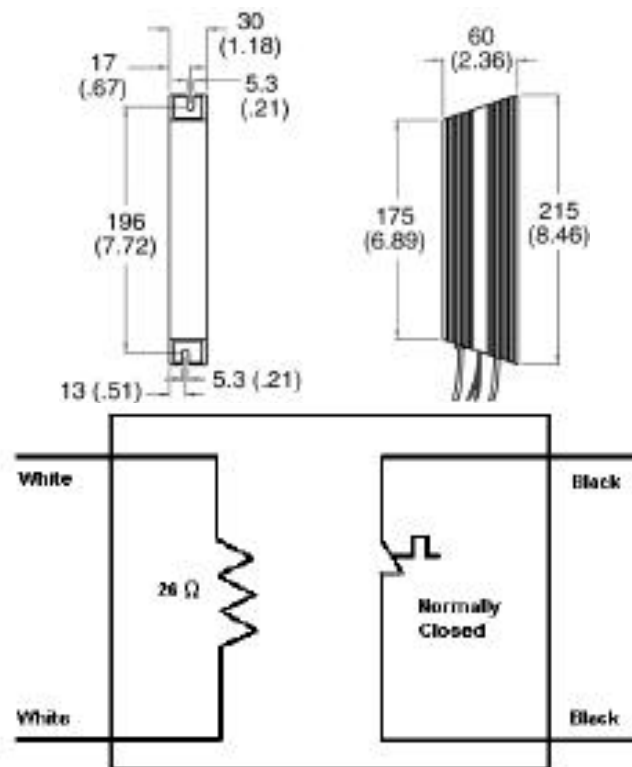


APPENDIX D

Resistive Regeneration Sizing

Shunt regeneration is required to dissipate energy that is pumped back into the DC bus during load deceleration. The loads need to be defined in terms of system inertia, maximum speed, and deceleration time. In addition, the duty cycle must be known.

Regen Resistor
Example is
Kollmorgen's ERH-26



The black wires are for the thermostat and the white wires are for the regen resistor on the external regenerative resistor (pictured above).

Energy Calculations

To determine if a system needs a regeneration resistor, use the following procedure:

EQUATION 1

Define the term E_M which is the kinetic energy of the motor/load minus the system losses.

$$E_M = (1.356/2)(J_M + J_L) \omega_M^2 - 3I^2M (R_M/2)t_d - (1.356/2)T_F \omega_M t_d \text{ Joules}$$

Where: J_M = rotor inertia (lb – ft – sec²)

J_L = load inertia (lb – ft – sec²)

$$\omega_M = \text{motor speed before decel (rad/sec)} = \frac{\text{RPM}}{9.55}$$

I_M = motor current during deceleration

R_M = motor resistance (Ω L – L)

t_d = time to decel (sec)

T_F = friction torque (lb-ft)

If this energy is less than that which the BUS Module can store, then no regen resistor is needed. Thus, the condition for which no regen resistor is required is:

EQUATION 2

$$E_M < (1/2) C (V_M^2 - V_{NOM}^2)$$

Where: C = BUS Module capacitance (Farads)

V_M = max BUS voltage (V)

$$V_{NOM} = \text{nominal BUS voltage (V)} = V (L-L) \sqrt{2}$$

Where: all negative E_M are set equal to zero before summation (sum all non-negative E_M). This represents a worst case in which only the motors that are regenerating ($E_{MJ} > 0$) decelerate while those whose system losses exceed their regenerative energy ($E_{MJ} \leq 0$) remain idle. If Equation 2 is not satisfied, then a regeneration resistor is required.

Regeneration Calculations

The procedure for calculating regeneration requirements is twofold. Both the regen resistance value and the resistor wattage rating must be determined.

DETERMINING RESISTANCE VALUE

The maximum allowable resistance of the regen resistor is that value which will hold the BUS under its maximum value when the regen circuit is initially switched on. For an AC servo system, the maximum allowable regen resistance is given by:

EQUATION 3

$$R_{MAX} = \frac{V_M^2}{V_B I_M \sqrt{3}}$$

Where: V_M = maximum BUS voltage

V_B = motor back EMF less motor losses

EQUATION 4

$$V_B = K_B N - \sqrt{3} I_M (R_M / 2)$$

Where: K_B = back EMF constant (V (L-L) /KRPM)

N = motor speed prior to decel (KRPM)

I_M = deceleration current in motor (A_{RMS} / phase)

R_M = motor resistance (UL-L)

I_M = deceleration current in motor (A_{RMS} / phase)

DETERMINING DISSIPATED POWER

The average wattage rating of the regen resistor is a function of energy to be dissipated and the time between decelerations. This average wattage rating for a single axis system is given by:

EQUATION 5

$$P_{AV} = \frac{E_M - (1/2)C(V_M^2 - V_{HYS}^2)}{t_{cycle}}$$

Where: t_{cycle} = time between decels + time to decel (sec)

V_{HYS} = hysteresis point of regen circuit

When the time between decelerations becomes very large, Equation 5 become very small. In cases such as these, the average wattage is not a meaningful number. Peak wattage and the time which the resistor will see peak wattage become the main concerns. The peak wattage of the regen resistor is:

$$P_{PK} = \frac{V_M^2}{R_{REGEN}} \quad \text{Where:} \quad R_{REGEN} = \text{REGEN Resistance}$$