ABSTRACT

Alternating Current machines play important roles in many types of industrial processes. In all the types of AC machines, Induction Motors (IM) are commonly used in industries. For the speed control of IM, Adjustable Speed Drives (ASD) are required. ASDs are sophisticated non linear power electronic equipment, but they are complex. ASD is a electrical control device and that can change the operating performance of a motor. ASDs are one of the most sensitive loads to Power Quality (PQ) problems. Transients, voltage sag, voltage swell, harmonics etc., are some of the PQ problems.

Sag is a period of low voltage and it is about 70% of the registered disturbances. Swell is a period of high voltage, which occurs rarely. According to the fault occurrence in various phases and lines, there are seven types of voltage sags. They are type A, B, C, D, E, F and G voltage sags. Moreover, there are three voltage swells namely, instantaneous, momentary and temporary and they may be balanced or unbalanced. In the sag types, type A (worst case) is the balanced, symmetrical voltage sag, types B and E are unbalanced, symmetrical voltage sags and types C, D, F and G are the unbalanced unsymmetrical voltage sags. Voltage of 10% - 30% below nominal with 3 - 30 cycle durations accounts for the majority of the power system disturbances. They are the major cause of industry process disruptions
which lead to the large financial losses. Though voltage swells occur less frequently than sags, even relatively minor swells can damage the equipment.

Variable-speed AC drives using a Pulse Width Modulation (PWM) controlled IM fed from a constant voltage DC-link circuit have maturity as a standard drive technology for a wide range of industrial applications. In this system, the amount of energy stored in the DC-link capacitor is relatively small. When the supply of power is interrupted, the DC-link energy is absorbed by the motor load within a few milliseconds. Since the electronic control system loses power, the machine gets de-energized. A variety of energy storage technologies are candidates for providing the needed full power to ASD ride-through which includes battery backup systems, super capacitors, motor-generator sets, fuel cells and boost converter etc.,

An approach, to achieve ride-through for ASDs under sag and swell conditions with Cuk and buck-boost converters is presented. If voltage sag and swell occur in the circuit, the converter provides the required ride-through to ASD. These are DC-DC power converters whose output voltages can be varied below and above the input voltage. The converter operates, whenever the DC-bus voltage of ASD drops below the threshold voltage. Under voltage dip conditions, the DC-bus voltage starts to decay. The ride-through of an ASD can be improved by connecting a Cuk converter or buck-boost converter to the DC-bus link of the drive. Control is provided by the Proportional
Integral (PI) controller to estimate DC-bus voltage from the output voltage error. The proportional error value can be compared with the saw tooth waveform, and the pulse will be generated according to the desired switching frequency. When the instantaneous voltage deviates from the threshold level, the converter starts to buck or boost the DC-bus voltage and it is maintained as constant.

The 3φ supply with all types of voltage sags, instantaneous and balanced voltage swells are analyzed using MATLAB simulation tool. The performance of 3φ IM is analyzed for all the types of voltage sags with 50% sag depth and 30% swell are tested under ¼, ½ and full load conditions. Similarly, the IM performance is also tested for 60% sag depth and 25% swell conditions. The above results are compared and analyzed with the IM drive, during normal (without fault) condition, with Cuk and buck-boost converters.

The Cuk converter is designed for 1.5kW, 400 V, 50 Hz three phase IM. This experimental set-up validates the simulation results and proves the effectiveness of Cuk converter for ride-through method. By using the experimental set-up, for type A sag with 50% depth and 15% balanced swell, the DC-bus voltage are measured. They are compared with the simulation results.

The simulation and hardware experimental results are identical and it is found that the proposed converter topologies improve the performance of the IM drive system under various power quality issues.