ISSN: 1863-5598

ZKZ 64717
03-11

Bodo´s Power Systems®

Electronics in Motion and Conversion

March 2011

ACCELERATING YOUR PROJECTS

Auxiliary Power Supplies for Medium and High Voltage Applications

New IGBTs and IGCTs, together with appropriate snubber and freewheeling diodes up to 5.5 kV (6.5 kV respectively), are opening up the possibility of establishing power electronics for the medium voltage level with manageable effort. Tri–level switching topologies and cascaded switching systems are the preferred architectures used here.

By Werner Bresch, Managing Director of GvA Leistungselektronik GmbH, and Dr. Henrik Siebel, Managing Director of Siebel & Scholl GmbH

Surprisingly, it is not so much a case of the semiconductor silicon causing problems. It's rather a question of the required "standard auxiliary components", such as heat sinks, capacitors, clamping devices and auxiliary voltage supplies, which no longer meet higher-level requirements concerning insulation properties in medium voltage applications.

This mainly affects auxiliary power supplies used to power IGBT, IGCT and GTO driver boards, for example. First and foremost, auxiliary power supplies must provide reliable galvanic insulation between the medium voltage level and the power side. The "insulation voltage" specification in the data sheet is less informative. It simply states that the auxiliary voltage supply was applied under the constraints specified, and with the voltage value specified, without there being a disruptive breakdown. It does not state whether the auxiliary voltage supply may be operated continually under these voltage conditions without there being deterioration, and hence damage to the insulation barrier.

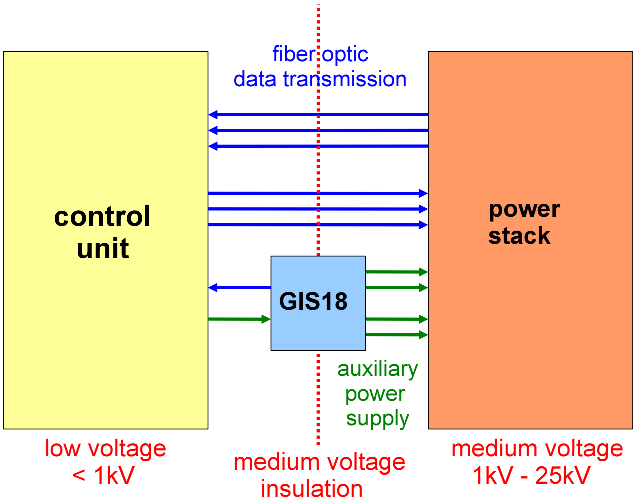

Figure 1: Auxiliary voltage supplies provide galvanic insulation between medium voltage level and power side

The requirements for made of insulation in medium voltage applications are laid down in IEC 60071 standards as regards test conditions, creepage distances and air gaps.

These are, in short:
- Creepage distance 20 mm/kV for pollution degree 2
- Creepage distance 25 mm/kV for pollution degree 3
- Insulation test voltage in accordance with the standard applied (generally twice the nominal voltage)
- There must be no partial discharges in the range of rated voltage load

New 4-channel auxiliary voltage supply in the GIS18 family with higher insulation voltage

In the development of auxiliary power supplies with insulation in the two-digit kV range, best possible insulation must take top priority. It must be free of partial discharges during operation to withstand high voltages over a long time.

Partial discharges occur whenever the electrical field causes excessive peaks in local field strength leading to overstressing of the insulation material.

Once impaired, insulation gets more and more susceptible for discharges resulting in long-term damage and disruptive breakdowns.

Irregular, sharp-edged geometries always result in non-homogenous electrical fields. Ideally, uniform field strength distribution is achieved in the homogenous field of a plate-type capacitor. Because of that the insulation barrier has been implemented in a similar way in GIS18 voltage converters.

Situated between two electrically conducting potential surfaces is the insulation barrier which has a uniform thickness of a few millimetres. The edges of the potential surfaces are rounded. Energy is transferred via the insulation barrier, which runs centrally through the transformer of the switch converter. Therefore the ferrite core has been split into two halves. On one half of the core is the primary coil, on the other half the secondary coil.

Figure 2: The GIS18 (right) with four channels guarantees an insulation strength of min. 18 kV; on the left is the single-channel SW32 variant

High insulation voltage, free of partial discharge
The new 4-channel GIS18 voltage converters have been specially designed for the requirements in 3- and 5-level medium voltage inverters. They therefore have four supply channels which are galvanically insulated from each other. Their insulation voltage rating allows GTO and IGCT driver boards to be supplied directly with sufficient power. Devices with 35 VDC and 35 VAC (70 kHz square wave) output voltages are available. The 70 kHz square-wave provides the option to convert the given output to another voltage level (e.g. as required to power IGBT-driver boards).

When all four supply channels are used simultaneously, an output rating of 75 W per channel is available. If not all the supply channels are used simultaneously, the applied load for a supply channel may be up to 150 W.

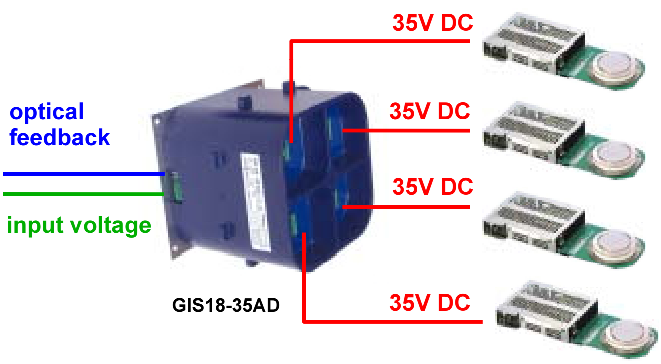

Figure 3: Application example: Powering four IGCTs in one IGCT 3-level phase component

The insulation voltage between individual supply channels is 10 kVAC (without partial discharge). Between supply channels and ground potential, the insulation voltage is at least 18 kVAC, 50 Hz, 10 sec, without partial discharge (<10 pC).

The couple capacity between primary and secondary sides is only 30 pF, resulting in a high dv/dt immunity of up to 25 kV/us.

Wide voltage input with PFC (Power Factor Correction)
On the primary electronic of the GIS18 is an uncontrolled rectifier with a downstream PFC stage on the input side. This allows for the implementation of a DC/AC wide voltage input. A voltage of 110 VDC to 300 VDC, or alternatively 110 VAC to 250 VAC, can be applied as input voltage. The PFC stage provides a power factor of 1 on the supply side and a stabilized DC voltage supply for the power inverter at the same time. The transformer has comparatively high stray inductances and only a moderate coupling between primary and secondary coils of about 30–50%. Classic switch converter topologies such as flyback converters and forward converters cannot be used on this transformer.

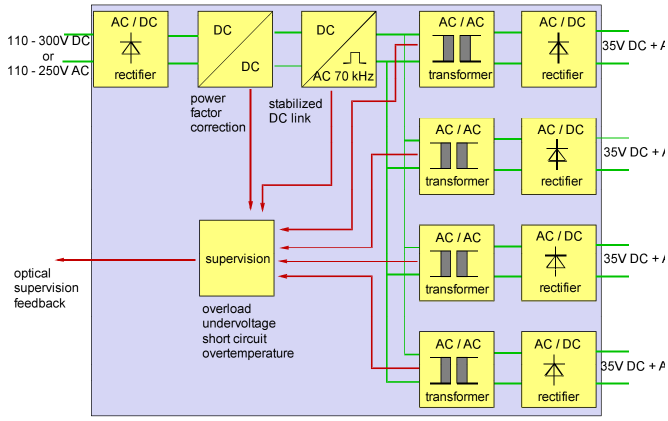

Figure 4: Schematic block diagram of the GIS18

In GIS18 a resonance converter is used, on which resonance capacitors are arranged in series with the transformer coil on the input and output sides. These capacitors are designed such that the stray inductances of the transformer are compensated. This enables transfer of energy despite the moderate coupling.

Under normal operating conditions the power inverter is operated with fixed duty cycle and a frequency of 70 kHz. In the event of a short-circuit on the output side, the output frequency is changed to prevent destroying the GIS18 auxiliary voltage supply resulting the device being short-circuit-protected.

Furthermore, the GIS18 offers diagnostics and a fault reporting system. Output overload, input undervoltage and overtemperature can

Figure 5: Every GIS18 is subject to intensive high-voltage testing prior to delivery

be detected. Fault situations are reported via an optical fault output, enabling them to be read and analysed by the control electronics.

Outlook: 4-channel auxiliary voltage supply with very high insulation voltage

Based on the technology presented here, and the empirical values of single-channel auxiliary voltage supplies with even higher insulation voltages, Siebel & Scholl is currently developing on voltage supplies in the GIS18 family with even higher insulation voltages. The properties of the GIS18 essentially remain the same, but insulation voltages of up to 40 kVAC without partial discharge should be achieved.

Customized other input and output voltages are available on request.

Single-channel SW32 auxiliary voltage supply

The predecessor to the 4-channel GIS18 auxiliary voltage supply presented here is the single-channel SW32 auxiliary voltage supply. This is broadly identical to the GIS18 with respect to inverter, transformer and output voltages. However, the input side is different. Whereas the GIS18 has a wide voltage input and a downstream PFC stage, the SW32 requires a stabilized input voltage of 24 VDC. The output voltage is as on the GIS18, 35 VDC or alternatively 35 VAC, 70 kHz, but the insulation voltage is different: 30 kVAC without partial discharge.

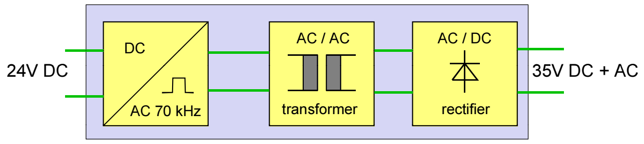

Figure 6: Block diagram of the SW32

This makes the SW32 an ideal auxiliary voltage supply for switching power semiconductors connected in series, cascaded systems and multi-level switching topologies.

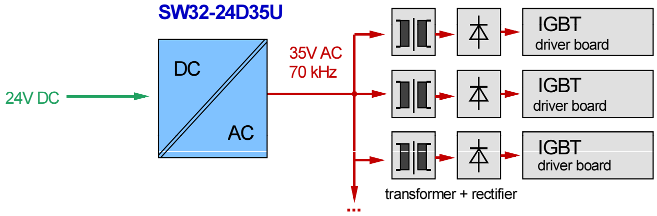

Figure 7: A SW32 powers 12 IGBT driver boards connected in series and implements the base insulation from earth potential

The following application example shows a solution in which a SW32 powers twelve IGBTs connected in series. Reliable galvanic insulation from earth potential is implemented by the SW32. In the 35 VAC, 70 kHz output there are 12 transformers which carry out voltage adaptation for the IGBT driver boards and provide the base insulation between individual IGBTs.

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