SERVO**STAR**® S- and CD-Series

Dynamic Braking

This document provides an overview of the various dynamic braking approaches that can be applied to a servomotor system. Its ultimate purpose is to give the reader an understanding of the SERVO**STAR**®'s electronic StopMode feature.

Modern machinery has become much safer for both the operator and the material being processed. Electronic servo systems have replaced mechanical linkages, large open gear trains, belts, and hydraulic rams. Added safety often requires that these systems be able to stop quickly upon demand. Most positioning systems do a fine job controlling these stops, but carry a fair degree of risk as they are not able to reliably stop a system under certain failure modes.

Braking a motor has definite legal implications. The only acceptable methods to brake a motor for personal safety do not include electronic means. Any method employed in a drive relying on active components should not be promoted as safe. However, there are times when the objective of braking is not personal safety but other needs such as protecting machinery, preventing a vertical load from free-falling, or simply stopping a spindle quicker than a coast. Additionally, electronic braking of a motor using the existing drive electronics has a great economic advantage - it is free.

Braking Overview

There are basically three ways to brake a permanent magnet motor. The first is simply at the user's request where the host positioning system performs a functional stop during normal operation. The second is dynamically-braking (fail-safe) the motor for personal safety reasons where liability issues are involved and the system must be stopped quickly and reliably. The third is to prevent the motor from coasting to a stop when a process fault has occurred (electronic) and system mechanical damage is at risk. For this section, we will review the latter two reasons for dynamically-braking the motor.

Fail-Safe Braking

There are two accepted methods of braking for fail safe operation. Electronic approaches are not acceptable due to reliability factors.

The first method is to apply motor brakes. This is often the best method because it works over the widest range of failure modes. Motor brakes work well but have a limitation on how much stopping force they can apply. One disadvantage is that frequent replacement of these brakes (depending on use) are necessary because of their relatively short cycle-life.

The second method is to have a contactor short the motor windings through resistors. The resistors are sized so that the motor currents do not exceed the de-magnetization current of the motor. The resistors must be chosen to handle large instantaneous power surges. The contactor should be DC-rated. This makes it relatively expensive and large. It should have an auxiliary contact that is used to disable the drive just before the main contacts short the motor windings. This is to ensure that the motor energy does not return through the power stage of the drive.

Electronic Braking

There are numerous methods you can use to get a motor to stop electronically. However, the ability of these methods to stop the motor in all failure modes are limited. For example, a failed power device or OverVoltage fault may prevent these methods from functioning.

The first electronic method uses a contactor in conjunction with a current limiting resistor to short the DC BUS of a drive system. It uses the back-diodes across the transistors in the IGBT block in the power stage. When the BUS collapses (due to the resistive short), the motor's energy regenerates through the diodes. Since the current through the diodes is limited by the resistor, the resistor must be sized with respect to the diodes' current capabilities. In most cases, the maximum BUS voltage and drive's peak current rating can be used to calculate the value of the resistor.

With this method, care must be taken to operate the contactor (DC rating only) correctly. The main DC BUS should be disconnected by the contactor. This allows the resistor to drain (or dissipate) only the energy from the motor and the drive's BUS capacitors. The contactor should reconnect the BUS before the BUS Module is re-energized. The contactor is operated by logic that causes the it to drop out in the event of a drive fault or a request to stop. The auxiliary contacts on this contactor can be wired to drop out the contactor for the BUS Module.

The second electronic method reconfigures the drive's current loops (upon a fault or a drive disable) using a number of approaches. Consideration should be given to the fact that the drive may not have a feedback signal from the motor due to a feedback device fault and should not be expected to commutate the motor.

The first approach forces the transistors to regulated the amount of current through two motor phases. This DC current causes the motor to want to lock into a motor-pole detent, creating a stepping action as it rotates to a stop through the torque detents. This same current regulation approach can be used with all three phases. Should one of the transistor bridges fail, two are left to stop the motor. This approach has a drawback in that the drive will, at times, need to pump current out of the motor. This regeneration can cause the DC BUS to rise above the drive's OverVoltage fault limit. The braking sequence needs to be aborted under these conditions.

A second approach forces the transistors to fire all three motor leads to the same DC BUS rail. The current generated from the motor flows through the transistors (or back diodes) to create a motor short. Regulating the maximum currents in this scenario is nearly impossible as the drive is not able to limit current though the back diodes. The drive would need to know how to switch the transistors between shorting through the top and bottom rails to prevent more than one back diode from conducting at any given time. For example, positive current in two-of-three phases causes the drive to connect the transistors to the bottom rail, and negative current in two-of-three phases causes the drive to connect the transistors to the positive rail.

The currents still need to be regulated so as not to exceed the drive's peak current capability or the motor's de-magnetization current.

SERVOSTAR® **Quick-Stop Feature**

The SERVO**STAR**'s Quick-Stop feature uses a variation of the last approach. This feature shorts the motor leads together through a current-controlled process. It switches the transistors on (alternating top or bottom rails), while pulse-width modulating (PWM) the output stage's enable line (not to be confused with the drive's hardware enable). The PWM's duty cycle of the enable line must be such that the Ldi/dt never allows the drive's current to reach a level that could destroy the output stage.

The SERVO**STAR** has added two software variables to give you some control over how this feature is used. The STOPMODE variable allows you to setup the drive's response when encountering a fault or drive disable. The ISTOP variable allows you to control current (up to the peak current rating of the drive - or motor rating, whichever is smaller) into the output stage. A full description of these variables can be found in the *SERVO**STAR**® S- and SERVO**STAR**® CD VarCom Reference Manual* that can be downloaded from our website.