# *SCCW77400A / SCCW77400B*
# *Product Preview*

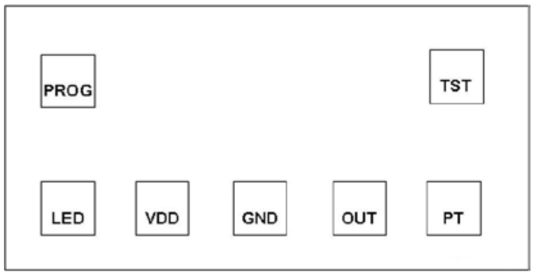
The SCCW77400 is an ASIC for reflective optical switch. Embedded with an infrared light emitting diode (LED) and a phototransistor, this ASIC controls the infrared emitter, read the detector-signal and convert it into a digital signal. The reflective interrupter will be implemented into mobile communication devices.

ON Semiconductor

http://onsemi.com

**Features**

- Low current consumption: 40u A.
- Operating voltage 2.3 V to 3.6 V.
- Adjustable LED current.
- Adjustable Threshold current.




**CHIP LAYOUT**
(Chip dimensions and arrangement of bond pads. Pads for test and trim could be added)

**Typical Applications**

Short to medium distance proximity sensor for:

- Cell phone
- PDAs
- Portable entertainment devices.

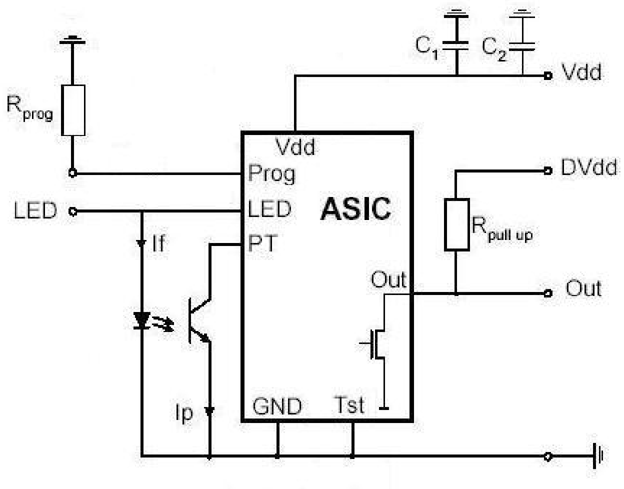



**Figure 1: Typical Application Circuit**

**ORDERING INFORMATION**

| Orderable Part Number | Version |
|---|---|
| SCCW77400A | ROSa_Long |
| SCCW77400B | ROSa |

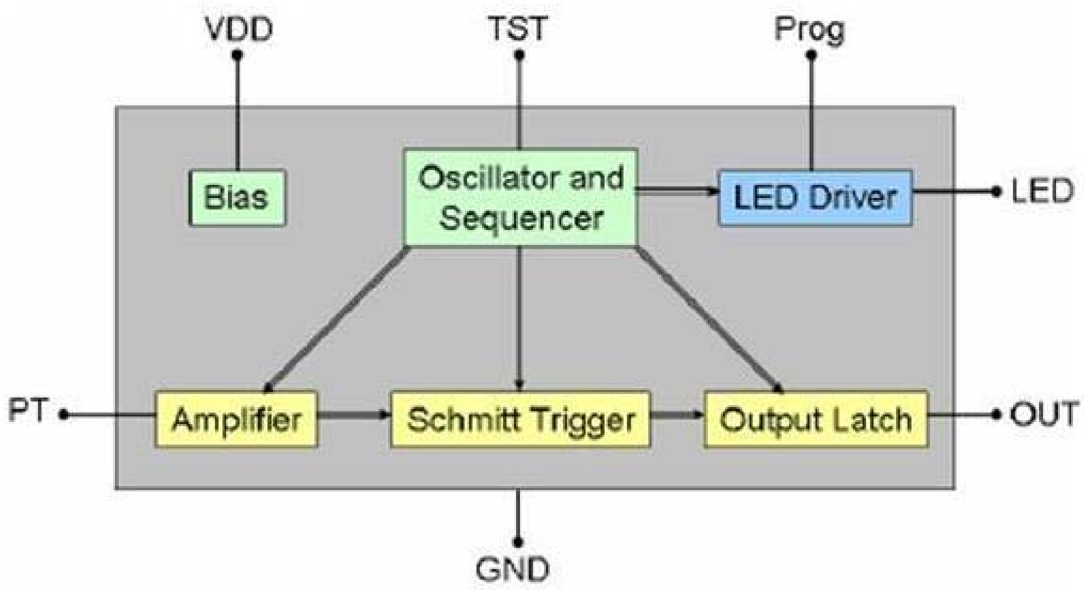



**Figure 2: Simplified Block Diagram**

## PIN FUNCTION DESCRIPTION

| PIN | PIN NAME | TYPE | DESCRIPTION |
|---|---|---|---|
| 1 | VDD | POWER | Supply voltage |
| 2 | GND | POWER | Ground |
| 3 | OUT | OUTPUT | Digital output, NMOS open drain |
| 4 | LED | OUTPUT | LED anode, supplies current to anode of emitter |
| 5 | PT | INPUT | Analog input from phototransistor |
| 6 | PROG | INPUT | Tune the LED current by connecting external resistor |
| 7 | TST | INPUT | Digital pin, accelerate the system. |

## MAXIMUM RATINGS (NOTE 1)

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| VDD: Power Supply Voltage (Note 2) | VDD | -0.3 to +6.0 | V |
| Input and output pin(Note 2) | Led,Pt, Prog, Tst | -0.3 to +6.0 | V |
| Output pin(Note 3) | Out | -0.3 to +6.0 | V |
| Human Body Model (HBM) ESD Rating are (Note 4) | ESD HBM | 2000 | V |
| Machine Model (MM) ESD Rating are (Note 4) | ESD MM | 200 | V |
| Latch-up protection (Note 5) | LU | 20 | mA |
| Storage Temperature Range | Ts | -40 to +150 | °C |
| Operating Junction Temperature Range | $T_J$ | -40 to +125 | °C |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Notes:

1. Maximum electrical ratings are defined as those values beyond which damage to the device may occur.
2. According to JEDEC standard JESD22-A108B.
3. Max current 25mA.
4. This device series contains ESD protection and passes the following tests:
   Human Body Model (HBM) +/-2.0 kV per JEDEC standard: JESD22-A114 for all pins.
   Machine Model (MM) +/-200 V per JEDEC standard: JESD22-A115 for all pins.
5. Latch up Current Maximum Rating: ±20 mA per JEDEC standard: JESD78 class I.

## OPERATING CONDITIONS (NOTE 6)

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Analog supply voltage | VDD | +2.3 to +3.6 | V |
| Digital supply voltage (Note7) | DVDD | +1.7 to +3.6 | V |
| Supply voltage ripple (Note8) | dVDD | ±0.3 | V |
| Full operational ambient temperature range | Ta | -40 to +85 | °C |

Notes:

6. Device functionality is guaranteed within operational limits.
7. See Figure 1: “Typical application circuit”.
8. Voltage difference on VDD, frequency range: 0 to 20 kHz. Never below 2.3V.

**ELECTRICAL CHARACTERISTICS** Min & Max Limits apply for $T_A$ between -40°C to +85°C and for $V_{DD}$ between 2.3 V to 3.6 V (Unless otherwise noted). Typical values are referenced to $T_A$ = + 25 °C and $V_{DD}$ = 3.0 V (Unless otherwise noted).

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{MEAN}$ | Current consumption without $I_{LED}$ and $I_{PT}$ | Without external load, TST="Low" | - | 20 | 40 | µA |
| $I_{MEAN,TM}$ | Current consumption for operation in permanent test mode (without $I_{LED}$ and $I_{PT}$). (Note 9) | Without external load, TST="High" | - | 280 | 600 | µA |
| **LED driver** | | | | | | |
| $I_{LED,ON}$ | DC emitter on current ($R_{PROG}$ = ∞) | $V_{DD}$ = 3.0 V , $V_{LED}$ = 1.4 V | 9 | 10 | 11 | mA |
| $I_{LED,ON}$ | DC emitter on current ($R_{PROG}$ = 450 Ω) (Note 10) | $V_{DD}$ = 3.0 V , $V_{LED}$ = 1.7 V | 45 | 50 | 55 | mA |
| $I_{LED,ON}$ | DC emitter on current ($R_{PROG}$ = 100 Ω) (Note 10) | $V_{DD}$ = 2.3 V , $V_{LED}$ = 1.6 V<br>$V_{DD}$ = 3.0 V , $V_{LED}$ = 1.9 V<br>$V_{DD}$ = 3.6 V , $V_{LED}$ = 1.9 V | 50<br>98<br>128 | 78<br>119<br>157 | 115<br>180<br>225 | mA |
| $I_{LED,ON}$ | DC emitter on current ($R_{PROG}$ = 220 Ω) (Note 9,10) | $V_{DD}$ = 2.3 V , $V_{LED}$ = 1.7 V<br>$V_{DD}$ = 3.0 V , $V_{LED}$ = 1.9 V<br>$V_{DD}$ = 3.6 V , $V_{LED}$ = 1.9 V | 45<br>67<br>85 | 56<br>84<br>106 | 80<br>125<br>160 | mA |
| $I_{LED,ON}$ | DC emitter on current ($R_{PROG}$ = 330 Ω) (Note 9,10) | $V_{DD}$ = 2.3 V , $V_{LED}$ = 1.7 V<br>$V_{DD}$ = 3.0 V , $V_{LED}$ = 1.9 V<br>$V_{DD}$ = 3.6 V , $V_{LED}$ = 1.9 V | 37<br>52<br>65 | 47<br>67<br>81 | 70<br>100<br>120 | mA |
| $I_{LED,OFF}$ | Emitter off current | | - | - | 1 | µA |
| $G_{PROG}$ | Current programming gain (Note 10,11) | 450 < $R_{prog}$ < 10kΩ | 5.4 | 6 | 6.6 | |
| **Receiver and Schmitt Trigger** | | | | | | |
| $V_{CE,BIAS}$ | Phototransistor bias voltage | Up to $I_{INDC}$ = 1000µA | 0.8* $V_{DD}$ | - | - | V |
| | | $I_{INDC}$ from 1000 to 2000µA | 0.4* $V_{DD}$ | - | - | V |
| $I_{INDC}$ | Max. ambient light level(dc)<br>Ambient light suppression<br>- Version A :(long ROSa) | $V_{DD}$ = 2.3 V<br>$V_{DD}$ = 3 V<br>$V_{DD}$ = 3.6 V | 250<br>400<br>450 | 500<br>700<br>700 | -<br>-<br>- | µA |
| $I_{INDC}$ | Max. ambient light level(dc)<br>Ambient light suppression<br>- Version B :( ROSa) | | 70 | - | - | µA |
| $I_{ST,HIGH}$ | Switching threshold (Note 9)<br>Output Vo: L to H<br>(Independent of LED on/off)<br>- Version A: (long ROSa)<br>- Version B: (ROSa) | Level below dc-light level,@25°C, max ambient light current 100µA | 11<br>76.5 | 12<br>85 | 13<br>93.5 | µA |
| $I_{ST,HIGH}$ | Switching threshold (Note 9)<br>Output Vo: L to H<br>(Independent of LED on/off)<br>- Version A: (long ROSa)<br>- Version B: (ROSa) | Level below dc-light level max ambient light current $I_{INDC}$ | 8<br>70 | 12<br>85 | 16<br>100 | µA |
| $I_{INDCMAX}$ | Max. ambient light level(dc)(Note 12)<br>Ambient light suppression<br>- Version A :(long ROSa) | $V_{DD}$ = 2.3 V<br>$V_{DD}$ = 3 V<br>$V_{DD}$ = 3.6V | 800<br>1000<br>1500 | -<br>-<br>- | -<br>-<br>- | µA |
| $I_{ST,HYST}$ | (Note 9) | Ambient light level up *to* $I_{INDC}$ | 10<br>10 | 15<br>15 | 30<br>- | % |

Notes:

9. *Guaranteed by design and characterized.*
10. *$R_{PROG}$ tolerance -/+ 1%.*
11. *$I_{LED,ON}$ current remains linear for $R_{PROG}$ up to infinity. See* Figure 11.
12. Guaranteed functionality, but threshold maybe out of range.

**ELECTRICAL CHARACTERISTICS** Min & Max Limits apply for $T_A$ between -40°C to +85°C and for $V_{DD}$ between 2.3 V to 3.6 V (Unless otherwise noted). Typical values are referenced to $T_A$ = + 25 °C and $V_{IN}$ = 3.0 V (Unless otherwise noted).

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **TST Input** | | | | | | |
| $V_{IL}$ | Digital low level input voltage | | - | - | 0.3* $V_{DD}$ | V |
| $V_{IH}$ | Digital high level input voltage | | 0.7* $V_{DD}$ | - | - | V |
| $I_{IL}$ | Low level input current | | 0 | - | 145 | µA |
| $I_{IH}$ | High level input current | | 0 | - | 460 | µA |
| $R_{PD}$ | Internal pull down resistor | TST-Input | 8 | 30 | 37 | kΩ |
| **Output** | | | | | | |
| $V_{OH}$ | High level output voltage | See figure 1 | 0.8*$DV_{DD}$ | - | 3.6 | V |
| $I_{OH}$ | High level output current | OUT='High'<br>$V_{OUT}$ = 3.6V | - | - | 1 | µA |
| $V_{OL}$ | Low level output voltage | $I_{OL}$ = 8mA<br>($V_{DD}$ = 2.3V) | - | - | 0.34 | V |
| | | $I_{OL}$ = 10mA<br>($V_{DD}$ = 2.3V) | - | - | 0.4 | V |
| | | $I_{OL}$ = 18mA<br>($V_{DD}$ = 2.3V) | - | - | 0.6 | V |
| | | $I_{OL}$ = 23mA<br>($V_{DD}$ = 2.3V) | - | - | 0.8 | V |
| $Rds_{on}$ | Output ON resistance | | - | 12 | - | Ω |
| **Oscillator and Sequencer** | | | | | | |
| $T_{pulse}$ | Pulse time | | 30.8 | 44 | 57.2 | µs |
| $T_{sep}$ | Separation time (Note 13) | | 30.8 | 44 | 57.2 | µs |
| $T_{awake}$ | Awake time | | 123.2 | - | 228.8 | µs |
| $T_{sleep}$ | Sleep time | TST="low" | 62.95 | - | 116.91 | ms |
| | | TST="high" | 369.6 | | 686.4 | µs |
| $T_{start}$ | Start-up time | TST="low" , $V_{DD}$ rise time up to 2 ms. | 62.95 | 90 | 116.91 | ms |
| $V_{dd,start}$ | Minimum required supply voltage for startup | | 1.6 | 1.8 | - | V |

Notes:

13. Guaranteed by design.

## TYPICAL OPERATING CHARACTERISTICS

TBD

**Figure 3: $I_{st,high}$ vs. Temperature**

TBD

**Figure 4: $I_{st,hyst}$ vs. Temperature**

TBD

**Figure 5: $I_{LED,on}$ vs. $R_{prog}$**
(Rprog > 450Ω)

TBD

**Figure 6: $I_{LED,on}$ vs. Temperature**
(Rprog= 100, 220, 330Ω)

TBD

**Figure 7: $I_{mean}$ vs. Temperature**
(VDD = 2.3, 3, 3.6V)

TBD

**Figure 8: Sensitivity f(amb. light)**
(VDD = 2.3, 3, 3.6V)

## DETAIL OPERATING DESCRIPTION

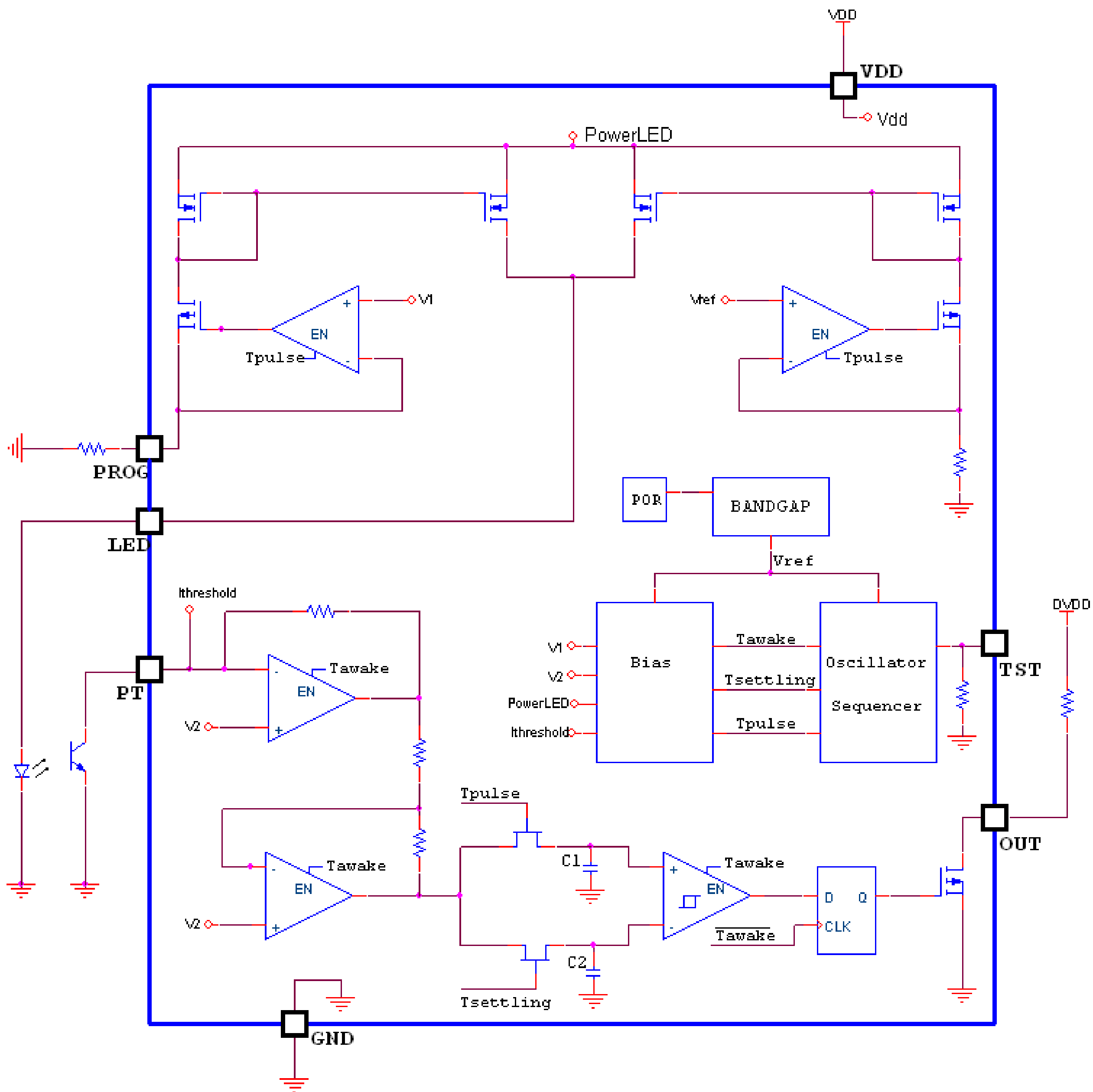



**Figure 9: Functional Block Diagram**

## Functional Descriptions

### Oscillator and Sequencer

The operation of the ASIC is controlled by a sequencer witch is clocked by an internal oscillator. The switch operates in a pulsed mode to realize low current consumption. Most of the time the ASIC is in sleeps mode $T_{SLEEP}$. After the start-up sequence, the active phase starts with enabling the transimpedance amplifier. After a settling time $T_{SETTLING}$ the CDS Schmitt trigger stores the received photo current caused by ambient light and transistor leakage current. After expiration of the separation time $T_{SEP}$ the LED is switched on ($T_{PLUSE}$) and the CDS Schmitt trigger begins to compare the difference between the new photo-current and the stored one with taking into account the appropriate switching threshold. The result of the comparison is store in a latch and occurs at the output (see Figure 10: Timing Diagram)

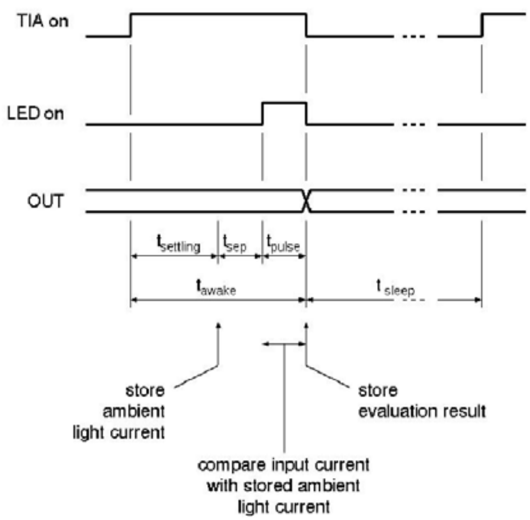



**Figure 10: Timing Diagram**

For shortening production test time the sleep time $T_{SLEEP}$ can be decreased by a "High" signal on pin TST.

### LED Driver

The LED driver generates a regulated current pulse for the LED anode for a defined period triggered by the sequencer (see Figure 10: Timing Diagram). During the on-phase of the LED current can be adapted by the $R_{PROG}$ resistor connected to the pin PROG of the ASIC according to the following formula:

$$I_{led} = I_{led,on} + G_{prog} \cdot \frac{V_{dd}}{R_{prog}} \qquad \text{For } R_{PROG} > 450\Omega.$$

The current gain $G_{PROG}$ has a typical value of 6. By means of the external resistor $R_{PROG}$ the LED current can be programmed between typical 10mA and 58mA for $R_{PROG}$ superior to 450Ω.

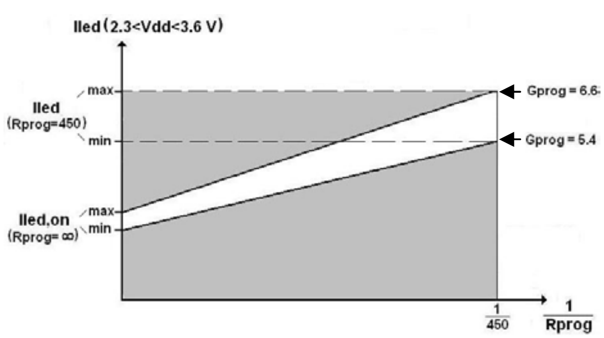



**Figure 11. $I_{LED,ON}$ vs. $(1/R_{PROG})$**

For $R_{PROG}$ < 450 Ω refers to the electrical characteristics.

### TIA Amplifier

The transimpedance amplifier (TIA) converts the collector current from the phototransistor to a voltage. The TIA has a low impedance input regulated voltage $V_{CE,BIAS}$, witch is ratio metric to the supply voltage VDD.

### CDS Schmitt trigger

The implemented Schmitt trigger uses correlated double sampling (CDS). The first phototransistor readout is performed with the LED turned off in order to detect the ambient light level and the phototransistor leakage current. This value is stored for further comparison. The second measurement is done with LED on in order to detect the reflective signal. The difference between the both samples must be larger than the upper threshold $I_{ST,HIGH}$ to switch the output of the Schmitt trigger into the "High" state. Respectively, the difference between the both samples must be lower than the lower threshold $I_{ST,LOW}$ to switch into the "Low" state. If the difference is between both thresholds, the Schmitt trigger does not change its state.

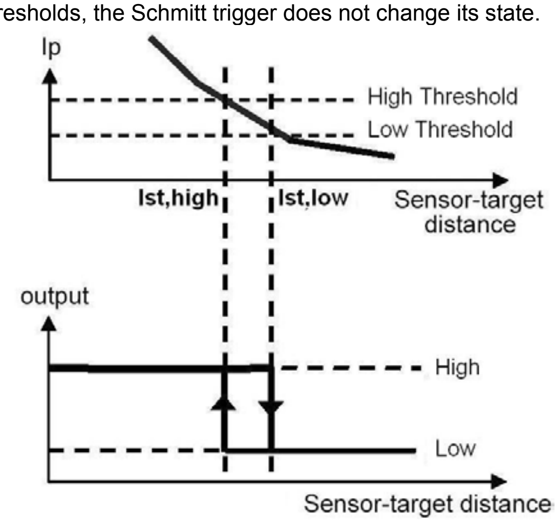



**Figure 12. Output vs. photocurrent**

The hysteresis is performed by addition of the threshold ($I_{THRESHOLD}$) current during the first phototransistor readout to the ambient light current. The added threshold current is $I_{ST,HIGH}$ when output is "*Low*" and $I_{ST,LOW}$ (see the following formula) when output is "*High*".

$$I_{st,low} = \left(1 - I_{st,hyst}\right) \times I_{st,high}$$

### Bias

The bias current generator supplies the other blocks with appropriate bias currents during the appropriate timing phase.

| | V1(V) | V2(V) | PowerLED(V) | Threshold(A) |
|---|---|---|---|---|
| $T_{AWAKE}$ | NA | $V_{CE,BIAS}$ | NA | NA |
| $T_{SETTLING}$ | NA | $V_{CE,BIAS}$ | 0 | OUT ='L': $I_{ST,HIGH}$<br>OUT='H': $I_{ST,LOW}$ |
| $T_{PULSE}$ | 0.2*VDD | $V_{CE,BIAS}$ | VDD | 0 |
| $T_{SLEEP}$ | 0 | 0 | 0 | 0 |

### Output

When the voltage supply is powered, the digital signal from the Schmitt trigger is latched in a D-type flip-flop to bridge the sleep time. The flip-flop controls an open drain NMOS low-side output stage allowing the output to be read at any time.
When the power supply is not connected, sensor is in off mode and the output is always high. And there is no current via output pin to/from component.

| Condition | VDD set to operational voltage |
|---|---|
| Output state | DVDD set to operational voltage<br><br>**Active** (Output is high or low depending on state of interrupter) |

| Condition | VDD set floating ("open") |
|---|---|
| Output state | DVDD set to operational voltage<br><br>**High** (Current consumption minimized via component) |

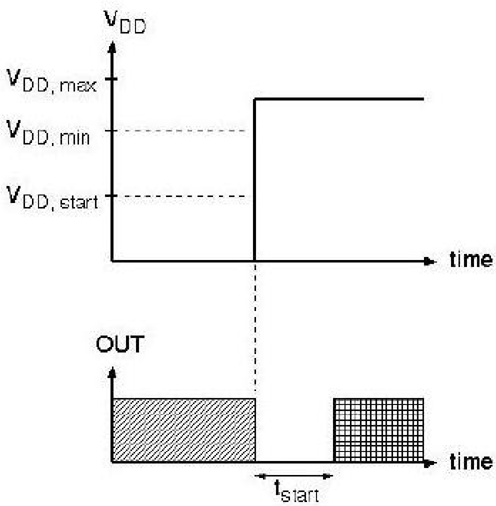



Figure 13: Fast $V_{DD}$ ramp

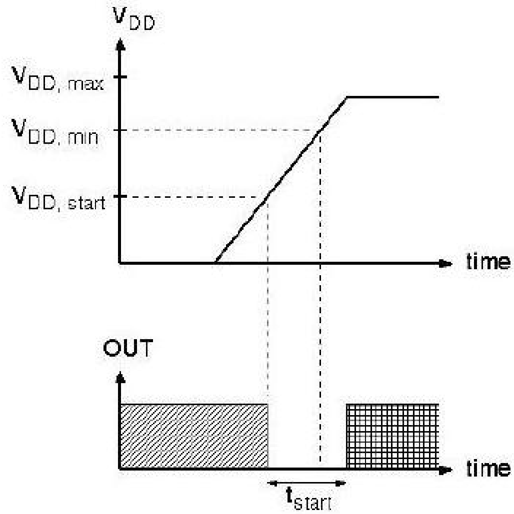



Figure 14: Moderate $V_{DD}$ ramp

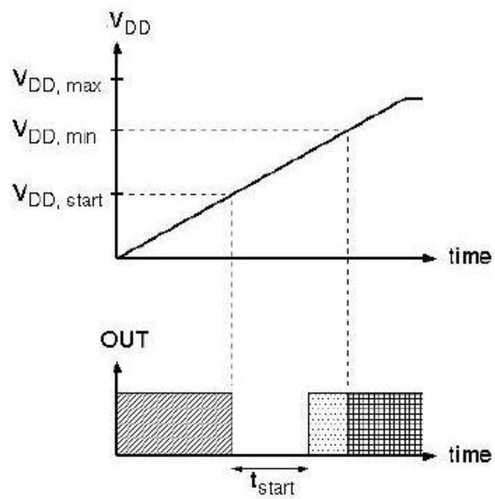
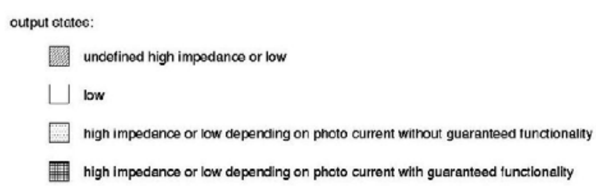


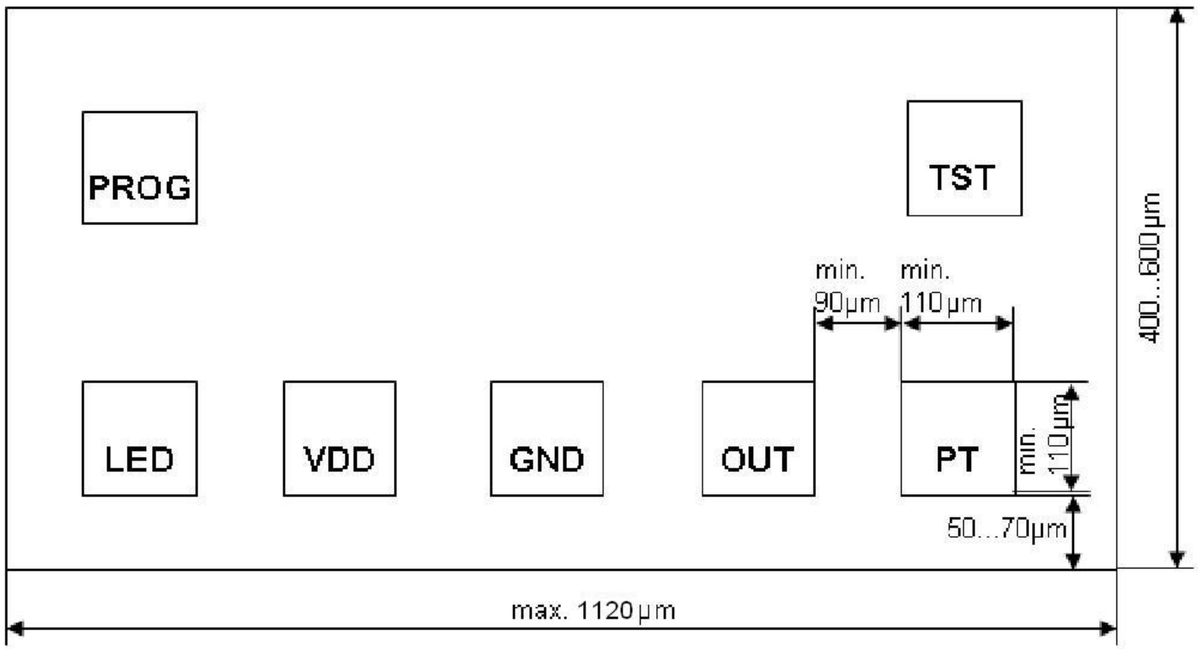

Figure 15: Slow $V_{DD}$ ramp



## Mechanical data

| | |
|---|---|
| Delivery | Tested, inked and unsawn wafer |
| Scribe line | 80µm |
| Sawing grid | Max. 1120µm x 600µm |
| Chip thickness | 250±10µm, grinded and wet etched |
| Pad opening | Min. 110µm x 110µm |

## Chip layout



**PARAMETERS AND FUNCTIONS UP DATE:**

| Date | Revision | Change | Author |
|---|---|---|---|
| 7-Nov | 1.0 | Creation of document | S. BRAS |
| 28-Nov | 1.1 | Updates:<br>• Threshold current limits<br>• Product name<br>• Chip layout | S. BRAS |
| 2 - Dec | 2.0 | Updates according to customer remarks:<br>• Max rating table<br>• Operating condition table<br>• Electrical characteristics<br>• Typical operating characteristics<br>• Functional description | S. BRAS |
| 10 - Dec | 2.1 | Updates:<br>• $T_{START}$ time | S. BRAS |
| 16 - Dec | 2.2 | Updates (Operating condition table):<br>• $T_{START}$ time<br>• Voltage condition on LED pin | S. BRAS |
| 26 - Jan | 2.3 | Updates:<br>• Operating condition $T_{START}$ time.<br>• Operating condition $G_{PROG}$ parameter.<br>• Addition Figure 11. | S. BRAS |
| 26 - Fev | 2.4 | Updates:<br>• Chip thickness. | S. BRAS |
| 12 -Mar | 2.5 | • OPN table added page 1<br>• Typo product preview page 1 | S. BRAS |
| 5 -June | 3.0 | Electrical table updates according to design review and OSRAM target spec 2.0 | S. BRAS |