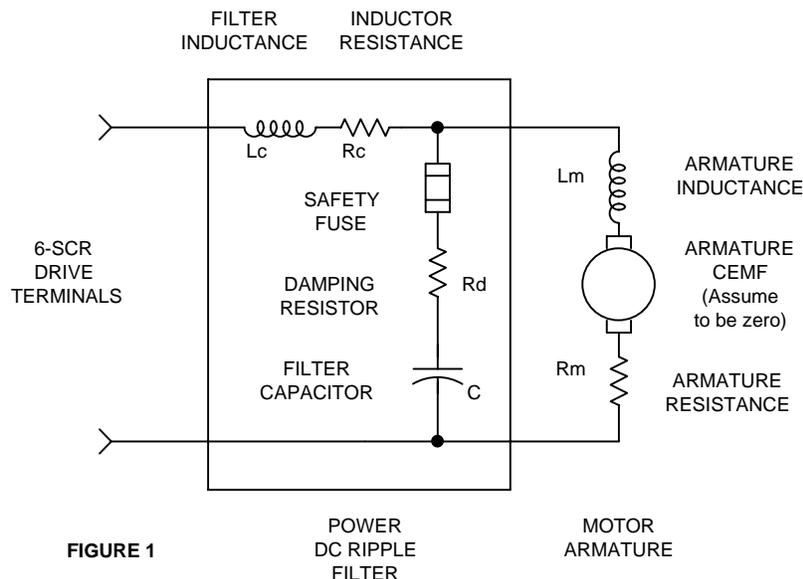


SUBJECT: Using DC Motor Ripple Filters; Recommendations for Using a Ripple Filter with the DSD 412 DC Elevator Drive

A power ripple filter commonly used in the elevator industry to reduce acoustic noise in DC hoist motors is shown in Figure 1. Reactor L_c holds off ripple voltage coming from the 6-SCR power converter, reducing the overall amount of ripple current. That which remains is diverted to flow through the shunt capacitor leg, bypassing the motor armature. The reduction of ripple voltage at the motor is easily measured by monitoring the AC content of voltage at the motor armature terminals, before and after the filter is placed in the circuit. The mathematics tell us that the reactance of inductor (L_c) and capacitor (C) combine with that of the motor armature (L_m) to form a two pole low pass filter. Tuning of the filter is not overly critical, but if the resonant frequency is too low it will interfere with operation of motor torque, velocity and position controls. In order for the filter to pass DC and low frequency currents on to the motor, but yet sharply attenuate those at 360 Hz, it has been determined that the frequency response of the filter should have a resonant peak at approximately 100 Hz and that the response amplitude of the resonant peak, known as the “Q”, should be about 1.4. It is the “Q” that affects the sharpness of cut-off of higher frequencies. But if the “Q” is too high, there will be high circulating current in the L and C components causing catastrophic over voltage or heat damage. A damping resistor, R_d , is placed in series with the capacitor to control the “Q”, and thereby limit current and voltage amplitudes at the resonant frequency.



Unfortunately the mathematics also tell us that the resonant frequency point and “Q” are interactively affected by all L, C and R components in the circuit. So the L and R characteristics of the motor are indeed part of the filter. Consequently calculation of ideal values for filter components to add is not straightforward until knowledge of motor inductance, L_m , and motor resistance, R_m , have been determined. In most cases, this information is not available in advance. (But good educated guesses based on history and motor data tables do help.) Components for the ripple filter are likely to have been purchased and be on site before one can measure the characteristics of the motor. However, the value of capacitance is usually adjustable in steps by reconnection of individual capacitors in a bank. The following procedure may be used to optimize values for filter components. The equations are not mathematically pure but will indicate effective values for the capacitor, C, and damping resistor, R_d , fairly close to ideal.

PROCEDURE

1. First determine a value for the filter reactor, L_c . Use the motor model number and manufacturers data tables (or past experience) to determine the motor armature inductance. Or, bypass the filter (including removal of the capacitor fuse) and use the DSD412 drive Self-Tune procedure to measure motor inductance, L_m , and armature circuit resistance R_m . (Record those values for use later.) Select a reactor that has about the same inductance and is thermally rated for motor nameplate amperes. The actual inductance value is not overly critical, but the filter will be most effective when the two circuit inductances are about the same value. Acceptable filter operation can be obtained when the reactor inductance is between 0.5 times and 2 times the motor inductance. It is very important, however, that the inductance of the filter reactor be relatively constant throughout the operating range of DC current. It must not saturate at high currents required for elevator acceleration. Less than 15% inductance droop at maximum accelerating current is usually adequate.
2. Use the nameplate value of selected reactor, L_c , and the motor inductance, L_m , as determined in step 1 to calculate a capacitor value using the following equations.

$$C = \frac{L_m + L_c}{L_m \times L_c} \times \frac{1}{(2\pi f)^2}$$

Where C is in Farads, L_m and L_c are in Henries and f is in Hz.

When $f=100\text{Hz}$ and L_m and L_c are expressed in milliHenries, then

$$C = \frac{L_m + L_c}{L_m \times L_c} \times 2535 \text{ microfarads}$$

3. An approximate damping resistor value can then be calculated by:

$$R_d = \left[\sqrt{\frac{L_m \times 1000}{2 \times C}} / (2 \times Q) \right] - R_m \quad \text{As mentioned above, let } Q=1.4.$$

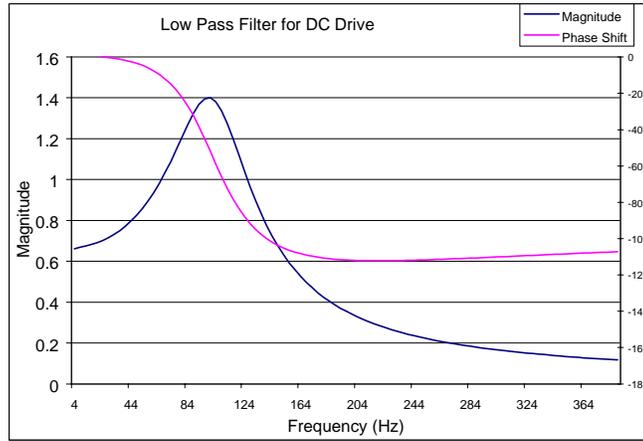
Where, L_m is in milliHenries, C is in microfarads and R_d and R_m are in ohms.

4. Connect up the components to achieve the values calculated for C and Rd, but leave the capacitor fuse out. Self-Tune the drive. The expected value of measured L should be $L_c + L_m$. Measured R will include wiring resistance and be slightly larger than $R_c + R_m$. Record these values so they can be used later for tuning the current regulator in case the drive must be operated with the capacitor bank disconnected.
5. Insert the filter capacitor fuse and perform a drive Self-Tune again. The resulting L value should be only somewhat larger than that of the reactor. (Certainly not $L_c + L_m$.) The expected R value should again be $R_c + R_m$. Tune the drive to uses these measured values for L and R. Record them for later use so one does not have to repeat the measurement process again.
6. Verify proper operation. Connect an AC voltmeter across the motor armature terminals. Run the elevator. Measure and record the average AC volts reading during long runs. The attenuated AC ripple voltage should be 5% or less of rated (nameplate) DC armature volts.
7. If operation of the filter is not satisfactory and values for C or Rd are re-adjusted, repeat steps 5 and 6.
8. Drive tuning of the current regulator is significantly different with and without the capacitor bank and damping resistor connected. In the event that the capacitor bank fuse blows or must be disconnected it is important that the drive current regulator be re-tuned by entering the L and R values determined in step 4. When operation with capacitors is restored, re-tune the drive again using the values determined in step 5.

Note: An EXCEL Spreadsheet program is available from the Magnetek Elevator Products Group (www.elevatordrives.com) that enables the user to easily determine what the Ripple Filter Component values should be, and the Filter Characteristics, for a given Motor Inductance and Resistance. See figure 2 on page 4 for a sample of what the program looks like.

RPLFLTR.XLS Determines motor current ripple filter characteristics and component values

10	Motor Inductance, mH
0.04	Motor resistance, Ohms
5	Choke inductance, mH
0.04	Choke resistance, Ohms
685	Trial Capacitance value, MFD
1.20	Trial Rdamping value, Ohms
Frequency Peak is	100 Hz
Peak Magnitude is	1.40 (the "Q")
Atten. @ 360 Hz is	0.130 , or about
	14.9 Vac on a 500 Vdc motor
Phase shift is	0.896 @ 12 Hz
	(degrees)
Press CTRL-T to tune for	
Fo=100Hz and Q=1.4	
Good guess for C =	761 MFD



Good guess for Rd = 0.88 Ohms

Figure 2