Data Bulletin

The Effects of Available Short-Circuit Current on AC Drives

Class Number 8800

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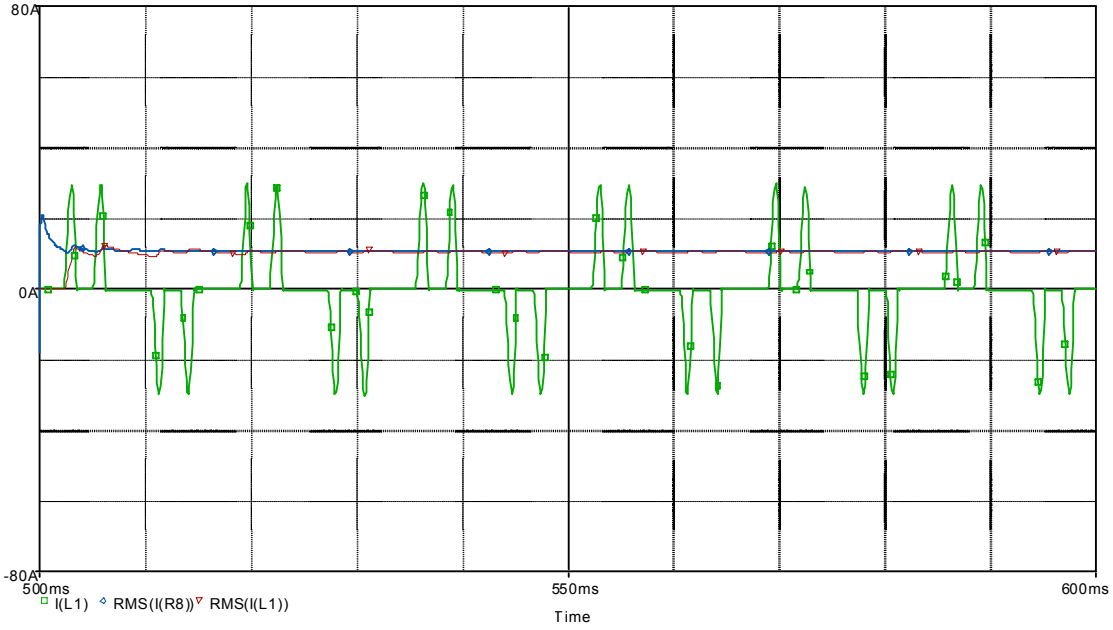
Introduction

This document explores the effects of short-circuit current rating (SCCR) values with respect to potential equipment damage. In particular, what happens to the line current when a drive with a 6-diode rectifier section is combined with different power systems and different types of added inductance.[1] This application note applies to Altivar® 61 drives and Altivar® 71 drives, as well as other variable frequency drives with a 6-pulse rectifier circuit. It does not apply to Altivar® 21 devices as they have a greatly reduced amount of DC bus capacitance.

5 kA Short-Circuit Power System

This example uses an ATV71HU40N4 (the largest Altivar 71 drive rated for a 5 kA system) running at the full 5 hp output load (Figure 1). The input power system impedance is modeled with 104 µH and 39.2 mOhms, resulting in 5 kA available short current with a power factor of 0.7.

Figure 1: 5 kA Short-Circuit Power System



- Vertical Scale = -80 to 80 A, 20 A/Div
- Peak Input Current = 28.4 A (green)
- RMS Input Current = 10.6 A (red)
- RMS AC Current in the DC Bus Capacitors = 10.4 A (blue)

[1] The word “drive” as used in this document refers to the controller portion of the adjustable speed drive according to the NEC (NFPA70).

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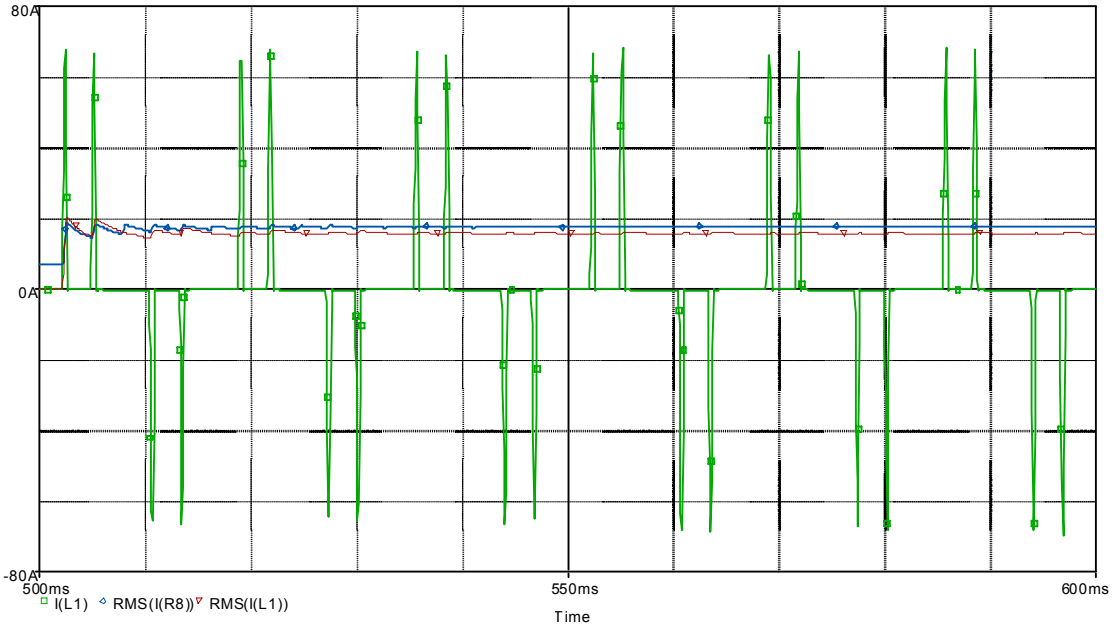
The double hump input current waveform is typical of all drives due to the diode and capacitor rectification of the input line power. The RMS current in the DC bus capacitors is caused by alternate charges and discharges during the cycle.

100 kA Short-Circuit Power System

In Figure 2 the same model drive and output load are used as in Figure 1, but the input power system impedance is modified to provide 100 kA available short-circuit current at a power factor of 0.2. The input power system impedance parameters were 7.2 µH and 0.54 mOhms.

Figure 2: 100 kA Short-Circuit Power System



- Vertical Scale = -80 to 80 A, 20 A/Div
- Peak Input Current = 68 A (green)
- RMS Input Current = 16.3 A (red)
- RMS AC Current in the DC Bus Capacitors = 18 A (blue)

The peak input currents increased by 139%, from 28.4 to 68 A. This increase of input current causes premature diode failure, which may occur within minutes. RMS input currents increased by 54%, from 10.6 to 16.3 A, rising above the current listed on the nameplate. This causes additional heating in the input wiring, which may result in damage to the installation.

The increase in RMS currents in the DC bus capacitors is 73% ($18 \div 10.4 = 1.73$). Since temperature rise is proportional to the square of the current, there will be up to 3 times the heating in the DC bus capacitors causing the expected life cycle to be reduced from 20,000 hours to a few hundred hours.

Adding a 3% Line Reactor

Adding a 3% line reactor greatly reduces the input current peaks (Figure 3). A line reactor for 5 hp and 480 V with an inductance of 3 mH is used in this example. The input power system line impedance was set to provide 100 kA of short-circuit current at a power factor of 0.2. The input power system

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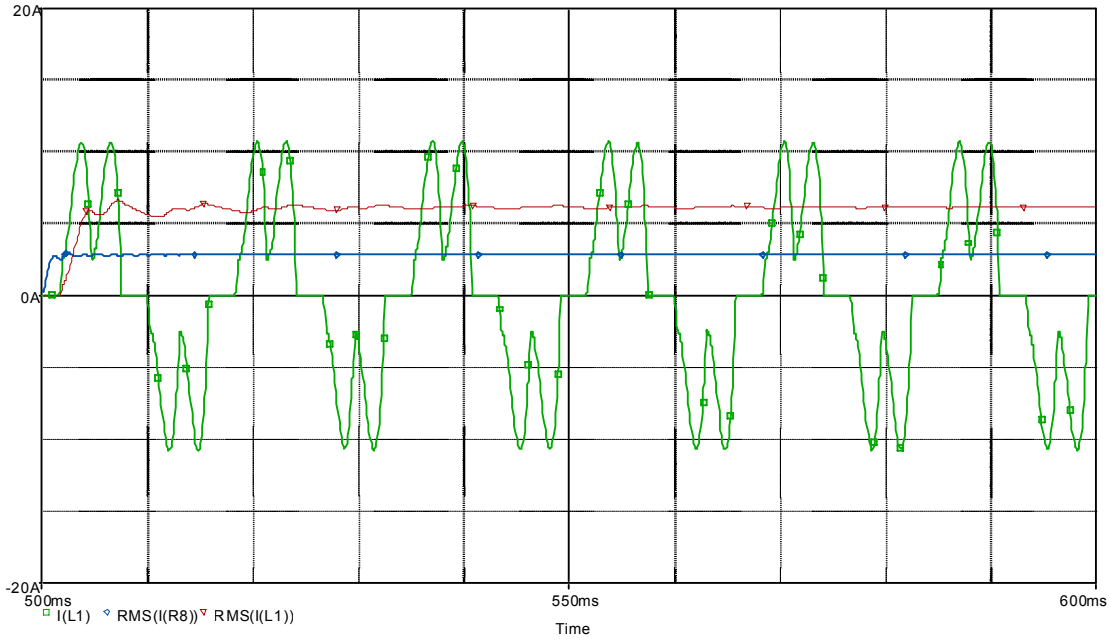
inductance plus the input line reactor inductance results in a total input inductance of 3.007 mH.

NOTE: The addition of a line reactor does not, by itself, allow the installation of the drive on a mains supply with an SCCR higher than that of the drive. A higher rating may be published in the drive's instruction bulletins for tested combinations of overcurrent protective devices (OCPD), line reactors, drives, and enclosures. Contact the manufacturer for the latest ratings.

Figure 3: Adding a 3% Line Reactor



- Vertical Scale = -20 to 20 A, 5 A/Div
- Peak Input Current = 10.7 A (green)
- RMS Input Current = 6.1 A (red)
- RMS AC Current in the DC Bus Capacitors = 2.8 A (blue)
- DC Bus Voltage = 639 V (not shown on graph)

The large impedance provided by the line reactor dominates the input power system impedance. For this reason, virtually identical results are achieved with this line reactor on a 5 kA input line as on a 100 kA input line.

Adding a DC Choke with an Impedance Equivalent to the 3% Line Reactor

The input power system line impedance was set to provide 100 kA of short-circuit current at a 0.2 power factor. A 6 mH DC choke was added between the diode bridge and the DC bus capacitors. This value for the DC choke gives a similar effect as the 3% line reactor used earlier, with a lower ripple current in the capacitors and a higher DC bus voltage (Figure 4).

NOTE: The addition of a DC choke does not allow the installation of the drive on a mains supply with an SCCR higher than that of the drive. A higher rating may be published in the drive's instruction bulletins for tested combinations of OCPD, line reactors, drives and enclosures. Contact the manufacturer for the latest ratings.

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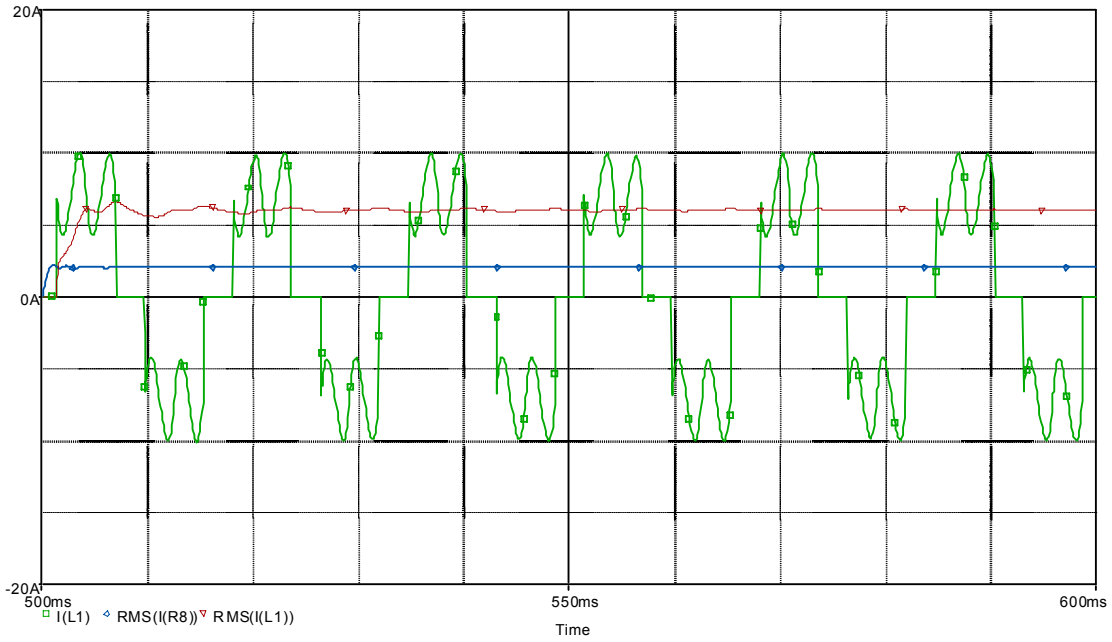
Figure 4: Adding a DC Choke with an Impedance Equivalent to the 3% Line Reactor



- Vertical Scale = -20 to 20 A, 5 A/Div
- Peak Input Current = 10 A (green)
- RMS Input Current = 6.0 A (red)
- RMS AC Current in the DC Bus Capacitors = 2.0 A (blue)
- DC Bus Voltage = 647 V (not shown on graph)

The waveshape of the input current is slightly different with the DC choke as compared to an AC line reactor. For a system with balanced three-phase voltage, the current in the DC choke never goes to zero, unlike the AC line reactor which has the current reversing at a 60 Hz rate. An advantage of the DC choke is that it has a slightly lower voltage drop as compared to an AC line reactor. However, the AC line reactor can help protect the input diodes from voltage spikes on the line.

Conclusion

Running a drive, without additional inductance, on a power system with a short-circuit current greater than the published SCCR of the drive severely reduces the life of the drive. Using an appropriately sized input line reactor or DC choke reduces both the input line current peaks and the heating in the DC bus capacitors, bringing the drive's life expectancy back to specified levels. Attention must be paid to the manufacturer's specified OCPD and the enclosure type used with the recommended reactor or choke at the UL Listed higher SCCR in order to properly apply the adjustable speed drive power converter.

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