WINTECHCON

Integrating functional safety in AC/Servo drives with redundancy and diagnostic coverage

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Agenda

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- Safety Sub-Functions in IEC 61800-5-2
- Motor Drives System Block Diagram
- What is Safe Torque Off (STO)?
- How to implement STO?
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- How to implement SBC?
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Motor drives and relevant safety standard

- Industrial and automation processes involve some kind of motion
- Motor drives become an integral part of these processes

Robotics

Pumps & compressors

- No such thing as “zero risk”
- No physical item has “zero” fail rate
- No human make “zero” errors
- No software design can foresee “every” operational possibility

Functional safety standards and technology help

- Protect People
- Protect Machinery
- Protect Environment
- Increase Productivity

- IEC 61800-5-2 is a product standard which specifies requirements for design and development of safety related power drive systems in terms of their functional safety considerations.

Safety Sub-Functions in IEC 61800-5-2

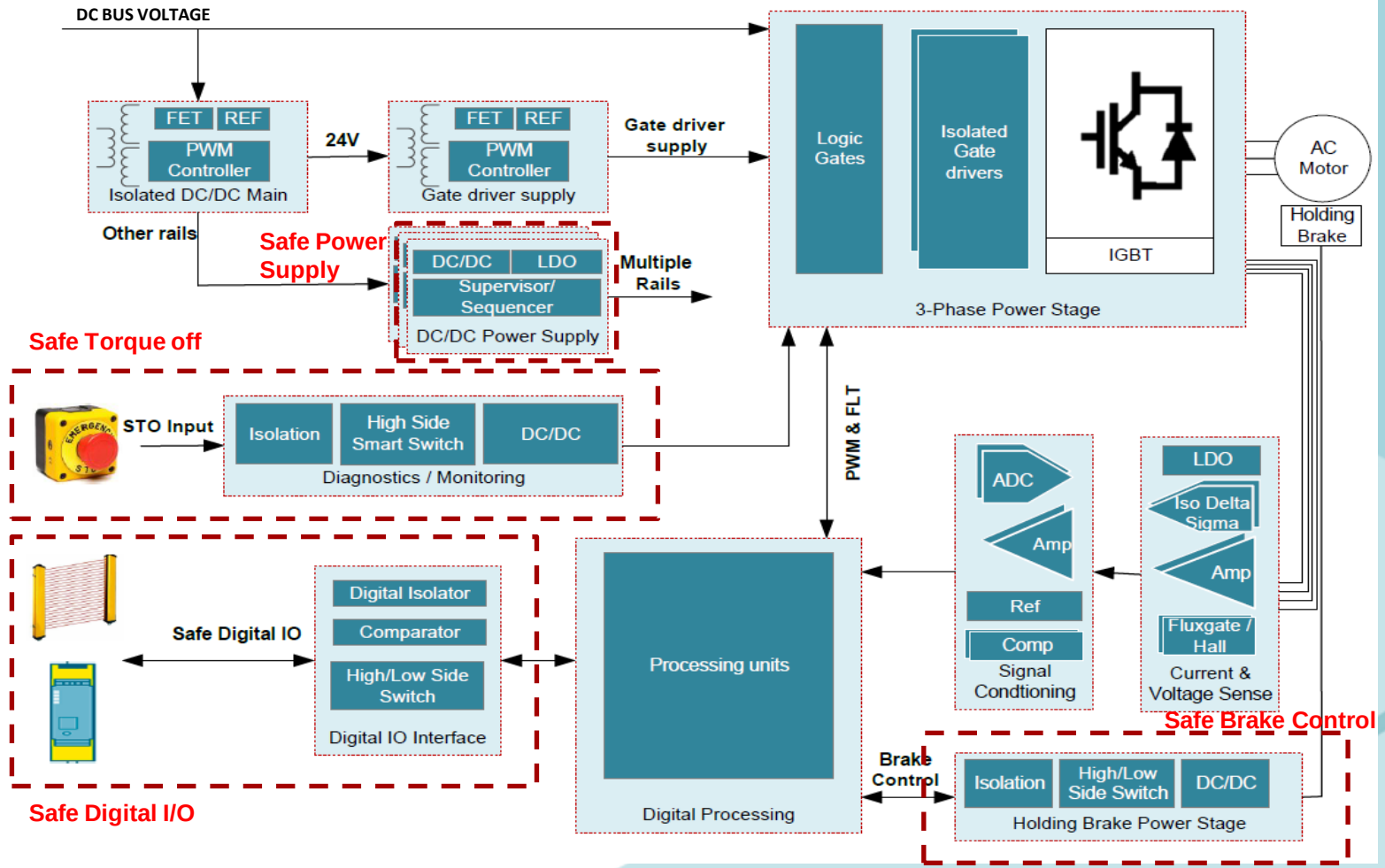
IEC 61800-5-2 classifies safety sub-functions into three broad categories:

Stop the drive in case of emergency

Drive components like a motor brake to hold the motor shaft in case motor power is lost

Stopping Functions	Monitoring Functions	Output Functions
Safe torque off (STO)	Safe operating stop (SOS)	Safe brake control (SBC)
Safe stop 1 (SS1)	Safely limited position (SLP)	
Safe stop 2 (SS2)	Safely limited acceleration (SLA)	
	Safely limited speed (SLS)	
	Safe acceleration range (SAR)	
	Safe Speed range (SSR)	
	Safely-limited torque (SLT)	
	Safe Torque Range (STR)	
	Safely-limited increment (SLI)	
	Safe Direction (SDI)	
	Safe motor temperature (SMT)	
	Safe cam (SCA)	
	Safe Speed monitor (SSM)	

Motor Drives System Block Diagram



What is Safe Torque Off (STO)?

STO Application

- In any industrial scenario, a production cell is often protected by an interlocked guard door. Operators commonly (and mistakenly) open the guard door without stopping the machine.
- STO functionality mitigates such hazardous situations and triggers an emergency stop.

Safe torque off (STO)

It is a stopping function that prevents torque-producing power from being provided to the motor.

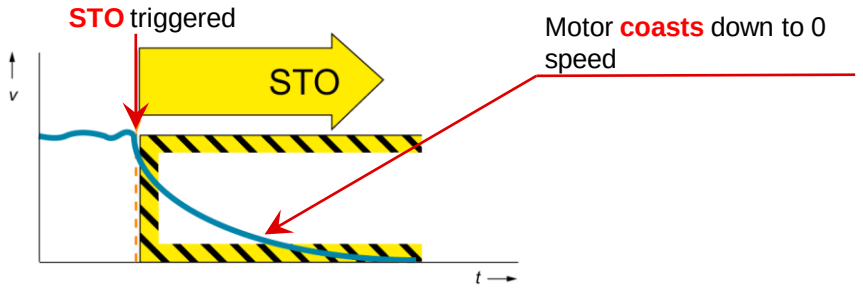
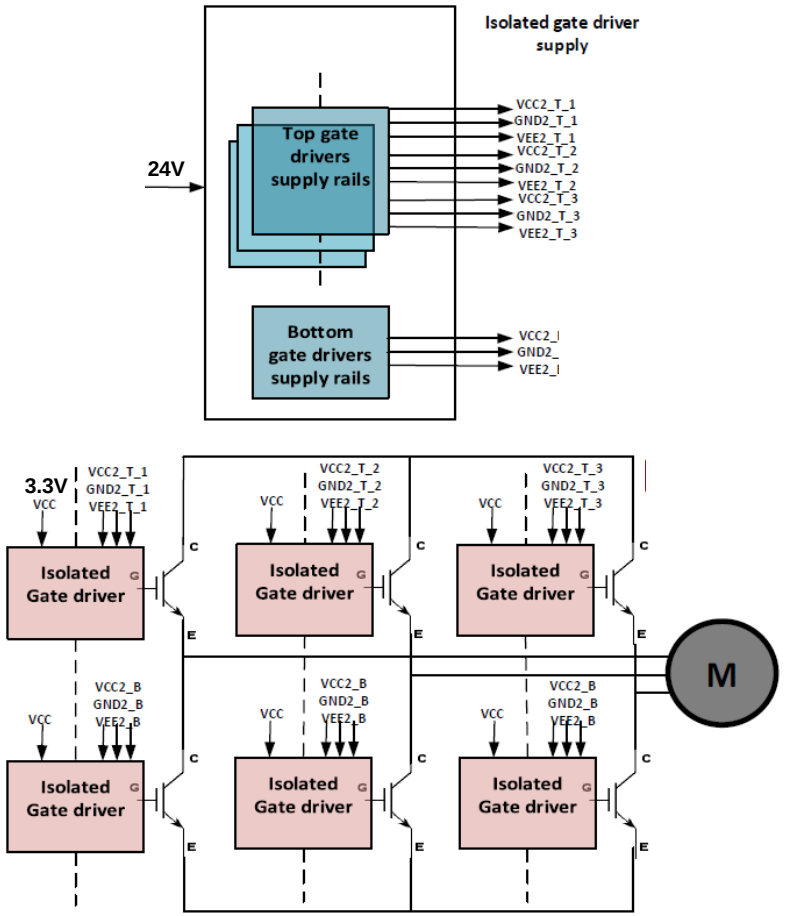
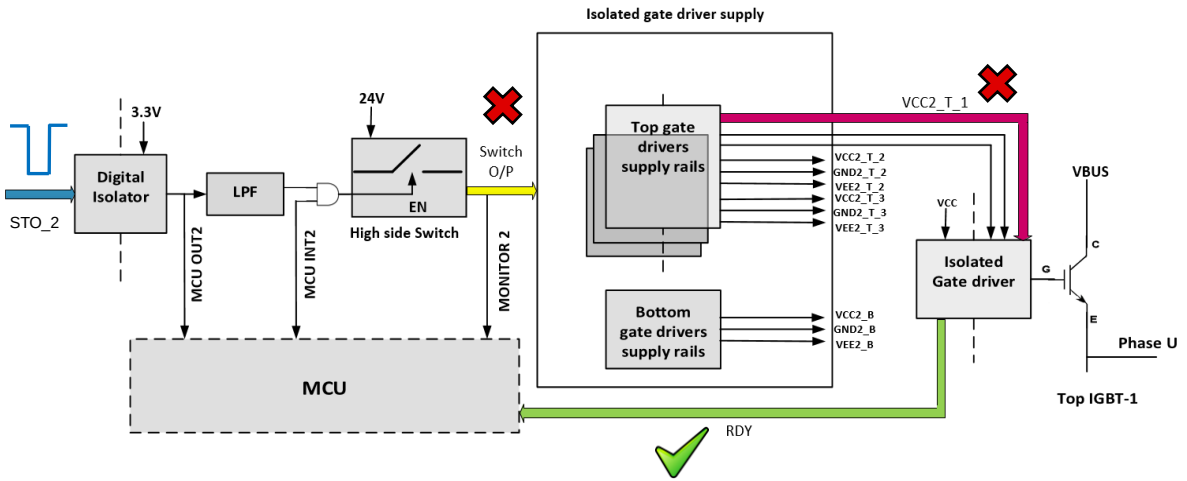


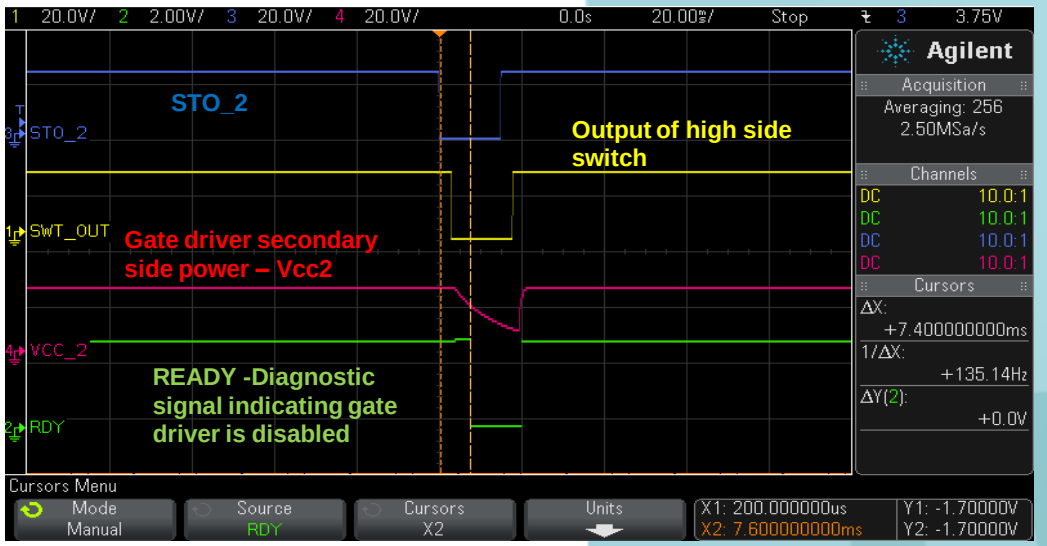
Image source: Siemens

How to implement STO?



Experimental Results – STO2





STO 2 Functionality

- **STO2 is active low input.**
- **When the signal becomes low the switch disconnects 24V to the gate driver power supply.**
- **The gate driver power supply switches off and the secondary side isolated power supply for the gate driver is cut off.**
- **This activates the UVLO of the gate driver and Ready pin turns low**
- **The IGBT switch turns off and torque producing power is removed from the motor**

What is Safe Brake Control (SBC)?

SBC Application

- Vertical or inclined axes can be a danger, in particular when disconnected from the power supply because of the risk of unintentional falling.
- Safe braking and holding system provides protection against such dangers.

SBC

The SBC output drives an external mechanical holding brake ensuring that the axis does not move

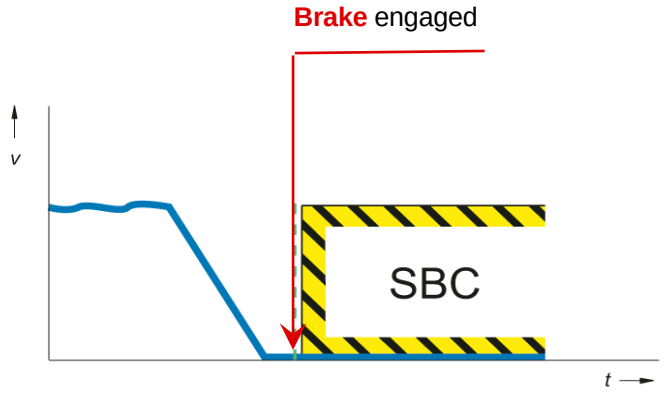
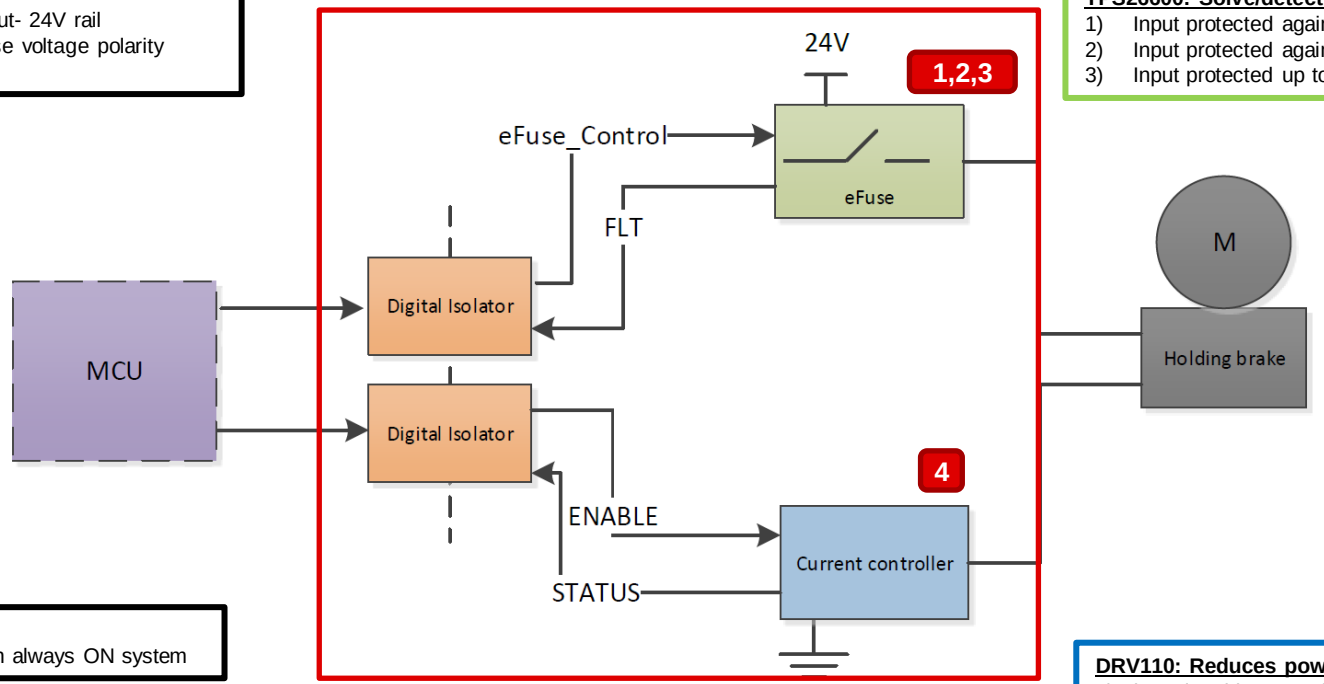


Image source: Siemens

How to implement SBC?

Input Fault conditions
1) Overvoltage on the input- 24V rail
2) Input connect w/ reverse voltage polarity
3) +/-60V DC at input

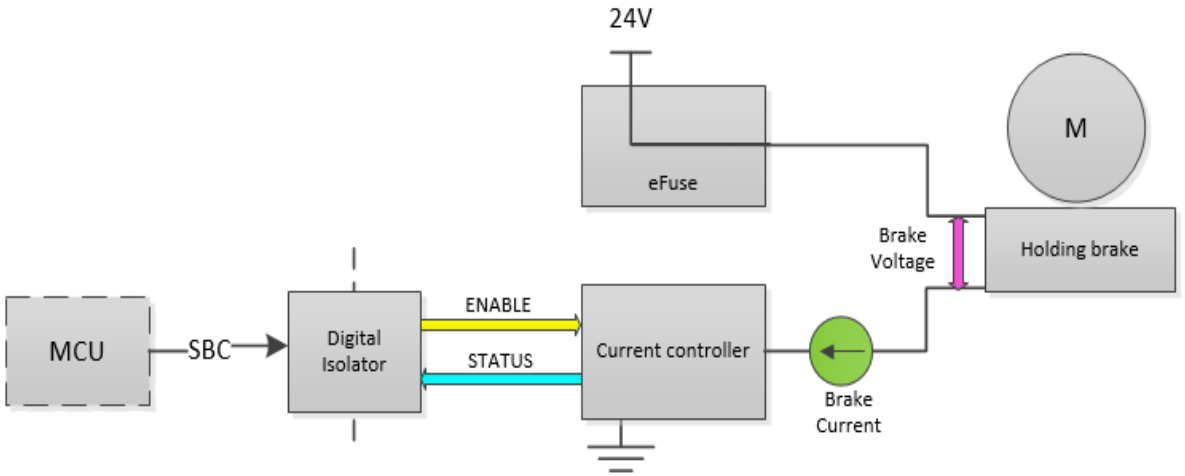


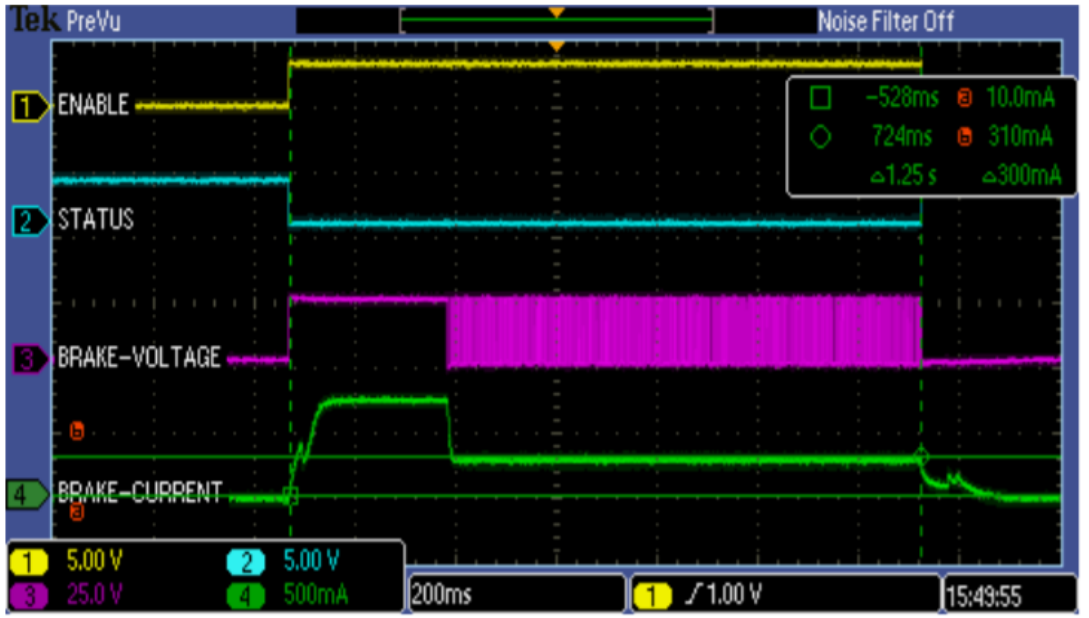
TPS26600: Solve/detect fault condition
1) Input protected against overvoltage
2) Input protected against reverse voltage polarity
3) Input protected up to +/-60V DC

Power consideration
4) Power dissipation as it is an always ON system

DRV110: Reduces power consumption
4) The solenoid current is ramped up fast, to ensure opening of the brake.
After the initial ramping, the current is reduced to a lower value to ensure correct operation.

Experimental Results- SBC





- **ENABLE signal activates the current controller**
- **STATUS signal**
- **24V is applied to the electromagnetic brake of the motor**
- **The peak current is flexibly allowed to vary according to supply voltage and internal resistance of the brake coil.**
- **The hold current is set by the designer and helps reduce excess power dissipation.**

Highlights

- Safety in drives is extremely **CRUCIAL**. All possible hazard scenarios needs to be analyzed while dealing with safety.

- This proposal implements safety functions like Safe Torque Off and Safe Brake Control

- STO is implemented through two redundant channels which are controlled independently by switches. These switches provide diagnostic coverage to detect different fault conditions.

- The implementation of SBC is highlighted using dual switches. It uses solenoid current controller to regulate peak and hold currents of the electromagnetic brake coil thereby improving efficiency. Excess brake current can cause over heating of the break coil which can trigger a false break engagement.

Thank You