Solving DC Drive Harmonics with Matrix Harmonic Filters

Matrix Filters may be used for phase controlled DC drive applications to improve power factor and reduce line harmonics. Application to DC drives is similar to AC drives with a few important differences in filter performance and the selection of the appropriate filter rating. The following paragraphs cover these differences.

Matrix Filter Selection

Selection of the proper Matrix Filter rating for a DC drive is based on the horsepower and voltage rating of the drive. Applications for DC motors rated at 500 volts or higher may use a 480 VAC filter rated at the same horsepower as the DC drive provided the motor efficiency is a minimum of 85%. DC motors with lower efficiencies will typically draw higher ac input current and therefore a Matrix Filter rated for higher horsepower may be required. The following equation should be used to select the correct filter rating:

$$\text{Matrix Filter HP} = \frac{\text{DC Drive HP} \times 85\%}{\text{DC motor efficiency}}$$

If the calculated filter horsepower falls between two standard horsepower ratings, the next larger filter rating should be selected. This will insure that the drive may be used at full rated horsepower without overheating the Matrix Filter components. Do not use this equation to downsize the Matrix Filter when motor efficiencies are greater than 85%. The same type of scaling is necessary for motors with armature voltage ratings less than 500 volts. To select a Matrix Filter for a DC drive, when the motor armature voltage is less than 500 volts use the following equation.

$$\text{Matrix Filter HP} = \frac{\text{DC Drive HP} \times 500\text{Volts}}{\text{Rated Armature Voltage}}$$

If the calculated filter horsepower falls between two standard horsepower ratings, the next larger filter rating should be selected.

Matrix Filter Performance

Matrix Filters are suitable for use with DC drives and other phase controlled rectifier applications, but harmonic performance will vary based upon controller output voltage (speed) and output current (load). While it is not possible to specify guaranteed levels of harmonic distortion for Matrix Filters used with phase controlled SCR applications, Matrix filters are extremely effective at solving harmonics problems associated with DC Drives and other six-pulse phase controlled rectifiers.

The performance of the Matrix Filter with a DC drive differs from that with an AC drive due to two main factors: (1) the harmonic content of the DC drive line current waveform tends to have higher amplitude harmonics at the 11^{th} and higher, and (2) the line current of the DC drive is mainly dependent on motor torque, not motor power. The effect of these differences is an increase of about 10% - 50% in THID under full torque conditions and a noticeable rise in THID during lightly loaded low speed operation. Although for this reason, the Matrix Filter performance guarantee does not apply to DC drive applications, Matrix Filters are very effective at solving DC drive harmonic problems.

This rise in percent distortion is not due to an increase in absolute harmonic current, but results from the cancellation of the lagging fundamental drive current with the leading filter capacitor current. See figures 1, 2, and 3 for nominal THID curves of a 500-volt DC motor at 100%, 50%, and 10% speed. In this example the drive is operating from a nominal 480 VAC line.

FIG. 1

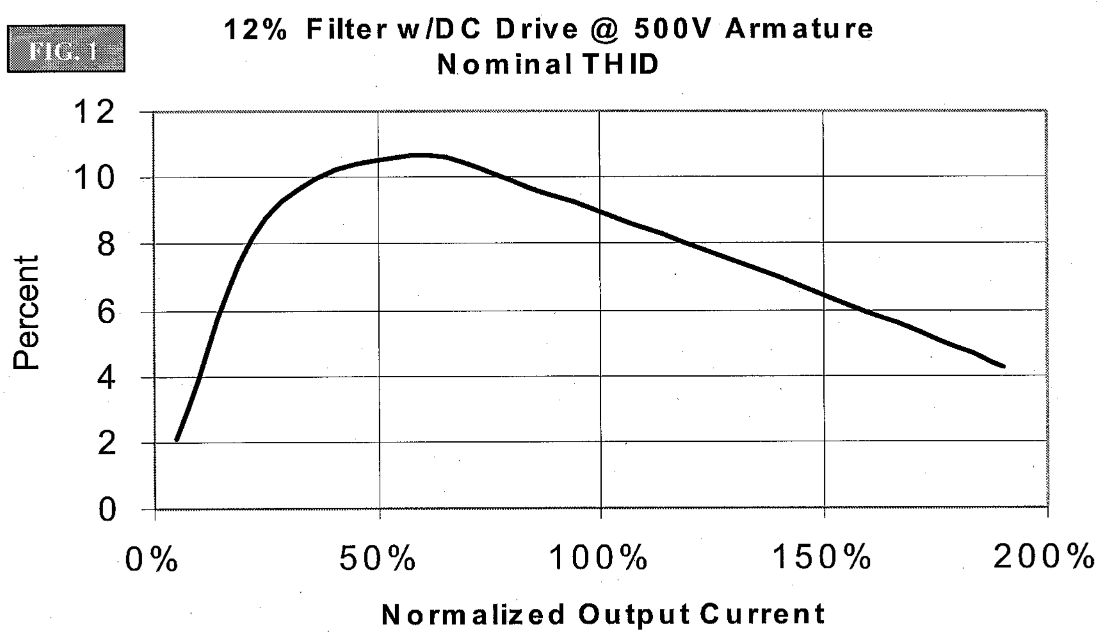
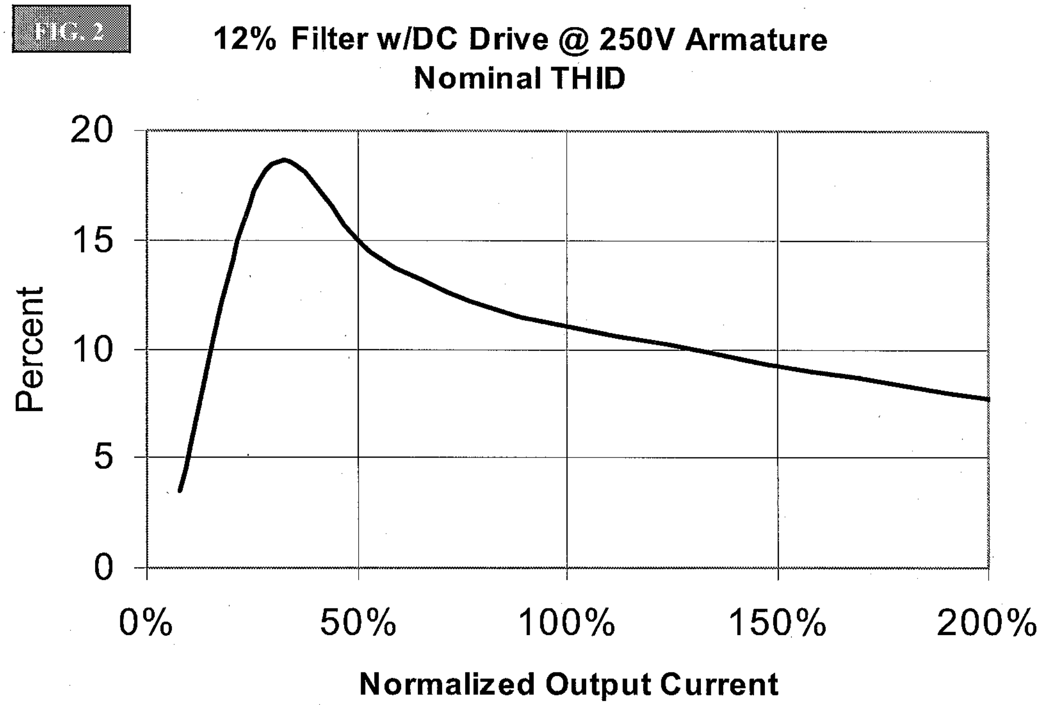
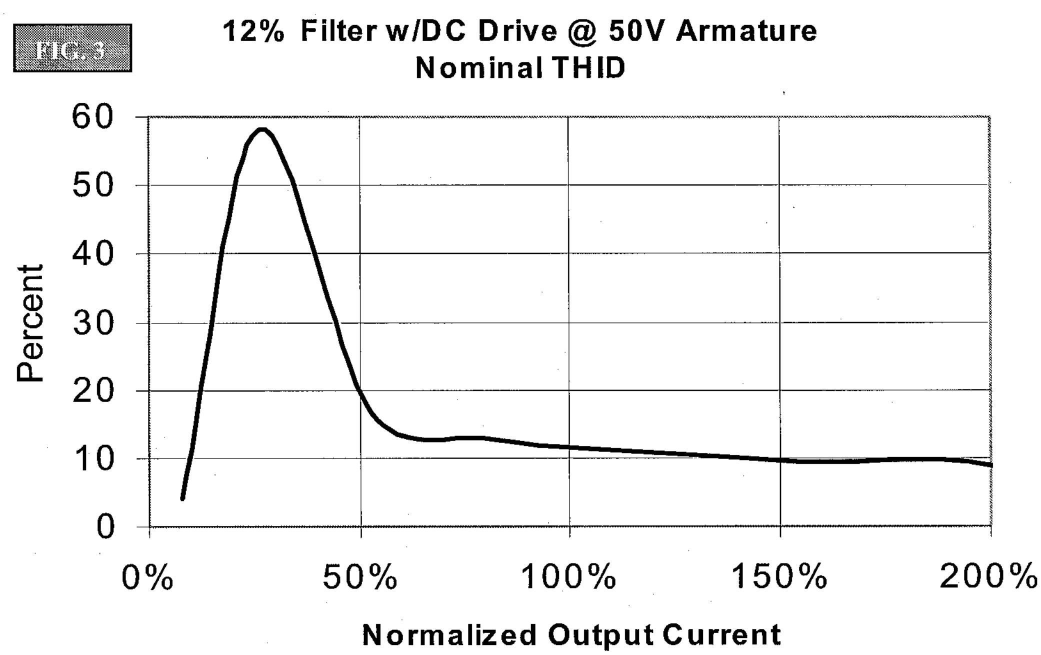


FIG. 2



12% Filter w/DC Drive @ 250V Armature
Nominal THID
Percent
20
15
10
5
0
0%
50%
100%
150%
200%
Normalized Output Current

FIG. 3



12% Filter w/DC Drive @ 50V Armature
Nominal THID
Percent
60
50
40
30
20
10
0
0%
50%
100%
150%
200%
Normalized Output Current

Available Motor Overload Current

The limitation on available motor overload current with a Matrix Filter on a DC drive depends on many of the same factors as an AC application. Rated motor voltage, operating speed, line impedance, and filter type are all important parameters. The worst case conditions are full armature voltage, low line voltage, high line impedance, and an 8% versus a 12% filter. Figures 4 and 5 show the worst case available currents with 6% line impedance as armature percent resistance varies. Figures 6 and 7 are the same curves with 3% line impedance.

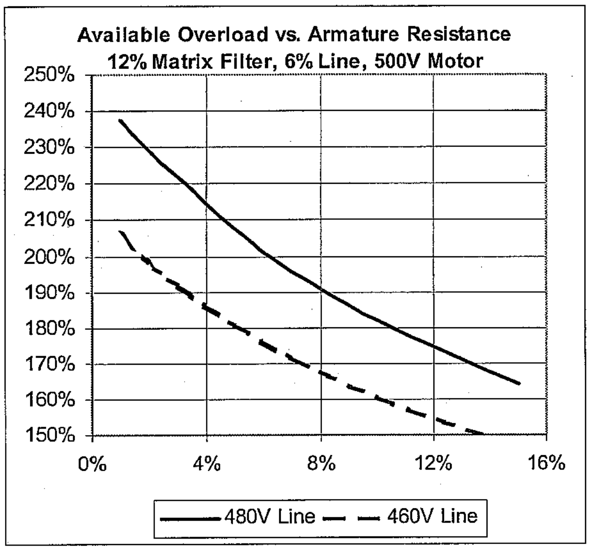


Figure 4

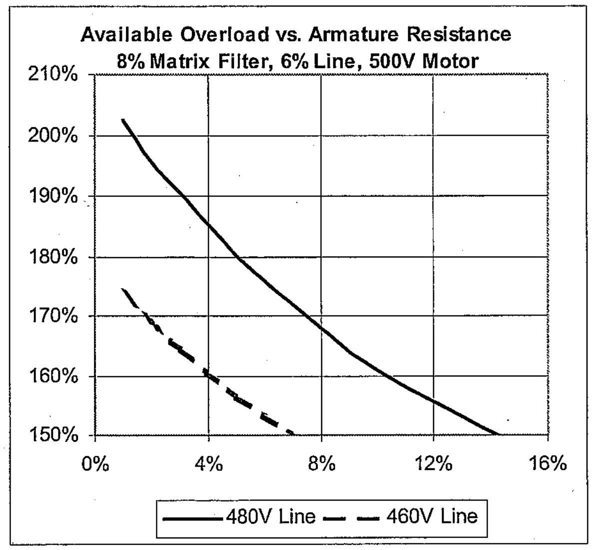


Figure 5

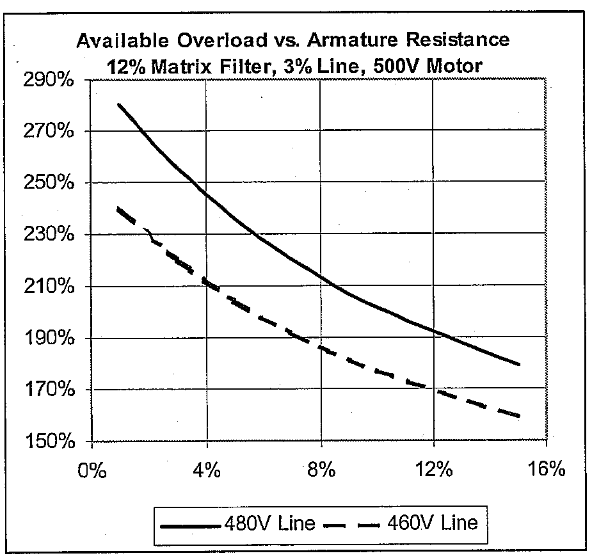


Figure 6

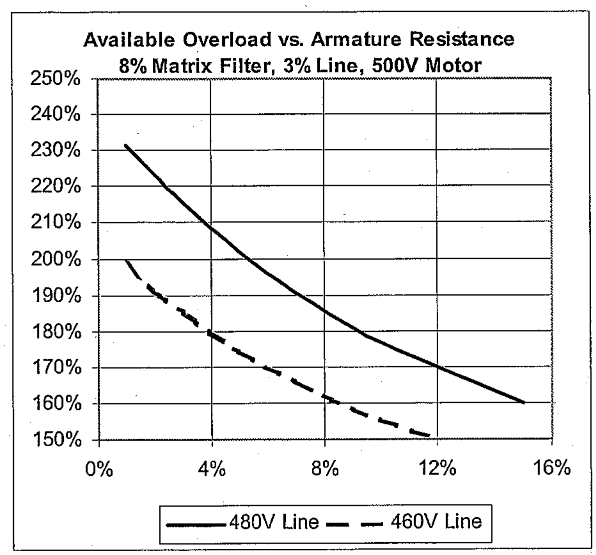


Figure 7