

Understanding the Stop and EN954-1 Safety Categories Generating an Emergency Stop

Industrial machinery has several operating and safety standards that it must meet for avoidance of hazardous conditions and for protection of personnel. Lenze-AC Tech frequency inverters are often installed in this type of machinery and from a safety point of view, the control functions of our drives should comply with these standards.

Industrial equipment often needs to follow both the NFPA 79 (Electrical standard for Industrial Machinery) and EN 60204 (Safety of Machinery & Electrical Equipment). There are two Category types when dealing with machine safety and the means to generate an emergency stop condition: Stop and Safety.

Stop Category: The NFPA 79 and EN 60204 standards use Stop Category 0, 1, and 2.

Category 0: An uncontrolled stop by immediately removing power to the machine actuators.

Category 1: A controlled stop with power to the machine actuators available to achieve the stop then remove power once the stop has occurred.

Category 2: A controlled stop with power left available to the machine actuators.

Lenze-AC Tech frequency inverters are rated for stop category 0. From the above definition, Category 0 means that power to the motor is immediately removed (COAST TO STOP). This could only be accomplished by opening a contactor¹ between the drive and the motor to immediately remove the output voltage. However, this method of stopping is NOT recommended for Lenze-AC Tech drives.

Do not just use a contactor or disconnect switch between the drive and motor. Operating a motor contactor or disconnect between the VFD and the AC motor while the VFD is running, can cause nuisance tripping. Such devices should only be operated when the VFD is in a STOP mode. There is also the possibility of noise from the output feeding back and potentially cause other damage to the drive electronics.

If this contactor is absolutely necessary, an “early-break” auxiliary set of contacts on this device should be interlocked with the VFD’s digital input and programmed for an “External Fault” or to the Stop input so that if the device is opened while the VFD is running, it will stop the drive and consequently shut off the output power from the VFD immediately. Remember that if it is wired to the VFD’s Stop input, the stop method must be set to COAST. Category 1 involves the use of applying dynamic braking instead of just coasting to a stop. Lenze-AC Tech frequency inverter drives including the SM Vector drive cannot do this.

¹ EN60204 states the following regarding software involvement:

11.3.4 Use of safety-related functions: Programmable electronic equipment shall not be used for category 0 stop functions.

NFPA 79 requires that equipment used for safety function with a software control system must be listed as such and be tested to an appropriate standard. Lenze-AC Tech does not do this and therefore uses an output contactor and auxiliary contacts.

Safety Category: EN-954-1 (or ISO 13849)

EN-954-1 (or ISO 13849) uses the Safety Category in conjunction with safety risk and fault effects; where B is the most risk then 1, 2, 3 and 4. All require the use of “well tried” components and “well tried safety principles” with an assumption that software isn’t part of the requirements. Lenze-AC Tech PositionServo drives use Stop Category 0 and Safety Category 3. The safety stop circuit in the PositionServo relies on a software overriding mechanism that has redundant implementation (a single fault will still stop the drive). Refer to the Table 1 for a better description of the Safety categories.

Table 1: Safety Categories

Category	System Behavior	Principle
B	The occurrence of a fault can lead to the loss of the safety function.	Mainly characterized by the selection of components
1	The occurrence of a fault can lead to the loss of the safety function, but the probability of occurrence is lower than in category B.	Mainly characterized by the selection of components
2	The occurrence of a fault can lead to the loss of the safety function between the checks. The loss of the safety function is detected by the check.	Mainly characterized by the structure.
3	If the single fault occurs, the safety function is still maintained. Some, but not all faults are detected. Accumulation of undetected faults can lead to the loss of the safety function.	Mainly characterized by the structure.
4	If faults occur, the safety function is still maintained. Faults are detected in good time to prevent the loss of the safety function.	Mainly characterized by the structure.



NOTE

Lenze-AC Tech frequency inverters do not have this extra hardware emergency stop mechanism; therefore they cannot be used for Category 3 applications. Category 1 is possible but this is done strictly by using an external fault input to the drive to trip the alarm circuit.

Figure 1 illustrates the X11 terminal block inside a Lenze Compact Servo (ECS). The hardware relay completely cuts off voltage to the IGBT bridge that is controlled by an external hardware relay. No software or firmware is involved. This Category 3 Safe Standstill circuit is standard in Lenze ECS and 9400 drives. A similar EN954-1 safety circuit is available as an option in the 82V, 9300, 940 and 941 drives.

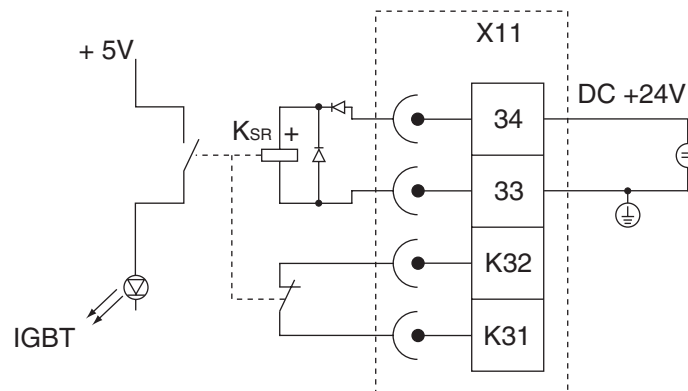


Figure 1: Lenze EN954-1 Safety Standstill Circuit