# SAFE TORQUE OFF

**Understanding STO**
A Built-in Safety Function

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# INTRODUCTION

## DESIGNING WITH MACHINE SAFETY IN MIND

A variety of procedures can be used to ensure the safety of a machine. The machine should be designed to be as inherently safe as is possible. However, in many cases some risks will remain and must be actively reduced with suitable control measures. These control measures could be various kinds of interlocks, light curtains, or other safeguards which prevent the machine from functioning when access is possible such as through the opening of a guard.

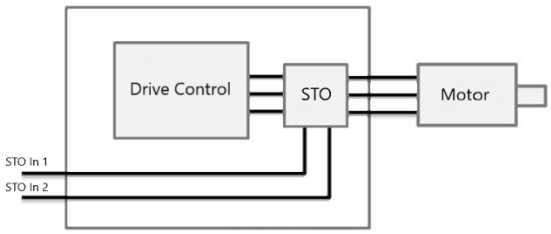
## HISTORY OF MACHINE SAFETY

Machine safety protocol often requires disabling drive controls. Many early driver systems worked by killing power which limited operator control and still presented a danger. As technology developed, driver controls became more sophisticated. Safety contactors were used to shut down the motor drives, and while it was effective at removing power and stopping motion, it came at the cost of valuable position data and other information. Eventually contactors and other components were built into the drive, thereby creating the STO feature which was later defined by IEC 61800 5-2.

There are many different safe stopping methods that all aim to protect operators and equipment. Safe Torque Off (STO) is a modern safety feature that is being adopted into motion control products. This feature adds an additional layer of safety onto motion applications and helps keep end users safe in a reliable manner. Recently, STO has become the most common drive safety control feature.

## GENERAL DESCRIPTION

Safe torque off is a functional safety feature that allows the drive output to be disabled so that the drive cannot generate torque in the motor. The STO feature functions off two independent inputs.

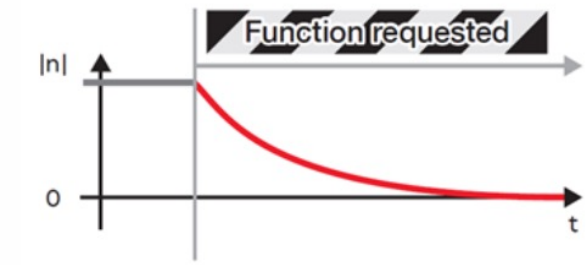


| STO Logic State Table | | |
|---|---|---|
| Input | | Output |
| 1 | 2 | STO |
| LOW | LOW | ACTIVE |
| LOW | HIGH | ACTIVE |
| HIGH | LOW | ACTIVE |
| HIGH | HIGH | NOT ACTIVE |

**When one or more of these inputs is deactivated or set as a logic "LOW" value, STO will activate and the drive will be disabled.**

The drive is set torque-free and the motor will coast until speed reaches zero. STO being active will also prevent unexpected start up.

The time it takes to stop is determined by the physical properties of the system, including friction, weight, and torque.




*Torque speed curves STO*

Note on E-Stop functions – STO is often looked upon as an emergency stop function. Depending on the safety requirements for the application it may be possible to use the STO as part of the E-Stop system. However, its purpose is as a dedicated safety control whose function is to remove power without the use of an E-Stop. Although it is not intended for use during machine maintenance, repair, replacement, or other similar activities, it has been found to be a useful tool during setup and changeover. For these activities recognized electrical power isolation devices and lock-out procedures should be used.

# OTHER SAFETY FUNCTIONS

There are several other types of stops that can be confused with STO. These include: safe stop 1, safe stop 2, safe operating stop, and safe standstill.

## COMPARISONS

### Safe stop 1

- Power is still available to the achieve the stop, then power is removed once the stop is achieved.
- Torque is maintained while stopping and is removed once a stop is achieved.

### Safe stop 2

- Power is maintained throughout the stop process.
- Enters safe operating stop once a stop is achieved, full torque remains available.
- Safe standstill is monitored by the drive.
- Requires an additional braking system.
- Cannot be used for an emergency stop.
- Useful in vertical applications.

### Safe operating stop

- Motor is stopped at a specific position and held there by the drive.
- Torque is maintained throughout.
- Cannot be used for and emergency stop function because of the risk that comes with maintaining the torque throughout the stop.

### Safe standstill

- Motion has stopped and is monitored by a device whose output signals control the release of the guard locking devices.

## BENEFITS

- Using STO will not damage electronics of the device.
- Motor cannot start unexpectedly, requires both STO channels to reactivate to allow motion to occur.
- Reduces wear on the drive from powering on and off.
- Reduces need for additional input contactors or safety relays.

## LIMITATIONS

- STO uses solid state techniques. It does not provide separation of electrical connections and is not intended to provide electrical isolation.
- STO does not provide braking. No motor braking is available because it disables the drive output and motor. External brake must be used.
- In vertical applications activating STO without a braking system can cause the axis to fall.

## SAFETY OVER INDUSTRIAL NETWORKS

The availability of fast and efficient industrial Ethernet systems such as EtherNet/IP and Profinet made it possible to use the “black channel” approach recommended in IEC 61784-3. The intent of the black channel is the data going from one safety device to another is secured so the communication system carrying the data has no influence on the safety of the data – if it were to tamper accidentally or intentionally with the safety data, it would be detected and do no harm. This enables safety protocol containers to be “tunneled” inside the fieldbus system, considerably simplifying the hardware and software for safety systems. Most devices for industrial Ethernet functional safety are rated for SIL3.

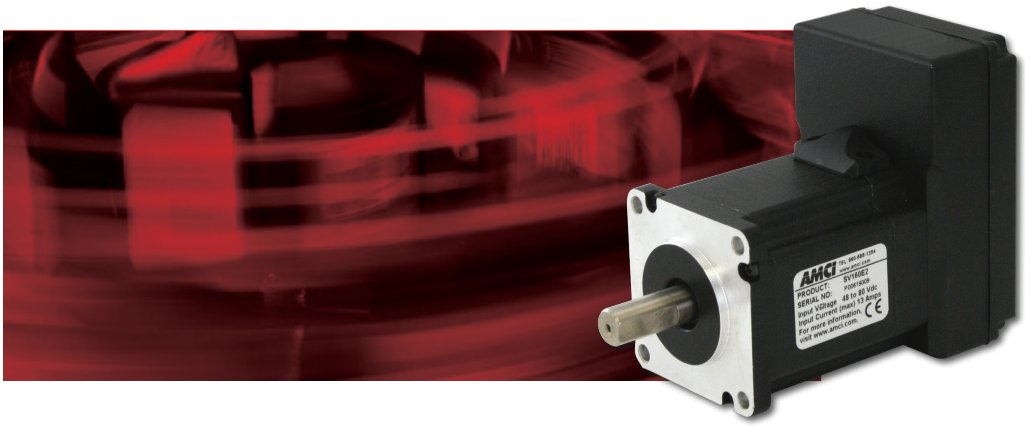
The trends for functional safety have been the acceptance of safety logic controllers and safety input/output (I/O) devices from multiple vendors. There are many companies making products that complement a functional safety system.

Additionally, the availability of servo drives with safe motion functions onboard has streamlined automation design for users of motion control products because the motion controller can issue safety function commands directly to drives for safe stop, safe torque, safe speed, and safe position.

# APPLICATIONS

## APPLICATION 1 – AGV CONTROL

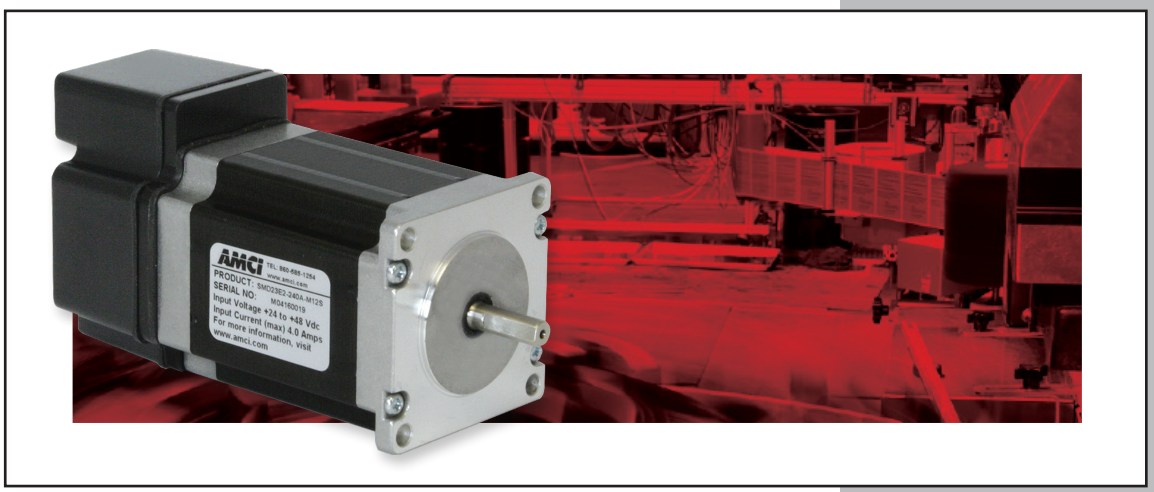
A manufacturer of AGVs needed a compact integrated servo motor and drive for the steer and drive motors. When the AGV was in operation it would travel from one work station to another. At each work station an operator would engage with the work station that was being moved along the production line. When at each station they needed a method to prevent the AGV from moving without removing power from the system. The solution was the SV160E2-STO integrated servo. The STO of the SV160E2-STO prevented any unexpected movement of the AGV while the control system remained active allowing the rest of the system to function without interruption.



**SV160E2**

## APPLICATION 2 – MACHINE ZONING

In today's production environment machine flexibility is a must and downtime must be kept to a minimum. The AMCI SMD23E2 integrated steppers have long been used as the preferred choice for integrated stepper motors to control set up axes on conveyors. The STO feature of the SMD23E2-240A-S12 allows for machine zoning so operators can clear jams, size for different products, and access guards to place or remove products while the rest of the line can continue to operate.




**SMD23E2**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