

# ADJD-E622-QR999

## RGB Color Sensor in QFN Package



## Data Sheet

### Description

ADJD-E622-QR999 is a high performance, small in size, cost effective light to voltage converting sensor. The sensor combines a photodiode array and three transimpedance amplifiers in a single monolithic CMOS IC solution. With a Red (R), Green (G) and Blue (B) color filters coated over the photodiode array, the sensor converts RGB light to analog voltage outputs, denoted by VROUT, VGOUT and VBOUT, respectively. The sensor is packaged in a 5x5x0.75 [mm] surface mount QFN-16 package.

### Applications

- Ideal choice of light sensor in automotive applications such as dashboard lighting, automotive interior lighting, infotainment and navigational panel.
- Other potential applications are such as environmental lighting, cabin lighting, decorative lighting, general color detection, industrial process, etc.
- Can also be coupled with Avago Technologies' patented color controller, HDJD-J822, to form a closed loop color management system

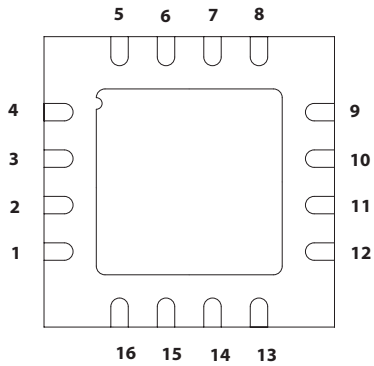
### Features

- Convert light to R,G,B voltage output
- Monolithic CMOS IC solution comprises of an array of photodiode coated with R,G, B color filter and integrated with transimpedance amplifier.
- Independent gain selection options for each R,G,B channel
- 3 sets of 3x3 photodiode array design to minimize the effect of contamination and optical aperture misalignment
- Qualified per Automotive AEC-Q100 Standard (Grade 3)
- Robust package and small in size 5x 5x 0.75 mm

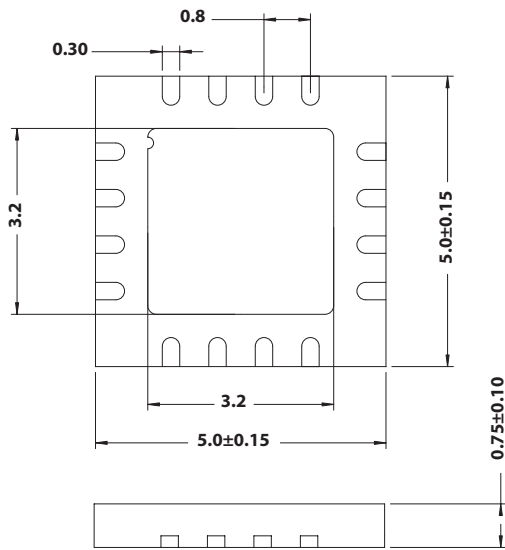
**ESD WARNING:** Standard CMOS handling precautions should be observed to avoid static discharge.

*THIS PRODUCT IS NOT CERTIFIED OR WARRANTED FOR AUTOMOTIVE APPLICATIONS. IF THE CUSTOMER INTENDS TO USE IT FOR AUTOMOTIVE APPLICATIONS, THEY DO SO AT THEIR OWN RISK. AVAGO WILL NOT BE RESPONSIBLE FOR ANY CLAIM OF PRODUCT FAILURE DURING OPERATION OR RELIABILITY ASSESSMENT.*

### Package Dimension



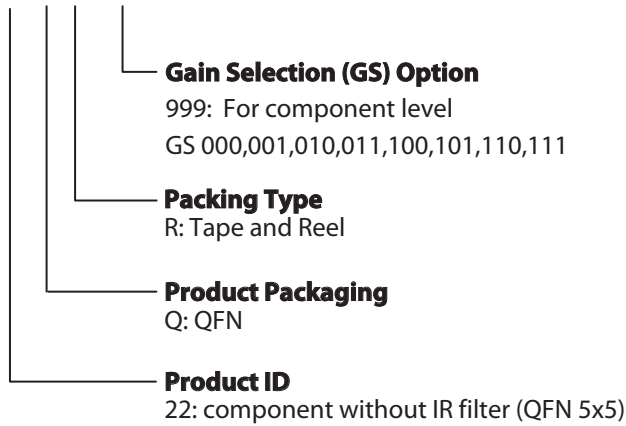
**Bottom View**



Note: Dimensions are in millimeters (mm)

### Part Numbering System

ADJD-E 6 XX - X X XXX



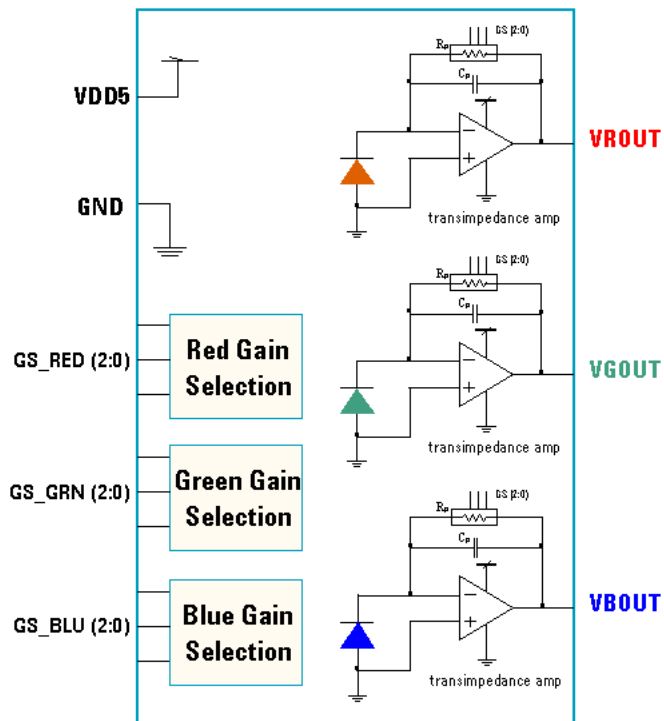
## Theory of Operation

The integral R,G,B color filters on the photodiode array detect the R,G,B components of the light falling on the sensor. The photodiode convert the R,G,B light components into photocurrents. The integrated transimpedance amplifiers for R,G,B components then converts the photocurrent to analog voltage outputs. The voltage output of each R,G,B channel increases linearly with increasing light intensity.

## Pin Out for ADJD-E622-QR999

| Pin    | Pin Name          | Normal Operation                |
|--------|-------------------|---------------------------------|
| Pin 1  | VB <sub>OUT</sub> | Analog output voltage for BLUE  |
| Pin 2  | VG <sub>OUT</sub> | Analog output voltage for GREEN |
| Pin 3  | VR <sub>OUT</sub> | Analog output voltage for RED   |
| Pin 4  | VDD               | 5V DC Supply                    |
| Pin 5  | GSGRN2            | Gain Selection Green bit 2      |
| Pin 6  | GSGRN1            | Gain Selection Green bit 1      |
| Pin 7  | GSRED2            | Gain Selection Red bit 2        |
| Pin 8  | GSRED1            | Gain Selection Red bit 1        |
| Pin 9  | GSRED0            | Gain Selection Red bit 0        |
| Pin 10 | NC                | No connection                   |
| Pin 11 | NC                | No connection                   |
| Pin 12 | GSBLUE0           | Gain Selection Blue bit 0       |
| Pin 13 | GSBLUE1           | Gain Selection Blue bit 1       |
| Pin 14 | GSBLUE 2          | Gain Selection Blue bit 2       |
| Pin 15 | GSGRN 0           | Gain Selection Green bit 0      |
| Pin 16 | GND               | Ground                          |

## Sensor IC Block Diagram



### Absolute Maximum Ratings [1,2]

| Parameter                          | Symbol      | Min | Max | Unit | Notes |
|------------------------------------|-------------|-----|-----|------|-------|
| Supply Voltage                     | $V_{DD}$    | 4.5 | 5.5 | V    |       |
| Storage Temperature                | $T_S$       | -50 | 105 | °C   |       |
| Operating Temperature              | $T_A$       | -40 | 85  | °C   |       |
| Human Body Model ESD Rating        | $ESD_{HBM}$ |     | 8   | kV   |       |
| Machine Model ESD Rating           | $ESD_{MM}$  |     | 200 | V    |       |
| Charge Device Model ESD Rating [3] | $ESD_{CDM}$ |     | 500 | V    |       |

Note:

1. Subjecting the part to stresses beyond those listed under this section may cause permanent damage to the device. These are stress ratings only and do not imply that the devices will function beyond these ratings. Exposure to the extremes of these conditions for extended periods may affect device reliability.
2. Unless otherwise specified, voltages are referenced to ground.
3. Maximum ESD rating for corner pin is 750V

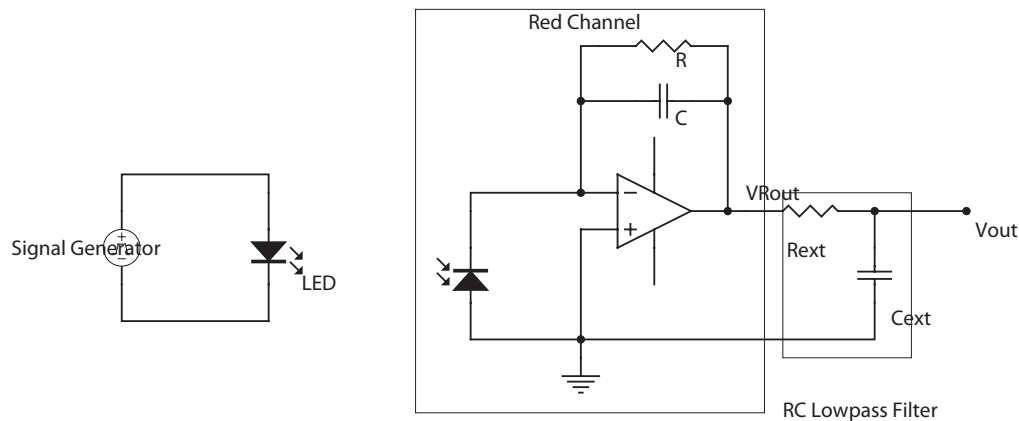
### Recommended Operating Conditions

| Parameter             | Sym.     | Min. | Typ. | Max. | Units | Notes   |
|-----------------------|----------|------|------|------|-------|---|
| Operating Temperature | $T_A$    | 0    | 25   | 70   | °C    |   |
| Supply Voltage        | $V_{DD}$ | 4.5  | 5.0  | 5.5  | V     | A decoupling capacitor of 100nF between $V_{DD}$ and ground is recommended. |

Remarks:

1. The device is with moisture sensitivity level 3.
2. For optimized signal output, RC filters must be added at each of the R, G and B voltage output.

| Gain Selection   | Rext | Cext  |
|------------------|------|-------|
| GS:000 to GS:101 | 15kΩ | 1nF   |
| GS:110 to GS:111 | 15kΩ | 6.8nF |



For illustration purpose, only red channel is shown. The same circuit applies to green and blue channel.

## Operating Conditions and Electrical Requirements

### Electrical Characteristics at $V_{DD} = 5V$ , $T_A = 25^\circ C$ , $R_L = 68k\Omega$

| Parameter                            | Sym.       | Remark   | Min. | Typ. | Max. | Unit                        |
|--------------------------------------|------------|--|------|------|------|-----------------------------|
| Dark voltage                         | $V_D$      | $E_e = 0$  |      |      | 20   | mV                          |
| Max. output voltage swing            | $V_{OMAX}$ |  |      | 4.7  |      | V                           |
| Supply current                       | $I_{DD}$   | $E_e = 0$  |      | 2.4  |      | mA                          |
| Irradiance Responsivity              | Re         | GS:111, $\lambda_p = 460 \text{ nm}^{[2]}$ (Blue Channel)  |      | 12   |      | V/<br>(mW/cm <sup>2</sup> ) |
|                                      |            | GS:111, $\lambda_p = 542 \text{ nm}^{[3]}$ (Green Channel) |      | 18   |      |                             |
|                                      |            | GS:111, $\lambda_p = 645 \text{ nm}^{[4]}$ (Red Channel)   |      | 26   |      |                             |
| Irradiance Responsivity              | Re         | GS:110, $\lambda_p = 460 \text{ nm}^{[2]}$ (Blue Channel)  |      | 10   |      | V/<br>(mW/cm <sup>2</sup> ) |
|                                      |            | GS:110, $\lambda_p = 542 \text{ nm}^{[3]}$ (Green Channel) |      | 14   |      |                             |
|                                      |            | GS:110, $\lambda_p = 645 \text{ nm}^{[4]}$ (Red Channel)   |      | 20   |      |                             |
| Irradiance Responsivity              | Re         | GS:101, $\lambda_p = 460 \text{ nm}^{[2]}$ (Blue Channel)  |      | 7    |      | V/<br>(mW/cm <sup>2</sup> ) |
|                                      |            | GS:101, $\lambda_p = 542 \text{ nm}^{[3]}$ (Green Channel) |      | 11   |      |                             |
|                                      |            | GS:101, $\lambda_p = 645 \text{ nm}^{[4]}$ (Red Channel)   |      | 16   |      |                             |
| Irradiance Responsivity              | Re         | GS:100, $\lambda_p = 460 \text{ nm}^{[2]}$ (Blue Channel)  |      | 6    |      | V/<br>(mW/cm <sup>2</sup> ) |
|                                      |            | GS:100, $\lambda_p = 542 \text{ nm}^{[3]}$ (Green Channel) |      | 8    |      |                             |
|                                      |            | GS:100, $\lambda_p = 645 \text{ nm}^{[4]}$ (Red Channel)   |      | 12   |      |                             |
| Irradiance Responsivity              | Re         | GS:011, $\lambda_p = 460 \text{ nm}^{[2]}$ (Blue Channel)  |      | 5    |      | V/<br>(mW/cm <sup>2</sup> ) |
|                                      |            | GS:011, $\lambda_p = 542 \text{ nm}^{[3]}$ (Green Channel) |      | 6    |      |                             |
|                                      |            | GS:011, $\lambda_p = 645 \text{ nm}^{[4]}$ (Red Channel)   |      | 9    |      |                             |
| Irradiance Responsivity              | Re         | GS:010, $\lambda_p = 460 \text{ nm}^{[2]}$ (Blue Channel)  |      | 4    |      | V/<br>(mW/cm <sup>2</sup> ) |
|                                      |            | GS:010, $\lambda_p = 542 \text{ nm}^{[3]}$ (Green Channel) |      | 5    |      |                             |
|                                      |            | GS:010, $\lambda_p = 645 \text{ nm}^{[4]}$ (Red Channel)   |      | 7    |      |                             |
| Irradiance Responsivity              | Re         | GS:001, $\lambda_p = 460 \text{ nm}^{[2]}$ (Blue Channel)  |      | 3    |      | V/<br>(mW/cm <sup>2</sup> ) |
|                                      |            | GS:001, $\lambda_p = 542 \text{ nm}^{[3]}$ (Green Channel) |      | 4    |      |                             |
|                                      |            | GS:001, $\lambda_p = 645 \text{ nm}^{[4]}$ (Red Channel)   |      | 6    |      |                             |
| Irradiance Responsivity              | Re         | GS:000, $\lambda_p = 460 \text{ nm}^{[2]}$ (Blue Channel)  |      | 2    |      | V/<br>(mW/cm <sup>2</sup> ) |
|                                      |            | GS:000, $\lambda_p = 542 \text{ nm}^{[3]}$ (Green Channel) |      | 3    |      |                             |
|                                      |            | GS:000, $\lambda_p = 645 \text{ nm}^{[4]}$ (Red Channel)   |      | 4    |      |                             |
| Saturation Irradiance <sup>[5]</sup> |            | GS:111, $\lambda_p = 460 \text{ nm}^{[2]}$ (Blue Channel)  |      | 0.39 |      | mW/cm <sup>2</sup>          |
|                                      |            | GS:111, $\lambda_p = 542 \text{ nm}^{[3]}$ (Green Channel) |      | 0.26 |      |                             |
|                                      |            | GS:111, $\lambda_p = 645 \text{ nm}^{[4]}$ (Red Channel)   |      | 0.18 |      |                             |
| Saturation Irradiance <sup>[5]</sup> |            | GS:110, $\lambda_p = 460 \text{ nm}^{[2]}$ (Blue Channel)  |      | 0.47 |      | mW/cm <sup>2</sup>          |
|                                      |            | GS:110, $\lambda_p = 542 \text{ nm}^{[3]}$ (Green Channel) |      | 0.34 |      |                             |
|                                      |            | GS:110, $\lambda_p = 645 \text{ nm}^{[4]}$ (Red Channel)   |      | 0.23 |      |                             |

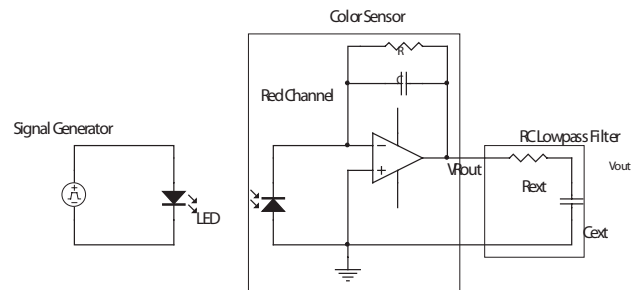
| Parameter                            | Sym.  | Remark   | Min. | Typ. | Max. | Unit               |
|--------------------------------------|-------|--|------|------|------|--------------------|
| Saturation Irradiance <sup>[5]</sup> |       | GS:101, $\lambda_p = 460 \text{ nm}$ <sup>[2]</sup> (Blue Channel)                                   |      | 0.67 |      | mW/cm <sup>2</sup> |
|                                      |       | GS:101, $\lambda_p = 542 \text{ nm}$ <sup>[3]</sup> (Green Channel)                                  |      | 0.43 |      |                    |
|                                      |       | GS:101, $\lambda_p = 645 \text{ nm}$ <sup>[4]</sup> (Red Channel)                                    |      | 0.29 |      |                    |
| Saturation Irradiance <sup>[5]</sup> |       | GS:100, $\lambda_p = 460 \text{ nm}$ <sup>[2]</sup> (Blue Channel)                                   |      | 0.78 |      | mW/cm <sup>2</sup> |
|                                      |       | GS:100, $\lambda_p = 542 \text{ nm}$ <sup>[3]</sup> (Green Channel)                                  |      | 0.59 |      |                    |
|                                      |       | GS:100, $\lambda_p = 645 \text{ nm}$ <sup>[4]</sup> (Red Channel)                                    |      | 0.40 |      |                    |
| Saturation Irradiance <sup>[5]</sup> |       | GS:011, $\lambda_p = 460 \text{ nm}$ <sup>[2]</sup> (Blue Channel)                                   |      | 0.94 |      | mW/cm <sup>2</sup> |
|                                      |       | GS: 011, $\lambda_p = 542 \text{ nm}$ <sup>[3]</sup> (Green Channel)                                 |      | 0.78 |      |                    |
|                                      |       | GS: 011, $\lambda_p = 645 \text{ nm}$ <sup>[4]</sup> (Red Channel)                                   |      | 0.53 |      |                    |
| Saturation Irradiance <sup>[5]</sup> |       | GS:010, $\lambda_p = 460 \text{ nm}$ <sup>[2]</sup> (Blue Channel)                                   |      | 1.18 |      | mW/cm <sup>2</sup> |
|                                      |       | GS:010, $\lambda_p = 542 \text{ nm}$ <sup>[3]</sup> (Green Channel)                                  |      | 0.94 |      |                    |
|                                      |       | GS:010, $\lambda_p = 645 \text{ nm}$ <sup>[4]</sup> (Red Channel)                                    |      | 0.71 |      |                    |
| Saturation Irradiance <sup>[5]</sup> |       | GS:001, $\lambda_p = 460 \text{ nm}$ <sup>[2]</sup> (Blue Channel)                                   |      | 1.57 |      | mW/cm <sup>2</sup> |
|                                      |       | GS:001, $\lambda_p = 542 \text{ nm}$ <sup>[3]</sup> (Green Channel)                                  |      | 1.18 |      |                    |
|                                      |       | GS:001, $\lambda_p = 645 \text{ nm}$ <sup>[4]</sup> (Red Channel)                                    |      | 0.85 |      |                    |
| Saturation Irradiance <sup>[5]</sup> |       | GS:000, $\lambda_p = 460 \text{ nm}$ <sup>[2]</sup> (Blue Channel)                                   |      | 2.35 |      | mW/cm <sup>2</sup> |
|                                      |       | GS:000, $\lambda_p = 542 \text{ nm}$ <sup>[3]</sup> (Green Channel)                                  |      | 1.57 |      |                    |
|                                      |       | GS:000, $\lambda_p = 645 \text{ nm}$ <sup>[4]</sup> (Red Channel)                                    |      | 1.34 |      |                    |
| Output rise time                     | $t_r$ | GS:000 to GS101 Test Condition: Refer to note <sup>[1]</sup><br>(min $V_o = 0V$ , peak $V_o = 2V$ )  |      | 45   |      | $\mu s$            |
|                                      |       | GS:110 to GS:111 Test Condition: Refer to note <sup>[1]</sup><br>(min $V_o = 0V$ , peak $V_o = 2V$ ) |      | 220  |      | $\mu s$            |
| Output fall time                     | $t_f$ | GS:000 to GS101 Test Condition: Refer to note <sup>[1]</sup><br>(min $V_o = 0V$ , peak $V_o = 2V$ )  |      | 50   |      | $\mu s$            |
|                                      |       | GS:110 to GS:111 Test Condition: Refer to note <sup>[1]</sup><br>(min $V_o = 0V$ , peak $V_o = 2V$ ) |      | 240  |      | $\mu s$            |

## Notes:

1. Test condition: The rise and fall time is measured with RC lowpass filter added to sensor output:
2. Test condition: using blue diffuse light of peak wavelength ( $\lambda_p$ ) 460nm and spectral half width ( $\Delta\lambda_{1/2}$ ) 25nm as light source.
3. Test condition: using green diffuse light of peak wavelength ( $\lambda_p$ ) 542nm and spectral half width ( $\Delta\lambda_{1/2}$ ) 35nm as light source.
4. Test condition: using red diffuse light of peak wavelength ( $\lambda_p$ ) 645nm and spectral half width ( $\Delta\lambda_{1/2}$ ) 20nm as light source.
5. Saturation irradiance = (Max output voltage swing)/(Irradiance responsivity)

Remarks: For illustration purpose, only red channel is shown. The same circuit applies to green and blue channel.

| Gain Selection   | Rext         | Cext  |
|------------------|--------------|-------|
| GS:000 to GS:101 | 15k $\Omega$ | 1nF   |
| GS:110 to GS:111 | 15k $\Omega$ | 6.8nF |



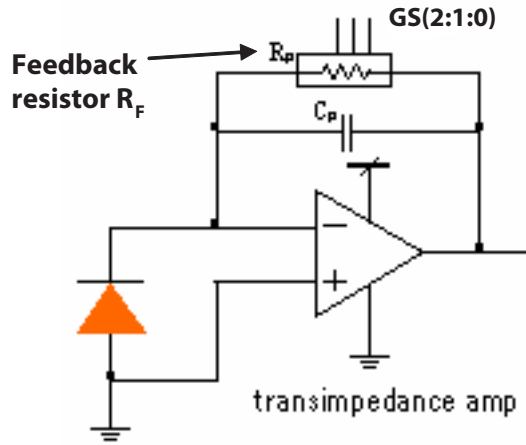
Test Circuit

### Gain Selection Feedback Resistor Table

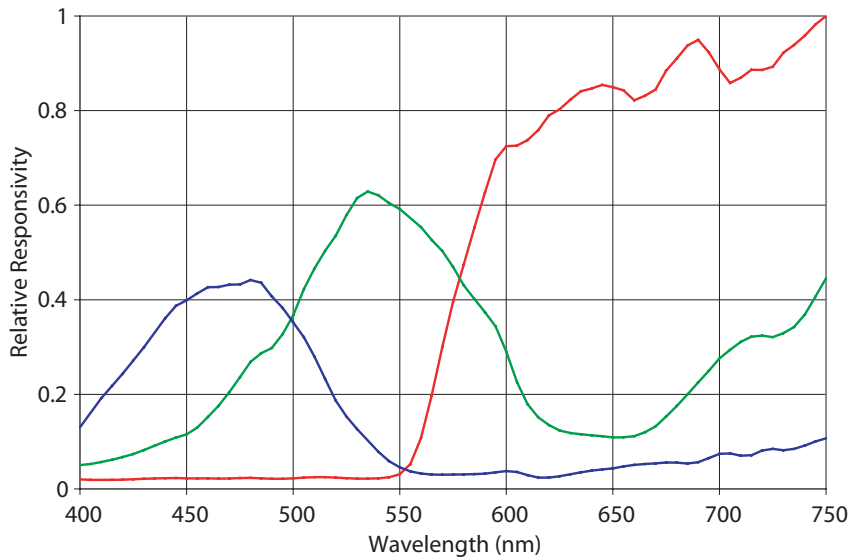
| GS: Bit 2 | GS: Bit 1 | Bit 0 | Feedback Resistor, $R_F$ |
|-----------|-----------|-------|--------------------------|
| 0         | 0         | 0     | 1.9 M $\Omega$           |
| 0         | 0         | 1     | 2.5 M $\Omega$           |
| 0         | 1         | 0     | 3.2 M $\Omega$           |
| 0         | 1         | 1     | 4.1 M $\Omega$           |
| 1         | 0         | 0     | 5.3 M $\Omega$           |
| 1         | 0         | 1     | 7 M $\Omega$             |
| 1         | 1         | 0     | 9 M $\Omega$             |
| 1         | 1         | 1     | 11.7 M $\Omega$          |

Note:

1. Gains selections, GS: Bit 2 Bit 1 Bit 0 are applicable for each Red, Green and Blue Channel.
2. Gain selections for each channel can be selected independently of each other.
3. Feedback resistor value is proportional to responsivity. Refer to block diagram below.
4. 0 indicates that the pin is connected to ground. 1 indicates no connection.



### Typical Characteristics



**Figure 1. Spectral Responsivity**

Note:

Test condition is when Gain Selection Jumpers are set to

GSBLUE2=1      GSGRN2=1      GSRED2=1  
 GSBLUE1=1      GSGRN1=1      GSRED1=1  
 GSBLUE0=1      GSGRN0=1      GSRED0=1

in which 0=connect to Ground, 1=no connection.

Refer to Gain Selection Feedback Resistor Table.

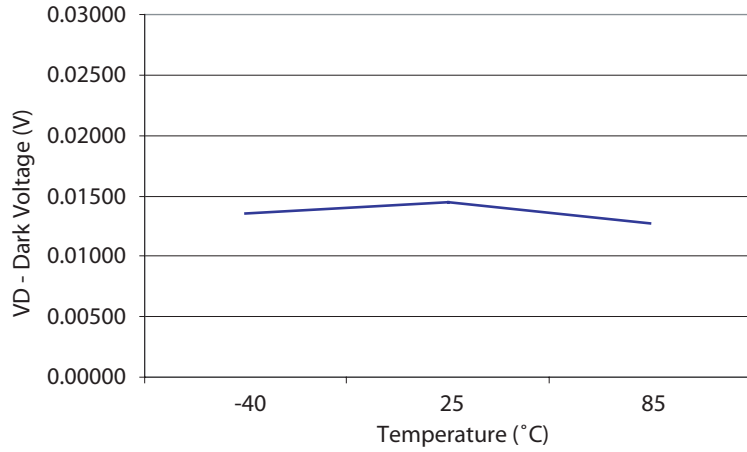


Figure 2. Dark Voltage vs Operating Temperature

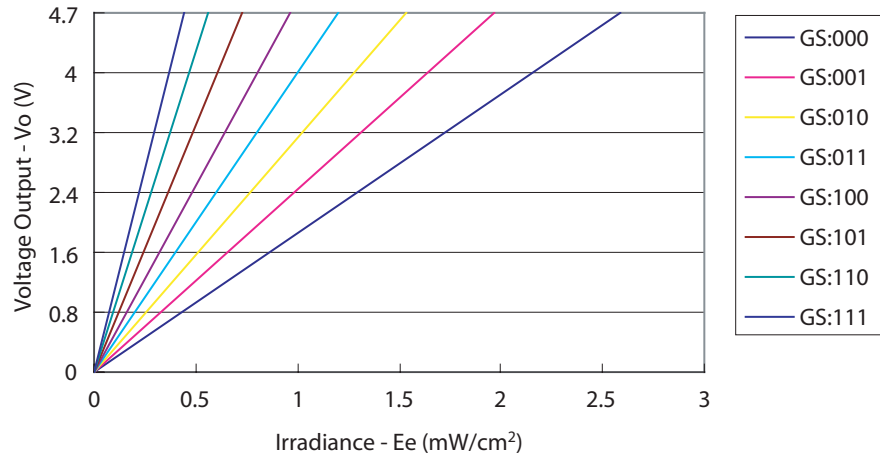


Figure 3. Voltage Output of Blue Channel vs Irradiance (Ip = 460 nm)

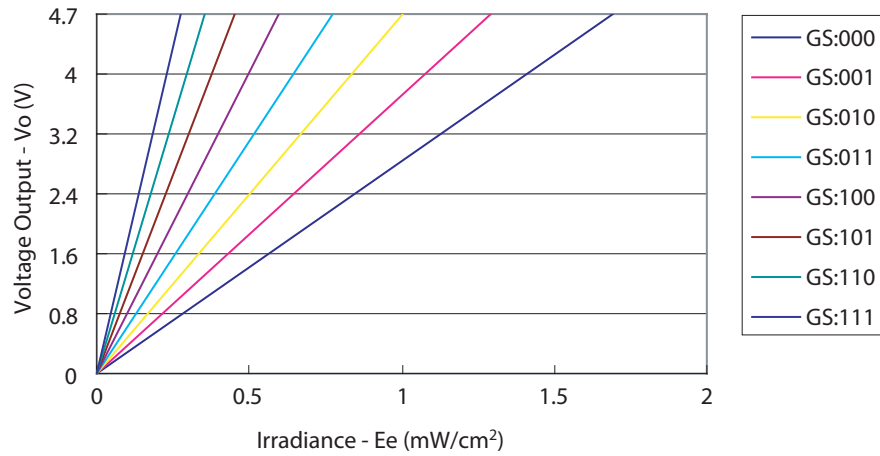


Figure 4. Voltage Output of Green Channel vs Irradiance (Ip = 542 nm)



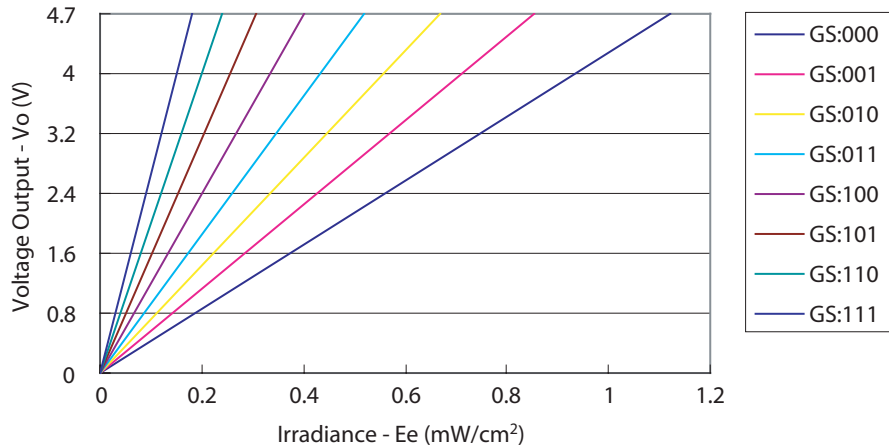


Figure 5. Voltage Output of Red Channel vs Irradiance ( $I_p = 645 \text{ nm}$ )

### Recommended Reflow Profile

It is recommended that Henkel Pb-free solder paste LF310 be used for soldering ADJD- E622-QR999. Below is the recommended reflow profile.

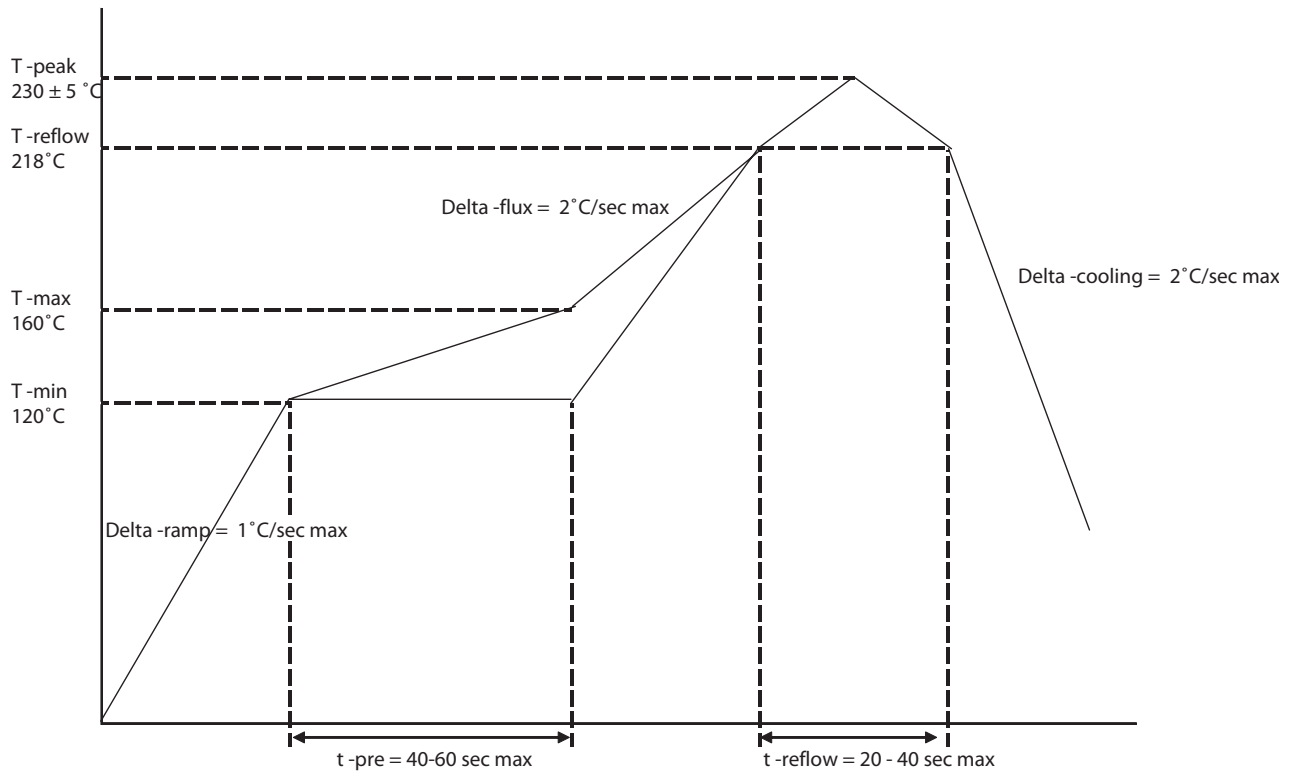


Figure 6. Recommended Reflow Soldering Profile

### 16 Lead QFN Recommended PCB Land Pad Design

IPC-SM-782 is used as the standard for the PCB land-pad design. Recommended PCB finishing is gold plated.

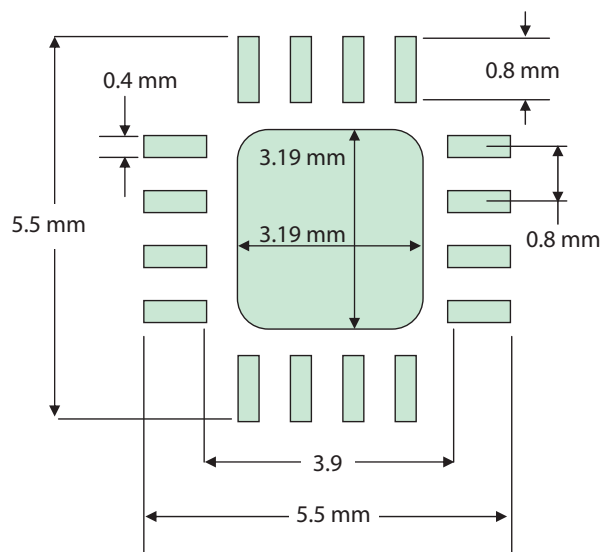


Figure 7.

### 16 Lead QFN Recommended Stencil Design

A stencil thickness of 2.18mm (6mils) for this QFN package is recommended.

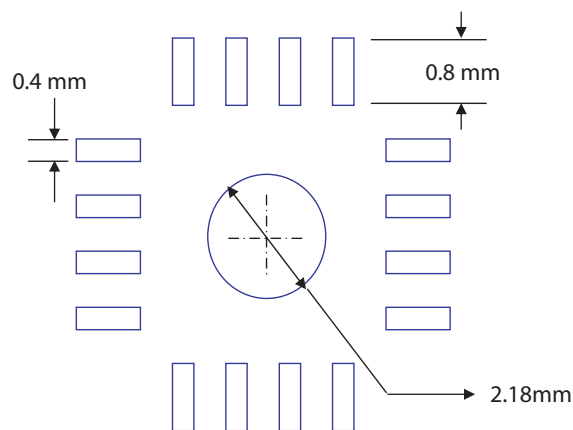


Figure 8.

### Recommendations for Handling and Storage of ADJD E622 QR999

This product is qualified as Moisture Sensitive Level 3 per Jedec J-STD-020. Precautions when handling this moisture sensitive product is important to ensure the reliability of the product. Do refer to Avago Application Note AN5305 Handling Of Moisture Sensitive Surface Mount Devices for details.

#### A. Storage before use

- Unopened moisture barrier bag (MBB) can be stored at 30°C and 90%RH or less for maximum 1 year
- It is not recommended to open the MBB prior to assembly (e.g. for IQC)
- It should also be sealed with a moisture absorbent material (Silica Gel) and an indicator card (cobalt chloride) to indicate the moisture within the bag

#### B. Control after opening the MBB

- The humidity indicator card (HIC) shall be read immediately upon opening of MBB
- The components must be kept at <30°C/60%RH at all time and all high temperature related process including soldering, curing or rework need to be completed within 168hrs

#### C. Control for unfinished reel

- For any unused components, they need to be stored in sealed MBB with desiccant or desiccator at <5%RH

#### D. Control of assembled boards

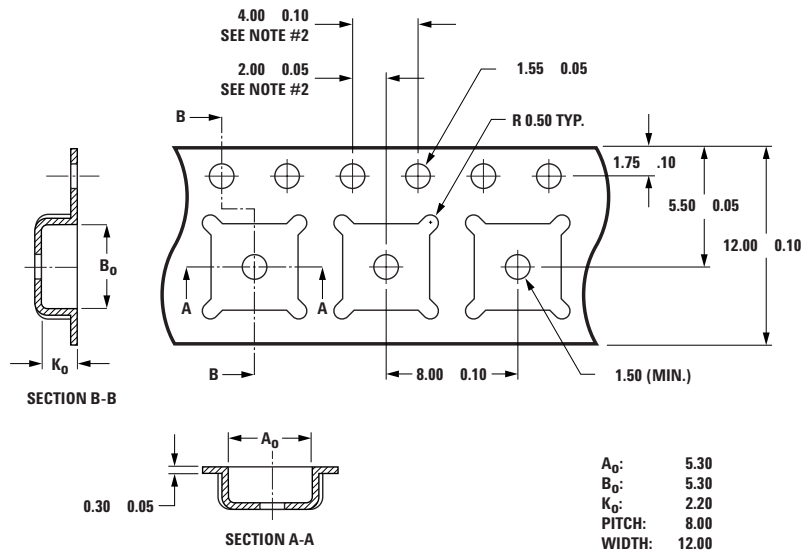
- If the PCB soldered with the components is to be subjected to other high temperature processes, the PCB need to be stored in sealed MBB with desiccant or desiccator at <5%RH to ensure no components have exceeded their floor life of 168hrs

#### E. Baking is required if:

- "10%" or "15%" HIC indicator turns pink
- The components are exposed to condition of >30°C/60%RH at any time.
- The components floor life exceeded 168hrs
- Recommended baking condition (in component form): 125°C for 24hrs

## Package Tape and Reel Dimensions

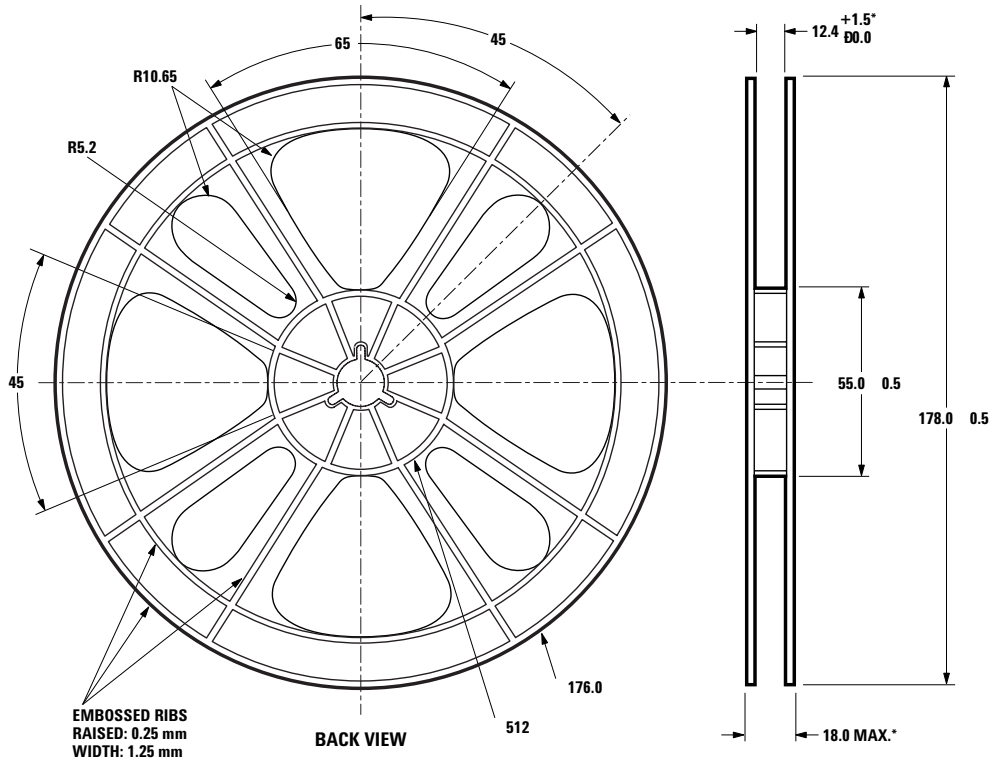
### Carrier Tape Dimensions



**NOTES:**

1. A<sub>0</sub> AND B<sub>0</sub> MEASURED AT 0.3 mm ABOVE BASE OF POCKET.
2. 10 PITCHES CUMULATIVE TOLERANCE IS 0.2 mm.
3. DIMENSIONS ARE IN MILLIMETERS (mm).

### Reel Dimensions



**NOTES:**

1. \*MEASURED AT HUB AREA.
2. ALL FLANGE EDGES TO BE ROUNDED.

**ESD WARNING:** *Standard CMOS handling precautions should be observed to avoid static discharge.*

*THIS PRODUCT IS NOT CERTIFIED OR WARRANTED FOR AUTOMOTIVE APPLICATIONS. IF THE CUSTOMER INTENDS TO USE IT FOR AUTOMOTIVE APPLICATIONS, THEY DO SO AT THEIR OWN RISK. AVAGO WILL NOT BE RESPONSIBLE FOR ANY CLAIM OF PRODUCT FAILURE DURING OPERATION OR RELIABILITY ASSESSMENT.*

For product information and a complete list of distributors, please go to our web site: [www.avagotech.com](http://www.avagotech.com)

Avago, Avago Technologies, and the A logo are trademarks of Avago Technologies, Limited in the United States and other countries.  
Data subject to change. Copyright © 2007 Avago Technologies Limited. All rights reserved.  
AV01-0143EN - January 8, 2007

