IGBT v Thyristors

Introduction

Various systems utilize Insulated Gate Bipolar Transistor (IGBT) for all power conversion processes (AC/DC converter, DC/DC chopper and the DC/AC inverter). IGBTs are much faster than the traditional thyristor and can be controlled by simply toggling an on/off gate signal using a digital signal processor and a field programmable gate array as opposed to waiting for a zero crossing. When the gate signal is removed, the IGBT turns off. The combination creates a series of pulses to re-shape existing voltages (conversion from AC to DC and from DC back to AC).

As with any switching power electronic, the device itself has power losses. For the IGBT, the two primary losses are the conduction losses and the switching losses. Since the IGBTs are being turned on and turned off much faster, the switching losses will increase creating a less efficient system. This is a challenge most manufacturers have been unable to overcome in larger capacity systems.

For this reason, many manufacturers will still use thyristors as opposed to IGBTs in the converter sections of the system (rectifier section). Although there are many benefits in using IGBTs in the converter section, a decrease in efficiency prevents this from being a preferred option for most in larger kW rated systems (above 200 kW). In an inverter, the benefits of the IGBT switching speed have far outweighed the decrease in efficiency.

Background

Thyristors and IGBTs are based on different technologies, but can be used for similar applications. The basic difference is that the thyristor is based on a 4-layer bipolar transistor, while the IGBT is based on a 4-layer MOSFET design, See here, on Wikipedia:

IGBTs and thyristors both have a control "gate" that controls the firing angle of the output current, and can withstand high-power levels used to control the output signal of a VFD. See the explanations on this article:

http://en.wikipedia.org/wiki/Variable-frequency_drive

All VFDs use their output devices (IGBTs, transistors, thyristors) only as switches, turning them only on or off. Using a linear device such as a transistor in its linear mode is impractical for a VFD drive, since the power dissipated in the drive devices would be about as much as the power delivered to the load, The inverter circuit is probably the most important section of the VFD, changing DC energy into three channels of AC energy that can be used by an AC motor.

The usual method used to achieve variable motor voltage is pulse-width modulation (PWM). With PWM voltage control, the inverter switches are used to construct a quasi-sinusoidal output waveform by a series of narrow voltage pulses with pseudosinusoidal varying pulse durations,(Note: this is the part of the VFD where thyristors or IGBTs circuits are required).

As new types of semiconductor switches have been introduced, these have promptly been applied to inverter circuits at all voltage and current ratings for which suitable devices are available. Introduced in the 1980s, the insulated-gate bipolar transistor (IGBT) became the device used in most VFD inverter circuits in the first decade of the 21st century.

http://en.wikipedia.org/wiki/Thyristors
http://en.wikipedia.org/wiki/IGBT

Before the advances in controls and the benefits of the IGBT in the converter and inverter can start to be appreciated, the primary and secondary purposes of the transformer in traditional systems must first be discussed.

Although some manufacturers have started using IGBTs in the converter section, most are still switching the IGBTs based on the traditional SCR logic. The benefit of using a slower switching speed for the IGBT converter is a higher efficiency (less switching means less switching losses). In this case, the IGBT converter will still produce larger amounts of harmonics, which will require the input harmonic filter (similar to the harmonic filter for the SCR rectifiers).

The problem with traditional harmonic filters on the converter is the leading power factor at small loads. When the system is operating at a reduced load, the ratio of capacitance in the input filter to the load becomes very large and will produce a leading power factor from the system. This leading power factor can result in generator compatibility issues. To eliminate these issues, an active input filter (switching harmonic filter capacitors in and out of the circuit depending on the load) will need to be used or the input filter would need to be disconnected both resulting in an increased harmonic content.

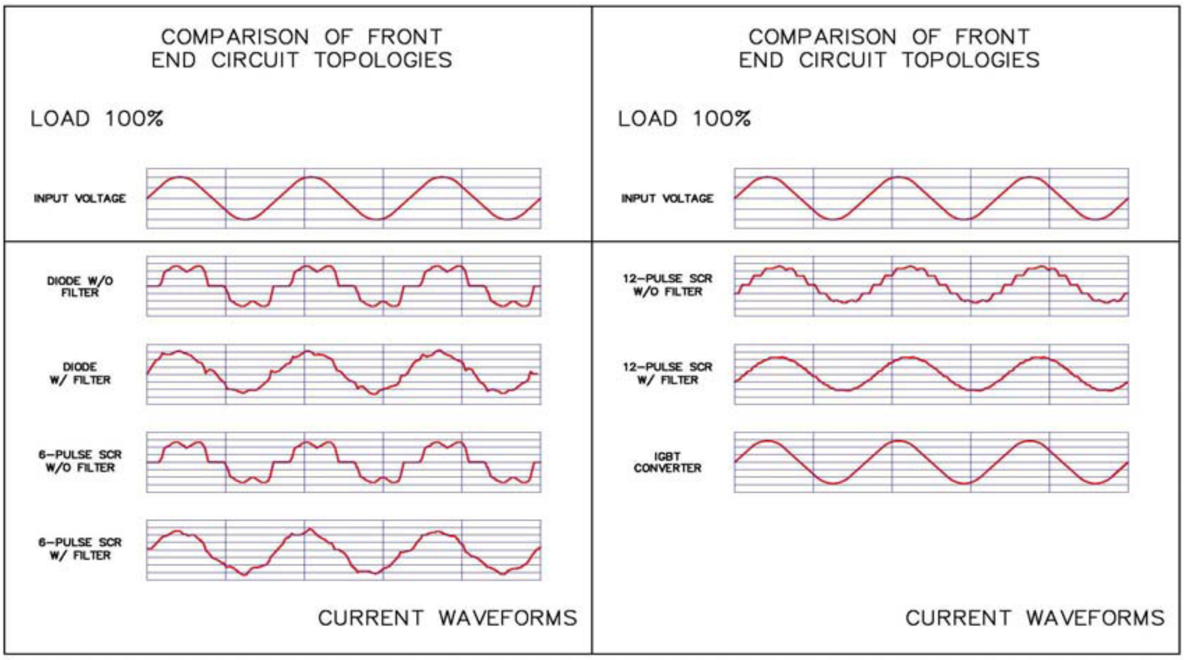
Digitally controlled IGBT converters:

IGBT converters can offer benefits over SCR type rectifiers if applied correctly. The IGBT converter can switch at speeds in the kilo-hertz range as opposed to the slower SCR rectifier, which fires pulses in the hundreds-hertz range.

The reason the SCR rectifiers cannot be switched faster is because the thyristors are turned on by a gate signal, but turned off by natural commutation (zero crossing of the AC input sine wave) or by a snubber circuit. If used properly with a digital signal processor and a Field Programmable Gate Array, the IGBT switching can be controlled to minimize the harmonics normally produced by a converter, thus eliminating the input harmonic filter.

As stated above, the problem exists with the efficiency. If the IGBT converter is turning on and off in the kilo-hertz range, and the IGBT inverter is turning on and off in the kilo-hertz range, the switching losses will quickly add up creating a less efficient system.

Wave Forms of Thryistor v IGBT



As we are proposing a 12 pulse Thyristor the wave produced is similar to that of an IGBT.

Ultimately we see that Thyristors are more resilient that IGBTs meaning they are less likely to blow and when they do they are easier and cheaper to replace.