

IC for Inductive Proximity Switches with 0.5 A Output Stage

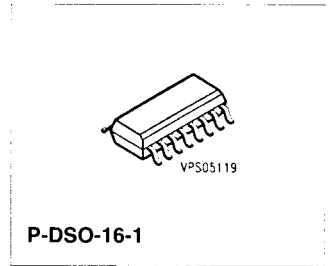
TCA 705

Advance Information

SPT IC

Features

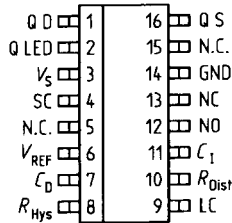
- Output current up to 500 mA
- Switch-ON and switch-OFF
- High-side-switch and low-side-switch
- Short-circuit and overload protection
- Supply voltage range from 7.5 V to 65 V
- Few external components
- LED output for "switch-ON/OFF" and short-circuit failure indication
- High switching frequency
- High noise immunity, low temperature coefficient
- Temperature protection



Type	Ordering Code	Package
▼ TCA 705 G	Q67000-A8310	P-DSO-16-1 (SMD)

▼ New type

The TCA 705 is a monolithic IC in the new Smart Power Technology (SPT) for designing excellent inductive proximity switches at low cost and with little space. Features like 0.5 A output current, short-circuit, overload and temperature protection classify the TCA 705 as a versatile general-purpose circuit. The separate LED output indicates the switching state of the sensor (switch-ON / switch-OFF) and an eventual short-circuit failure.

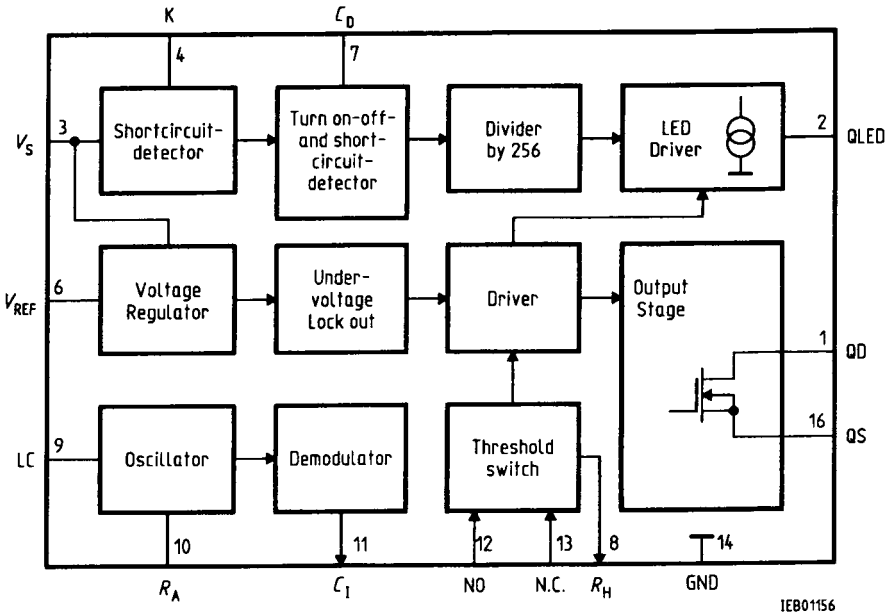


IEP01155

Pin Configurations
(top view)

Pin Definitions and Functions

Pin	Symbol	Function
1	QD	Output; open drain
2	Q LED	Output LED
3	V_S	Supply voltage
4	SC	Short-circuit detector
5	N.C.	Not connected
6	V_{REF}	Reference voltage
7	C_D	Turn-ON delay / Turn-OFF delay / Short-circuit delay
8	R_{Hys}	Hysteresis
9	LC	Oscillator
10	R_{Dist}	Distance
11	C_I	Integrating capacitance
12	NO	Input driver (normally open)
13	NC	Input driver (normally closed)
14	GND	Ground
15	N.C.	Not connected
16	QS	Output; open source



Block Diagram

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Pin Functions

Pins 1/16: QD, QS

A load has to be connected between QS and ground, i.e. high-side switch respectively between QD and V_S , i.e. low-side switch. The current through the load is 500 mA max. To protect the IC against destruction by short-circuit or overload, a capacitor has to be connected between pin C_D and ground.

Pin 2: Q LED

Output QLED drives a LED with up to 10 mA, connected between QLED and V_S . The LED indicates the switching state (switch-ON / switch-OFF) and blinks during an eventual short-circuit failure.

Pin 3: V_S

Outputs QD, QS and QLED are inhibited as long as the voltage on V_S is below approx. 7.5 V. They are enabled between approx 8.0 and 8.5 V, the basic function of the circuit is then ensured. During the turn-ON and turn-OFF of V_S there are consequently no undesirable static states. The operating data and characteristics apply upwards from 8.5 V. See pin C_D for the avoidance of erroneous pulses during oscillator built-up.

Pin 4: SC

SC serves for short-circuit sensing in the output circuit that is to be protected. The current can be sensed referred to ground or V_S (see application circuits 2 and 3). The current sensing is made by a dedicated resistor (R_{SC}) in the output circuit. For a voltage drop ≥ 0.3 V across V_S and SC or across ground and SC, all outputs are turned off after the turn-OFF delay (brief glitches on the outputs or the charging of line capacitances therefore do not trigger the short-circuit protection). After a pause of about 200 times of the turn-OFF delay, the outputs turn on again. If the short-circuit is still present, the turn-OFF cycle will start up a new.

Pin 6: V_{REF}

The internal stabilized voltage of the IC of approx. 3.5 V appears on this pin. A capacitor can be connected between V_{REF} and ground to improve the noise immunity of the overall circuit function. The output current at this pin is up to 10 mA.

Pin 7: C_D

A capacitor on this pin delays the activation of the output after the supply voltage is applied (turn-ON delay). In this way erroneous pulses are prevented on the output during built-up of the oscillator.

If V_S falls to less than 7.8 to 8 V, the output is not inhibited until after a turn-OFF delay time, this also being determined by C_D . In this way the delayed turn-ON operation described above is suppressed if there are just short glitches (voltage dips) on V_S . This is of particular advantage for large core diameters, because in such cases a relatively long turn-ON delay has to be selected, since this would otherwise start to run every time there was a brief voltage dip.

The capacitor C_D also sets the turn-OFF delay and the pause duration in short-circuit operation.

Pin 8: R_{Hys}

Depending on the status of the circuit, R_{Hys} will be high-impedance or low-impedance to ground (open collector). If the distance resistance (see R_{Dist}) is split into two resistors R_{Dist} and R_{Hys} , a distance hysteresis can be set by means of R_{Hys} . If series hysteresis is applied, R_{Hys} is connected in series with R_{Dist} or shorted. If parallel hysteresis is applied, R_{Hys} is connected in parallel with R_{Dist} or made high-impedance (**see application circuit 1**).

Pin 9: LC

The resonant circuit of the proximity switch is connected between LC and ground.

Pin 10: R_{Dist}

A resistor between this pin and ground sets the current in the oscillator circuit. The greater the value of the resistor, the smaller is the current feed from the oscillator into the resonant circuit and the greater therefore is the switching distance. The greater the quality of the resonant circuit, the greater is the value of the distance resistor necessary for setting a certain switching distance.

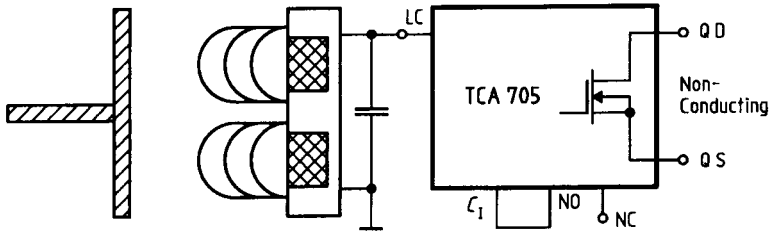
Pin 11: C_1

C_1 can remain open; if high noise immunity is to be achieved however, this pin should be provided with a serial RC element (R_1 , C_1). If pin 7 (C_D) is not used, a correctly dimensioned RC element on pin C_1 will also prevent any erroneous pulses on the output when the supply voltage is turned on (**see application circuit 1**).

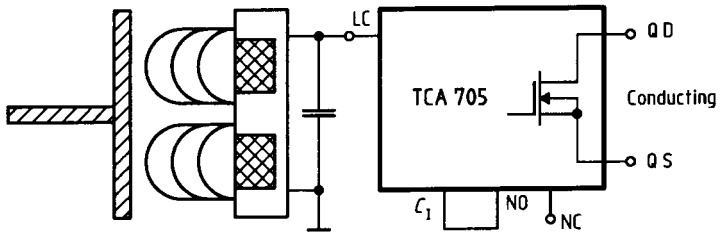
Pins 11/12/13: C_1 , NO, NC

A direct connection between C_1 and NO will result in a "normally open" output stage, i. e. switch-ON. A direct connection between C_1 and NC will result in a "normally closed" output stage, i. e. switch-OFF.

Resonant circuit, normally open, not damped:



Resonant circuit, normally open, damped:



	Not Damped	Damped
Normally Open C_1 / NO	Non-Conducting	Conducting
Normally Closed C_1 / NC	Conducting	Non-Conducting

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Operational Diagram

Functional Description

This circuit is used to design inductive proximity switches. The resonant circuit of the LC oscillator is implemented with an open half-pot ferrite and a capacitor in parallel (pin LC). If a metallic target is moved closer to the open side of the half-pot ferrite, energy is drawn from the resonant circuit and the amplitude of the oscillation is decreasing accordingly. This change in amplitude is transmitted to a threshold switch by means of a demodulator and triggers the output (**see operation schematic**).

By means of an external distance resistor R_A on the oscillator (pin R_{Dist}) it is possible to set the switching distance within wide limits. The optimal distances are 0.1 to 0.6 of the diameter of the half-pot ferrite in use, but extensions to both of these parameters can also be produced. The circuit also enables the setting of a path hysteresis by switching an external distance resistor (R_H) via pin R_{Hys} (**see application circuit 1**).

The device includes one integrated output stage for max. 500 mA output current. It can be used as "normally open" or "normally closed" by means of programming the NO-respectively NC-input driver and as a high-side- or low-side-switch (**see application circuits 2 and 3**). The output stage is automatically protected against destruction by short-circuit or overload.

By means of a capacitor on pin C_D it is possible to set the response delay and the turn-OFF time of short-circuit protection. The same capacitor also defines the turn-ON delay of the output stage when the supply voltage is applied, whereby the output stage is inhibited during built-up of the oscillator. Finally C_D is used to produce a turn-OFF delay of the output stage so that the turn-ON delay is prevented from running its full length if there are brief voltage dips on V_S .

Absolute Maximum Ratings

$T_A = -40$ to 110 °C

Parameter	Symbol	Limit Values		Unit	Test Condition
		min.	max.		
Supply voltage	V_S	-0.3	70	V	-
Output voltage	V_Q	-0.3	$V_S + 1$	V	-
Output current	$-I_Q$	-	-	-	internally limited
Current from V_{REF}	$-I_{REF}$	0	1	mA	-
Voltage on SC	V_{SC}	0	V_S	V	-
Current from R_{Dist}	$-I_{RDist}$	0	2	mA	-
Current to R_{Hys}	I_{RHys}	0	2	mA	-
Storage temperature	T_{stg}	-65	125	°C	-
Thermal resistance (system-air)	$R_{th,SA}$	-	110	K/W	-
Junction temperature	T_j	-	125	°C	-
	T_j	-	150	°C	max. 70.000 h
Capacitor on C_D	C_V	-	50	nF	-

Operating Range

Supply voltage	V_S	7.5	65	V	-
Ambient temperature	T_A	-40	110	°C	-
Distance and hysteresis resistance					
R_A and R_H in series	R_A	300	-	Ω	-
	R_H	0	-	Ω	-
R_A and R_H parallel	R_A / R_H	300	-	Ω	-
Output current	$-I_Q$	-	500	mA	-

Characteristics

$7.5 \text{ V} \leq V_S \leq 65 \text{ V}$; $T_A = -40$ to $110 \text{ }^\circ\text{C}$

Parameter	Symbol	Limit Values			Unit
		min.	typ.	max.	
Current consumption	I_S	–	550	750	μA
Turn-ON threshold (output active)	V_{TON1}	–	8.0	8.5	V
Turn-OFF threshold (output disabled)	V_{TOFF1}	7.5	8.0	–	V
Hysteresis $V_{\text{TON1}} - V_{\text{TOFF1}}$	ΔV_{Hys1}	–	40	–	mV
Reference Voltage	V_{REF}	3.0	3.3	3.5	mV

Oscillator (LC, R_{Dist})

Oscillator frequency	f_{OSC}	–	–	3	MHz
Oscillator amplitude	A_{OSC}	–	0.8	–	V_{PP}

Demodulator, Threshold Switch (C_1 , R_{Hys})

Threshold on C_1	V_{Cl}	–	2	–	V
Hysteresis on C_1	V_{HysCl}	–	0.8	–	V
Current in C_1	I_{Cl}	–	7	–	μA
Current from C_1	$-I_{\text{Cl}}$	–	6	–	μA
Switching frequency ($C_1 < 50 \text{ pF}$)	f_s	–	5	–	kHz
Integrating capacitance	C_1	–	1	–	nF

Reference Voltage (V_{REF})

Reference voltage	V_{REF}	3.0	3.3	3.5	V
$I_{\text{REF}} = 0$ to 1 mA					

Turn-ON, Turn-OFF and Short-Circuit Delay (C_b)

Turn-ON delay	t_{DON}	0.48	0.65	0.82	ms/nF
Turn-OFF delay	t_{VA}	17.0	25	34.0	$\mu\text{s/nF}$
Short-circuit turn-OFF delay	t_{SC}	1.70	2.5	3.40	$\mu\text{s/nF}$
Short-circuit pause	t_p	0.35	0.5	0.65	ms/nF

Characteristics (cont'd)

$7.5\text{ V} \leq V_S \leq 65\text{ V}$; $T_A = -40\text{ to }110\text{ }^\circ\text{C}$

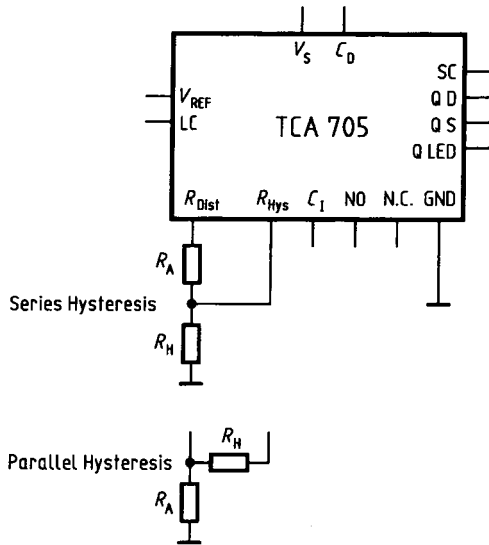
Parameter	Symbol	Limit Values			Unit
		min.	typ.	max.	

Outputs (QD, QS, Q LED)

Current on Q LED	I_{QLED}	–	–	10	mA
	R_{DSON}	0.3	–	0.5	Ω
Residual current on QD, QS	I_{QRES}	–	–	100	μA

Short-Circuit Detector (SC)

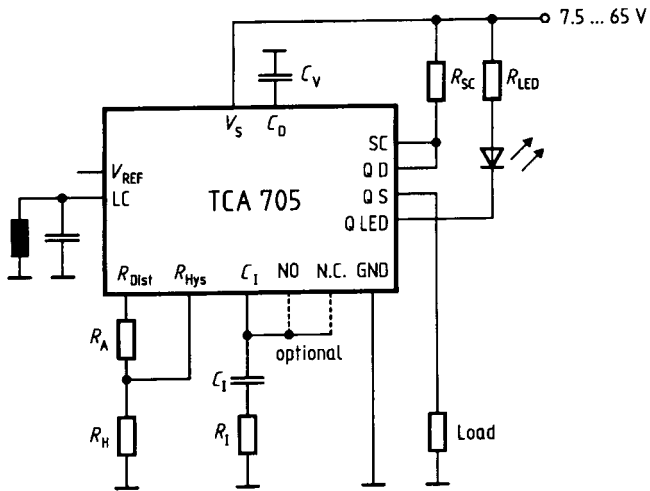
Trigger level ref. to V_S	V_{SCS}	0.255	0.3	0.345	V
Trigger current	I_{SCS}	–	–	30	μA
Trigger level ref. to ground	V_{SCO}	0.255	0.3	0.345	V
Trigger current	$-I_{\text{SCO}}$	–	–	6	μA



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Application Circuit 1
Series Hysteresis / Parallel Hysteresis

For explanation see under "Pin Functions".

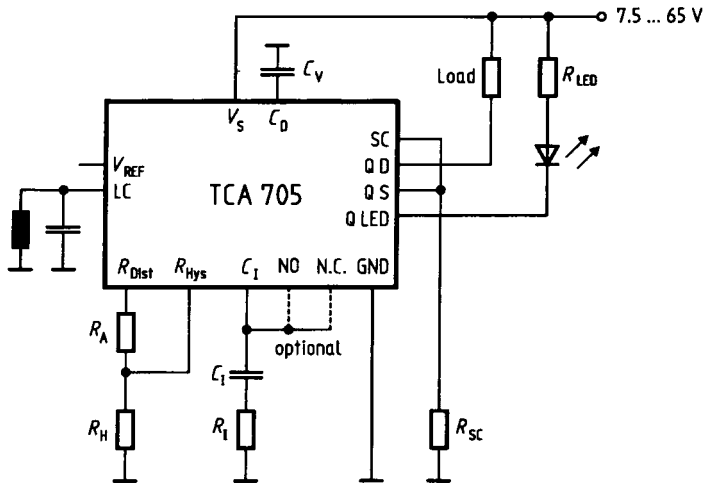


High-side-switch, short-circuit-proof, LED indicator, normally closed (normally open).

Short-circuit sensing: $R_{sc} = \frac{0.3 \text{ V}}{\text{max. } I_Q}$

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Application Circuit 2



Low-side-switch, short-circuit-proof, LED indicator, normally open (normally closed).

Short-circuit sensing: $R_{sc} = \frac{0.3 \text{ V}}{\text{max. } I_Q}$

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Application Circuit 3