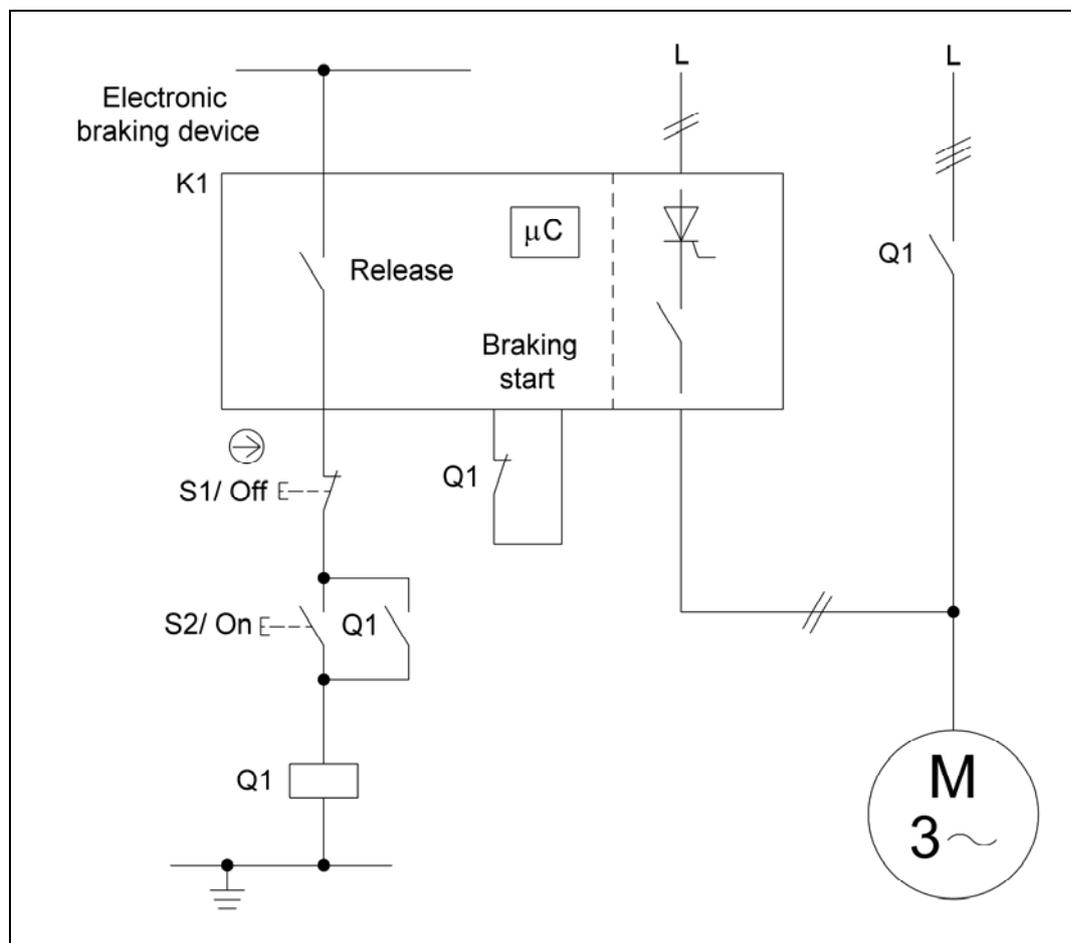


## 8.2.8 Stopping of woodworking machines – Category 1 – PL c (Example 8)

Figure 8.15:  
Combination of electromechanical control equipment and a programmable 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 thyristors employing phase-angle control, and which is connected to the motor winding by internal relays.
- The run-down time must not exceed a maximum value (e.g. 10 seconds). The desired run-down time and any other required parameters (e.g. braking current, threshold for zero-speed detection) can be set on the braking device.



- Once the motor is stationary or upon expiration of the maximum braking time, the braking device switches off the braking current and disconnects the motor again from the supply. 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.
- Fault-free performance of the braking function is monitored regularly by the braking device K1. Should a fault be detected, e.g. exceeding of the maximum permissible braking time, a release contact in the device prevents the motor from restarting. Measures for fault detection are not implemented in S1 or Q1.

### 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 direct 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 device K1, which is controlled by a microcontroller, meets all requirements for Category 2 and PL c. The safety-related functions are tested at regular intervals. The program sequence timing of the microcontroller is monitored by a separate watchdog.

### 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 Performance Level b is attained (GS-HO-01 “Test principles for woodworking machines”).

### Calculation of the probability of failure

- Since a standard module is employed for the electronic braking device K1, its probability of failure ( $5.28 \times 10^{-7}$  per hour [M]) is added following calculation by SISTEMA. For the remaining part of the control system, the probability of failure is calculated below.
- S1 is a pushbutton with direct 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 for the mechanical components within the push-button.



- $MTTF_d$ : a  $B_{10d}$  value of 2,000,000 switching operations [S] at nominal load is assumed 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. This is also the  $MTTF_d$  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, consisting of S1 and Q1, corresponds to Category 1 with a high  $MTTF_d$  (100 years). This results in an average probability of dangerous failure of  $1.14 \times 10^{-6}$  per hour. Following addition of the subsystem K1, the average probability of dangerous failure is  $1.67 \times 10^{-6}$  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](http://www.dguv.de), Webcode d14898

Figure 8.16:  
Determining of the PL by means of SISTEMA