SV9000 DYNAMIC BRAKING

1. General

1.1 Dynamic Braking Basics

Dynamic braking is one method used to dissipate excess energy generated when the load controlled by an adjustable frequency drive (AFD) is quickly slowed or stopped.

When a motor is quickly slowed down, it becomes a generator, feeding energy back into the AFD. The energy that is fed back increases the DC link voltage. The AFD attempts to compensate for this by increasing its output frequency.

The rate of deceleration, the load and motor inertia, the power losses of the motor, and the power loss of the AFD determine what energy level will be fed back.

In general, the braking magnitude for a standard motor and AFD is about 15% of the AFD rated power, primarily due to the power losses in both the motor and the AFD.

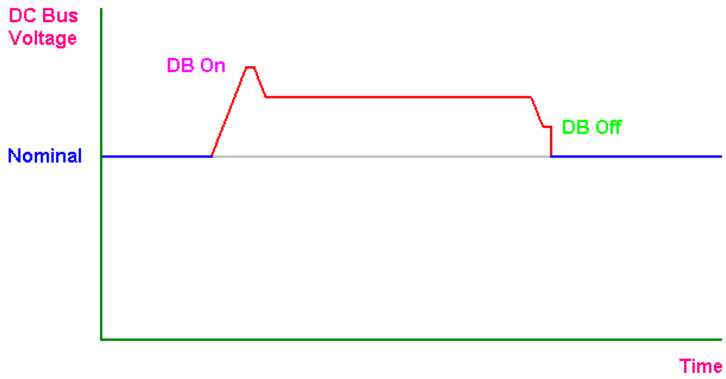
The SV9000 AFD minimizes braking time, with no additional hardware, by using *fuzzy control* algorithms based on power losses in the motor and AFD. This is sufficient in many applications such as pumps, mixers and conveyors, etc., where the kinetic energy stored in the load is small and the braking time is not critical.

When the motor and its load must be braked more quickly than the motor and AFD power losses will allow, additional energy absorption must be provided. This is achieved by the addition of an external brake resistor, in conjunction with a factory installed brake chopper. The extra energy is absorbed by the brake resistor, then dissipated as heat.

Applications where dynamic braking is usually needed include the following: centrifuges, cranes, some conveyors, fans, and drives requiring rapid slowdown and reversing.

1.2 Hardware Components

Dynamic braking requires two components: the factory installed brake chopper and the external brake resistor. The brake chopper consists of an IGBT assembly and logic function that is factory mounted internally to the SV9000 AFD. The chopper controls the DC link voltage by connecting the brake resistor across the link when the voltage reaches a predetermined level, dissipating the excessive energy in the brake resistor.



The brake chopper size is fixed by the drive rating. The brake resistor is selected on the basis of the SV9000 AFD rating, the magnitude of the energy to be dissipated, and the braking duty cycle.

The compact NEMA 1 SV9000 AFD, has a brake chopper installed as a standard feature. An optional brake chopper is available for the other types of SV9000 AFD.

The brake protection hardware is discussed in section 3.4.

1.3 Application

Dynamic braking should be considered for applications that require frequent or rapid braking, especially of heavy loads. Some applications require continuous braking, or a holding brake, for which dynamic braking is not recommended.

2. Technical Data

2.1 Resistor Rating

Cutler-Hammer has pre-selected resistor assemblies for the SV9000 AFD based on two common braking levels. The standard brake resistor series is rated for a 20% duty cycle at 100% motor torque. The heavy duty resistor series is rated for 50% duty cycle at 150% motor torque. Resistor selection, based on these ratings and the application, will be covered in section 3.

2.2 Environmental Issues

The surface temperature of the resistor assembly can reach 90 °C. Care must be exercised in selecting a suitable location with adequate ventilation. The maximum allowable ambient temperature for the resistor assembly is 50 °C.

3. Choosing the Brake Resistor

3.1 General

The pre-selected resistor assemblies are based on typical user requirements based on a 20 percent duty cycle at 100 percent braking or a 50 percent duty cycle at 150 percent braking.

The duty cycle rating is based on a 60 second period. For example, the 20 percent duty cycle resistor can carry 100 percent current for 12 seconds out of every 60 seconds, while the 50 percent duty cycle resistor can carry 150 percent current for 30 seconds out of every 60 seconds.

3.2 Determining the Braking Requirements

In order to determine the braking requirements the following properties of the mechanical system must be known.

- Motor horsepower rating (HP)
- Motor's rated speed (N_0)
- Motor minimum (N_1) and maximum (N_2) operating speed
- Motor (WK^2_M) and load (WK^2_L) inertia as seen at the motor shaft, including any gearing effect (g)
- Desired braking or stopping time for the worst case speed reduction (t).
- Speed and load variation during an operating cycle

3.2.1 Motor Rated Torque

The first calculated value needed is motor rated torque, which is calculated using the motor's horsepower rating and speed rating, as below:

$$T_M = \frac{5250 \times Hp}{N_0} \text{ foot-pounds (ft-lbs)}$$

3.2.2 Inertia

The total inertia must then be calculated.

$$WK^2 = WK^2_M + WK^2_L \times g^2 \text{ pound-feet}^2 \text{ (lb-ft}^2\text{)}$$

If motor inertia is unknown it can be estimated by:

$$WK_M{}^2 = \left[0.02 \text{ x } 2^{\left[\frac{\text{Poles}}{2}\right]} \text{ x HP}^{\left[1.35 - 0.05 \text{ x } \frac{\text{Poles}}{2}\right]} \right]$$

Where g = the ratio of the gear box (or belt and sheave) output speed to input speed. If there is no gear or belt and sheave present, use g=1 for the calculation.

3.2.3 Braking Torque Required

Using the total inertia calculated above, determine the braking torque required using the following calculation:

$$T_B = \frac{WK^2 \times (N_2 - N_1)}{308 \times t} \text{ foot-pounds (ft-lbs)}$$

where (N_2-N_1) is the maximum speed change required, in rpm, for either stopping or slowing.

3.2.4 Braking Percentage

Finally, calculate the braking percentage, based on the calculated motor torque and braking torque required, as below:

$$T_{\%} = \frac{T_B \times 100\%}{T_M}$$

If the braking percentage (T%) is less than 15%, dynamic braking is not required since the regenerated energy will be dissipated in the drive and motor losses. If the braking percentage (T%) exceeds 15%, one of the two standard braking resistor assemblies and an SV9000 AFD with a braking chopper option must be chosen.

3.3

3.4 Choosing the Appropriate Resistor

If the braking percentage (T%) is greater than 15%, but less than 100%, and the duty cycle does not exceed 12 sec. /min.(20%), the standard brake resistor (20% duty cycle/100% motor torque) series may be used.

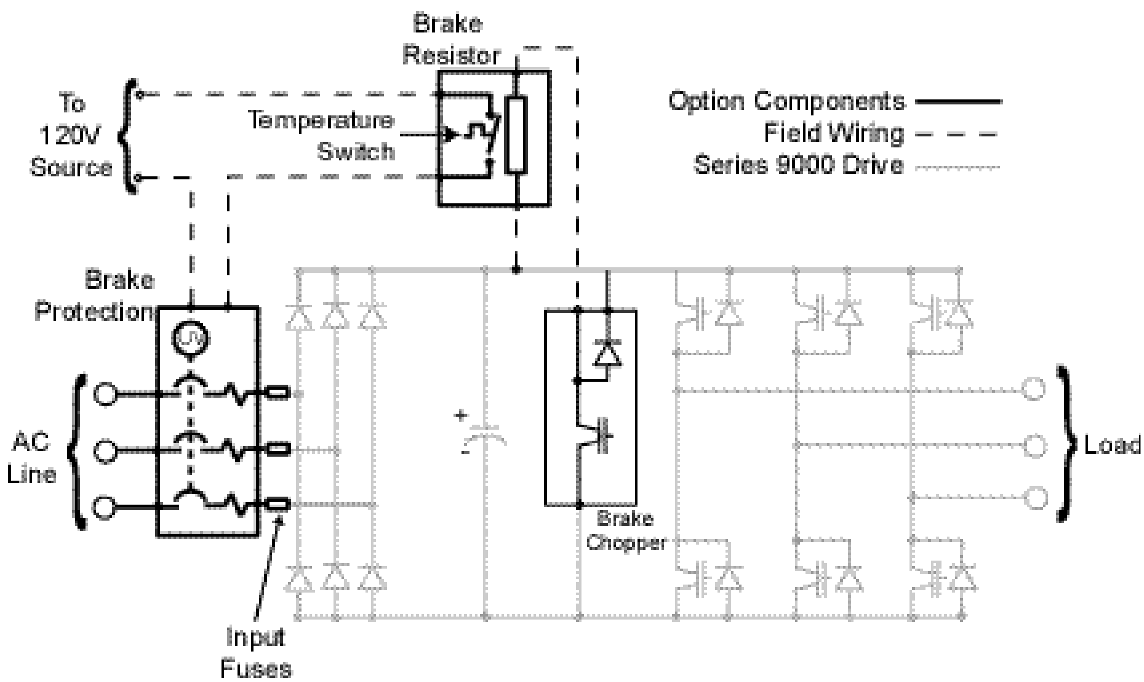
If the braking percentage (T%) is between 15% and 100%, but the duty cycle is between 20% and 50% (greater than 12sec, but less than 30 sec./min duty cycle), the heavy duty brake resistor (50% duty cycle/150% motor torque) series should be used.

If the braking percentage (T%) is greater than 100%, but less than 150%, and the duty cycle does not exceed 30 sec./min. (50% duty cycle), the heavy duty brake resistor (50% duty cycle/150% motor torque) series may be used.

If the duty cycle exceeds 50% (more than 30 seconds of braking per minute), a special resistor package will be required. Contact your local Cutler-Hammer representative.

3.5 Protection

A failure of the brake chopper or the overheating of a resistor bank can lead to a hazardous condition. Cutler-Hammer highly recommends that an input disconnect with undervoltage trip be installed when using dynamic braking***. Caution must be practiced to determine the reason for an input disconnect trip, and its resolution before the drive is put back into service.***



The input disconnect with undervoltage trip can be supplied as a factory mounted option. It is only available in units with oversized enclosures. If you choose to supply your own disconnect device, Cutler-Hammer recommends a type HMCP disconnect.

3.5.1 Thermal

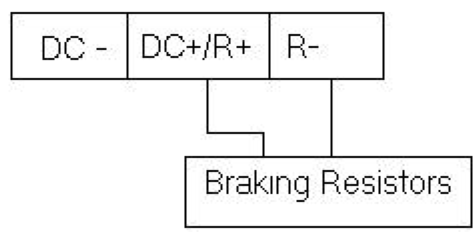
The dynamic braking resistor is supplied with a thermal sensor to determine excessive operating temperatures. This thermal sensor is to be wired to the undervoltage trip unit of the drive's input disconnect device. This will provide protection against resistor burnout from excessive operation or high ambient temperature. If the resistor bank is made of multiple units, each with its own thermal sensor, the thermal sensors will need to be connected in series to trip the disconnect. If no thermal sensor is supplied, the resistors must be rated for continuous duty.

3.5.2 Short Circuit

The SV9000 AFD's input fuse option provides short circuit protection to the drive in situations where the brake chopper, braking resistor, or other major component may fail. If a fault condition occurs, the fuses will clear, removing line voltage from the SV9000 AFD.

3.6 Programming

Refer to the SV9000 Instruction Manual for proper programming of the drive with brake chopper.



3.7 Wiring

Use the following for the connection of the dynamic
braking resistors for all frame sizes.

Table 4: Series 9000 Drive Terminal Designations

Frame Size	**Connect Dynamic Braking Resistor to the Series 9000 Drive Terminals Below**		**Notes**
M3 through M7	R+	R-	
M8	DC+	R1* or R- *	**Jumper drive terminals R1 and R2**
M9	DC+	R1* or R- *	**Jumper drive terminals R1, R2 and R3**
M10	DC+	R1* or R- *	**Jumper drive terminals R1, R2, R3 and R4**
M11 through M13	DC+	R-	

* *Note: Terminal designaton depends on type of drive.*