OSRAM
Opto Semiconductors

Ambient light sensor SFH5701

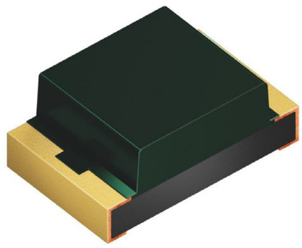
Application Note

Valid for:
SFH5701 (and its derivatives)

Abstract

The SFH5701 is a small, two-wire, linear output current ambient light sensor (ALS) with current amplifier and dark current compensation. The ALS is capable of resolving a wide range of ambient light levels (10 mlx – 10 klx) tailored to the spectral response of the human eye and operational from -40 °C to 100 °C.

This application note describes the device operation and application methods.



Further information:
Ambient light sensors – general application note
High-accuracy ambient light sensor SFH 5711
Overview ALS portfolio

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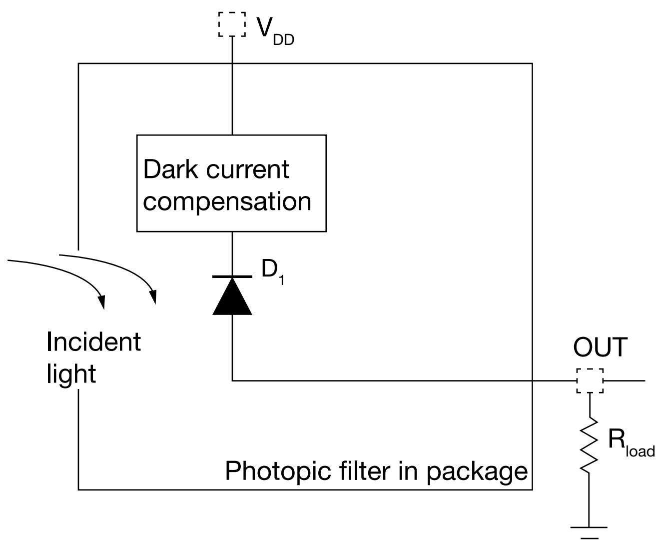
A. Overview

The SFH5701 generates a linear output current with incident light with a sensitivity of typically 1 µA/ lx. The part operates with 1.45 V to 5.5 V (VDD to output pin) and requires up to 10 mA at maximum illuminance. The package comes with a built-in IR light filter to optimize the response to the human eye.

Figure 1: SFH5701 block diagram



The definition of polarities for supply voltage (VDD), supply current (IDD), forward voltage (VF) and forward current (IF) are depicted in Figure 2.

Figure 2: Definition of polarities for supply voltage, supply current, forward voltage and forward current.

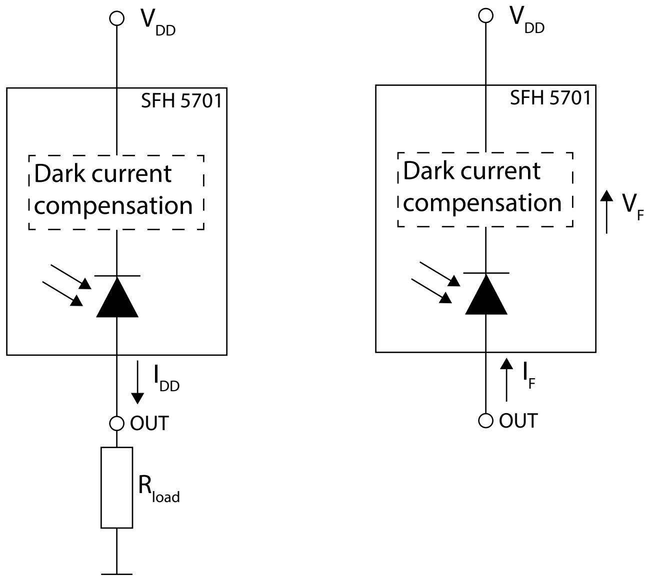


Table 1 shows typical key specifications for the SFH5701 ambient light sensor at 25°C.

Table 1: SFH5701 typical key specifications at 25 °C

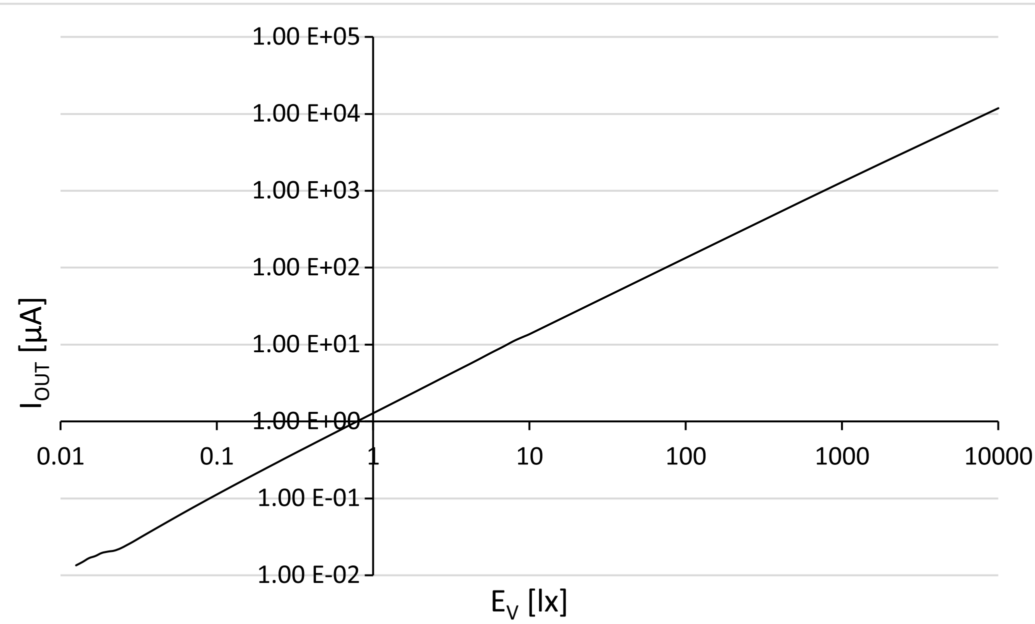
Parameter		**Symbol**	**Values**	**Unit**
Spectral sensitivity (V_{DD}=5 V, E_V=100 lx (white LED))	(typ)	S	1	µA/ lx
Wavelength of max. sensitivity	(typ)	$\lambda_{S\ max}$	600	nm
Spectral range of sensitivity	(min) (max)	$\lambda_{10\%}$ $\lambda_{10\%}$	450 705	nm nm
Dimensions of radiant sensitive area	(typ)	L x W	0.75 x 0.75	mm x mm
Half angle	(typ)	Φ	± 60	°
Output impedance	(typ)	Z_{OUT}	10	MΩ
Forward voltage (I_F=200 µA, E=0)	(typ)	V_F	0.52	V
Rise time (R_L=33 kΩ, E_V=100 lx, (for different testing conditions refer to Figure 9))	(typ)	t_r	14	ms

Table 1: SFH5701 typical key specifications at 25 °C

Parameter		Symbol	Values	Unit
Output dark current (E_V=0 lx)	(typ) (max)	$I_{OUT\ dark}$ $I_{OUT\ dark}$	3.3 50	nA nA
Temperature coefficient	(typ)	$T_{C\ IOUT}$	- 0.06	%/ K
Operating temperature range			- 40 to 100	°C
Output voltage range	(typ)	Vout	0 to (V_{DD} -1.45)	V
Max. linear output current E_V=10 klx (white LED)	(typ)	IDD $_{max}$	10	mA
Supply current E_V=100 lx (white LED)	(typ)		115	µA
Detection range	(typ)		0.01 - 10 k	lx

Figure 3 shows the output current versus the light intensity as a straight line (log-log plot) with a gradient of ~1, indicating a linear response to light over 5 decades with a typical sensitivity S of 1 µA/ lx.

Figure 3: Output current versus incident light intensity



Above operating temperature, the lowest value of luminance detectable by the SFH5701 is determined by the dark current of the device at that temperature. The minimum detectable luminance increases with increasing temperature as shown in Figure 4. In addition, the dark current is also influenced by the voltage drop across the device (x-axis in Figure 4).

Figure 4: Dark current versus VDD for various temperature

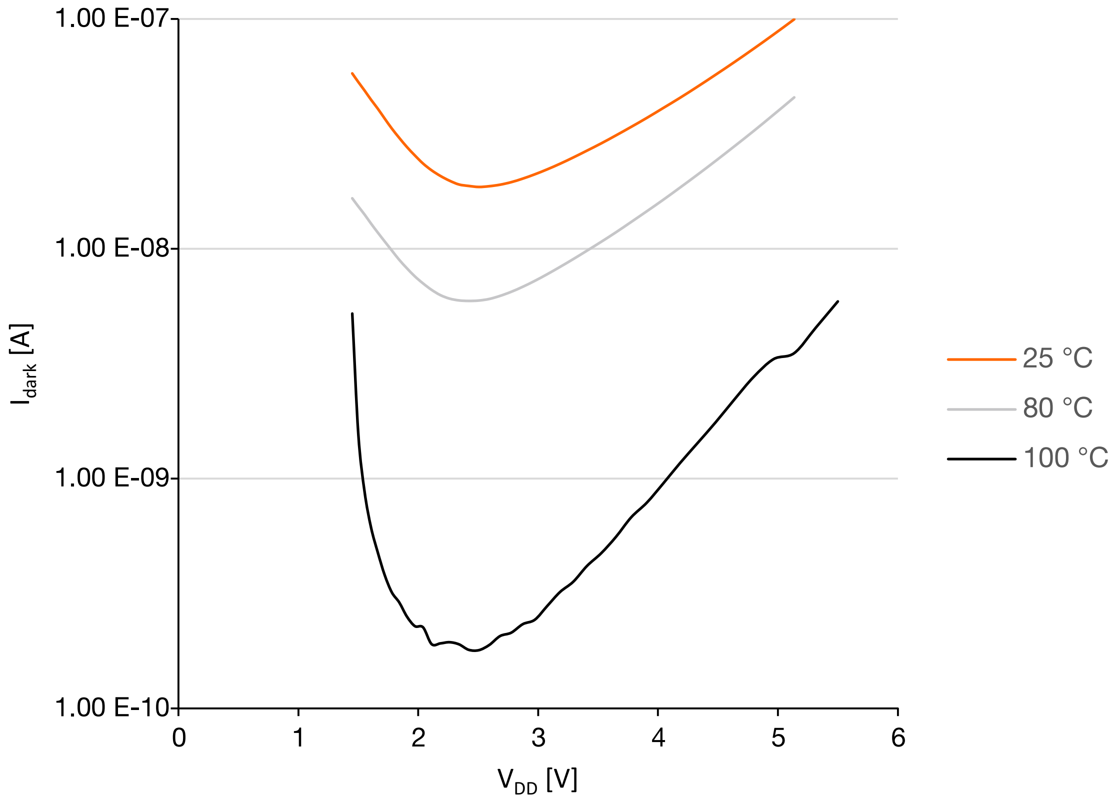


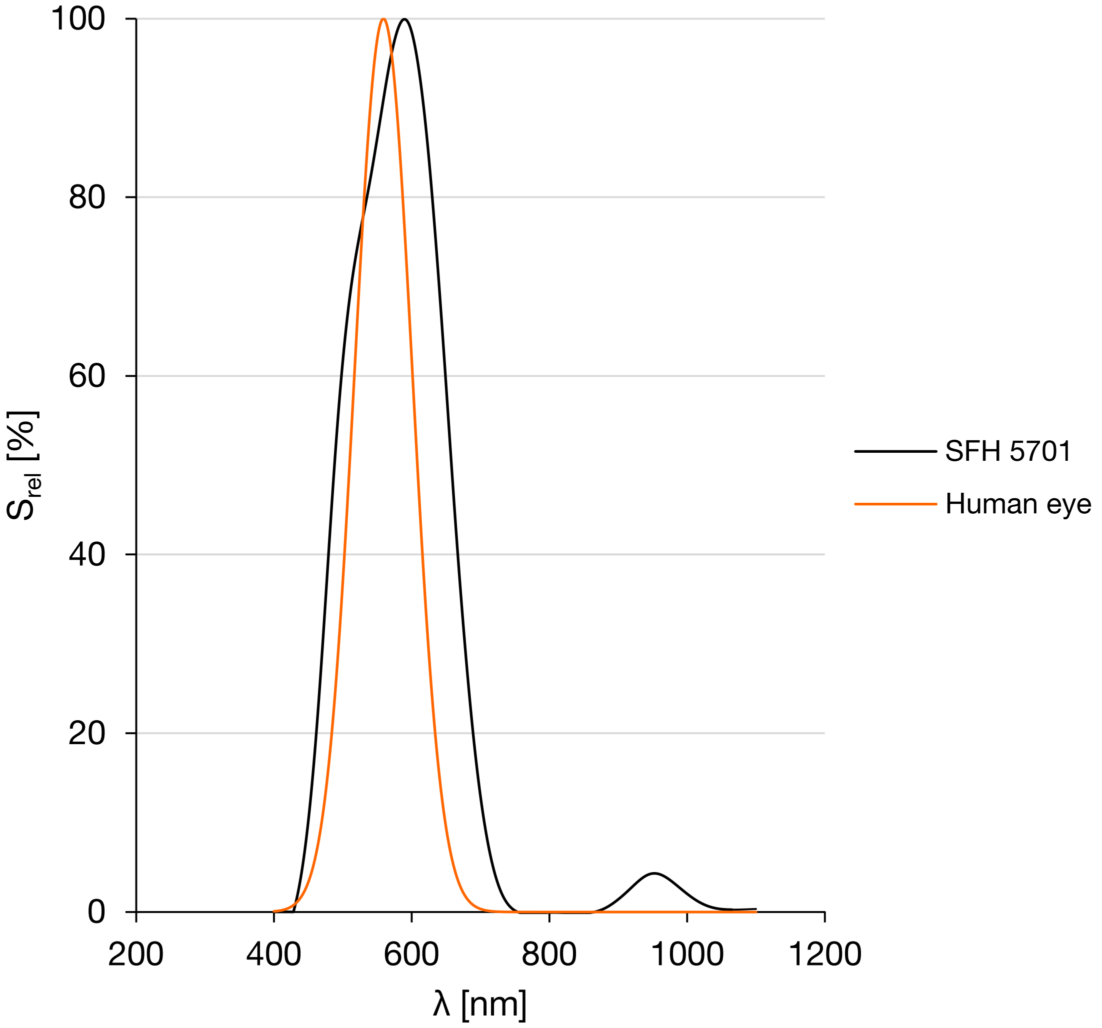
Table 2 shows some examples of the typical illuminance under various conditions (taken from the application note "Ambient light sensors — general application note" from OSRAM Opto Semiconductors and Wikipedia):

Table 2: Illuminance value examples

Light source	**Brightness (lx)**
Full moon on a clear night	0.05-0.3
Candle (1 m distance)	1
Street light at street level	20
Office desk lighting	300
Overcast day	3,000
Day with clouds ans sunshine	20,000
Direct sunlight	100,000

Figure 5 shows that the spectral response of the SFH5701 matches the human eye sensitivity well. Even though the sensitivity at 940 nm is only a few percent, visible light cut-off and IR transmissive cosmetic cover materials can increase the influence of the 940 nm sensitivity.

Figure 5: SFH5701 spectral response

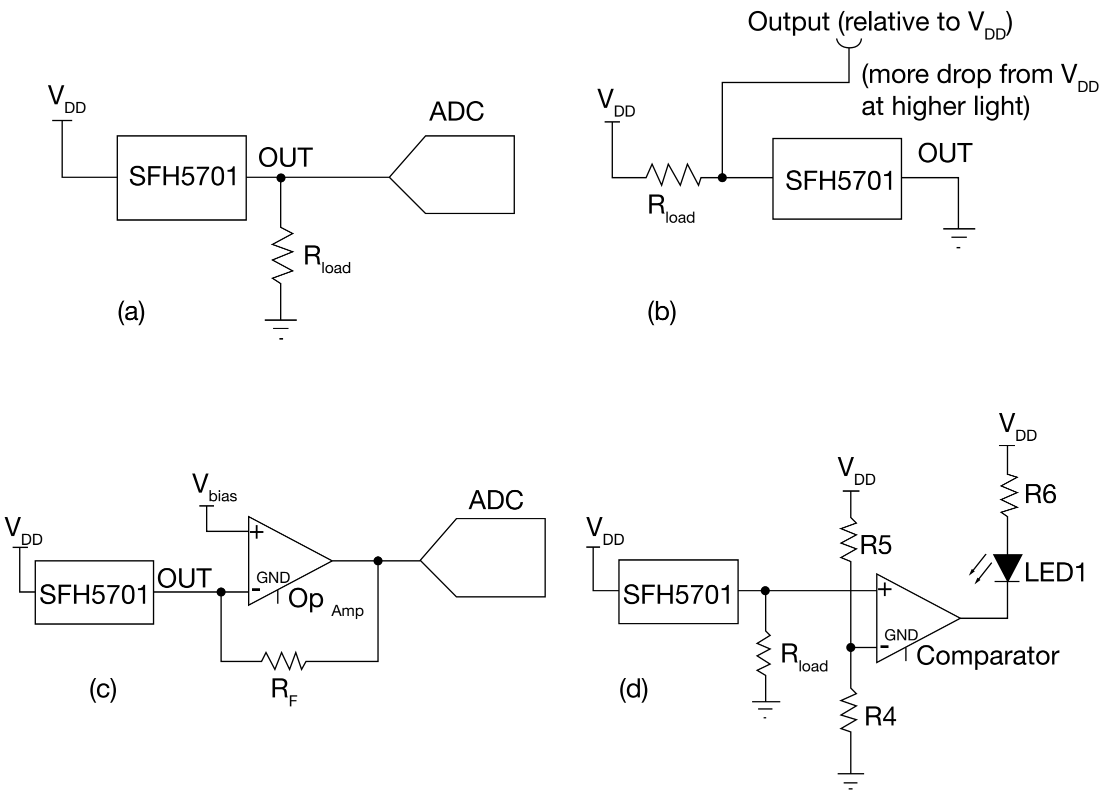


B. Output interface

Common methods

Figure 6 shows common methods of interfacing the SFH5701.

Figure 6: Common interfaces for ALS

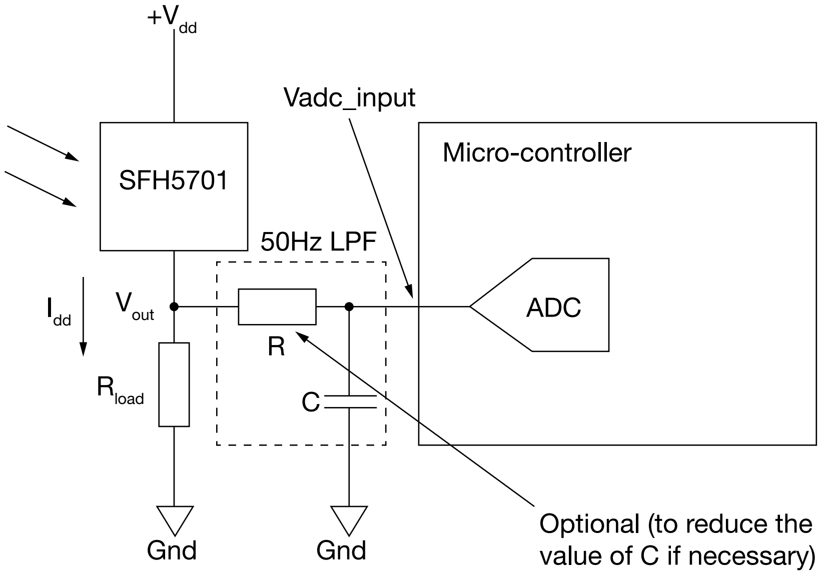


In most applications, the SFH5701 interfaces directly with an ADC (Figure 6a). Alternatively, the setup shown in Figure 6b can produce an output voltage referenced to VDD (decreasing relative to the incident light). Combined with a low input current Op $_{Amp}$, it is also possible to use the SFH5701 in a TIA (trans-impedance amplifier) configuration (Figure 6c) which can gain-up the output current. This configuration is recommended for low light conditions to reduce the output current variation by keeping a constant voltage drop across the device (VDD – V_{bias}), and to minimize the impact of the ADC input leakage / bias current which could be comparable to the device current. Figure 6d shows a light level detector where the LED switches on when the light intensity falls below a certain level determined by the voltage on the negative terminal of the comparator.

As shown in Figure 7, additional low pass filters (LPF, R & C) can be easily implemented to de-sensitize the circuit to pulsed light (such as LED lights with PWM control). In this case, 50 Hz is chosen to ensure that most building lighting fluctuations can be filtered out. With higher switching frequencies (e.g. electronic ballasts operating above the audible range, ~25 kHz), the SFH5701 upper frequency limit precludes the need for an LPF, even though having one in place does not affect performance.

In this case, the ALS only responds to the “RMS” value of the ambient light and is impervious to the pulsating light.

Figure 7: Typical interface to ADC with LPF



Output interface design notes

1. R_{load} selection: Choose the value of R_{load} to comply with the ADC full scale (FS) voltage. Most designs use 90 % of FS voltage for the maximum light intensity condition. Bear in mind that the SFH5701 requires 1.45 V minimum headroom (VDD – V_{OUT}) and if necessary reduce R_{load}.

2. LPF selection: Choose the components R and C for 50 Hz roll-off frequency:

   $$f_{roll\text{-}off} = \frac{1}{2\Pi R_{eq} C}$$, where $R_{eq} = R_{load} + R$

Table 3 shows four different examples to provide more clarity. The use of the highlighted value of R_{load} is recommended.

Table 3: Examples of R_{load} and LPF values

Entry #	Max. Light (lx)	Vdd (V)	FS (V)	Idd (A)	R_{load} Selection		LPF Selection	
					For output headroom (Ω)	For 90 % FS (Ω)	C (F)	Optional R (Ω)
1	10 k	3	1	10 m	150	90 Use this value!	0.33 µ	10 k
2			2		150 Use this value!	180	0.33 µ	10 k

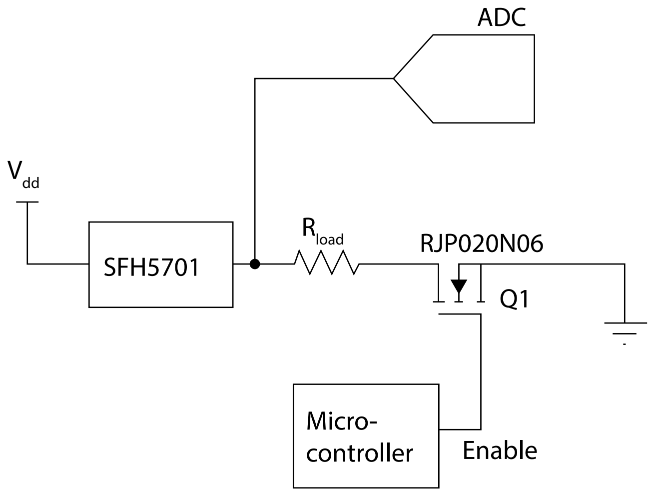
Table 3: Examples of R_{load} and LPF values

Entry #	Max. Light (lx)	Vdd (V)	FS (V)	Idd (A)	R_{load} Selection		LPF Selection	
					For output headroom (Ω)	For 90 % FS (Ω)	C (F)	Optional R (Ω)
3	100	3	1	100 µ	15 k	9 k Use this value!	0.33 µ	650
4			3		15 k Use this value!	18 k	0.22 µ	0

C. Shutdown

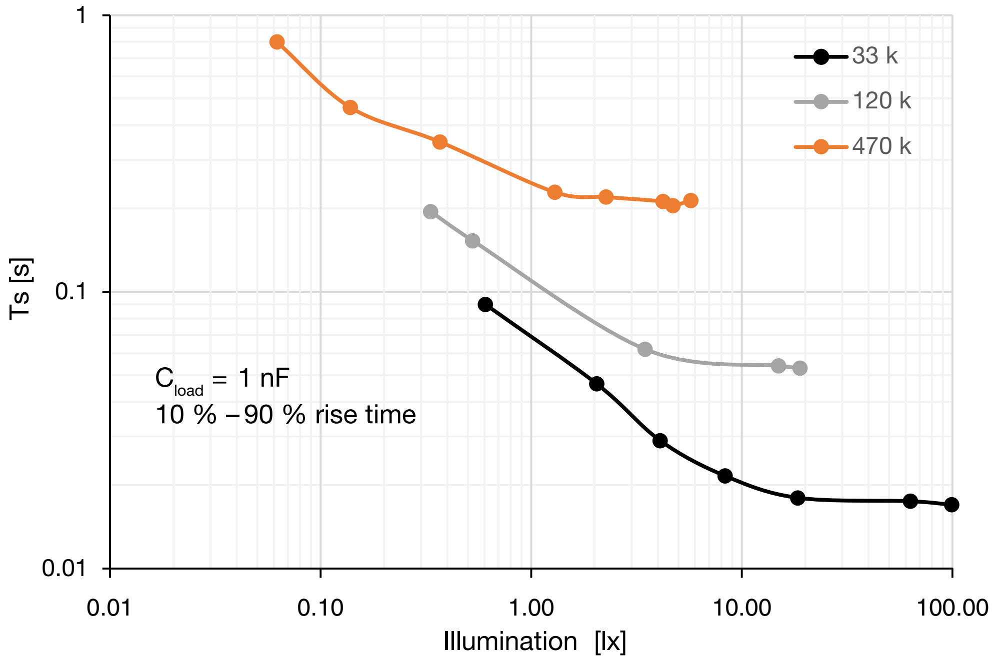
For applications where the SFH5701 does not continuously monitor the ambient light, the ALS function can be shut down when not needed to save power. The circuit shown in Figure 7 allows the micro-controller to remove the gate drive to Q1 so that no power is consumed by the ALS.

Figure 8: ALS power down implementation



Please bear in mind that the response of the SFH5701 to light slows down at lower light intensities. This should be considered when a shutdown scheme such as that shown in Figure 8 is being performed, especially when low-intensity ambient light is detected. Figure 9 shows the 10 %-90 % response time (ts) of the SFH5701 as a function of the illumination level.

Figure 9: Response time versus illumination intensity



D. Circuit board / layout

To operate properly, the SFH5701 does not require a VDD supply decoupling capacitor nearby. However, if the detection range is < 1 lux (i.e. < 100 nA output current), it may be necessary to create a guard ring around the SFH5701 output pin to reduce external leakage current. Factors such as humidity, board contamination, and higher potentials in the PC board vicinity can exacerbate the situation. To create a guard ring, the output pin / traces / external components (including R_{load}, LPF, etc.) should be “surrounded” with copper trace / plane at or close to the output pin potential.

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