

# IS31SE5000

## IR SENSOR FOR TOUCHLESS MOTION AND PROXIMITY

October 2012

### GENERAL DESCRIPTION

The IS31SE5000 is a low-power, reflectance-based infrared light sensor with advanced signal processing and digital output. The sensor can detect making touchless motion possible.

The IS31SE5000 uses one infrared LED and 2-channel receivers which pick up the reflectance signal from the 2 photodiodes to perform touchless motion detection. When horizontal motion or proximity motion happen, the flag bits in status register will be triggered and an interrupt signal is generated to inform the master to read the flag bit through I2C interface.

IS31SE5000 is available in UTQFN-12 (2mm × 2mm). It operates from 2.7V to 5.5V over the temperature range of -40°C to +85°C.

### FEATURES

- Supply voltage from 2.7V~5.5V
- 400kHz I2C compatible interface
- 1μA shutdown current
- 0.6mA low supply current
- Detection range can be adjusted
- Motion Mode and Proximity Mode
- Integrated signal processing and digital output
- Auto interrupt clear
- Package in UTQFN-12 (2mm × 2mm)

### APPLICATIONS

- Smart phones/GPS/MID/PAD/MP3
- Lighting/switch controller/ household electrical appliances
- Toys/game machine

### TYPICAL APPLICATION CIRCUIT

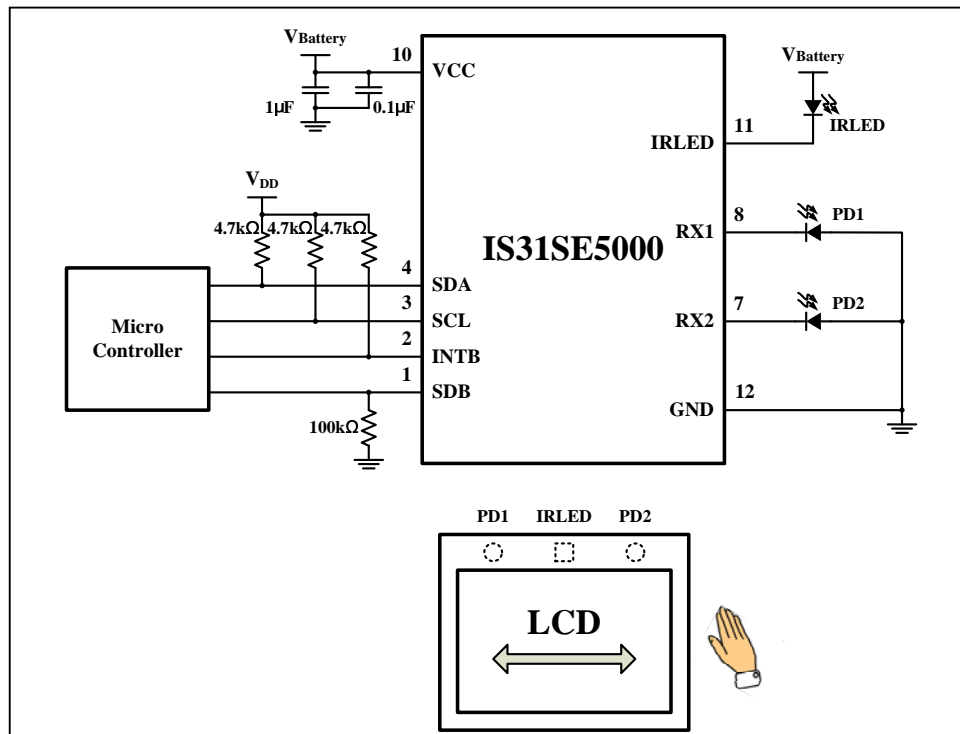
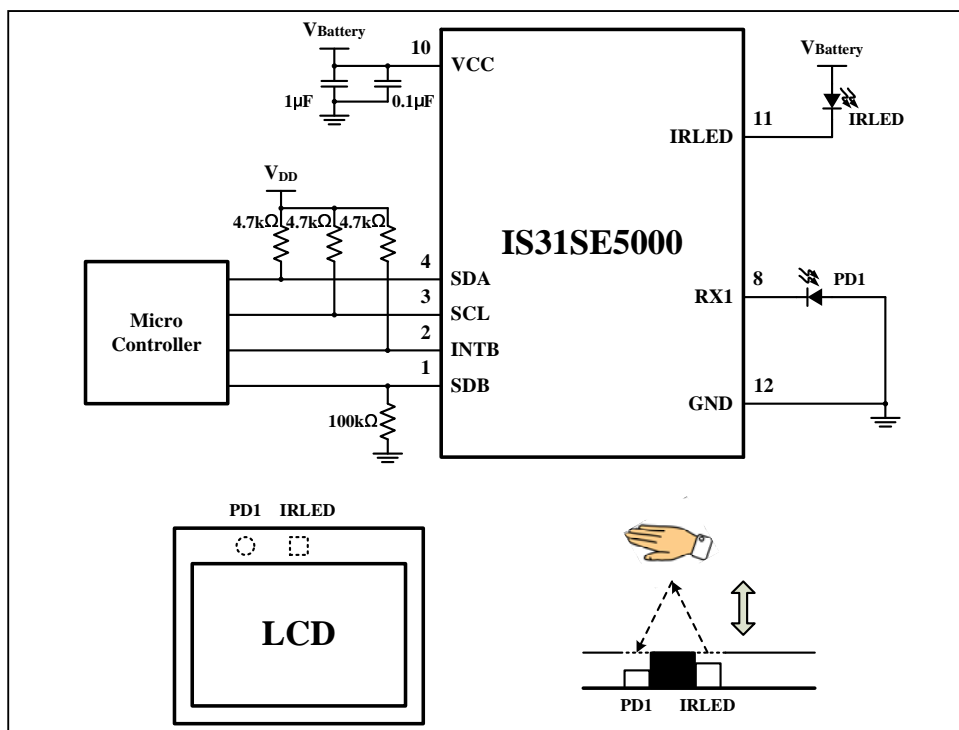


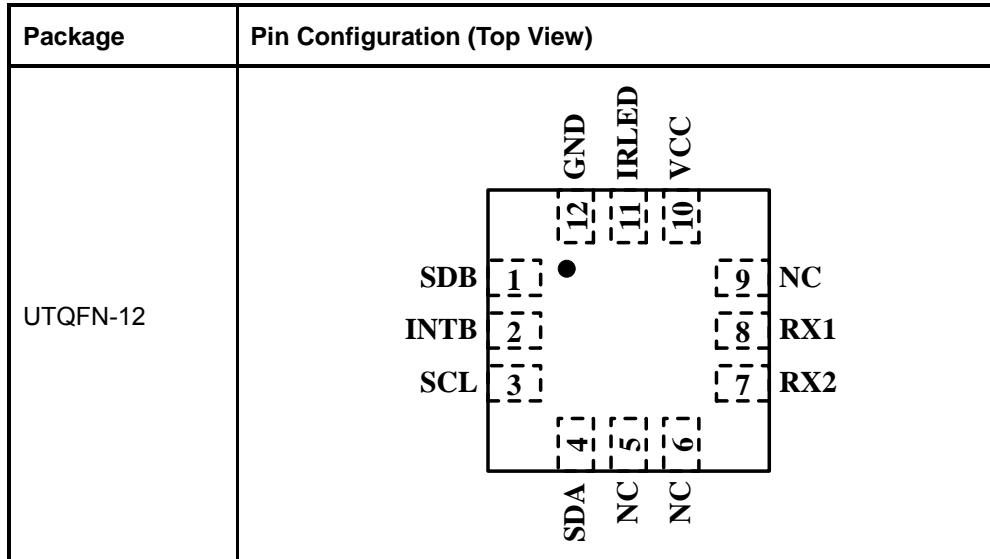
Figure 1 Typical Application Circuit (Motion Mode)



**Figure 2** Typical Application Circuit (Proximity Mode)

# IS31SE5000

## PIN CONFIGURATION



## PIN DESCRIPTION

No.	Pin	Description
1	SDB	Shutdown pin, low active.
2	INTB	Interrupt signal, pulled down to inform master to read data.
3	SCL	The input for the I2C clock signal.
4	SDA	The input for the I2C data signal.
5,6,9	NC	Not connect.
7	RX2	Input signal of channel 2 infrared LED receiver.
8	RX1	Input signal of channel 1 infrared LED receiver.
10	VCC	Power supply.
11	IRLED	IRLED emitting pin. Connect to IRLED.
12	GND	Ground.

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# IS31SE5000

## ORDERING INFORMATION

Industrial Range: -40°C to +85°C

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Order Part No.	Package	QTY/Reel
IS31SE5000-UTLS2-TR	UTQFN-12, Lead-free	3000

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# IS31SE5000

## ABSOLUTE MAXIMUM RATINGS

Supply voltage, $V_{CC}$	-0.3V ~ +6.0V
Voltage at any input pin	-0.3V ~ $V_{CC}+0.3V$
Maximum junction temperature, $T_{JMAX}$	150°C
Operating temperature range, $T_A$	-40°C ~ +85°C
Storage temperature range, $T_{STG}$	-65°C ~ +150°C

### Note:

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 condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

$T_A = 25^\circ\text{C}$ ,  $V_{CC} = 2.7V \sim 5.5V$ , unless otherwise noted. Typical value are  $T_A = +25^\circ\text{C}$ ,  $V_{CC} = 3.6V$ .

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
$V_{CC}$	Supply voltage		2.7		5.5	V
$I_{CC}$	Quiescent current	$V_{SDB} = V_{CC}$		0.6		mA
$I_{SD}$	Shutdown current	$V_{SDB} = 0V$		1	3	$\mu\text{A}$
$I_{IR}$	Average current of IRLED	$V_{LED} = 3.6V$ (Note 1)		0.8		mA
$I_P$	Peak current of IRLED	EC = “000” (Note 1,2)		400		mA
$V_{INT}$	INTB pin output voltage low	$I_{OL} = 4\text{mA}$			0.2	V
L	Maximum detect distance	EC = “000” (Note 3)		9		cm
$V_{IH}$	Input logic high voltage	$V_{CC} = 2.7V$			0.4	V
$V_{IL}$	Input logic low voltage	$V_{CC} = 5.5V$	1.4			V

## DIGITAL INPUT SWITCHING CHARACTERISTICS (Note 1)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
$f_{SCL}$	Serial-Clock frequency				400	kHz
$t_{BUF}$	Bus free time between a STOP and a START condition		1.3			$\mu\text{s}$
$t_{HD, STA}$	Hold time (repeated) START condition		0.6			$\mu\text{s}$
$t_{SU, STA}$	Repeated START condition setup time		0.6			$\mu\text{s}$
$t_{SU, STO}$	STOP condition setup time		0.6			$\mu\text{s}$
$t_{HD, DAT}$	Data hold time				0.9	$\mu\text{s}$
$t_{SU, DAT}$	Data setup time		100			ns
$t_{LOW}$	SCL clock low period		1.3			$\mu\text{s}$
$t_{HIGH}$	SCL clock high period		0.7			$\mu\text{s}$
$t_R$	Rise time of both SDA and SCL signals, receiving	(Note 4)		20+0.1Cb	300	ns
$t_F$	Fall time of both SDA and SCL signals, receiving	(Note 4)		20+0.1Cb	300	ns

**Note 1:** Guaranteed by design.

**Note 2:** The EC bit is used to set the emitting current. Please refer to the detailed information in Page 8.

**Note 3:** Because of different IRLED, receive LED and material of cover, the detection distance will be different. The detail parameter should be tested. IR11-21C/TR8 (for IRLED) and PD15-22C-R/TR8 (for PD) is recommended.

**Note 4:** Cb = total capacitance of one bus line in pF.  $I_{SINK} \leq 6\text{mA}$ .  $t_R$  and  $t_F$  measured between  $0.3 \times V_{CC}$  and  $0.7 \times V_{CC}$ .

# IS31SE5000

## DETAILED DESCRIPTION

### I2C INTERFACE

The IS31SE5000 uses a serial bus, which conforms to the I2C protocol, to control the chip's functions with two wires: SCL and SDA. The IS31SE5000 has a 7-bit slave address (A7:A1), followed by the R/W bit, A0. Set A0 to "0" for a write command and set A0 to "1" for a read command.

The complete slave address is:

**Table 1 Slave Address (Write only):**

Bit	A7:A1	A0
Value	1010101	1/0

The SCL line is uni-directional. The SDA line is bi-directional (open-collector) with a pull-up resistor (typically 4.7kΩ). The maximum clock frequency specified by the I2C standard is 400kHz. In this discussion, the master is the microcontroller and the slave is the IS31SE5000.

The timing diagram for the I2C is shown in Figure 3. The SDA is latched in on the stable high level of the SCL. When there is no interface activity, the SDA line should be held high.

The "START" signal is generated by lowering the SDA signal while the SCL signal is high. The start signal will alert all devices attached to the I2C bus to check the incoming address against their own chip address.

The 8-bit chip address is sent next, most significant bit first. Each address bit must be stable while the SCL level is high.

After the last bit of the chip address is sent, the master checks for the IS31SE5000's acknowledge. The master releases the SDA line high (through a pull-up resistor). Then the master sends an SCL pulse. If the IS31SE5000 has received the address correctly, then it holds the SDA line low during the SCL pulse. If the SDA line is not low, then the master should send a "STOP" signal (discussed later) and abort the transfer.

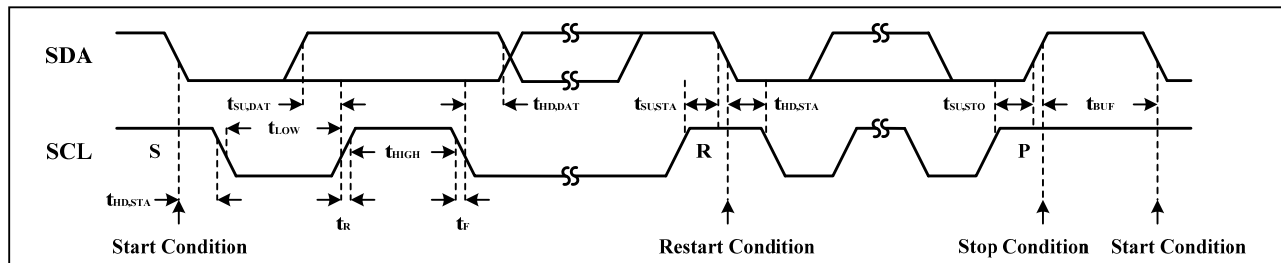
Following acknowledge of IS31SE5000, the register address byte is sent, most significant bit first. IS31SE5000 must generate another acknowledge indicating that the register address has been received.

Then 8-bit of data byte are sent next, most significant bit first. Each data bit should be valid while the SCL level is stable high. After the data byte is sent, the IS31SE5000 must generate another acknowledge to indicate that the data was received.

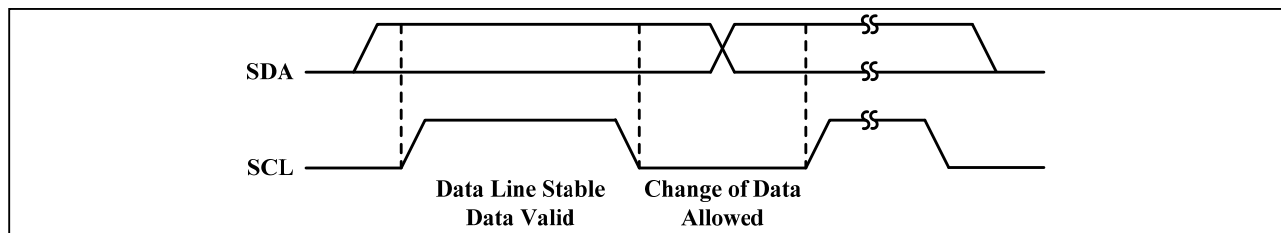
The "STOP" signal ends the transfer. To signal "STOP", the SDA signal goes high while the SCL signal is high.

### READING PORT REGISTERS

To read the device data, the bus master must first send the IS31SE5000 address with the R/ $\bar{W}$  bit set to "0", followed by the command byte, which determines which register is accessed. After a restart, the bus master must then send the IS31SE5000 address with the R/ $\bar{W}$  bit set to "1". Data from the register defined by the command byte is then sent from the IS31SE5000 to the master (Figure 6).

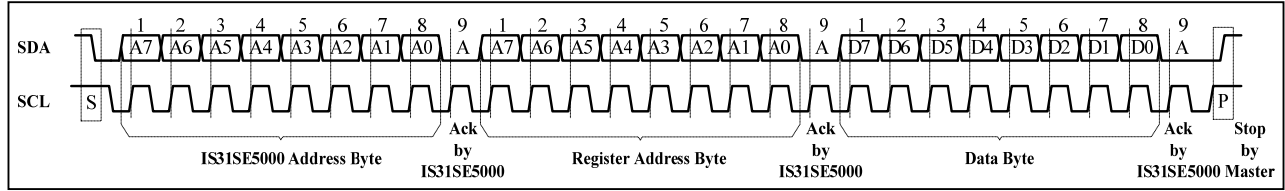


**Figure 3** Interface timing

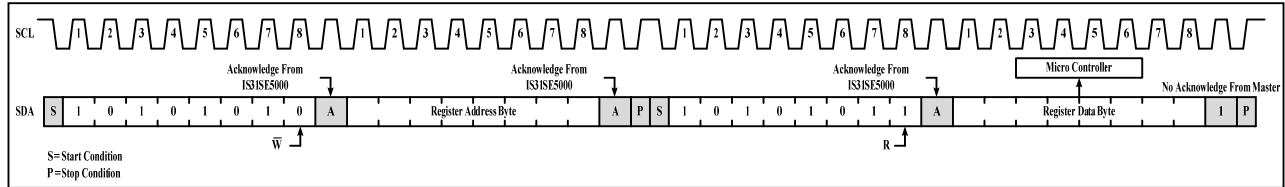


**Figure 4** Bit transfer

# IS31SE5000



**Figure 5** Writing to IS31SE5000



**Figure 6** Reading from IS31SE5000

# IS31SE5000

## REGISTERS DEFINITIONS

**Table 2 Register Function**

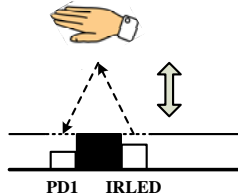
Address	Name	Function	R/W	Table	Default
00h	Status Register	Store the motion information	R	3	xxxx xxxx
01h	Shutdown Register	Set software shutdown	W	4	0000 0000
11h	Configuration Register	Configure operating function	W	5	

**Table 3 00h Status Register (Read Only)**

Bit	D7:D4	D3:D2	D1:D0
Name	-	PD	MD
Default	-		

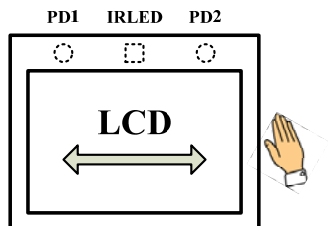
The Status Register stores the motion information which detected by IS31SE5000.

- PD** Proximity Detection (Figure 7)
- 01 Be off
  - 10 Be close
  - Others No motion



**Figure 7** Proximity Mode Detect (Side View)

- MD** Motion Detection (Figure 8)
- 01 From PD2 to PD1
  - 10 From PD1 to PD2
  - Others No motion



**Figure 8** Motion Mode Detect (Top View)

**Table 4 01h Shutdown Register**

Bit	D7:D1	D0
Name	-	SSD
Default	0000000	0

The Shutdown Register sets software shutdown mode of IS31SE5000.

- SSD** Software Shutdown Enable
- 0 Software shutdown mode
  - 1 Normal operation

**Table 5 11h Configuration Register**

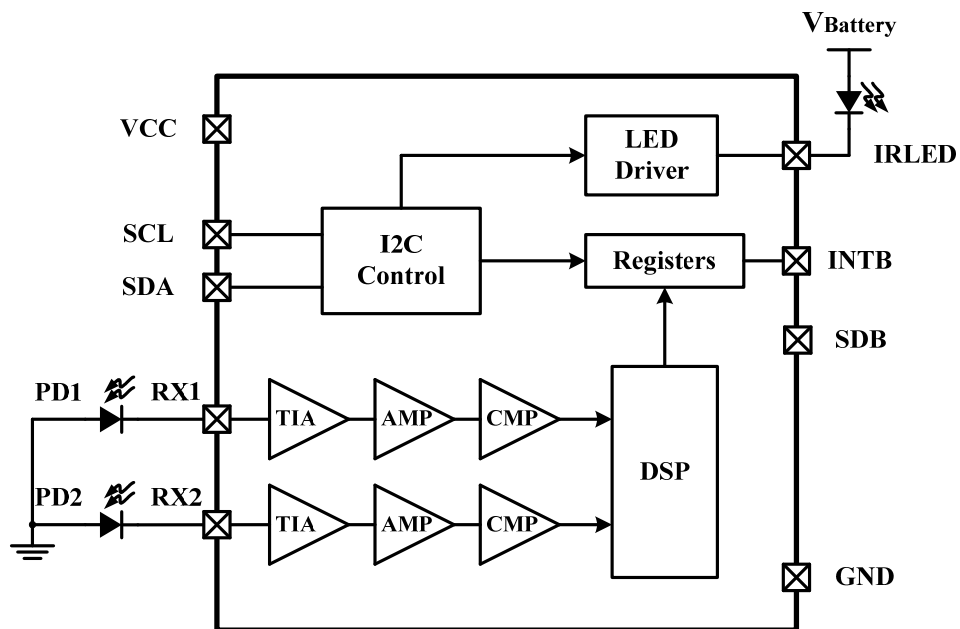
Bit	D7:D4	D3:D1	D0
Name	-	EC	MODE
Default	0000	000	0

The Configuration Register sets the operating function.

- EC** Emitting Current Setting  
(Adjusting detection distance, refer to detail information in Page 10)
- 000 400mA
  - 001 280mA
  - 01x 210mA
  - 1xx 70mA
- MODE** Mode Selection
- 0 Motion mode
  - 1 Proximity mode



## FUNCTIONAL BLOCK DIAGRAM



# IS31SE5000

## APPLICATION INFORMATION

### GENERAL DESCRIPTION

The IS31SE5000 is a low-power, reflectance-based infrared light sensor with advanced signal processing and digital output. The sensor can detect making touchless motion possible.

### MODE CONTROL

By setting the MODE bit of Configuration Register (11h) IS31SE5000 operates in Motion Mode or Proximity Mode.

When setting the MODE bit to “0”, IS31SE5000 operates in the Motion Mode. When the MODE bit is set to “1”, IS31SE5000 operates in the Proximity Mode.

### STATUS INFORMATION

Master can get the current motion information by reading the PD, MD bits of Status Register (00h).

### MOTION MODE

The MD bit is available when IS31SE5000 operates in the Motion Mode. If the MD bit is “01”, it means the current motion is from PD2 to PD1. If the MD bit is “10”, it means the current motion is from PD1 to PD2 (Table 3). If MD bit is other data, there is no motion.

### PROXIMITY MODE

The PD bit is available when IS31SE5000 operates in the Proximity Mode. If the PD bit is “01”, it means the object is away from the IC. If the PD bit is “10”, it means the object is close to the IC (Table 3). If PD bit is other data, there is no motion.

### INTERRUPTION

The changing of motion can be signed by the INTB pin. The INTB pin will be pulled low when object moving before the LCD panel (PD or MD bit changing). And the MCU can get the information via reading the Status Register (00h). The INTB will be back to high until the MCU reading the Status Register (00h). The INTB pin will be high automatically when it stays low last 10ms to ensure system operating normally.

### DETECTION DISTANCE

The emitting current can be adjusted by the EC bit of Configuration Register (11h). The larger current is, the longer distance detected.

Because of the different IRLED, receiver and material of cover, the detection distance will be different for the same emitting current. Detail information should be decided by testing.

In the stable mode, the average emitting current for both two modes,  $I_{IR}$ , can be calculated by the Equation (1):

$$I_{IR} = \frac{1}{512} \times I_{EC} \quad (1)$$

In the operating mode, the average emitting current for the Proximity Mode is the same as stable mode. And the average emitting current for the Motion Mode can be calculated by the Equation (2):

$$I_{IR} = \frac{1}{8} \times I_{EC} \quad (2)$$

The  $I_{EC}$  is the emitting current which setting by the EC bit.

### SHUTDOWN MODE

Shutdown mode can be used as a means of reducing power consumption. During shutdown mode all registers retain their data.

### SOFTWARE SHUTDOWN

By setting SSD bit of the Shutdown Register (01h) to “0”, the IS31SE5000 will operate in software shutdown mode.

### HARDWARE SHUTDOWN

The chip enters hardware shutdown mode when the SDB pin is pulled low, wherein they consume only 1 $\mu$ A (Typ.) current.

# IS31SE5000

## CLASSIFICATION REFLOW PROFILES

Profile Feature	Pb-Free Assembly
<b>Preheat &amp; Soak</b> Temperature min (T <sub>smin</sub> ) Temperature max (T <sub>smax</sub> ) Time (T <sub>smin</sub> to T <sub>smax</sub> ) (t <sub>s</sub> )	150°C 200°C 60-120 seconds
Average ramp-up rate (T <sub>smax</sub> to T <sub>p</sub> )	3°C/second max.
Liquidous temperature (T <sub>L</sub> ) Time at liquidous (t <sub>L</sub> )	217°C 60-150 seconds
Peak package body temperature (T <sub>p</sub> )*	Max 260°C
Time (t <sub>p</sub> )** within 5°C of the specified classification temperature (T <sub>c</sub> )	Max 30 seconds
Average ramp-down rate (T <sub>p</sub> to T <sub>smax</sub> )	6°C/second max.
Time 25°C to peak temperature	8 minutes max.

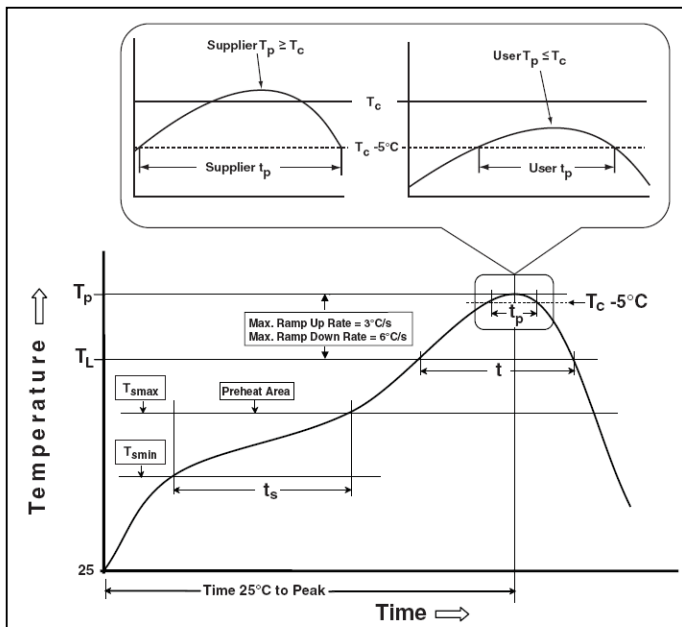
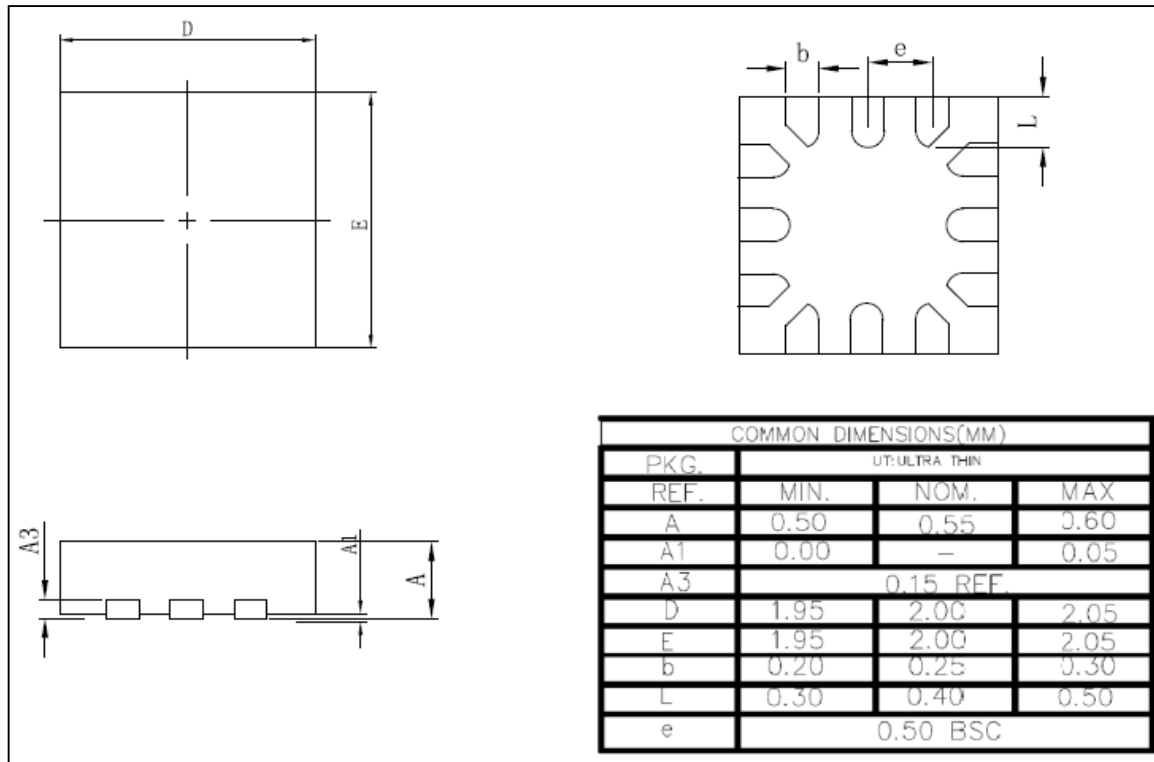


Figure 9 Classification Profile

# IS31SE5000

## PACKAGE INFORMATION

### UTQFN-12



**Note:** All dimensions in millimeters unless otherwise stated.

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