

Application of current control and overcurrent protection in the SVX9000, SPX9000, and LCX9000 adjustable frequency drives

Application

This application note describes the details of the SVX/SPX/LCX9000 current control function and overcurrent protection, both hardware and software. This information also applies to DC fed frames.

Overview

Current control and overcurrent protection on the 9000X drive is based on motor current measurement in all three phases. In the FR9/CH61 and above drives, the current sensors are built into the IGBT SKIP modules, and the current signals are combined and fed into a 14-bit A/D converter on the lower ASIC board. The ASIC board sends the current levels to the control board via a fiber optic serial link. In the smaller drives, FR8/CH5 and below, the measured current signal is fed directly to the control board. The SVX has a 10-bit A/D converter and the SPX has a 14-bit A/D converter.

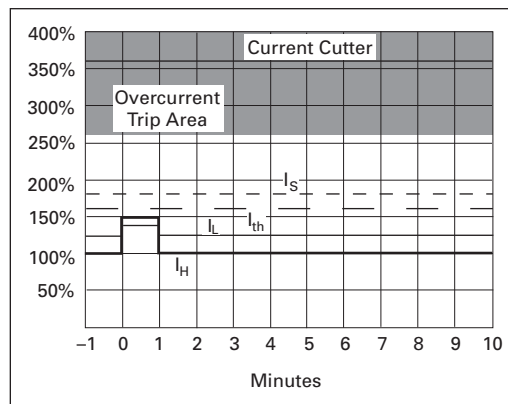


Figure 1. Current Ratings

Product description

SVX/SPX current rating

The 9000X air-cooled frequency converter ratings are based on a "High Overload" (I_H) capability. This means the drive can provide 150% rated output current for 1 minute if the drive was operating at rated output current (I_H) for at least 9 minutes. To get continued 150% overcurrent capability, the average current over the duty cycle cannot exceed the rated output current. The maximum drive output current (I_s) for starting produces approximately 200% rated motor torque but because the currents are vector sums, I_s is less than 200% I_H . The drive can deliver I_s for 2 seconds every 20 seconds. The drive current limit can be set to 200% ($2 \times I_H$) to deliver I_H but to reduce the chance of an overcurrent or IGBT over temperature trip, it is better to set the current limit to 150% ($1.5 \times I_H$) or less.

The actual drive output current available to the motor is dependent on ambient temperature at the intake to the drive, restrictions in airflow to the drive, and the drive frame size. Drive frames FR4–FR9 can deliver rated current (I_H) at 50°C. Drive frames FR10 and above can deliver rated current (I_H) at 40°C except for the highest ratings of a drive frame, which may be limited to 35°C. The "Low Overload" (I_L) rating is typically used for variable torque loads where an overload is not necessary even though a 1 (out of 10) minute overload of 110% is allowed. All drive frames are limited to 40°C or less for the I_L rating. The rated currents of each frame depend on a reduction of switching frequency when unit temperature reaches the warning level.

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LCX thermal current rating

The liquid-cooled drive has a "Thermal" maximum continuous rms current (I_{th}). Use this value for continuous or any overload requirements of the process. The liquid-cooled drive does not have a 1-minute overload current rating. The thermal current rating is dependent on proper coolant flow to each module and a module coolant inlet temperature of 30°C.

Current limit (software-function)

The drive will attempt to limit drive output current to the current limit setting by overriding and lowering the frequency reference until current is within the current limit setting. If unit temperature nears the warning level, the drive will reduce the output frequency in an attempt to bring drive output current down to a continuous current that is approximately the "Low Overload" (I_L) current rating. The control will not allow any further overcurrent conditions until the average current over the duty cycle is less than the drive's current rating. The liquid-cooled drive control will attempt to limit the output current to the current limit setting up to the drive's thermal rating, I_{th} . The application should be designed to avoid using the current limiter for control. The safest way to operate the drive is to keep the drive output current within ratings with appropriate ramp times or a controlled reference to the drive.

Current cutter (hardware-function)

If the drive software cannot prevent output current from exceeding 200% I_{tr} , a current cutter stops firing the IGBTs when the measured instantaneous value of the current exceeds 360% I_H to reduce current quickly before an overcurrent trip occurs. They are re-fired on the next top of the triangle wave. The current cutter is active on select units FR8/CH5 and smaller.

Overcurrent trip (hardware-function)

If the measured instantaneous value of current exceeds the trip limit value (260–400% depending on drive size), all IGBTs are switched off and the drive displays an F1, overcurrent trip. The drive is protected from a short circuit at the motor if the motor leads are greater than 16 feet (5m) in length.

I²t protection (software-function)

Based on measured current and the calculated losses of the IGBTs, a time integral calculation estimates the temperature rise of the IGBTs before the sensors can detect the rise. If this simulated temperature plus the actual heat sink temperature exceeds 125°C, an overtemperature trip occurs and the drive displays an F41, IGBT Temp trip. The drive can be reset after a 1-minute delay.

I²t protection (hardware-function)

On drives FR9/CH61 and larger, the temperature rise of each IGBT pack is simulated by a hardware circuit. When the time integral of the circuit based on measured output current reaches a limit, an overtemperature trip occurs and the drive displays an F31, IGBT Temp HW trip.

Saturation fault (hardware-function)

If the other current control and protection functions are not fast enough to prevent an extreme overcurrent condition, the IGBT saturates and the resulting voltage drop across the IGBT causes an F7, Saturation trip and all IGBTs are immediately switched off by the gate driver board. The brake chopper IGBT also has saturation protection and gives the same trip indication. Power to the drive must be cycled to reset this trip. This function is not yet available on drives FR10/CH61 and larger.

Supporting documentation

For more information, please reference the 9000X Drive User Manual, MN04001004E.

In the event that additional help is needed, please contact the Technical Resource Center at 1-877-ETN-CARE (386-2273).

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