

	<p>KEMENTERIAN PENDIDIKAN DAN KEBUDAYAAN POLITEKNIK NEGERI SRIWIJAYA Jalan Srijaya Negara, Palembang 30139 Telp. 0711-353414 Fax. 0711-355918 Website : www.polisriwijaya.ac.id E-mail : info@polsri.ac.id</p>	
KESEPAKATAN BIMBINGAN LAPORAN AKHIR (LA)		

Kami yang bertanda tangan di bawah ini,

Pihak Pertama

Nama : Khiarul Arham
NIM : 061330330278
Jurusan : Teknik Elektro
Program Studi : Teknik Telekomunikasi

Pihak Kedua

Nama : Nasron, S.T., M.T.
NIP : 196808221993031001
Jurusan : Teknik Elektro
Program Studi : Teknik Telekomunikasi

Pada hari ini tanggal telah sepakat untuk melakukan konsultasi bimbingan Laporan Akhir.

Konsultasi bimbingan sekurang-kurangnya 1 (satu) kali dalam satu minggu. Pelaksanaan bimbingan pada setiap hari pukul, tempat di Politeknik Negeri Sriwijaya.

Demikianlah kesepakatan ini dibuat dengan penuh kesadaran guna kelancaran penyelesaian Laporan Akhir.

Pihak Pertama, Palembang,
Pihak Kedua,

(Khlarul Arham)
NIM 061330330278

(Nasron, S.T., M.T.)
NIP 196808221993031001

Mengetahui,
Ketua Jurusan

(Yudi Wijanarko, S.T., M.T.)
NIP 196705111992031003

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Nama : Khiarul Arham
NIM : 061330330278
Jurusan : Teknik Elektro
Program Studi : Teknik Telekomunikasi

Pihak Kedua

Nama : Sopian Soim, S.T., M.T.
NIP : 197103142001121001
Jurusan : Teknik Elektro
Program Studi : Teknik Telekomunikasi

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LEMBAR BIMBINGAN LAPORAN AKHIR

Lembar :

1

Nama : Khiarul Arham
NIM : 061330330278
Jurusan/Program Studi : Teknik Elektro / Teknik Telekomunikasi
Judul Laporan Akhir : Sistem Kecerdasan Navigasi Pada *Wall Follower* Pemadam Api Beroda dengan Algoritma *Fuzzy* dan *Environment Mapping*
Pembimbing I : Nasron, S.T., M.T.

No.	Tanggal	Uraian Bimbingan	Tanda Tangan Pembimbing
1.			
2.			
3.			
4.			
5.			
6.			
7.			

Lembar : 2

No.	Tanggal	Uraian Bimbingan	Tanda Tangan Pembimbing
8.			
9.			
10.			
11.			
12.			

Palembang,

Ketua Program Studi,

(Ciksadan, S.T., M.Kom)
NIP 196809071993031003

Catatan:

*) melingkari angka yang sesuai.

Ketua Jurusan/Ketua Program Studi harus memeriksa jumlah pelaksanaan bimbingan sesuai yang dipersyaratkan dalam Pedoman Laporan Akhir sebelum menandatangani lembar bimbingan ini.

Lembar pembimbingan LA ini harus dilampirkan dalam Laporan Akhir.



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Pembimbing I : Sopian Soim, S.T., M.T.

No.	Tanggal	Uraian Bimbingan	Tanda Tangan Pembimbing
1.			
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Lembar : 2

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Website : www.polisriwijaya.ac.id **E-mail** : info@polsri.ac.id**REKOMENDASI UJIAN LAPORAN AKHIR (LA)**

Pembimbing Laporan Akhir memberikan rekomendasi kepada,

Nama : Khiarul Arham
NIM : 061330330278
Jurusan/Program Studi : Teknik Elektro / Teknik Telekomunikasi
Judul Laporan Akhir : Sistem Kecerdasan Navigasi Pada
Wall Follower Pemadam Api Beroda
dengan Algoritma *Fuzzy* dan
Environment Mapping

Mahasiswa tersebut telah memenuhi persyaratan dan dapat mengikuti Ujian
Laporan Akhir (LA) pada Tahun Akademik 2015/2016

Palembang,

Pembimbing I,

Pembimbing II,

(Nasron, S.T., M.T.)
NIP 196808221993031001

(Sopian Soim, S.T., M.T.)
NIP 197103142001121001





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BUKTI PENYERAHAN HASIL KARYA/RANCANG BANGUN

Pada hari ini tanggal bulan tahun telah diserahkan seperangkat karya/rancang bangun kepada Jurusan Teknik Elektro Program Studi Teknik Telekomunikasi di Politeknik Negeri Sriwijaya,

Nama Perangkat	Spesifikasi
Robot SAR Pemadam Api Beroda	Arduino Due, sharp GP, TCS3200, flame sensor, motor PG28, PIXY CMU Cam

Hasil karya/rancang bangun dari,

Nama	NIM	Nama Pembimbing
Khiarul Arham	061330330278	Nasron, S.T., M.T.
		Sopian Soim, S.T., M.T.

Yang menerima *),

(Sopian Soim, S.T., M.T.)
NIP 197103142001121001

Mengetahui,
Ketua Program Studi,

(Ciksadan, S.T., M.Kom)
NIP 196809071993031003

*) pejabat Jurusan/PS yang ditunjuk (Kepala Lab./Bengkel atau Kepala Seksi)
**) perwakilan mahasiswa dari pembuat karya/rancang bangun.

Palembang,
Yang menyerahkan **),

(Khiarul Arham)
NIM 061330330278



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		Sopian Soim, S.T., M.T.

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(Sopian Soim, S.T., M.T.)
NIP 197103142001121001

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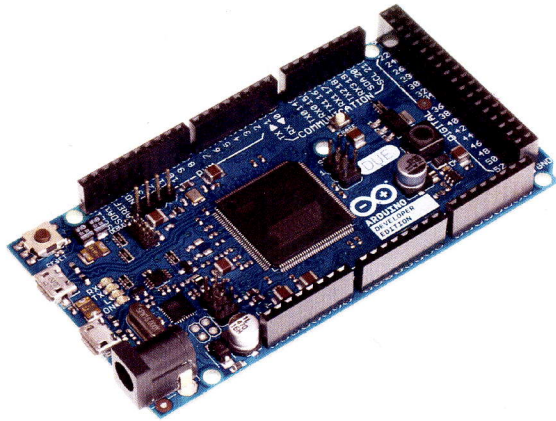
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**) perwakilan mahasiswa dari pembuat karya/rancang bangun.

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Yang menyerahkan **),

(Khiarul Arham)
NIM 061330330278

Arduino New Products



Arduino DUE

The Arduino Due is the newcomer microcontroller board in the Arduino boards family. It's the first board based on a 32 bit processor (Atmel SAM3X8E ARM Cortex-M3 MCU), which improves all the standard Arduino functionalities and adds many new features.

The arduino DUE offers 54 digital input/output pins (of which 16 can be used as PWM outputs, with selectable resolution), 12 analog inputs with 12 bits of resolution, 4 UARTs (hardware serial ports), two DAC (digital to analog converter) outputs, an 84 MHz crystal oscillator, two USB connections, a power jack, an ICSP header, a JTAG header, and a reset button.

The Due has two micro USB connectors: one intended for debugging purposes and a second one capable of acting as a USB host, allowing external USB peripherals such as mouse, keyboards, smartphones, etc. to be connected to the Arduino Due. More information will be soon on line at the page <http://arduino.cc/ArduinoDUE>

Technical Specifications

Microcontroller	AT91SAM3X8E
Operating Voltage	3.3V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 16 provide PWMoutput)
Analog Input Pins	12
Analog Outputs Pins	2 (DAC)
Total DC Output Current on all I/O lines	130mA
DC Current for 3.3V Pin	800 mA
DC Current for 5V Pin	theoretical 1A, realistic 800 mA
Flash Memory	512 KB all available for the user applications
SRAM	96 KB (64 + 32 KB)
DataFlash	2 Mbit (250 KB)
Clock Speed	84 MHz



Getting started with the Arduino Due

To connect the Arduino Due to your computer, you'll need a Micro-B USB cable. The USB cable will provide power and allow you to program the board.

Attach the USB micro side of the USB cable to the Due's *Programming* port (this is the port closer to the DC power connector). To upload a sketch, choose **Arduino Due (Programming port)** from the **Tools > Board** menu in the Arduino IDE, and select the correct serial port from the **Tools > Serial Port** menu.

The Due has a [dedicated forum](#) for discussing the board.

On this page... ([hide](#))

- [Differences from ATMEGA based boards](#)
 - [Voltage](#)
 - [Serial ports on the Due](#)
 - [Automatic \(Software\) Reset](#)
 - [USB Host](#)
 - [ADC and PWM resolutions](#)
 - [Expanded SPI functionality](#)
- [Installing Drivers for the Due](#)
 - [OSX](#)
 - [Windows \(tested on XP and 7\)](#)
 - [Linux](#)
- [Uploading Code to the Due](#)

Differences from ATMEGA based boards

In general, you program and use the Due as you would other Arduino boards. There are, however, a few important differences and functional extensions.

The Due has the same footprint as the Mega 2560.

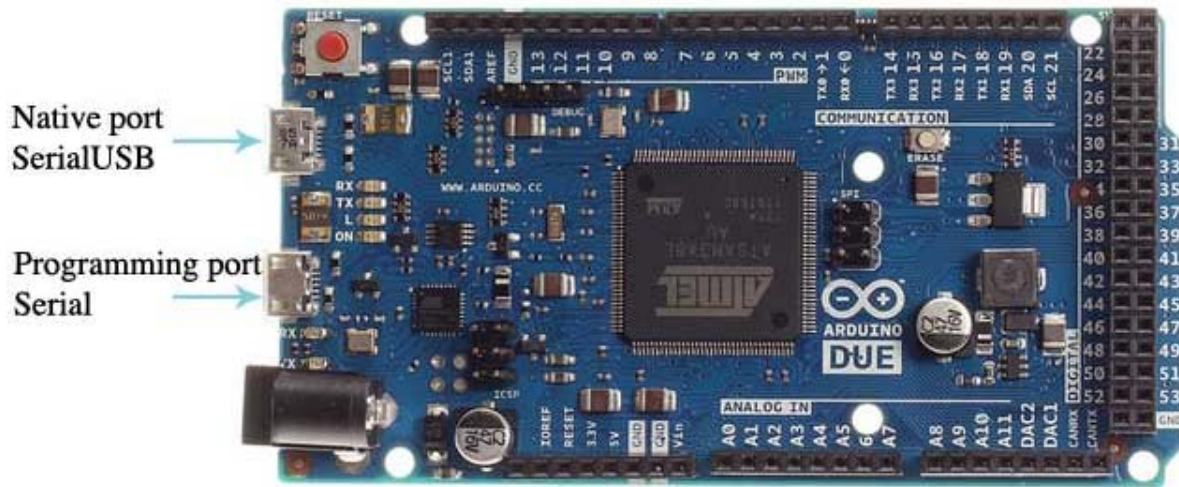
Voltage

The microcontroller mounted on the Arduino Due runs at 3.3V, this means that you can power your sensors and drive your actuators only with 3.3V. **Connecting higher voltages, like the 5V commonly used with the other Arduino boards will damage the Due.**

The board can take power from the USB connectors or the DC plug. If using the DC connector, supply a voltage between 7V and 12V.

The Arduino Due has an efficient switching voltage regulator, compliant with the USB host specification. If the *Native* USB port is used as host by attaching a USB device to the micro-A usb connector, the board will provide the power to the device. When the board is used as a usb host, external power from the DC connector is required.

Serial ports on the Due



The Arduino Due has two USB ports available. The *Native* USB port (which supports CDC serial communication using the *SerialUSB* object) is connected directly to the SAM3X MCU. The other USB port is the *Programming* port. It is connected to an ATMEEL 16U2 which acts as a USB-to-Serial converter. This *Programming* port is the default for uploading sketches and communicating with the Arduino.

The USB-to-serial converter of the *Programming* port is connected to the first UART of the SAM3X. It's possible to communicate over this port using the "Serial" object in the Arduino programming language.

The USB connector of the *Native* port is directly connected to the USB host pins of the SAM3X. Using the *Native* port enables you to use the Due as a client USB peripheral (acting as a mouse or a keyboard connected to the computer) or as a USB host device so that devices can be connected to the Due (like a mouse, keyboard, or an Android phone). This port can also be used as a virtual serial port using the "SerialUSB" object in the Arduino programming language.

Automatic (Software) Reset

The SAM3X microcontroller differs from AVR microcontrollers because the flash memory needs to be erased before being re-programmed. A manual procedure would involve holding the erase button for a second, pressing the upload button in the IDE, then the reset button.

Because a manual erase-flash procedure is repetitive, this is managed automatically by both USB ports, in two different ways:

Native port

Opening and closing the "Native" port at the baud rate of 1200bps triggers a "soft erase" procedure: the flash memory is erased and the board is restarted with the bootloader. If, for some reason, the MCU were to crash during this process, it is likely that the soft erase procedure wouldn't work as it's done in software by the MCU itself.

Opening and closing the *Native* port at a baudrate other than 1200bps will not reset the SAM3X. To use the serial monitor, and see what your sketch does from the beginning, you'll need to add few lines of code inside the `setup()`. This will ensure the SAM3X will wait for the SerialUSB port to open before executing the sketch:

```
while (!Serial) ;  
\[Get Code\]
```

Pressing the Reset button on the Due causes the SAM3X reset as well as the USB communication. This interruption means that if the serial monitor is open, it's necessary to close and reopen it to restart the communication.

Programming port

The *Programming* port uses a USB-to-serial chip connected to the first UART of the MCU (RX0 and TX0). The USB-to-serial chip has two pins connected to the Reset and Erase pins of the SAM3X. When you open this serial port, the USB-to-Serial activates the Erase and Reset sequence before it begins communicating with the UART of the SAM3X. This procedure is much more reliable and should work even if the main MCU has crashed.

To communicate serially with the *Programming* port, use the "Serial" object in the IDE. All existing sketches that use serial communication based on the Uno board should work similarly. The *Programming* port behaves like the Uno's serial port in that the USB-to-Serial chip resets the board each time you open the serial monitor (or any other serial communication).

Pressing the Reset button while communicating over the *Programming* port doesn't close a USB connection with the computer because only the SAM3X is reset.

USB Host

The Due has the ability to act as a USB host for peripherals connected to the SerialUSB port. For additional information and examples, see the [USB host reference page](#).

When using the Due as a host, it will be providing power to the attached device. It is strongly recommended to use the DC power connector when acting as a host.

ADC and PWM resolutions

The Due has the ability to change its default analog read and write resolutions (10-bits and 8-bits, respectively). It can support up to 12-bit ADC and PWM resolutions. See the [analog write resolution](#) and [analog read resolution](#) pages for information.

Expanded SPI functionality

The Due has expanded functionality on its SPI bus, useful for communicating with multiple devices that speak at different speeds. See the [Due extended SPI library usage page](#) for more details.

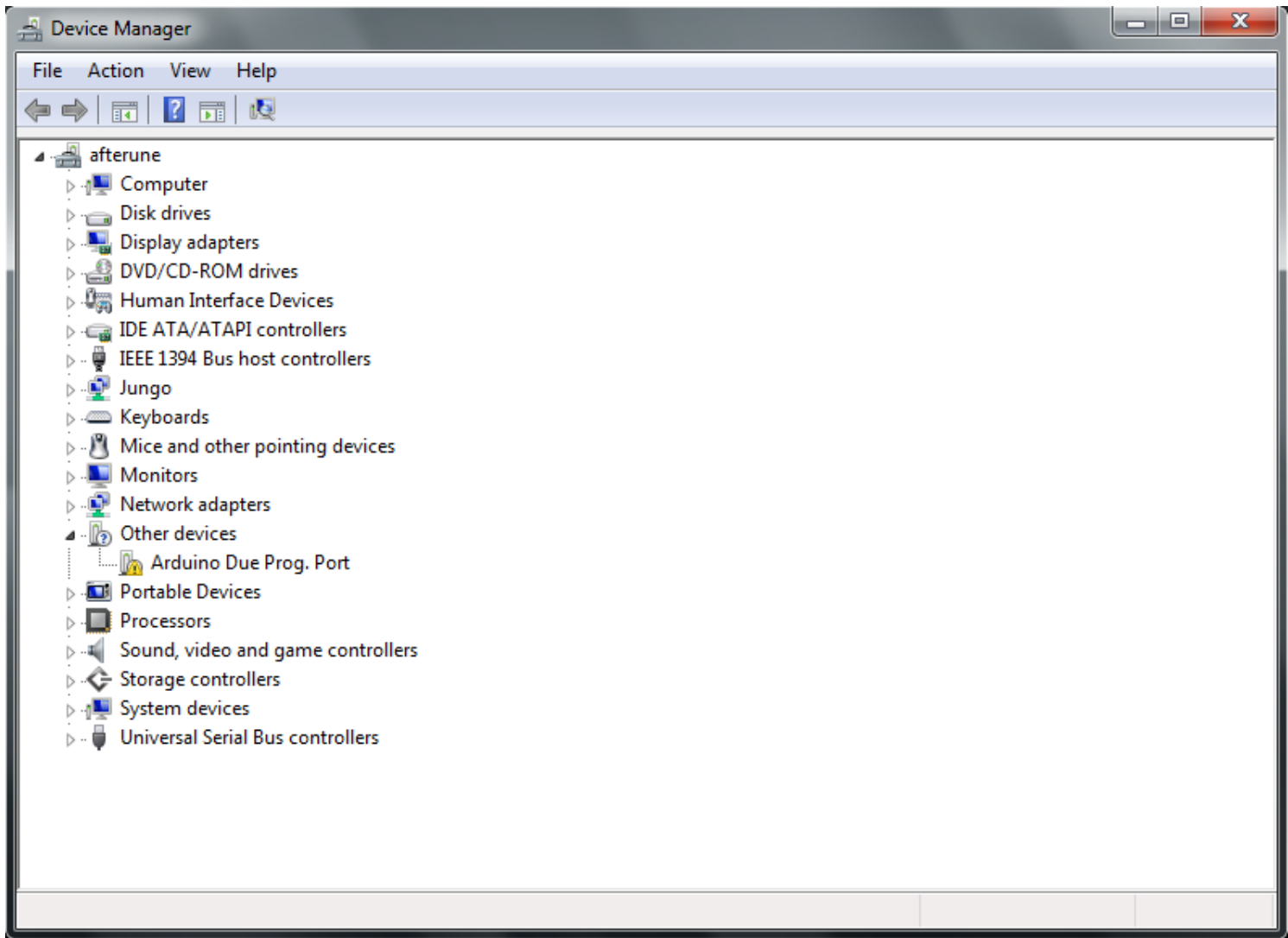
Installing Drivers for the Due

OSX

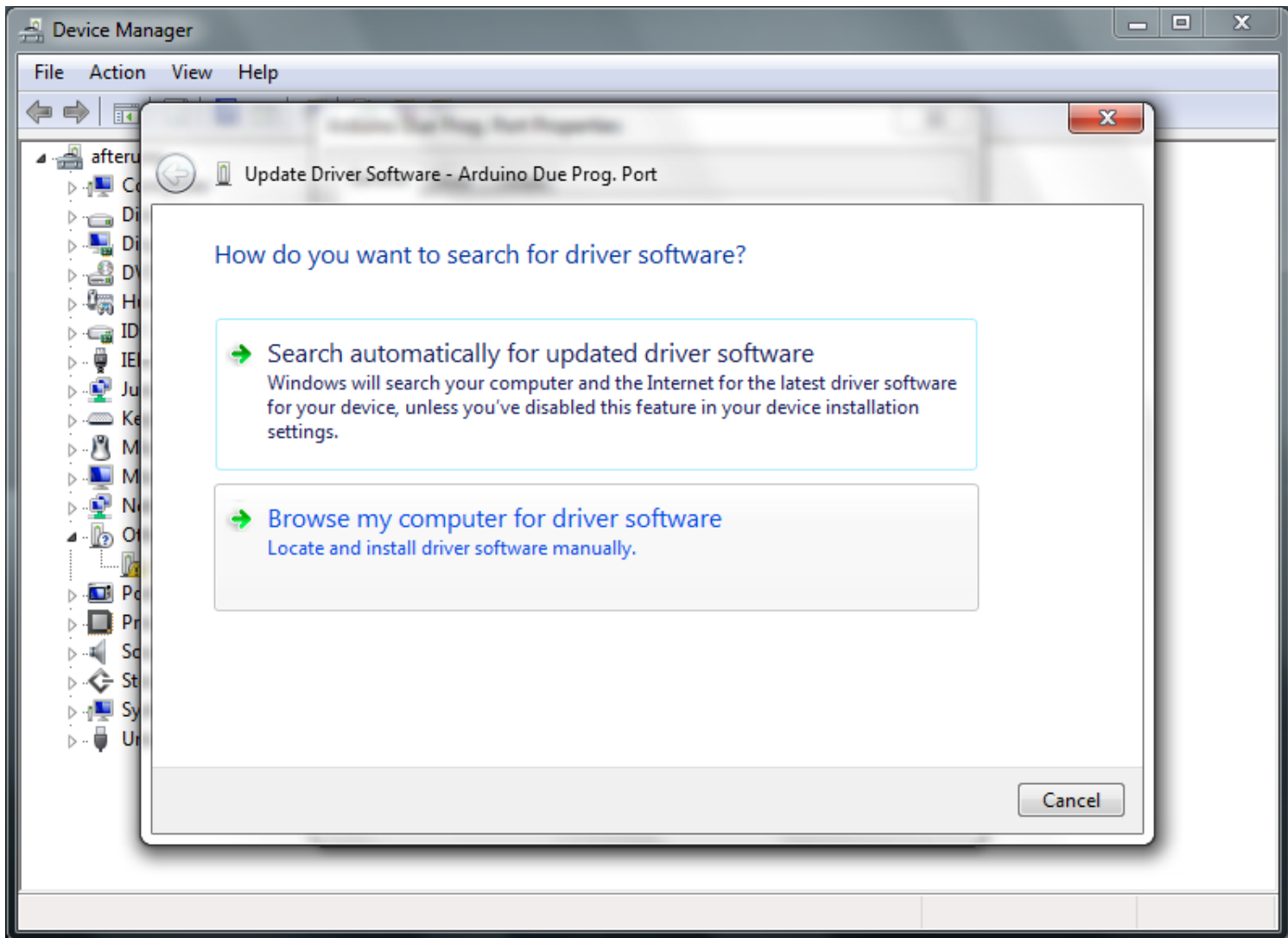
- No driver installation is necessary on OSX. Depending on the version of the OS you're running, you may get a dialog box asking you if you wish to open the "Network Preferences". Click the "Network Preferences..." button, then click "Apply". The Uno will show up as "Not Configured", but it is still working. You can quit the System Preferences.

Windows (tested on XP and 7)

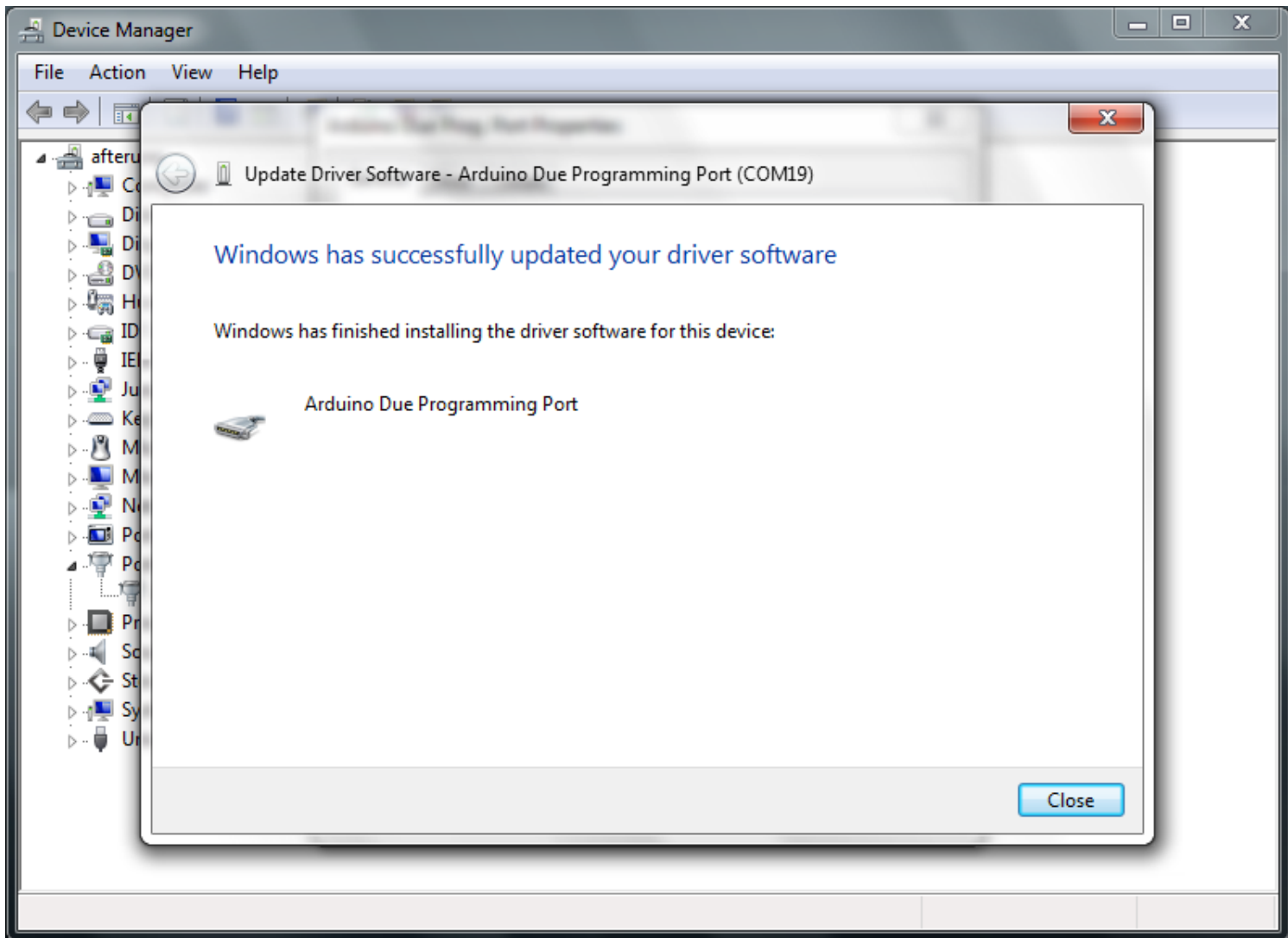
- Download the Windows version of the Arduino software. When the download finishes, unzip the downloaded file. Make sure to preserve the folder structure.
- Connect the Due to your computer with a USB cable via the *Programming* port.
- Windows should initiate its driver installation process once the board is plugged in, but it won't be able to find the driver on its own. You'll have to tell it where the driver is.
- Click on the Start Menu and open the Control Panel
- Navigate to "System and Security". Click on System, and open the Device Manager.
- Look for the listing named "Ports (COM & LPT)". You should see an open port named "Arduino Due Prog. Port".
- Select the "Browse my computer for Driver software" option.



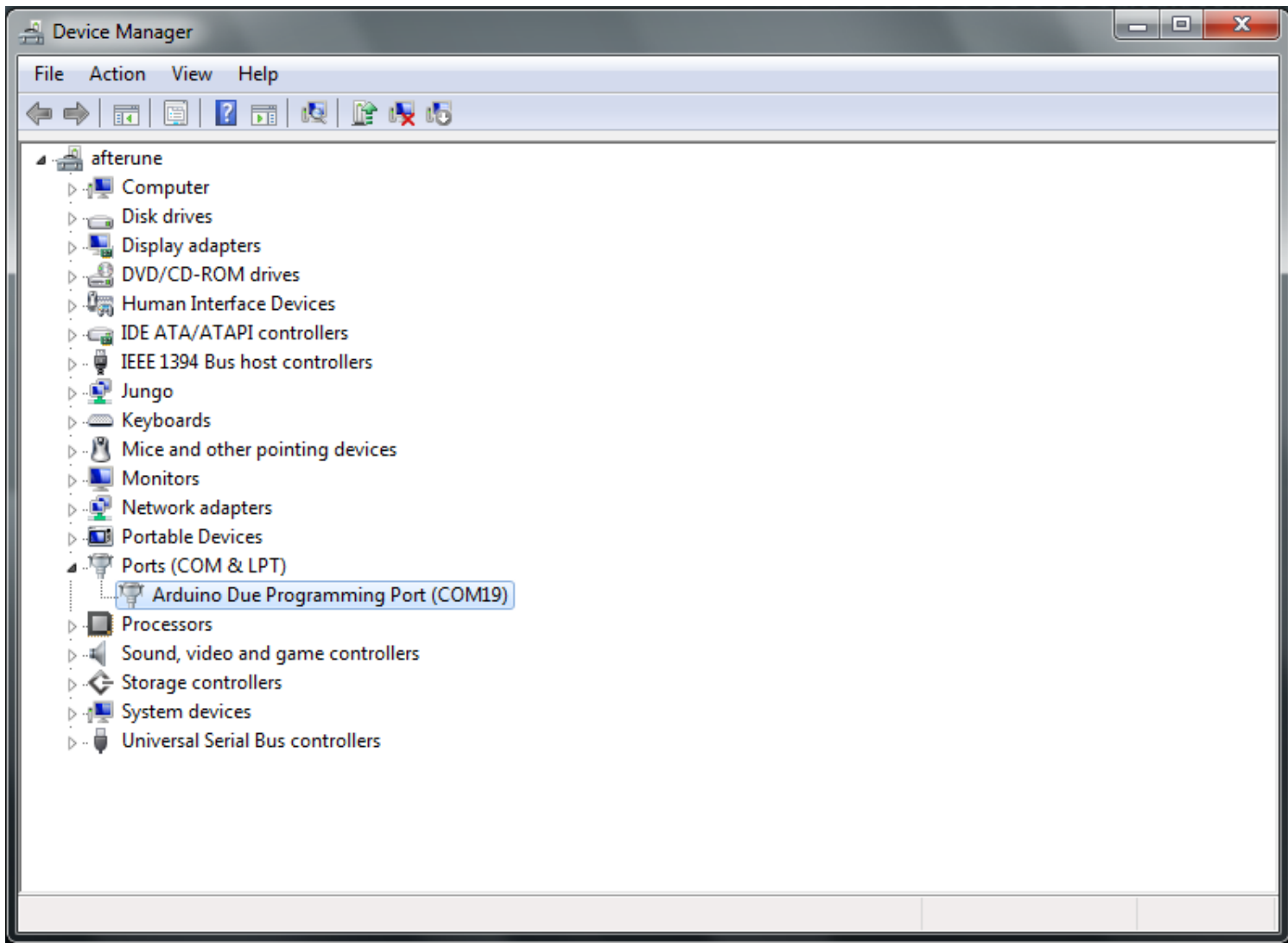
- Right click on the "Arduino Due Prog. Port" and choose "Update Driver Software". Descriptive text



- Navigate to the folder with the Arduino IDE you downloaded and unzipped earlier. Locate and select the "Drivers" folder in the main Arduino folder (not the "FTDI USB Drivers" sub-directory). Press "OK" and "Next" to proceed.
- If you are prompted with a warning dialog about not passing Windows Logo testing, click "Continue Anyway".
- Windows now will take over the driver installation.



- You have installed the driver on your computer. In the Device Manager, you should now see a port listing similar to "Arduino Due Programming Port (COM4)".



Linux

- No driver installation is necessary for Linux.

Uploading Code to the Due

The uploading process on the Arduino Due works the same as other boards from a user's standpoint. It is recommended to use the *Programming* port for uploading sketches, though you can upload sketches on either of the USB ports.

For uploading with the *Programming* port follow this steps:

- Connect your board to the computer by attaching the USB cable to the Due's *Programming* port (this is the port closer to the DC power connector).
- Open the Arduino IDE.
- In the "Tools" menu choose "Serial Port" and select the serial port of the Due
- Under the "Tools > Boards" menu select "Arduino Due (Programming port)"

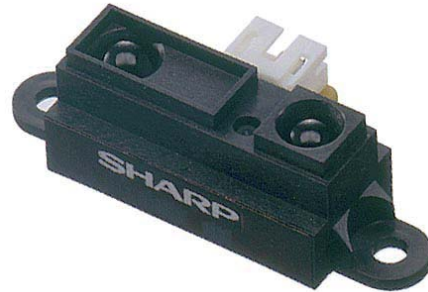
You are now ready to upload sketches to your Arduino Due.

For more details on the Arduino Due, see the [hardware page](#).

The text of the Arduino getting started guide is licensed under a [Creative Commons Attribution-ShareAlike 3.0 License](#). Code samples in the guide are released into the public domain.

GP2Y0A21YK0F

Distance Measuring Sensor Unit
Measuring distance: 10 to 80 cm
Analog output type



■Description

GP2Y0A21YK0F is a distance measuring sensor unit, composed of an integrated combination of PSD (position sensitive detector), IRED (infrared emitting diode) and signal processing circuit.

The variety of the reflectivity of the object, the environmental temperature and the operating duration are not influenced easily to the distance detection because of adopting the triangulation method.

This device outputs the voltage corresponding to the detection distance. So this sensor can also be used as a proximity sensor.

■Features

1. Distance measuring range : 10 to 80 cm
2. Analog output type
3. Package size : 29.5×13×13.5 mm
4. Consumption current : Typ. 30 mA
5. Supply voltage : 4.5 to 5.5 V

■Agency approvals/Compliance

1. Compliant with RoHS directive (2002/95/EC)

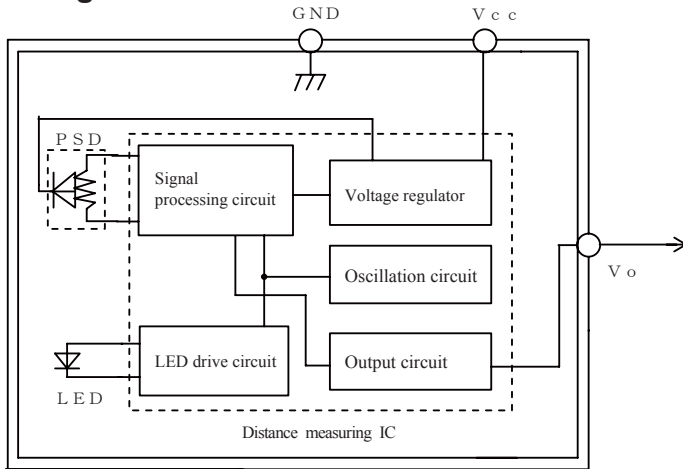
■Applications

1. Touch-less switch
(Sanitary equipment, Control of illumination, etc.)
2. Robot cleaner
3. Sensor for energy saving
(ATM, Copier, Vending machine)
4. Amusement equipment
(Robot, Arcade game machine)

Notice The content of data sheet is subject to change without prior notice.

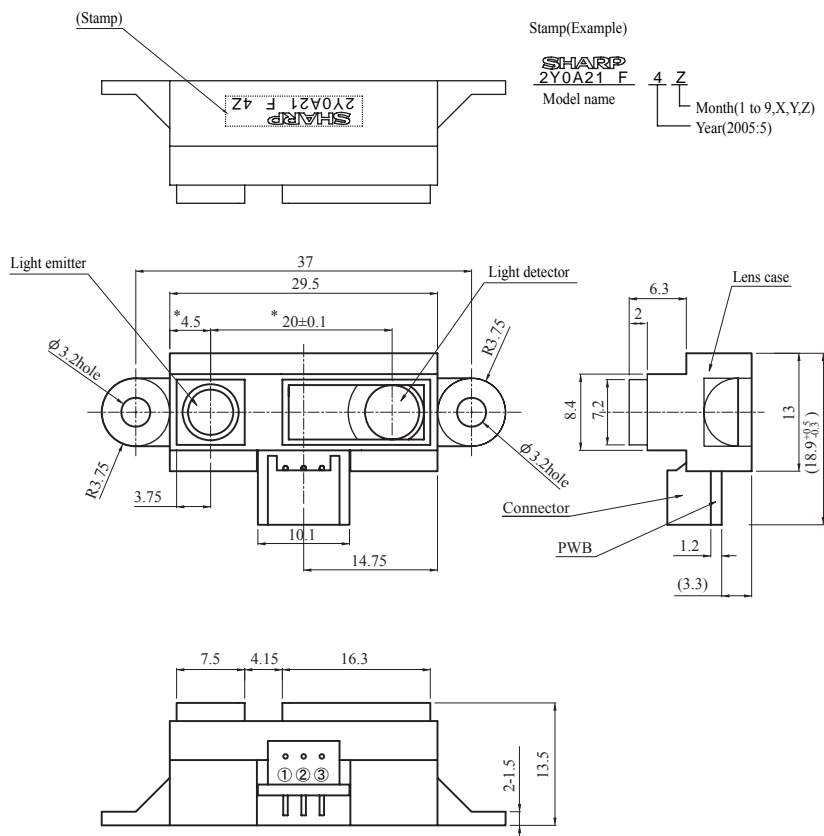
In the absence of confirmation by device specification sheets, SHARP takes no responsibility for any defects that may occur in equipment using any SHARP devices shown in catalogs, data books, etc. Contact SHARP in order to obtain the latest device specification sheets before using any SHARP device.

Block diagram



Outline Dimensions

(Unit : mm)



Connector signal

signal name
① Vo
② GND
③ Vcc

Connector :
J.S.T. TRADING COMPANY, LTD,
S3B-PH

Materials

Lens : Acrylic acid resin
(Visible light cut-off resin)
Case : Carbonic ABS
(Conductive resin)
PWB : Paper phenol

Note 1. The dimensions marked * are described the dimensions of lens center position.

Note 2. Unspecified tolerances shall be ± 0.3 mm.

Note 3. The dimensions in parenthesis are shown for reference.

Product mass : Approx. 3.6g

■ Absolute Maximum Ratings (T_a=25°C, V_{CC}=5V)

Parameter	Symbol	Rating	Unit
Supply voltage	V _{CC}	-0.3 to +7	V
Output terminal voltage	V _O	-0.3 to V _{CC} +0.3	V
Operating temperature	T _{opr}	-10 to +60	°C
Storage temperature	T _{stg}	-40 to +70	°C

■ Electro-optical Characteristics (T_a=25°C, V_{CC}=5V)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Average supply current	I _{CC}	L=80cm (Note 1)	—	30	40	mA
Distance measuring	ΔL	(Note 1)	10	—	80	cm
Output voltage	V _O	L=80cm (Note 1)	0.25	0.4	0.55	V
Output voltage differential	ΔV _O	Output voltage difference between L=10cm and L=80cm (Note 1)	1.65	1.9	2.15	V

* L : Distance to reflective object

Note 1 : Using reflective object : White paper (Made by Kodak Co., Ltd. gray cards R-27·white face, reflectance; 90%)

■ Recommended operating conditions

Parameter	Symbol	Rating	Unit
Supply voltage	V _{CC}	4.5 to 5.5	V

Fig. 1 Timing chart

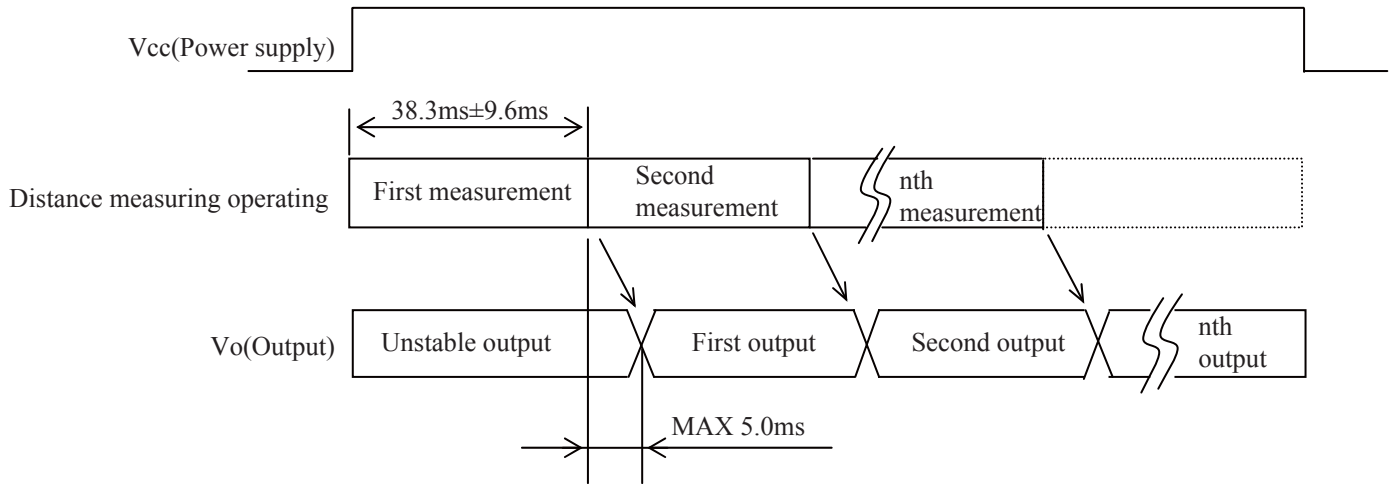
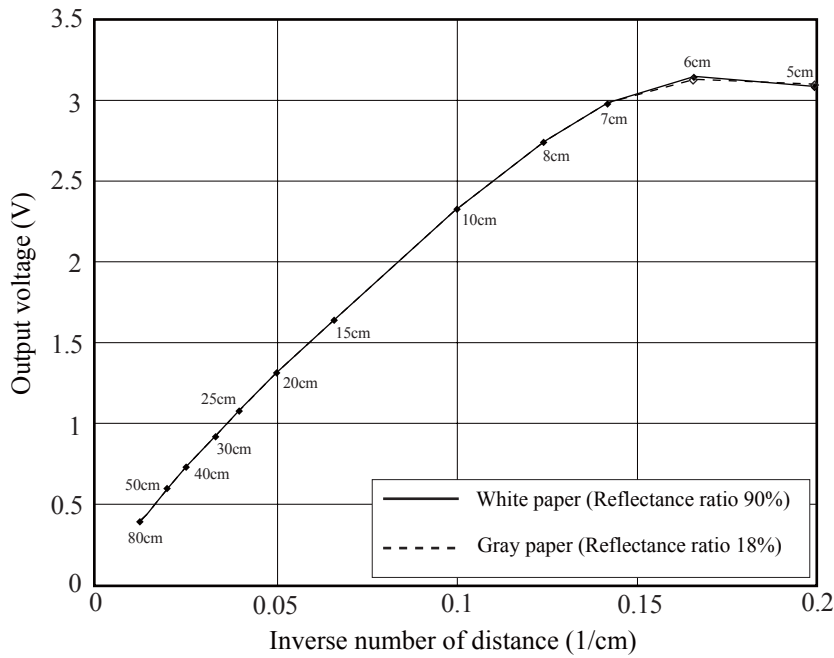
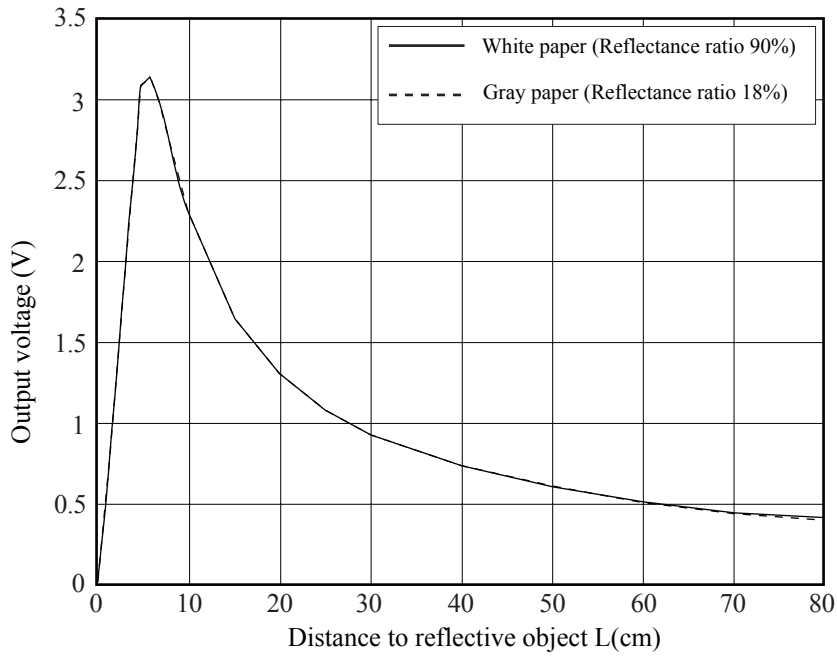


Fig. 2 Example of distance measuring characteristics(output)



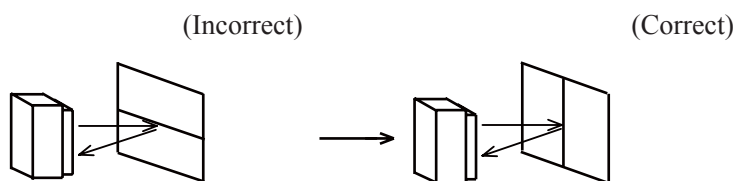
■ Notes

● Advice for the optics

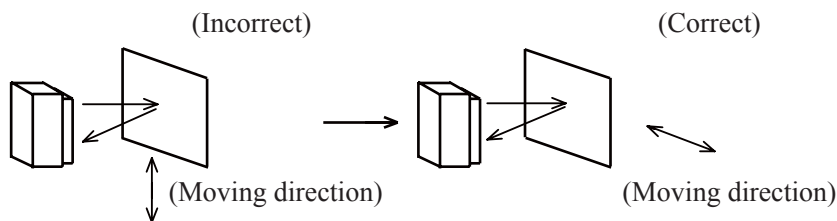
- The lens of this device needs to be kept clean. There are cases that dust, water or oil and so on deteriorate the characteristics of this device. Please consider in actual application.
- Please don't do washing. Washing may deteriorate the characteristics of optical system and so on. Please confirm resistance to chemicals under the actual usage since this product has not been designed against washing.

● Advice for the characteristics

- In case that an optical filter is set in front of the emitter and detector portion, the optical filter which has the most efficient transmittance at the emitting wavelength range of LED for this product ($\lambda = 870 \pm 70\text{nm}$), shall be recommended to use. Both faces of the filter should be mirror polishing. Also, as there are cases that the characteristics may not be satisfied according to the distance between the protection cover and this product or the thickness of the protection cover, please use this product after confirming the operation sufficiently in actual application.
- In case that there is an object near to emitter side of the sensor between sensor and a detecting object, please use this device after confirming sufficiently that the characteristics of this sensor do not change by the object.
- When the detector is exposed to the direct light from the sun, tungsten lamp and so on, there are cases that it can not measure the distance exactly. Please consider the design that the detector is not exposed to the direct light from such light source.
- Distance to a mirror reflector can not be sometimes measured exactly. In case of changing the mounting angle of this product, it may measure the distance exactly.
- In case that reflective object has boundary line which material or color etc. are excessively different, in order to decrease deviation of measuring distance, it shall be recommended to set the sensor that the direction of boundary line and the line between emitter center and detector center are in parallel.



- In order to decrease deviation of measuring distance by moving direction of the reflective object, it shall be recommended to set the sensor that the moving direction of the object and the line between emitter center and detector center are vertical.



● Advice for the power supply

- In order to stabilize power supply line, we recommend to insert a by-pass capacitor of 10 μF or more between Vcc and GND near this product.

● Notes on handling

- There are some possibilities that the internal components in the sensor may be exposed to the excessive mechanical stress. Please be careful not to cause any excessive pressure on the sensor package and also on the PCB while assembling this product.

● Presence of ODC etc.

This product shall not contain the following materials.

And they are not used in the production process for this product.

Regulation substances : CFCs, Halon, Carbon tetrachloride, 1.1.1-Trichloroethane (Methylchloroform)

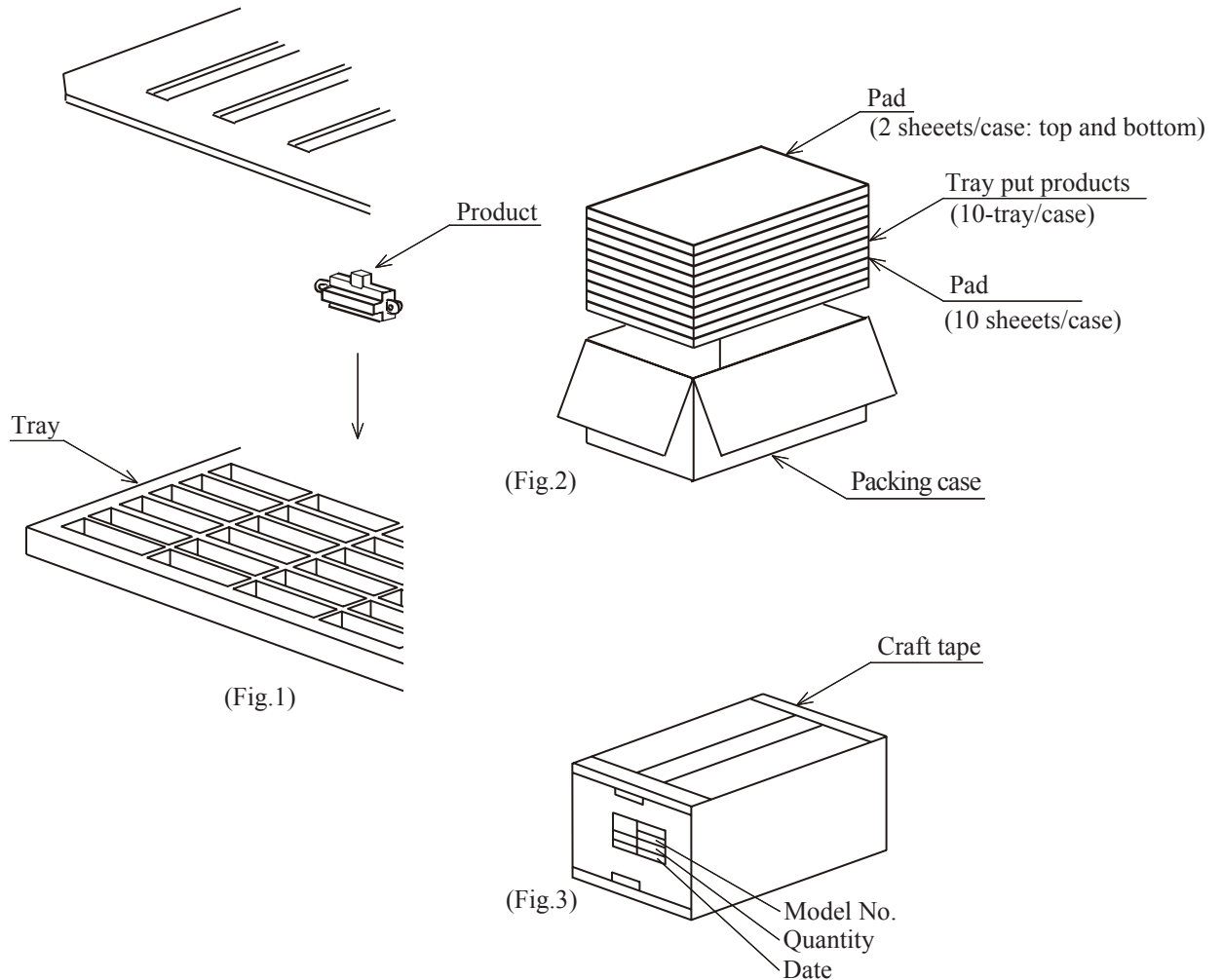
Specific brominated flame retardants such as the PBB and PBDE are not used in this product at all.

This product shall not contain the following materials banned in the RoHS Directive (2002/95/EC).

- Lead, Mercury, Cadmium, Hexavalent chromium, Polybrominated biphenyls (PBB), Polybrominated diphenyl ethers (PBDE).

■ **Package specification**

Package composition



Packaging method

1. Put products of 100pcs. in tray. packing method is showed in the above fig.(Fig.1)
2. Put them(10-tray) in the packing box. Put pads on their top and bottom.
And put pads on each trays(Total 10 sheets) (Fig.2).
3. Seal the packing box with craft tape.
Print the model No.,quantity,inspection date (1000 pcs./a packing box)(Fig.3).

■ Important Notices

· The circuit application examples in this publication are provided to explain representative applications of SHARP devices and are not intended to guarantee any circuit design or license any intellectual property rights. SHARP takes no responsibility for any problems related to any intellectual property right of a third party resulting from the use of SHARP's devices.

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· Observe the following points when using any devices in this publication. SHARP takes no responsibility for damage caused by improper use of the devices which does not meet the conditions and absolute maximum ratings to be used specified in the relevant specification sheet nor meet the following conditions:

(i) The devices in this publication are designed for use in general electronic equipment designs such as:

- Personal computers
- Office automation equipment
- Telecommunication equipment [terminal]
- Test and measurement equipment
- Industrial control
- Audio visual equipment
- Consumer electronics

(ii) Measures such as fail-safe function and redundant design should be taken to ensure reliability and safety when SHARP devices are used for or in connection

with equipment that requires higher reliability such as:

- Transportation control and safety equipment (i.e., aircraft, trains, automobiles, etc.)
- Traffic signals
- Gas leakage sensor breakers
- Alarm equipment
- Various safety devices, etc.

(iii) SHARP devices shall not be used for or in connection with equipment that requires an extremely high level of reliability and safety such as:

- Space applications
- Telecommunication equipment [trunk lines]
- Nuclear power control equipment
- Medical and other life support equipment (e.g., scuba).

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· Contact and consult with a SHARP representative if there are any questions about the contents of this publication.

- High-Resolution Conversion of Light Intensity to Frequency
- Programmable Color and Full-Scale Output Frequency
- Communicates Directly With a Microcontroller
- Single-Supply Operation (2.7 V to 5.5 V)
- Power Down Feature
- Nonlinearity Error Typically 0.2% at 50 kHz
- Stable 200 ppm/°C Temperature Coefficient
- Low-Profile Lead (Pb) Free and RoHS Compliant Surface-Mount Package

Description

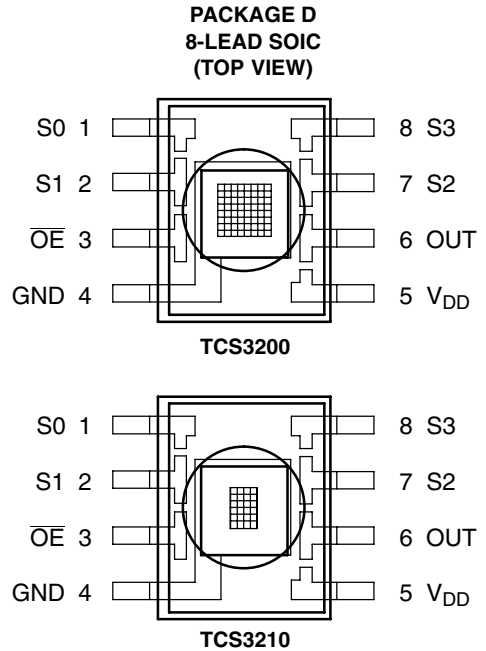
The TCS3200 and TCS3210 programmable color light-to-frequency converters that combine configurable silicon photodiodes and a current-to-frequency converter on a single monolithic CMOS integrated circuit. The output is a square wave (50% duty cycle) with frequency directly proportional to light intensity (irradiance).

The full-scale output frequency can be scaled by one of three preset values via two control input pins. Digital inputs and digital output allow direct interface to a microcontroller or other logic circuitry. Output enable (\overline{OE}) places the output in the high-impedance state for multiple-unit sharing of a microcontroller input line.

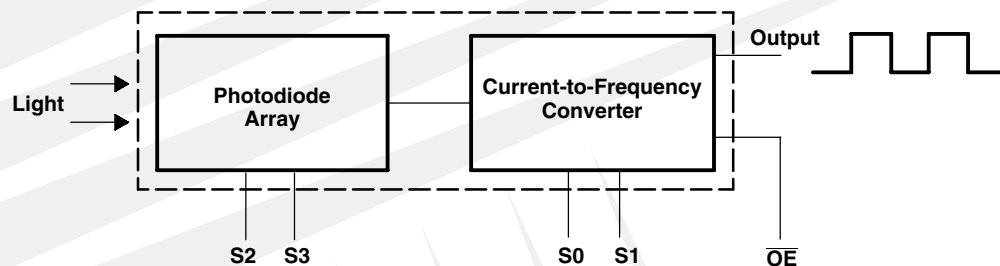
In the TCS3200, the light-to-frequency converter reads an 8 x 8 array of photodiodes. Sixteen photodiodes have blue filters, 16 photodiodes have green filters, 16 photodiodes have red filters, and 16 photodiodes are clear with no filters.

In the TCS3210, the light-to-frequency converter reads a 4 x 6 array of photodiodes. Six photodiodes have blue filters, 6 photodiodes have green filters, 6 photodiodes have red filters, and 6 photodiodes are clear with no filters.

The four types (colors) of photodiodes are interdigitated to minimize the effect of non-uniformity of incident irradiance. All photodiodes of the same color are connected in parallel. Pins S2 and S3 are used to select which group of photodiodes (red, green, blue, clear) are active. Photodiodes are 110 μm x 110 μm in size and are on 134- μm centers.



Functional Block Diagram



TCS3200, TCS3210 PROGRAMMABLE COLOR LIGHT-TO-FREQUENCY CONVERTER

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Terminal Functions

TERMINAL NAME	NO.	I/O	DESCRIPTION
GND	4		Power supply ground. All voltages are referenced to GND.
\overline{OE}	3	I	Enable for f_o (active low).
OUT	6	O	Output frequency (f_o).
S0, S1	1, 2	I	Output frequency scaling selection inputs.
S2, S3	7, 8	I	Photodiode type selection inputs.
V _{DD}	5		Supply voltage

Table 1. Selectable Options

S0	S1	OUTPUT FREQUENCY SCALING (f_o)
L	L	Power down
L	H	2%
H	L	20%
H	H	100%

S2	S3	PHOTODIODE TYPE
L	L	Red
L	H	Blue
H	L	Clear (no filter)
H	H	Green

Available Options

DEVICE	T _A	PACKAGE – LEADS	PACKAGE DESIGNATOR	ORDERING NUMBER
TCS3200	–40°C to 85°C	SOIC–8	D	TCS3200D
TCS3210	–40°C to 85°C	SOIC–8	D	TCS3210D

Absolute Maximum Ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, V_{DD} (see Note 1)	6 V
Input voltage range, all inputs, V_I	–0.3 V to $V_{DD} + 0.3$ V
Operating free-air temperature range, T_A (see Note 2)	–40°C to 85°C
Storage temperature range (see Note 2)	–40°C to 85°C
Solder conditions in accordance with JEDEC J–STD–020A, maximum temperature (see Note 3) ...	260°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES: 1. All voltage values are with respect to GND.
 2. Long-term storage or operation above 70°C could cause package yellowing that will lower the sensitivity to wavelengths < 500nm.
 3. The device may be hand soldered provided that heat is applied only to the solder pad and no contact is made between the tip of the solder iron and the device lead. The maximum time heat should be applied to the device is 5 seconds.

Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
Supply voltage, V_{DD}		2.7	5	5.5	V
High-level input voltage, V_{IH}	$V_{DD} = 2.7$ V to 5.5 V	2		V_{DD}	V
Low-level input voltage, V_{IL}	$V_{DD} = 2.7$ V to 5.5 V	0		0.8	V
Operating free-air temperature range, T_A		–40		70	°C

Electrical Characteristics at $T_A = 25^\circ\text{C}$, $V_{DD} = 5$ V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{OH}	High-level output voltage	$I_{OH} = -2$ mA	4	4.5		V
V_{OL}	Low-level output voltage	$I_{OL} = 2$ mA		0.25	0.40	V
I_{IH}	High-level input current				5	μA
I_{IL}	Low-level input current				5	μA
I_{DD}	Supply current	Power-on mode		1.4	2	mA
		Power-down mode			0.1	μA
	Full-scale frequency (See Note 4)	$S0 = H, S1 = H$	500	600		kHz
		$S0 = H, S1 = L$	100	120		kHz
		$S0 = L, S1 = H$	10	12		kHz
	Temperature coefficient of responsivity	$\lambda \leq 700$ nm, $-25^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$		±200		ppm/°C
k_{SVS}	Supply voltage sensitivity	$V_{DD} = 5$ V ±10%		±0.5		%/V

NOTE 4: Full-scale frequency is the maximum operating frequency of the device without saturation.

TCS3200, TCS3210 PROGRAMMABLE COLOR LIGHT-TO-FREQUENCY CONVERTER

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Operating Characteristics at $V_{DD} = 5\text{ V}$, $T_A = 25^\circ\text{C}$, $S_0 = \text{H}$, $S_1 = \text{H}$ (unless otherwise noted)
(See Notes 5, 6, 7, and 8). Values for TCS3200 (TCS3210) are below.

PARAMETER	TEST CONDITIONS	CLEAR PHOTODIODE S2 = H, S3 = L			BLUE PHOTODIODE S2 = L, S3 = H			GREEN PHOTODIODE S2 = H, S3 = H			RED PHOTODIODE S2 = L, S3 = L			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
f_O Output frequency (Note 9)	$E_e = 47.2\ \mu\text{W}/\text{cm}^2$, $\lambda_p = 470\ \text{nm}$	12.5 (4.7)	15.6 (5.85)	18.7 (7)	61%	84%	22%	43%	0%	6%	kHz			
	$E_e = 40.4\ \mu\text{W}/\text{cm}^2$, $\lambda_p = 524\ \text{nm}$	12.5 (4.7)	15.6 (5.85)	18.7 (7)	8%	28%	57%	80%	9%	27%				
	$E_e = 34.6\ \mu\text{W}/\text{cm}^2$, $\lambda_p = 640\ \text{nm}$	13.1 (4.9)	16.4 (6.15)	19.7 (7.4)	5%	21%	0%	12%	84%	105%				
R_e Irradiance responsivity (Note 10)	$\lambda_p = 470\ \text{nm}$	331 (124)			61%	84%	22%	43%	0%	6%	Hz/ ($\mu\text{W}/\text{cm}^2$)			
	$\lambda_p = 524\ \text{nm}$	386 (145)			8%	28%	57%	80%	9%	27%				
	$\lambda_p = 640\ \text{nm}$	474 (178)			5%	21%	0%	12%	84%	105%				
Saturation irradiance (Note 11)	$\lambda_p = 470\ \text{nm}$	1813 (4839)			--	--	--	--	--	--	$\mu\text{W}/\text{cm}^2$			
	$\lambda_p = 524\ \text{nm}$	1554 (4138)			--	--	--	--	--	--				
	$\lambda_p = 640\ \text{nm}$	1266 (3371)			--	--	--	--	--	--				
f_D Dark frequency	$E_e = 0$	2	10	2	10	2	10	2	10	Hz				
Nonlinearity (Note 12)	$f_O = 0$ to 5 kHz	± 0.1			± 0.1			± 0.1			% F.S.			
	$f_O = 0$ to 50 kHz	± 0.2			± 0.2			± 0.2						
	$f_O = 0$ to 500 kHz	± 0.5			± 0.5			± 0.5						
Recovery from power down		100			100			100			μs			
Response time to output enable ($\overline{\text{OE}}$)		100			100			100			ns			

- NOTES: 5. Optical measurements are made using small-angle incident radiation from a light-emitting diode (LED) optical source.
6. The 470 nm input irradiance is supplied by an InGaN light-emitting diode with the following characteristics: peak wavelength $\lambda_p = 470\ \text{nm}$, spectral halfwidth $\Delta\lambda_{1/2} = 35\ \text{nm}$, and luminous efficacy = 75 lm/W.
7. The 524 nm input irradiance is supplied by an InGaN light-emitting diode with the following characteristics: peak wavelength $\lambda_p = 524\ \text{nm}$, spectral halfwidth $\Delta\lambda_{1/2} = 47\ \text{nm}$, and luminous efficacy = 520 lm/W.
8. The 640 nm input irradiance is supplied by a AlInGaP light-emitting diode with the following characteristics: peak wavelength $\lambda_p = 640\ \text{nm}$, spectral halfwidth $\Delta\lambda_{1/2} = 17\ \text{nm}$, and luminous efficacy = 155 lm/W.
9. Output frequency Blue, Green, Red percentage represents the ratio of the respective color to the Clear channel absolute value.
10. Irradiance responsivity R_e is characterized over the range from zero to 5 kHz.
11. Saturation irradiance = (full-scale frequency)/(irradiance responsivity) for the Clear reference channel.
12. Nonlinearity is defined as the deviation of f_O from a straight line between zero and full scale, expressed as a percent of full scale.

TYPICAL CHARACTERISTICS

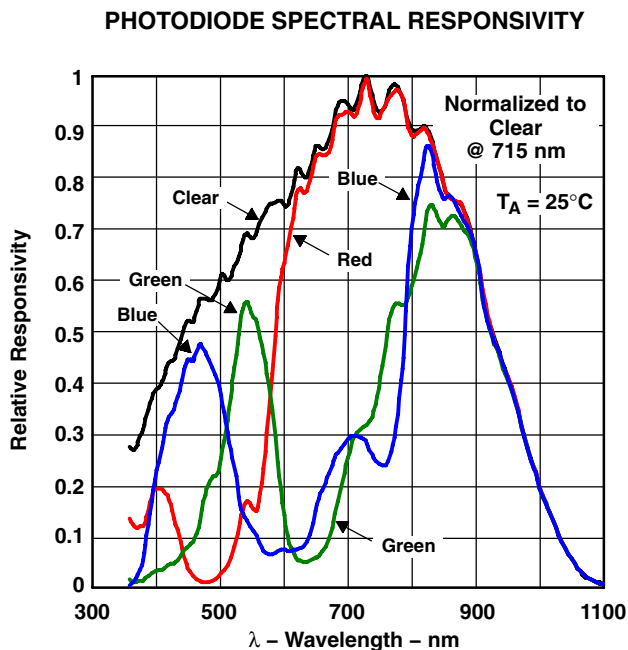


Figure 1

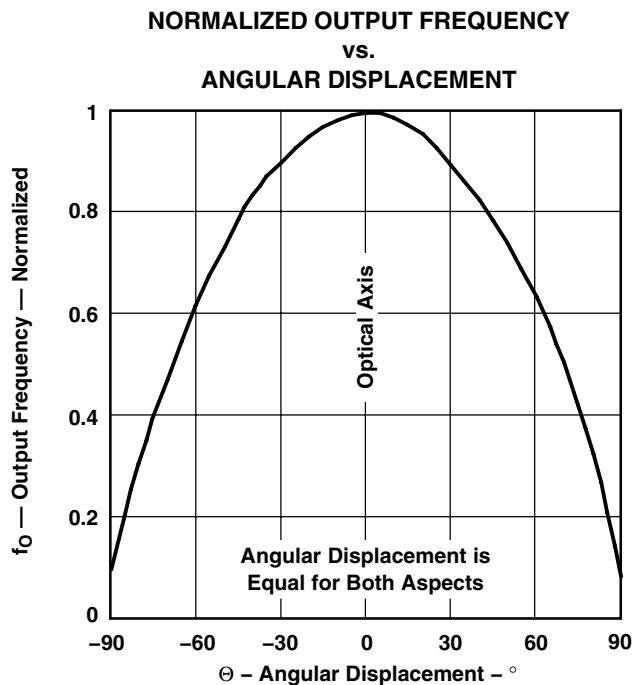


Figure 2

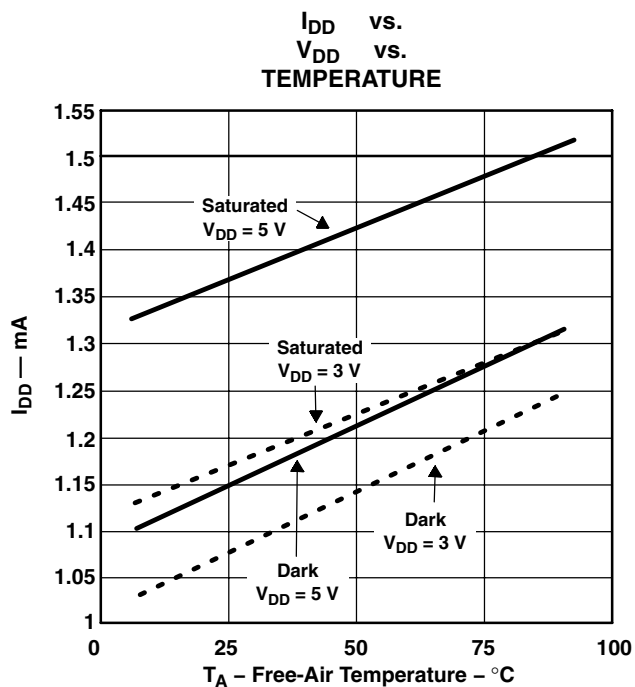


Figure 3

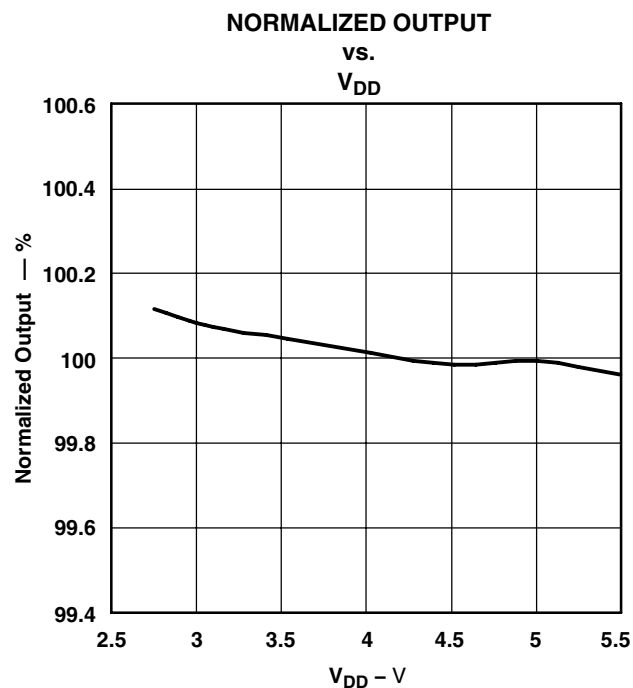


Figure 4

TYPICAL CHARACTERISTICS

PHOTODIODE RESPONSIVITY TEMPERATURE COEFFICIENT
vs.
WAVELENGTH OF INCIDENT LIGHT

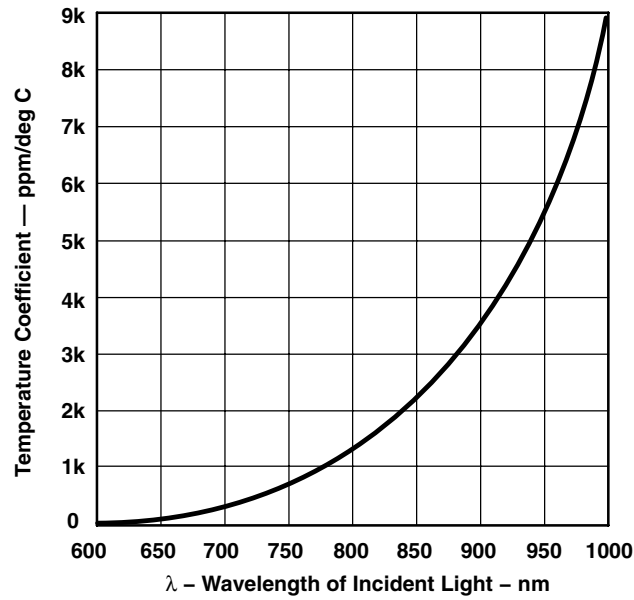


Figure 5

APPLICATION INFORMATION

Power supply considerations

Power-supply lines must be decoupled by a 0.01- μ F to 0.1- μ F capacitor with short leads mounted close to the device package.

Input interface

A low-impedance electrical connection between the device \overline{OE} pin and the device GND pin is required for improved noise immunity. All input pins must be either driven by a logic signal or connected to VDD or GND — they should not be left unconnected (floating).

Output interface

The output of the device is designed to drive a standard TTL or CMOS logic input over short distances. If lines greater than 12 inches are used on the output, a buffer or line driver is recommended.

A high state on Output Enable (OE) places the output in a high-impedance state for multiple-unit sharing of a microcontroller input line.

Power down

Powering down the sensor using S0/S1 (L/L) will cause the output to be held in a high-impedance state. This is similar to the behavior of the output enable pin, however powering down the sensor saves significantly more power than disabling the sensor with the output enable pin.

Photodiode type (color) selection

The type of photodiode (blue, green, red, or clear) used by the device is controlled by two logic inputs, S2 and S3 (see Table 1).

Output frequency scaling

Output-frequency scaling is controlled by two logic inputs, S0 and S1. The internal light-to-frequency converter generates a fixed-pulsewidth pulse train. Scaling is accomplished by internally connecting the pulse-train output of the converter to a series of frequency dividers. Divided outputs are 50%-duty cycle square waves with relative frequency values of 100%, 20%, and 2%. Because division of the output frequency is accomplished by counting pulses of the principal internal frequency, the final-output period represents an average of the multiple periods of the principle frequency.

The output-scaling counter registers are cleared upon the next pulse of the principal frequency after any transition of the S0, S1, S2, S3, and \overline{OE} lines. The output goes high upon the next subsequent pulse of the principal frequency, beginning a new valid period. This minimizes the time delay between a change on the input lines and the resulting new output period. The response time to an input programming change or to an irradiance step change is one period of new frequency plus 1 μ s. The scaled output changes both the full-scale frequency and the dark frequency by the selected scale factor.

The frequency-scaling function allows the output range to be optimized for a variety of measurement techniques. The scaled-down outputs may be used where only a slower frequency counter is available, such as low-cost microcontroller, or where period measurement techniques are used.



APPLICATION INFORMATION

Measuring the frequency

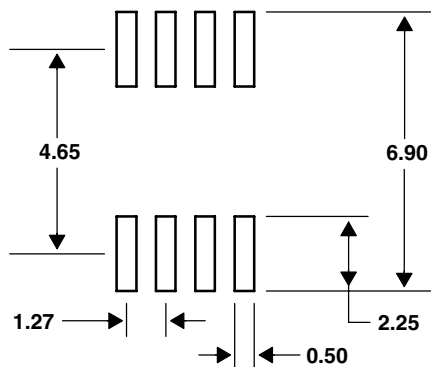
The choice of interface and measurement technique depends on the desired resolution and data acquisition rate. For maximum data-acquisition rate, period-measurement techniques are used.

Output data can be collected at a rate of twice the output frequency or one data point every microsecond for full-scale output. Period measurement requires the use of a fast reference clock with available resolution directly related to reference clock rate. Output scaling can be used to increase the resolution for a given clock rate or to maximize resolution as the light input changes. Period measurement is used to measure rapidly varying light levels or to make a very fast measurement of a constant light source.

Maximum resolution and accuracy may be obtained using frequency-measurement, pulse-accumulation, or integration techniques. Frequency measurements provide the added benefit of averaging out random- or high-frequency variations (jitter) resulting from noise in the light signal. Resolution is limited mainly by available counter registers and allowable measurement time. Frequency measurement is well suited for slowly varying or constant light levels and for reading average light levels over short periods of time. Integration (the accumulation of pulses over a very long period of time) can be used to measure exposure, the amount of light present in an area over a given time period.

PCB Pad Layout

Suggested PCB pad layout guidelines for the D package are shown in Figure 6.



- NOTES: A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.

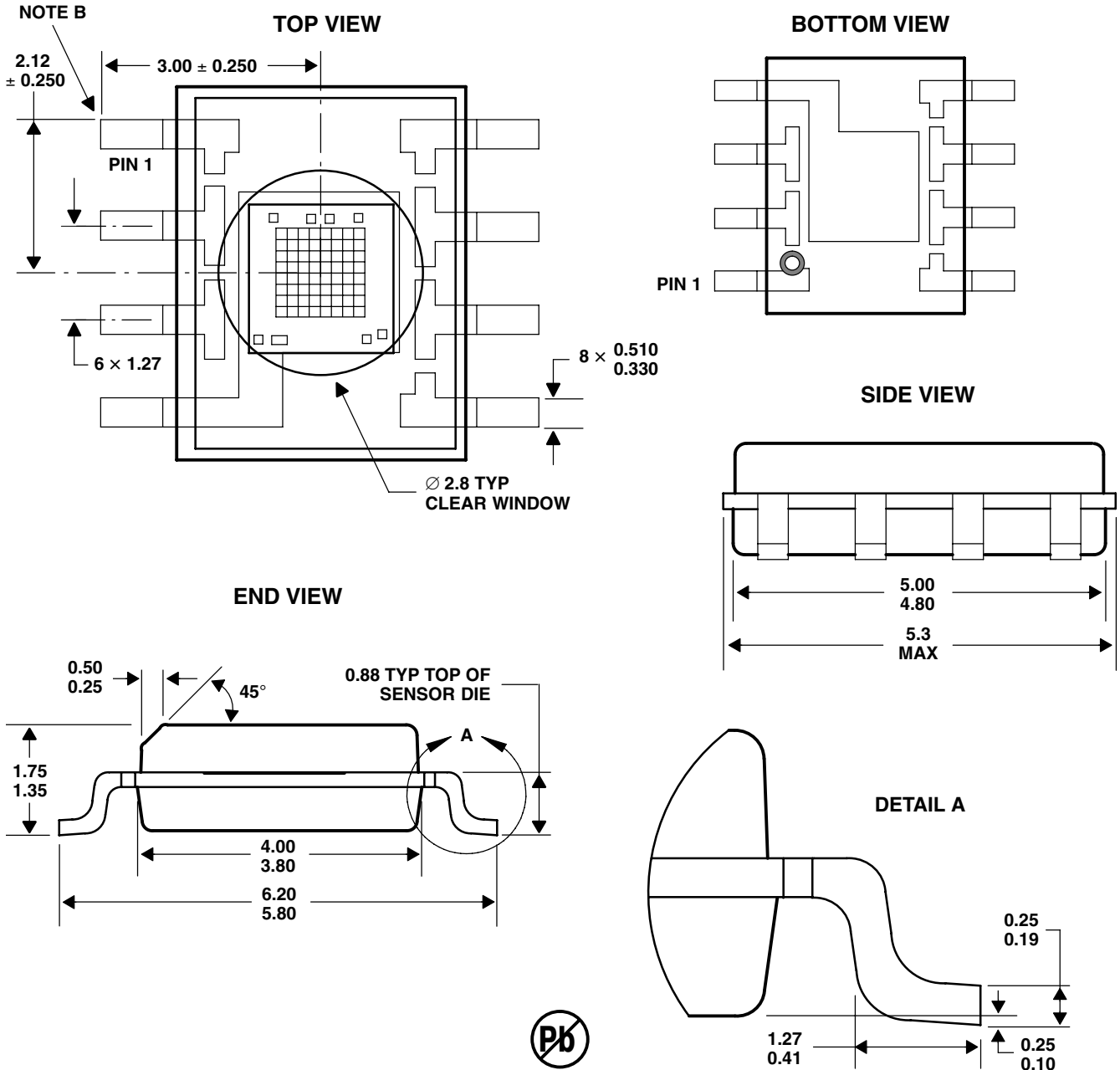
Figure 6. Suggested D Package PCB Layout

MECHANICAL INFORMATION

This SOIC package consists of an integrated circuit mounted on a lead frame and encapsulated with an electrically nonconductive clear plastic compound. The TCS3200 has an 8 × 8 array of photodiodes with a total size of 1 mm by 1 mm. The photodiodes are 110 μm × 110 μm in size and are positioned on 134 μm centers.

PACKAGE D

PLASTIC SMALL-OUTLINE



- NOTES: A. All linear dimensions are in millimeters.
B. The center of the 1-mm by 1-mm photo-active area is referenced to the upper left corner tip of the lead frame (Pin 1).
C. Package is molded with an electrically nonconductive clear plastic compound having an index of refraction of 1.55.
D. This drawing is subject to change without notice.

Figure 7. Package D — TCS3200 Plastic Small Outline IC Packaging Configuration

TCS3200, TCS3210
PROGRAMMABLE
COLOR LIGHT-TO-FREQUENCY CONVERTER

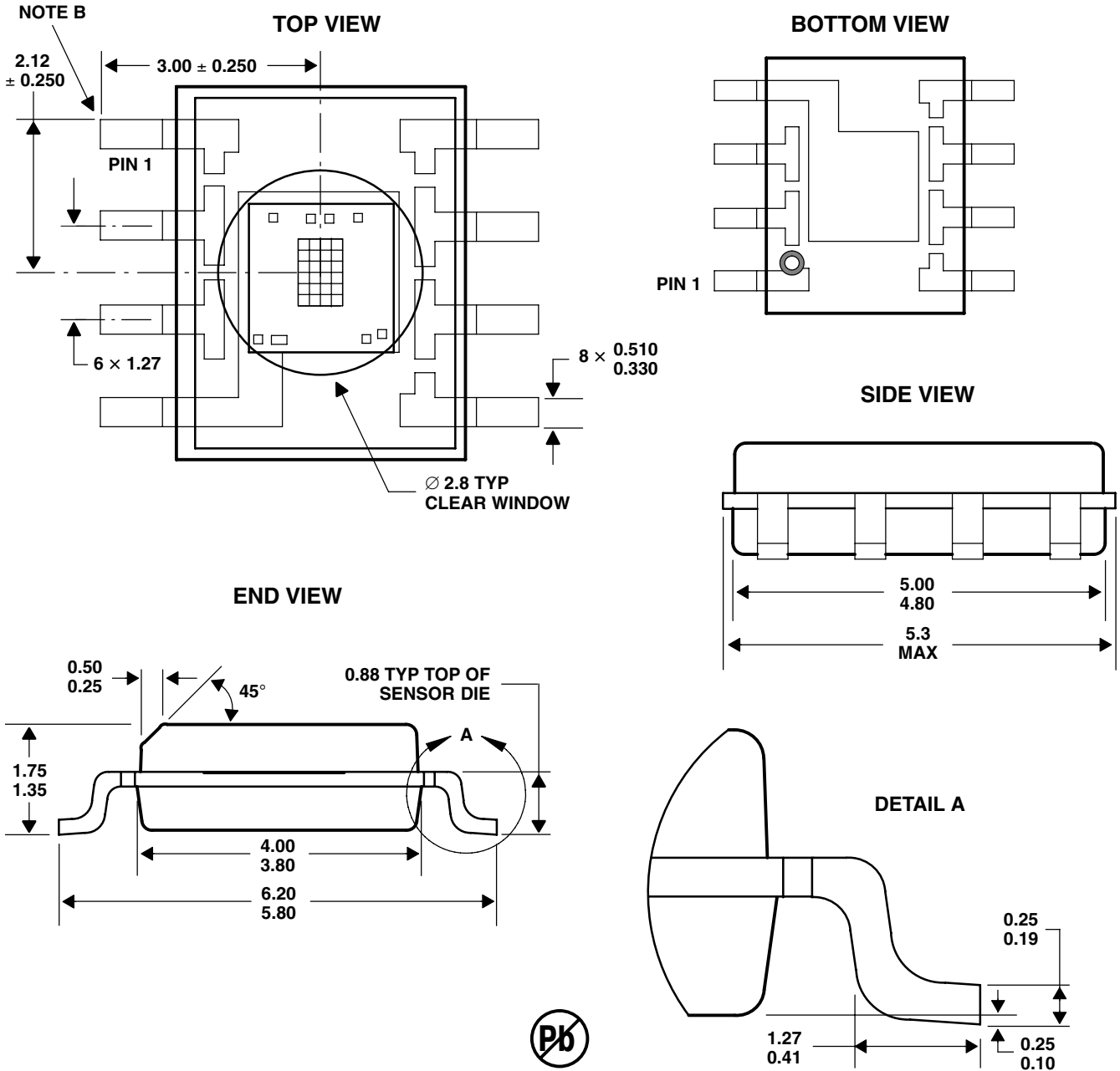
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MECHANICAL INFORMATION

This SOIC package consists of an integrated circuit mounted on a lead frame and encapsulated with an electrically nonconductive clear plastic compound. The TCS3210 has a 4 × 6 array of photodiodes with a total size of 0.54 mm by 0.8 mm. The photodiodes are 110 μm × 110 μm in size and are positioned on 134 μm centers.

PACKAGE D

PLASTIC SMALL-OUTLINE

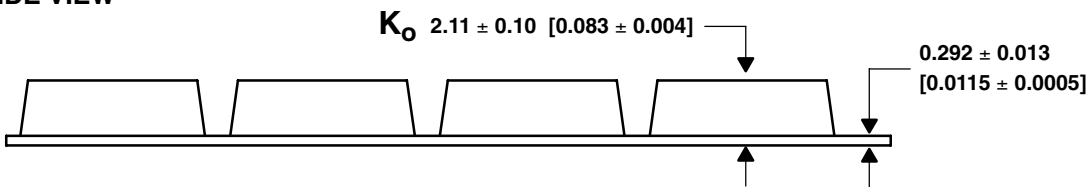


- NOTES: A. All linear dimensions are in millimeters.
 B. The center of the 0.54-mm by 0.8-mm photo-active area is referenced to the upper left corner tip of the lead frame (Pin 1).
 C. Package is molded with an electrically nonconductive clear plastic compound having an index of refraction of 1.55.
 D. This drawing is subject to change without notice.

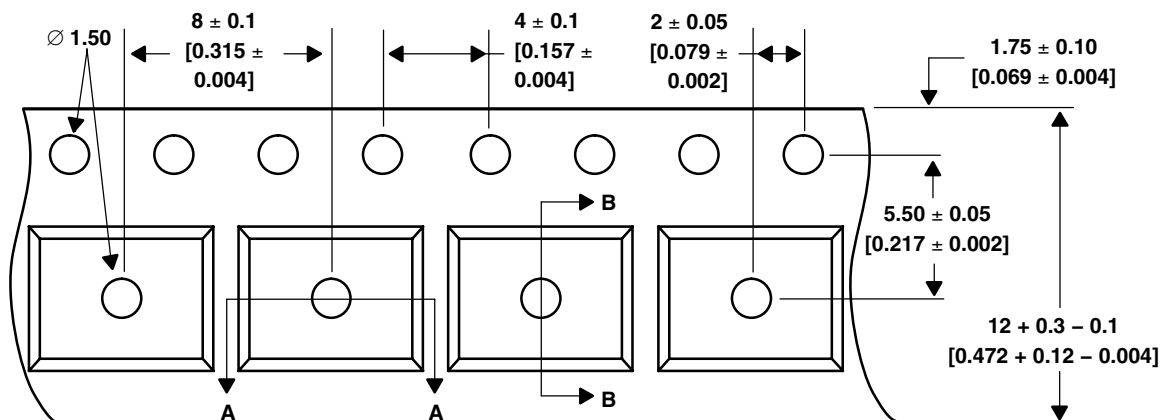
Figure 8. Package D — TCS3210 Plastic Small Outline IC Packaging Configuration

MECHANICAL INFORMATION

SIDE VIEW



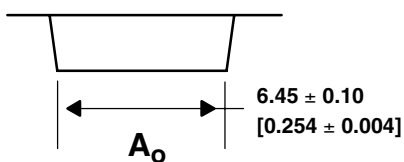
TOP VIEW



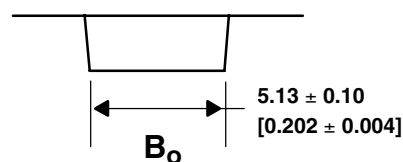
END VIEW



DETAIL A



DETAIL B



- NOTES: A. All linear dimensions are in millimeters [inches].
B. The dimensions on this drawing are for illustrative purposes only. Dimensions of an actual carrier may vary slightly.
C. Symbols on drawing A_o , B_o , and K_o are defined in ANSI EIA Standard 481-B 2001.
D. Each reel is 178 millimeters in diameter and contains 1000 parts.
E. TAOS packaging tape and reel conform to the requirements of EIA Standard 481-B.
F. This drawing is subject to change without notice.

Figure 9. Package D Carrier Tape

**TCS3200, TCS3210
PROGRAMMABLE
COLOR LIGHT-TO-FREQUENCY CONVERTER**

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MANUFACTURING INFORMATION

The Plastic Small Outline IC package (D) has been tested and has demonstrated an ability to be reflow soldered to a PCB substrate.

The solder reflow profile describes the expected maximum heat exposure of components during the solder reflow process of product on a PCB. Temperature is measured on top of component. The component should be limited to a maximum of three passes through this solder reflow profile.

Table 2. TCS3200, TCS3210 Solder Reflow Profile

PARAMETER	REFERENCE	TCS32x0
Average temperature gradient in preheating		2.5°C/sec
Soak time	t_{soak}	2 to 3 minutes
Time above 217°C	t_1	Max 60 sec
Time above 230°C	t_2	Max 50 sec
Time above $T_{peak} - 10^\circ\text{C}$	t_3	Max 10 sec
Peak temperature in reflow	T_{peak}	260° C (-0°C/+5°C)
Temperature gradient in cooling		Max -5°C/sec

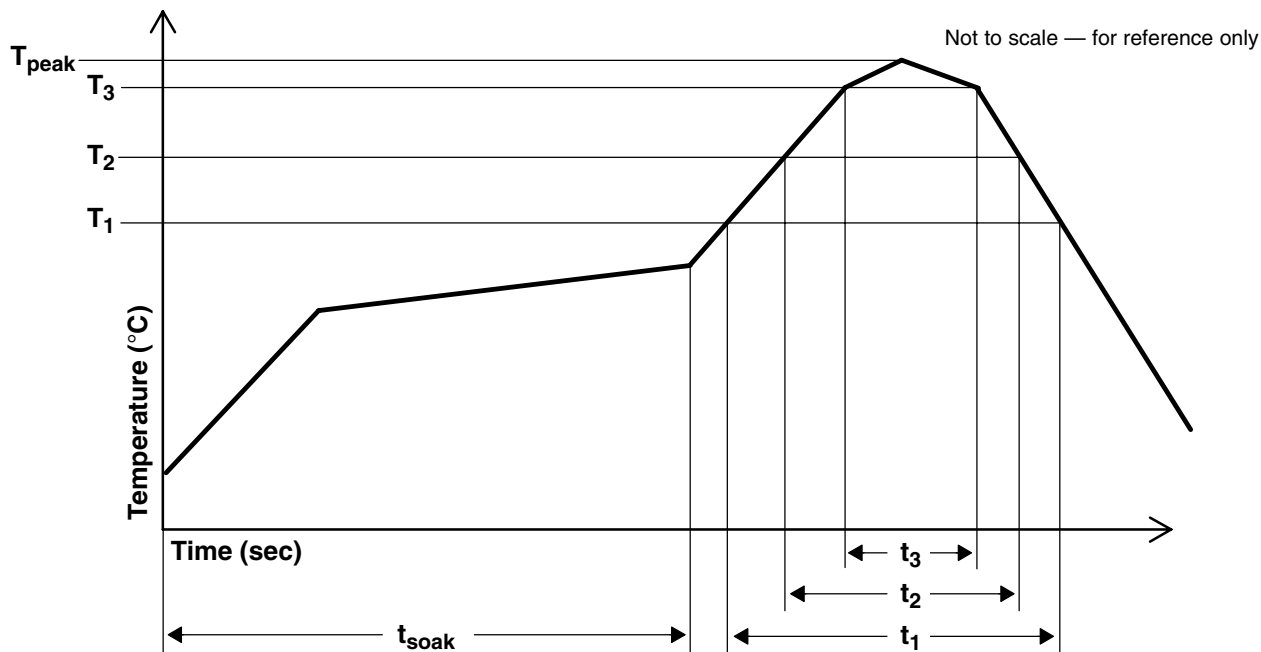


Figure 10. TCS3200, TCS3210 Solder Reflow Profile Graph

Moisture Sensitivity

Optical characteristics of the device can be adversely affected during the soldering process by the release and vaporization of moisture that has been previously absorbed into the package molding compound. To prevent these adverse conditions, all devices shipped in carrier tape have been pre-baked and shipped in a sealed moisture-barrier bag. No further action is necessary if these devices are processed through solder reflow within 24 hours of the seal being broken on the moisture-barrier bag.

However, for all devices shipped in tubes or if the seal on the moisture barrier bag has been broken for 24 hours or longer, it is recommended that the following procedures be used to ensure the package molding compound contains the smallest amount of absorbed moisture possible.

For devices shipped in tubes:

1. Remove devices from tubes
2. Bake devices for 4 hours, at 90°C
3. After cooling, load devices back into tubes
4. Perform solder reflow within 24 hours after bake

Bake only a quantity of devices that can be processed through solder reflow in 24 hours. Devices can be re-baked for 4 hours, at 90°C for a cumulative total of 12 hours (3 bakes for 4 hours at 90°C).

For devices shipped in carrier tape:

1. Bake devices for 4 hours, at 90°C in the tape
2. Perform solder reflow within 24 hours after bake

Bake only a quantity of devices that can be processed through solder reflow in 24 hours. Devices can be re-baked for 4 hours in tape, at 90°C for a cumulative total of 12 hours (3 bakes for 4 hours at 90°C).

TCS3200, TCS3210 PROGRAMMABLE COLOR LIGHT-TO-FREQUENCY CONVERTER

TAOS099 – JULY 2009

PRODUCTION DATA — information in this document is current at publication date. Products conform to specifications in accordance with the terms of Texas Advanced Optoelectronic Solutions, Inc. standard warranty. Production processing does not necessarily include testing of all parameters.

LEAD-FREE (Pb-FREE) and GREEN STATEMENT

Pb-Free (RoHS) TAOS' terms *Lead-Free* or *Pb-Free* mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TAOS Pb-Free products are suitable for use in specified lead-free processes.

Green (RoHS & no Sb/Br) TAOS defines *Green* to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material).

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