DC Injection Braking

By Bill Szatkiewicz, Senior Software Engineer
KB Electronics, Inc.
for more information, email: info@kbelectronics.net
or visit: www.kbelectronics.com

DC injection braking is a method of stopping an induction motor without the use of a frictional braking mechanism or additional braking resource, like a dynamic brake resistor. This article explains how KB Electronics motor controls (also referred to as VFDs and drives) implement DC injection braking and how applications benefit from it when additional braking resources are undesirable. In addition, we will compare other braking methods and discuss the advantages and disadvantages of each. KB Electronics offers a full line of motor controls capable of providing satisfactory stopping with DC injection braking.

How KB Controls Implement DC Injection Braking

KB controls implement DC injection braking by injecting a direct current (DC) into the motor stator windings after the alternating current (AC) has been switched off. The applied DC voltage, creates a fixed magnetic field, which provides a strong stationary braking torque to stop the motor. An illustration of what happens inside the motor control is shown in Figure 1.

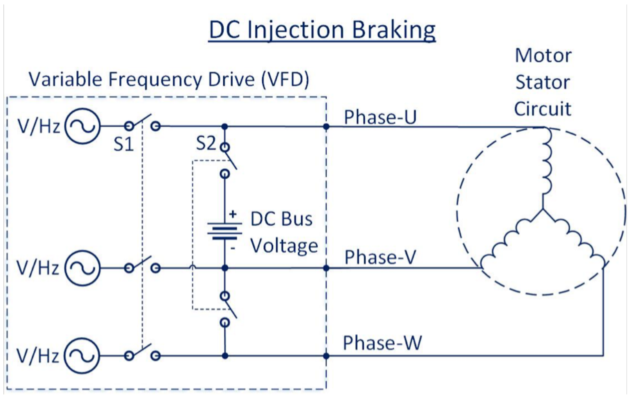

Figure 1: Visual Illustration of DC Injection Braking

When switch S1 is closed the control is providing a rotating magnetic field (alternating current) to the induction motor stator circuit. The rotor attempts to follow this magnetic field creating motion on the motor shaft. This is considered normal operation of a motor control. The operator can vary the command speed and the VFD will vary the voltage and frequency (V/Hz) to the motor which will adjust the motor speed accordingly.

When DC injection braking is required the control will open switch S1 before closing switch S2. The control then applies a DC voltage to the motor, sourced by the DC bus, which is controlled by the VFD to prevent the braking current from exceeding the ratings of the drive's power devices. This DC current provides a fixed magnetic field to which the rotor attempts to align, thereby resulting in a strong braking action.

Switches S1 and S2 cannot be closed at the same time. This would result in a catastrophic failure. The processes inside the VFD prevent this from happening.

A typical current waveform of one motor phase is shown in Figure 2, before and during DC injection braking. In this figure you can first observe the sinusoidal AC V/Hz waveform applied to the motor and then a slight delay, which guarantees the S1 switch is off, before the S2 switch turns on, and the DC voltage is applied.

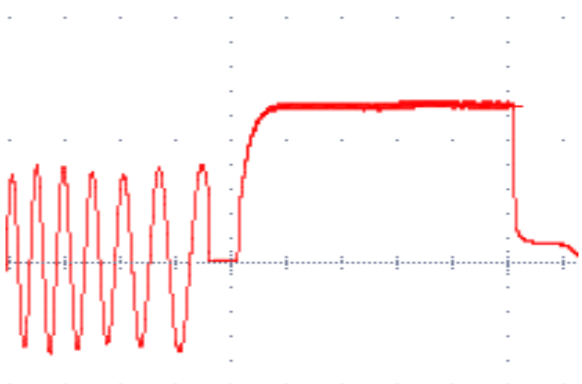

Figure 2: DC Injection Braking Motor Current Waveform

Note that DC injection braking always requires a power source. Therefore, it is not always a viable option for safety reasons when applications require a fail-safe braking mechanism.

DC injection braking energy is dissipated by the control and motor in the form of heat. Thermal and electrical limitations of the motor and control limit how much braking current can be utilized. The higher the current the stronger the braking action. For most applications, quick stopping of high inertia motor loads can be achieved with DC injection braking, which does not add to system cost or complexity.

DC Injection Braking Compared to Other Stopping Methods (Coast-to-Stop, Regenerative Braking, and Dynamic Braking)

Coast-to-Stop: Allowing the motor to coast to a stop is a standard option for most drives. This method of stopping implies exactly what the name infers. The motor is disconnected from the drive output stage upon a stop command and will coast down to a stop at a rate determined by the frictional components of the system. In applications where a high inertia load is present, it can take a long and undesirable amount of time for the motor to stop, which may pose safety hazards due to rotating machinery.

Regenerative Braking: Regenerative braking generates energy back into the DC bus capacitors. This method can stop the motor quickly in applications where the inertia is small or there is a significant friction load. However, if a large inertia is present the motor will generate energy to the DC bus capacitors and cause an undesirable overvoltage condition for the bus capacitors. Drives typically have built-in protection that prevents the bus voltage on the capacitors from getting high enough to damage the drive. However, if the overvoltage condition is reached, a fault will occur.

Dynamic Braking: Dynamic braking is used in conjunction with regenerative braking. When the bus voltage in a regenerative braking condition is approaching unsafe levels for the bus capacitors, the voltage on the DC bus is connected across a dynamic braking resistor, by use of a solid-state switch, to bleed off the energy and dissipate it in the resistor. This prevents the bus voltage from reaching a value that is higher than the maximum rating of the bus capacitors, and prevents an unsafe condition. Dynamic braking is a good method for providing controlled braking, but will increase system complexity and resources.

An Example Application for DC Injection Braking

An example application where DC injection braking has been successfully implemented is in the belt sanding industry. A belt sander shown in Figure 3 has a high inertia load. The high inertia will cause the belt sander to rotate for a significant amount of time during a coast-to-stop or regenerate-to-stop condition, resulting in a hazardous condition for the operator of the belt sander.

Figure 3: Belt Sanding DC Injection Braking Application

In the coast-to-stop condition there is no additional braking mechanism other than the normal friction of the system, which is negligible with a high inertia load.

During regenerative braking, the high inertia will cause the drive to regenerate energy back into the DC bus causing an overvoltage condition on the bus if the deceleration time is set too fast. When quick stopping is the goal, regenerative braking is not always a solution.

The option of a dynamic brake resistor can be utilized with some drives during regenerative braking to prevent the DC bus from reaching unsafe levels, but this option adds unwanted and unnecessary resources.

When rapid stopping is desired, which cannot be achieved with regenerative braking or coast-to-stop modes, due to a large inertia, then DC injection braking is a viable alternative.

DC injection braking does not add additional resources and the capabilities of the drive can be utilized to stop the belt sander in a quick amount of time. Thus, reducing the chance of a hazardous condition and improving operator safety and reliability of the product.

Conclusion

DC injection braking has been a viable alternative to more expensive stopping methods for numerous original equipment manufacturers (OEMs) that utilize KB controls. KB offers a full range of motor controls shown in Figure 4, which include DC injection braking.

Figure 4: VFDs available from KB Electronics

If you need to stop your motor quickly, contact KB Electronics, to explore the option of DC injection braking in your application.