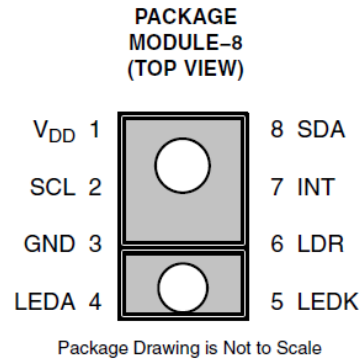# Description

HRS3301 is an optical digital heart rate sensor, 525nm green LED and driver in a single 8-pin package.

The sensor incorporates with a fast, two-wire $I^2C$ bus (up to 800kHz) to communicate with micro-controller or embedded system. Its excellent background light rejection allows the device to operate in environments from sunlight to dark rooms.

The heart rate sensing is realized by using an 525nm green light LED with current driver, a reflection light detector for the PPG signal from the human body, as well as heart rate algorithm.

**PACKAGE MODULE−8 (TOP VIEW)**

| V_DD 1 | 8 SDA |
| SCL 2 | 7 INT |
| GND 3 | 6 LDR |
| LEDA 4 | 5 LEDK |

Package Drawing is Not to Scale

Typical heart rate measurement samples the reflected PPG signal at a frequency of 25Hz, then the resulting light intensity signal can be transferred to the host controller by I2C interface and the heart rate is calculated by the controller utilizing the algorithm.

The device can be used in a health wearable devices, such as sport band or smart watch. Its signal can also be analyzed to indicate the detach of the device.

# Features

- **Heart Rate Sensor: 525nm wavelength PPG signal and provide algorithm**

- **HRS: Programmable green light intensity and analog gain**

- **HRS sensor with reduced background noise**

- **ALS cancellation**

- **$I^2C$ interface(up to 800kHz)**

- **Low power consumption**

- **Wide Input Voltage: From 2.3V to 3.6V**

- **Package size:3.94mm×2.36mm×1.35mm**

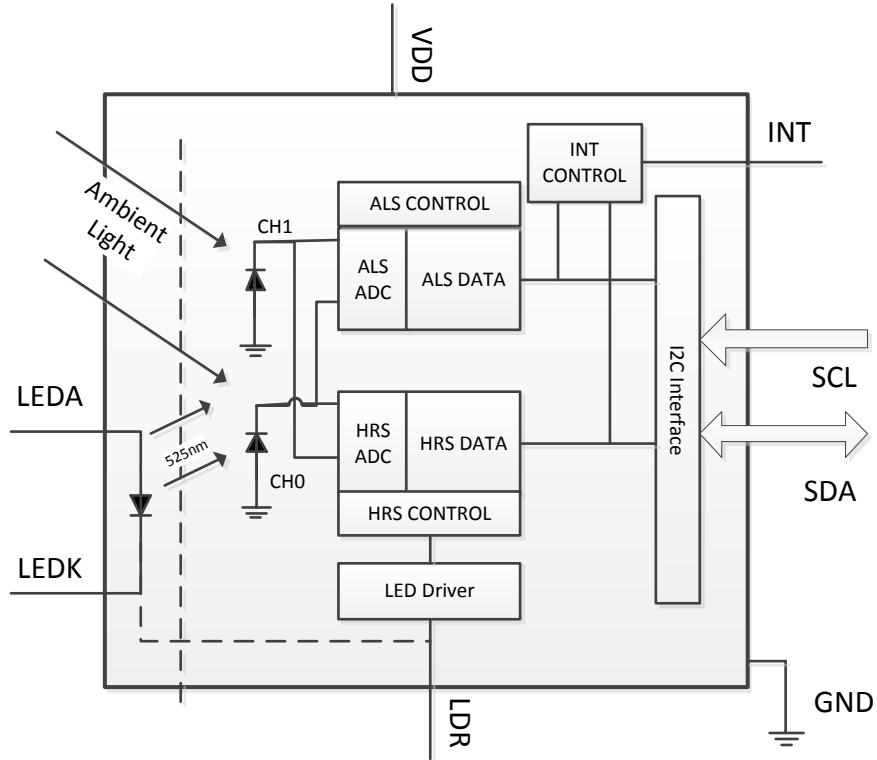- **Pb free and ROHS compliant**

# Function Block Diagrams



Figure 1. Function Block Diagrams

**Note:**

1. LEDK and LDR terminals are shorted internally in the package, to be compatible with most PCB designs for sensors with internal LED driver.

2. For PCB traces connecting to LEDK and LDR, they can be shorted or leave float, but not connect to ground.

# Applications

- Sport Bands

- Smart Watch

- Children Watch

- Wearable Health Devices

- Sensor Application

# Terminal Functions

| PIN | Name | Type | Description |
|---|---|---|---|
| 1 | VDD | | Power supply voltage |
| 2 | SCL | I | $I^2C$ serial clock input terminal-clock signal for $I^2C$ serial data |
| 3 | GND | | Power supply ground |
| 4 | LEDA | I | LED anode |
| 5 | LEDK | O | LED cathode, connect to LDR pin internally. |
| 6 | LDR | I | LED driver for Green LED, connect to LEDK pin internally. |
| 7 | INT | O | Interrupt-open drain |
| 8 | SDA | I/O | $I^2C$ serial data I/O terminal-serial data I/O for $I^2C$ –open drain |

# Specifications

**Absolute Maximum Ratings($T_a$=25℃, unless otherwise specified)**

| Parameter | Symbol | | Unit |
|---|---|---|---|
| Supply voltage | $V_{DD}$ | 4.0 | V |
| Digital output voltage range | $V_O$ | -0.5 to 4.0 | V |
| Digital output current | $I_O$ | -1 to 10 | mA |
| Analog voltage range | LDR | -0.5 to 5.5 | V |
| Storage temperature | $T_{stg}$ | -40 to 85 | ℃ |
| ESD tolerance(HBM) | | 3000 | V |

**Recommended Operating Conditions**

| | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|
| Supply voltage, $V_{DD}$ | 2.3 | 3 | 3.6 | V |
| Supply voltage accuracy | -10 | | 10 | % |
| Operating free-air temperature, $T_a$ | -30 | | 85 | ℃ |

**Operating Characteristics($V_{DD}$=3.3V,Ta=25℃, HRS sample time 40ms, unless otherwise specified, ALS resolution is 14bit, HRS resolution is 14bit)**

| Parameter | Min | Typ. | Max | Unit | Description |
|---|---|---|---|---|---|
| $I_{DD}$ | --- | 0.01 | 0.1 | μA | Supply current: Sleep mode |
| | --- | 110 | 115 | μA | Supply current, HRS on |
| | --- | 2.6 | 2.8 | mA | LEDA current ,HRS on |
| $V_{OLSDA}$ | 0 | | 0.4 | V | SDA output low voltage: 3mA sink current |
| $V_{OLINT}$ | 0 | | 0.4 | V | INT output low voltage: 3mA sink current |
| $I_{LEAK}$ | --- | 0.03 | 0.05 | μA | Leakage current, SDA pin |
| | --- | 0.01 | 0.05 | μA | Leakage current, SCL pin |
| | --- | 0.02 | 0.05 | μA | Leakage current, INT pin |
| | --- | 0.01 | 0.05 | μA | Leakage current, LDR pin |
| $V_{IL}$ | | | 0.55 | V | SCL, SDA input low voltage |
| $V_{IH}$ | 1.25 | | | V | SCL, SDA input high voltage |

**Electrical Characteristics($V_{DD}=V_{LEDA}$=3.3V , $T_a$=25℃, unless otherwise specified, HRS resolution is 14bit)**

| Parameter | Test Conditions | Min | Typ. | Max | Units |
|---|---|---|---|---|---|
| Dark ALS ADC count | $E_e$=0,AGAIN=1 | 0 | 3 | 5 | counts |
| ALS ADC integration time | | --- | 100 | --- | ms |
| HRS ADC conversion time | | | 25 | | ms |
| HRS Cycle Wait Time | | 0 | 12.5 | 800 | ms |
| LED current, $I_{LED}$ [2] | PDRIVE=00 | | 12.5 | | mA |
| | PDRIVE=01 | | 20 | | |
| | PDRIVE=10 | | 30 | | |
| | PDRIVE=11 | | 40 | | |

**Notes:**

1.  The 525nm LED with peak 525nm and spectral half-width $\Delta\lambda^{1/2}$=20nm is used for final mass product testing.

2.  No reflective surface above the module.

3.  No glass or aperture above the module. Tested value is the average of 5 consecutive reading.

**AC Electrical Characteristics($V_{DD}$= 3V,$T_a$=25℃,unless otherwise specified)**

| Parameter | Symbol | Min. | TYP | Max. | Units |
|---|---|---|---|---|---|
| Clock Frequency | $f_{SCL}$ | 0 | | 800 | kHz |
| Bus free time between start and stop condition | $t_{BUF}$ | 1.3 | | | μs |
| Hold time(repeated) START condition<br>After this period, the first clock pulse is generated | $t_{HDSTA}$ | 0.6 | | | μs |
| Set-up time for a repeated START condition | $t_{SUSTA}$ | 0.6 | | | μs |
| Set-up time for STOP condition | $t_{SUSTO}$ | 0.6 | | | μs |
| Data hold time | $t_{HDDAT}$ | 0 | | | μs |
| Data setup time | $t_{SUDAT}$ | 100 | | | ns |
| SCL clock low period | $t_{LOW}$ | 1.3 | | | μs |
| SCL clock high period | $t_{HIGH}$ | 0.6 | | | μs |
| Clock/data fall time | $t_F$ | | | 300 | ns |
| Clock/data rise time | $t_R$ | | | 300 | ns |
| Input pin capacitance | $C_i$ | | | 10 | pF |

**Note**：Specified by design and characterization.
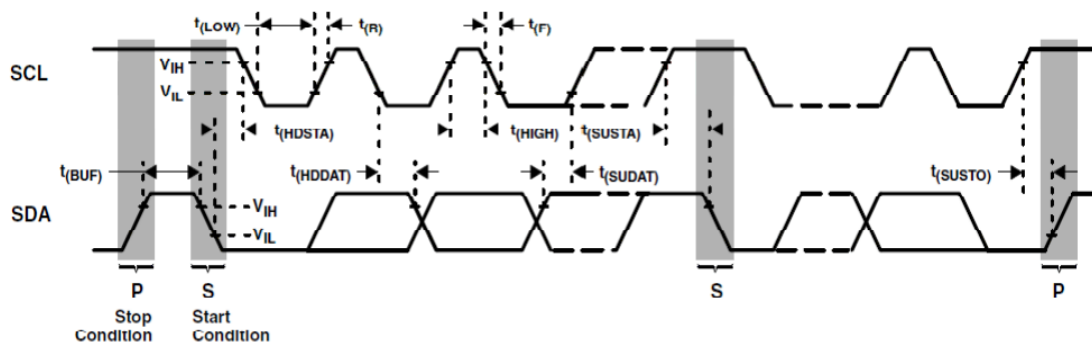


Figure 2. Timing Diagram

# Application Note

**Heart rate sensor**

Heart rate measurement is accomplished by measuring the reflected amount of green energy from the internal green LED. Light rays emitting from the internal green LED, reflecting back from the skin of human, and being absorbed by the photo-diode. The internal green LED is driven by the integrated current driver. The LED current driver provides a regulated current sink on the LDR terminal that eliminated the need for an external current limiting resistor. The PDRIVE(PDRIVE[1] register 0x01,bit 3, PDRIVE[0] register 0x0C,bit 6) register setting sets the sink current from 12.5mA to 40mA. The heart rate engine uses a novel technique to suppress background noise effectively. Then the HRS ADC converts a value and stores the result in (CH0DATAx) register

## I$^2$C Protocol

Interface and control are accomplished through an I$^2$C serial compatible interface to a set of registers that provide access to device control functions and output data. The address of HRS3301 is 0x44, the device also supports the 7-bit I$^2$C addressing protocol. HRS3301 supports the standard writing and reading protocol. The register index will automatically increase by 1 after the addressed register has been accessed (read or write).

A   Acknowledge (0)

P   Stop Condition

R   Read (1)

S   Start Condition

W   Write (0)

Sr  Repeated Start Condition
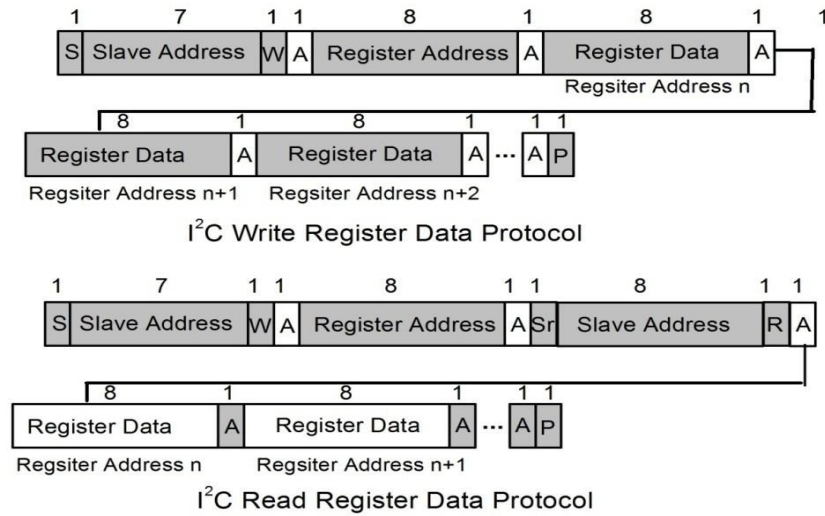
■ Master-to- Slave

□ Slave-to-Master

Figure 2. I²C Protocols

**Register Set**

The device is controlled and monitored by data registers accessible through the serial interface. These registers provide for a variety of control functions and can be read to determine results of the ADC conversions. The register set is summarized in Table 1.

Table 1. Register Address

| Address | name | R/W | function | Recommend Value |
|---------|------|-----|----------|-----------------|
| 0x00 | ID | R/W | Device ID | 0x21 |
| 0x01 | Enable | R/W | Enable HRS | 0x68 |
| 0x08 | C1DATAM | RO | CH1 data register bit 10~3 | 0x00 |
| 0x09 | C0DATAM | RO | CH0 data register bit 15~8 | 0x00 |
| 0x0A | C0DATAH | RO | CH0 data register bit 7~4 | 0x00 |
| 0x0C | PDRIVER | R/W | HRS LED driver/PON/PDRIVE[0] | 0x68 |
| 0x0D | C1DATAH | RO | CH1 data register bit 17~11 | 0x00 |
| 0x0E | C1DATAL | RO | CH1 data register bit 2~0 | 0x00 |
| 0x0F | C0DATAL | RO | CH1 data register bit 17~16 and 3~0 | 0x00 |
| 0x16 | RES | R/W | ALS and HRS resolution | 0x66 |
| 0x17 | HGAIN | R/W | HRS gain | 0x10 |

## ID Register(0x00)

The ID Register(read-only) provides the value for the part number.

Table 2. ID Register

| BITS | FIELD | Description |
|------|-------|-------------|
| 7:0 | ID | 0x21 |

## ENABLE Register(0x01)

The ENABLE register is used to enable and disable ALS and HRS functions.

Table 3. ENABLE Register

| BITS | FIELD | Description |
|------|-------|-------------|
| 7 | HEN | HRS enable. This bit activates the HRS function. Writing a 1 enables. Writing a 0 disables |
| 6:4 | HWT | HRS wait time |
| | | 000:wait time between each conversion cycle is 800 ms |
| | | 001:wait time between each conversion cycle is 400 ms |
| | | 010:wait time between each conversion cycle is 200 ms |
| | | 011:wait time between each conversion cycle is 100 ms |
| | | 100:wait time between each conversion cycle is 75 ms |
| | | 101:wait time between each conversion cycle is 50 ms |
| | | 110:wait time between each conversion cycle is 12.5 ms |
| | | 111:wait time between each conversion cycle is 0 ms |
| 3 | PDRIVE[1] | Bit1 for LED drive current setup, see also Register 0xOC Bit6. |
| | | 00: set current 12.5mA |
| | | 01: set current 20mA |
| | | 10: set current 30mA |
| | | 11: set current 40mA |
| 2:0 | Reserved | Reserved |

## CH1 Data register(0x08,0x0D,0x0E)

Table 4. ALS Data Register

| BITS | ADDRESS | REGISTER | Description |
|---|---|---|---|
| 7:0 | 0x08 | C1DATA[10:3] | CH1 data register |
| 6:0 | 0x0D | C1DATA[17:11] | CH1 data register |
| 2:0 | 0x0E | C1DATA[2:0] | CH1 data register |

## CH0 Data Register(0x09,0x0A,0x0F)

Table 5. HRS Data Register

| BITS | ADDRESS | REGISTER | Description |
|---|---|---|---|
| 7:0 | 0x09 | C0DATA[15:8] | CH0 data register |
| 3:0 | 0x0A | C0DATA[7:4] | CH0 data register |
| 5:4 | 0x0F | C0DATA[17:16] | CH0 data register |
| 3:0 | | C0DATA[3:0] | |

## HRS LED Driver Set Register (0x0C)

Table 6. HRS LED Driver Set Register

| BIT | FIELD | Description |
|---|---|---|
| 7 | Reserved | Reserved |
| 6 | PDRIVE[0] | Bit0 for LED drive current setup, see also Register 0x01 Bit3. |
| | | 00: set current 12.5mA |
| | | 01: set current 20mA |
| | | 10: set current 30mA |
| | | 11: set current 40mA |
| 5 | PON | Write 1 active OSC, write 0 disable OSC. Generate PD signal to analog(1 for work, 0 for Power down) |
| 4 | Reserved | Reserved |
| 3:0 | Reserved | Reserved |

## RESOLUTION Register(0x16)

The RESOLUTION register is used to control resolution of ALS ADC and HRS ADC.

Table 7. Resolution Register

| BIT | FIELD | Description |
|---|---|---|
| 7:4 | Reserved | |
| 3:0 | ALS_RES | ALS ADC resolution. Generate TSEL to analog in ALS mode.<br><br>0000: 8 bits<br><br>0001 9 bits<br><br>0010: 10 bits<br><br>0011: 11 bits<br><br>0100: 12 bits<br><br>0101: 13 bits<br><br>0110: 14 bits<br><br>0111: 15 bits<br><br>1000: 16 bits<br><br>1001: 17 bits<br><br>others: 18 bits |

## HGAIN Register(0x17)

The HGAIN register is used to control the gain of HRS ADC.

Table 8. HGAIN Register

| BIT | FIELD | Description | |
|---|---|---|---|
| 7:5 | Reserved | Reserved | |
| 4:2 | HGAIN | FIELD VALUE | HRS gain |
| | | 000 | ×1 |
| | | 001 | ×2 |
| | | 010 | ×4 |
| | | 011 | ×8 |
| | | Other | ×64 |
| 1:0 | Reserved | Reserved | |

# Application Information

A typical application for HRS3301 is shown in Figure 3. The $I^2C$ signals and the Interrupt are open-drain outputs and require pull-up resistor ($R_P$). It is recommended use 1.5 kΩ resistor when running at 400kbps.    Pin INT can be disconnected in typical HRS
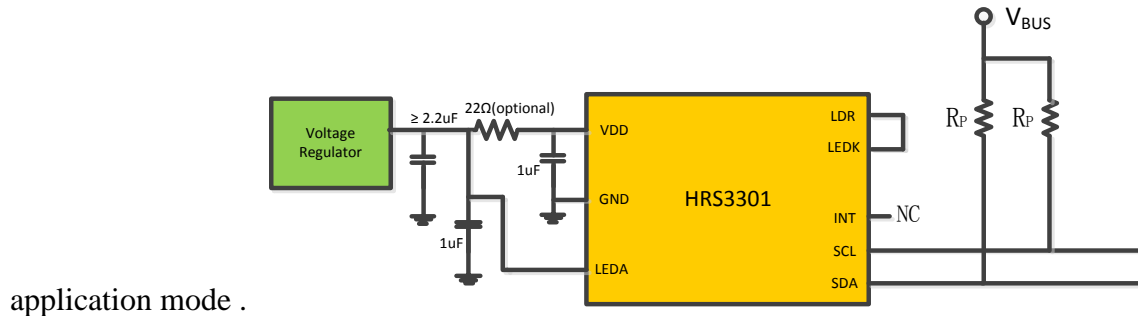


application mode .

Figure 3. Typical Application Schematic Diagram

**The 1uF decoupling capacitor between VDD and GND must be placed close to the sensor package , recommended distance in 0.5mm .**

# PCB Pad Layout

Suggest PCB pad layout guidelines for the surface module are shown in Figure4. Flash Gold is recommended surface finish for the landing pads.
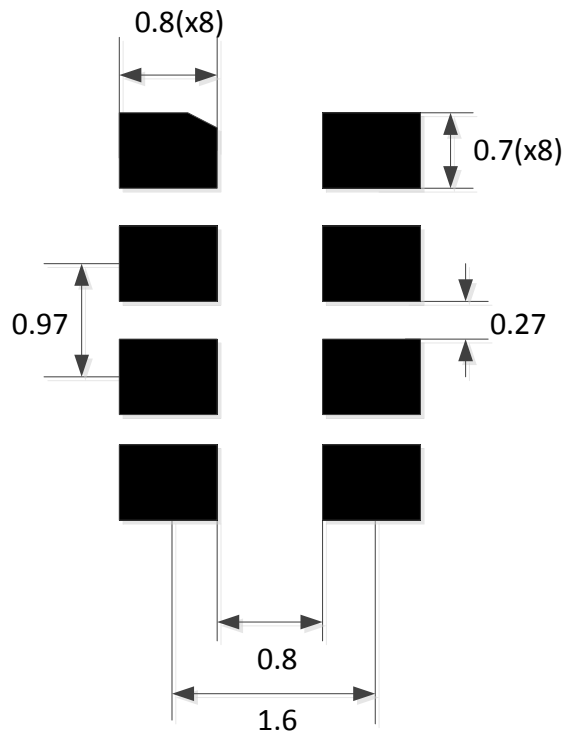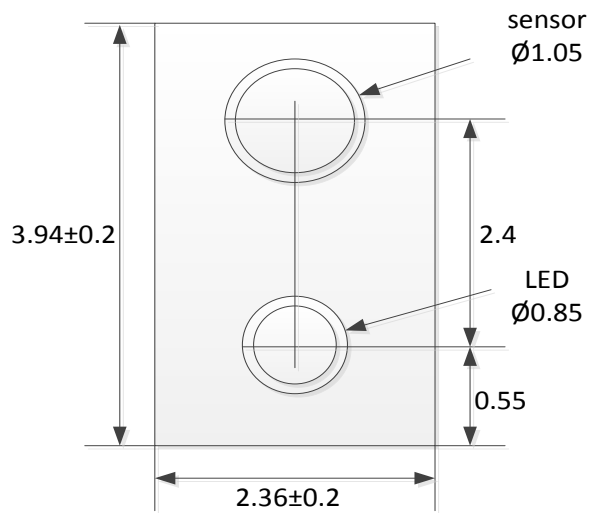
Figure 4. Suggested Module PCB layout
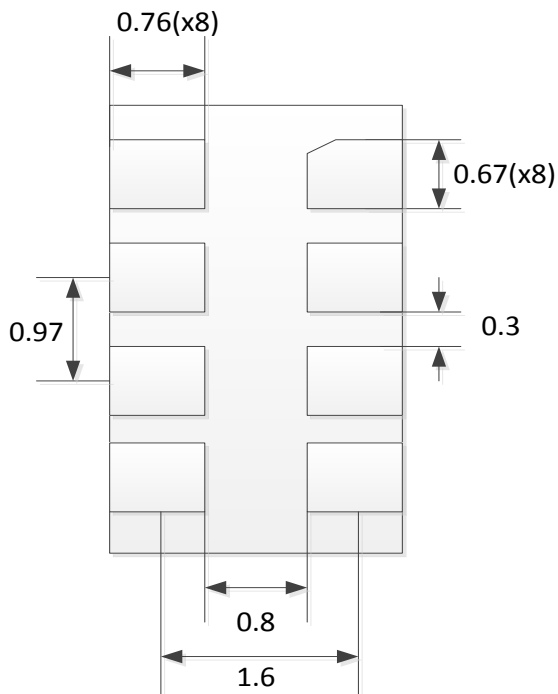
Note: All linear dimensions are in mm

# Package Information

MODULE

Top View

sensor
Ø1.05

3.94±0.2

2.4

LED
Ø0.85

0.55

2.36±0.2

Bottom View

0.76(x8)

0.67(x8)

0.97

0.3

0.8

1.6

Side View

1.35±0.1

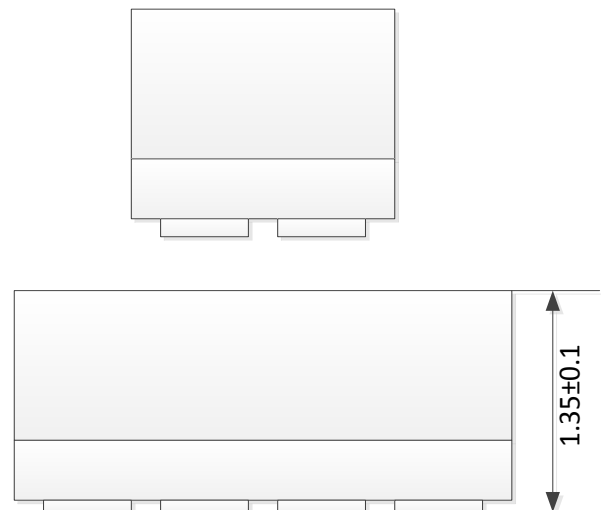Figure 5. Package information

Notes: All linear dimensions are in mm. Dimension tolerance is ±0.05mm unless otherwise noted.

# Soldering Information

The module has been tested and has demonstrated an ability to be reflow soldered to a PCB substrate. The process, equipment, and material used in these test are detailed below. 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 components should be limited to a maximum of three passes through this solder reflow profile.
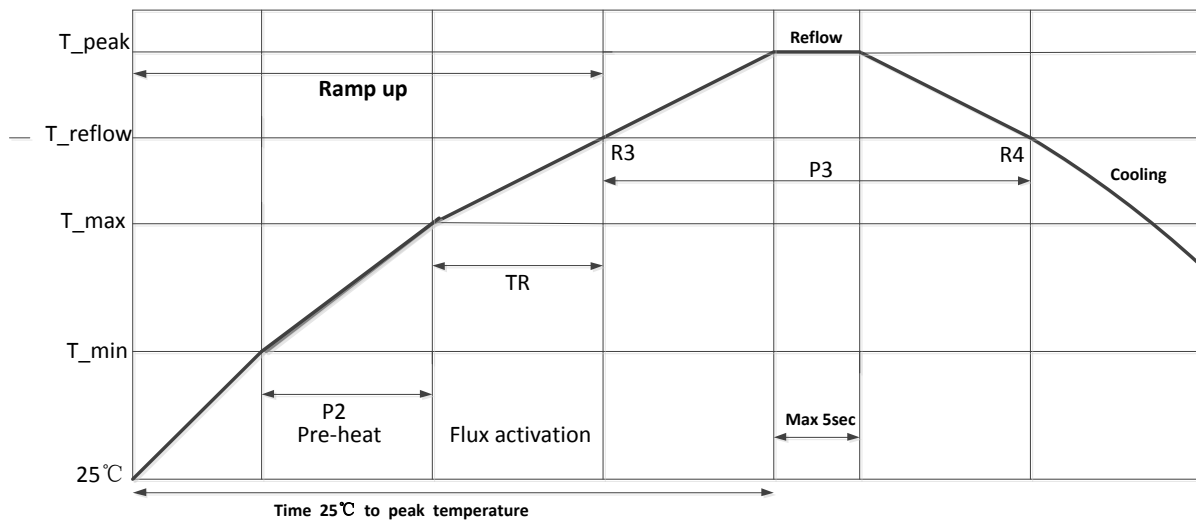


Figure 6. Solder reflow profile grap

| | | |
|---|---|---|
| | Peak temperature (Tpeak) | 250-255℃ ；Max 5sec |
| Pre-Heat | Temperature min (Tmin) | 150℃ ；2℃/Sec |
| | Temperature max(Tmax) | 150-217℃ ；100S to 180S |
| | P2：（T min to max ） | 90-110s |
| Time maintain above | Temperature (Treflow) | 217 ℃ |
| | Time (P3) | 60-90sec |
| | R3 Slope (from 217℃ -＞ peak) | 2℃/sec(typ)-＞2.5℃/sec(max) |
| | R4 Slope (from peak -＞ 217℃) | 1.5℃/sec(typ)-＞4℃/sec(max) |
| | Time to peak temperature | 480s Max |
| | Cooling down slope (peak to 217℃) | 2-4 ℃/sec |

Table 9. Solder Reflow Profile