AVW Technical Guide

Safe Torque Off (STO) and Drive Safety Functions

Author: Anton Woodward OBE CEng MInstMC FRSA
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1. Introduction

Modern stage automation systems frequently use variable speed drives (VSDs) or servo drives to control motors that move scenery, lifts, and other stage machinery. These drives often include built-in safety functions designed to prevent hazardous motion.

One of the most common safety features is **Safe Torque Off (STO)**. STO prevents a motor from generating torque and therefore prevents unintended movement of machinery.

Understanding how STO works is important for engineers and technicians involved in the design and operation of stage automation systems.

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2. What is Safe Torque Off?

Safe Torque Off is a safety function that removes the drive's ability to produce motor torque.

When STO is activated:

- the drive disables the power stage controlling the motor
- torque production stops
- the motor cannot generate movement

Importantly, STO **does not remove electrical power from the drive itself**. Instead, it ensures that the drive cannot energise the motor.

This allows the system to achieve a safe state quickly while maintaining drive diagnostics and control system communication.

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3. Why STO is Used

Traditional emergency stop systems often relied on removing power from the entire drive system. However, modern automation systems benefit from more controlled safety responses.

STO provides several advantages:

- rapid stopping response
- reduced wear on electrical components
- improved system diagnostics

- faster system restart after faults

For stage automation systems, STO is commonly used in combination with **emergency stop circuits and safety controllers**.

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4. Related Safety Functions

Many modern motor drives include additional safety functions beyond STO.

Examples include:

Safety Function	Purpose
Safe Torque Off (STO)	Prevents motor torque generation
Safe Stop 1 (SS1)	Controlled stop followed by STO
Safe Stop 2 (SS2)	Controlled stop with monitoring
Safe Limited Speed (SLS)	Limits motor speed
Safe Direction (SDI)	Prevents movement in a prohibited direction

These functions allow engineers to design safety responses appropriate to the specific hazards of the system.

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5. Standards

Drive safety functions are typically designed according to recognised safety standards such as:

- IEC 61800-5-2
- ISO 13849
- EN IEC 61508

Manufacturers normally specify the **SIL or Performance Level rating** supported by the drive safety functions.

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6. STO in Stage Automation

In theatre automation systems, STO is typically activated when:

- an emergency stop button is pressed
- a safety controller detects a hazardous condition
- motion limits are exceeded
- safety sensors detect a fault

The safety controller sends a signal to the motor drive which activates the STO function and prevents further motion.

Mechanical brakes may also be applied to ensure that heavy loads remain securely held.

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7. Limitations of STO

Although STO prevents torque generation, it does not actively stop a moving load.

For systems with large moving masses, additional measures may be required:

- controlled stopping functions
- mechanical braking systems
- load holding devices

These measures ensure that motion stops safely and that loads remain secure.

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8. Practical Takeaways

- Safe Torque Off prevents motors from generating torque.
- STO is commonly used in modern motor drives.
- It forms an important part of automation safety systems.
- STO is often used together with safety controllers and emergency stop circuits.
- Additional braking systems may be required for heavy loads.

About the Author

Anton Woodward works in theatre engineering and stage automation systems.

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