

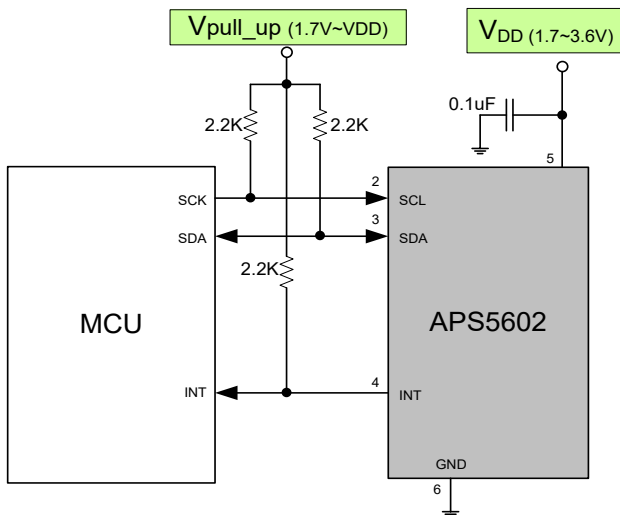
Features

- **Optical Package: OTFN™-8**
 - 1.79 x 1.4 x 0.7mm
 - Support Smallest Lens Hole Design
 - Closest Edge Layout
 - MSL1
- **Operation 1.7V~3.6V**
- **Immunity On Fluorescent Light Flicker**
- **I²C Bus Protocol Interface**
 - Supports Interruption Feature (INT)
 - Software Shutdown Mode Control
- **Lowest Power**

Applications

- Smartphone
- Mobile Device
- TV
- Monitor

Simplified Application Circuit



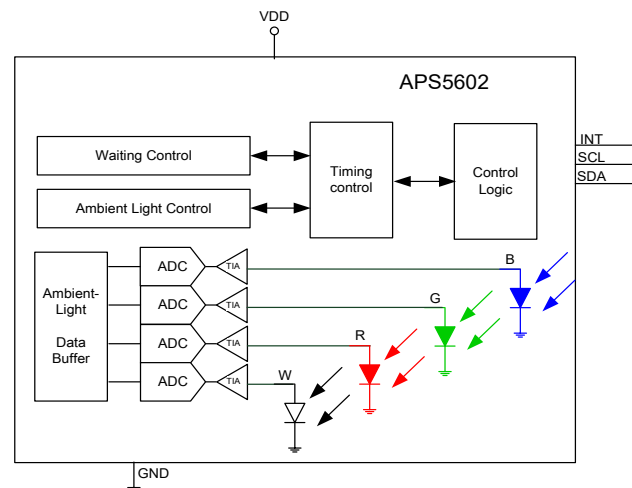
General Description

The APS5602 is an incorporated Color sensor that provides best spectral sensitivity used to closer human eye measurements with very low power consumption in a small OTFN™-8, 1.79 x 1.4 x 0.7mm optical package.

The optical-based sensor includes photo detector, trans-impedance amplifier, 16bits analog to digital converter to be integrated Advance 0.18μm CMOS process.

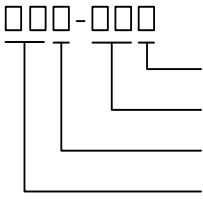
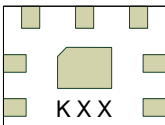
The APS5602 digital features include programmable interrupt thresholds to provide alerts and offer shutdown mode that power down the device and gives a shutdown current of 1μA typical.

Function Diagram



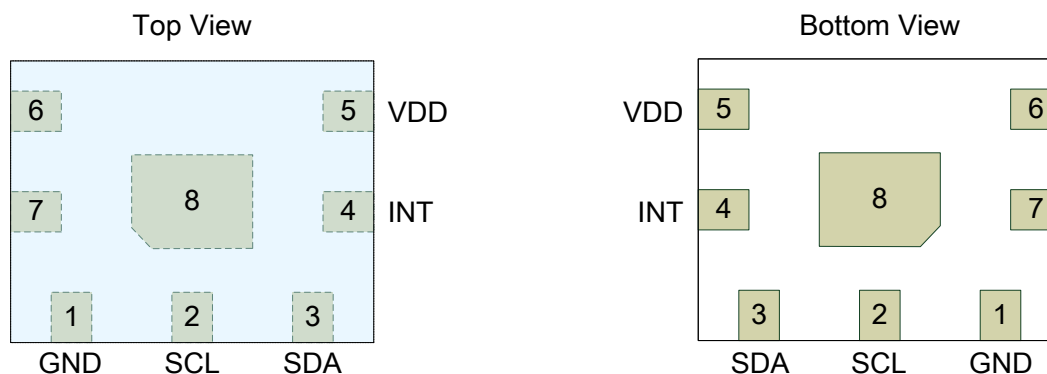
Ordering and Marking Information

PART NAME	PACKING	PACKAGE	QUANTITY	LEAD FREE	PIN COUNT
APS5602QBI-TRG	Tape and Reel	1.79 x 1.4 x 0.7mm	3000	Compliant	8

APS5602 □□□-□□□  Assembly Material Handling Code Temperature Range Package Code	Package Code QB : OTFN™-8 Operating Ambient Temperature Range I : -40 to 85°C Handling Code TR : Tape & Reel Assembly Material G : Green Part
APS5602 QB :  K : Product Code XX : Date Code	

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

Pin Configuration and Descriptions



Pin Description

PIN		FUNCTION
NO.	NAME	
1	GND	Ground.
2	SCL	I ² C bus clock input.
3	SDA	I ² C bus data in/output.
4	INT	Active low when alert interrupt. Open drain output.
5	VDD	Power supply input.
6, 7, 8	NC	Non-contact.

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 ² C		-	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 $V_{DD}=2.8V$, $25^{\circ}C$.

Symbol	Parameter		Test Conditions	Specification			Unit
				Min.	Typ.	Max.	
V _{DD}	Supply Voltage			1.7	-	3.6	V
I _{DD_CS}	Supply Current	CS Only		-	257	-	μA
I _{DD_wait}		Waiting		-	55	-	μA
I _{DD_SD}	Shutdown Current			-	1.0	-	μA
V _{IH}	I ² C Signal Input	Logic High		1.6	-	V _{DD}	V
V _{IL}		Logic Low		-	-	0.4	V
T _A	Operating Temperature			-40	-	+85	°C
R Channel Characteristics							
λ _P	Peak Sensitivity Wavelength			-	630	-	nm
R _{FULL}	R Full Scale			-	-	65535	counts
R _{Dark}	R Dark Offset		Note 1	-	-	1	counts
R _{Tol}	R Sensing Tolerance		Note 2	-	-	±10	%
G Channel Characteristics							
λ _P	Peak Sensitivity Wavelength			-	550	-	nm
G _{FULL}	G Full Scale			-	-	65535	counts
G _{Dark}	G Dark Offset		Note 1	-	-	1	counts
G _{Tol}	G Sensing Tolerance		Note 2	-	-	±10	%
G _{Sensitivity}	Sensitivity of G		Note 3	-	0.00022	-	lx/count
B Channel Characteristics							
λ _P	Peak Sensitivity Wavelength			-	440	-	nm
B _{FULL}	B Full Scale		Note 1	-	-	65535	counts
B _{Dark}	B Dark Offset		Note 2	-	-	1	counts
B _{Tol}	B Sensing Tolerance			-	-	±10	%
W Channel Characteristics							
W _{FULL}	W Full Scale			-	-	65535	counts
W _{Dark}	W Dark Offset		Note 1	-	-	1	counts
W _{Tol}	W Sensing Tolerance		Note 2	-	-	±10	%

Note 1: Test condition: CS_IT=0.64ms, CS_GAIN=X1.

Note 2: Test condition: CS_IT=2.56ms, CS_GAIN=X16, light source: WLED.

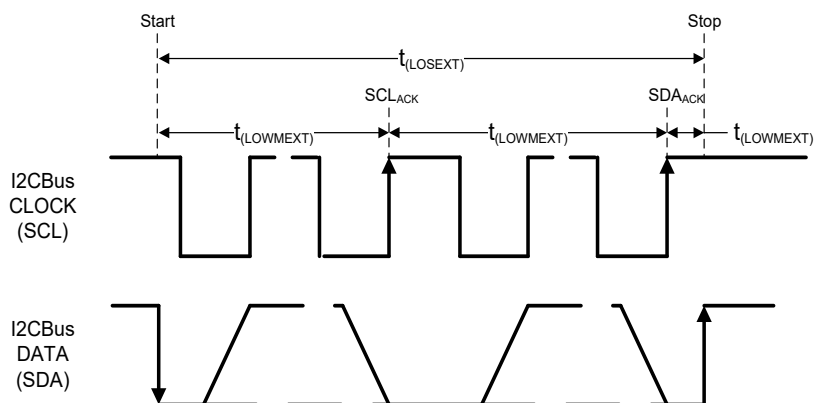
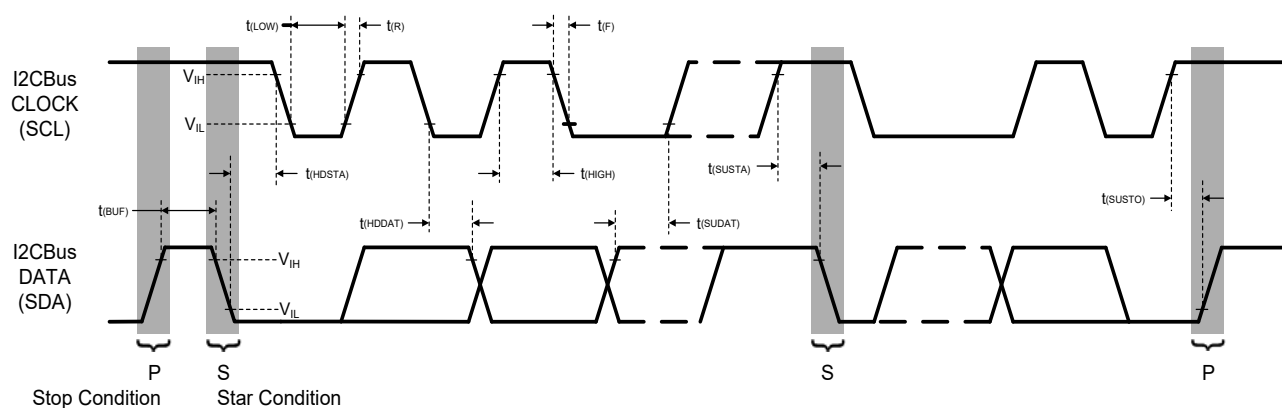
Note 3: Test condition: CS_IT=327.68ms, CS_GAIN=X16, light source: 6500K WLED.

I²C Bus Timing Characteristics

Typical specifications are at 25°C. All specifications are at $1.7V \leq V_{DD} \leq 3.6V$, and a 15pF capacitive load on SDA, unless otherwise specified.

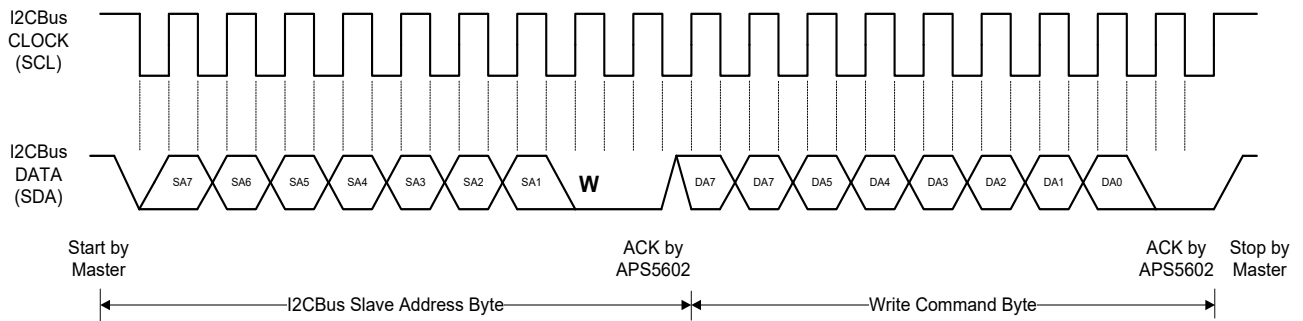
Symbol	Parameter	Specification			Unit
		Min.	Typ.	Max.	
$f_{(I2CCLK)}$	Clock frequency	-	-	400	kHz
$t_{(BUF)}$	Bus free time between stop and start condition	1.3	-	-	us
$t_{(HDSTA)}$	Hold time after (repeated) start condition After this period, the first clock is generated	0.6	-	-	us
$t_{(SUSTA)}$	Repeated 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

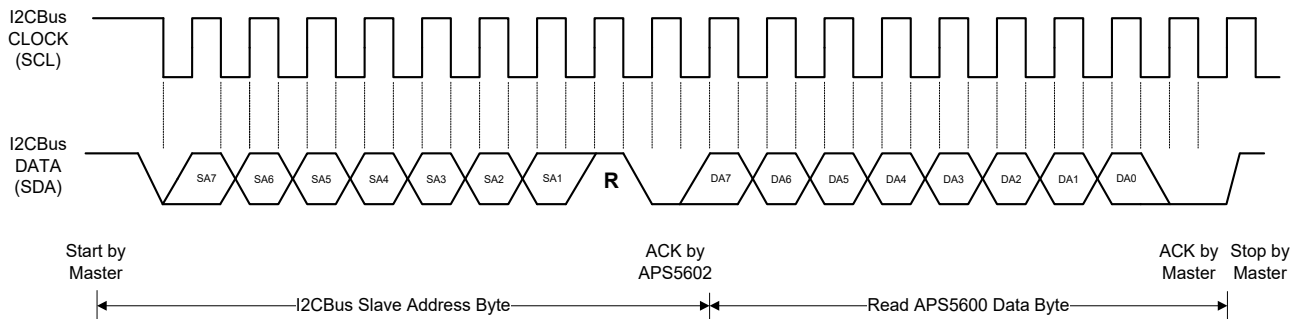


Timing Chart of the SDA and SCL

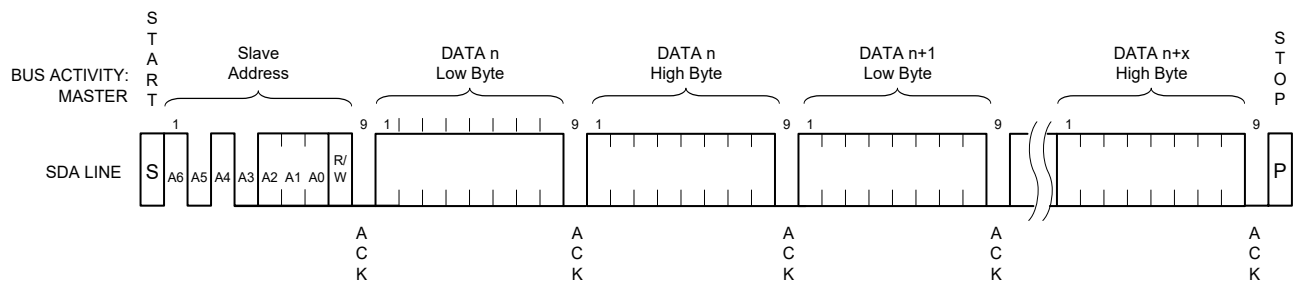
I²C Timing Chart (Cont.)



Write Command Timing



Read Data Timing



Sequential Read Timing

Slave Address

The APS5602 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

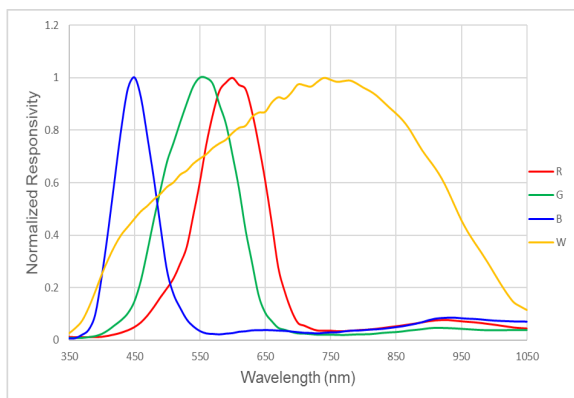


Figure 1. Normalized Spectral Response

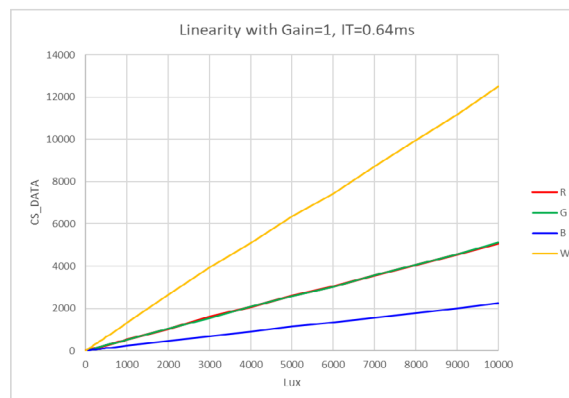


Figure 2. Linearity with Gain=1, IT=0.64ms

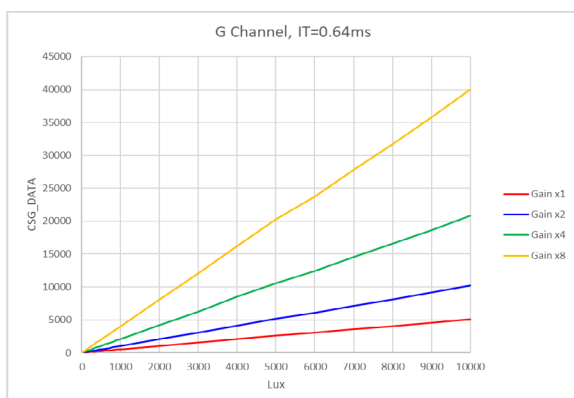


Figure 3. Detection Range vs. Gain Setting

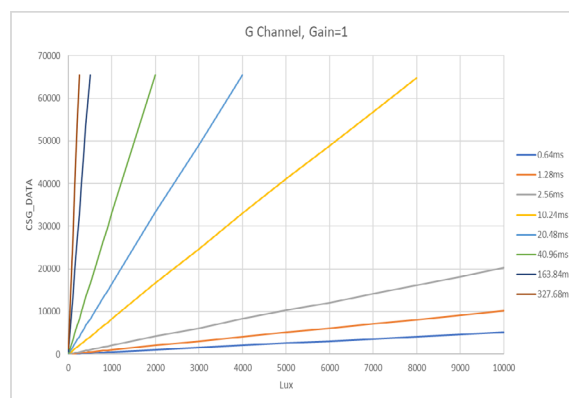


Figure 4. Detection Range vs. Integration Time

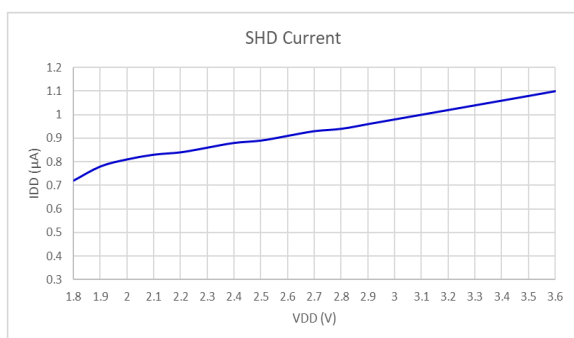


Figure 5. Shutdown Mode IDD vs. VDD

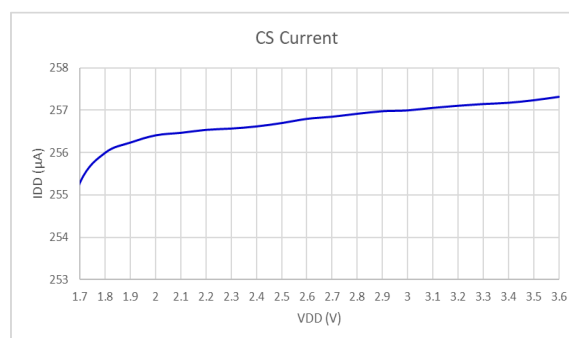


Figure 6. Operation Current vs. VDD

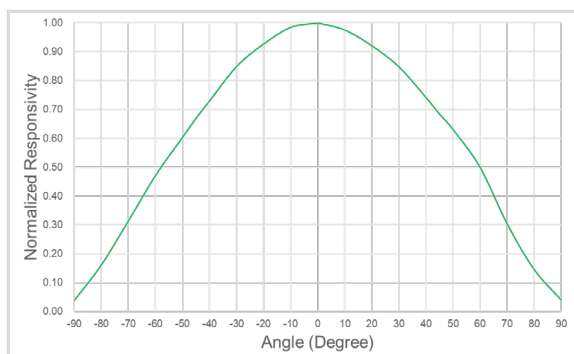


Figure 7. Normalized Responsivity vs. Angular

Register Description

ADDR	REG Name	Bit								Default
		7	6	5	4	3	2	1	0	
0x00	Enable	Reserved				CS_HG_EN	CS_AVG_EN	WAIT_E	CS_E	0x00
0x01	CSCTRL	CS_PRS[7:6]		CS_GAIN[5:4]		Reserved	CS_IT[2:0]			0x32
0x02	INT	Reserved							INT_CS_G	0x00
0x03	WTIME	Reserved	WAIT[6:0]							0x00
0x04	G_THDHH	G_THDH[15:8]								0xFF
0x05	G_THDHL	G_THDH[7:0]								0xFF
0x06	G_THDLH	G_THDL[15:8]								0x00
0x07	G_THDLL	G_THDL[7:0]								0x00
0x10	FLAG	Reserved					F_CS_DR	F_CSG_INT	0x00	
0x11	R_DATAH	R_DATAH[15:8]								0x00
0x12	R_DATAH	R_DATAH[7:0]								0x00
0x13	G_DATAH	G_DATAH[15:8]								0x00
0x14	G_DATAH	G_DATAH[7:0]								0x00
0x15	B_DATAH	B_DATAH[15:8]								0x00
0x16	B_DATAH	B_DATAH[7:0]								0x00
0x17	W_DATAH	W_DATAH[15:8]								0x00
0x18	W_DATAH	W_DATAH[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]: CS_E

Bit[0]	Description
0	CS Disable
1	CS Enable

2. Bit[1]: WAIT_E

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

3. Bit[2]: CS_AVG_EN

Bits[2]	Description
0	CS reading average mode Enable
1	CS reading average mode Disable

4. Bit[3]: CS_HG_EN

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

CSCTRL Register (0x01)

1. CS_IT[3:0]

Bits[3:0]	Integration Time	Multiple
0000	0.64ms	X1
0001	1.28ms	X2
0010	2.56ms	X4
0011	10.24ms	X16
0100	20.48ms	X32
0101	40.96ms	X64
0110	163.84ms	X256
0111	327.68ms	X512
Others	Reserved	

2. CS_GAIN[5:4]

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

3. CS_PRS[7:6]

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

This register is supportive for Interrupt mode. As INT_CS_G="1", G_THD Register has been set the threshold window. INT will be asserted based on CS_PRS setting how many times G_DATA reading was out of threshold. Please refer the example, Figures 8.

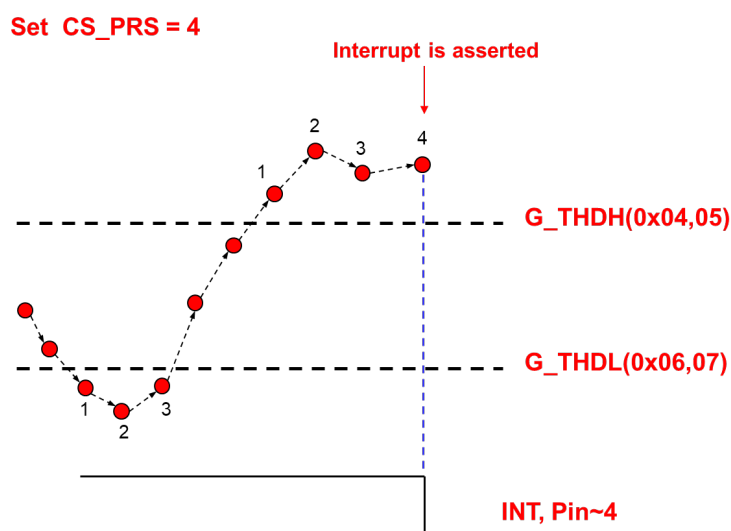


Figure 8. Interrupt Persistence

INT Register (0x02)

INT_CS_G[0]

Bits[1]	Description
0	CS Green INT Disable
1	CS Green INT Enable

WTIME Register (0x03)

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

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

Register	Address	Bit	Description
G_THDHH	0x04	7:0	High side of interrupt high threshold setting (MSB)
G_THDHL	0x05	7:0	Low side of interrupt high threshold setting (LSB)
G_THDLH	0x06	7:0	High side of interrupt low threshold setting (MSB)
G_THDLL	0x07	7:0	Low side of interrupt low threshold setting (LSB)

As the interrupt function enabled (INT_CS_G=1), these 4 bytes of G_THD provides the interrupt threshold setting to effect G channel detection. Both of G_THDHH/HL bytes, it's setting for high boundary of G channel reading threshold, G_THDLH/LL is for low boundary of G channel reading threshold.

FLAG Register (0x10)

1. F_CSG_INT[0]

Bits[0]	Description
0	CS Green Interrupt is cleared or not triggered yet
1	CS Green Interrupt is triggered

2. F_CSG_DR[1]

Green channel Data Ready Flag. This flag is used to confirm whether the Green channel 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 Green channel data registers are read.

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

R_G_B_W channel DATA Register (0x11, 0x12, 0x13, 0x14, 0x15, 0x16, 0x17, 0x18)

The APS5602 has eight 8-bit read only register to hold the data from ADC of R, G, B and W 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 R_G_B_W 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		-	unlimited	year
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/-5°C (Max: 260°C)	10 seconds
Preheat temperature range and timing	150 ~ 200°C	60 ~ 180 seconds
Timing within 5°C to peak temperature	-	10 ~ 30 seconds
Timing maintained above temperature / time	217°C	60 ~ 150 seconds
Timing from 25°C to peak temperature	-	8 minutes (Max.)
Ramp-up rate	3°C / seconds (Max.)	-
Ramp-down rate	6°C / seconds (Max.)	-

2. Recommend Normal Solder Reflow is: 235 ~ 255°C.

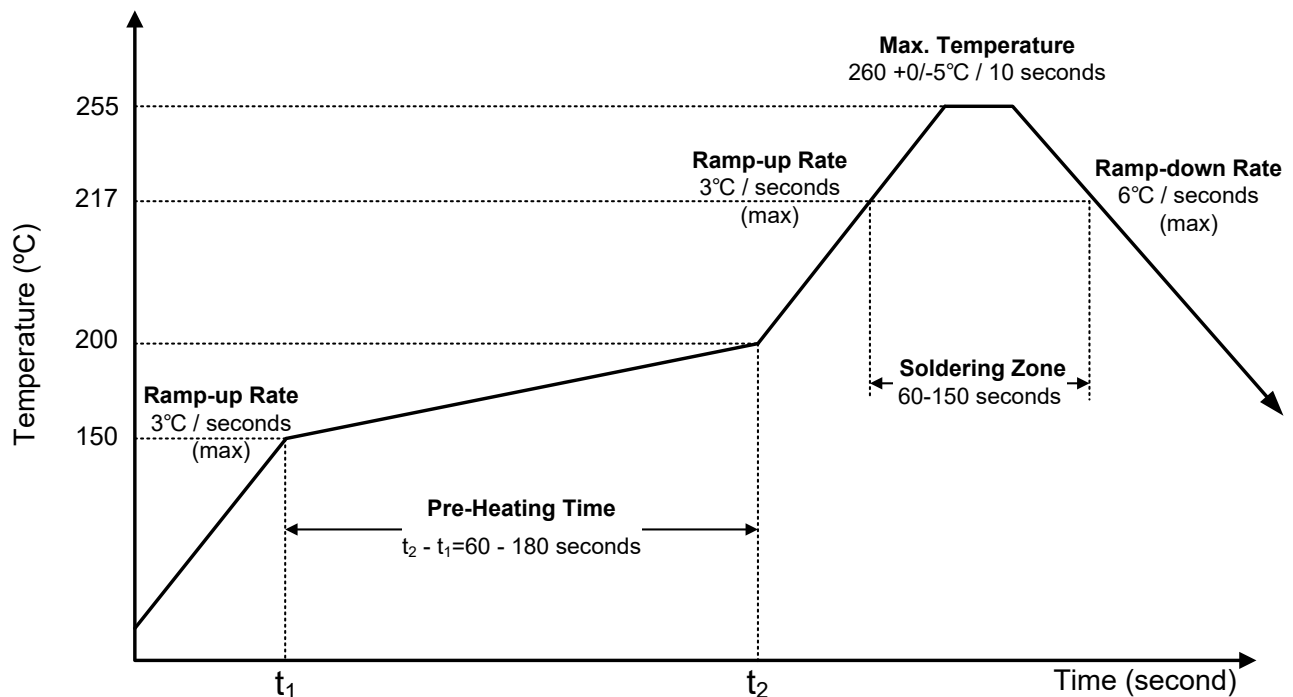


Figure 9. APS5602 Solder Reflow Profile Chart

Layout Pad Recommendation

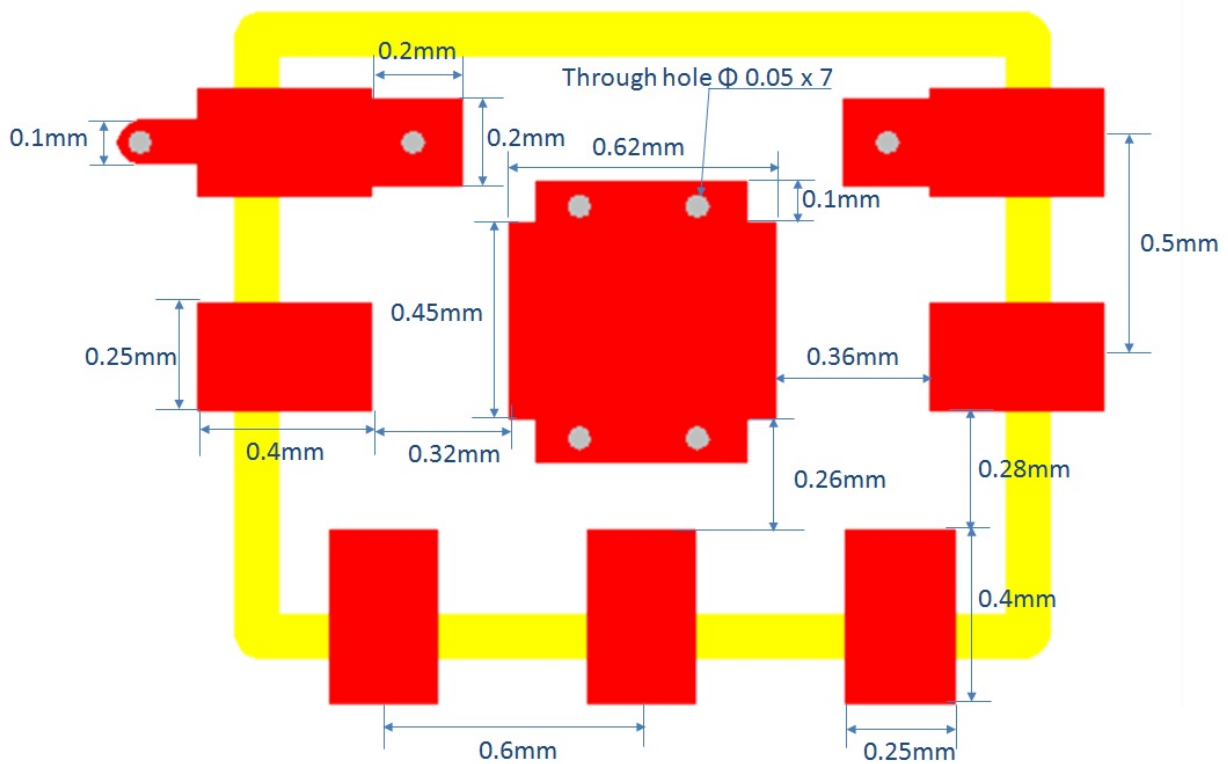
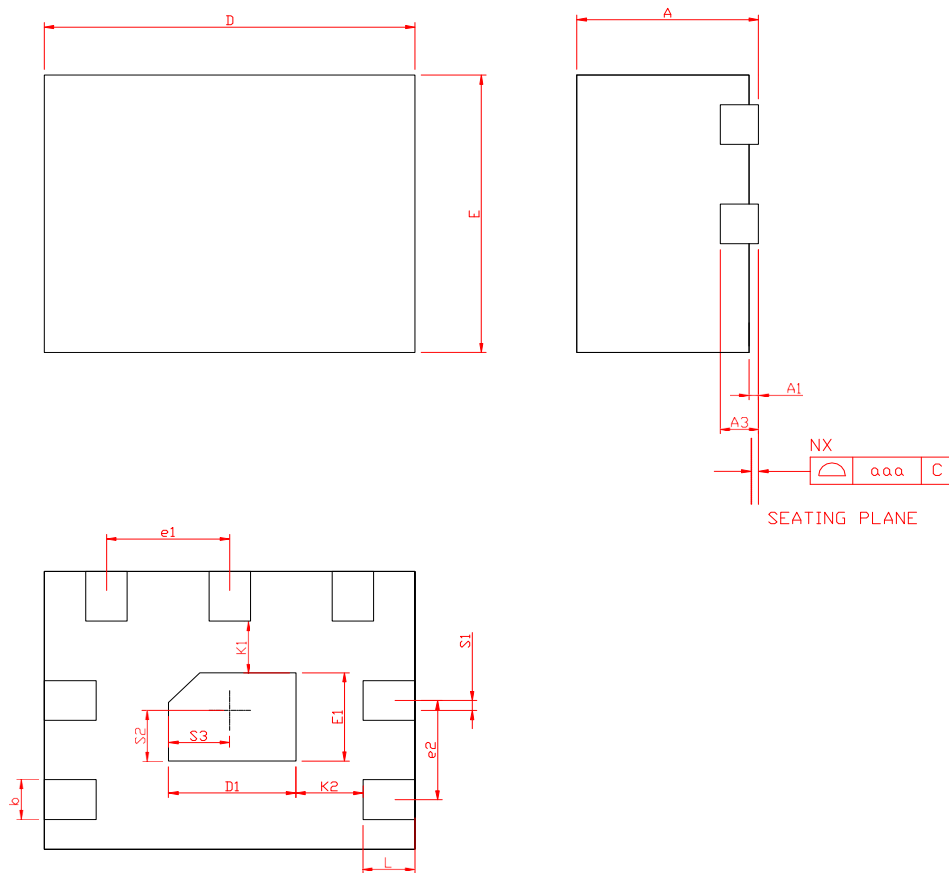


Figure 10. APS5602 OTFN™ Layout Footprint

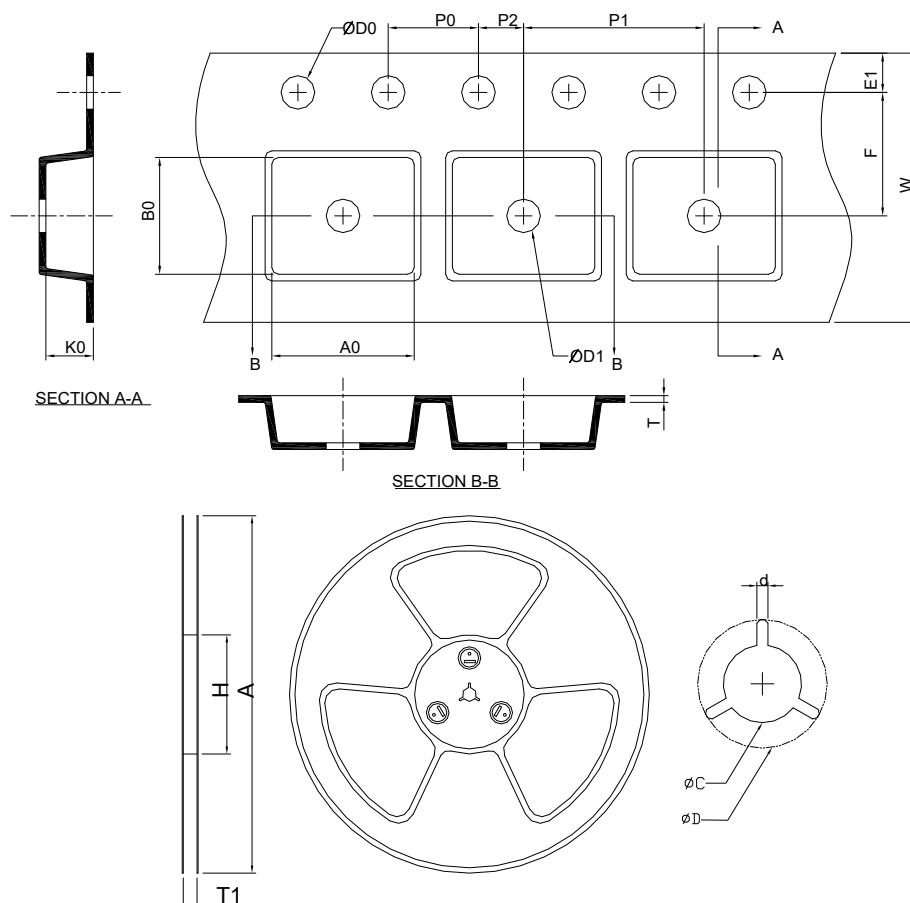
Package Information

OTFN 1.4x1.79-8



SYMBOL	OTFN1.4x1.79-8			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
A3	0.20 REF		0.008 REF	
b	0.15	0.25	0.006	0.010
D	1.69	1.89	0.067	0.074
E	1.30	1.50	0.051	0.059
e1	0.595 BSC		0.023 BSC	
e2	0.500 BSC		0.020 BSC	
D1	0.565	0.665	0.022	0.026
E1	0.395	0.495	0.016	0.019
L	0.150	0.350	0.006	0.014
S1	0.015	0.085	0.001	0.003
S2	0.220	0.290	0.009	0.011
S3	0.260	0.330	0.010	0.013
K1	0.210	0.310	0.008	0.012
K2	0.275	0.375	0.011	0.015
aaa	0.08		0.003	

Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
OTFN1.4x1.79	178.0±2.00	50 MIN.	8.0±0.10	13.0+0.50	1.5 MIN.	20.2 MIN.	8.0±0.30	1.75±0.10	3.5±0.10
	P0	P1	P2	D0	D1	T	A0	B0	K0
	4.0±0.10	4.0±0.10	2.0±0.05	1.5±0.10	1.0±0.25	0.25±0.05	1.58±0.10	1.98±0.10	0.93±0.10

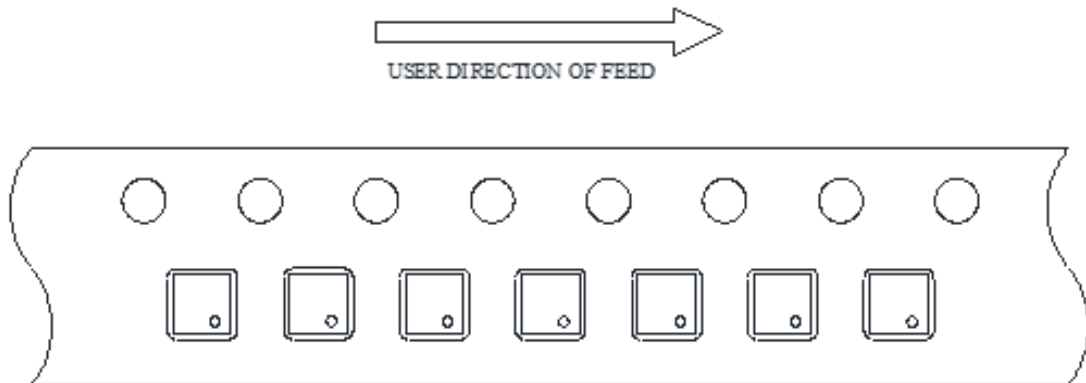
(mm)

Devices Per Unit

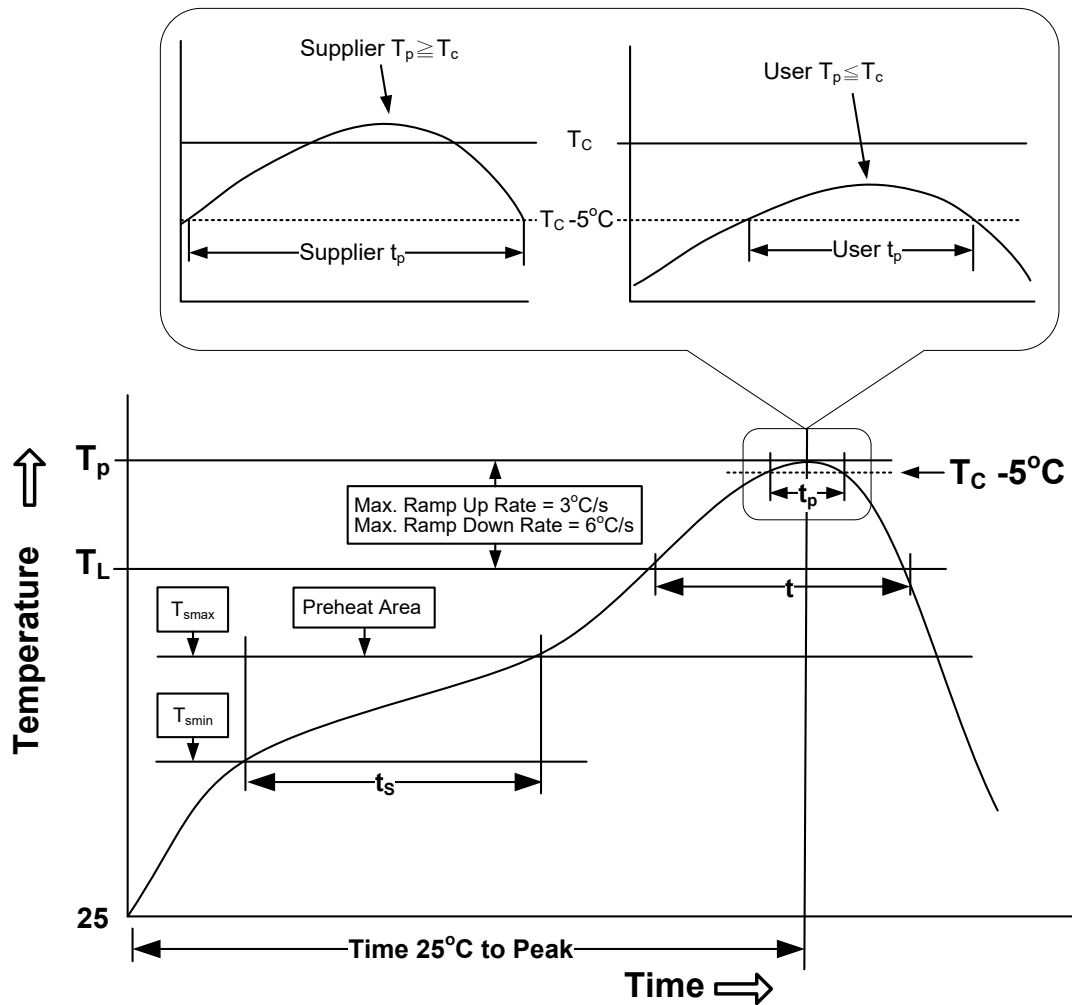
Package type	Packing	Quantity
OTFN1.4x1.79	Tape & Reel	3000

Taping Direction Information

OTFN 1.4x1.79-8



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 (T_c)

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 (T_c)

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 @ $T_j=125^\circ\text{C}$
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, $1_{tr} \geq 100\text{mA}$

Customer Service

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