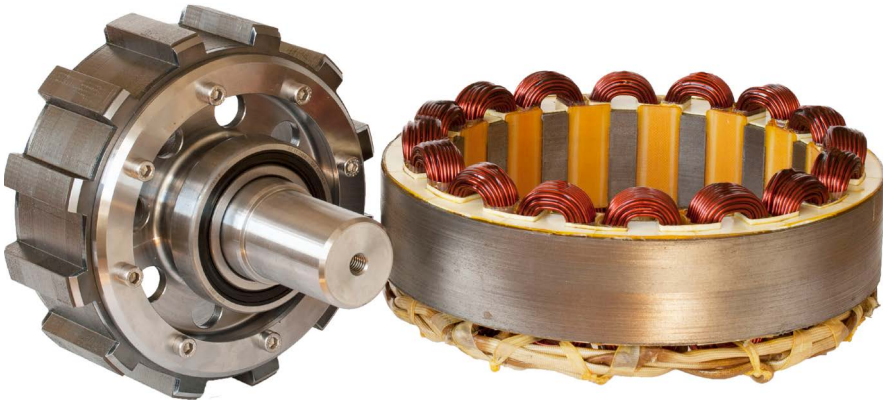
Switched Reluctance Generators

In contrast to well-known conventional generators Switched Reluctance Generator (SRG) have "toothed" stator and rotor, and have neither windings nor permanent magnets in the rotor. For their operation the excitation unit which is controlled in accordance with the rotor angle position is necessary. During the operation, active stator poles (i.e., those with winding coils through which the current flows) repel the nearest rotor poles. When the poles are repelled enough, the phase current via diodes is charging DC link capacitor. The excitation current is changed to the next phase by means of the power electronic switches depending of voltage of the DC link capacitor. This way the machine generates the power and keeps DC voltage stable.



The unique operation results in unique advantages of the SRG. Absence of magnets and a passive rotor simplify construction and lower the cost of manufacturing. Rotor does not dissipate heat to speak of and in fact can be used to cool the stator, also making the machine less sensitive to high temperatures. Ease of cooling in turn simplifies the task of making construction hermetic. Magnets in conventional electric machines lose their strength when heated or with time, but SRG has no such problem. Passive rotor reduces overall losses in copper winding because it does not have any. The power/weight and torque/weight ratios are higher than those of conventional machines. Since phases of an SRG are independent, the machine is very tolerant to open-coil fault (in the windings) and faults in the power converter.

The above features make SRG the most cost effective, the most fault tolerant and the most repairable electric machine in existence. But wait, it gets better! Due to sophisticated electronic sensorless control algorithms, the machine works perfectly like motor or generator. This feature allows to use this electric machine as a starter-generator in many applications.

The layout of SRG can be so flexible that not only the machine can be designed flat as a disk or oblong as a tube, but the rotor can even be placed outside the stator. This flexibility combined with simplified overall construction opens up an entirely new field of mechatronics that combines mechanics and electronics with information technology and computer control.

Switched Reluctance Generators are very reliable and efficient in low-speed applications such as wind power systems, water turbines, and in such high-speed applications as steam and gas turbines, turboexpanders, starter-generators for combustion engines, micro-CHP systems etc. High-speed switched reluctance generators make it possible to get rid of gearboxes in electric power systems.

Switched Reluctance Generator features:

- High efficiency over a wide speed range;
- Controlled excitation;
- The most fault tolerant generator known;
- 4-quadrant operation, the machine can run forward or backward as either a motor or generator;
- A simple rotor without magnets of windings;
- Only stator requires cooling, due to low rotor heat dissipation;
- The lowest manufacturing cost of any generator;
- High power-weight ratio;
- Optimum generator for wide speed range;
- Optimum generator for high temperature environments;
- High repairability;
- Flexible layout construction: generator can be long or short (pancake construction), rotor can be inside or outside stator;
- Simple hermetic construction due to the fact that only stator requires cooling.

Gen-sets based on Switched Reluctance Starter-Generators

Ordinary gen sets have a diesel or fuel combustion engine that is governed to run at fixed speed such that the directly coupled alternator driven by the engine produces a fixed frequency output of either 50 or 60 Hz.

Switched Reluctance Generators (SRG) running the engine at variable speed and using power electronics to convert the variable frequency to a fixed voltage and frequency can allow more efficient operation of the gen-set. With advanced fuel or diesel engines and variable speed technology it is possible to reduce weight by 30-60% or even more by using liquid cooling and increase fuel efficiency up to 30-40% by changing the speed of the engine depending of the load. The speed of the engine is determined from user selectable interface that allows the engine to run at it most efficient operating point for a given load and ambient thermal conditions. It also possible to control the engine to run where it is most audibly quiet, at its least-polluting operating point. DC power capacitors of the SR generator make the gen-set less sensitive to load transients and increase the output voltage stability.

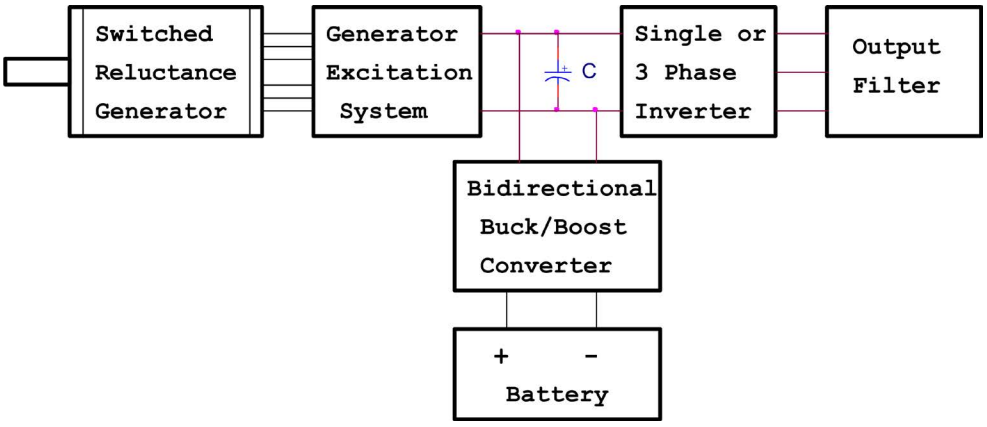
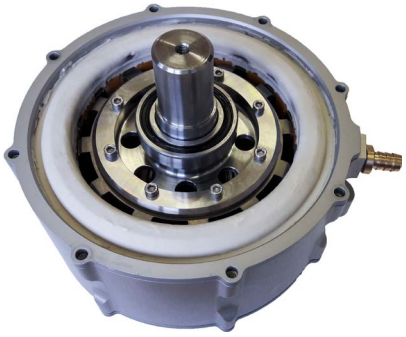


Figure 1. Functional block diagram of power conversion components in switched reluctance generator set

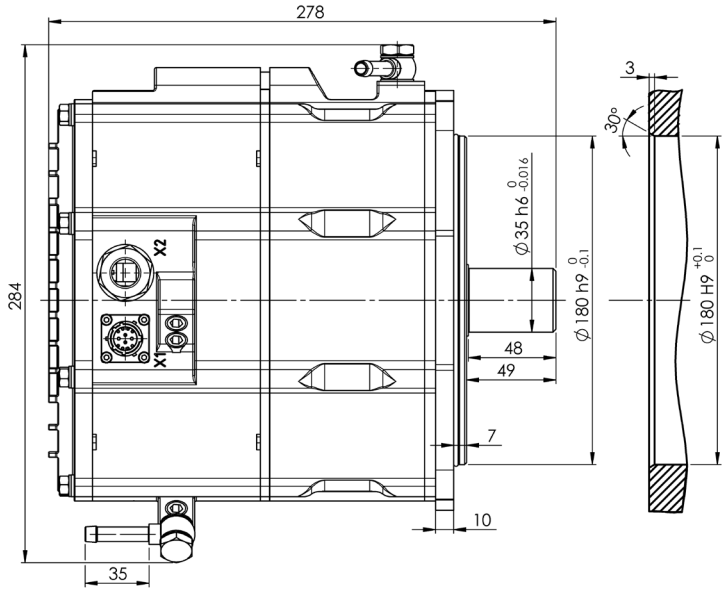
A block diagram of electronic power conversion system for the gen-set with switched reluctance starter-generator is shown in Figure 1. The variable frequency pulses produced by the switched reluctance generator via diodes of excitation system charging C capacitor stabilizing DC voltage and an inverter is used to produce selectable-frequency, controllable AC voltage. Bidirectional back/boost converter is used to charge the battery in operating mode and converts the battery voltage during the starting mode.

Liquid Cooled Switched Reluctance Generators with integrated sensorless excitation system and inverter.

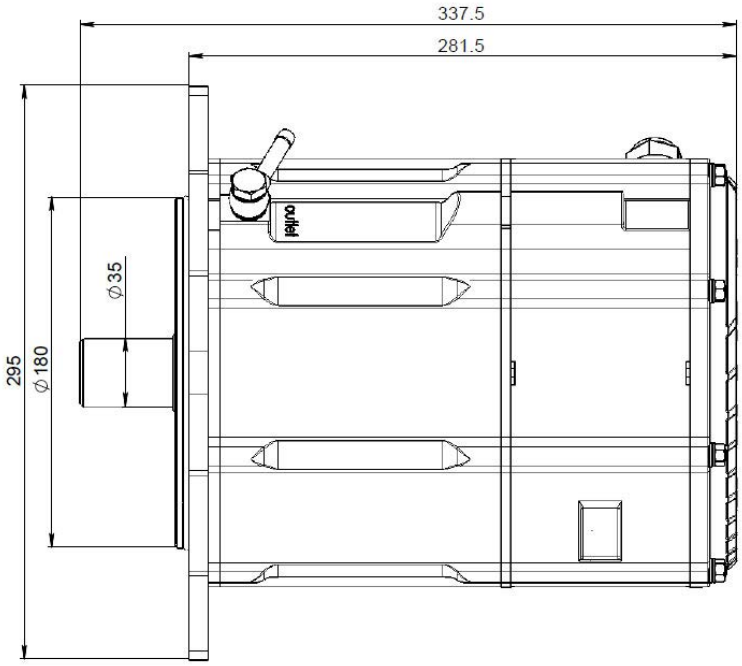


Cooling: Liquid, water glycol;
RPM range: 1000 – 4500;
Sensorless control: New advanced algorithms;
Nominal power: 2kW or 5kW or 10kW;
Output Voltage: 208Vrms (L-L)/3-phase continuous at 60 or 400Hz or 380Vrms or 400Vrms (L-L)/ 3-phase continuous at 50 or 60Hz;
Output Wave Form: Sinusoidal;
Total Harmonic Distortion: Less than 3% at full load;

Line/Load Regulation: Maximum ± 4% from no load to full load;
Output Noise: High frequency ripple is less than 500mVrms (20MHz BW);
Output Overload Protection: Current limiting with short circuit protection. Thermal shutdown with automatic recovery in case of insufficient cooling;
System Efficiency: Typically 92% at full load;
Operating Temperature Range: -40°C to +60°C;
Temperature Drift: 0.05% per °C over operating temperature range;
Generator protection class: IP66;
Humidity: 5 - 100%;
Control interface: CAN;
Weight: 116 (2kW), 19(5kW), 25kg (10kW);



5kw generator dimension drawings



10kw generator dimension drawings