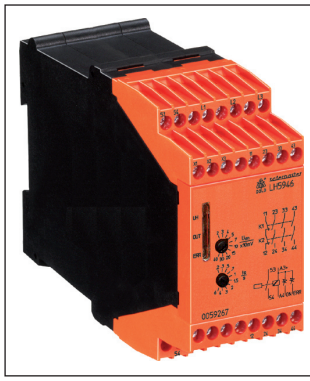
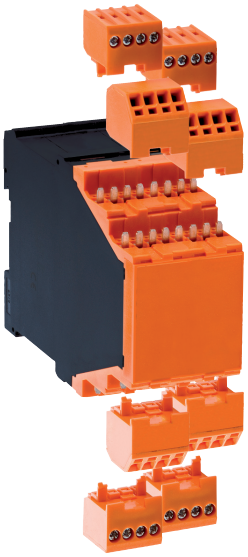
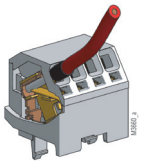
Standstill monitor LH 5946
safemaster



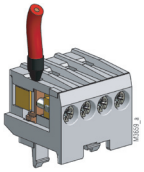
Options with plugin terminal blocks



LH 5946 P_



Terminal block
with cage clamp terminals
(PC / plugin cageclamp)

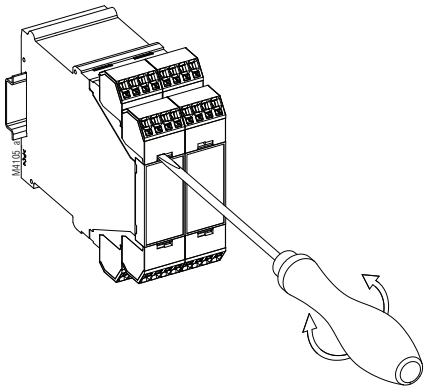


Terminal block
with screw terminals
(PS / plugin screw)

Notes

Removing the plugin terminal blocks

1. The unit has to be disconnected.
2. Insert a screwdriver in the side recess of the front plate.
3. Turn the screwdriver to the right and left.
4. Please note that the terminal blocks have to be mounted on the belonging plug in terminations.



- TÜV-Approval
  - Safety Integrity Level (SIL) 3 to IEC EN 61508
  - SIL Claimed Level (SIL CL) 3 to EN 62061
  - Performance Level (PL) e to DIN EN ISO 13849-1
  - Safety Category (SK) 4 to EN 954-1
- Safe standstill detection on 3- and single-phase motors
- no external sensors necessary
- independent of direction
- broken wire detection
- positive guided safety contacts:
  3 NO contacts, 1 NC contact for AC 250 V
- 2 semiconductor monitoring outputs
- 1 monitoring output (NO contact)
- adjustable voltage setting
- adjustable standstill time delay
- LED indicators for standstill, event of line breakage and operation voltage
- suitable for operation with inverters
- Width 45 mm

Approval and marking

Functional Safety Type Approved
TÜVRheinland FS
c UL us LISTED Canada / USA
CE

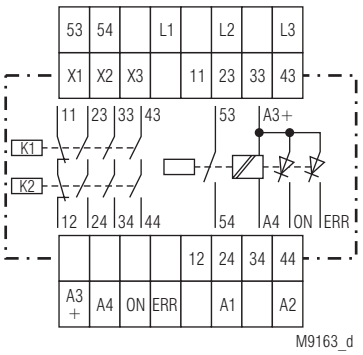
Applications

Safe standstill detection on 3- and single-phase motors, e.g. to enable gate interlocks on machine tools or to activate hold in brakes

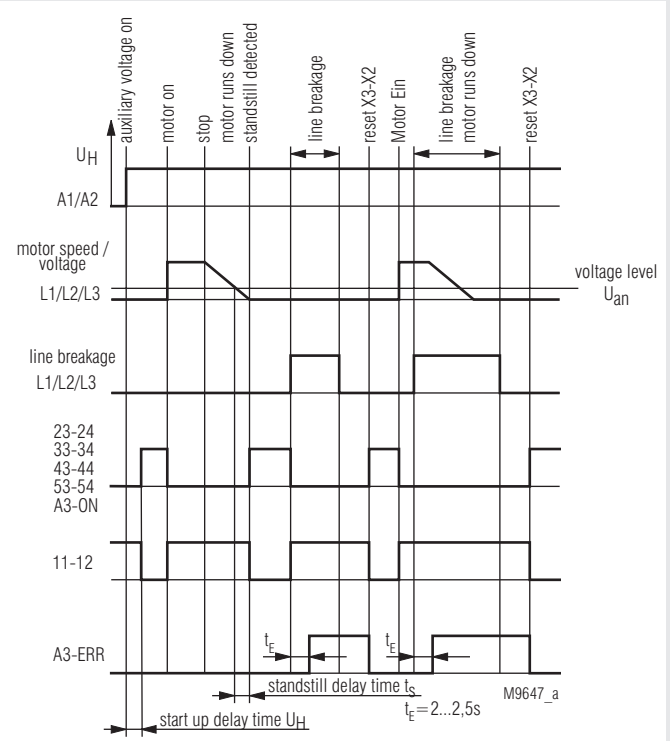
Function

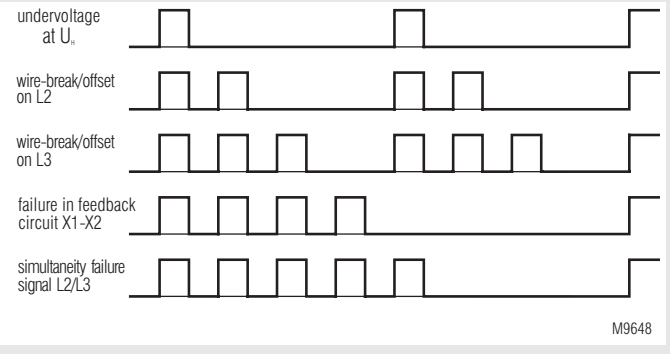
The LH 5946 is connected to the motor terminals and measures the induced back emf voltage of a freewheeling motor. 2 redundant measuring channels are used (L2-L1 and L3 L1). If the back emf voltage drops to 0 simultaneously in both channels this indicates standstill and the output relay is energised.
To adopt the unit to all different types of motors and applications the voltage threshold indicating standstill on LH 5946 is adjustable. Also the time delay between detection and energisation of the relay is adjustable (standstill time ts).
In addition the unit detects broken wire on the measuring inputs L1 / L2 / L3. If broken wire is detected the output relays goes into safe state (as with running motor). This state is stored and can be reset by bridging terminals X3-X2.
The input signals of both channels are permanently compared. If the signals are different for more then 2.5 sec a simultaneity failure is detected. This failure resets when both input channels receive simultaneous signals with a level, above the voltage threshold and hysteresis.
To the terminals X1-X2 the feedback circuit of external contactors (used for contact reinforcement) is connected (NC contact). If no feedback circuit is required, these terminals must be linked. Open terminals will cause a failure message.

Circuit diagram



Function diagramm





Flashing codes of the LED „ERR“ in sequence of priority

Notes

The terminals X1 - X2 - X3 has no galvanic separation to the measuring ciruit L1 - L2 - L3. They must be controlled with volt free contacts.

Indicators

green-red LED „UH“:	green on, when operation red on, with internal error
yellow-green LED „OUT“:	yellow on, at EMK > U_{an} flashes green at time progression of t_s permanent on, when output contacts are enable
red LED „ERR“:	flashes at error in measuring and feedback circuit and low auxiliary voltage U_H (see flashing codes)

Technical Data

Input (L1 - L2 - L3)

Measuring-/Motor voltage:	max. AC 690 V (UL: max. AC 600 V)
Input resistance:	500 kΩ
Response value U_{an}:	20 mV ... 400 mV, adjustable or 0.2 ... 4 V, adjustable
Hysteresis (for detection of running motor):	100 %
Release delay for detection of running motor:	< 100 ms
Standstill time delay t_s:	0.2 ... 6 s adjustable
Auxiliary voltage U_H (A1 - A2):	AC 115 V, AC 230 V, AC 400 V, DC 24 V
Recommended fusing:	2 A
Voltage range	
AC:	0.8 ... 1.1 U_N
DC:	0.9 ... 1.2 U_N
Nominal consumption:	5 VA, 3 W
Nominal frequency (AC):	50 / 60 Hz
Frequency range (AC):	45 ... 65 Hz
max. residual ripple (DC):	10 %
Start up delay when connecting U_H at standstill:	approx. 0.6 s + adjustable t_s

Output

Contacts (saftey contacts)		
LH 5946.48:	3 NO contacts, 1 NC contact	
Contact type:	relay, positive guide	
Nominal output voltage:	AC 250 V	
Thermal current I_{th}:	5 A (bis 40°C)	
Quadratic total current:	see derating curve	
Switching capacity		
to AC 15		
NO contact:	AC 3 A / 230 V	IEC/EN 60 947-5-1
NC contact	AC 2 A / 230 V	IEC/EN 60 947-5-1
to DC 13:	DC 2 A / 24 V	IEC/EN 60 947-5-1
Fusing of the safety contacts:	max. fuse rating 4AgL line circuit breaker C6A	
Max. operating frequency:	1200 / h	
Contact service life		
at AC 230 V / 5 A cosφ = 0.5:	≥ 2 x 10^5 switching cycles	
Mechanical life:	≥ 50 x 10^6 switching cycles	
Semiconductor monitoring output:	100 mA DC 24 V, plus switching, galvanic separation; supply via A3+ / A4 for output; „ON“ and „ERR“	
NO monitoring contact:	3 A AC 250 V (closed when enabled)	

General Data

Nominal operating mode:	continuous operation
Temperature range	
operation:	- 25 ... + 60°C (+ 40°C with max. contact current, see Derating)
storage:	- 40 ... + 75°C
Clearance and creepage distance	
rated impuls voltage / pollution degree:	IEC 60 664-1
Contacts 11/12, 23/24, 33/34, 43/44 against all others:	6 kV / 2
Contacts 11/12, 23/24, 33/34, 43/44 against each others:	4 kV / 2
Indicator contact 53/54 against all others:	4 kV / 2
Semiconductor outputs A3+/ ON / ERR / A4 against all others:	6 kV / 2

Technical Data

Auxiliary voltage A1 / A2 against all others		
at auxiliary voltage AC:	6 kV / 2	
at auxiliary voltage DC:	4 kV / 2	
Control terminal X1 / X2 / X3:	no galvanic separation to L1 / L2 / L3	
EMC		
Electrostatic discharge (ESD):	8 kV (air)	IEC/EN 61 000-4-2
HF irradiation:	20 V/m	IEC/EN 61 000-4-3
Fast transients:	2 kV	IEC/EN 61 000-4-4
surge voltage between measuring input L1 / L2 / L3: wires for power supply A1 / A2	2 kV	IEC/EN 61 000-4-5
at AC - U_H:	2 kV	
at DC 24 V:	1 kV	IEC/EN 61 000-4-5
HF-wire guided:	10 V	IEC/EN 61 000-4-6
Interference suppression:	limit value class B	EN 55 011
Degree of protection		
Housing:	IP 40	IEC/EN 60 529
Terminals:	IP 20	IEC/EN 60 529
Enclosure:	thermoplastic with VO behaviour according to UL subject 94	
Vibration resistance:	amplitude 0.35 mm frequency 10 ... 55 Hz,	IEC/EN 60 068-2-6
Climate resistance:	25 / 060 / 04	IEC/EN 60 068-1
Terminal designation:	EN 50 005	
Wire connection		DIN 46 228-1/-2/-3/-4
UL detail:	60°C Copper conductors only	
Screw terminals (integrated):	1 x 4 mm² solid or 1 x 2.5 mm² stranded ferruled or 2 x 1.5 mm² stranded ferruled or 2 x 2.5 mm² solid	
UL detail:	1 x AWG 20-12 Sol/Str Torque 0.8 Nm or 2 x AWG 20-14 Sol/Str Torque 0.8 Nm	
Insulation of wires or sleeve length:	8 mm	
Plugin with screw terminals		
max. cross section for connection:	1 x 2.5 mm² solid or 1 x 2.5 mm² stranded ferruled	
UL detail:	AWG 20-14 Sol Torque 0.8 Nm or AWG 20-18 Str Torque 0.8 Nm	
Insulation of wires or sleeve length:	8 mm	
Plugin with cage clamp terminals		
max. cross section for connection:	1 x 4 mm² solid or 1 x 2.5 mm² stranded ferruled	
min. cross section for connection:	0.5 mm²	
UL detail:	AWG 20-12 Sol/Str	
Insulation of wires or sleeve length:	12 $^{\pm 0.5}$ mm	
Wire fixing:	Plus-minus terminal screws M 3.5 box terminals with wire protection or cage clamp terminals	
Mounting:	DIN-rail	IEC/EN 60 715
Weight:	approx. 400 g	

Dimensions

Width x height x depth:	45 x 90 x 121 mm

Safety related data

PFD_{AVG}:	$14.0 \cdot 10^{-4}$
PFH_D:	$4.10 \cdot 10^{-10}$ 1/h
T_1:	20 Years
$MTTF_D$:	> 30 Years (heigh)
CFF:	> 65 points
DC_{AVG}:	> 99 % (heigh)

Standard type

LH 5946.48/61 DC 24 V

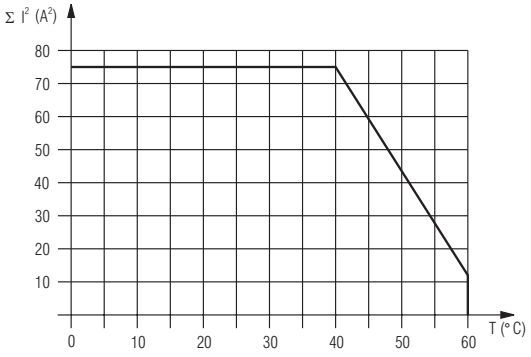
Article number:	0059266
• Safety output:	3 NO contacts, 1 NC contact
• Auxiliary voltage U_H:	DC 24 V
• Response value U_{an}:	20 ... 400 mV
• Standstill time t_s:	0.2 ... 6 s
• 1 semiconductor and 1 NO contact for indicator output	
• 1 semiconductor for fault indicator output	
• Width:	45 mm

Order example

LH 5946.48 _ _ 61 DC 24 V 20 ... 400 mV 0.2 ... 6 s

- Standstill time t_s
- Response value U_{an}
- Auxiliary voltage U_H
- UL-approval
- Type of terminals
  without indication: terminal blocks fixed, with screw terminals
  PC (plugin cage clamp) pluggable terminal blocks with cage clamp terminals
  PS (plugin screw) pluggable terminal blocks with screw terminals
- Type

Characteristic



Quadratic total current

$\Sigma = I_1^2 + I_2^2 + I_3^2$

I_1, I_2, I_3 - current in contact paths

max. permitted current up to 40°C on 3 contact paths = 5A

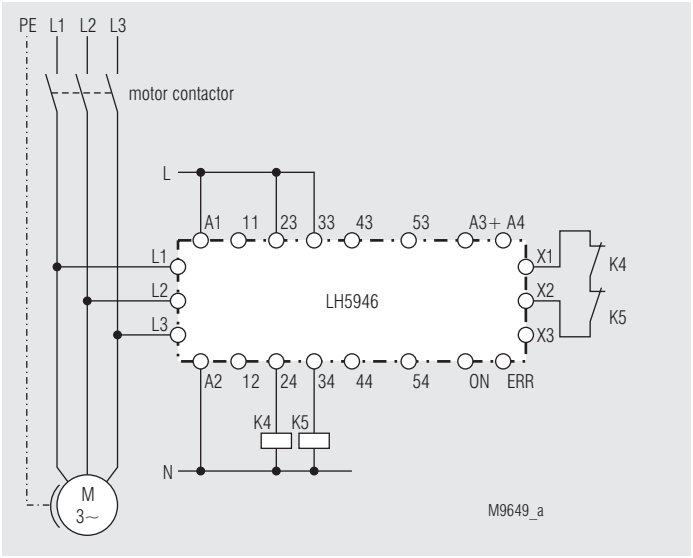
($5^2+5^2+5^2 = 75A^2$)

max. permitted current up to 60°C on 3 contact paths = 2A

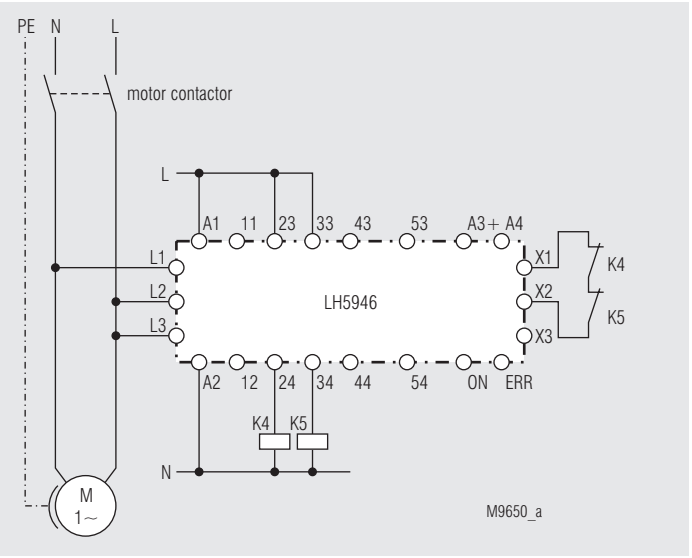
($2^2+2^2+2^2 = 12A^2$)

Derating curve for contact currents of safety contacts

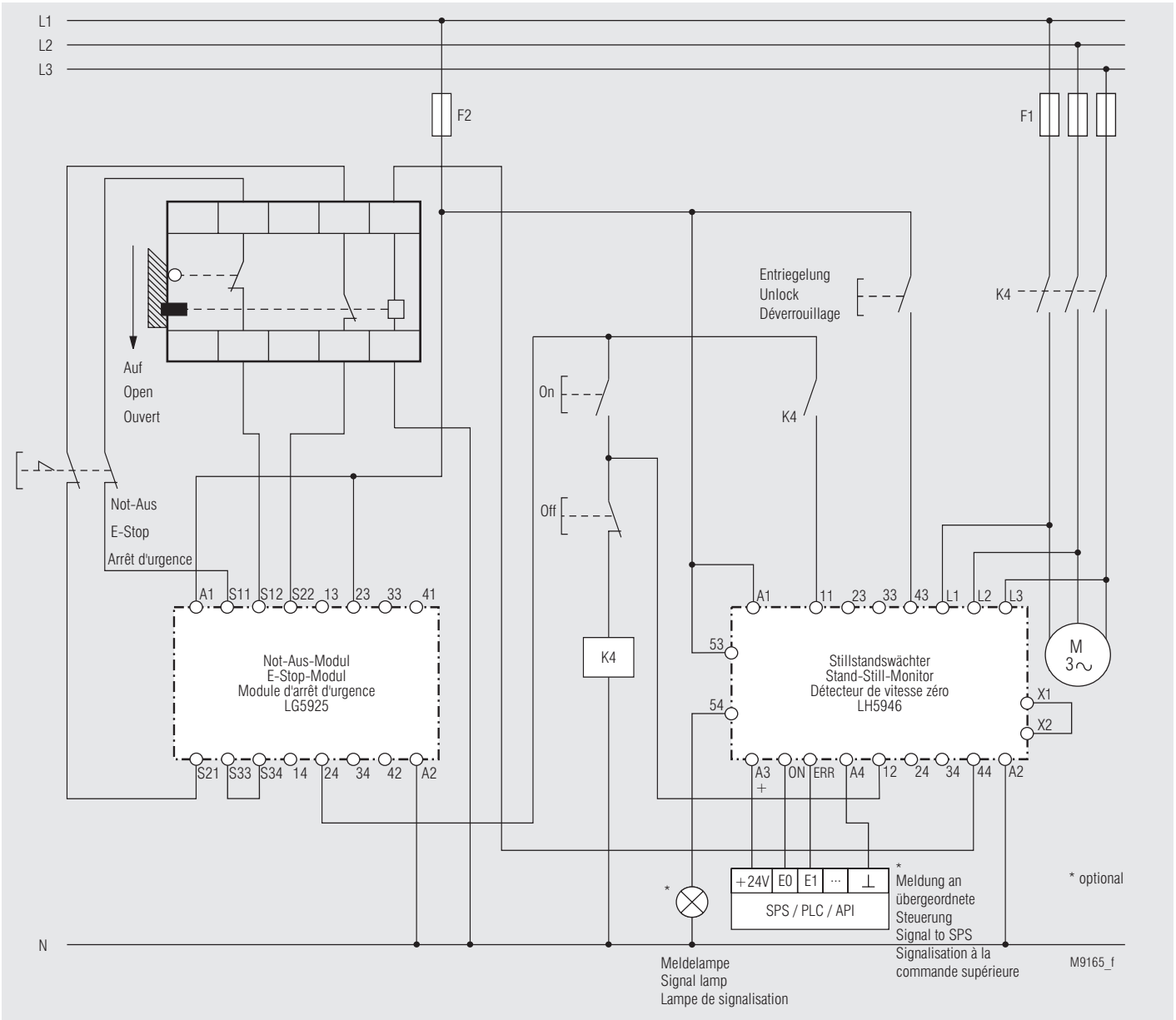
Application example



With 3-phase motor

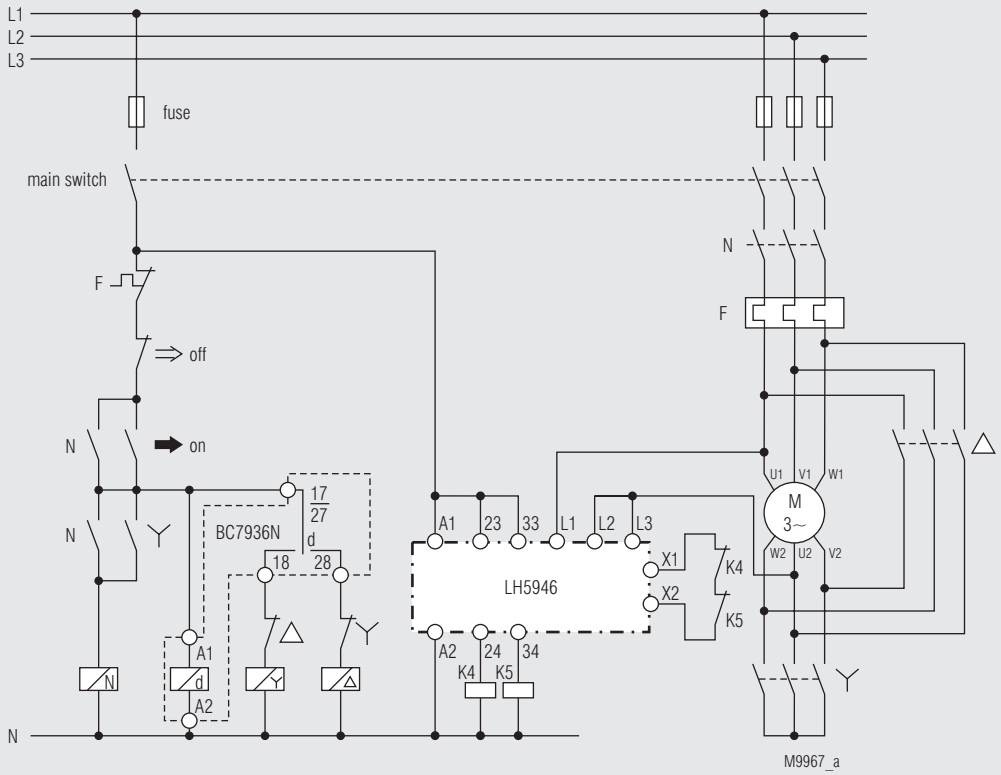


With single-phase motor



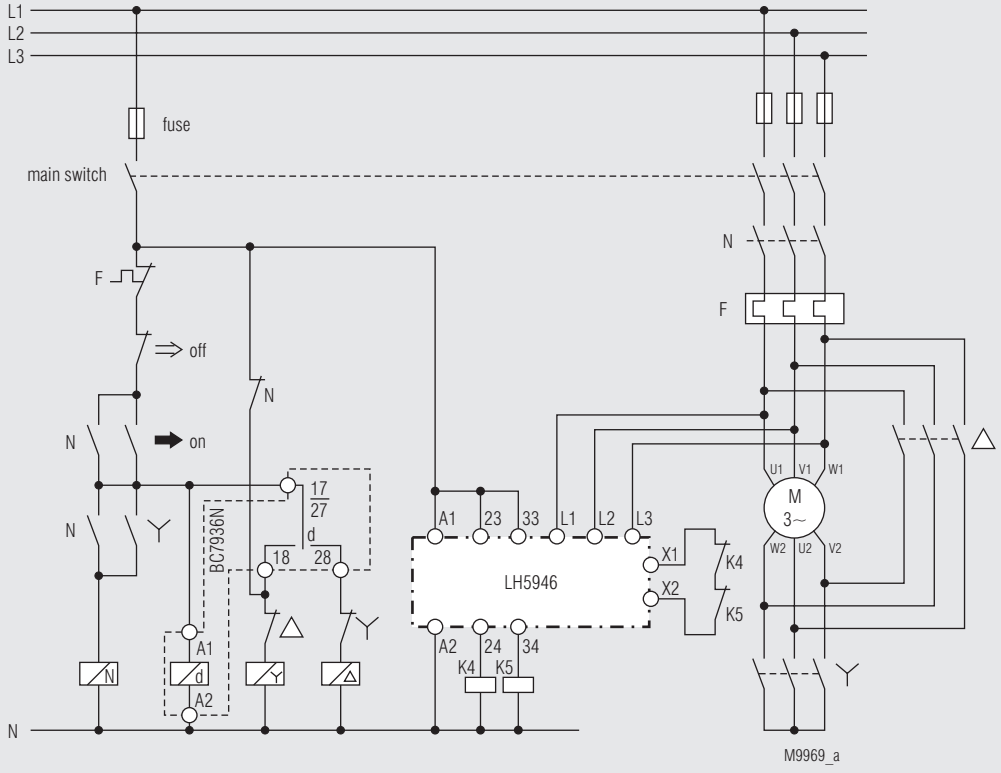
Typical connection combination with E-Stop

Application example



d = star delta timer
N = mains contactor
Y = star-contactor
△ = triangle contactor

Typical connection combination with star delta timer



d = star delta timer
N = mains contactor
Y = star-contactor
△ = triangle contactor

With "3-phase" connection of LH5946 the star contactor (Y) has to be closed after the motor is switched off to detect standstill. If this is not the case the failure signal "broken wire" blocks the output contacts in off posisition.

Typical connection combination with star delta timer

Safety remarks

- Installation and setup of the LH 5946 must only be carried out by well trained staff, with knowledge about all relevant standards for safety, accident avoidance and control circuits. This manual must be read and understood before installation and setup.

- The LH 5946 is suitable to operate as a part in safety circuits of a plant or machine. Usually also other components are part of these circuits. It is the liability of the builder of the plant or machine to guarantee the complete safety function by selecting the correct components, wiring and operation.
  Also the correct tripping point and time delay setting of LH5946 suitable for the application is in the liability of the user.

- When stocking , transporting and operating the LH 5946 the conditions stated in the technical data must be observed. Defective units must not be operated. Opening a device or making unauthorised changes can influence the safety function and finish warranty.

- When switching capacitive or inductive load over the output contacts appropriate protection should be provided in order not to overload the contacts. In addition a fuse must be provided to protect the contacts against welding (see technical data).

Application area

The LH 5946 is used for standstill detection on motors without sensors.

Standstill detection in safety circuits according to IEC/EN 60204 in machines with dangerous parts or tools to enable protection systems. To avoid damage if unexpected start can cause collision.
Motor control when reversing direction.

Safety category of the unit
SIL 3 according to IEC 61508
Cat. 4 according to DIN EN 954-1
Performance level e according to EN ISO 13849
SIL 3 according to IEC 61511
SIL CL 3 according to EN 62061

Function

The LH 5946 can be used for standstill detection on all 3-phase, single phase and DC motors, that generate a voltage caused by remanence when freewheeling. As the voltage level Uan for standstill monitoring and the time delay ts, after detection of standstill until the safety relays are switched on, are adjustable, the function can be adopted to different
motors and applications.

Terminals and settings

L1 - L2 - L3:	connection to monitored motor
11 - 12:	safety contacts (NO)
23 - 24, 33 - 34, 43 - 44:	safety contacts (NC)
53 - 54:	monitoring contact (NO)
X1 - X2:	connection of feedback circuit (for external contactors)
X2 - X3:	manual reset for external faults
A1 - A2:	auxiliary supply (U_H)
A3(+) - A4:	supply for semiconductor outputs
ON:	semiconductor output indicates state of safety contacts
ERR:	semiconductor output indicates failures
Poti „U_{an}“:	adjustment of voltage level for standstill detection
Poti „t_s“:	adjustment of time delay before activation of safety contacts

Attention: The outputs 53-54, ON and ERR are only monitoring outputs and must not be used in safety circuits!

Function

Basic function of LH 5946

The auxiliary voltage is connected to the terminals A1-A2; the LED „UH“ lights up green. On undervoltage or missing auxiliary supply the safety outputs are disabled.
If semiconductor monitoring outputs are used, their supply voltage must be connected to A3(+)-A4.

A motor connected to the terminals L1-L2-L3 of the LH 5946 generates a voltage when running down (motor is switched off). The voltage is proportional to the speed and caused by residual magnetism (remanence).
This voltage is measured redundant on 2 input channels via the terminals L2 and L3 with L1 as common reference.

If the voltage drops on both channels below the adjusted value U_{an}, the unit detects standstill. When the terminals X1-X2 of the feedback circuit are bridged and the time delay ts is finished, the safety contacts 23-24, 33-34 and 43-44 close while contact 11-12 opens. All 4 contact paths have 2 positive guided contacts of 2 safety relays wired in series.

At the same time the monitoring relay energises (53-54 closes), the semiconductor output „ON“ is switched on and the LED „OUT“ lights green. During time delay ts this LED flashes.

If the voltage measured on terminals L1-L2-L3 of LH 5946 rises over the adjusted value plus hysteresis in at least one channel (the motor is switched on or the shaft turns mechanically), the positive guided output contacts are switched off immediately (contacts 23-24, 33-34 and 43-44 open while contact 11-12 closes). The monitoring relay de-energises (53-54 opened), the semiconductor output „ON“ goes off and the LED „OUT“ lights yellow (= U_{an} over adjusted value).

Feedback circuit X1 - X2

If the safety contacts control external contactors/components (e.g. to re-enforce or multiply the contacts) the safety function of them must be monitored.
This is done with the feed back circuit (terminals X1-X2) to which the NC contacts of the contactors/components must be connected. (see also wiring diagrams).

The LH 5946 will only enable its safety output if the feedback loop X1-X2 is closed while standstill is detected, i.e. the external contactors/components are in initial state (NC contacts are closed).

The feedback circuit X1-X2 must be closed as long as the safety outputs (because of running motor or external failure) are not enabled. If not the failure „feedback circuit“ is indicated.

If the feedback circuit is not used, the terminals X1-X2 must be bridged.

Failure monitoring

The LH 5946 includes a number of facilities to to detect failures that could influence the safety function of the module. The failure check is carried out on power up of the unit and in cycles during normal operation. If a failure occurs the output relays switch off. The failure state is indicated with the LEDs „ERR“ and „UH“ and the semiconductor output „ERR“ switches on.
With safety relevant failures the unit differentiates between external failures (broken wire / offset, simultaneity failure, feedback circuit failure) and internal failures.
Broken wire / offset failures and feedback circuit failures can be stored or automatic reset after removing the fault. (see chapter failure storing).

Function

Broken wire / offset

The connection wires between LH 5946 and motor are continuously monitored for broken wire and on a DC-voltage offset higher then U_{an}. In the case of a broken wire or offset failure the output relays are switched off immediately and the LED „OUT“ lights yellow. In addition a failure signal comes up with delay (on broken wire after 2 s on offset failure after 8 s): the semiconductor output „ERR“ switches on and the LED „ERR“ flashes with failure code 2 or 3 depending on the failure located either between L1-L2 or L1-L3.

Simultaneity of the measuring signals

As additional safety feature the 2 input signals (L2 and L3) are compared continuously. This allows to detect also internal failures in one measuring channel.

If the signals are different for at least 2.5 s (one channel $>U_{an}$ the other $<U_{an}$) simultaneity failure is detected. The semiconductor output „ERR“ is switched on and the LED „ERR“ flashes with failure code 5.

If the measured signals return to the same level $<U_{an}$ the error remains stored and the outputs are disabled.

The simultaneity failure is only reset when both channels return to $> U_{an}$. If after that both channels drop below the setting value, get $< U_{an}$ the out relays will switch on.

Failure in feedback circuit X1-X2

As already mentioned the failure code „feedback circuit“ occurs when the outputs are disabled and there is no connection between terminal X1-X2. The semiconductor output „ERR“ is switched on and the LED „ERR“ flashes with failure code 4.
Also when both input signals drop now to $<U_{an}$ and besides the open feedback loop no other failures are present the feedback circuit failure remains active and the outputs remain disabled.
If the feedback circuit is now closed and the unit is on auto reset for external failures (see failure storing) the output relays are enable and switch on.

Internal device failure

Internal failures are always stored, independent of the reset input X3 and cause the output relays immediately to switch off, the semiconductor output „ERR“ to switch on and the LED „UH“ to change it’s colour from green to red.

Examples for internal failures:
- Failure on safety relays e.g. welded output contacts
- Internal failures on measuring channels and measuring circuits
- Internal failures on control circuits for the safety relays
- failures on setting potentiometers for U_{an} and t_s
- Undervoltage failure (LED „ERR“ flashes with failure code 1)

Failure indication with flash code of LED „ERR“

The flash codes indicate failures caused externally (see diagram on first page).
A series of flash pulses 1-5 followed by a slightly longer space is displayed. The flash code indicates the type of failure. If several failures are present at the same time only the failure with the highest priority (lowest flash code) is shown. When this failure is removed the other existing failures are displayed in the same way according to their priority.

Failure storing / reset (terminals X2-X3)

With the external failures broken wire/offset and feedback circuit the operator can choose between manual and automatic reset after the failure is removed.

X2-X3 open:	manual reset
X2-X3 closed:	automatic reset

Function

Attention

The a.m. storing function of the external failures broken wire /offset, and feedback circuit is not a safety function. I.e. in respect to safety aspects it can not be regarded as guaranteed. The reset for these failures must be therefore regarded as auto reset after removing the faults.

Internal device failures that could occur in seldom cases (e.g. caused by temporary interference) can be reset by switching the supply voltage off and on. If a reset is not possible also if the voltage is applied correctly, the device could be defective and should be sent back to the manufacturer for examination or repair.

Connection of LH 5946

The LH 5946 has to be connected according to connection examples or in a similar way. The connection of DC- motors is made as with single phase AC-motors.

L1 - L2 - L3

The measuring wires L1-L2-L3 have to be connected directly to the windings of the monitored motor (not via transformers) in order to provide a correct broken wire detection for the connection wires and motor windings.
The motor windings must not be disconnected from the measuring wires by motor contactors, because broken wire detection is activated and standstill monitoring is disabled.

Interference to the measuring wires should be avoided as no standstill may be detected by the LH 5946. If possible the measuring wires should be run separately from the motor wires or screened wires should be used. In this case the screen can be connected at the motor side.

A1 - A2

Connection of the auxiliary supply, recommended fuse : 2A.

A3+ / A4

DC 24 V supply (12 … 30 V) for the semiconductor monitoring outputs „ON“ and „ERR“, if these are used.

11-12, 23-24, 33-34, 43-44

Safety output contacts, connection according to the connection examples or similar.
Recommended fuse: 5 A fast acting, to avoid welding of the contacts in the case of external wiring or component failures. See also technical data.

53 - 54

Monitoring contact to indicate the state of the safety output (non safety contact)

X1 - X2 (feedback circuit)

Connection of NC contacts of external components or contactors for contact re-enforcement, must be linked if not used.

X2 - X3

Connection for manual or auto reset, connection is made according to the required application. When monitoring DC motors or in the case of DC-braking the broken wire / offset failure will be shown during operation. In this case the terminals must be linked because if storing the failure would not allow activation of the safety contacts at standstill.

Attention

The terminals X1-X2-X3 have electrical connections to the measuring inputs L1-L2-L3. Volt free contacts must be used for bridging. If terminal X3 should be controlled by a PLC via an interface relay this must have the necessary insulation between the motor voltage (measuring input) and PLC potential.

Operation notes

Motors with switched windings

(e.g. star delta starters, reversing circuits, multi speed motors)

With these applications please make sure, that the measuring inputs must be linked via the motor windings. An open connection will result in broken wire indication and disable the safety contacts.
When connecting the LH 5946 to a 3-phase motor with star delta starter the star contactor must be energised while the motor is switched off, in order to achieve closed circuits between L1-L2-L3 via the motor windings.

If it is not possible to switch in the star contactor after the motor is switched off, the measuring inputs of the LH 5946 have to be connected like a single phase connection. L2-L3 are bridged and connected to one end of a motor winding and L1 to the other end of the same winding.

For reversing circuits and multi speed motors please follow the same procedure.

If in a 3-phase connection of LH 5946 windings are switched over, and the interruptions of the measuring circuits are longer then 2 s, the standstill monitor detects broken wire. In order not to store this failure, the unit should work with auto reset.

Operation with DC motors

The LH 5946 can be used on DC motors if these generate a remanence voltage during run down.

The connection is made similar as with a single phase motor.

As the remanence voltage in this case is normally a DC voltage the unit will detect a broken wire / offset failure and indicate it on LED „ERR“ and semiconductor output „ERR“. Taking this in mind and operating the unit with auto reset for these failures the unit can be used for safety standstill monitoring.

Operation with electronic motor controller

(inverters, DC-brakes)

The operation of LH5946 to detect standstill on motors with electronic motor control is possible if the control units do not generate any voltage on standstill. (NO position control on inverters, no DC voltage on brakes after standstill).

If the inverter produces a DC offset or a DC brake is active, an offset or broken wire failure is indicated on LED „ERR“ and semiconductor output „ERR“. This error resets automatically if on terminals X2-X3 automatic reset is selected.

When there are inverters in the installation it is recommended to use screened measuring wires to the motor. The screen can be connected to the motor.

Setup and setting

Preparation

- Motor on standstill
- Terminals L1-L2-L3 connected to the motor windings
- Provide link on terminals X1-X2
- Provide also link on X2-X3 on DC motors or DC braking
- Adjust U_{an} to minimum
- Adjust t_s to minimum (0.2 s)

Connect correct auxiliary voltage to terminals A1-A2

⇒ After 1 sec the LEDs „UH“ and „OUT“ light up green and the safety contacts are switched on. Also the monitoring relay and the semiconductor output „ON“ must be activated.

If standstill is not detected (LED „OUT“ lights yellow), possibly interference is coupled on the measuring circuit. Adjust U_{an} higher or screen the measuring wires.

Start of motor

⇒ LED „OUT“ changes colour to yellow. The output relays and the semiconductor output „ON“ switch off. On DC motors the LED „ERR“ starts to flash after 2 s with flash code 2 and the output „ERR“ comes on.

Stop of motor – run down DC braking off

The speed at which standstill is detected (yellow LED „OUT“ changes to green/green flashing) can be adjusted on Potentiometer „U_{an}“. When the run down is slow or irregular the time delay must possibly be increased to avoid switching on and off of the output relays. Possibly this effect can also be avoided by slightly increasing Uan. During time delay ts the LED „OUT“ flashes green.

If standstill detection shall only take place at very low speed of the motor, U_{an} is set normally to minimum. By increasing the delay time ts a possible pulsing of the output relays can be avoided. A longer time delay will also guarantee standstill detection only when the motor has already stopped turning. (especially on motors that generate only a small remanence voltage).

On slow decrease of motor speed it is possible that a simultaneity failure occurs (see failure monitoring) when the measuring channels reach the tripping values slowly and not within 2.5 sec. To avoid this failure a single phase connection could be the solution (to make sure that both inputs get the same signal) or the increase of the setting value U_{an}.

If the run down time of the motor is short ts can be set to a minimum (0.2 s). This is suitable in production systems to shorten machine cycles.

Attention

It is the responsibility of the user to adjust Uan and ts in a way that standstill detection and enabling of the safety contacts in the application is only possible when danger to men and material by the rotating can be excluded.

Failure:
The unit enables the safety outputs while the motor is still turning (LED „OUT“ lights green).
Solution:
Reduce setting of U_{an} if necessary to minimum. If the outputs are still enabled a wiring problem on the measuring wires could be the reason (short circuit on terminals L2/L3 to L1). Please check connection of measuring inputs to motor winding according to the connection examples.

Failure:
The output contacts are enabled to early (motor has not finally stopped):
Solution:
Adjust setting value U_{an} to lower level. Additionally the delay time ts could be increased.

Failure:
Output contacts remain disabled while the motor is already on standstill
Solution:
Observe status of indicator LEDs:

1. LED „UH“ lights green?
   If **yes**, go to 2.
   If **no**, U_H has undervoltage or the unit has an internal device failure. (Internal failures can occur in the case of undervoltage, welded safety output contacts or seldom because of interference)
   ⇒ switch supply voltage off and on. If the failure still exists in spite of correct auxiliary supply UH the unit could be defective and has to be sent to manufacturer for test or repair.

2. LED „ERR“ (red) flashes with code 1?
   If **no**, go to 3.
   If **yes**, the unit has detected undervoltage
   ⇒ Apply correct auxiliary voltage

3. LED „OUT“ flashes green?
   If **no**, go to 4.
   If **yes**, standstill is detected, but the time ts till enabling of the outputs is not elapsed.
   ⇒ wait till time ts is finished.
   If after 6 s the outputs are not enabled, the measuring input L1-L2-L3 receives intermittent voltage peaks that are higher then U_{an}.
   This should normally be indicated by intermittent yellow flashes on the LED).
   ⇒ Adjust U_{an} to a higher value, clear interference on measuring wires (use screened cables).

4. LED „OUT“ lights yellow?
   If **yes**, the voltage on the measuring input is higher then the adjusted value U_{an}; go to 5.
   If **no**, LED is off
   Standstill is detected (voltage on measuring input is $<U_{an}$) but the outputs are not enabled because
   a) Feedback circuit X1-X2 is not closed or
   b) a simultaneity failure occurred (see failure monitoring) or
   c) a previous failure (broken wire / offset, feedback circuit) is still stored (terminals x2-x3 are not linked.

   The type of failure is indicated by flash code on the red LED „ERR“:

   a) flash code 4 (feedback circuit not closed)
   b) flash code 5 (simultaneity fault of the measuring signals on L2 L3)
   c) code 2, 3 or 4 depending on priority and failure.

   ⇒ - close feedback circuit
   - Bridge terminals X2-X3 (manual reset)

   If now still the simultaneity failure (flash code 5 on LED „ERR“) is indicated it can be reset by switching the auxiliary supply off and on. The reset also takes place, when both input signals rise above Uan e.g. when starting the motor. If the simultaneity failure remains active after start of the motor (e.g. because of short circuit between L2-L1 or L3-L1) the wiring of the measuring circuit has to be checked according to the connection example.
   If the simultaneity failure occurs often e. g. on slow decease of the motor speed, the problem can be solved by increasing the tripping value U_{an} or/and by making a single phase instead of a 3-phase connection of the measuring circuit to the motor.

Failure treatment

5. LED „OUT“ lights yellow while the motor is on standstill
   If the yellow LED „OUT“ is on this indicates that the measuring inputs still receive an input signal higher then the adjusted value U_{an}

   Observe in addition the LED „ERR“:

   a) if it stays off after a time of 8 s the problem could be a interference or residual voltage (induced AC voltage) on the measuring inputs
   ⇒ Increase the setting of U_{an}
   If this shows no result, or if an increase is not wished, the interference to the measuring lines must be reduced e.g. by screening, shortening or separating the wires, Test: Disconnect motor and short circuit terminals L1-L2-L3 on the unit, the yellow LED must change to green or green flashing.

   b) if the red LED flashes code 2 the unit has detected broken wire or DC voltage offset between the measuring inputs L1 and L2 (or between L1 and L2 and L1 and L3).

   c) if the red LED flashes code 3 the unit has detected broken wire or DC voltage offset on measuring input L3

   In the 2 last cases the wiring between LH5946 terminals L1-L2-L3 and the motor terminals has to be checked on interruption. Possibly the interruption comes from disregarding the operating remarks for motors with switchable windings (see remarks).

If failures by interruption of the input circuits can be excluded the failure can result from a DC voltage offset > Uan. This can come from motor controllers like inverters or DC brakes that are not completely switched off and supply a DC-voltage to the measuring circuit (check with Voltmeter).
If the DC content is only minor, the failure can be removed by increasing the setting value Uan The yellow LED „OUT“ must change to green or green flashing. If not the motor controllers must be switched off in a way that standstill can be detected correctly.

Failure:
While motor is on operation a failure is indicated.
If the LED „UH“ lights red, an internal failure occurred.
Solution:
Switch auxiliary supply off and on again (see 1.)

If the LED „ERR“ indicates a failure the flash code shows the type of fault and how to remove it. Flash code 2 or 3 are normal during operation of DC motors. If the terminals X2-X3 are bridged, The failure is reset automatically at standstill and the output relays are enabled. The same is valid for operation with electronic controllers, if these produce a DC voltage e.g. during braking of a DC-brake.