July 2022

POWER LOSS MINIMISED DISCHARGE FOR HV COMPONENTS

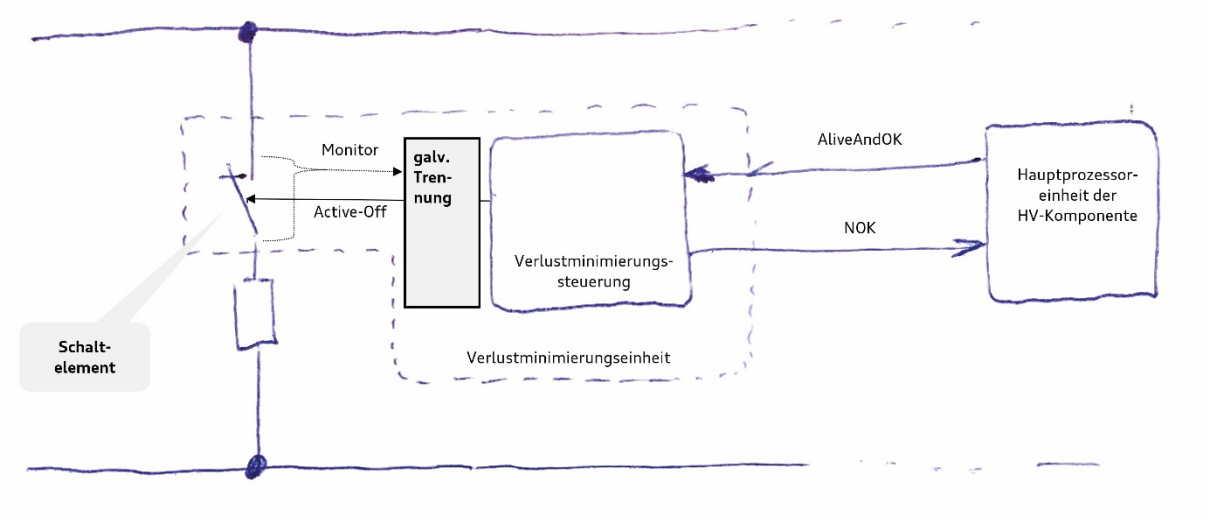
Axel Unger
Bertrandt Ingenieurbüro GmbH

POWER LOSS MINIMISED DISCHARGE FOR HV COMPONENTS

Initial situation:
HV components usually have a passive and an active discharge.
Passive discharge is intended to ensure that the electrical energy in the intermediate circuit Cx of an HV component is not permanently stored but discharged over a longer period of time so that no electrical hazard can emanate from the HV component (e.g. residual charge in the off-state during disassembly...).
Active discharge is intended to ensure that the electrical energy in the DC link Cx of an HV component is discharged in a short time in the event of a fault (typically a crash), also for HV safety.
The active discharge is actively controlled (e.g. crash signal), the passive discharge is always effective.
The discharge elements can be designed in different ways. In the simplest case, they are resistor components.

Disadvantage:
The disadvantage of a passive discharge (especially in the design as a resistor) is the fact that it permanently generates electrical losses when HV voltage is applied. However, these losses are only "used" in certain scenarios (e.g. HV contactors not closed, so e.g. off state).

Solution:
The idea is that the discharge element is preceded by a switching element that is initially closed.
If the loss minimisation control in the loss minimisation unit receives a signal from the main processor of the HV component that the control unit basic software is running and alive without relevant errors (AliveAndOK signal), then the switching element is actively opened via an Active-Off. The discharge losses in the discharge element then no longer occur.
If faults/states occur where the passive discharge is needed, the switching element falls back to its "initally on" state and the passive discharge is effective. This occurs either by the AliveAndOK signal (for criteria, see the following slide) dropping from the main processor, or by self-monitoring of the loss minimisation unit, or by a loss of supply voltage to the loss minimisation unit (e.g. off state).



AliveAndOK signal
The AliveAndOK signal from the main processor is used to evaluate whether passive discharge is needed or not. Criteria for not needing passive discharge can be:

- HV contactors closed
- no insulation fault in the HV system
- all supply voltages ok
- ...

Self-monitoring Loss minimisation unit

- Integrity of the switch via switching element voltage monitoring (monitor)
- Check of own temperature and supply voltage
- Watchdog

The "initially on" must be available with an ASIL level (HV safety). Furthermore, the connection to the switching element (monitor and active-off) must be galvanically isolated (HV safety). For safety reasons, the AliveAndOK signal should also be modulated or, at best, protocol-based. A discrete implementation in individual projects is unlikely to work financially (1 € per 1 watt energy saving), so a standard solution must be aimed for, which all HV components adopt, in order to finance the development via unit effects. Ideally with an ASIC as the central element specialised for this task.

Advantages:
The active switching off of the passive discharge will require energy in the actual implementation. This will be smaller than, for example, a purely resistive passive discharge. The main advantage is therefore energy saving.

By using the loss minimisation unit, one could think about using the passive discharge simultaneously for the active discharge in simple components according to the idea. Normally, this would hardly be possible, as the discharge element of the active discharge must be designed with very low resistance, which would lead to high losses at HV. But by minimising this during i.O. operation, it would be possible to combine the two discharges.