Hardware Description and Design-In Proposals for SMD Transmissive Sensors

By Reinhard Schaar

TCPT1300X01 (SINGLE), TCUT1300X01 (DUAL)

- AEC-Q101 qualified
- Transmissive sensor for automotive and industrial applications
- Gap dimension: 3 mm and aperture width: 0.3 mm
- Typical output current under test: $I_C = 0.6$ mA at $I_F = 15$ mA
- Emitter wavelength: 950 nm
- Moisture sensitivity level 1 (MSL): unlimited floor life
- Halogen-free

TCPT1350X01 (SINGLE), TCUT1350X01 (DUAL)

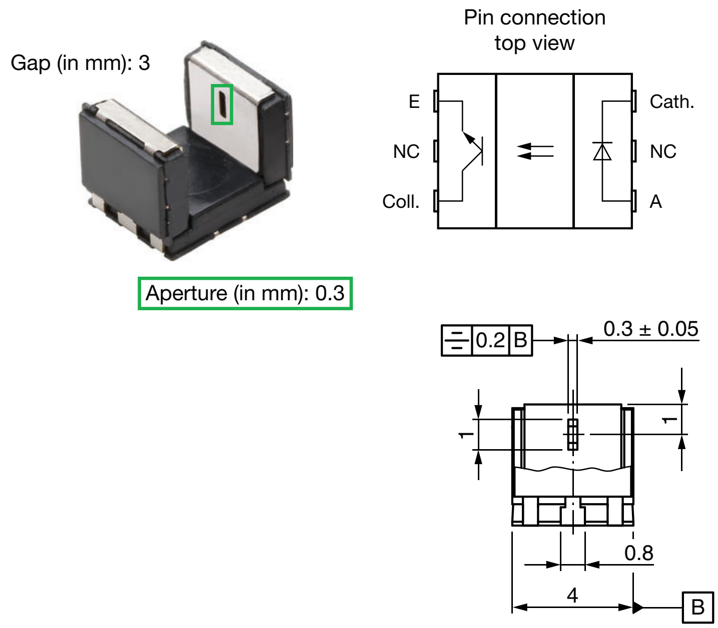
- AEC-Q101 qualified
- Transmissive sensor for automotive and industrial applications
- Gap dimension: 3 mm and aperture width: 0.3 mm
- Typical output current under test: $I_C = 1.6$ mA at $I_F = 15$ mA
- Emitter wavelength: 950 nm
- Moisture sensitivity level 1 (MSL): unlimited floor life
- Halogen-free
- Released for high operating temperatures up to 125 °C

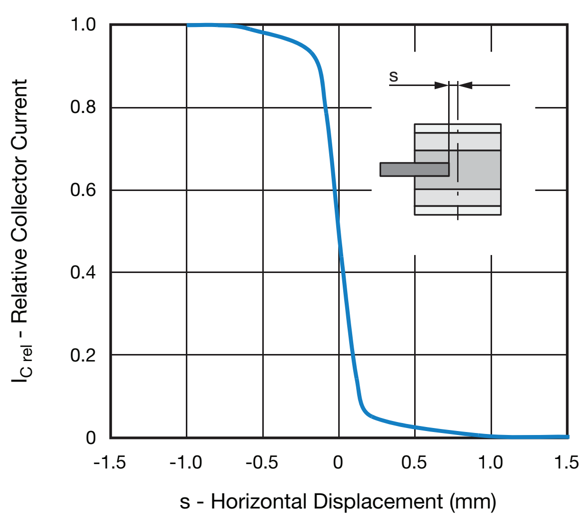
TCPT1600X01 (SINGLE), TCUT1600X01 (DUAL)

- AEC-Q101 qualified
- Transmissive sensor for automotive and industrial applications
- Gap dimension: 3 mm and aperture width: 0.3 mm
- Typical output current under test: $I_C = 1.6$ mA at $I_F = 15$ mA
- Emitter wavelength: 950 nm
- Moisture sensitivity level 1 (MSL): unlimited floor life
- Halogen-free
- Taller dome, more vertical headroom

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT



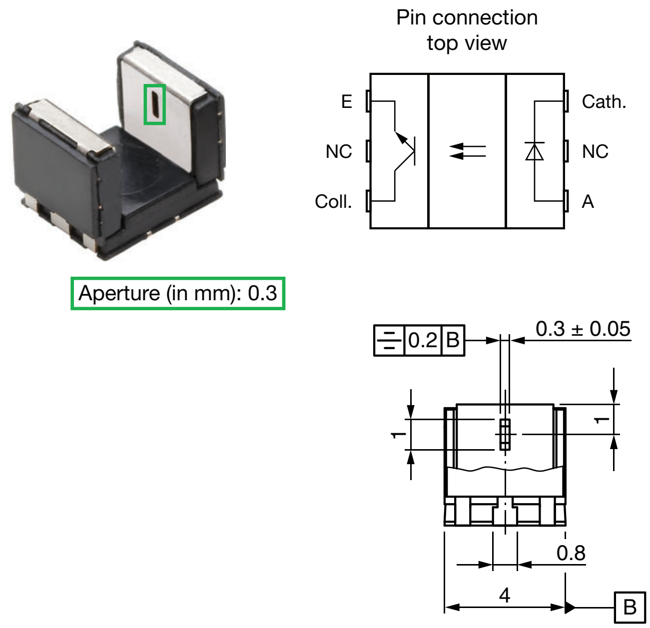


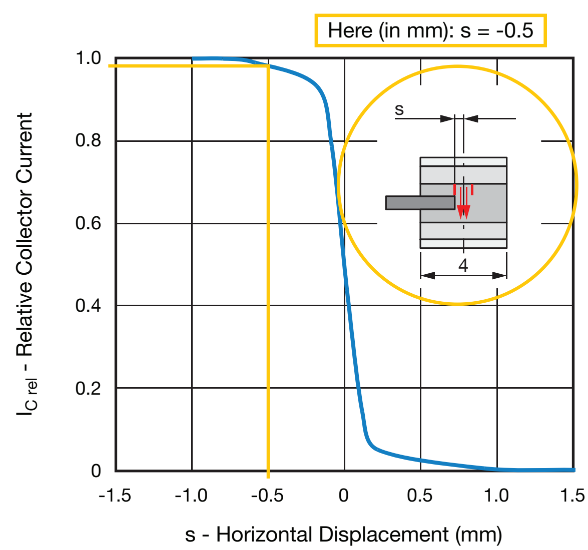
Relative Collector Current vs. Horizontal Displacement

Fig. 1

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT





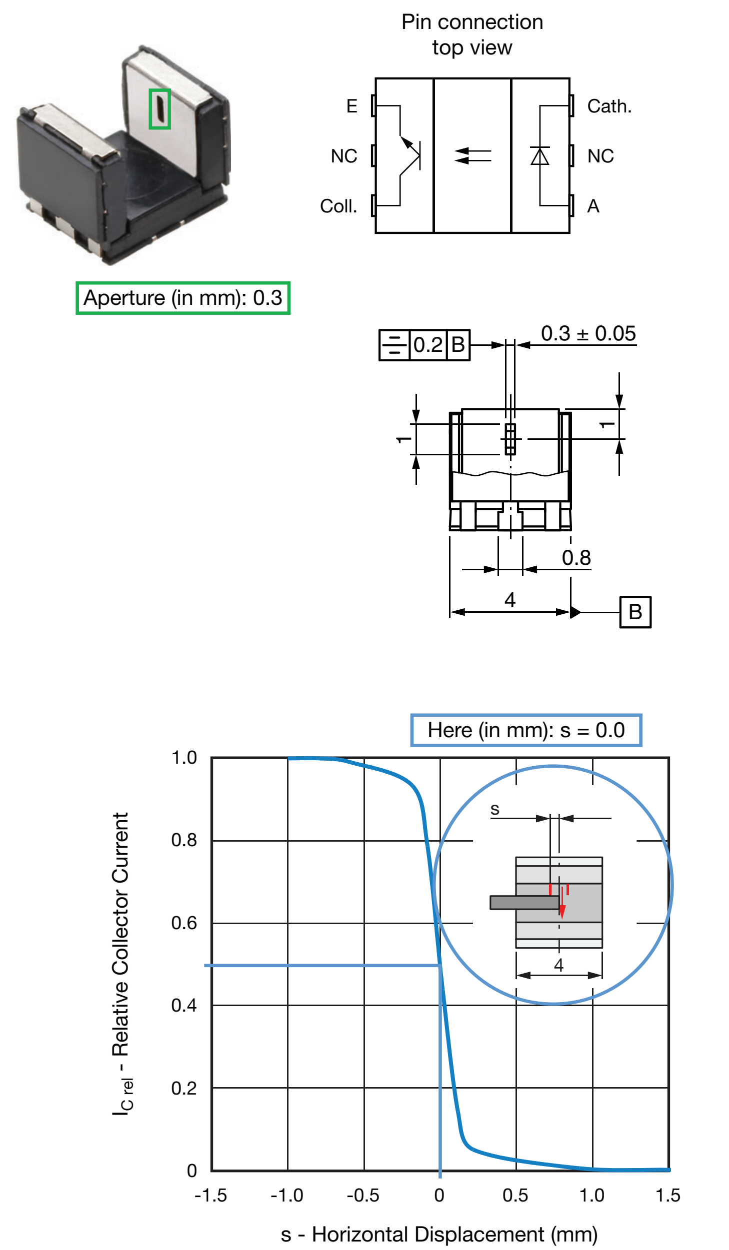
Relative Collector Current vs. Horizontal Displacement

With s = -0.5 mm, nearly all emitted IR light is also available at the detector side.

Fig. 2

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT



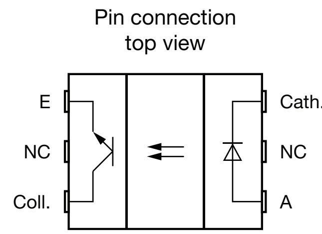
Relative Collector Current vs. Horizontal Displacement

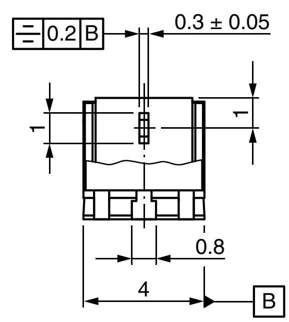
With s = 0 mm, nearly half of emitted IR light is blocked, but half of IR light is also available at the detector side.

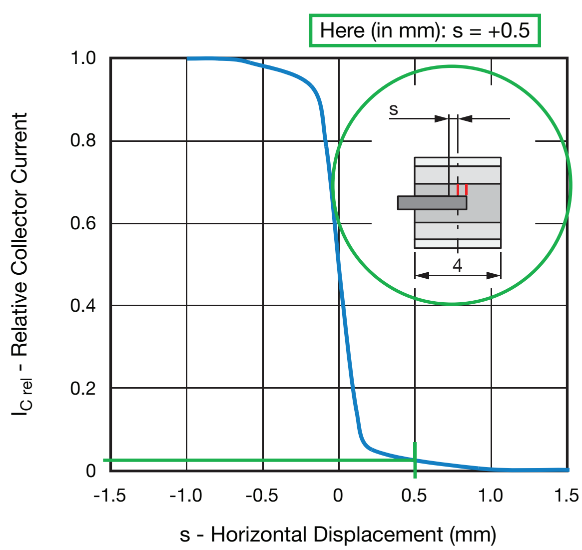
Fig. 3

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT







Relative Collector Current vs. Horizontal Displacement

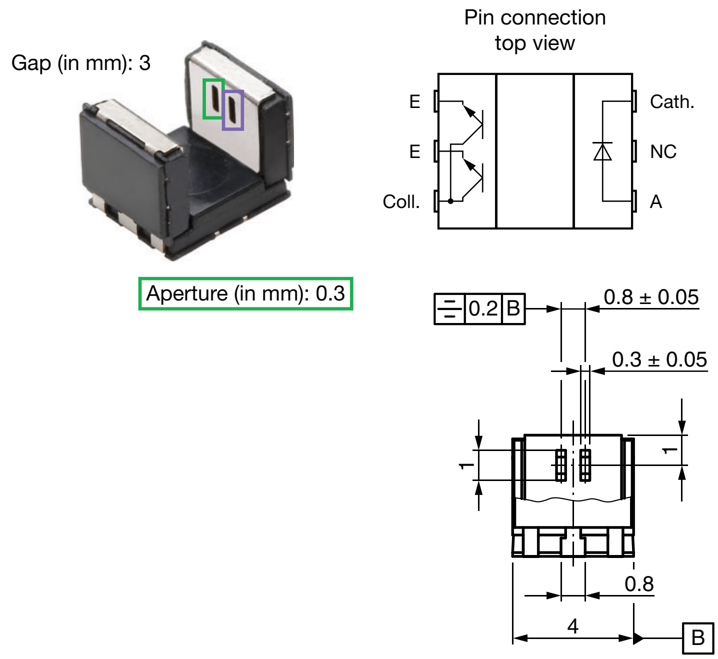
With s = +0.5 mm, nearly all emitted IR light is blocked and nearly nothing is available at the detector side.

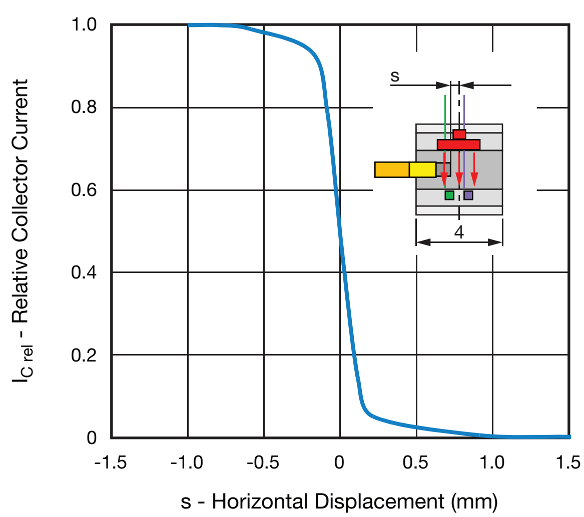
Fig. 4

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT

Transmissive Sensor: TCUT13.0X01





Relative Collector Current vs. Horizontal Displacement

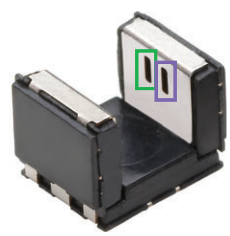
Distance between slots for detector 1 (D_1) and detector 2 (D_2) is 0.5 mm.

Fig. 5

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

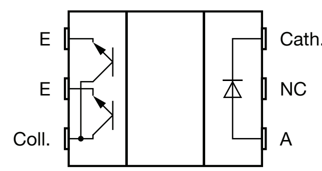
RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT

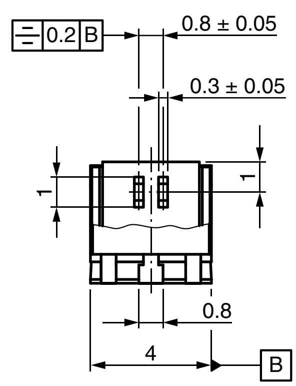
Transmissive Sensor: TCUT13.0X01

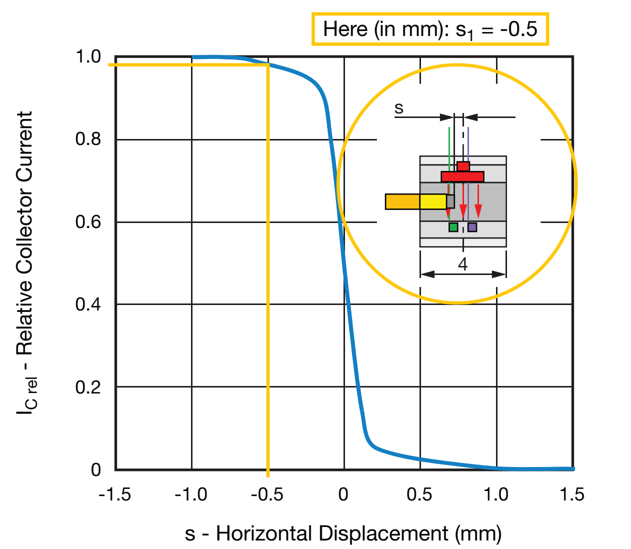


Aperture (in mm): 0.3

Pin connection
top view







Relative Collector Current vs. Horizontal Displacement

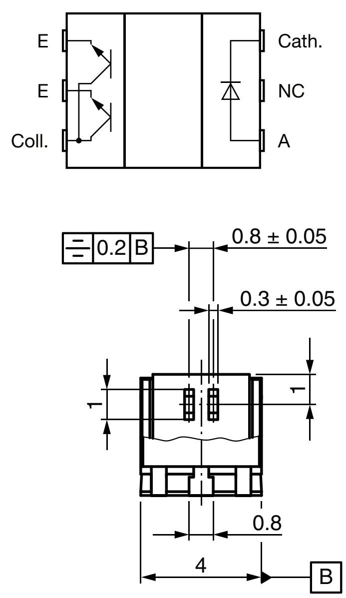
With s_1 = -0.5 mm, nearly all emitted IR light is also available at both detector sides D_1 and D_2: U_{D1} = 1, U_{D2} = 1

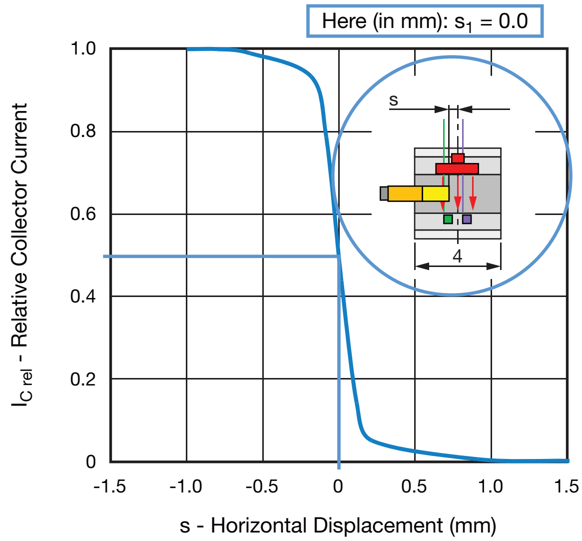
Fig. 6

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT

Transmissive Sensor: TCUT13.0X01





Relative Collector Current vs. Horizontal Displacement

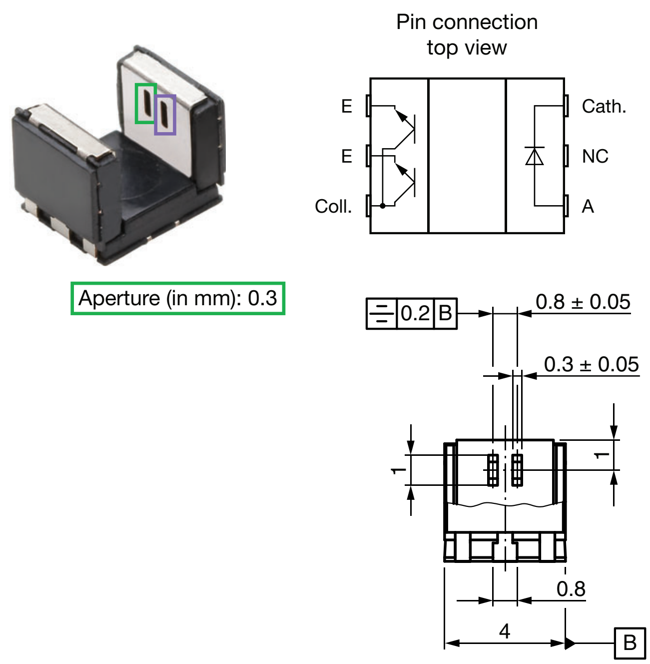
With s_1 = 0.0 mm, nearly half of emitted IR light is blocked (for D_1), but half of IR light is also available at D_1 and all IR light is available at D_2.

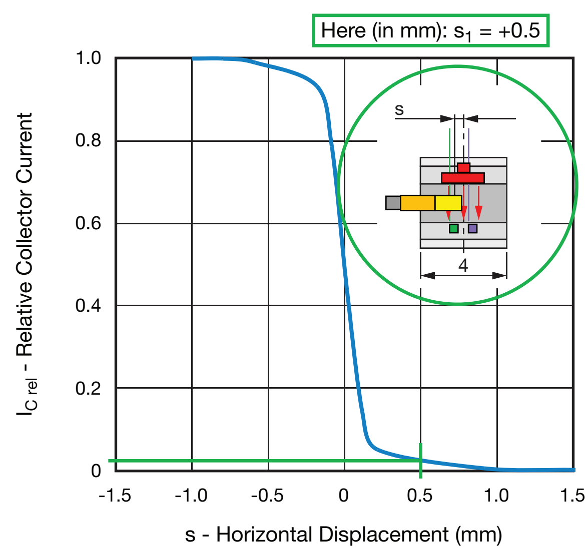
Fig. 7

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT

Transmissive Sensor: TCUT13.0X01





Relative Collector Current vs. Horizontal Displacement

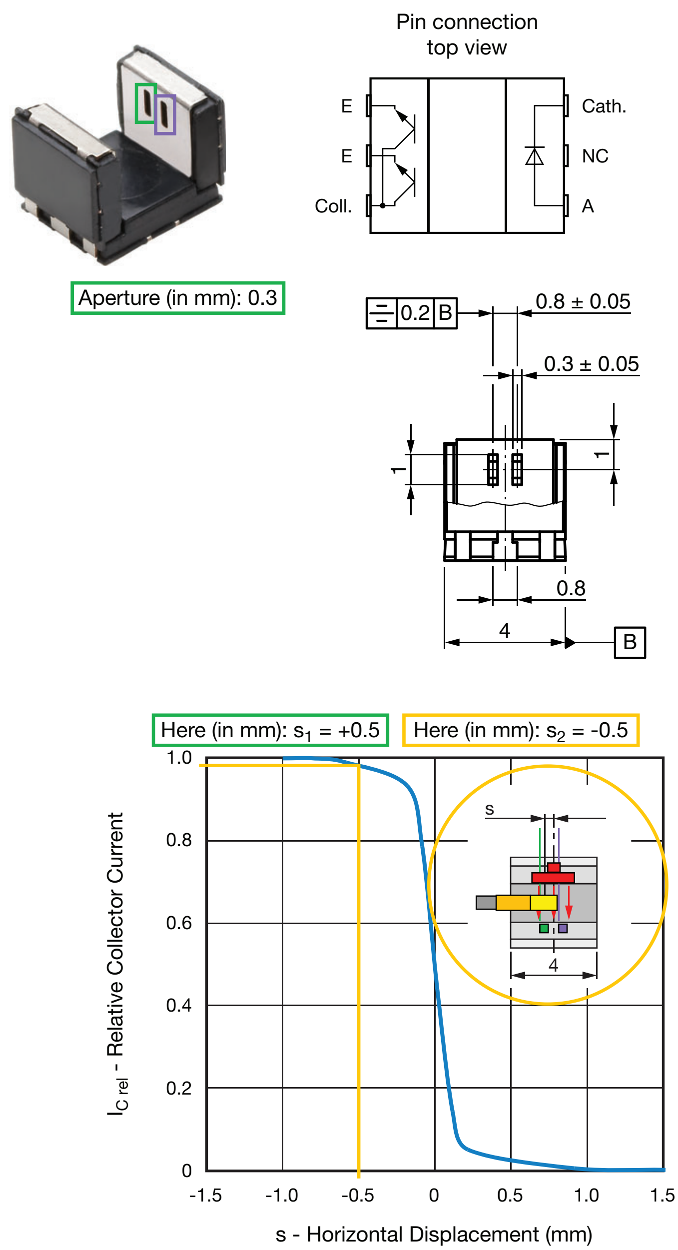
With s_1 = +0.5 mm, nearly all IR light is blocked (for D_1), but all IR light still available at D_2: U_{D1} = 0, U_{D2} = 1

Fig. 8

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT

Transmissive Sensor: TCUT13.0X01



Relative Collector Current vs. Horizontal Displacement

With s_2 = -0.5 mm, nearly all emitted IR light is available at D_2.

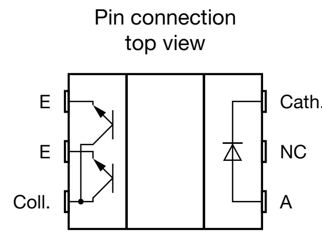
Fig. 9

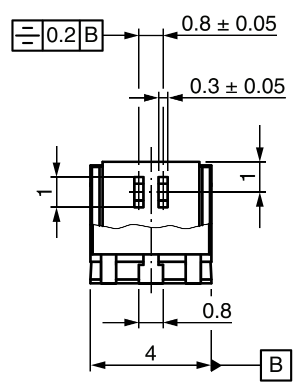
Hardware Description and Design-In Proposals for SMD Transmissive Sensors

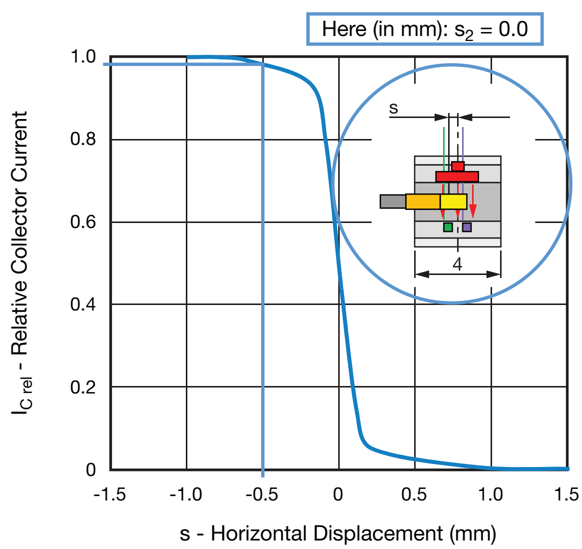
RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT

Transmissive Sensor: TCUT13.0X01

Aperture (in mm): 0.3







Relative Collector Current vs. Horizontal Displacement

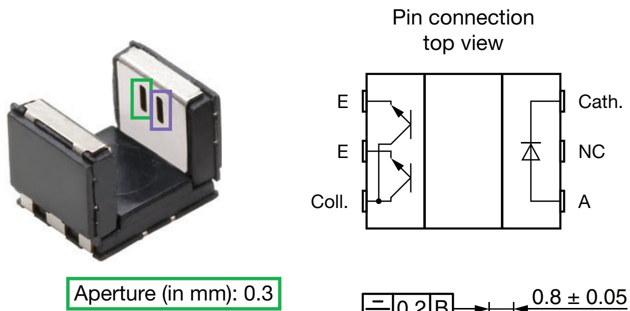
With s_2 = 0.0 mm, nearly half of emitted IR light is blocked for D_2.

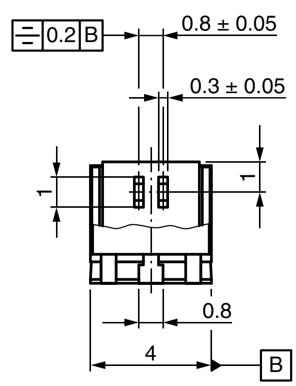
Fig. 10

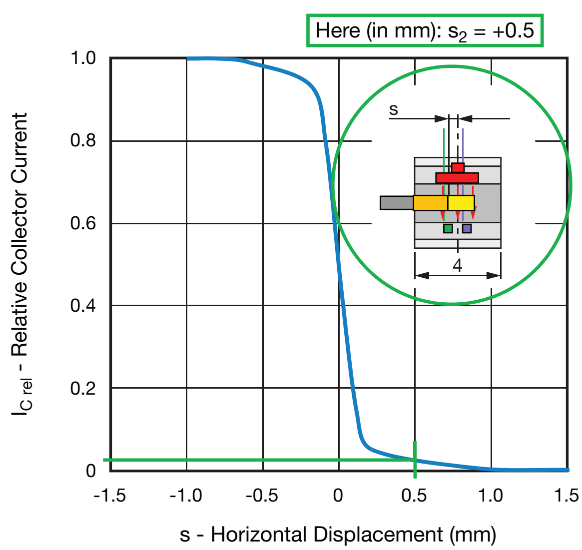
Hardware Description and Design-In Proposals for SMD Transmissive Sensors

RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT

Transmissive Sensor: TCUT13.0X01







Relative Collector Current vs. Horizontal Displacement

With s_2 = +0.5 mm, nearly all emitted IR light is now also blocked for D_2:
U_{D1} = 0, U_{D2} = 0

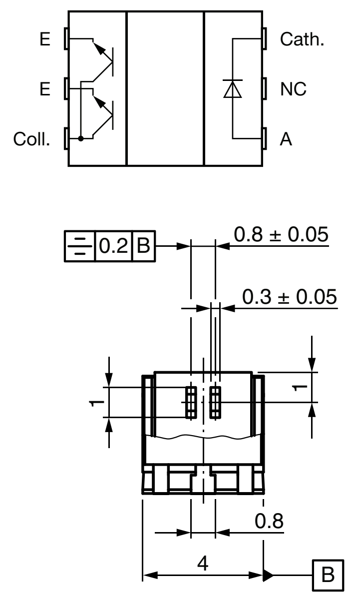
Fig. 11

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

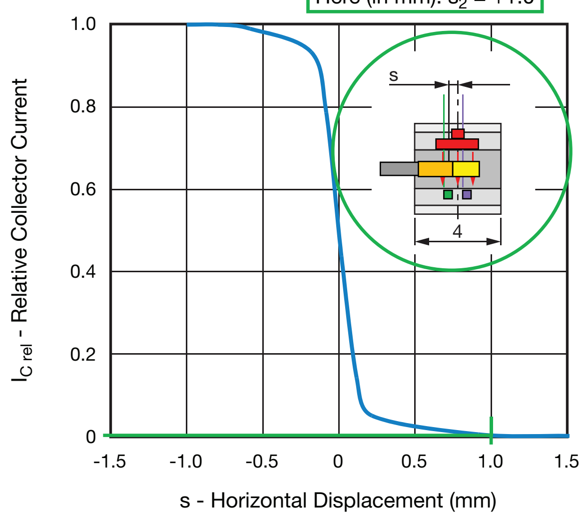
RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT

Transmissive Sensor: TCUT13.0X01

Aperture (in mm): 0.3



Here (in mm): s_2 = +1.0



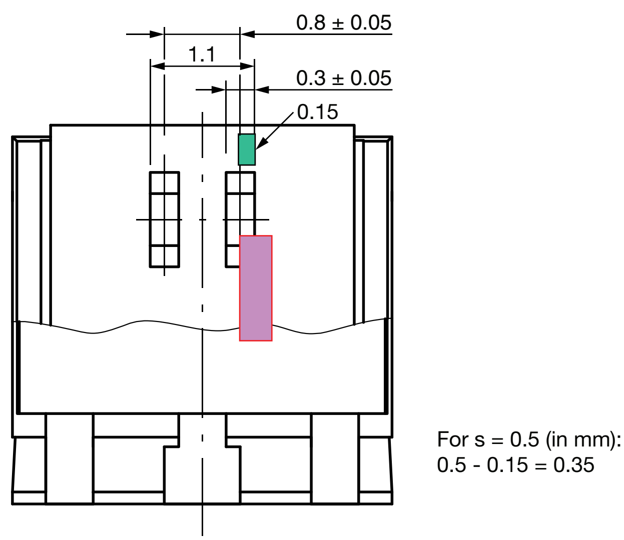
Relative Collector Current vs. Horizontal Displacement

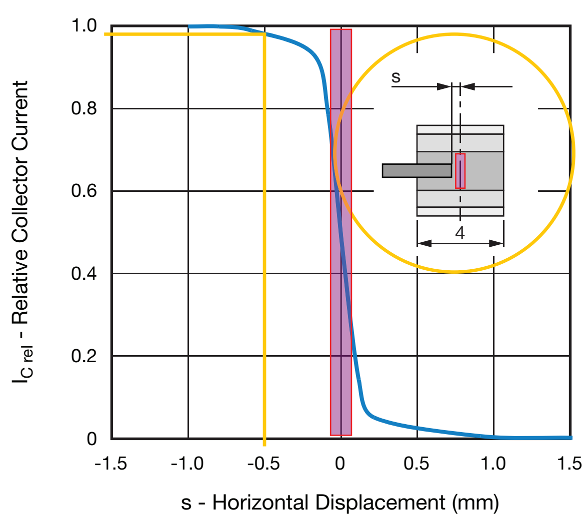
With s_2 = +1.0 mm, all emitted IR light is now also blocked for D_2:
U_{D1} = 0, U_{D2} = 0

Fig. 12

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT





Relative Collector Current vs. Horizontal Displacement

Fig. 13

With s = ± 0.5 mm for close to 100 % / 0 % of the collector current, just ± 0.35 mm is seen as added overlapping that needs to be added to that 1.1 mm total width. So, 1.1 mm + 2 x 0.35 mm = 1.8 mm for the total closing / opening.

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

RELATIVE COLLECTOR CURRENT VS. HORIZONTAL DISPLACEMENT

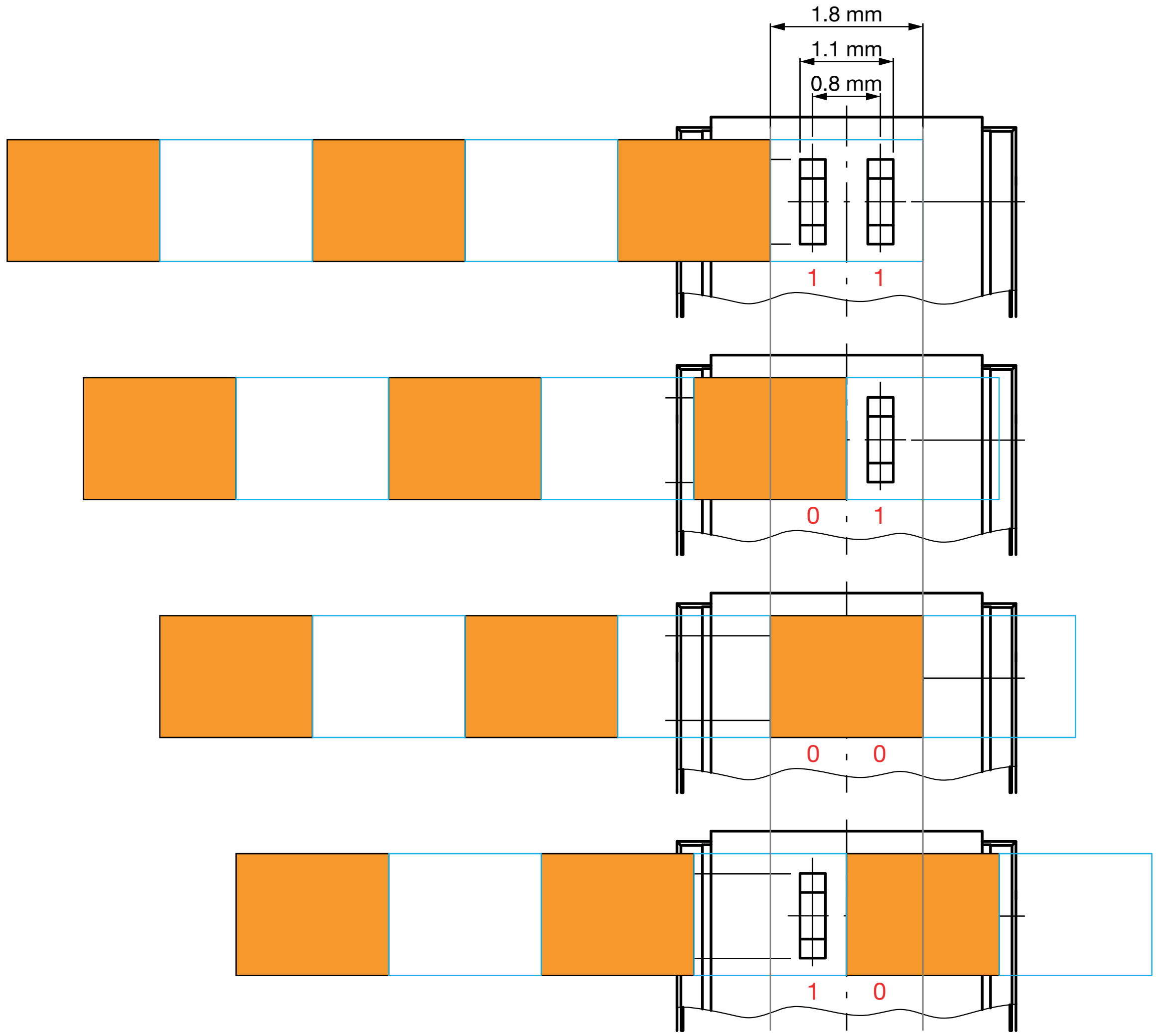


Fig. 14

With a 1.8 mm hole, 1.8 mm gaps / bars, and a constant shift of 0.9 mm, all four positions will be covered well.

With 64 holes and bars = 64 x 3.6 mm = 230.4 mm.

A code wheel diameter will have with this: d ≈ 73 mm.

Smaller wheels are also possible, but the exact high and low level will not be reached.

With 0.6 mm holes, 0.5 mm bars, and with 64 holes and bars it could be just about 22 mm, and with just 16 position (16 x 1.1 mm/π) = 5.6 mm diameter.

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

DETERMINING THE FORWARD CURRENT FOR THE IRED AND THE LOAD RESISTOR FOR THE PHOTOTRANSISTOR

First of all, one needs to also see the minimum specified and guaranteed values within basic characteristics of the datasheet:

BASIC CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified) **TCUT1300X01, TCPT1300X01**						
PARAMETER	**TEST CONDITION**	**SYMBOL**	**MIN.**	**TYP.**	**MAX.**	**UNIT**
COUPLER						
Collector current	V_{CE} = 5 V, I_F = 15 mA	I_C	0.3	0.6	-	mA

The TCUT1300X01 and TCPT1300X01 show here 0.3 mA (with an I_F = 15 mA), while the TCUT1350X01, TCPT1350X01, TCUT1600X01, and TCPT1600X01 show 0.7 mA:

BASIC CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified) **TCUT1350X01, TCPT1350X01, TCUT1600X01, TCPT1600X01**						
PARAMETER	**TEST CONDITION**	**SYMBOL**	**MIN.**	**TYP.**	**MAX.**	**UNIT**
COUPLER						
Collector current	V_{CE} = 5 V, I_F = 15 mA	I_C	0.7	1.6	-	mA

TCUT1300X01, TCPT1300X01

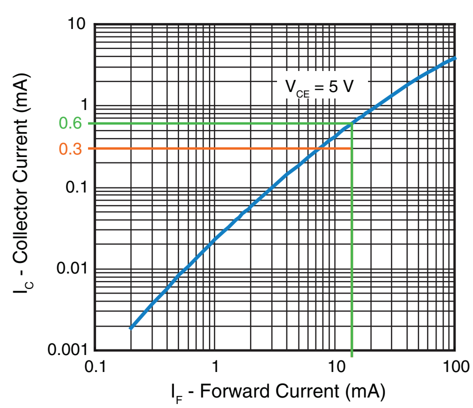


Fig. 1 - Collector Current vs. Forward Current

TCUT1350X01, TCPT1350X01, TCUT1600X01, TCPT1600X01

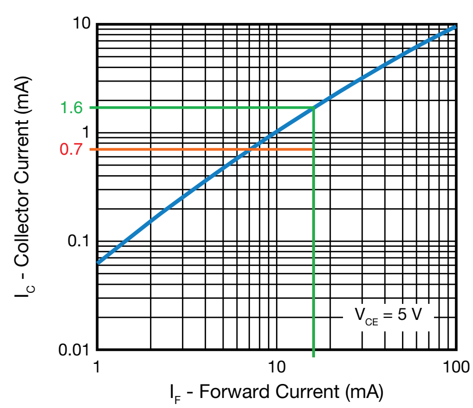


Fig. 2 - Collector Current vs. Forward Current

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

DETERMINING THE FORWARD CURRENT FOR THE IRED AND THE LOAD RESISTOR FOR THE PHOTOTRANSISTOR

Beside these tolerances, one also needs to see the typical temperature behavior:

TCUT1300X01, TCPT1300X01

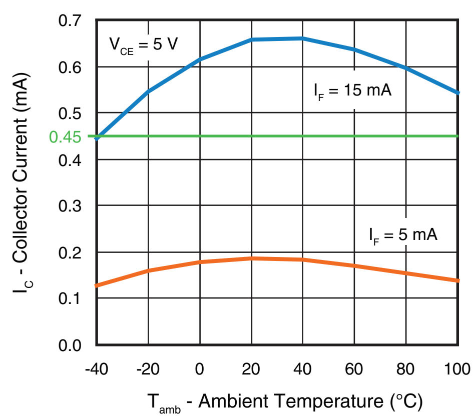


Fig. 3 - Collector Current vs. Ambient Temperature

TCUT1350X01, TCPT1350X01, TCUT1600X01, TCPT1600X01

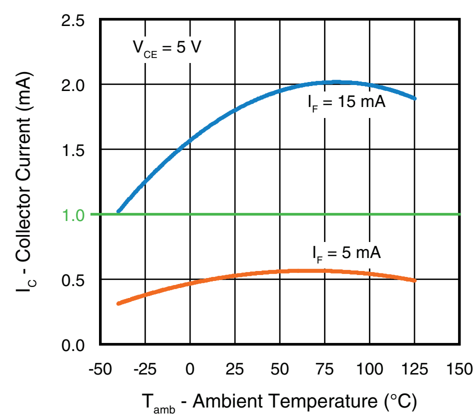


Fig. 4 - Collector Current vs. Ambient Temperature

The TCUT1300X01 and TCPT1300X01 show for -40 °C an I_C of 0.45 mA. 0.65 mA is typical for 25 °C, so this value is about 30 % less. For specified minimum current it would then be just 0.3 mA - 30 % = 0.21 mA.

For the TCUT1350X01, TCPT1350X01, TCUT1600X01, and TCPT1600X01 this is different.

Here for -40 °C an I_C of 1 mA is seen. 1.6 mA is typically seen for 25 °C, so this value is about 40 % less. Calculating here also with minimum specified data, it will lead to 0.7 mA - 40 % = 0.42 mA.

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

DETERMINING THE FORWARD CURRENT FOR THE IRED AND THE LOAD RESISTOR FOR THE PHOTOTRANSISTOR

The degradation of the IRED also needs to be seen. Dealing here with about 5 % will be sufficient for a normal operation profile over the whole lifetime of > 12 years.

A typical circuit will look like the example below. The resistor defining the forward current would then be:
R_E = (5 V - 1.2 V)/15 mA = 253 Ω. A bit lower normed value will be: 240 Ω.

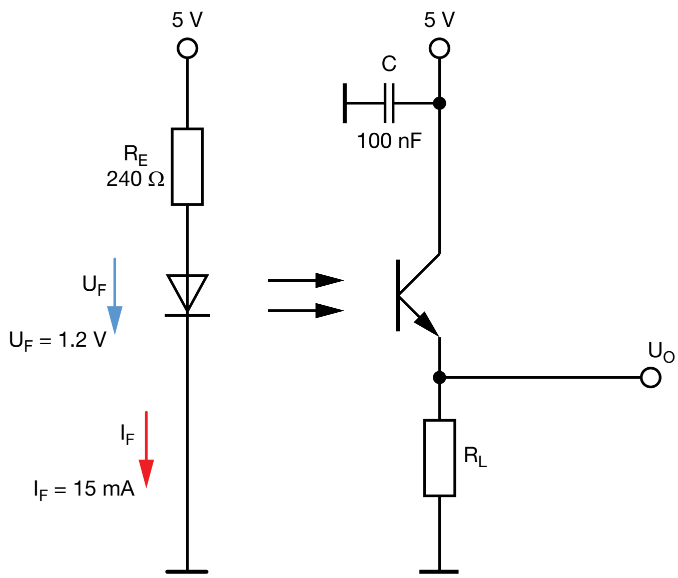


Fig. 15

The load resistor value is now dependant on the wanted and needed output voltage. If it needs to deliver a high level to fulfill the input conditions of the following circuitry, e.g. $U_O \geq$ 4.6 V, it would need to be quite high-ohmic.

With having all tolerance in mind, one should just calculate with 0.2 mA (for the TCUT1300X01 and TCPT1300X01) and with 0.46 mA for the TCUT1350X01, TCPT1350X01, TCUT1600X01, and TCPT1600X01.

This leads to a load resistor value of: 4.6 V/0.2 mA = 23 kΩ, so, a $R_L \geq$ 24 kΩ should be used for the TCUT1300X01 and TCPT1300X01 and 4.6 V/0.46 mA = 10 kΩ for the TCUT1350X01, TCPT1350X01, TCUT1600X01, and TCPT1600X01.

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

TIME-CRITICAL APPLICATIONS

To suppress possible ambient distortions and also improve switching times, it is wise to choose the lowest possible resistor value.

An output voltage of even less than 1 V will be enough for either a following A/D input or a simple transistor stage.

So, R_L could be about: R_L = 1 V/ 0.2 mA = 5 kΩ (for the TCUT1300X01 and TCPT1300X01) and R_L = 1 V/0.46 mA = 2.2 kΩ (for the TCUT1350X01, TCPT1350X01, TCUT1600X01, and TCPT1600X01)

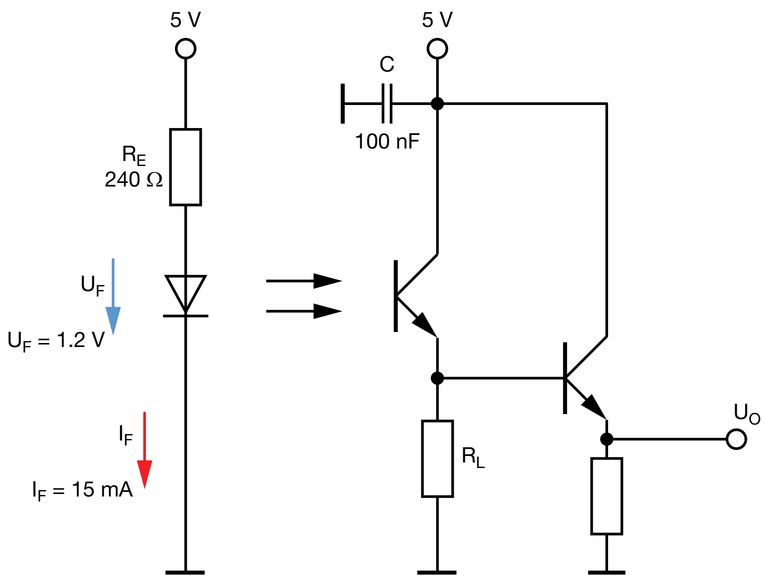


Fig. 16

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

TIME-CRITICAL APPLICATIONS

The TCUT1300X01 and TCPT1300X01 show a typical rise / fall time of 20 µs / 30 µs:

SWITCHING CHARACTERISTICS						
PARAMETER	**TEST CONDITION**	**SYMBOL**	**MIN.**	**TYP.**	**MAX.**	**UNIT**
Rise time	I_C = 0.3 mA, V_{CE} = 5 V, R_L = 100 Ω (see Fig. 6)	t_r	-	20	150	µs
Fall time	I_C = 0.3 mA, V_{CE} = 5 V, R_L = 100 Ω (see Fig. 6)	t_f	-	30	150	µs

The TCUT1350X01, TCPT1350X01, TCUT1600X01, and TCPT1600X01, as well as the TCUT1800X01 and TCUT1630X01 discussed later in this document, are specified with lower timings:

SWITCHING CHARACTERISTICS						
PARAMETER	**TEST CONDITION**	**SYMBOL**	**MIN.**	**TYP.**	**MAX.**	**UNIT**
Rise time	I_C = 0.7 mA, V_{CE} = 5 V, R_L = 100 Ω (see Fig. 6)	t_r	-	9	150	µs
Fall time	I_C = 0.7 mA, V_{CE} = 5 V, R_L = 100 Ω (see Fig. 6)	t_f	-	16	150	µs

For all devices this is valid only with the test circuit shown, typical collector current, and at T_{amb} = 25 °C.

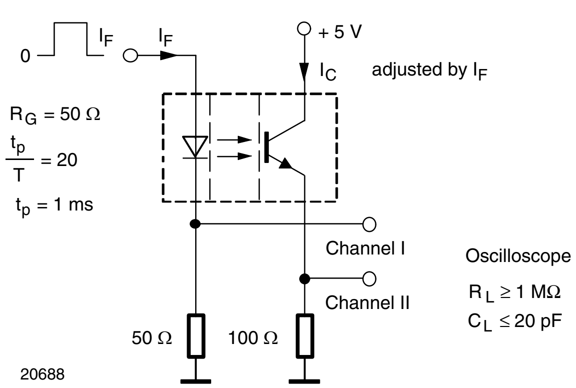


Fig. 5 - Test Circuit for t_r and t_f

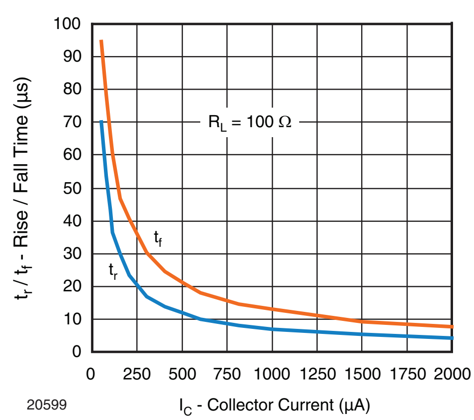


Fig. 6 - Rise / Fall Time vs. Collector Current

For higher load resistors = lower collector current, significantly higher timings will be seen, as also indicated within Fig. 22.

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

TIME-CRITICAL APPLICATIONS

For higher temperatures these timings will also increase. For a quite low load resistor of just 1 kΩ, specified typical values of 20 μs / 30 μs will also at 25 °C show already 27 μs / 43 μs, but for T_{amb} = 80 °C these may be as high as 38 μs (t_r) and 65 μs (t_f).

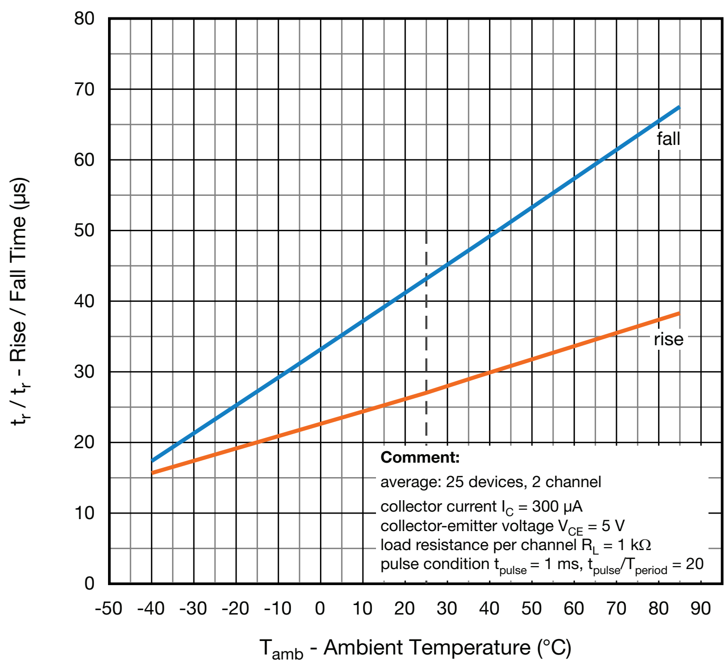


Fig. 7 - Rise / Fall Time vs. Ambient Temperature

With a load resistor of 22 kΩ the “ON” time will not increase that much, but the “OFF” time is ten times higher to about 270 μs, and this is already at T_{amb} = 25 °C. With 47 kΩ, again about a factor of three for fall time will be seen, so about 800 μs.

For an operation temperature of 85 °C this will increase then to about 1 ms, and for lower collector currents either due to a device coming with a specified minimum value or operating with lower forward current, this may again be doubled.

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

OPERATING WITH LOW FORWARD CURRENTS

Some applications may need to design the circuitry for the lowest-possible current consumption. All IR emitter diodes should work with a defined minimum forward current to deliver stable optical output. For the reflective sensors it should be ≥ 3 mA.

For lower emitter currents the typical CTR may also be different and the provided graph (I_C vs. I_F) may show different behavior. So, it is not possible to assume that a parallel line within the I_C vs. I_F graph could show the correct collector current.

TCUT1300X01, TCPT1300X01

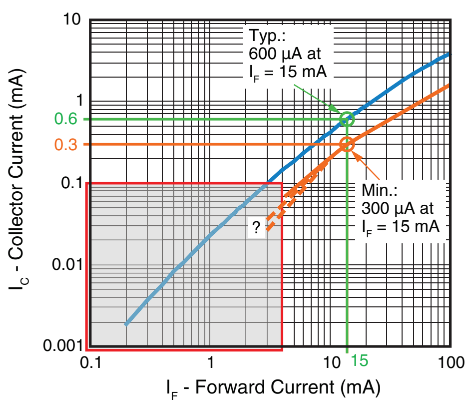


Fig. 8 - Collector Current vs. Forward Current

TCUT1350X01, TCPT1350X01, TCUT1600X01, TCPT1600X01

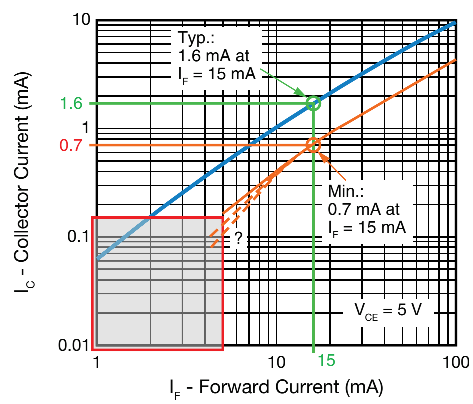


Fig. 9 - Collector Current vs. Forward Current

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

AMBIENT LIGHT DISTURBANCES

The sensors may also be used under critical light conditions. Some daylight or other light sources may be around and could affect the phototransistor, as this is not equipped with any filter. Due to the construction requirements, it is not possible to have a daylight filter added here.

A wide bandwidth will also allow for possible ambient light distortions.

The spectral bandwidth curve looks similar to the graph below (same phototransistor chip):

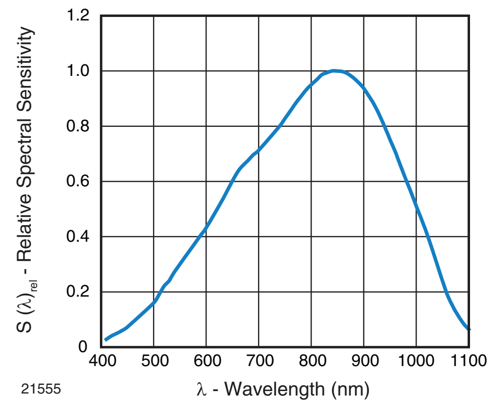


Fig. 10 - Relative Spectral Sensitivity vs. Wavelength

BASIC CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)						
PARAMETER	**TEST CONDITION**	**SYMBOL**	**MIN.**	**TYP.**	**MAX.**	**UNIT**
Wavelength of peak sensitivity		λ_p	-	825	-	nm
Range of spectral bandwidth		$\lambda_{0.1}$	-	440 to 1070	-	nm

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

AMBIENT LIGHT DISTURBANCES

Light with wavelengths higher than 450 nm will disturb the TCxTs because of their wide spectral sensitivity shown in Fig. 30. Even green LEDs distributing light at about 520 nm. White LEDs show a wide wavelength range - besides a blue peak at about 450 nm - mainly from 520 nm to 630 nm.

The relative spectral sensitivity of the photodetectors used within the TCxTs will recognize this with about 10 % to 50 % of its max. sensitivity.

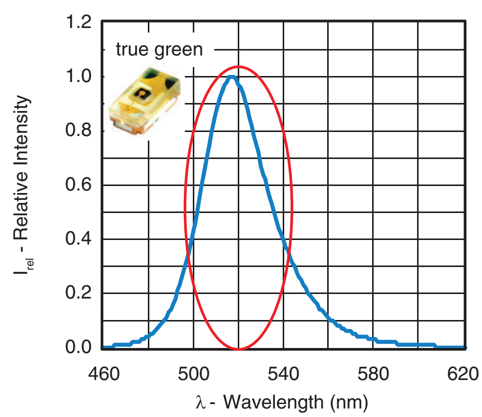


Fig. 11 - Relative Intensity vs. Wavelength (true green)

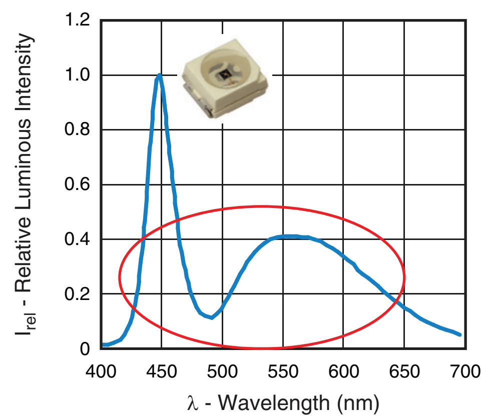


Fig. 12 - Relative Intensity vs. Wavelength

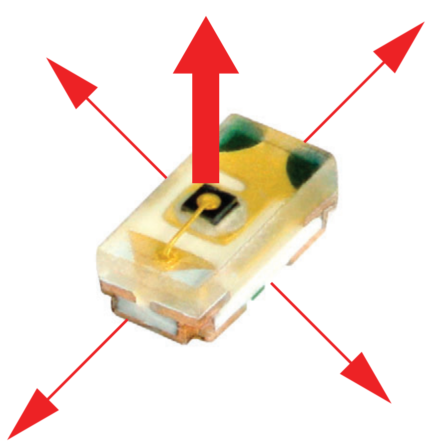


Fig. 17

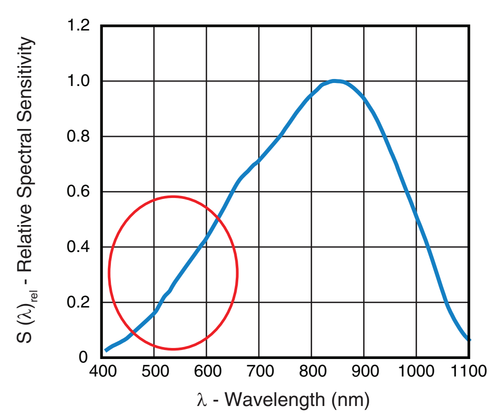


Fig. 13 - Relative Spectral Sensitivity vs. Wavelength

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

AMBIENT LIGHT DISTURBANCES

Very closely positioned red (or even white) LEDs could disturb the TCxTs detector, because all LEDs / IREDs send out light to all sides and there is no filter within the TCxTs.

Directing the LEDs straight to the TCxTs detector should be avoided.

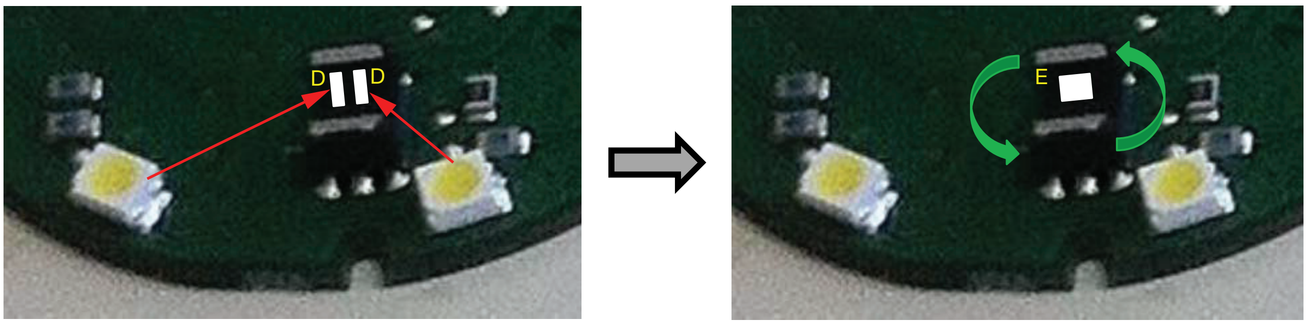


Fig. 18

One possible improvement could be to turn the TCxTs around. That would avoid the possibility that the LEDs reach the photodetector(s) (D) directly.

Too wide slots of the code wheel for the TCxTs detector should be avoided.

An improvement could be to reduce the width of the openings / slots. That would avoid the possibility that the LEDs reach the photodetector(s) (D) directly.

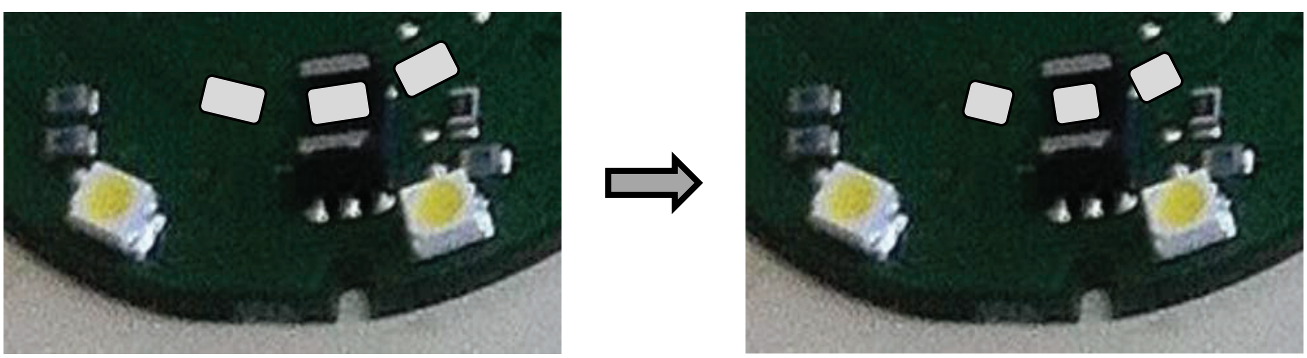


Fig. 19

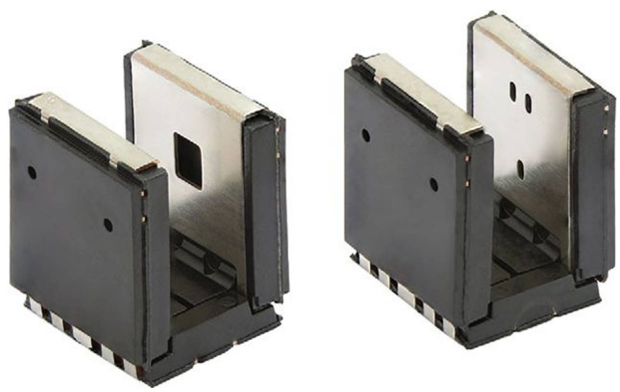
Also, a quite high forward current for the TCxTs emitter and a low load resistor value at the detector side would help to reduce sensitivity to stray light.

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

TRANSMISSIVE SENSORS TCUT1630X01 AND TCUT1800X01

In addition to the TCxT1300X01, the TCxT1350X01, and the TCxT1600X01 there are now also new devices: TCUT1630X01 and TCUT1800X01. These new ones offer one additional detector within TCUT1630X01 and even two additional detectors plus also one additional emitter within TCUT1800X01.

TCUT1630X01 (TRIPLE CHANNEL)



- Package type: surface-mount
- Detector type: phototransistor
- Dimensions (L x W x H in mm): 5.7 x 5.9 x 7.1
- AEC-Q101 qualified
- Gap (in mm): 3
- Aperture (in mm): 0.3
- Typical output current under test: I_C = 1.3 mA
- Emitter wavelength: 950 nm
- Lead (Pb)-free soldering released
- Moisture sensitivity level (MSL): 1
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

TCUT1800X01 (QUAD CHANNEL)

- Package type: surface-mount
- Detector type: phototransistor
- Dimensions (L x W x H in mm): 5.7 x 5.9 x 7.1
- AEC-Q101 qualified
- Gap (in mm): 3
- Aperture (in mm): 0.3
- Typical output current under test: I_C = 1.3 mA
- Emitter wavelength: 950 nm
- Lead (Pb)-free soldering released
- Moisture sensitivity level (MSL): 1
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

These new devices come with one or two more detectors respectively and the TCUT1800X01 also with one additional emitter.

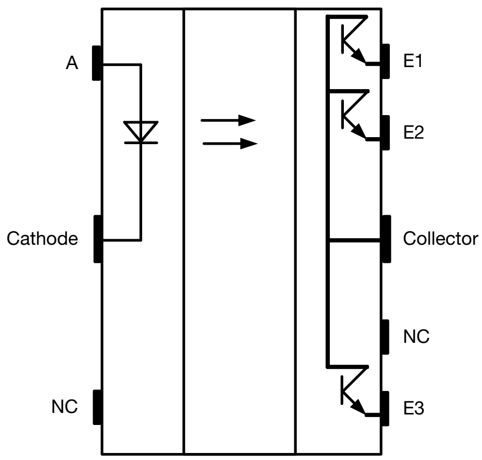


Fig. 14 - TCUT1630X01

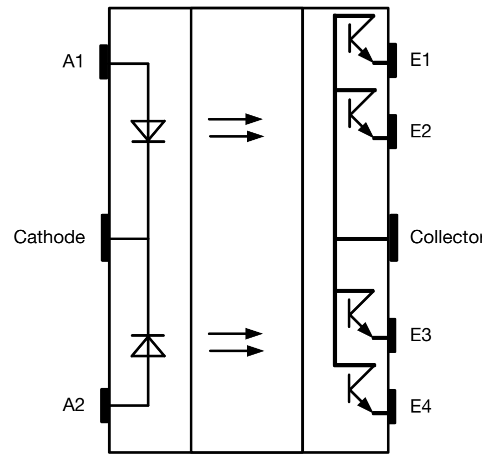


Fig. 15 - TCUT1800X01

So for these new devices a bigger package footprint was needed. The new package dimensions are now (L x W x H in mm): 5.7 x 5.9 x 7.1

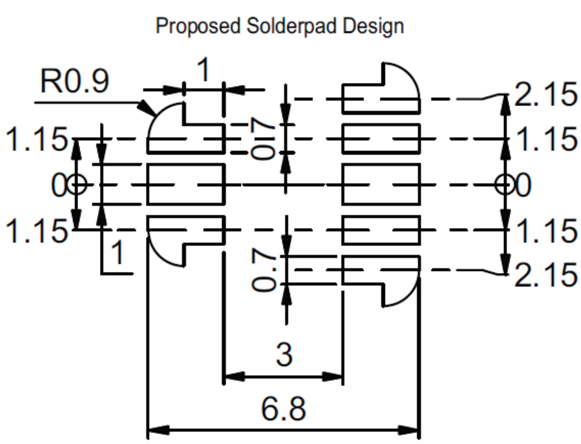


Fig. 16 - TCUT1630X01

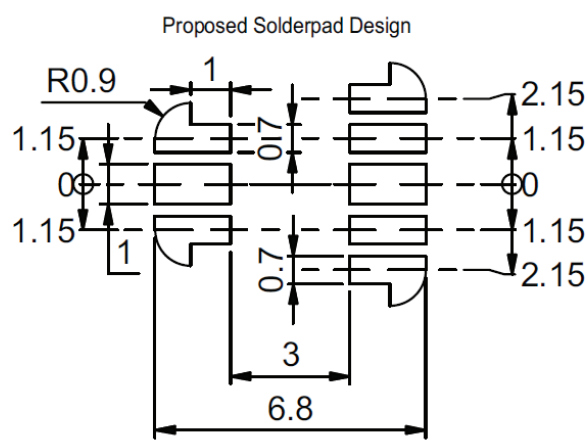


Fig. 17 - TCUT1800X01

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

For these new devices, TCUT1630X01 and TCUT1800X01, the optical axes have also changed. All versions before have the emitter straight across from the detectors, so on the same optical axis:

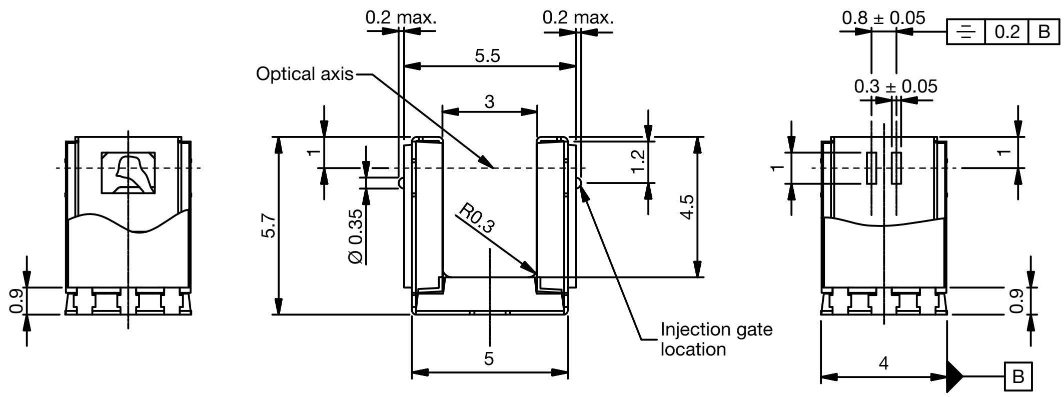


Fig. 20

Now, for these new devices, TCUT1630X01 and TCUT1800X01, the optical axes are at an angle, due to the off axis position of the emitter with regard to the detector chips:

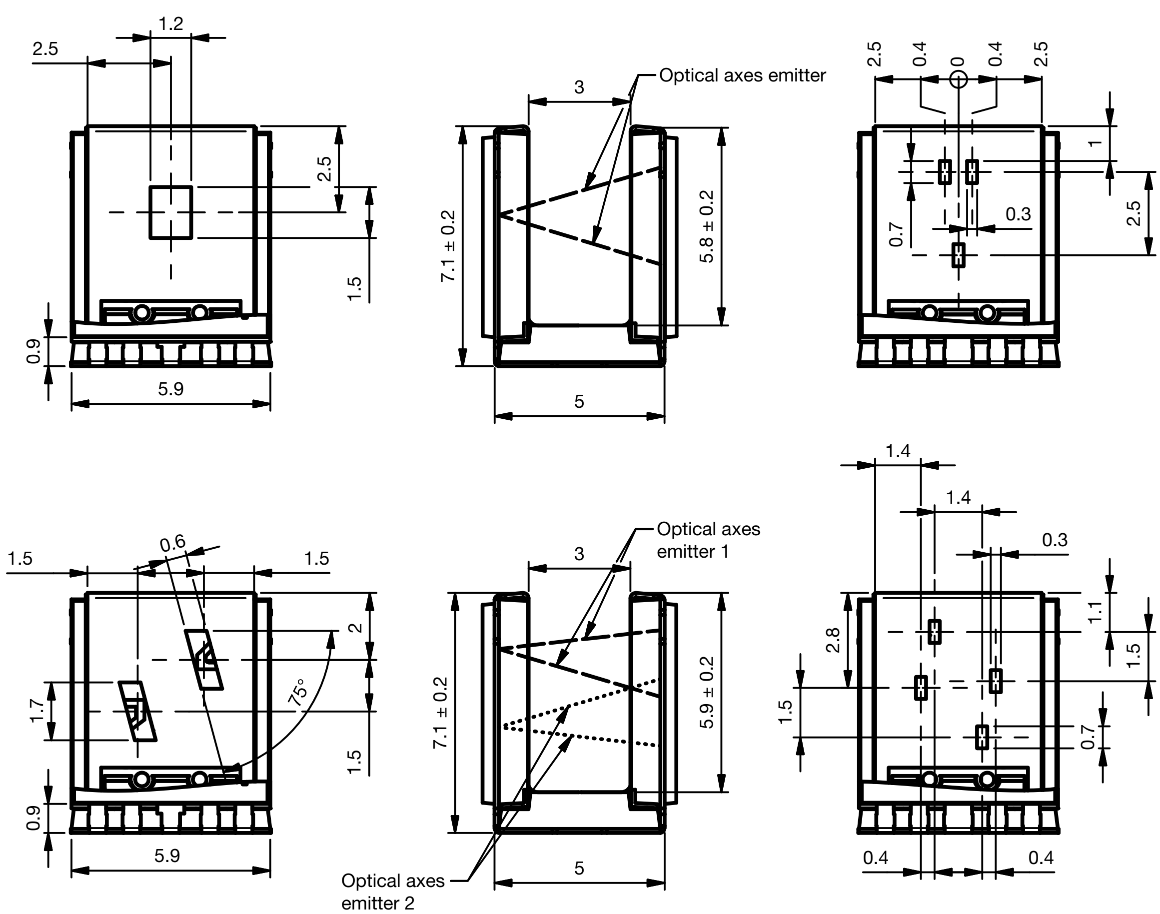


Fig. 21

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

The smaller apertures and the fact that the emitters are no longer on the same optical axis as the detectors are the reasons that for both the TCUT1630X01 and the TCUT1800X01 the collector current is a bit lower, typical 1.3 mA instead of 1.6 mA:

ELECTRICAL CHARACTERISTICS (T_{amb} = 25 °C, unless otherwise specified)						
PARAMETER	**TEST CONDITION**	**SYMBOL**	**MIN.**	**TYP.**	**MAX.**	**UNIT**
COUPLER						
Collector current per channel	V_{CE} = 5 V, I_F = 15 mA	I_C	0.45	1.3	-	mA

The temperature behavior is almost identical to the TCxT1350X01 and TCxT1600X01, just the nominal collector current is different.

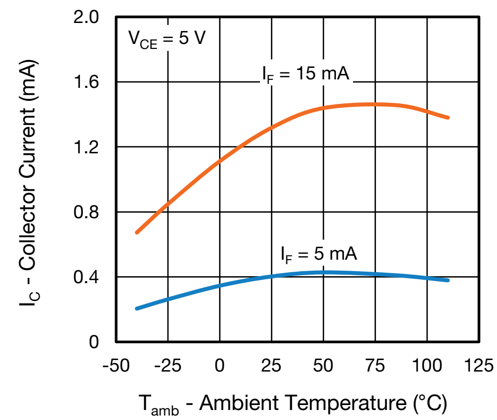


Fig. 18 - Collector Current vs. Ambient Temperature

Also the timing behavior is almost identical to the TCxT1350X01 and TCxT1600X01, as shown before on pages 19 to 21.

The mentioned precautions against disturbances from ambient light shown on pages 23 to 25 should also be taken into consideration when designing with the TCUT1630X01 or TCUT1800X01.

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

Also these “Displacement” figures look different because the arrangement of emitters and detectors are different. Here for the TCUT1630X01:

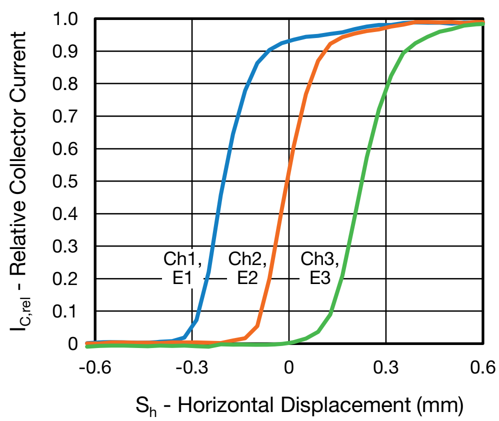


Fig. 19 - Relative Collector Current vs. Horizontal Displacement Horizontal Shutter (0.25 mm thickness)

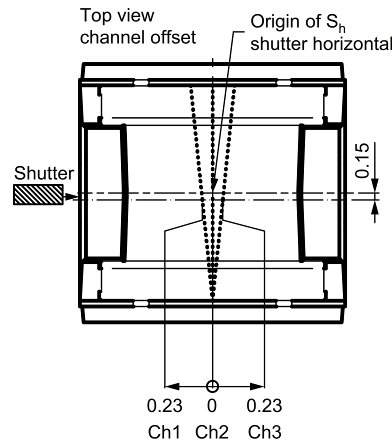
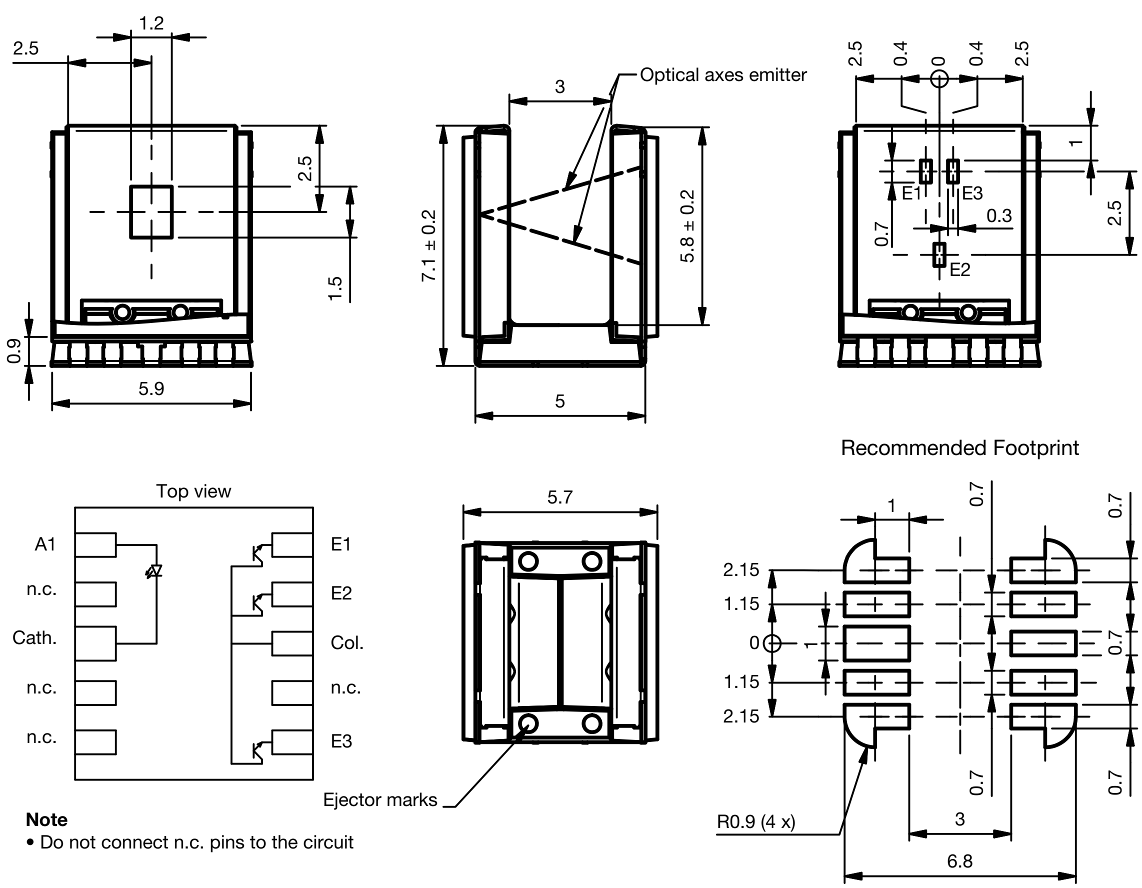


Fig. 20 - Top View Sensor Channel Positions and Origin of Horizontal Shutter



Note
- Do not connect n.c. pins to the circuit

Fig. 22

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

And these "Displacement" figures are very different for the TCUT1800X01, because of the new arrangement of now two emitters and four detectors.

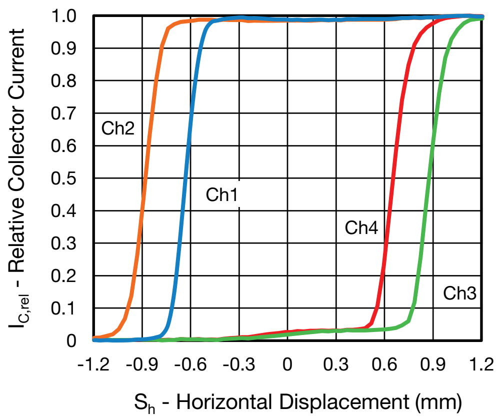


Fig. 21 - Relative Collector Current vs. Horizontal Displacement Horizontal Shutter (0.25 mm thickness), tolerances ± 0.2 mm

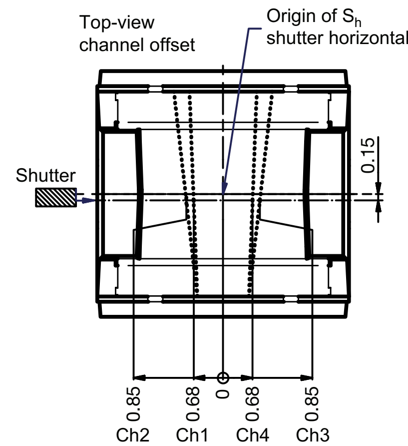


Fig. 22 - Top View Sensor, Channel Positions and Origin of Horizontal Shutter, tolerances ± 0.2 mm

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

For this TCUT1800X01 the arrangement of the emitter and detector apertures need to be closely analyzed, such that the order of signal response when an object passes through the sensor is understood.

To aid this understanding, its best to look at the following cross sections showing the internal view of the emitter side, the side view of the component as a whole and the view of he detector side with the emitter apertures superimposed over the detector apertures:

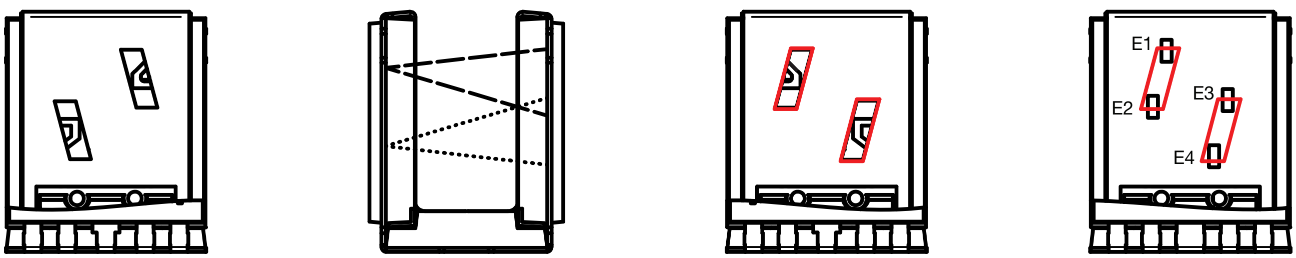


Fig. 23

When this shutter (light blocking element) is shifted through the TCUT1800X01 horizontaly, channel 2 (E2) will first get opened and collector current for channel 2 will rise-up, then channel 1 just about 0.2 mm later. Channel 4 will need about additional 1.3 mm before current is flowing and channel 3 with same distance as before between channel 2 and 1.

One needs also to see the placement of the shutter within the gap.

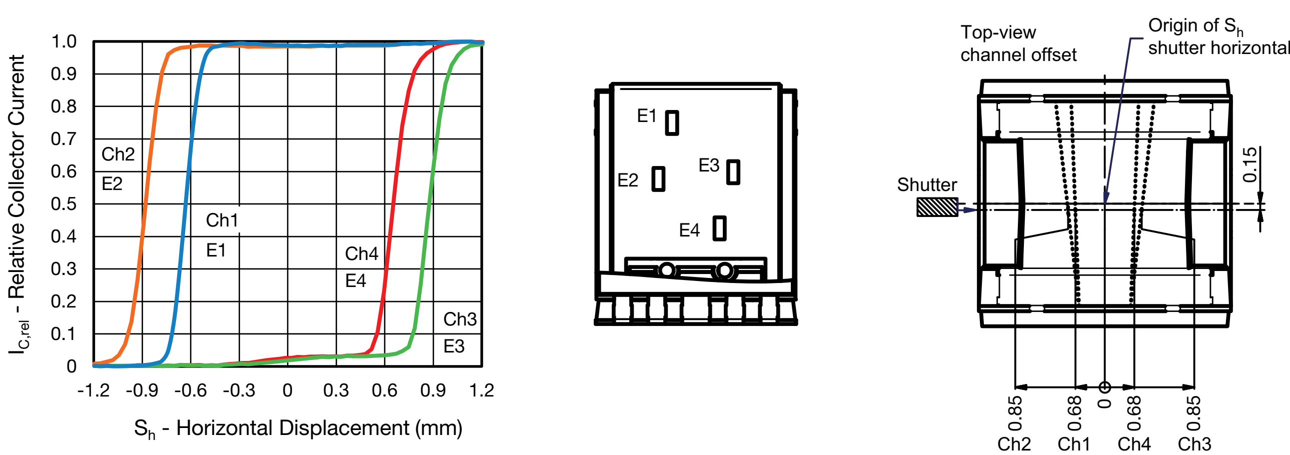


Fig. 24

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

For vertical displacement Ch1 (E1) and Ch2 (E2) are driven by the upper emitter of the TCUT1800X01 and Ch3 (E3) plus Ch4 (E4) from the lower one.

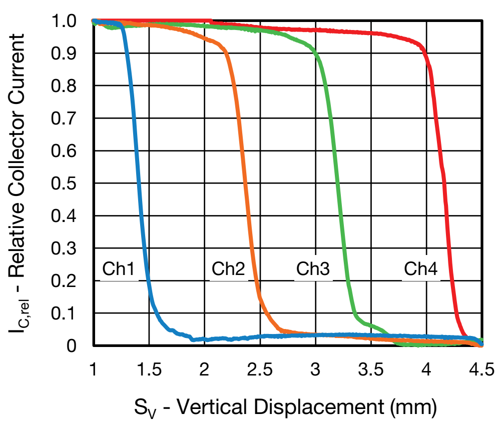


Fig. 23 - Relative Collector Current vs. Vertical Displacement Vertical Shutter (0.25 mm thickness), tolerances ± 0.2 mm

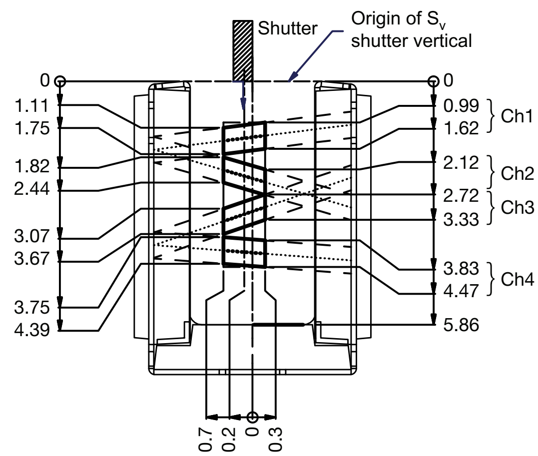
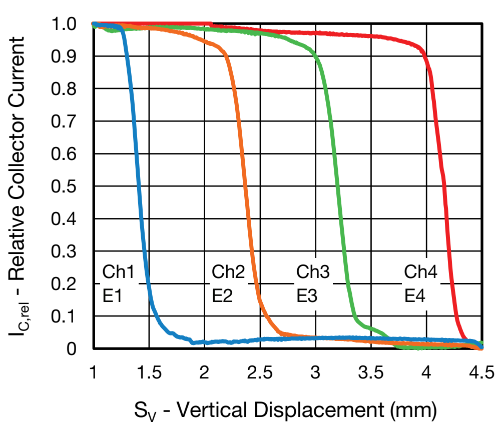


Fig. 24 - Top View Sensor, Channel Positions and Origin of Vertical Shutter, tolerances ± 0.2 mm



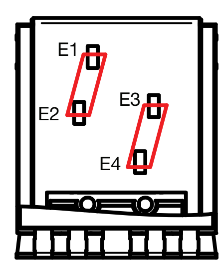


Fig. 25

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

The footprint for the TCUT1800X01 is identical to that the TCUT1600X01, just the added Channel 4 (E4) is now available where for the TCUT1630X01 "n.c." is shown.

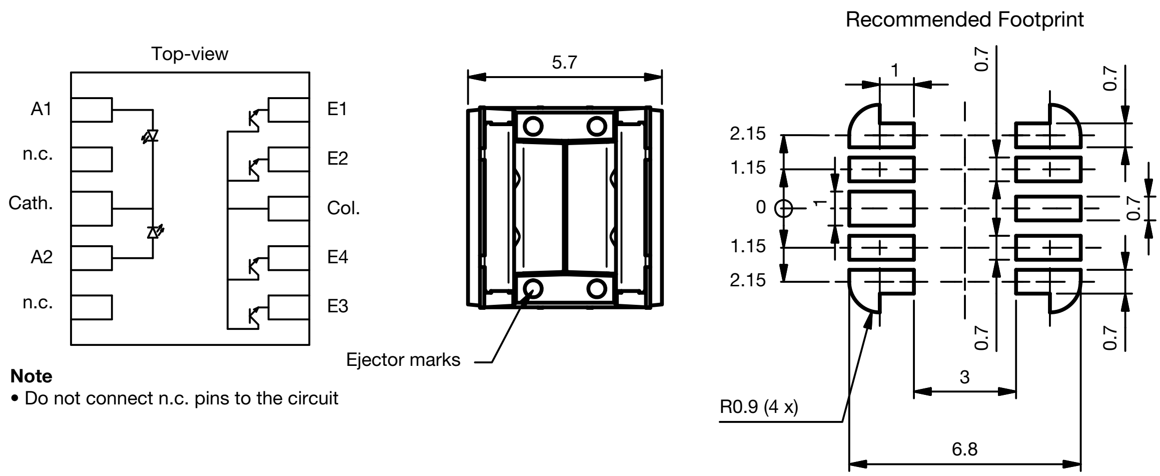


Fig. 26

Hardware Description and Design-In Proposals for SMD Transmissive Sensors

Possible circuitries for TCUT1630X01 and TCUT1800X01:

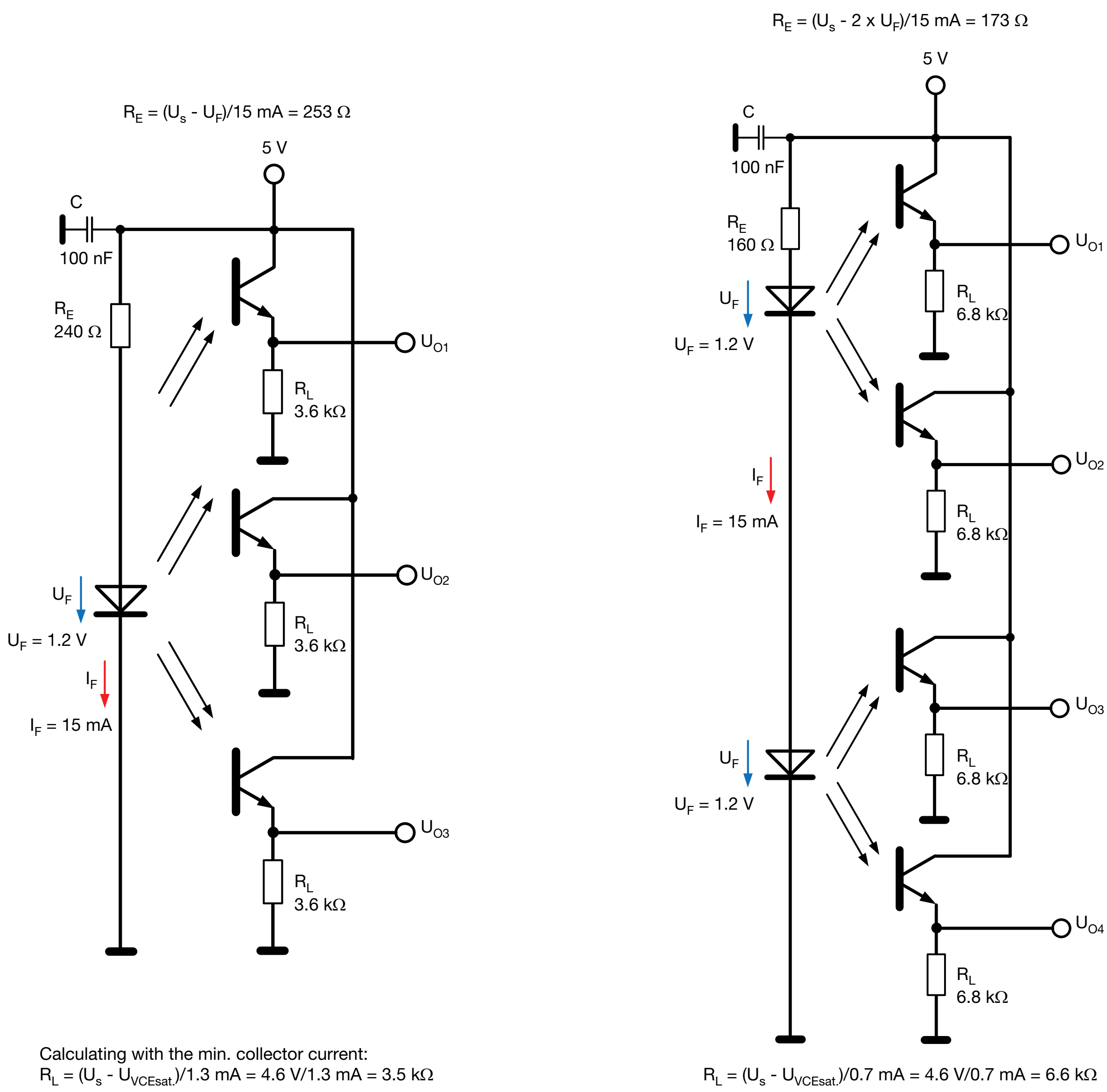


Fig. 27

For encoding and code wheel proposal please see also the dedicated application note.

For the TCUT1630X01: www.vishay.com/doc?84905

and for the TCUT1800X01: www.vishay.com/doc?84906