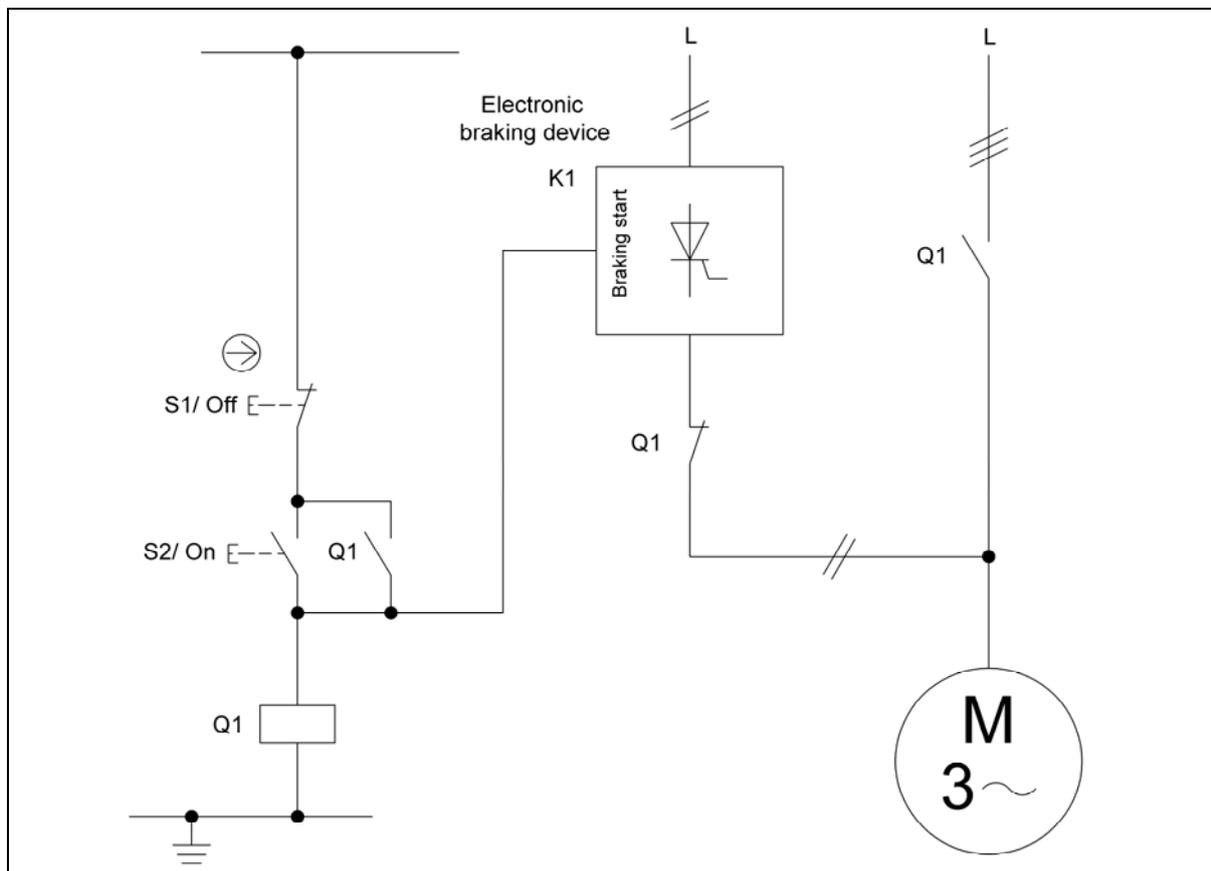




8.2.4 Stopping of woodworking machines – Category 1 – PL c (Example 4)

Figure 8.9:
Combination of electromechanical control equipment and a simple electronic braking device for the stopping of woodworking machines

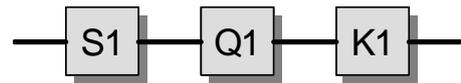


Safety function

- Actuation of the Off button leads to SS1 (safe stop 1), a controlled stopping of the motor within a maximum permissible time.

Functional description

- Stopping of the motor is initiated by actuation of the Off button S1. The motor contactor Q1 drops out and the braking function is initiated. The motor is braked by a direct current generated in braking unit K1 by a thyristor employing phase-angle control and generating a braking torque in the motor winding.
- The run-down time must not exceed a maximum value (e.g. 10 seconds). The level of braking current required for this purpose can be set by means of a potentiometer on the braking unit.



- Upon expiration of the maximum braking time, the control signal to the thyristor ceases and the current path for the braking current is interrupted. The stopping process corresponds to a Category 1 stop in accordance with EN 60204-1.
- The safety function cannot be maintained with all component failures, and is dependent upon the reliability of the components.
- No measures for fault detection are implemented.

Design features

- Basic and well-tried safety principles are observed and the requirements of Category B are met. Protective circuits (e.g. contact protection) as described in the initial paragraphs of Chapter 8 are implemented. The de-energization principle (closed-circuit current) is employed as the basic safety principle. For protection against unexpected start-up following restoration of the power supply, the control system features latching-in at Q1.
- S1 is a pushbutton with positive mode of actuation to IEC 60947-5-1, Annex K (direct opening action). S1 is therefore regarded as a well-tried component.
- Contactor Q1 is a well-tried component provided the additional conditions in accordance with Table D.4 of EN ISO 13849-2 are observed.
- The braking unit K1 is designed exclusively from simple electronic components such as transistors, capacitors, diodes, resistors and thyristors, which are regarded as well-tried components. Fault-free performance of the safety-related braking function is characterized by the selection of the components. Internal measures for fault detection are not implemented. No complex electronic components (e.g. microprocessors) are employed that are not considered to be in accordance with EN ISO 13849-1, Section 6.2.4 as being equivalent to well-tried components.

Application

- On woodworking machines or similar machines on which unbraked stopping would result in an impermissibly long run-down of the hazardous tool movements. The control system must be designed such that at least PL b is attained (GS-HO-01 test principles for woodworking machines).

Calculation of the probability of failure

- S1 is a pushbutton with positive mode of actuation to IEC 60947-5-1, Annex K (direct opening action). If a pushbutton of this type is employed as a control device, fault exclusion is possible for failure of the electrical contact to open, including the mechanical components within the push-button.
- $MTTF_d$: a B_{10d} value of 2,000,000 switching operations [S] is assumed at nominal load for the contactor Q1. At 300 working days, 8 working hours and a cycle time of 2 minutes, n_{op} is 72,000 cycles per year and the $MTTF_d$ is



277 years. The $MTTF_d$ for the braking unit K1 was determined by means of the parts count method. The parts information from the parts list and the values from the SN 29500 database [36] produce an $MTTF_d$ of 518 years [D]. The combination of Q1 and K1 results in an $MTTF_d$ of 180 years for the channel, which is capped to 100 years (“high”).

- DC_{avg} and measures against common cause failures are not relevant in Category 1.
- The electromechanical control system corresponds to Category 1 with a high $MTTF_d$ (100 years). This results in an average probability of dangerous failure of 1.14×10^{-6} per hour. This corresponds to PL c. The PL_r of b is therefore surpassed.

More detailed reference

- Grundsätze für die Prüfung und Zertifizierung von Holzbearbeitungsmaschinen GS-HO-01 (12/2007).
www.dguv.de, Webcode d14898

Figure 8.10:
Determining of the PL by means of SISTEMA

SISTEMA - Safety Integrity Software Tool for the Evaluation of Machine Applications

File Edit View Help

New Open... Save Close Project Library Report Help Wizard-Help

Projects

- PR 04 Stopping of woodworking machines
 - SF SS1 Safe Stop 1
 - SB Control system
 - CH Channel 1
 - BL Off button S1
 - EL Off button S1
 - BL Motor contactor Q1
 - EL Motor contactor Q1
 - BL Braking unit K1
 - CH Channel 2
 - TE Test channel

SS1 Safe Stop 1

| | |
|-----------|---------|
| PL_r | b |
| PL | c |
| PFH [1/h] | 1,14E-6 |

Control system

| | |
|----------------|--------------|
| PL | c |
| PFH [1/h] | 1,14E-6 |
| Cat. | 1 |
| $MTTF_d$ [a] | 100 (High) |
| DC_{avg} [%] | not relevant |
| CCF | not relevant |

Clipboard: X

Subsystem | BGIA

Documentation PL Category MTTFd Blocks

Channel 1

| Name | DC [%] | MTTFd [a] |
|-----------------------|--------------|------------|
| BL Off button S1 | not relevant | FE (-) |
| BL Motor contactor Q1 | not relevant | 277,78 (-) |
| BL Braking unit K1 | not relevant | 518,89 (-) |

Switch content of channels

Channel 2

| Name | DC [%] | MTTFd [a] |
|------|--------|-----------|
|------|--------|-----------|