Allen-Bradley

PowerFlex 7000

Medium Voltage Drive

Application Notes

Rectifier Design Selection – What design is best for my customer?

There are three configurations offered as options for the front-end rectifier of the PowerFlex 7000 MV Drive. It is advantageous when selecting a rectifier design to have a good understanding of what the customers needs and limitations are with regards to power factor, space requirements, harmonic specifications and cost, etc, The quality of power supply, as well as the rating, condition and duty cycles of the motors, will also be important criteria to consider when selecting a rectifier for the Power Flex 7000 MV Drive. All three options offer efficiency, motor protection, energy savings and optimization of power quality in varying degrees. All three of these options comply with the recommended IEEE-519 requirements regarding harmonic distortion.

- A ***6-pulse thyristor-controlled rectifier with passive-tuned harmonic filters*** is shown in Figure 1. The line current before and after the filter is shown. The input waveforms shown in Figure 1 illustrate that the current before the filter contains the 5th, 7th and 11th harmonics, but the current after the filter is more sinusoidal since these harmonics are redirected through the tuned filters (tuned at 5th, 7th, and 11th harmonic respectively). The 6-pulse rectifier is ideal in installations where power supply to the drive is limited and cannot exceed a certain percentage of total plant load. In installations where harmonics are not a major concern, the 6-pulse configuration is the most economical one. An AC line reactor is also offered as a recommended option on installations involving new motors.

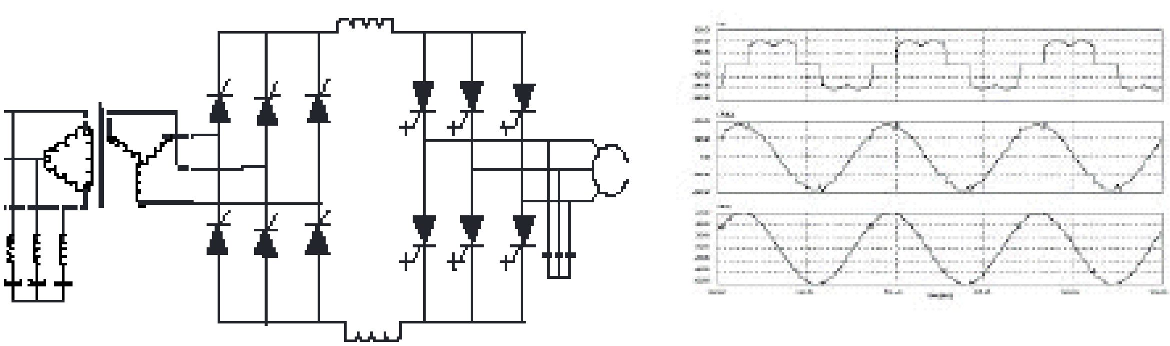

Figure 1 - 6-pulse rectifier with input waveforms
(top to bottom: line current before the filter, line current after the filter and line-to-line voltage at PCC)

- An ***18-pulse phase-controlled rectifier*** is shown in Figure 2. In an 18-pulse configuration, IEEE-519 requirements regarding harmonic distortion are met without the need for passive filters. However, a multi-winding isolation transformer is required to mitigate the low order harmonics by incorporating phase shifting principles. The resulting line current and voltage are shown in Figure 2. This option is a simple, highly efficient and easy to use one involving series rectifiers and only three sets of secondary windings on the isolation transformer. Due to the requirement for the isolation transformer, this option does carry with it a larger footprint that requires additional control room space.

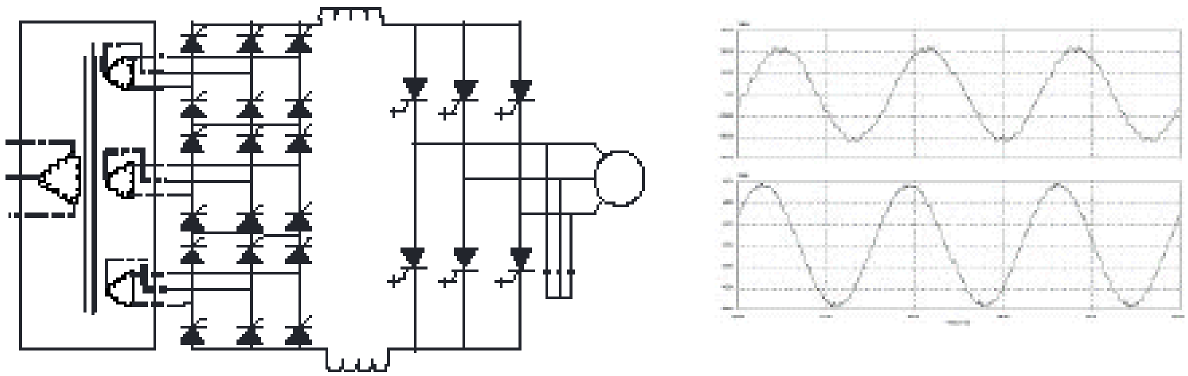

Figure 2 - 18-pulse rectifier and its input waveforms
(top to bottom: line current and line-to-line voltage at PCC.)

- A ***Pulse-Width Modulation (PWM) rectifier*** is the third option and is shown in Figure 3. The PWM is an active front-end rectifier suitable for Current Source Inverter (CSI) topologies. This is a particularly attractive option for applications involving the use of new motors, since it does not require an isolation transformer to meet IEEE-519 requirements. This results in a drive system that has the highest efficiency, most compact footprint and offers the lowest total cost of ownership. The typical drive efficiency rating at full load full speed is 97.5%. Most available technologies in todays Medium Voltage market require a multi-winding transformer to mitigate the undesirable harmonic distortion through cancellation by phase shifting the transformer secondary windings. Depending on the topology, the transformer can have up to 15 sets of secondary windings. This can compound the complexity of the system should the isolation transformer be required.

The PWM rectifier requires a switching pattern that complies with similar rules as the inverter. The pattern used is a 7-pulse Selective Harmonic Elimination (SHE) pattern that eliminates the 5th, 7th and 11th harmonics. The input capacitors are designed to reduce the current harmonics of the higher order. The filter resonant frequency is placed below 300Hz where no residual harmonics exist. The filter transfer function technique is used to place the filter break frequency in a region where no harmonics are present. This prevents the excitation of system harmonic frequencies. Other factors that are considered when designing the filter are the input power factor and the requirement on Total Harmonic Distortion (THD) of input current and voltage waveforms. The small AC line reactor, as shown in Figure 3, provides additional filtering and current limiting features to a line side short circuit fault. A current THD of less than 5% is achieved.

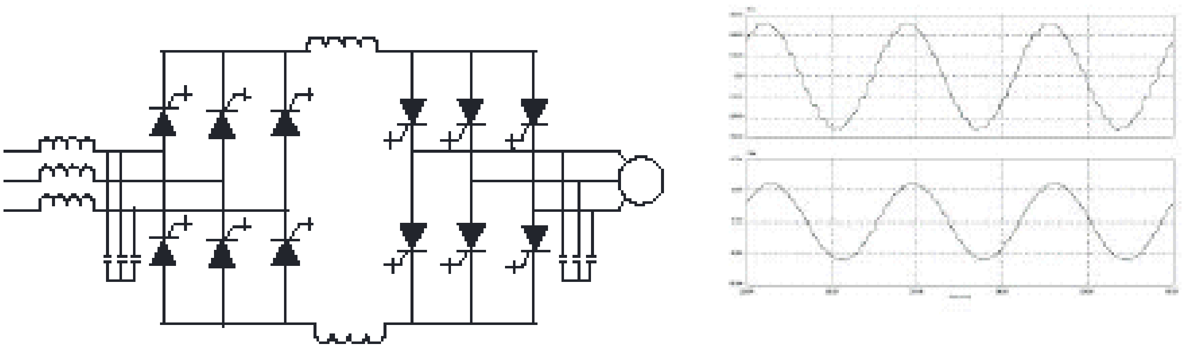

Figure 3 - A Current Source Inverter drive with Pulse Width Modulation rectifier option and its input current/voltage waveforms (top to bottom: line current and line-to-line voltage at PCC)

www.rockwellautomation.com

Corporate Headquarters
Rockwell Automation, 777 East Wisconsin Avenue, Suite 1400, Milwaukee, WI, 53202-5302 USA, Tel: (1) 414.212.5200, Fax: (1) 414.212.5201

Headquarters for Allen-Bradley Products, Rockwell Software Products and Global Manufacturing Solutions
Americas: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
Europe: Rockwell Automation SA/NV, Vorstlaan/Boulevard du Souverain 36-BP 3A/B, 1170 Brussels, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
Asia Pacific: Rockwell Automation, 27/F Citicorp Centre, 18 Whitfield Road, Causeway Bay, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

Headquarters for Dodge and Reliance Electric Products
Americas: Rockwell Automation, 6040 Ponders Court, Greenville, SC 29615-4617 USA, Tel: (1) 864.297.4800, Fax: (1) 864.281.2433
Europe: Rockwell Automation, Brühlstraße 22, D-74834 Elztal-Dallau, Germany, Tel: (49) 6261 9410, Fax: (49) 6261 17741
Asia Pacific: Rockwell Automation, 55 Newton Road, #11-01/02 Revenue House, Singapore 307987, Tel: (65) 351 6723, Fax: (65) 355 1733

Medium Voltage Products, 135 Dundas Street, Cambridge, ON, N1R 5X1 Canada, Tel: (1) 519.623.1810, Fax: (1) 519.623.8930, www.ab.com/mvb

Publication 7000-AT001A-EN-E – February 2002