High Sensitivity Ambient Light Sensor

Features

- **Optical Package: OMDFN-5**
  - **2.95 x 1.5 x 1.4mm**
  - **Support Smallest Lens Hole Design**
  - **Closest Edge Layout**
  - **MSL3**
- **Operation 1.7V~3.6V**
- **Immunity On Fluorescent Light Flicker**
- **I^2C Bus Protocol Interface**
- **Supports Interruption Feature (INT)**
- **Software Shutdown Mode Control**
- **Lowest Power**

General Description

The APS5201E is a high sensitivity Ambient Light sensor that provides programmable gain, sensitivity, integration time for wider dynamic range of light measurement with very low power consumption in a small OMDFN-5, 2.95 x 1.5 x 1.4mm optical package.

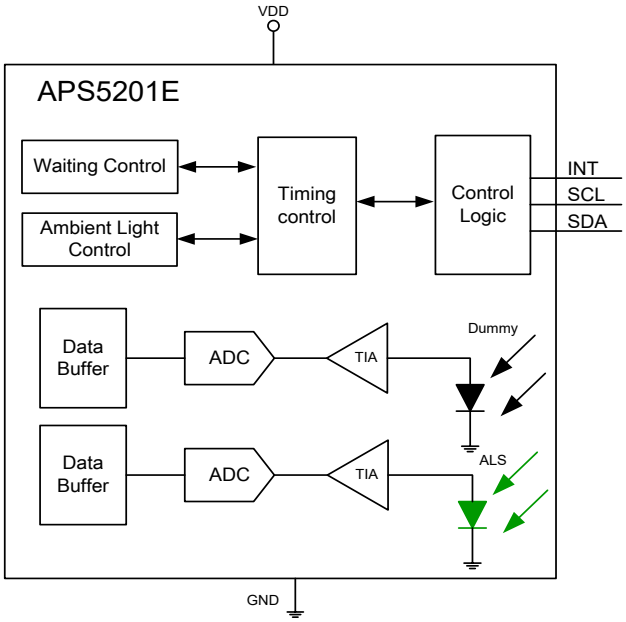
The optical-basedsensor includes photo detector, tran-simpedance amplifier, 16bits analog to digital converter to be integrated advance 0.18μm CMOS process.

The APS5201E digital features include programmable interrupt thresholds to provide alerts and offer shutdown mode that power down the device and gives a shutdown current of 1.0μA typical.

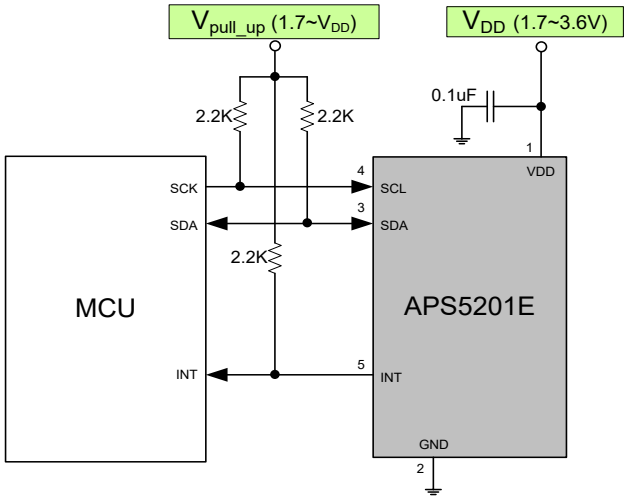
Applications

- **Smartphone**
- **Mobile Device**
- **TV**

Function Diagram



Simplified Application Circuit



Ordering and Marking Information

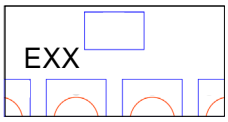
PART NAME	PACKING	PACKAGE	QUANTITY	LEAD FREE	PIN COUNT
APS5201EQMI-TRG	Tape and Reel	2.95 x 1.5 x 1.4mm	2500	Compliant	5

APS5201E □□□-□□□

- Assembly Material
- Handling Code
- Temperature Range
- Package Code

Package Code
QM : OMDFN-5
Operating Ambient Temperature Range
I : -40 to 85°C
Handling Code
TR : Tape & Reel
Assembly Material
G : Green Part

APS5201E QM :

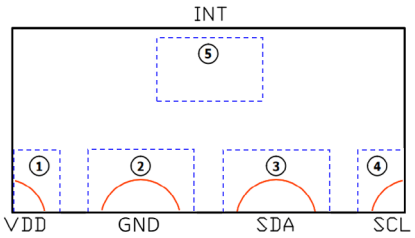


E : Product Code
XX : Date Code

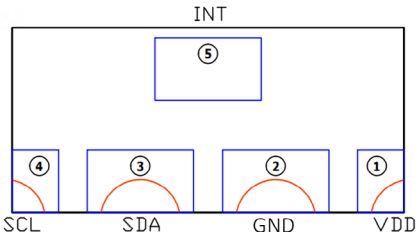
Note: ANPEC's green product compliant RoHS and Halogen free.

Pin Configuration and Descriptions

Top view



Bottom view



Pin Description

PIN		FUNCTION
NO.	NAME	
1	VDD	Power supply input.
2	GND	Ground.
3	SDA	I^2C bus data in/output.
4	SCL	I^2C bus clock input.
5	INT	Active low when alert interrupt. Open drain output. (INT only for top view mount)

Absolute Maximum Ratings

Symbol	Parameter	Min.	Max.	Unit
T_S	Storage Temperature	-40	+100	°C
T_A	Operating Temperature	-40	+85	°C
V_{DD}	Supply Voltage	-0.3	3.8	V

Recommended Operating Conditions

Symbol	Parameter	Test Conditions	Min.	Max.	Unit
V_{DD}	Supply Voltage		1.7	3.6	V
f_{I2C}	Clock frequency of I^2C		-	400	kHz
T_A	Temperature		-40	85	°C
ESD	Electrostatic discharge protection	Human Body Model	-	2	KV
		Machine Model	-	200	V

Electrical & Optical Specifications

Electrical Characteristics over Recommend Operating Range, typical at VDD=2.8V, 25°C.

Symbol	Parameter		Test Conditions	Specification			Unit
				Min.	Typ.	Max.	
V_{DD}	Supply Voltage			1.7	-	3.6	V
I_{DD_ALS}	Supply Current	ALS Only		-	257	-	μA
I_{DD_wait}		Waiting		-	55	-	μA
I_{DD_SD}	Shutdown Current			-	1.0	-	μA
V_{IH}	I^2C Signal Input	Logic High		1.6	-	V_{DD}	V
V_{IL}		Logic Low		-	-	0.4	V
T_A	Operating Temperature			-40	-	+85	°C
Optical Characteristics							
λ_P	Peak Sensitivity Wavelength			-	550	-	nm
ALS_{FULL}	ALS Full Scale			-	-	65535	counts
ALS_{Dark}	ALS Dark Offset		Note 1	-	-	1	counts
ALS_{Tol}	ALS Sensing Tolerance		Note 2	-	-	±10	%
$ALS_{Sensitivity}$	Sensitivity of ALS		Note 3	-	0.00022	-	lx/count

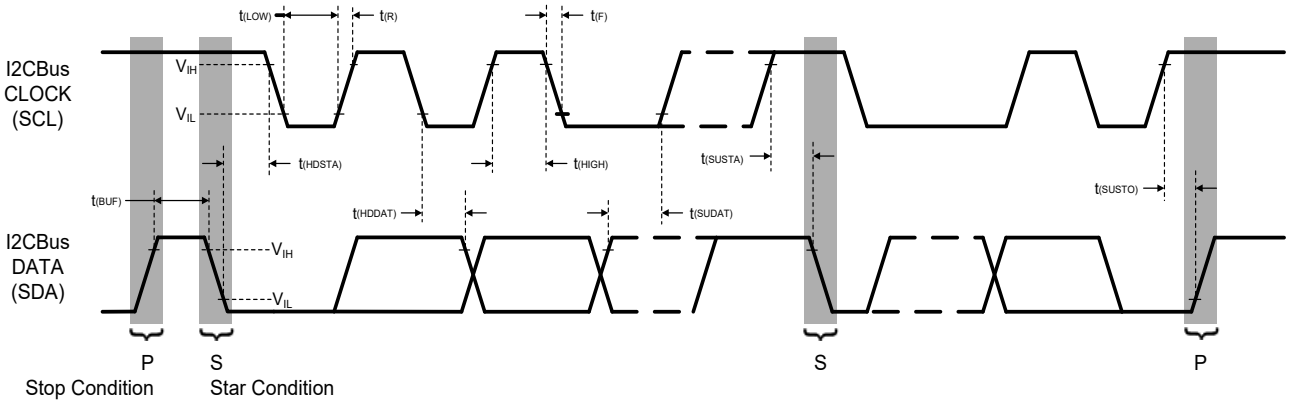
Note 1: Test condition: ALS_IT=0.64ms, ALS_GAIN=X1.
Note 2: Test condition: ALS_IT=2.56ms, ALS_GAIN=X16, light source: WLED.
Note 3: Test condition: ALS_IT=327.68ms, ALS_GAIN=X16, light source: 6500K WLED.

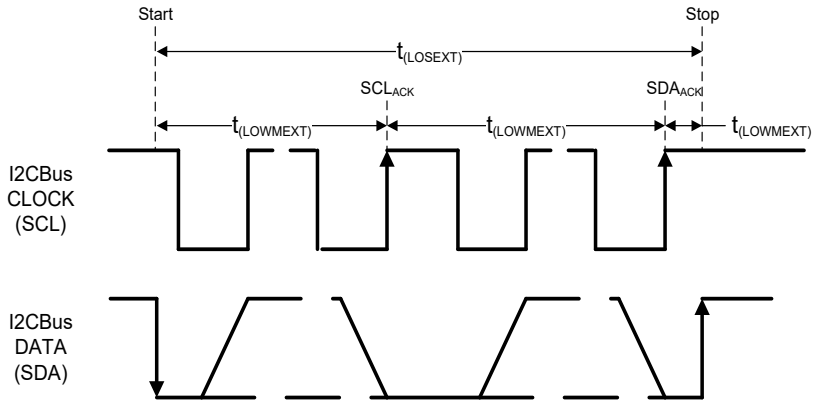
I²C Bus Timing Characteristics

Typical specifications are at 25ºC. All specifications are at 1.7V ≤ VDD ≤ 3.6V, and a 15pF capacitive load on SDA, unless otherwise specified.

Symbol	Parameter	Specification			Unit
		Min.	Typ.	Max.	
$f_{(I2CCLK)}$	Clock frequency	-	-	400	kHz
$t_{(BUF)}$	Bus free time between stop and start condition	1.3	-	-	us
$t_{(HDSTA)}$	Hold time after (repeated) start condition After this period, the first clock is generated	0.6	-	-	us
$t_{(SUSTA)}$	Repeated start condition setup time	0.6	-	-	us
$t_{(SUSTO)}$	Stop condition setup time	0.6	-	-	us
$t_{(HDDAT)}$	Data hold time	100	-	-	us
$t_{(SUDAT)}$	Data setup time	100	-	-	us
$t_{(LOW)}$	I2C Bus clock (SCK) low period	1.3	-	-	us
$t_{(HIGH)}$	I2C Bus clock (SCK) high period	0.6	-	-	us
$t_{(TIMEOUT)}$	Detect clock/data low timeout	-	-	50	ms
$t_{(F)}$	Clock / Data fall time	-	-	300	ns
$t_{(R)}$	Clock / Data rise time	-	-	300	ns

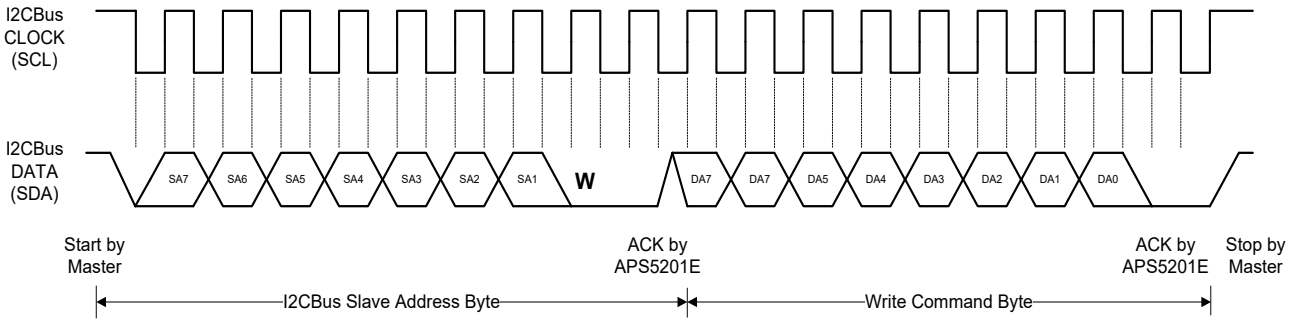
I²C Timing Chart



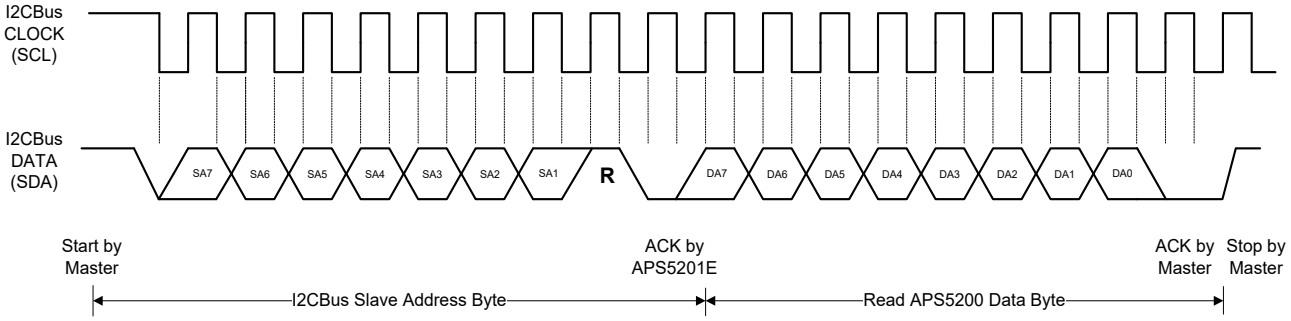


Timing Chart of the SDA and SCL

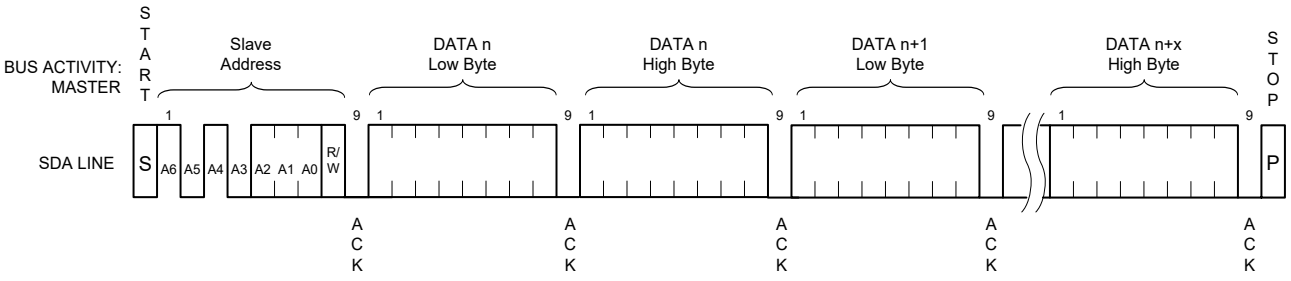
I²C Timing Chart (Cont.)



Write Command Timing



Read Data Timing



Sequential Read Timing

Slave Address

The APS5201E supports 7 bit I2C addressing protocol with chip address of 0x50.

Slave Address	R/W Command Bit	Operation
0x50	0	Write Command
	1	Read Command

Typical Performance Characteristics

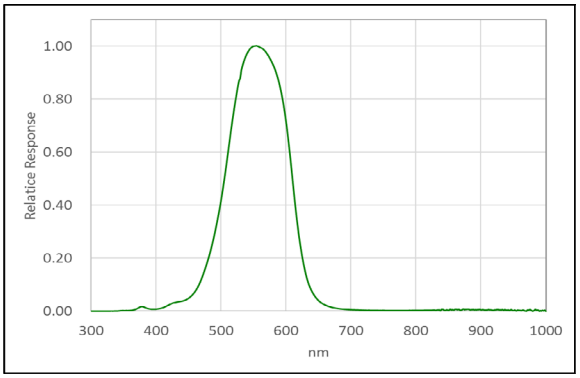


Figure 1. Normalized Spectral Response

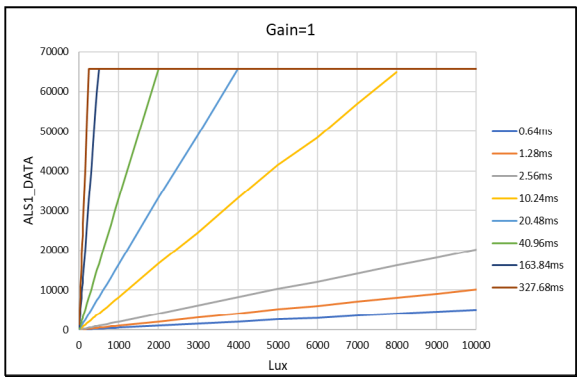


Figure 2. Detection Range vs. Integration Time

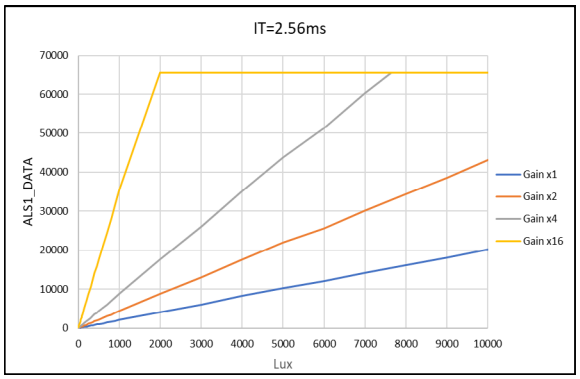


Figure 3. Detection Range vs. Gain Setting

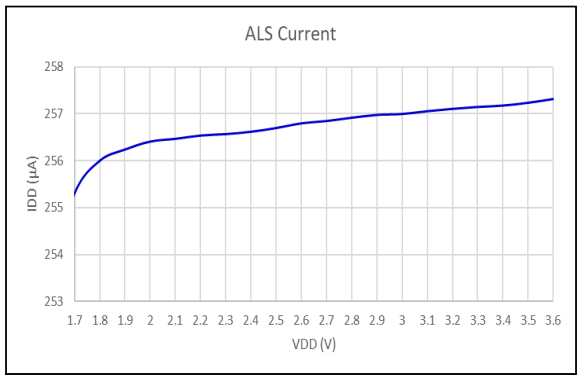


Figure 4. Operation Current vs. VDD

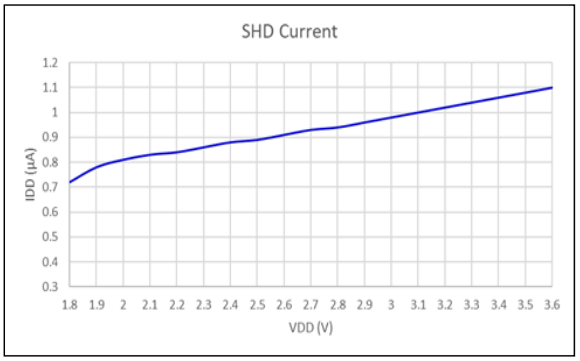


Figure 5. Shutdown Mode vs. VDD

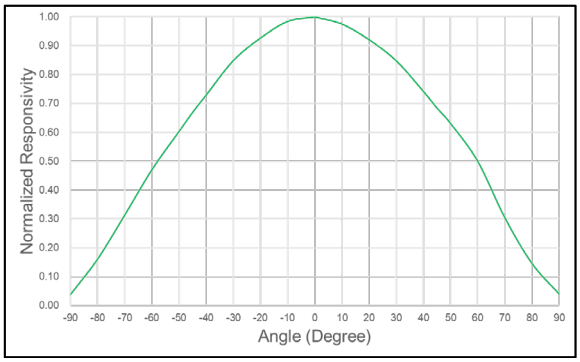


Figure 6. Normalized Responsivity vs. Angular

Register Description

ADDR	REG Name	Bit								Default
		7	6	5	4	3	2	1	0	
0x00	Enable	Reserved				ALS_HG_ EN	ALS_AVG_EN	EN_WAIT	EN_ALS	0x00
0x01	ALSCTRL	ALS1_PRS[7:6]		ALS_GAIN[5:4]		Reserved	ALS_IT[2:0]			0x32
0x02	INT	Reserved							INT_ALS1	0x00
0x03	WTIME	Reserved	WAIT[6:0]							0x00
0x04	ALS1_THDHH	ALS1_THDH[15:8]								0xFF
0x05	ALS1_THDHL	ALS1_THDH[7:0]								0xFF
0x06	ALS1_THDLH	ALS1_THDL[15:8]								0x00
0x07	ALS1_THDLL	ALS1_THDL[7:0]								0x00
0x10	FLAG	Reserved						F_ALS1_ DR	F_ALS1_ INT	0x00
0x11	ALS0_DATAH	ALS0_DATAH[15:8]								0x00
0x12	ALS0_DATAL	ALS0_DATAL[7:0]								0x00
0x13	ALS1_DATAH	ALS1_DATAH[15:8]								0x00
0x14	ALS1_DATAL	ALS1_DATAL[7:0]								0x00
0x15	ALS2_DATAH	ALS2_DATAH[15:8]								0x00
0x16	ALS2_DATAL	ALS2_DATAL[7:0]								0x00
0x17	W_DATAH	W_DATAH[15:8]								0x00
0x18	W_DATAL	W_DATAL[7:0]								0x00
0x3E	Device ID	0	1	0	1	0	0	0	0	0x50
0x80	Reset	Software Reset								0x00

Enable Register (0x00)

The ENABLE register is used to tune the device on/off and enable functions.

1. Bit[0]: EN_ALS

Bits[1]	Description
0	ALS Disable
1	ALS Enable

2. Bit[1]: EN_WAIT

Bits[2]	Description
0	Wait Time Disable
1	Wait Time Enable

3. Bit[2]: ALS_AVG_EN

Bits[4]	Description
0	ALS reading average mode Enable
1	ALS reading average mode Disable

4. Bit[3]: ALS_HG_EN

Bits[3]	Description
0	ALS reading high gain mode Enable
1	ALS reading high gain mode Disable

ALSCTRL Register (0x01)

1. ALS_IT[2:0]

Bits[2:0]	Integration Time	Multiple
000	0.64ms	X1
001	1.28ms	X2
010	2.56ms	X4
011	10.24ms	X16
100	20.48ms	X32
101	40.96ms	X64
110	163.84ms	X256
111	327.68ms	X512

2. ALS_GAIN[5:4]

Bits[5:4]	Gain
00	X1
01	X2
10	X4
11	X16

3. ALS1_PRS[7:6]

Bits[7:6]	Consecutive Out-Of-Threshold Als Occurrences
00	1 Time
01	2 Times
10	4 Times
11	8 Times

This register is supportive for Interrupt mode. As INT_ALS1="1", ALS1_THD Register has been set the threshold window. INT will be asserted based on ALS1_PRS setting how many time ALS1 reading was out of threshold. Please refer the example, Figures 7.

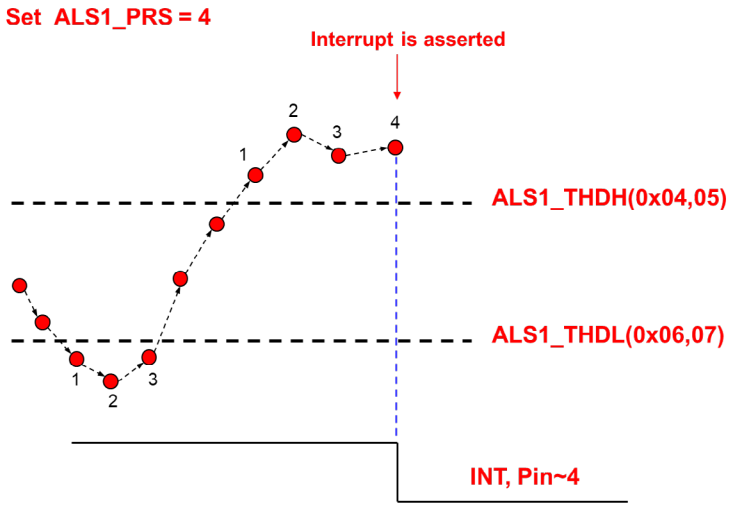


Figure 7. Interrupt Persistence

INT Register (0x02)

INT_ALS1[0]

Bits[2]	Description
0	ALS1 INT Disable
1	ALS1 INT Enable

WTIME Register (0x03)

Bits[6:0]	Wait Time
0x00	5.12ms Wait time after ALS operation
0x01	10.24ms Wait time after ALS operation
0x02	15.36ms Wait time after ALS operation
…..	…..
0x7F	655.36ms Wait time after ALS operation
Others	Reserved

ALS1_THD Register (0x04, 0x05, 0x06, 0x07)

Register	Address	Bit	Description
ALS1_THDHH	0x04	7:0	High side of interrupt threshold setting (MSB)
ALS1_THDHL	0x05	7:0	Low side of interrupt threshold setting (LSB)
ALS1_THDLH	0x06	7:0	High side of interrupt threshold setting (MSB)
ALS1_THDLL	0x07	7:0	Low side of interrupt threshold setting(LSB)

As the interrupt function enabled (INT_ALS1=1), these 4 bytes of ALS1_THD provides the interrupt threshold setting to effect ALS1 detection. Both of ALS1_THDHH/HL bytes, it's setting for high boundary of ALS1 threshold, ALS1_THDLH/LL is for low boundary of ALS1 threshold.

FLAG Register (0x10)

1. F_ALS1_INT[0]

Bits[5]	Description
0	ALS1 Interrupt is cleared or not triggered yet
1	ALS1 Interrupt is triggered

2. F_ALS1_DR[1]

ALS1 Data Ready Flag. This flag is used to confirm whether the ALS1 data registers are read or not. The bit will be 1 when the data refreshed and not be read. The bit is automatically cleared to zero after the ALS1 data registers are read.

Bits[7]	Description
0	ALS1 data be read
1	ALS1 data ready, and not be read

ALS0, ALS1, ALS2 and W DATA Register (0x11, 0x12, 0x13, 0x14, 0x15, 0x16, 0x17, 0x18)

The APS5201E has eight 8-bit read only register to hold the data from ADC of ALS0, ALS1, ALS2 and ALS3 channels. The most significant bit (MSB) is accessed at register 0x11, 0x13, 0x15, 0x17, and the least significant bit (LSB) is accessed at register 0x12, 0x14, 0x16, 0x18. For 16-bit resolution, the data is from ALS0, ALS1, ALS2 and ALS3 channel respectively. The registers are updated for every refresh time.

Recommended Storage and Re-baking Conditions

Parameter	Test Conditions	Min.	Max.	Unit
Storage Temperature		5	50	°C
Relative Humidity		-	60	%
Open Time		-	168	hrs
Total Time	12 months from the date code on the aluminized envelope (unopened)			
Re-baking	Tape and Reel: 60°C, 22hours			

Recommended Infrared Reflow

Soldering conditions are based on J-STD-020 C definition.

1. IR Reflow Profile Conditions

Parameter	Temperature	Time
Peak temperature	255+0/-5ºC (Max: 260ºC)	10 seconds
Preheat temperature range and timing	150 ~ 200ºC	60 ~ 180 seconds
Timing within 5ºC to peak temperature	-	10 ~ 30 seconds
Timing maintained above temperature / time	217ºC	60 ~ 150 seconds
Timing from 25ºC to peak temperature	-	8 minutes (Max.)
Ramp-up rate	3ºC / seconds (Max.)	-
Ramp-down rate	6ºC / seconds (Max.)	-

2. Recommend Normal Solder Reflow is: 235 ~ 255ºC.

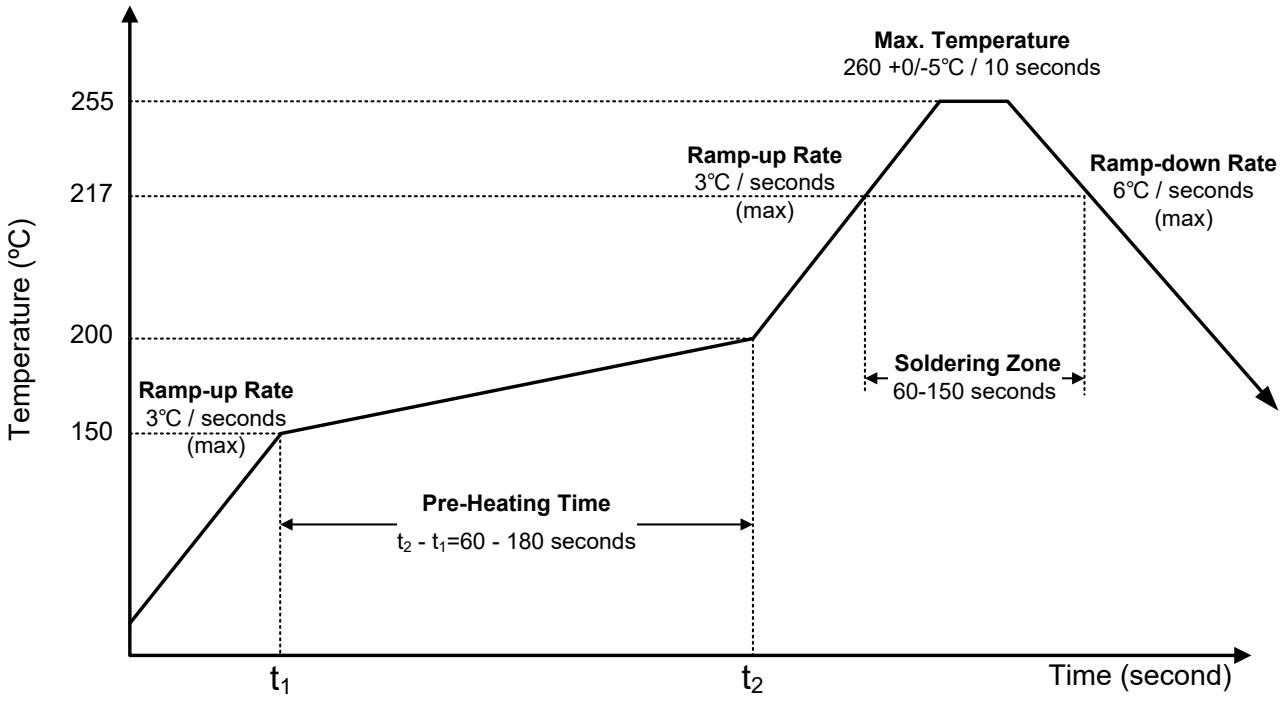


Figure 8. APS5201E Solder Reflow Profile Chart

Pad and Layout Reference

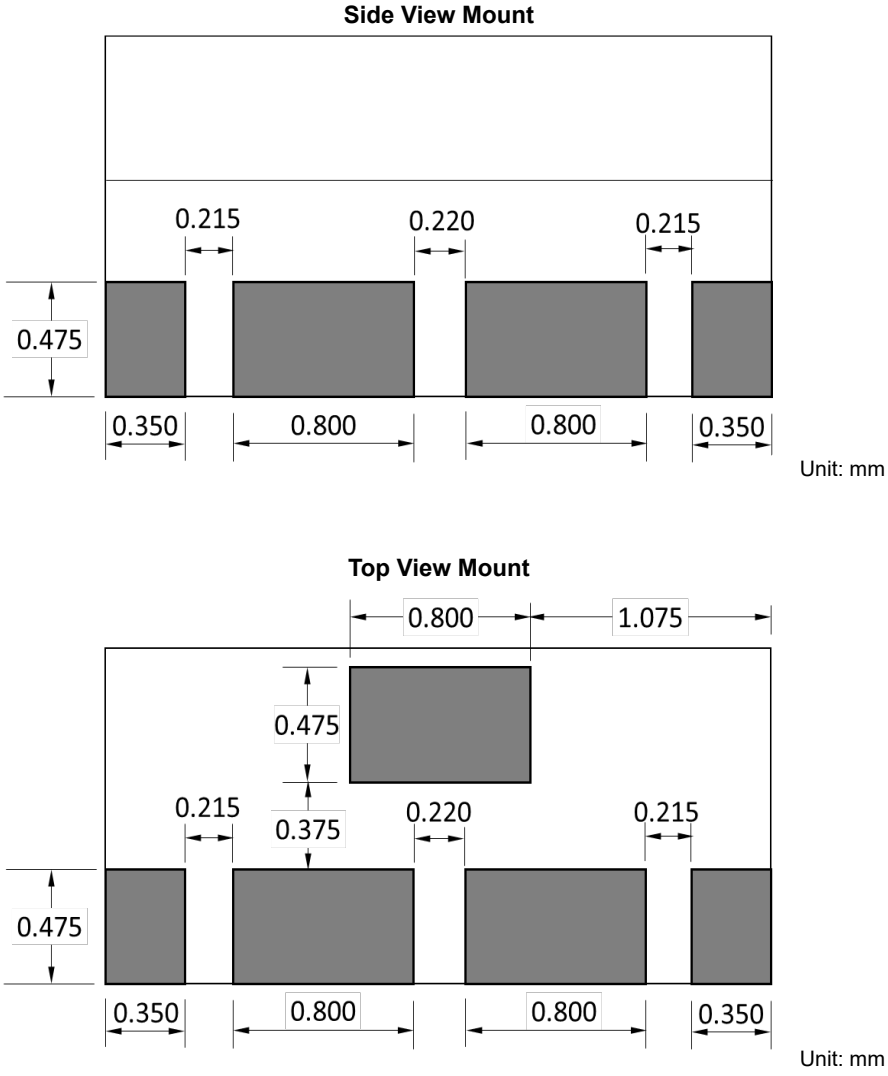
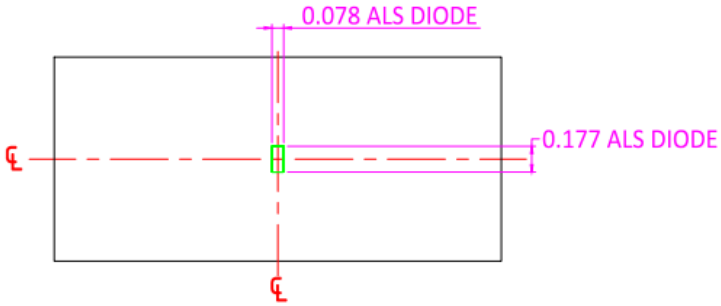


Figure 9. APS5201E OMDFN Layout Footprint

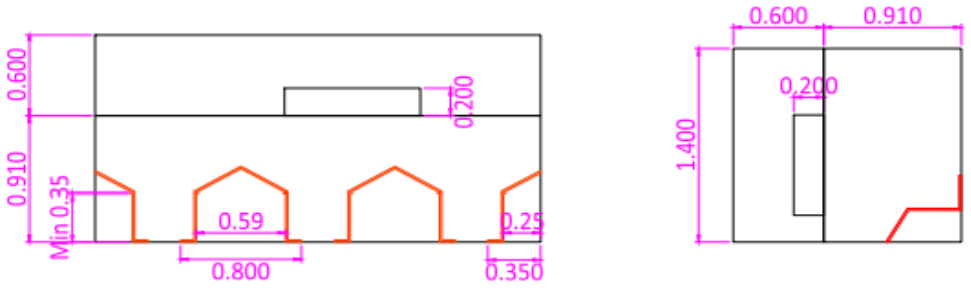
Package Information

OMDFN-5, 2.95x1.5x1.4

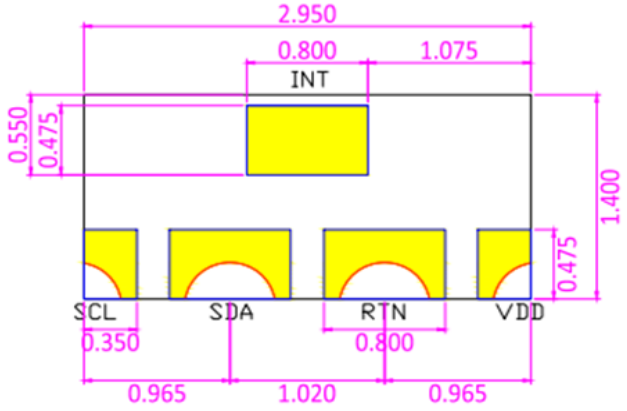
Top View



Side View

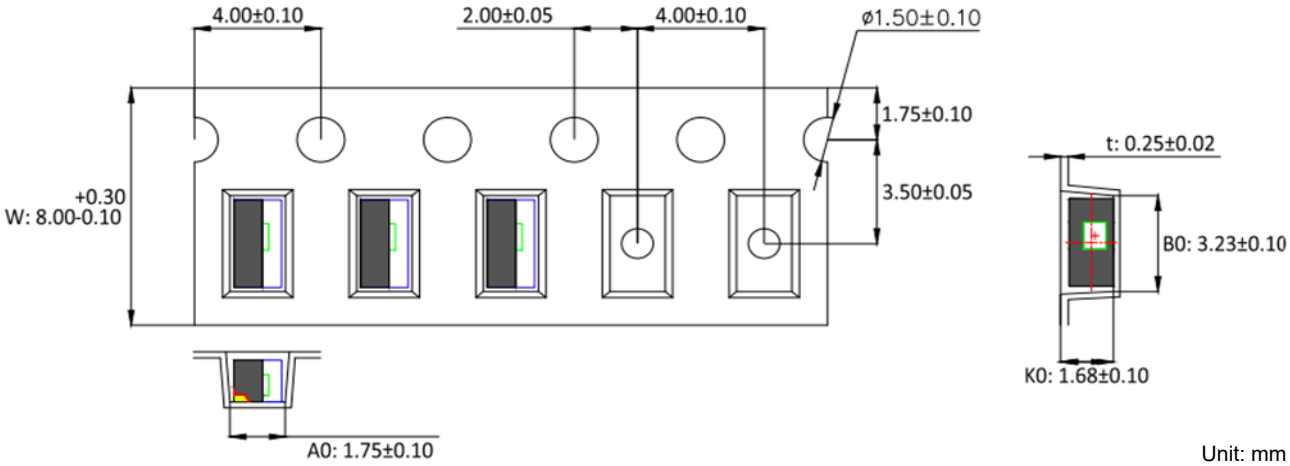


Bottom View



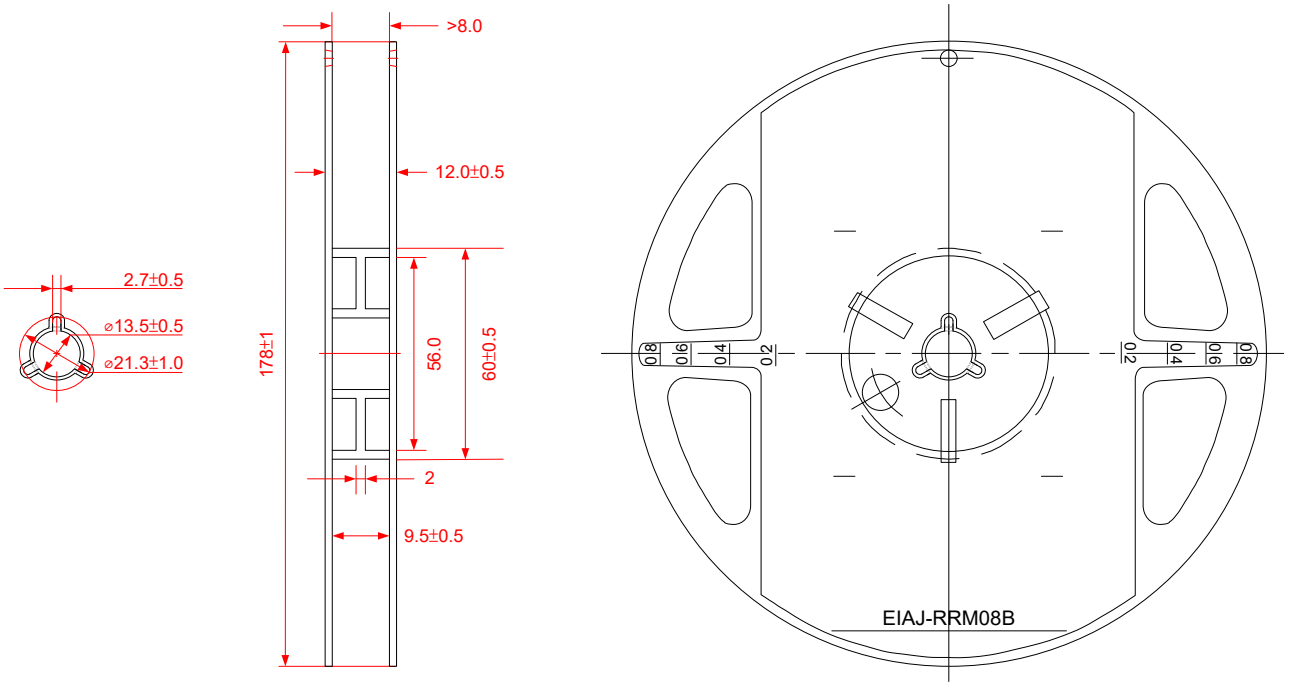
Unit: mm

Carrier Tape & Reel Dimensions



Unit: mm

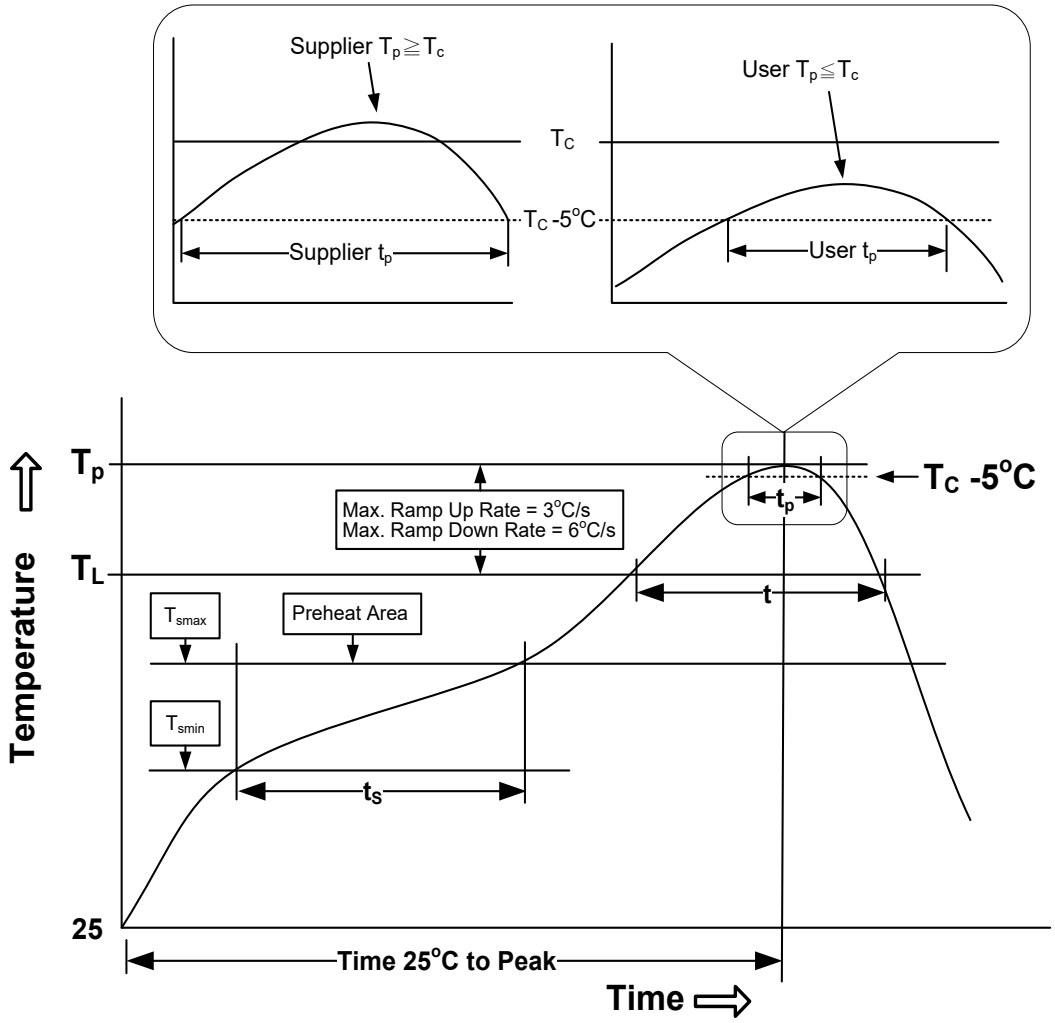
Figure 10. APS5201E Carrier Tape Dimension



Unit: mm

Figure 11. APS5201E 7" Reel Dimension

Classification Profile



Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat & Soak Temperature min (T_{smin}) Temperature max (T_{smax}) Time (T_{smin} to T_{smax}) (t_s)	 100°C 150°C 60-120 seconds	 150°C 200°C 60-120 seconds
Average ramp-up rate (T_{smax} to T_P)	3°C/second max.	3°C/second max.
Liquidous temperature (T_L) Time at liquidous (t_L)	183°C 60-150 seconds	217°C 60-150 seconds
Peak package body Temperature (T_p)*	See Classification Temp in table 1	See Classification Temp in table 2
Time (t_P)** within 5°C of the specified classification temperature (T_c)	20** seconds	30** seconds
Average ramp-down rate (T_p to T_{smax})	6°C/second max.	6°C/second max.
Time 25°C to peak temperature	6 minutes max.	8 minutes max.
* Tolerance for peak profile Temperature (T_p) is defined as a supplier minimum and a user maximum. ** Tolerance for time at peak profile temperature (t_p) is defined as a supplier minimum and a user maximum.		

Note: ANPEC's green products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020D for MSL classification at lead-free peak reflow temperature.

Table 1. SnPb Eutectic Process – Classification Temperatures (Tc)

Package Thickness	Volume mm^3 <350	Volume mm^3 ≥350
<2.5 mm	235°C	220°C
≥2.5 mm	220°C	220°C

Table 2. Pb-free Process – Classification Temperatures (Tc)

Package Thickness	Volume mm^3 <350	Volume mm^3 350-2000	Volume mm^3 >2000
<1.6 mm	260°C	260°C	260°C
1.6 mm – 2.5 mm	260°C	250°C	245°C
≥2.5 mm	250°C	245°C	245°C

Reliability Test Program

Test item	Method	Description
SOLDERABILITY	JESD-22, B102	5 Sec, 245°C
HOLT	JESD-22, A108	1000 Hrs, Bias @ T_j=125°C
PCT	JESD-22, A102	168 Hrs, 100%RH, 2atm, 121°C
TCT	JESD-22, A104	500 Cycles, -65°C~150°C
HBM	MIL-STD-883-3015.7	VHBM ≧ 2KV
MM	JESD-22, A115	VMM ≧ 200V
Latch-Up	JESD 78	10ms, 1_{tr} ≧ 100mA

Customer Service

Anpec Electronics Corp.
Head Office :
No.6, Duxing 1st Rd., East Dist.,
Hsinchu City 300096, Taiwan (R.O.C.)
Tel : 886-3-5642000
Fax : 886-3-5642050

Taipei Branch :
2F, No.11, Ln. 218, Sec. 2, Zhongxing Rd., Xindian Dist.,
New Taipei City 231037, Taiwan (R.O.C.)
Tel : 886-2-2910-3838
Fax : 886-2-2917-3838