Technical Note 072

Maximum current and overload protection Equipment, motor, and VFD protection

Variable frequency drives (VFDs) have a variety of protective circuits and algorithms that are meant to protect the VFD, motor, and/or equipment. This Technical Note 072 focuses on the Maximum current (limit) parameter within a VFD, along with how this parameter differs from motor overload protection. VFD overcurrent and thermal protection are also reviewed. While all these concepts apply to ABB AC drives in general, the examples and parameters used within this document are based on the 580 series. The 580 series consists of the ACH580, ACQ580, and ACS580 family of drives.

Equipment protection (current limit)

VFDs have current limit settings that limit the amount of current the VFD can supply the motor. In the 580 series, this is parameter 30.17 Maximum current. This current limit can be considered a slower acting type of protection. This limit is not meant to limit instantaneous current spikes, such as a sudden draw of current caused by a short in the motor windings. The current limit feature of a VFD is not intended to protect the VFD or the motor. This current limit was originally designed to protect the mechanical equipment from damage during heavy loading conditions that exceed expected design limits. As VFD technology has advanced over the years, certain sensitive equipment/applications may benefit more by using a torque limit instead of current limit.

The current limit feature first monitors the current consumption of the motor. If the motor attempts to draw more current than the VFD is configured to allow, then the VFD attempts to limit the current to the motor. The VFD limits the current by slowing down the motor speed in hopes of reducing the motor load. In a perfect scenario, the temporary heavy loading condition passes, and then current demand drops below the current limit threshold, and the VFD will no longer need to limit the current.

Only certain applications experience temporary heavy loading conditions that moderate and return to normal levels. Those are the applications that benefit the most from the current limit functionality of a VFD. However, the typical HVAC pump and fan variable torque application would not benefit from the current limit function. These applications for the most part have uniform loading profiles and are not subject to intermittent, random heavy loads. There are occasions where a pump/fan was not sized correctly for the application, or the motor was not sized correctly for the pump/fan. In those situations, the VFD's Maximum frequency setting should be leveraged to limit how fast the equipment can operate.

The 30.17 Maximum current parameter should be programmed based on the application need, and not solely based on the motor rating. A common misconception is to set the Maximum current parameter equal to the motor's current rating. This is not recommended, as this would interfere with the VFD's motor overload protection (I^2t). The Maximum current parameter setting should be left at factory default unless the equipment requires current limit protection.

Motor protection (I^2t)

While the current limit feature discussed above is designed to protect equipment, there is a separate motor overload function designed to thermally protect the motor. This functionality is also known as I^2t protection. There is an algorithm within the VFD that looks at how much current (I) the motor is consuming and for how long (t). The VFD then compares that current and time to the motor's nameplate current. The VFD will allow the motor to operate longer in a slightly overloaded situation than in a heavily loaded situation. The motor overload protection within a VFD has the same general functionality as a conventional motor overload relay. In the 580 series drive, parameter 35.57 Motor overload class allows the VFD to be configured for different overload classes, such as Class 10 or Class 20, to meet NEMA ICS 2 requirements (IEC 60947-4-1).

The motor nameplate data, specifically the motor Amp rating, must be programmed accurately into parameter 99.06 Motor nominal current, for the I^2t protection to function appropriately. Failure to properly program the VFD during start-up will prevent the motor overload protection feature from working correctly. Motor service factor should not be considered when entering motor nameplate data. The actual motor current rating listed on the motor nameplate should be programmed into the VFD. In most cases, the motor service factor is 1.0 when powered from a VFD.

VFD internal protection for current and temperature

The VFD also has overload related protections that protect the VFD from failure. There are two types of protections. One is related to high level of current draw by the load. The other is related to VFD temperature. Even though these are separate protections for the VFD, they are closely tied to each other because high current draw leads to higher component temperature.

VFDs have an instantaneous Overcurrent fault protection where the VFD will go into a fault state to protect itself. The magnitude of that current spike must reach 250-350% of the VFD's current rating to trigger this fault, but the exact value varies based on each VFD size. Overcurrent faults can occur when there is a short within the motor or motor wiring. Depending on the nature of the short, the VFD's Earth fault protection may activate before the Overcurrent fault. The Overcurrent fault can also occur when there is an extreme load change that happens so fast that the previously discussed current limit did not respond fast enough to reduce the current. The Overcurrent fault is intended to protect the VFD from failure, thus the magnitude of the Overcurrent fault is not adjustable.

A VFD also has thermal protection that will cause the VFD to enter a fault condition if the VFD gets too hot. This protection measures the temperature of the VFD, such as the VFD's power devices (IGBTs) and control board. Heavy loading will cause the VFD to run hotter. Heavy loading combined with a dirty heatsink, restriction of air flow, and/or a high ambient environment will lead to a VFD running even hotter. Electrical components experience a shortened lifespan when operated at a high temperature. VFDs have a variety of internal temperature related faults, such as IGBT temperature. The purpose of the VFD's internal thermal protection is to protect the VFD from near term failure or significantly premature failure.

Equipment, motor, and VFD protection

VFDs have a variety of protection features that protect the equipment, motor, and VFD. In many ways, these various features and how they function are related to each other. In most cases the Maximum current limit should be left at factory default, or at least a value greater than motor nameplate current rating. Only sensitive mechanical equipment and processes should have the current limit reduced, and that value should still be above the motor's current rating. Setting the current limit at/near the motor's current rating will reduce the effectiveness of the I^2t motor overload protection. Nuisance motor speed oscillation may occur, with the motor bouncing in and out of a current limit, if the current limit value is set too low.

Properly programming the VFD with accurate motor nameplate current (Amp) information is important for I^2t motor overload protection. Improper programming of the current limit and/or motor nameplate information can result in a motor failure that could have been prevented. There are also internal protections meant to prevent VFD failure. These VFD protections are not adjustable. Reference Table 1 for a summary of the protection features.

Table 1: 580 series protection features

Protection	Equipment protection	Motor protection	VFD protection	Important to adjust from factory default (pump and fan applications)
Current limit	✓			
I^2t		✓		✓ (motor nameplate information)
VFD internal			✓	