

# **Buildup Test Platform for Stand-Alone OPT300x**

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## **ABSTRACT**

Electronic devices, such as smart watches and smart phones that use light sensors, are becoming much more prevalent. The OPT300x is an ambient light sensor (ALS) designed to have a similar spectral response to that of the human eye. OPT300x is usually mounted on a sensor board that goes together with display, extra test flows are needed to guarantee ALS can work properly before the display is assembled together with smart watches and phones, that calls for standalone test in customer’s product line for OPT300x. This application report describes the care-about for this stand-alone test, including material inspection, hardware design consideration, and the buildup of test platforms.

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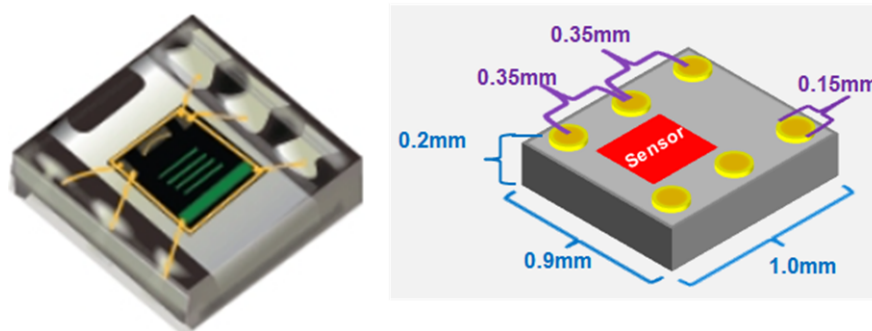
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## **1 Opt300x Introduction**

An ALS is a device that outputs a signal proportional to the amount of visible light incident upon the sensor. In many user scenarios, placing a TI ALS behind a glass window or display becomes a popular way in both personal electronics and automotive applications to sense ambient light to adjust the display brightness.

OPT300x is usually mounted on a sensor board (flex or non-flex PCB), that goes together with the display ALS function and should be guaranteed before the display is assembled together with smart watch and phones or automotive panels. Extra test processes that can test ALS functions in standalone mode are needed in the display manufacturer's product line. This application report describes the care-about for this stand-alone test, including material inspection, hardware design consideration as well as the buildup of test platforms.

There are several popular devices in TI ALS portfolio, for example, OPT3001, OPT3004, OPT3006, and OPT3007. Generally speaking, OPT3006/3007's sensor and pins are on the same side while OPT3001/OPT3004 has the sensor and pins on opposite side. As shown in [Figure 1](#), the left device is OPT3001 while the right device represents OPT3006/3007. OPT3001 also has Q1 version OPT3001-Q1 for automotive application.



**Figure 1. Sensor Position of OPT3001/3004 vs OPT3006/3007**

The main difference between OPT3006 and OPT3007 is that OPT3006 is a 6-pin device while OPT3007 is lack of address and Interrupt function to give end customer more tolerance in assembly.

## 2 Material Inspection

OPT300x will experience 100% appearance test when shipped out from TI factories. But as with any optical product, the customer continues to need to pay attention when handling the OPT300x since it has low sensitivity to dust and scratches. If a customer needs more tests for appearance, electrical characteristics, and so on. The guideline is [OPT3001 Ambient Light Sensor \(ALS\) Data Sheet](#). Please also strictly follow the Do's and Don'ts in the data sheet of respective devices, for example, OPT3001 section 8.3 data sheet.

Customers can also refer to SMT process like QFN and refer to [QFN and SON PCB Attachment](#).

## 3 Care-about for Sensor Board Hardware Design

The schematic of OPT300x design is not complicated, as shown in [Figure 2](#). As the OPT300x is usually mounted on the sensor board which is separate from main board, there're some tips customer should refer to:

- Pull up resistors are needed for SDA/SCL pins, customer can either add the resistor in sensor board or main board, long wires are not recommended to guarantee signal quality. Pull-up resistors are not shown in [Figure 2](#) as they are added in main board.
- The OPT3001 VDD pin must have a stable, low-noise power supply with a 100-nF bypass capacitor close to the device and solid grounding.
- The INT pin test is optional depending on the OPT device as well as the design, but if needed, pull-up resistor is needed as this pin is Open Drain.
- OPT3007 don't have ADDR and INT pins.

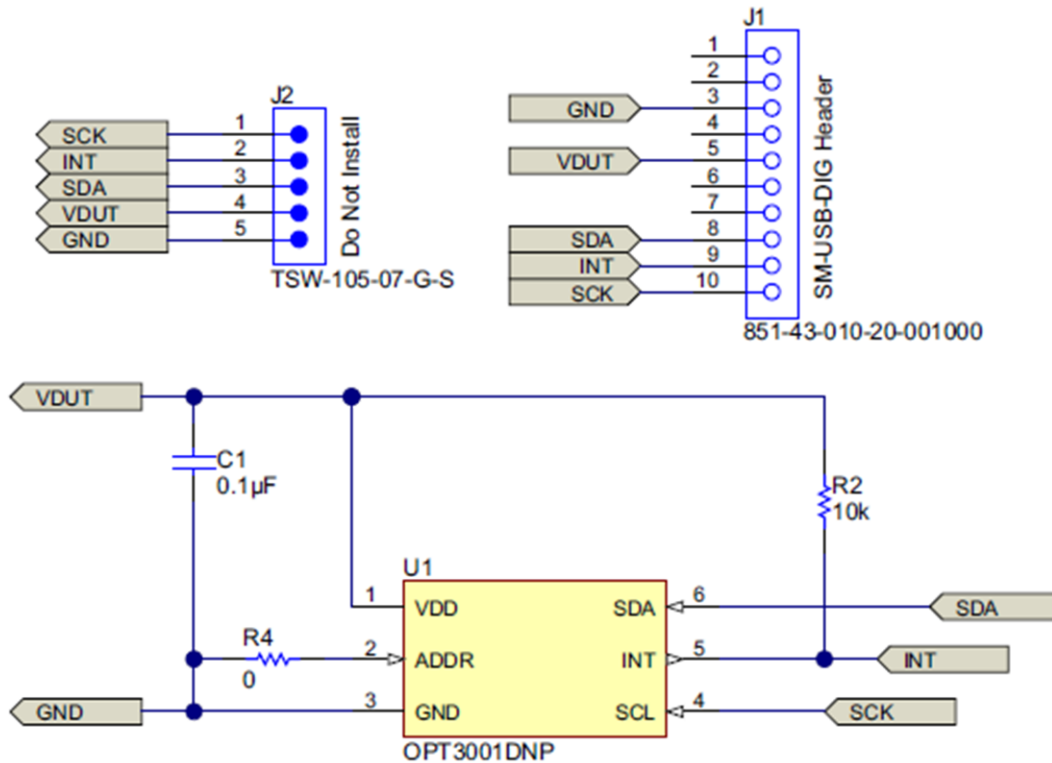


Figure 2. OPT3001 Schematic

Please also strictly follow the PCB Layout guidelines for OPT3001, OPT3004, OPT3006, and OPT3007, for example, refer to Section 10 in the [OPT3001 data sheet](#).

## 4 Buildup Stand-alone ALS Text Platform

After putting the ALS sensor board together with touch panel to the display, extra test flows can verify if ALS functions are usually needed before the display is assembled to the main controller board. For example, now the ALS board is in standalone mode which we need to build another system to test it in display manufacture's product line.

To the automotive applications, the functional tests should be similar, but the user should judge if they need to change test platform socket to automotive level.

### 4.1 Functional Test

There are two main tests needed to prove the OPT300x works correctly:

1. Test if I<sup>2</sup>C works properly.
2. Test if the digital values ALS converted is changing together with light source.

#### 4.1.1 Communication Test

One simple way to verify if I<sup>2</sup>C works is to read the Device ID Register, as shown in [Table 1](#) and [Table 2](#) for OPT3001. If the device ID read from register is 3001h, for example I<sup>2</sup>C communication is correct. Attention is needed to be paid when you use other OPT devices, the read-out is 3001 for all 300x devices, for example, if you use OPT3006, 3001h is also read in Device ID Register.

**Table 1. OPT3001 Device ID Register**

Device ID Register (offset = 7Fh) [reset = 3001h]							
This register is also intended to help uniquely identify the device							
<b>15</b>	<b>14</b>	<b>13</b>	<b>12</b>	<b>11</b>	<b>10</b>	<b>9</b>	<b>8</b>
DID15	DID14	DID13	DID12	DID11	DID10	DID9	DID8
R	R	R	R	R	R	R	R
<b>7</b>	<b>6</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>
DID7	DID6	DID5	DID4	DID3	DID2	DID1	DID0
R	R	R	R	R	R	R	R

R = Read Only

**Table 2. OPT3001 Device ID Register Field Descriptions**

BIT	FIELD	TYPE	RESET	DESCRIPTION
15:0	DID[15:0]	R	3001H	<b>Device ID:</b> The device ID reads 3001h

Another I<sup>2</sup>C test is to write and then read back to Configuration Register (offset = 01h), this may be desired in addition to the read device ID to exercise both read and write functions.

#### 4.1.2 Sensor Function Test

In order to test ALS sensor function, the user need to observe if the converted digital value changes under different light sources. That means, to check if the Exponent and Fractional result changes, registers are show in below [Table 3](#) and [Table 4](#) for OPT3001.

**Table 3. OPT3001 Result Register (Read Only)**

Result Register (Read Only)							
<b>15</b>	<b>14</b>	<b>13</b>	<b>12</b>	<b>11</b>	<b>10</b>	<b>9</b>	<b>8</b>
E3	E2	E1	E0	R11	R10	R9	R8
R	R	R	R	R	R	R	R
<b>7</b>	<b>6</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>
R7	R6	R5	R4	R3	R2	R1	R0
R	R	R	R	R	R	R	R

**Table 4. OPT3001 Result Register Field Descriptions**

BIT	FIELD	TYPE	RESET	DESCRIPTION
15:12	E[3:0]	R	0h	<b>Exponent:</b> These bits are the exponent bits. <b>*** Table 8 ***</b> provides further details.
11:0	R[11:0]	R	000h	<b>Fractional result:</b> These bits are the result in straight binary coding (zero to full-scale).

And Lux can be calculated using below formula:  $\text{lux} = 0.01 \times (2E[3:0]) \times R[11:0]$ . Users can set up standard test platform to compare the lux value OPT300x get and the Lux meter. They may not exactly the same, but should be positive correlation under different light sources.

## 4.2 Test Equipment

For light source related platform setup, users can refer to OPT3001-Only Based Approach and Lux-Meter Based Approach sessions from the application note SBEA002A.

We recommend the following part numbers for calibration:

- Lux meter: Konica Minolta Illuminance Meter T-10MA
- Light source: Large White LED Array: CREE XLamp Cool White 5000k
- LED power supply: Yokogawa GS610 Source Measure Unit (SMU)

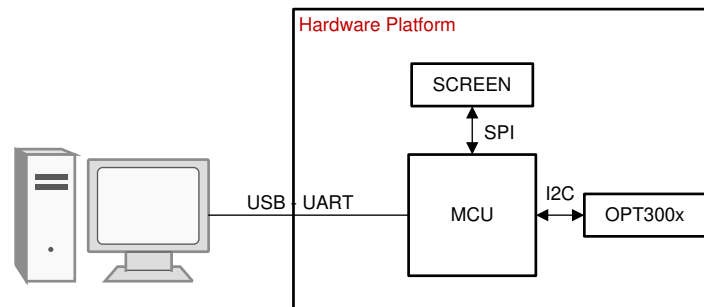
Attention should be paid under 800-ms mode and 100ms mode, the total integration time are different, see [Table 5](#), tester should wait enough time for the OPT300x finish conversion to get the correct lux values.

**Table 5. Integration Time Under Different Mode**

DIGITAL					
I/O pin capacitance		3			pF
Total integration time	(CT = 1), 800-ms mode, fixed lux range	720	800	880	ms
	(CT = 0), 100-ms mode, fixed lux range	90	100	110	ms

## 4.3 Hardware Platform

From hardware perspective, the test platform should reserve interface to test I<sup>2</sup>C communication and ALS functions, INT and ADDR are optional. The device ID and Lux can be printed to PC via UART, to these product lines which have limited space, suggest display device ID and Lux values directly on the screen. As shown in [Figure 3](#).



**Figure 3. OPT300x Hardware Test Platform**

TI provides reference design which can accelerate the production of test tools, known as micro controller MSP-EXP432P401 and sensor plus display board BOOSTXL-EDUMKII in [Figure 4](#) and [Figure 5](#). OPT3001 is put on BOOSTXL-EDUMKII board. Plug BOOSTXL-EDUMKII into MSP-EXP432P401, download correct firmware introduced in [Section 4.4](#), the lux will be printed on the screen of BOOSTXL-EDUMKII and will change with light source and ambient. Make sure J5 jumper on the BOOSTXL-EDUMKII is connected to LCD backlight.

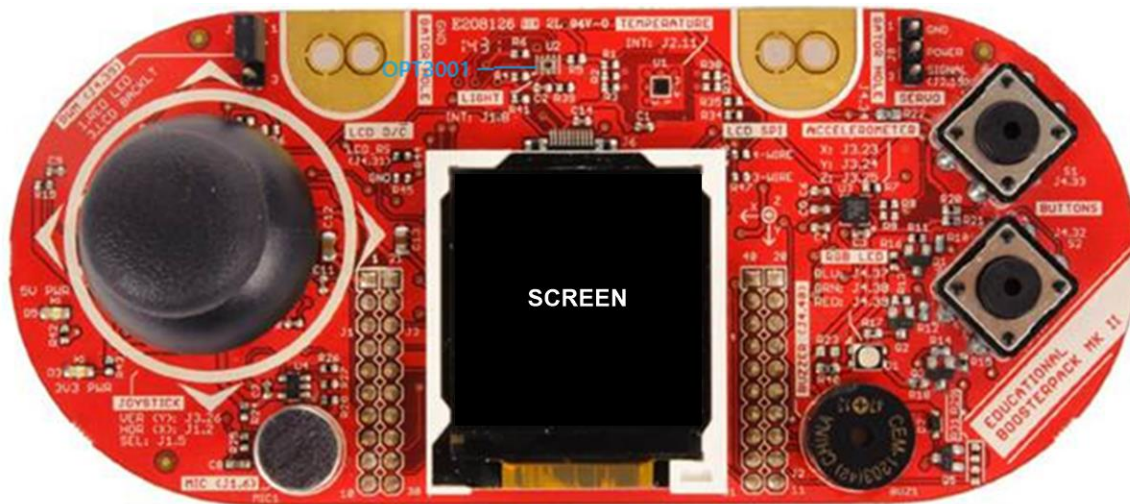


Figure 4. BOOSTXL-EDUMKII Board

MSP-EXP432P401owns an UART – USB interface, that can connect to PC and show the printers.

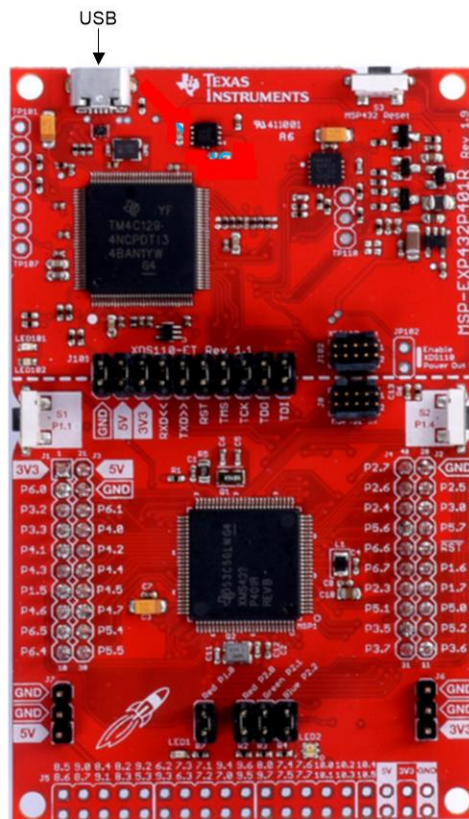


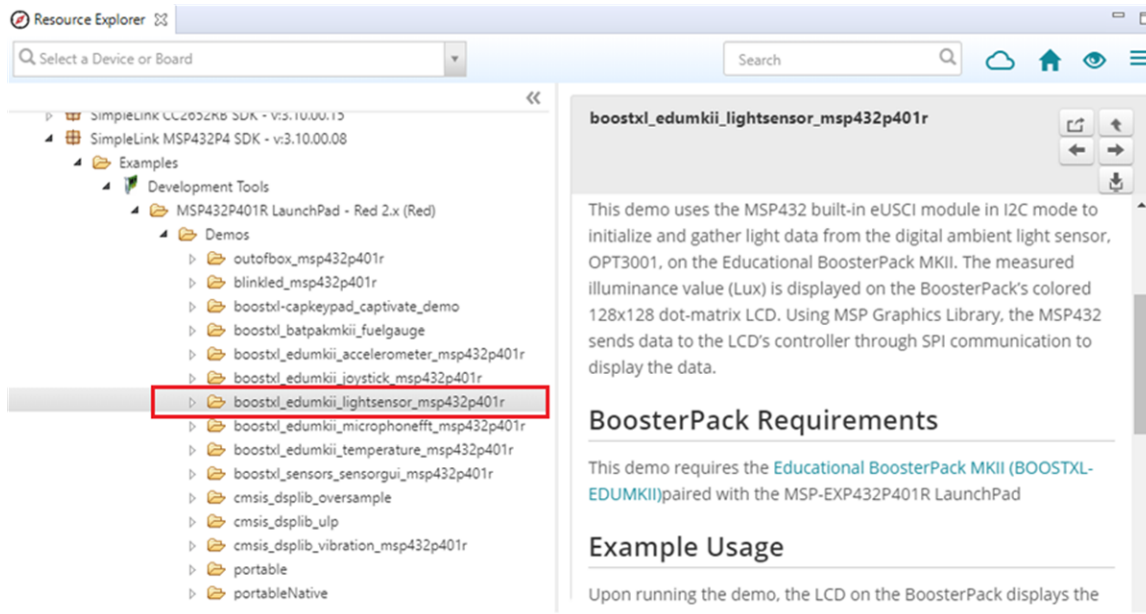
Figure 5. MSP-EXP432P401 Board

Users can reserve OPT3001 not placed while lead wires to their own sensor boards and use BOOSTXL-EDUMKII for test directly. OPT3006 and OPT3007 tests are similar, but customer needs to build conversion boards as they may have different packages and pins with OPT3001.

Of course, [BOOSTXL-EDUMKII User's Guide](#) and [MSP432P401R Development Kit guide](#) provide all needed materials including schematic and BOM to customer, they can choose any MCU to build up the test tools.

## 4.4 Software Code Examples

TI provided OPT3001 drivers based on both micro-controller and Android operation system. With above hard ware platform, an example code is also provided which displays lux value measured by the OPT300x on the colored LCD. The MSP432 communicates with the sensor through I<sup>2</sup>C. The ambient light measurement is also used to automatically adjust the LCD backlight. Install Code Composer Studio (CCS) software, the example code can easily be found at `/boostxl_edumkii_lightsensor_msp432p401r_MSP_EXP432P401R_nortos_ccs`, as shown highlighted in Figure 6.



**Figure 6. OPT300x Test Code Example Location in CCS**

Or the user can download MSP432-SDK, and the code example should be located in `/boostxl_edumkii_lightsensor_msp432p401r_MSP_EXP432P401R_nortos_ccs`

The code examples are open source, users can modify it if necessary.

## 5 Summary

This application note explains how to build platform to test standalone sensor board using OPT300x, and takes OPT3001 as an example, meanwhile, all OPT3001/3004/3006 and OPT3007 test flow should be similar. TI provides hardware develop kits and software examples to customer which can be used directly or can be used for customized secondary development. It should be very useful to display manufactures test both sensor and display functions before assembling display and main board together.

## 6 References

- [OPT3001 Ambient Light Sensor \(ALS\) Data Sheet](#)
- [OPT3001: Ambient Light Sensor Application Guide](#)
- [QFN and SON PCB Attachment](#)
- [OPT3007: Ultra-Thin Ambient Light Sensor](#)
- [OPT3006: Ultra-Thin Ambient Light Sensor](#)
- [BOOSTXL-EDUMKII Educational BoosterPack Plug-in Module Mark II User's Guide](#)
- [MSP432P401R SimpleLink Microcontroller LaunchPad Development Kit](#)
- [MSP-EXP432P401 Restore buy link](#)

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