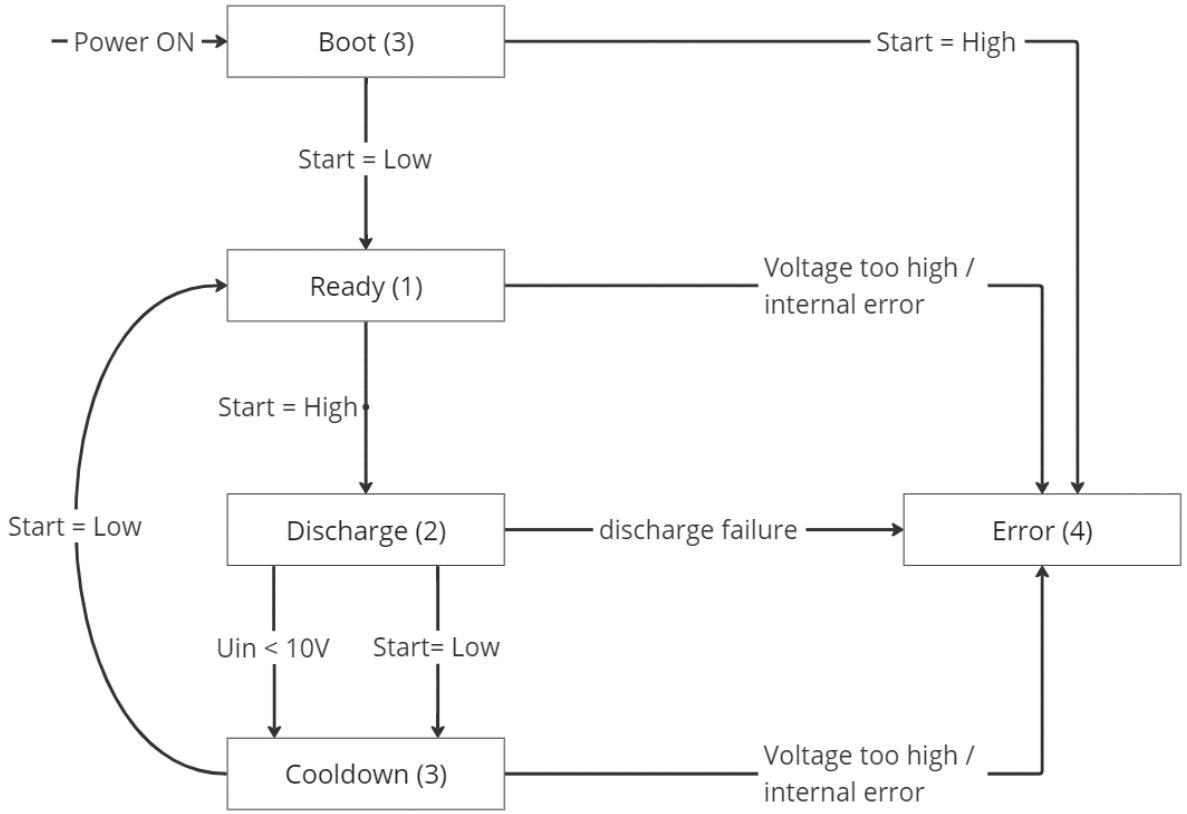
The time required to achieve a voltage drop of 20% at 100ms is calculated. The calculation also takes into account the measurement error.

Current Monitoring

By using an internal shunt resistor, the discharge current is actively monitored. In case of exceeding 10A, the current monitoring signals an error

State overview

#	Power	Error	Discharge	Status	Note
0	OFF	OFF	OFF	Switched off	No supply connected
1	**ON**	OFF	OFF	Ready	Device ready to discharge
2	**ON**	OFF	**ON**	Discharging	Discharge in progress
3	**ON**	**ON**	**ON**	Cooldown	Protective measure against overheating or currently booting
4	**ON**	**ON**	OFF	Error	Potentially dangerous failure, not able to safely discharge. Check wires and components and restart the device to reset



⇨ Error and Discharge outputs give the binary coded status information to the **PLC**

Application Examples

Typical error causes, automotive powertrain, inverter test bed

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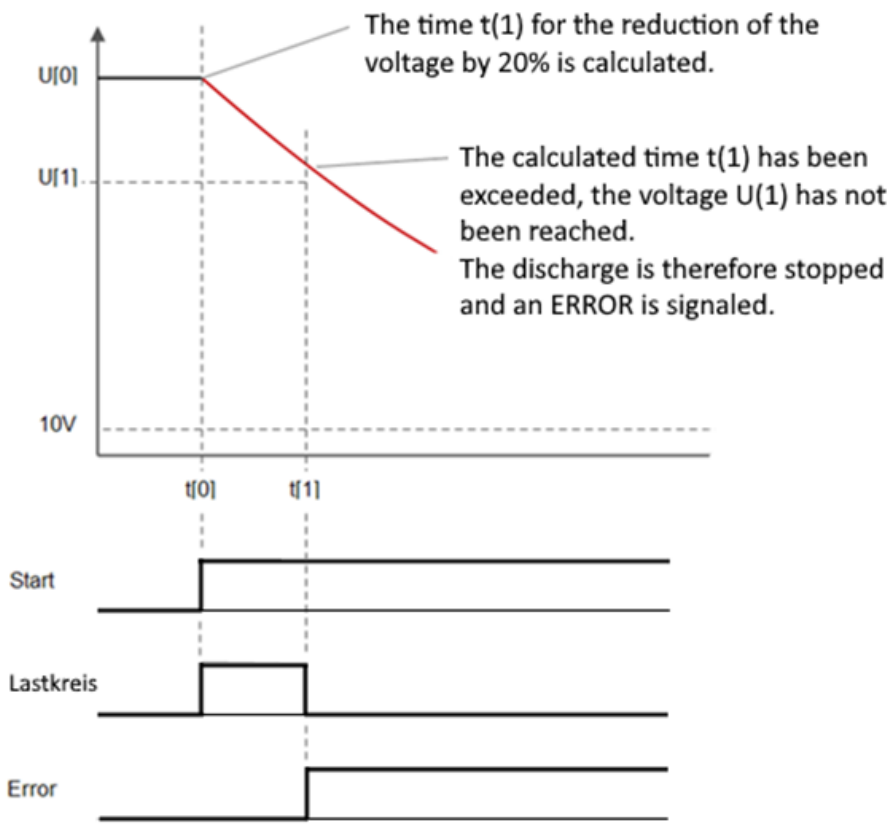
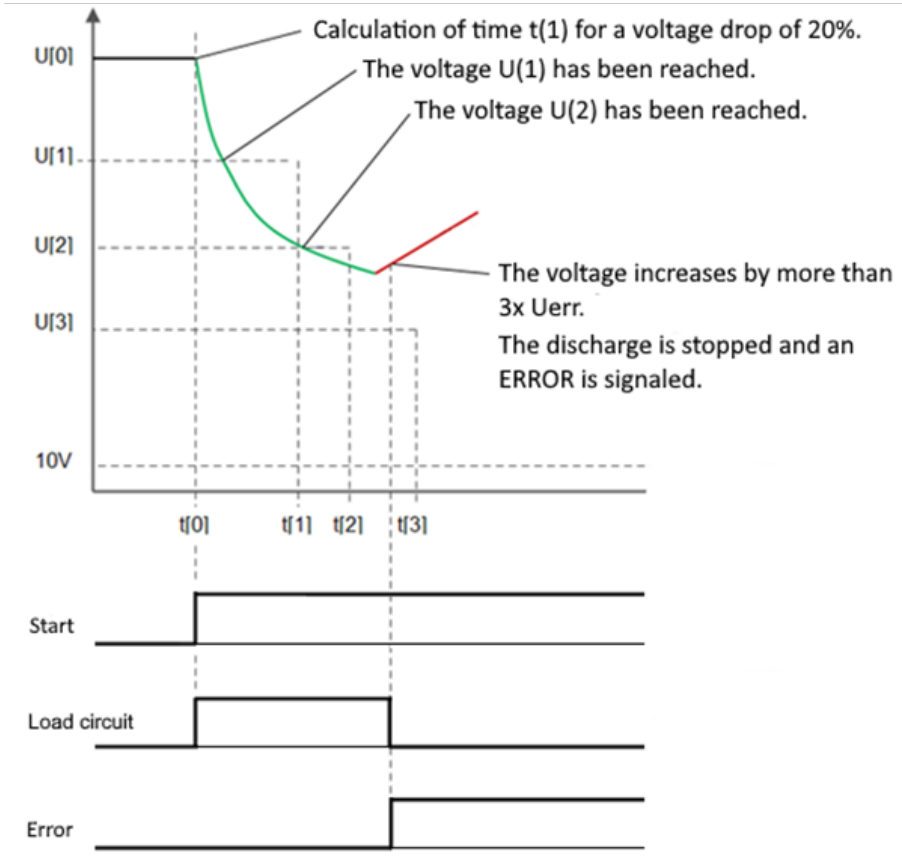
Example of typical error causes

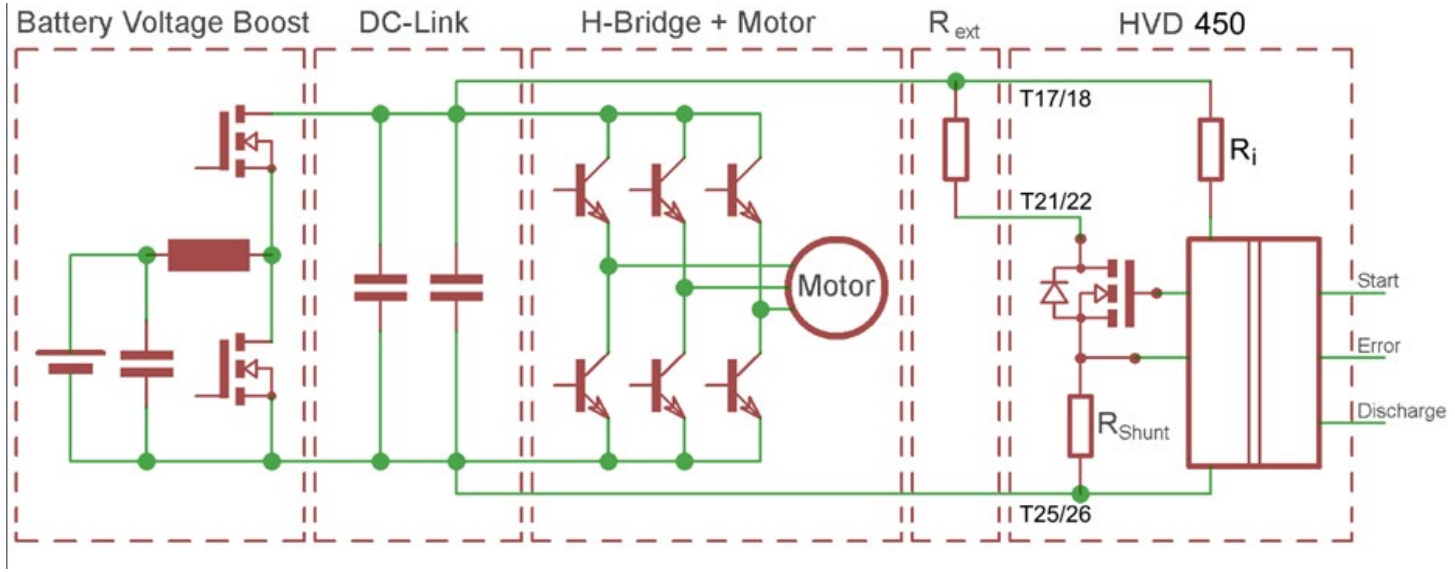


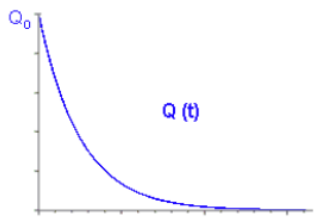
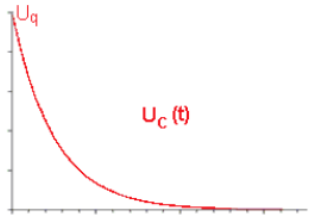
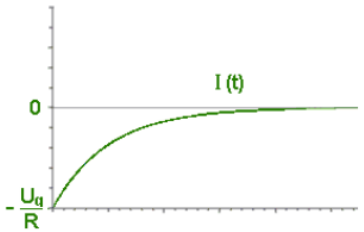
Failed discharge due to exceeding the assumed time constant



Failed discharge due to increasing voltage (e.g. re-activiation of DC link supply)

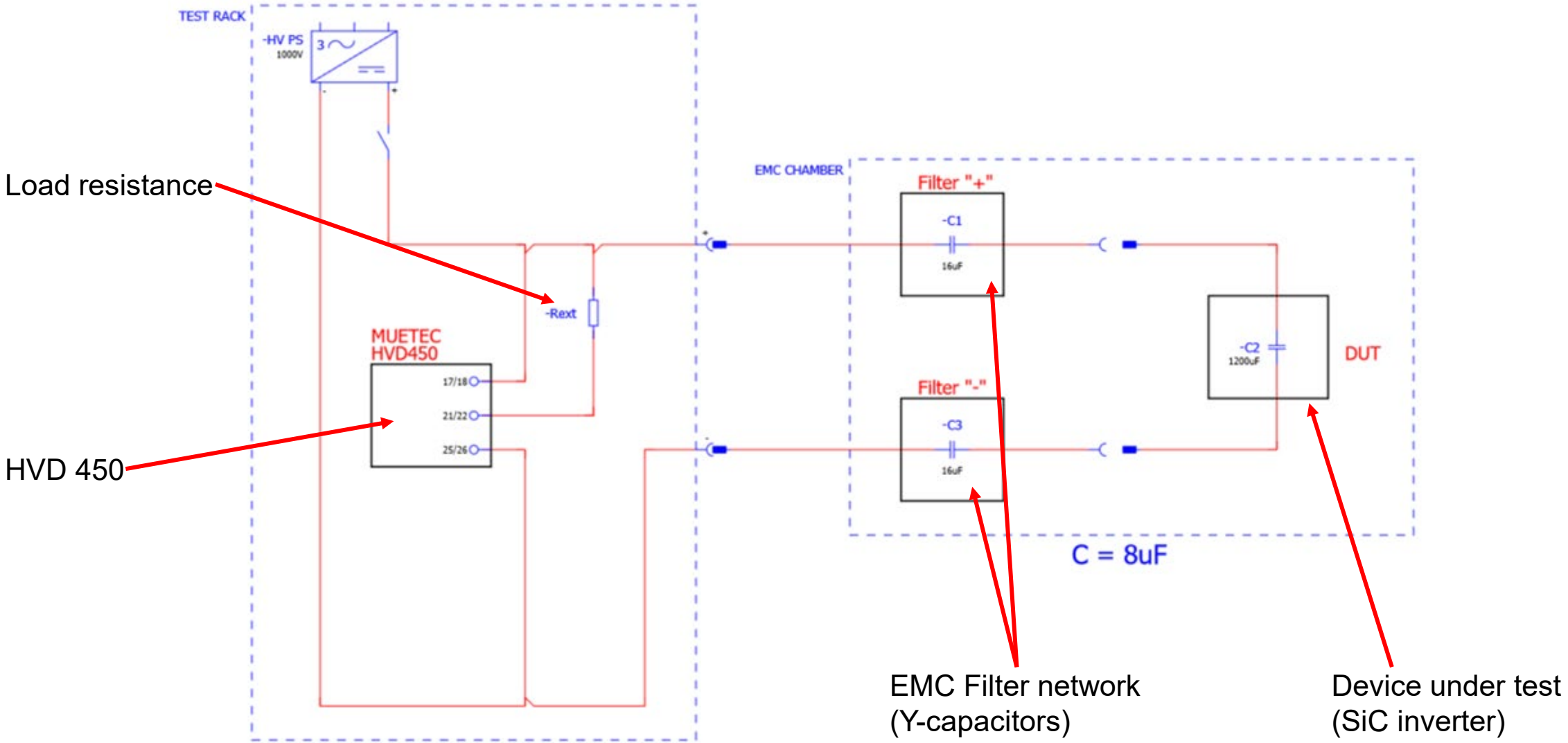
Application example: General HV Automotive Powertrain



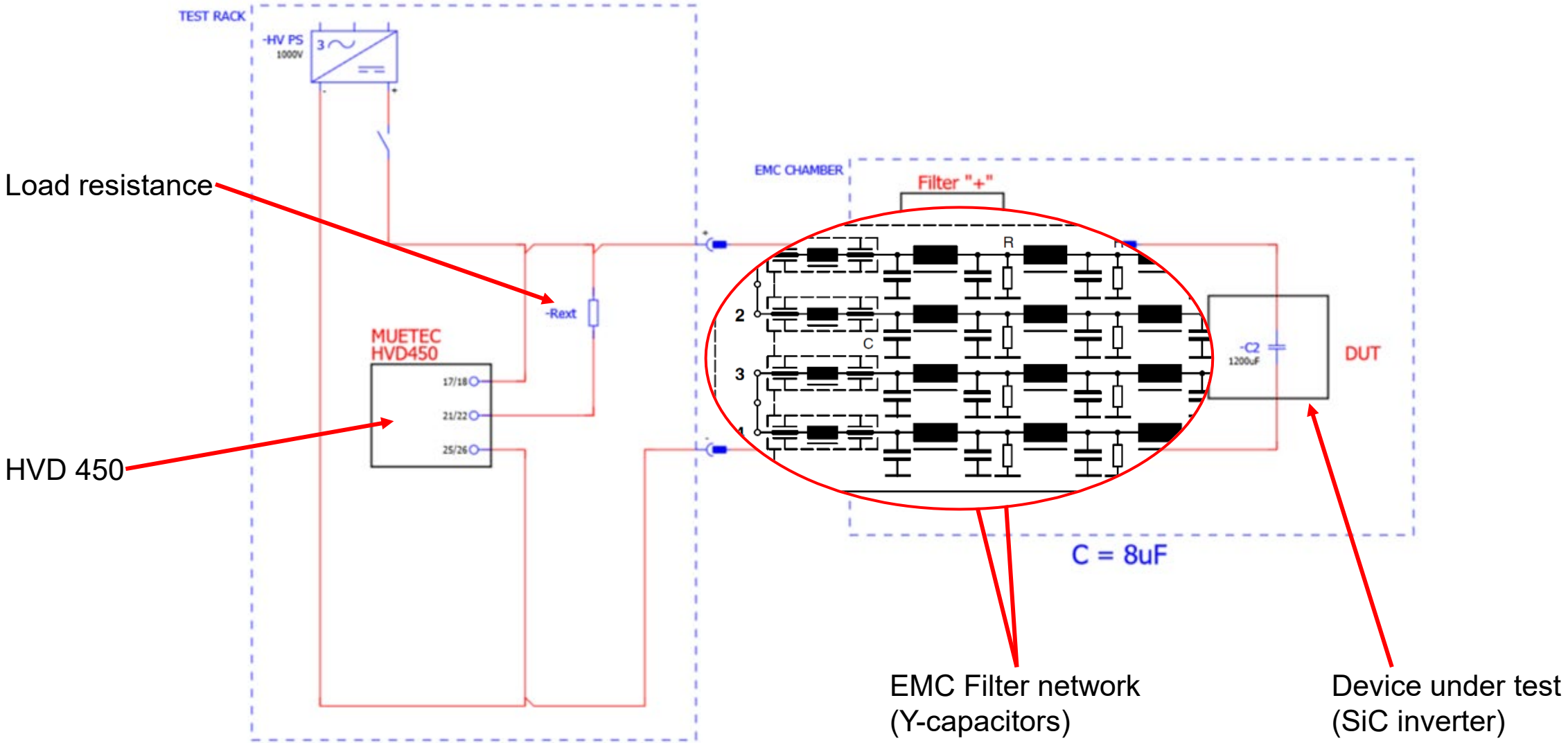
Ladung Q(t)	Spannung Uc(t)	Stromstärke I(t)
		
$Q(t) = C \cdot U_q \cdot e^{-\frac{1}{RC} \cdot t} = Q_0 \, e^{-\frac{1}{RC} \cdot t}$	$U_C(t) = U_q \cdot e^{-\frac{1}{RC} \cdot t}$	$I(t) = Q(t) = -\frac{U_q}{R} \cdot e^{-\frac{1}{RC} \cdot t}$

- Controlled and monitored discharging of 2000V high voltage intermediate circuits
- Wear-free solid state contactor in the load circuit
- Overvoltage and overcurrent monitoring
- Suitable for all capacities
- Ensures safe discharging below 10V
- 8A max current per device (parallel architecture possible)

Application example EMC filter / inverter test bed (1/2)



Application example EMC filter / inverter test bed (1/2)



Application example EMC filter / inverter test bed (2/2)

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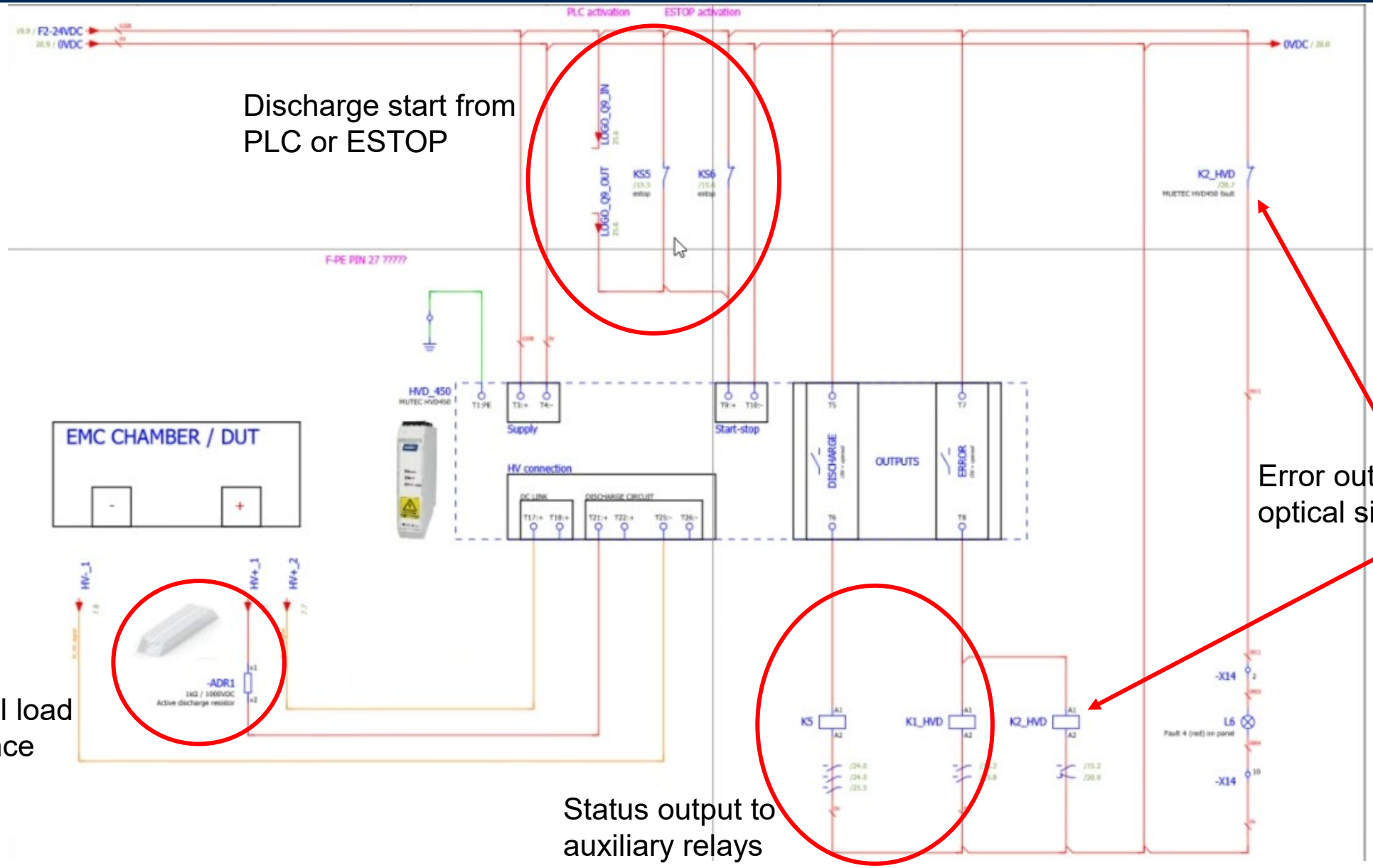
Your safe choice



Plug- & Play System Solution

Integrated 19“ rack

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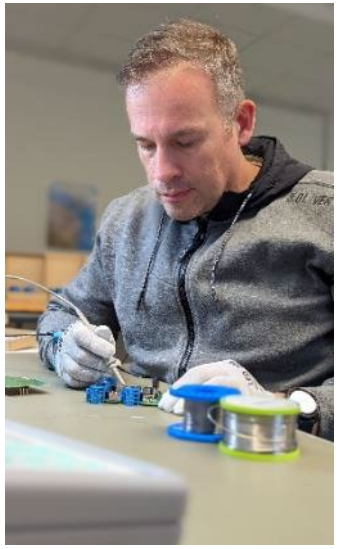
Plug- & Play System Solution

- Many customers don‘t want to design discharging circuits form scratch
- Together with a partner, Mütec will provide the HVD 450 in a ready-made system with everything that‘s needed to safely discharge an HV application
- Depending on the application, the system can be seamlessly tuned to the customers requirements.
- Customizable features are e.g. temperature monitoring, SIL2 voltage monitoring, analog or digital displays,…

Coming late Q1‘24

Discharging

Voltage Monitoring


Thanks a lot!

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www.linkedin.com/company/muetec

Backup

Technical Data

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Technical Data (draft)

Voltage U_c:	≤ 1500 V	Max. DC link voltage
Current I_C:	≤ 8 A	Max. discharge current
Current I_G:	≥ 9.6 A	Limit value current alarm
Residual voltage U:	< 10 V	
Discharge time constant τ:	100 ms … 10 s	
Measurement range:	0 … 1500 VDC	Measurement range:
T-3(+) and T-4(-) Supply voltage:	24 VDC (18…30 VDC)	
Power:	Green LED	Supply on
Error:	Red LED	Failure indication
Discharge:	Yellow LED	Discharging
3 port isolation:	Input / output / supply	
Input / Output:	4,3 kV AC test voltage	
Input / Supply:	4,3 kV AC test voltage	
Overvoltage category:	CAT II: 1500 V AC/DC	
Pollution level:	2 according to IEC 61010-1	
T-1 … T-12 (4-pole):	Screwed connector/black / 5,0 mm2	
T-17 … T-27 (3-pole):	Screwed connector / grey / 7,5 mm2