

Stopping in an Emergency

For safety reasons, it is often necessary to incorporate some form of emergency stop system into machinery fitted with stepper or servo motors. There are several reasons for needing to stop quickly.

- To prevent injury to the operator if he makes a mistake or operates the machinery improperly.
- To prevent damage to the machine or to the product as a result of a jam.
- To guard against machine faults. You should consider all the possible reasons for stopping to make sure that they are adequately covered.

How should you stop the system?

There are several ways to bring a motor to a rapid stop. The choice depends partly on whether it is more important to stop in the shortest possible time or to guarantee a stop under all circumstances. For instance, to stop as quickly as possible means using the decelerating power of the servo system. However, if the servo has failed or control has been lost, this may not be an option open to you. In this case, removing the power will guarantee that the motor stops; but if the load has a high inertia, this may take some time. If the load is moving vertically and can back-drive the motor, this introduces additional complications. In extreme cases where personal safety is at risk, it may be necessary to mechanically lock the system even at the expense of possible damage to the machine.

Emergency Stop Methods

1. Full-torque controlled stop.

Applying zero velocity command to a servo amplifier will cause it to decelerate hard to zero speed in current limit, in other words, using the maximum available torque. This will create the fastest possible deceleration to rest. In the case of a digital servo with step and direction inputs, cutting off the step pulses will produce the same effect.

The situation is different for a stepper drive. The step pulse train should be decelerated to zero speed to utilize the available torque. Simply cutting off the step pulses at speeds above the start-stop rate will de-synchronize the motor and the full decelerating torque will no longer be available. The controller needs to be able to generate a rapid deceleration rate independent of the normal programmed rate, to be used only for overtravel limit and emergency stop functions.

2. Disconnect the motor.

Although this method is undoubtedly safe, it is not highly recommended as a quick-stop measure. The time taken to stop is indeterminate, since it depends on load inertia and friction, and in high-performance systems the friction is usually kept to a minimum. Certain types of drives may be damaged by disconnecting the motor under power. This method is particularly unsatisfactory in the case of a vertical axis, since the load may fall under gravity.

3. Remove the AC input power from the drive.

On drives that incorporate a power dump circuit, a degree of dynamic braking is usually provided when the power is removed. This is a better solution than disconnecting the motor, although the power supply capacitors may take some time to decay and this will extend the stopping distance.

4. Use dynamic braking.

A motor with permanent magnets will act as a generator when driven mechanically. By applying a resistive load to the motor, a braking effect is produced that is speed-dependent. Deceleration is therefore rapid at high speeds, but falls off as the motor slows down.

A changeover contactor can be arranged to switch the motor connections from the drive to the resistive load. This can be made failsafe by ensuring that braking occurs if the power supply fails. The optimum resistor value depends on the motor, but will typically lie in the 1-3 ohms range. It must be chosen to avoid the risk of demagnetization at maximum speed as well as possible mechanical damage through excessive torque.

5. Use a mechanical brake.

It is very often possible to fit a mechanical brake either directly on the motor or on some other part of the mechanism. However, such brakes are usually intended to prevent movement at power-down and are seldom adequate to bring the system to a rapid halt, particularly if the drive is delivering full current at the time. Brakes can introduce friction even when released, and also add inertia to the system – both effects will increase the drive power requirements.

What is the best stopping method?

It is clear that each of the methods outlined above has certain advantages and drawbacks. This leads to the conclusion that the best solution is to use a combination of techniques, ideally incorporating a short time delay.

We can make use of the fact that a contactor used for dynamic braking will take a finite time to drop out, so it is possible to de-energize the contactor coil while commanding zero speed to the drive. This allows for a controlled stop to occur under full torque, with the backup of dynamic braking in the event that the amplifier or controller has failed.

WARNING! – *there is a risk that decelerating a servo to rest in full current limit could result in mechanical damage, especially if a high-ratio gearbox is used.* This does not necessarily ensure a safe stop, be sure that the mechanism can withstand this treatment.

A mechanical brake should also be applied to a vertical axis to prevent subsequent movement. An alternative to the electrically-operated brake is the differential drag brake, which will prevent the load from falling but creates negligible torque in the opposite direction.