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Regeneration and emergency braking (DS01015/B)

1. Description

As with most rotary electric motors, when a linear motor is over-running, that is the kinetic energy of the motor and load is propelling the motor, it will act as a generator. This normally occurs during deceleration and so the rate of energy feedback is dependant on the rate of deceleration. It is also possible that during an Emergency Stop or by disabling the amplifier that the system has potential energy (vertical loads) which will be translated into force and thus make the motor act as a generator.

This action will deliver electrical energy from the motor into the drive. The effect will be to raise the DC bus voltage of the drive. The maximum DC bus level for the drive will be limited due to the ratings of the drive components and in most cases dissipate excessive energy via a shunt resistor if the DC bus voltage level exceeds a safety level. Alternatively the drive may be capable of line regeneration, whereby the energy is supplied back into the supply circuit.

Regenerative energy can also be used to brake the motor in an emergency stop situation by disconnecting the motor from the drive and shorting the motor phases together.

2. Regeneration

If a third party amplifier or drive is used it may be necessary to determine whether a shunt board is required. The shunt board is normally fitted to the DC Bus connections at the power input terminals to the drive. The drive manual or drive supplier can provide information on calculating the shunt resistor requirements and their fitting. Please follow the user instructions carefully paying special attention to safety during installation.

Whereas the amount of energy generated is determined by the motor dynamics and the motion profile, in general the energy absorption capability of the drive is determined by the drives DC Bus capacitance, and the maximum rated voltage. If a shunt board is fitted the maximum energy absorption is determined by the shunt resistors capacity to dissipate the energy.

DC Bus capacitance Energy absorption is given by the following equation:

$E = ½ C(V^2_{max} - V^2_{dc})$ Joules

Where,

Nominal DC link Voltage	V_{dc}	Volts
Peak allowable DC Bus Voltage	V_{max}	Volts
DC Bus Capacitance	C	Farads

The maximum regeneration energy and power generated by the motor can be calculated as shown below. Note that this calculation assumes regenerative energy is produced during constant deceleration:

Change of Kinetic energy at constant deceleration = $dE = ½. m (v_1^2 – v_2^2)$ Joules

Power required to change velocity at constant deceleration = $P = m (v_1^2 – v_2^2)/dt$ Watts

Where,

Moving mass (including motor)	m	kg
Initial Velocity	v_1	m/s
Final Velocity	v_2	m/s
Time to decelerate	dt	sec

3. Emergency braking

A make before break contactor can be connected between the motor and the drive to provide an emergency stop. This method of braking absorbs the kinetic energy in the motor and dissipates it as heat in the braking resistors. Braking resistor sizing will depend on the power required for the braking event to be carried out safely and at the repetition rate required.

Please Note, this method does not provide a permanent brake.

The contactor is required to firstly connect the brake resistors in parallel with the motor windings and then break the contact to the drive, leaving the motor phases connected to the brake resistors. Failure to make the contact to the drive before breaking the contact during braking could result in serious arcing of the contactor caused by high voltages due to the motor inductance. The motor earth and cable shield should remain connected permanently.

If a relay is used in emergency stop situations to short circuit the motor phases and hence produce braking force, it should be rated to handle the peak voltages and currents produced within the motor.