Power Supply with Excellent Insulation for Medium-Voltage Systems

Power semiconductors with high reverse voltages and extensive current carrying capacity are indispensable for expanding an intelligent, locally supplied energy network. However, to operate these components reliably – be it for control, monitoring or communication purposes – external auxiliary voltage that is isolated from earth potential is always required, which places enormous demands on the insulation. The new "GvA Power Supply System" features high insulation voltage and partial discharge resistance, combined with remarkable performance and efficiency.

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The dramatic pace of change in electrical energy networks due to the use of generators that are increasingly decentralised is making it ever more challenging for network operators to guarantee network stability. The elimination of large synchronous generators that allowed the networks' protective devices to work flawlessly by providing reactive power and ensuring the required short-circuit current, has sparked intensive work on alternatives. The combination of large and small energy storage systems in the future means it is essential to adapt to the prevailing network conditions very quickly in order to guarantee instantaneous, primary and secondary control power. The required high-blocking power semiconductors such as IGBTs, IGCTs and thyristors with blocking voltages greater than 7000 V are already available on the market and are used in compensation systems, network interconnections and filters. But all of these semiconductor switches have one thing in common: to work, they need additional auxiliary voltage, using which the component in question can be controlled, monitored and protected. These essential auxiliary voltages are at a high level relative to the earth potential and so must have appropriate insulation. Not only the actual insulation strength is significant here, but also the freedom from partial discharges. GvA is launching an extremely compact, high-performance DC-DC converter that is designed perfectly for jobs like these.

GPSS (GvA Power Supply System)

The standout features of the GPSS are:
- Extremely compact (73 mm x 200 mm x 165 mm)
- Two separate outputs
- Continuous output: 150 W per channel
- Typical output voltage: 35 VDC
- Typical supply voltage: 24 VDC
- Max. efficiency: 94%
- Insulation voltage: 35 kVAC
- Partial discharge extinction voltage: 21 kVAC (prim. – sec.)
- Partial discharge extinction voltage: 14 kVAC (sec. – sec.)
- Clearance: 210 mm (prim. – sec.)
- Clearance: 165 mm (sec. – sec.)

The GPSS has been developed specifically to provide auxiliary voltages and provides two electrically isolated output voltages. What sets it apart is its extremely compact design and high power rating of at least 150 W per channel. Each channel is controlled individually and has an inrush current limiter to limit the output current for loads with a high capacitive input, and a short-circuit current limiter and shutdown facility. If there is a constant overload, the intelligent control ensures the channel affected is shut down and reactivated again automatically once the fault has been cleared.

Figure 1: Due to its high insulation voltage, the GvA Power Supply System is ideal for medium-voltage applications.

The converter topology used consists of a full-bridge series resonant converter on the primary side and a synchronous rectifier in a B2 circuit on the secondary side. This circuit configuration enables efficiency of up to 94% and therefore helps ensure that the device's inherent heating is very low and that minimal external cooling is required.

The typical supply voltage is 24 VDC, with the full available capacity lying in the range from 21.6 VDC to 25.2 VDC. As the two output channels are controlled separately from each other, unbalanced loads are also possible, and the outputs can be connected in series.

The base plate of the GPSS is used both as a mounting plate and as a cooling plate for the primary switching step. The low thermal power loss of both primary full bridges is dissipated externally via the base plate. It must therefore be ensured there is sufficient heat removal.

Figure 2: The new GPSS is the perfect insulating supply unit for IGCT and IGBT stacks.

Monitoring the operating statuses
Every GPSS monitors its key operating parameters and indicates the status via a fibre optic transmitter on the primary side of the device. The status of the outputs (overload or short circuit) is signalled after a defined delay, and inadmissible input voltage ranges or excessive temperatures in the primary switching step are indicated.

Figure 3: Due to its modular design, the GPSS can also be operated in parallel, multiplying the number of output channels.

Connecting GPSS modules in parallel
If an application requires more than two auxiliary voltages, the GPSS modules can be connected in parallel on the primary side in any configuration thanks to their flexible design. In this regard, it is possible to monitor all GPSS by means of a single light guide, greatly simplifying monitoring management. Coding takes place via the input plug and is designed to be fail-safe; consequently an open circuit is also recognised as a fault.

In principle, the power supply on the primary side of the GPSS modules can be looped through from module to module. In this case, only the max. current load of the input jack and connector strip needs to be observed.

The housing and its insulation
The GPSS has two output channels with an insulation voltage of at least 35 kVAC in respect of each other and the input side. As the fairly large potential differences occur between the outputs and the base plate of the GPSS, which is normally at earth potential, a partial-discharge extinction voltage of at least 21 kVAC is guaranteed for this insulation section, while the extinction voltage for the insulation between the two outputs is at least 14 kVAC.

To allow these parameters to be guaranteed over a long operating period, high priority was given to the electrical stability and the behaviour under environmental influences when choosing the material for the housing. The material used has been tried and tested for years and is also used to produce medium- and high-voltage insulators. It can be shaped easily by appropriate means and can be processed without air or gas being trapped. It is immune to aggressive environmental influences and does not change its characteristics, even during long periods of extreme electrical load. The specially developed geometry of the inner isolation barrier ensures the electrical field is distributed uniformly between the primary and secondary sides. This optimised field control prevents excessively high local field strengths, preventing associated inner partial discharges in the electronic module on the secondary side.

The external insulation is primarily ensured by the high tracking resistance – the housing material used has a CTI > 600 – and the large creepage and clearance distances of 210 mm and 180 mm respectively between the output and input.

Converter topology
The consistent demand for minimal losses and the lowest possible inherent heating requires a resonant converter topology with zero-voltage switching or zero-current switching behaviour. A series resonant circuit is used in the GPSS for operating reliability reasons and because of its good control characteristics, particularly in the event of an overload or short circuit. A pot core is used for the transformer, and the insulating material is located between its two halves. Due to the large air gap that results from this, the magnetic coupling of the two pot core halves is reduced and the leakage inductance increases. Nevertheless, appropriate circuitry measures optimise the transformer's efficiency, while simultaneously reducing the system-induced natural resonant frequency. This has a two-fold positive effect on the overall efficiency. Firstly, the transformer's magnetisation loss is reduced, and secondly, the lower switching frequency relieves the load on the output stage and less energy is required for driving the MOSFET.

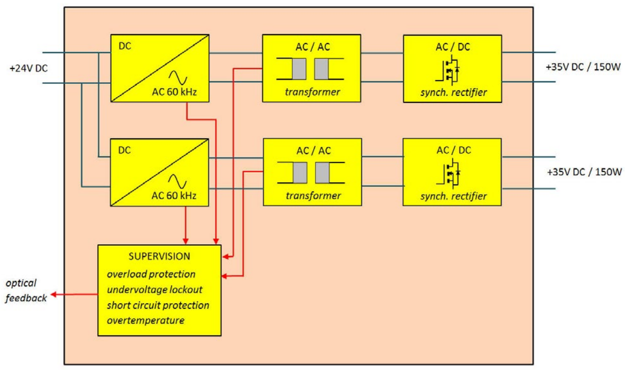

Figure 4: Schematic block diagram of a GPSS 221-24

Basic Electrical Characteristics

2 Channel System		Symbol	Min.	Typical	Max.	Unit
Supply voltage	Nominal input voltage	V_{cc}	21.6	24	25.2	V_{DC}
Output voltage	Unregulated DC output voltage	V_{out}	29	35	41	V_{DC}
Continuous output power	Continuous output power 1 channel	$P_{cont.\_1ch}$	130	150	170	W
Continuous output power	Continuous output power 2 channels together	$P_{cont.\_2ch}$	260	300	340	W
Input current	V_{cc} = 24 V_{DC} / P_{2ch} = 300 W	I_{cc}		14	16	A
Short circuit shutdown time	Output shortened	T		60		sec
Efficiency	P_{tot} = 300 W (sym. load)	η	91	92	94	%

The series resonant circuit topology enables relatively simple controlling and also offers excellent operating reliability, even in the event of an overload or short circuit, because it is inherent in the system itself.

The alternating voltage transmitted to the secondary side of the transformer is converted to DC voltage using an adaptive synchronous rectifier and offers minimal semiconductor losses in any operating state.

In a nutshell, the GPSS offers a simple, reliable power supply for active components and modules in cases where customary DC-DC converters cannot be used due to their limited insulation properties. These components not only include power semiconductors such as IGCTs and IGBTs in medium-voltage converters, but also general protection, monitoring or control modules that have a high potential relative to earth and require an electrically isolated power supply.

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