Safe landing with pulsed power

ABB semiconductor switches are improving radar control systems at US airports

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No airport can safely operate today without a radar control system. These systems send out radar pulses of high intensity and detect airplanes by the reflected signals. A crucial element in all these radar systems is the device that emits high-power pulses. Traditionally, pulses are generated with help of electron tubes like thyratrons. The era of electron tubes, also used in several other applications, is coming to an end as ABB has recently developed high-power, fully solid-state switches for pulsed applications.

This advanced technology, boasting significant benefits for the user, has become the main component for the modernization of airport radar systems in the United States. The fact that 300 systems have been ordered to equip all 132 civil airports in the United States underlines the strong market for this groundbreaking technology.

While electron tubes are especially suitable to shape the high power flow within an electrical system, the same capability has long been a big challenge for a semiconductor switch. Providing a rapid rise of a high electric current within mere microseconds and maintaining a high power flow through the solid-state component is not trivial.

The well-designed combination of a gate-controlled thyristor (GCT) with a fast driver unit, both developed by ABB, can meet the demand for fast switching and high current capability at the same time. These units can switch on – but not switch off – a power pulse, which is fully acceptable in a situation where a capacitor is discharged. The discharge automatically generates the declining edge of the current pulse. With such a switch it is possible to inject very high energy into a load, which can be a pulse transformer or a klystron, to emit radar pulses.

Following this principle, ABB has made a complete switch assembly with three IGCTs[1)] in series connection, integrated power supply, optical triggering and air-cooled heat sinks Factbox. The setup was thoroughly tested in the laboratory and in the field by researchers at the Massachusetts Institute of Technology (MIT), who recommended it to the Northrop Grumman Corporation in the United States, the provider of the airport radar systems.

A market breakthrough

In early 2007, ABB received an order from Northrop Grumman for 296 complete switch assemblies, each containing three IGCT devices 2. The several-million-dollar order is one of the largest orders for this application and is a clear breakthrough for the technology itself. The new solid-state technology was used to refurbish the existing radar systems at all 132 civil airports in the United States and to replace the traditional thyratron tubes, which are less reliable in long-term operation.

The solid-state semiconductor switch has, compared with thyratrons, a significantly longer lifetime and is almost maintenance free. Thyratron tubes have to be regularly replaced, resulting in operational costs for the tube, maintenance personnel and downtime of the system. The cost savings with solid-state switches compensate the higher initial costs of the switch and the payback time is short. As the ABB switch is built with bipolar monolithic – one wafer per device – IGCT components, it shows a very high reliability compared with other semiconductor technologies, especially for pulsed applications. While it is obvious that high reliability is critical in air traffic control applications, it is also greatly appreciated in other areas such as medical systems and environmental protection applications.

ABB's solid-state technology was used to refurbish the existing radar systems at all 132 civil airports in the US.

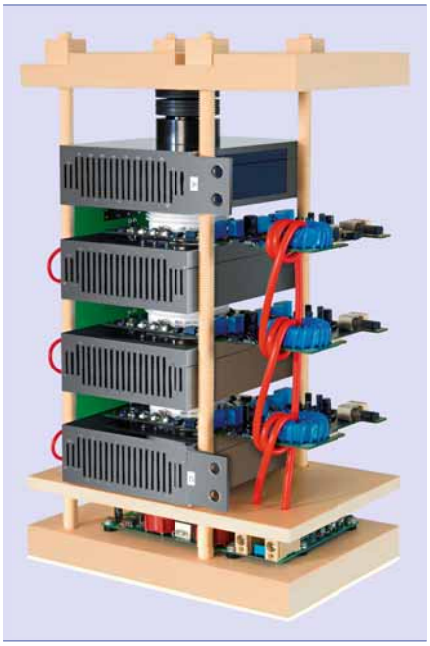
The demand for solid-state technology in pulsed power is rapidly increasing and ABB is involved in several other projects and deliveries for its application.

Factbox Technical performance

The solid-state switch is built of three IGCTs in series connection. The devices are reverse conducting and have a switching part with gate turn-off thyristor (GTO) structure and a freewheeling diode that is monolithically integrated on one 51 mm silicon wafer 1. The driver unit is specially designed for very fast turn-on, and as the application is for capacitor discharge, there is no need for turn-off. Three components, with a blocking voltage of 4,500 V each, are sandwiched between air-cooled heat sinks. All three driver units are powered with inductive coupling by one 25 kHz / 4 A current source through a high-voltage cable. The driver unit is triggered by an optical signal transferred from a light distribution box. The operation area for this type of switch is in the range of 6.5 kV DC with a peak current of 1.4 kA. The pulse duration is 2.5 µs with a current rise rate of 6 kA/µs, a pulse repetition rate of 1,200 Hz and an ambient temperature range between – 10 and 50 °C.

1 IGCT with driver unit: The switching part and freewheeling diode are monolithically integrated on one silicon wafer.

2 Switching unit for the airport radar system



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Footnote

1) IGCT: integrated gate-commutated thyristor