4. Solid State Switching Devices

[This material relates predominantly to module ELP032]

Electronic and computer systems are built on transistor technology and any course dealing with the application of electronics would contain considerable material on transistors. Renewable energy systems technology is also heavily based on electronics for data processing and control. These activities are not specific to RE but are common to many other engineering applications. Such activities are not included in the MSc course hence there is no need for the student to have specialist background knowledge of electronics. There is one area though, where RE technology is at present and will increasingly in the future be dependent on electronics. This is the topic of interfacing RE generators to power networks through converters based on power electronic switching devises. A qualitative understanding of the mode of operation of such switching devices is necessary.

Our earlier discussion established that a forward-biased PN junction is comparable to a low-resistance circuit element because it passes a high current for a given voltage. In turn, a reverse-biased PN junction is comparable to a high-resistance circuit element. Using the formula for power ($P = I^2R$) and assuming current is held constant, we can conclude that the power developed across a high resistance is greater than that developed across a low resistance. Thus, if a device (a transistor) were to contain two PN junctions (one forward-biased and the other reverse-biased), a low-power signal could be injected into the forward-biased junction and produce a high-power signal at the reverse-biased junction. In this manner, a power gain would be obtained across the device. This concept is a crude explanation of how a transistor amplifies.

This amplification property from an input to an output circuit can be used to operate a transistor as a switching device. With a zero input signal the transistor would behave as an open switch in the output circuit. Conversely with a small input signal, the transistor would behave as a closed switch in the output circuit. This fast switching ability is an essential property of devices that are essential in the construction of converters interfacing RE sources to a power grid. Transistors capable of switching large currents (hundreds of amperes) at several kilovolts have been developed for such applications. Insulated Gate Bipolar Transistors (**IGBT**) and Metal-Oxide Semiconductor Field Effect Transistor (**MOSFET**) are such power transistors.

A ***thyristor*** is another derivative of a transistor but with four rather than three semiconductor layers. In the thyristor a small input current can fire or trigger the device, changing it from practically an open circuit to a short circuit. After conduction from cathode to anode begins, removing the gate current has no effect. The only way to change it back to an open circuit is to reduce the load current to a value less than a minimum prescribed level. The thyristor has spawned two other variants: the Light-Triggered Thyristor (**LTT**) in which a light pulse through a fibre-optic cable fires the device and the Gate-Turn-Off (**GTO**) thyristor in which the input signal is capable of turning the thyristor off.

These power electronic devices and their applications to RE systems will be discussed in the Integration module.