SUBJECT: Measuring the Ripple Filter Inductance with the DSD 412

A ripple filter can be installed between the drive and the motor armature to reduce acoustic noise. Since the DSD 412 is rated for 250% current, there is a possibility that the inductor inside the ripple filter is not designed to handle this large amount of current and will saturate. If the ripple filter inductor saturates, the drive could operate poorly during acceleration. This procedure verifies the ripple filter inductor does not saturate with low, normal, and high currents.

The DSD 412 has an internal digital closed loop current regulator operating the SCR power converter, the Power Conversion Unit (PCU). This regulator is engineered specifically to work with DC motor armature R-L-CEMF loads. Tuning of the regulator is quite simple once the characteristics of the load and supply source are known. The regulator needs to know the resistance (R) and inductance (L) of the motor armature circuit, as well as the rated V_{ac} of the supply line and V_{dc} of the motor. Then, given a performance target value for crossover frequency response of the regulator, the CPU will automatically calculate P, I, D, and Feed-forward gains as used by the internal regulator. In most cases, Self Tune may be used to measure R and L of the motor load. However, there are some conditions that may yield incorrect results. If the drive can successfully pass PCU Diagnostic tests (function #998), the Self-Tune data should be valid. However…

MOTOR AND REACTOR

Some applications may require using a reactor (choke or inductor) in series with the dc motor armature to reduce ripple current flowing through it. Ripple in the dc current is caused by natural periodic variations of the voltage output of the SCR power converter acting against the inductance of the circuit. Most motors have adequate inductance for this purpose, but in some cases the inductance of the motor may be very small (older motors designed to be used with pure dc from an M-G set), causing a need to reduce ripple current to prevent commutator sparking. In other cases there may be a need to reduce acoustic noise (elevators) or torque ripple (process line). In either case, measuring of the total load inductance for the purpose of tuning the regulator may be accomplished by using Self Tune. However, it is important that the inductance characteristic of the reactor be relatively constant and not significantly change or saturate with low, normal or high dc currents flowing through it from normal operation of the drive. If the characteristics of the reactor are unknown, the following procedure may be used to measure inductance of the load attached to a DSD412 drive over a wide range of dc operating currents.

MEASUREMENT TECHNIQUE

1. Set Rated Field Current adjustment (function #3) to zero. This will reduce the ability of the motor to generate torque and thereby prevent motor rotation. It will also disable Field Loss Fault detection.
2. Lock the machine so that it cannot move. For an elevator, ensure that the brake cannot lift.
3. Set the Current Limit adjustment (function #1) to the desired dc current level.
4. Turn the drive ON, call for some rotation speed, let the drive produce Current Limit amperes.
5. Capture calibrated waveforms of drive output voltage and current with an oscilloscope or electronic chart recorder. When the drive reaches Current Limit, measure and record the peak to peak voltage, peak to peak current, and the Current Limit setting. (See Figures and comments below.)
6. Turn the drive OFF to prevent ‘burning’ of the commutator or causing an Overload Fault trip.

7. Readjust the Current Limit setting and repeat steps 3-6 at other current levels of interest. Be sure to include the highest Current Limit ampere setting that will be used for the equipment. Suggested test values are 25, 50, 100, 150, 200, 250% of Rated Amperes for elevator hoists, or stop at the highest Current Limit setting that will be used.
8. Calculate the load inductance at each dc test current level and graph plot measured inductance V_s dc amperes. At each data point, the inductance is:

$$L = \frac{Vdcpeak - peak}{2.88 * Idcpeak - peak} \quad \text{(milliHenries)}$$

Where V is in volts, I is in amperes, line frequency at 60 Hz, calculated L is in milliHenries.

The importance of a constant inductance value may become apparent during the tests. If the reactor saturates, the inductance will significantly reduce at large dc currents, causing the current regulator to become unbalanced or unstable, see Figure 3. If this happens, set Enable Self Tune (function #2) to a logic zero to use manually entered values for R – armature ohms (function #4) and L – armature inductance (function #6) for operating the current regulator. Manually enter the measured R data from measured inductance (function #613) into armature ohms (function #4), and enter in an L value into armature inductance (function #6) that is half of that shown in measured inductance (function #614). If the current regulator again becomes unstable as higher current tests are made, again enter a lower value for L at armature inductance (function #6) by dividing the number by 2.

Figure 1 - DSD 412 Output Voltage Waveform with No Motor Rotation (CEMF=0)

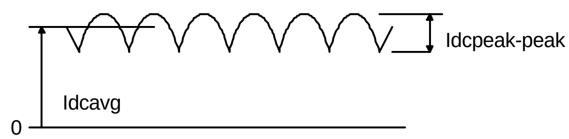

Figure 2 - DSD 412 Output Current with Inductive/Resistive Load (Normal Operation)

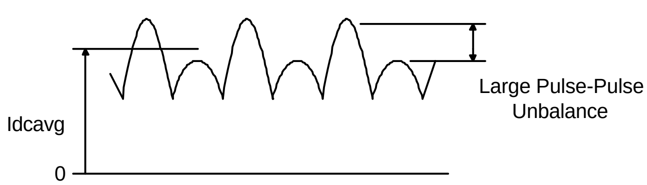

Figure 3 - Unbalanced Load Current, if Inductor Saturates (Unstable Current Regulator)

MEASUREMENT POINTS

The drive output voltage signal may be accomplished directly with differential oscilloscope probes at the drive output terminals.

WARNING

Lethal voltages exists at the drive output terminals. Use differential measurement probes rated for 1,000 volts, minimum. Do not connect single ended 'hot chassis' equipment to these terminals. Use caution when connecting measurement probes. Turn power OFF to prevent accidents

An isolated reduced image of the drive output voltage is available at TP30 on the main circuit card. Use TP24, 25 or 47 as circuit common. The scale factor at TP30 is actual volts/93.15.

Output current may be observed at TP37 on the main circuit card. Again, use TP24, 25 or 47 as circuit common. The scale factor at TP37 is drive size dependent as listed in Table 1 below.

500V hp	Rated Amps DC (typical)	Size ID Res.	Amps / V @TP37
3	6.3	26.7	2.57
7.5	12.6	86.6	4.34
15	26.1	196	8.68
30	51.3	332	17.4
60	102	499	35
125	204	715	61.7
150	252	953	83.3
200	331	1270	111
250	400	1690	156
300	480	2490	196
400	640	3320	262
500	800	4420	313
600	960	5900	392
700	1120	7870	392
800	1400	1050	522

Table 1 - DSD 412 Current Feedback Signal Scaling

POWER RIPPLE FILTERS

Elevator applications may require the use of a dc power ripple filter between the DSD 412 drive and the elevator motor armature to reduce acoustic noise generated by fundamental current ripple. (The characteristic 360 Hz hum of a 6-SCR drive) A typical filter is shown in Figure 4 below. This filter cannot change the amount of voltage ripple fluctuation at the output terminals of the drive. It will still look like that of Figure 1. But ripple current will now flow through the capacitor leg of the filter, bypassing the motor. The net result is that voltage ripple at the motor terminals, and resulting acoustic noise will be reduced. The drive however, measures current flowing out of its terminals. The ac ripple part of that current will continue to flow and be measured, even though it does not actually flow through the motor armature. The capacitor leg of the filter acts somewhat as a short circuit for the ripple current. The apparent inductance of the load as seen by the drive then is mostly that of only the filter choke. So in order to operate properly, the current regulator of the drive must be tuned to operate with the inductance of that reactor. When the ripple filter is tuned properly, the actual inductance of the motor has little effect on the ideal value of L used to tune the current regulator. (see Application Note DSD 412-106A on using dc motor ripple filters). It is obviously also important that the filter reactor not saturate at any normal dc operating current, up to and including Current Limit amperes.

The technique above can be used to measure the inductance of only the filter choke. Temporarily rewire the power circuit to bypass the motor armature and repeat steps 1-8 above. Self Tune the drive with the motor bypassed for initial starting values of R and L. The resulting data will be for the filter choke only. If a data plot of the inductance characteristic shows that the choke saturates below the dc Current Limit amperes required for the application, it is not suitable to be used with DSD 412.

Once confidence of a non-saturating filter choke has been established, and the correct values for ripple filter capacitance and damping resistance have been selected, it is important that the DSD 412 drive be Self Tuned again, with the ripple filter capacitor, fuse, and damping resistor in the circuit, to measure the effective values of R and L. These values should be entered in for R – armature ohms (function #4) and L – armature inductance (function #6).

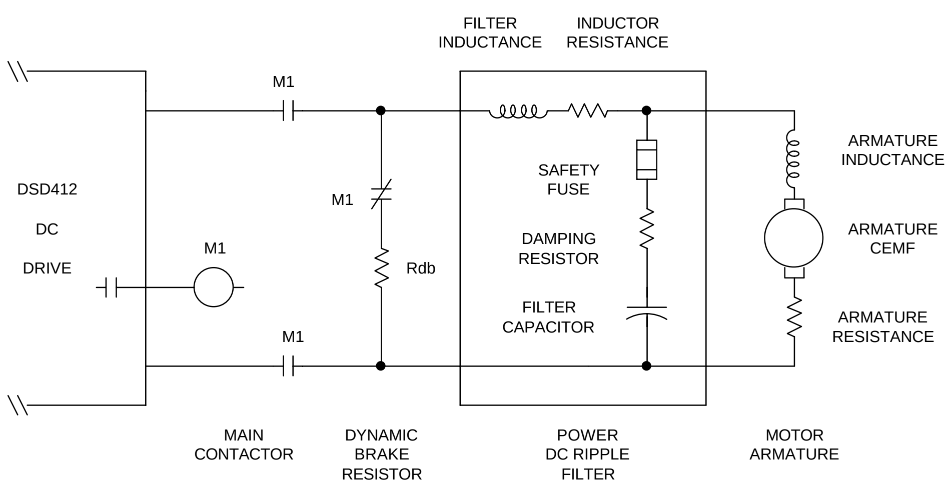

Figure 4 - Typical Power Ripple Filter