AmbiMate Sensor Module

NOTE
All numerical values are in metric units [with U.S. customary units in brackets]. Dimensions are in millimeters [and inches]. Unless otherwise specified, dimensions have a tolerance of ±0.13 [±.005] and angles have a tolerance of ±2°. Figures and illustrations are for identification only and are not drawn to scale.

1 INTRODUCTION

1.1 Applications

The AmbiMate Sensor Module (ASM) is suitable for sensing the characteristics of indoor environments, and utilizes a cluster of common sensors to report current conditions. The ASM measures temperature, humidity, ambient light, motion, and optionally sound and/or VOC/CO_2. The ASM reports data via an I2C bus to a customer supplied host PCB Assembly. The variety of sensors and small package size make the ASM suitable for multiple indoor applications:

- Indoor Lighting
- Thermostat and HVAC inputs
- Building Automation networks

1.2 Solution Overview

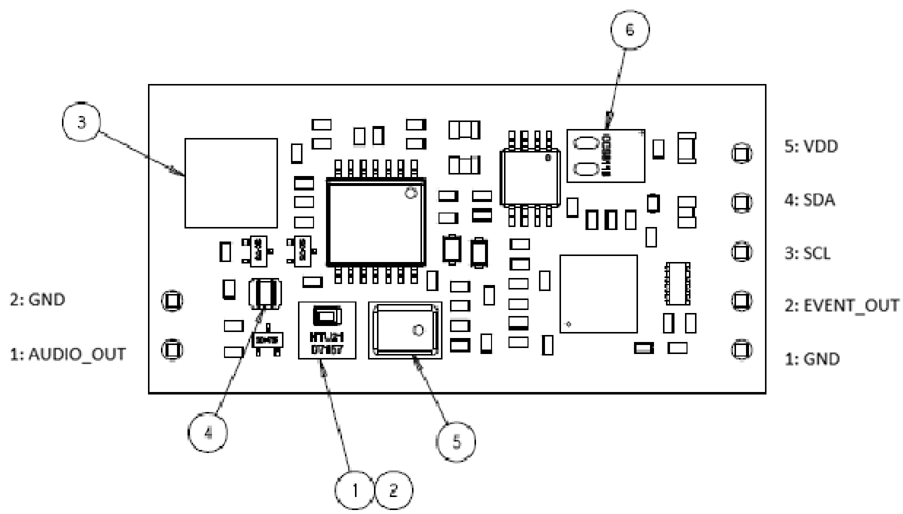


Figure 1: AmbiMate Layout
1: Temperature, 2: Humidity, 3: Motion, 4: Light, 5: Audio, 6: eCO_2/VOC

Figure 1 shows the defined sensor locations for the ASM. This diagram and the terminology in Table 1 are used throughout this document to describe functionality, capabilities and design practice.

1.3 Customer Assistance

Reference Product Base Part Number 2316851, 2316852, 2314277, and 2314291. Use of these numbers will identify the product line and help you to obtain product and tooling information when visiting www.te.com or calling the number at the bottom of this page.

1.4 Drawings

Customer drawings for product part numbers are available from www.te.com. Information contained in the customer drawing takes priority.

1.5 Specifications

Product Specification 108-133092 provides product performance and test results.

Application Specification 114-133115 provides information regarding application software.

2 REQUIREMENTS

2.1 Safety

Perform all electrical connections to the ASM with power turned OFF.

2.2 Limitations

The ASM is designed to operate in a temperature range of -5° to 50°C [23° to 122°F].

2.3 Material

This is a PCB assembly made from FR4 material.

2.4 Storage

2.4.1 Ultraviolet Light

Prolonged exposure to ultraviolet light may deteriorate the chemical composition used in the product material.

2.4.2 Shelf Life

The product should remain in the shipping containers until ready for use to prevent deformation to components. The product should be used on a first in, first out basis to avoid storage contamination that could adversely affect performance.

2.4.3 Chemical Exposure

Do not store product near any chemical listed below as they may cause stress corrosion cracking in the material.

Alkaline	Ammonia	Citrates	Phosphates Citrates	Sulfur Compounds
Amines	Carbonates	Nitrites	Sulfur Nitrites	Tartrates

2.5 Handling

The ASM is a PCB Assembly, and should be handled with care to avoid ESD

ATTENTION
— Observe precautions for handling electrostatic sensitive devices.

2.6 Cleaning

CAUTION
— Do not wash the product with aqueous or solvent based cleaners. Do not blow the product off with compressed air pressure greater than 20 psi.

3 ELECTRONIC DESIGN GUIDANCE

3.1 Electrical Design Guidance

Term/Acronym	Meaning
ASM	AmbiMate Sensor Module
ACK	Acknowledgement
ADC	Analog to Digital Converter
Baud	Pulses per second
CO_2	Carbon Dioxide
DAC	Digital to Analog Converter
I2C	Inter-Integrated Circuit bus protocol. Multi-master, multi-slave, single-ended, serial computer bus
NACK	Negative Acknowledgement
PCBA	Printed Circuit Board Assembly. A PCBA comprises a printed circuit board (PCB) and all the installed components to create a functional assembly.
PIR	Passive Infrared
SCL / SDA	Serial Clock / Serial Data
S/N	Signal to Noise Ratio
VOC	Volatile Organic Compound

Table 1. Terminology

3.2 Functional Element Overview

Figure 2 shows a block diagram of the functional blocks of the ASM printed circuit board assembly. The following sections overview the capability of each block. More detailed description, where applicable, can be found in the architecture and sensors sections.

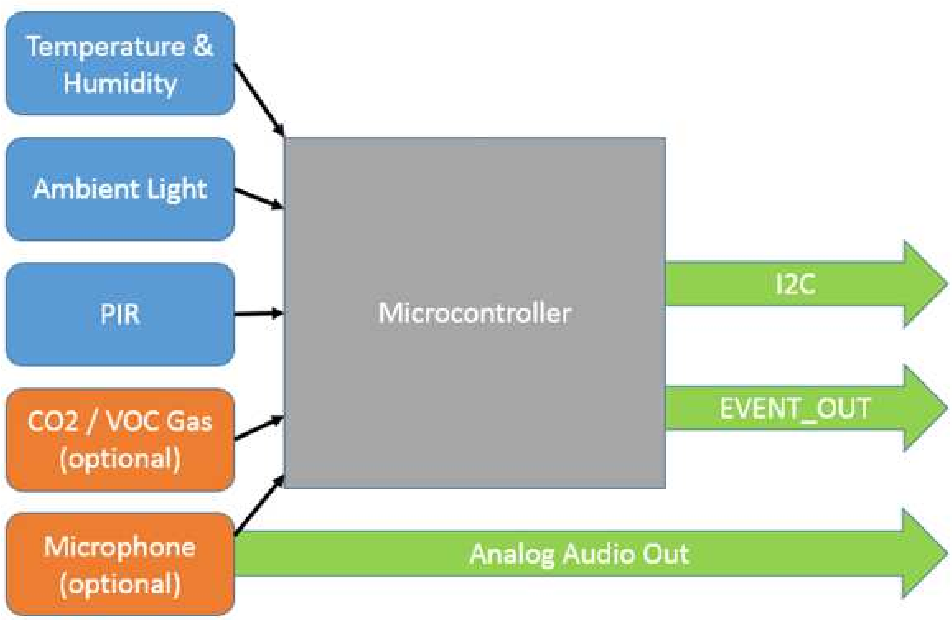


Figure 2. ASM Functional Block Diagram

3.3 Power Supply

The ASM is powered by the 3.3 ± 0.2 V dc rail required for I2C communication. This voltage is to be provided by the host board, whether that is a battery or other regulated supply.

3.4 Sensors

3.4.1 Temperature Sensor: The temperature sensor is combined with the relative humidity sensor in the same package. The sensor's I2C output is read by the ASM's microcontroller. The characteristics of the temperature sensor are summarized in the table below:

Characteristics		Symbol	Min	Typ	Max	Unit
Resolution	14 bit			0.01		°C
	12 bit			0.04		°C
Temperature Operating Range		T	-40		+125	°C
Temperature Accuracy @25°C	typ			±0.3		°C
	max		See graph 2			°C
Replacement			fully interchangeable			
Measuring time (1)	14 bit			44	50	ms
	13 bit			22	25	ms
	12 bit			11	13	ms
	11 bit			6	7	ms
PSSR					±25	LSB
Long term drift				0.04		°C/yr
Response Time (at 63% of signal) from 15°C to 45°C (2)		τ_T		10		s

(1) Typical values are recommended for calculating energy consumption while maximum values shall be applied for calculating waiting times in communication.
(2) At 1m/s air flow

Note: Actual performance may vary due to customer enclosure design. Enclosure should allow for air circulation to ensure sensor is responding to temperature changes within the intended environment of use.

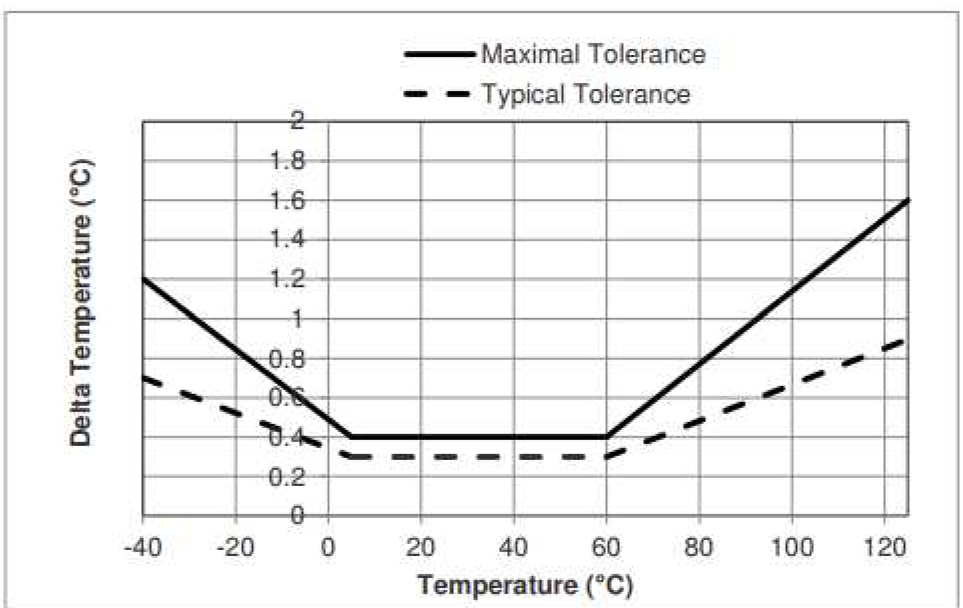


Figure 3, Temperature Sensor Tolerance vs Temperature Plot

3.4.2 Relative Humidity Sensor: The relative humidity sensor is combined with the temperature sensor in the same package. The sensor's I2C output is read by the ASM's microcontroller. The characteristics of the relative humidity sensor are summarized in the table below:

Characteristics		Symbol	Min	Typ	Max	Unit
Resolution	12 bits			0.04		%RH
	8 bits			0.7		%RH
Humidity Operating Range		RH	0		100	%RH
Relative Humidity Accuracy @25°C (20%RH to 80%RH)	typ			±2		%RH
	max		See graph 1			%RH
Replacement		fully interchangeable				
Temperature coefficient (from 0°C to 80°C)		T_{cc}			-0.15	%RH/°C
Humidity Hysteresis				±1		%RH
Measuring Time [1]	12 bits			14	16	ms
	11 bits			7	8	ms
	10 bits			4	5	ms
	8 bits			2	3	ms
PSRR					±10	LSB
Recovery time after 150 hours of condensation		t		10		s
Long term drift				0.5		%RH/yr
Response Time (at 63% of signal) from 33 to 75%RH [2]		τ_{RH}		5	10	s

Note: Actual performance may vary due to customer enclosure design. Enclosure should allow for air circulation to ensure sensor is responding to humidity changes within the intended environment of use.

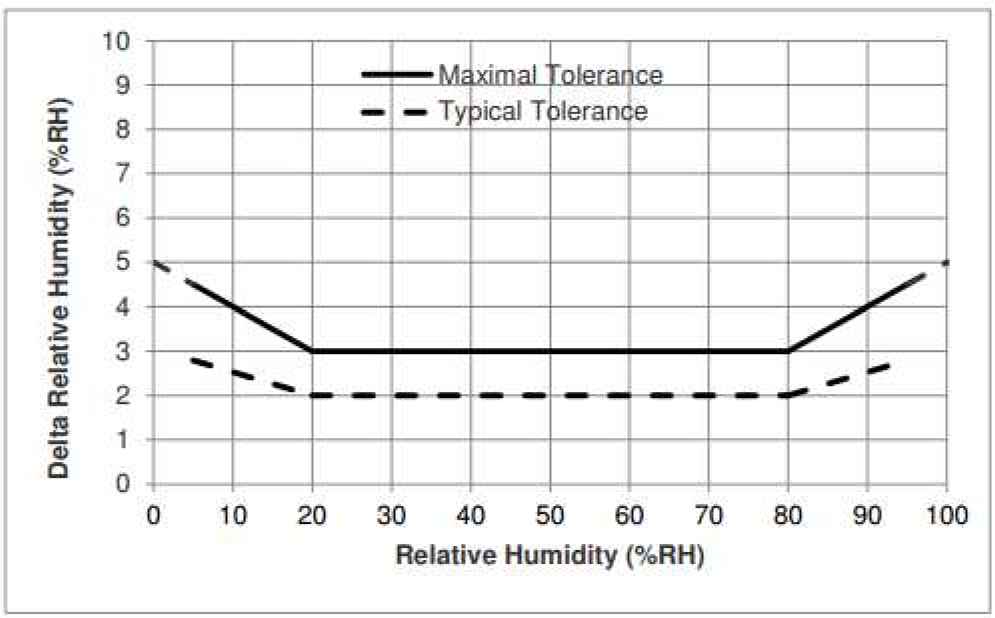


Figure 4, RH Sensor Tolerance vs RH Plot

3.4.3 Ambient Light Photo Sensor: The photo sensor mimics the responsivity of the human eye. The analog output from the sensor is read by the ASM's microcontroller's analog to digital converter. The characteristics of the photo sensor are summarized in the table below:

Operating Conditions: 25°C, Light source = fluorescent or white LED

Parameter	Symbol	Specification or Condition		SPECIFICATION		
			Units	Min	Typ.	Max
Spectral response[1]		Lux = 100	nm	500	560	650
Rise Time	Tr	0 to 100 Lux Transition	mS	-	5	-
Fall Time	Tf	100 to 0 Lux Transition	mS	-	5	-
Digital Output		Lux = 0	Hex out		0000	
Digital Output		Lux = 1023	Hex out		03FF	
Accuracy (linearity, repeatability, hysteresis)		BFSL	% FSO		3%	

Note (1) Ambient light impinges directly on the sensor, no light pipe. If in the final application the photo sensor becomes shadowed, then a light pipe will be required to achieve optimum performance. The light pipe design is dependent upon the final application and use and is beyond the scope of this application specification.

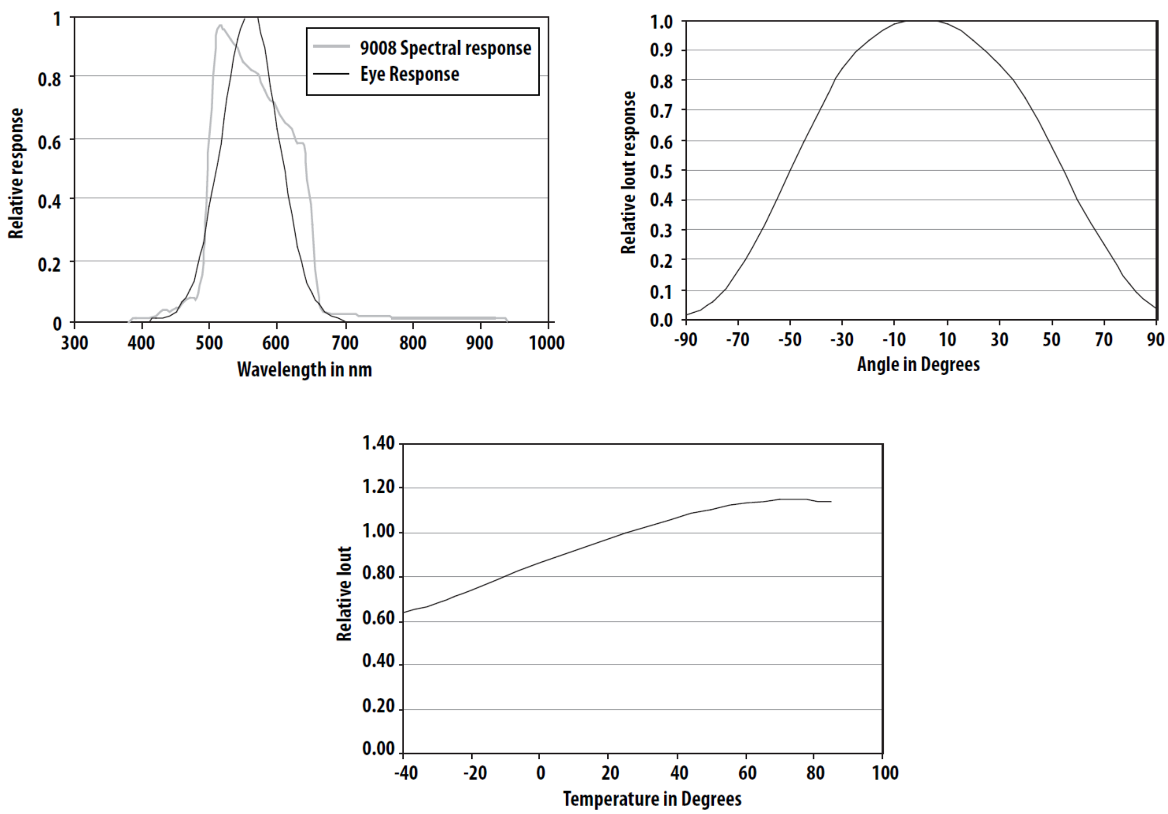


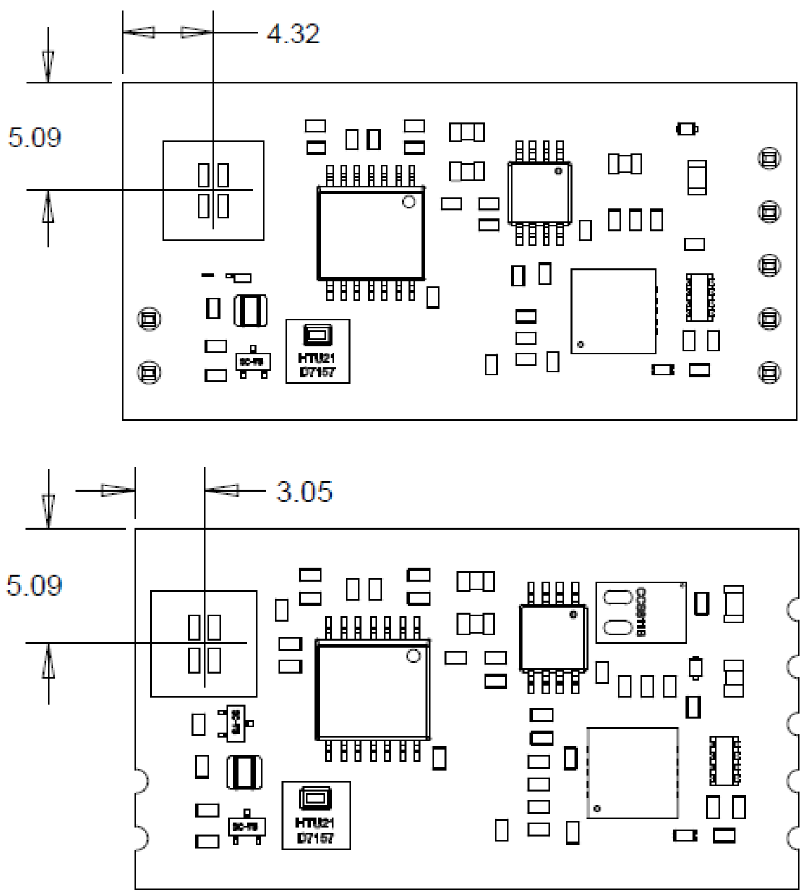
Figure 5, Ambient Light Sensor Response Curves

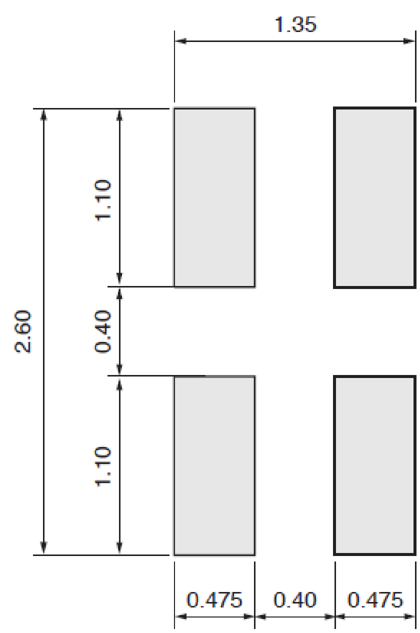
3.4.4 Passive Infrared Motion Sensor (PIR): The PIR senses motion. The output from the sensor is read by the ASM's microcontroller. During design-in and mounting the ASM consideration should be given for placement of the device on a ceiling, wall or in a corner to maximize the PIR sensors effectiveness. A Fresnel lens is required. The design of the Fresnel lens is beyond the scope of this application specification. Related to the PIR sensor is the motion event LED. When the ASM senses motion the motion event LED will illuminate and stay illuminated until the status register is read. The characteristics of the PIR sensor are summarized in the table below:

Operating Conditions: 25°C, Thermal Source = Standard Black Body

Parameter	Specification or Condition	SPECIFICATION		
		Min	Typ.	Max
IR Spectral Response	High Pass Threshold, No Lens	-	3	-
Unlatched Output	Status Register, Bit 0	"0" = no motion, "1" = motion		
Latched Output	Status Register, Bit 2, Bit 7	"0" = no motion, "1" = motion		
Field of View X Direction		-	70°	-
Field of View Y Direction		-	50°	-

Note: Actual performance may vary due to customer enclosure design.





Dimensions of active elements on PIR sensor.

Figure 6, Typical PIR sensor physical locations (additional detail available on TE product drawings).

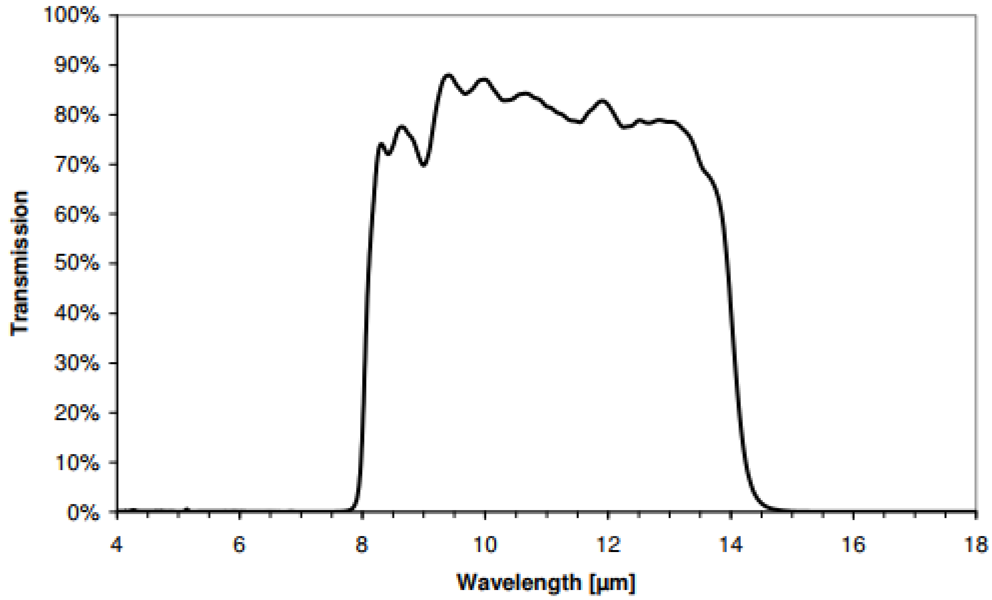


Figure 7, PIR Transmission vs Wavelength

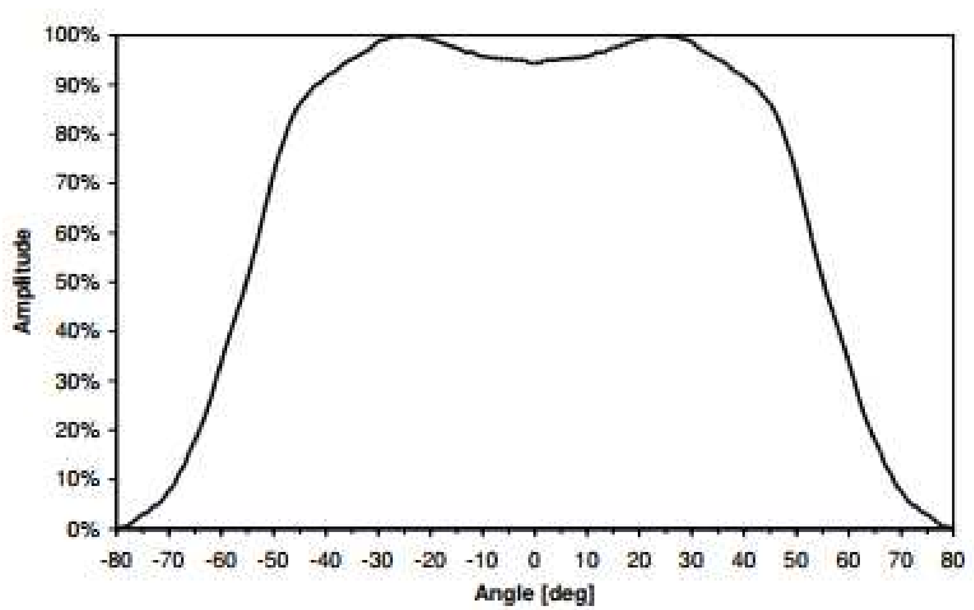


Figure 8, PIR Amplitude vs Angle Curve

3.4.5 Acoustic Microphone with Pre-Amp: The microphone is omnidirectional with an analog output. The analog output from the microphone is read by the ASM's microcontroller's analog to digital converter and is available to the host application via the 2-pin connector. The ASM is configured to identify an audio event that is above a specified preset 80dB level. Note due to quantization of the ADC on the ASM, when the audio event level is set below 75dB, the event will be triggered when the measurement exceeds the next highest discrete value above the trigger level. At audio levels below 75dB, quantization of the ADC will limit reported values to the following: 20, 58, 64, 67, 70, 73, 75. Above 75dB, the ASM will report in 1dB increments. The preset sound level can be adjusted by the host. Refer to section 3.6.5 of this document to review steps to adjust the sound event threshold level. The characteristics of the microphone are summarized in the table below:

Conditions: 23 ±2°C, 55 ±20% R.H.

Parameter	Symbol	Specification		SPECIFICATION		
			Units	Min	Typ.	Max
Sensitivity[1]	S	94 dB SPL @ 1 kHz	dBV/Pa	-25	-22	-19
S/N ratio	SNR	94 dB SPL @ 1 kHz, A-weighted	dB(A)	-	59	-
Total Harmonic Distortion	THD	94dB SPL @ 1 kHz, S=Typ	%	-	-	1
Acoustic Overload Point	AOP	10% THD @ 1 kHz, S=Typ	dB SPL	115	-	-
Directivity[1]	Omnidirectional					

Note (1) Actual performance may vary due to customer enclosure design. Customer enclosure design should be optimized to avoid resonances.

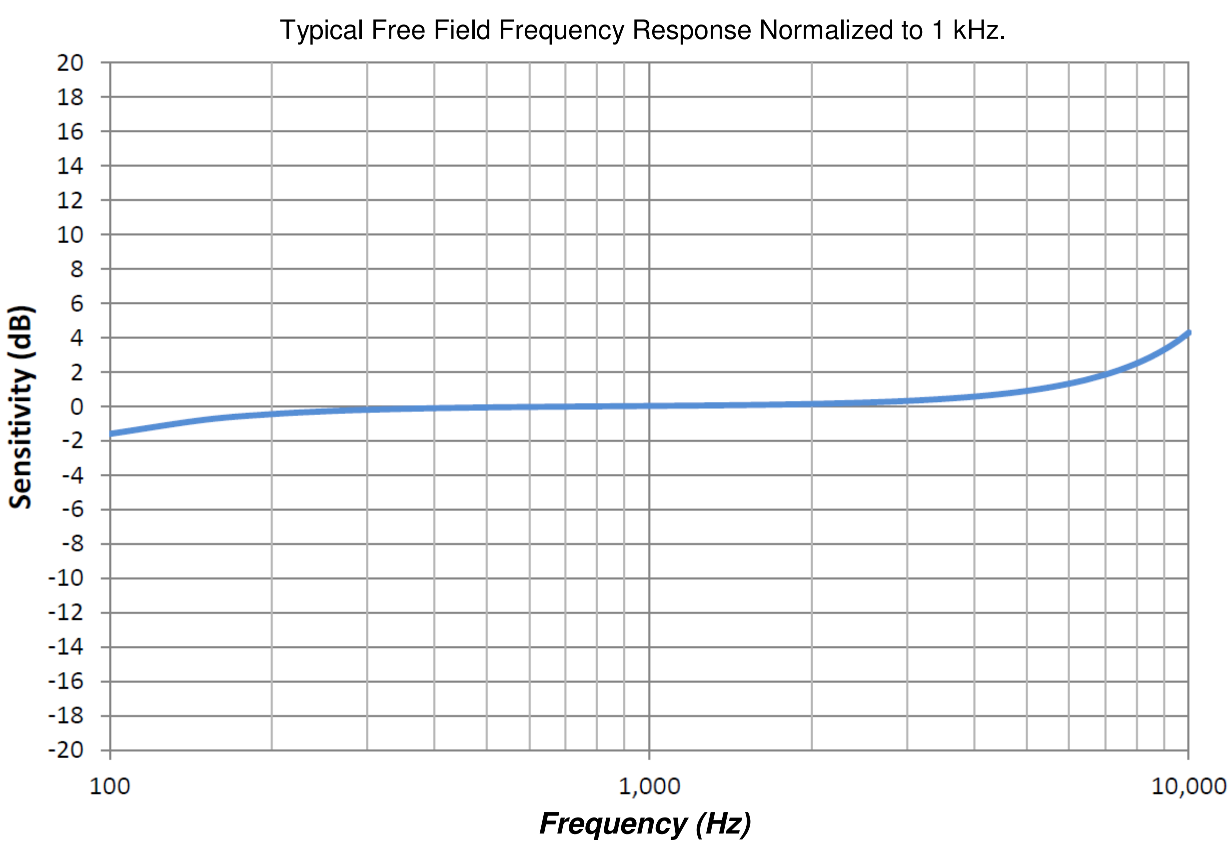


Figure 9, Microphone Sensitivity vs Frequency Curve

3.4.6 Equivalent CO2 / VOC Gas Sensor: The gas sensor measures TVOC or equivalent CO2 with a digital output via an I2C interface. The output from the sensor is read by the ASM's microcontroller. The characteristics of the sensor are summarized in the table below

Operating Conditions: 25°C

Parameter	Specification or Condition		SPECIFICATION		
		Units	**Min**	**Typ.**	**Max**
Operating Temperature Range	Operating temperature limits to remain within spec	°C	-5	-	50
Operating Humidity Range	Operating temperature limits to remain within spec	%RH	5	-	95
VOC measurement range	Measurement range for TVOC (Total Volatile Organic Compounds)	ppb	0	-	1187
CO2 measurement range (note 1)	Measurement range for eCO2 (Equivalent CO2)	ppm	400	-	8192
Sample Interval	Time between sample measurements	seconds	-	60	-

Notes:

- *CO2 concentration is inferred from VOC measurement and assumes VOC sources are primarily human bodies.*
- *The equivalent CO2 output range is from 400ppm to 8192ppm. Values outside this range are clipped.*
- *The Total Volatile Organic Compound (TVOC) output range is from 0ppb to 1187ppb, Values outside this range are clipped.*
- *Early life use (burn-in): The gas sensor performance and sensitivity will change during early life use. It is recommended to run the sensor for approximately 48 hours initially to ensure stable sensor performance.*

3.5 Signal Information

Table 2 and 3 provide the pin numbers, signal names and descriptions of the Customer Accessible pins on the ASM. “I” designates input pins and “O” designates output pins.

Pin	Signal	I/O	Description
1	GND	I/O	Common Connection
2	EVENT_OUT	O	Motion or Sound Level detected in environment
3	SCL	O	Clock signal for I2C bus
4	SDA	O	Data signal for I2C bus
5	Vdd	I	3.3VDC Input

Table 2. 5 Pin Header I2C Signals

Pin	Signal	I/O	Description
1	Audio Output	O	Analog Audio Output Signal
2	GND	O	Common connection

Table 3. 2 Pin Header Audio Signals

3.6 I2C considerations

The host I2C interface is addressable on address: 0x2A. The maximum practical baud rate is 100kBaud. Please make sure the host device using is capable of clock stretching, otherwise a lower baud rate is recommended.[1] The host interface will ensure I2C communication via Pin 3 (SCL) and Pin 4 (SDA), please be aware of considering a 3.3 V I2C communication.

There is an on-board I2C communication between the Humidity/Temperature sensor and the remaining sensor are connected via analog inputs on the microcontroller. Data will be delivered as raw data, therefore scaling and conversion is left to the host.

3.6.1 Module Registers (Read and write via I2C)

Sensor data is available in two register sets. Full resolution data consists of two registers (two bytes) for each sensor.
Table 4 shows the register address and data value for these registers. Temperature, Humidity, PIR, and Light are available on all modules. Audio and CO_2 are optional and only fitted to some modules but registers are always available but will read maximum (0xFF, 0xFF) if the sensor is not fitted. The input is pulled up to 3.3 volts when a sensor is not fitted. During initialization, the ASM ADC initially uses a 3.3 V reference to measure the optional sensors. If an optional register reads greater than 0x80, equivalent to 1.65 volts, the ASM firmware determines that the sensor is not installed and not scan that sensor and will report it missing in the status byte.
The host computer can read all registers or can stop at any time with an I2C NACK and Stop. For example, if the host knows that Audio and Gas sensors are not installed, and if the host is not concerned with the Battery voltage, it can read the status byte, temperature, humidity and light value and send a NACK on the Light Low Byte followed by an I2C stop to minimize the communication time.

Register Address	Data Value
0x00	Status High Byte
0x01	Temperature High Byte
0x02	Temperature Low Byte
0x03	Humidity High Byte
0x04	Humidity Low Byte
0x05	Light High Byte

[1] For more information about host-devices and application software, please check 114-133115.

0x06	Light Low Byte
0x07	Audio High Byte
0x08	Audio Low Byte
0x09	Battery Volts High Byte
0x0A	Battery Volts Low Byte
0x0B	CO2 High Byte
0x0C	CO2 CO Low Byte
0x0D	VOC High Byte
0x0E	VOC Low Byte

Table 4. Sensor data registers.

In some cases, 8-bit resolution is adequate as shown in Table 5. A second set of registers is available with the high bytes in sequence to allow the host to read them with a single transaction.

Register Address	Data Value
0x40	Status High Byte
0x41	Temperature High Byte
0x42	Humidity High Byte
0x43	Light High Byte
0x44	Audio High Byte
0x45	Battery Volts High Byte
0x46	CO2 CO High Byte
0x47	VOC High Byte

Table 5. 8-bit Sensor data registers.

Other registers shown in Table 6.

Register Address	Data Value
0x80	Firmware version
0x81	Firmware sub-version
0X82	Optional Sensors

Table 6. Other registers.

Writeable registers are shown in Table 7.

Register Address	Data Value	Read/Write
0xC0	Scan Start Byte	W
0xC1	Audio Event Level	R/W
0xF0	0xA5 initiates a processor reset All other values ignored	

Table 7. Writeable registers.

3.6.2 Status Byte

The status byte contains bit encoded information on the state of the module and on the specific configuration of the module.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
PIR_EVENT	Reserved	Reserved	Reserved	Reserved	EVENT	Audio	PIR

Bit 0 PIR indicates motion near the ASM when the bit is 1. This bit is not latched.
Bit 1 Audio indicates a sound loud enough to trigger the internal detector when the bit is 1.
Bit 2 EVENT indicates that an event has occurred. This signal is also available as a discrete output at pin 4 of the ASM connector. This bit is latched until the STATUS byte is read by the host.
Bits 3 – 6 are reserved for other possible event or status data.

Bit 7 PIR_EVENT indicates the EVENT (bit2) was generated by a PIR (motion) event. This bit is latched until the STATUS byte is read by the host.

3.6.3 Optional Sensors Byte

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	MIC	Reserved	CO2

Bit 0 CO2 indicates that an optional CO2 sensor is installed on the ASM module when the bit is 1
Bit 2 MIC indicates that an optional Microphone audio sensor is installed when the bit is 1
Note that CO and CO2 are mutually exclusive. Only one can be fitted on any module.

3.6.4 Writeable Registers

Scan Start Byte

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	GAS	BATT	AUD	LIGHT	HUM	TEMP	PIR

Bit 0 PIR, when set, initiates a measurement of the PIR motion sensor.
Bit 1 TEMP, when set, initiates a measurement of the TEMPERATURE sensor.
Bit 2 HUM, when set, initiates a measurement of the HUMIDITY sensor.
Bit 3 LIGHT, when set, initiates a measurement of the LIGHT sensor.
Bit 4 AUD, when set, initiates a measurement of the AUDIO sensor if installed.
Bit 5 BATT, when set, initiates a measurement of the BATTERY voltage.
Bit 6 GAS, when set, initiates a measurement of the CO2 sensor if installed.
Writing to this register initiates a one-time update of the internal measurements for each bit that is set. To update all internal measurements, write 0xFF to this register.

Note that writing to this register does not initiate communication of the updated values to the host. To update and read all data registers first write 0xFF to this register then read all data registers as described above and in the I2C communication section.

It is also possible to update one or more internal measurements by writing a single bit or multiple bits to this register. For example, if an EVENT occurs (the EVENT line goes high), it may be desirable to update and read the PIR motion sensor on a repeated basis to determine when the motion ends. Write 0x01 to this register, then read the STATUS byte (address 0x00) and repeat if needed.
Scanning all channels requires about 70 milliseconds. It is best to wait at least that time before reading the data to be sure to get the most recent data.
This register is clear when the measurement is complete. It is possible to poll this register to determine when it is OK to read the new values.

3.6.5 Audio Event Level

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

The host can read or write this register. The level is in the same units as the audio. When the audio value exceeds the value in this register an EVENT is initiated. The EVENT and AUDIO bits of the status register are set and the discrete output at pin 4 of the MSM connector is raised. Maximum accepted value for this register is 100, effectively never trigger. Minimum accepted value for this register is 1.
For example, if the level is set at 70 and the reported value exceeds 70, the EVENT line is raised and the audio and EVENT bits in the status register will be set.

Reset Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

Writing the value 0xA5 to this register initiates an ASM processor reset, which reinitializes all sensors. Any value other than 0xA5 will be ignored with no effect on the processor.

3.6.6 I2C Communication

This section describes the specific details of I2C communication with the ASM module.
I2C address: 0x2A
I2C baud rate: 100 kBaud (100 kHz clock)
I2C write: indicate with bit 0 = 0
I2C read: indicate with bit 0 = 1

Before reading data registers, the host should assure that data is recent, this can be done by writing a value to the Scan Start register: see paragraph above.
To write to a register, send an I2C start, write the I2C address with the least significant bit clear to indicate a write, the write the register address and then write the new value for that register, followed by an I2C stop.
Write Sequence:

- I2C start
- Write to I2C address
- Write register address
- Write register value
- I2C stop

The table below is an indication of a typical write to the Start Scan register. Note that the first byte, the device I2C address is shifted left one bit so that 0x2A becomes 0x54 for a write. The second byte is the Scan Start Register address, 0xC0.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S	0	1	0	1	0	1	0	0	ACK	1	1	0	0	0	0	0	0	ACK
	I2C address + write									Scan start register (0xC0)								→…

To read a register or sequence of registers, send an I2C start, write to the I2C address listed above with the second byte being the first register address to read. Send an I2C restart, then read to the I2C address and then read the register value. To read multiple registers in sequence, ACK the first read byte and continue reading and ACKing until the last byte which should be NACKed followed by an I2C stop.
Read Sequence:

- I2C start
- Write to I2C address. (0x54 shifted left one bit with bit 0 = 0 to indicate a write)
- Write (first) register address
- I2C restart
- Read to I2C address. (0x54 shifted left one bit with bit 0 = 1 to indicate a read, thus 0x55)
- Read I2C byte with ACK (byte is value in register) Register automatically increments.
- Repeat until last register
- Read last I2C byte with NACK (byte is value in register)
- I2C stop

The table below is an indication of the start of a multi-byte read. First, the transmission is started by a write indication and pointer is set at first address 0x00. After reading address 0x00, other addresses will be read.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S	0	1	0	1	0	1	0	0	ACK	0	0	0	0	0	0	0	0	ACK
	I2C address + write									Write to start at register 0x00								→…

	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
S	0	1	0	1	0	1	0	1	ACK	x	x	x	x	x	x	x	x	ACK
	I2C address + read									Read at address 0x00								→…

3.7 Data Conversion

Data from the ASM Module arrives as a series of bytes due to the inherent characteristics of the I2C bus. The host sends a “SCAN ALL” command to the ASM. Alternately, the host could read individual addresses. In either case the data needs to be reassembled in the host (or PC) code. This discussion and examples assumes a “SCAN ALL” but the same principles apply to scanning individual addresses.

The first byte returned from a “SCAN ALL” command is the content of the status register. Since this register is 8 bits wide, no additional conversion is required.

Temperature from the HTU21 is the second value, communicated as two bytes which need to be assembled into a 16-bit integer, converted to a floating-point value then divided by 10.0 to get 0.1-degree resolution. If desired the temperature can be converted to degrees Fahrenheit. This C code snippet shows the conversion:

```
temperature_val_C = ((double)(read_data[1]*256 + read_data[2])) / 
10.0;
temperature_val_F = 32.0 + ((9.0 / 5.0) * temperature_val_C);
```

Humidity from the HTU21 is the third value, communicated as two bytes which need to be assembled into a 16-bit integer, converted to a floating-point value then divided by 10 to get 0.1 percent resolution. This C code snippet shows the conversion:

```
humidity_val = ((double)(read_data[3]*256 +read_data[4])) / 10.0;
```

Light intensity is the fourth value, communicated as two bytes which need to be assembled into a 16-bit integer. This C code snippet shows the conversion:

```
light_val = (read_data[5]*256 + read_data[6]);
```

Sound intensity is the fifth value, communicated as two bytes which need to be assembled into a 16-bit integer.
The audio ranges from very low (20 in a perfectly quiet environment) to a max of 119. The reported value is the log of the value measured by the microphone so is in dB but may not exactly match an audio meter due to the low sampling rate available from this small processor and the necessary filtering to work at the low sample rate. At audio levels below 75dB, quantization of the ADC will limit reported values to the following: 20, 58, 64, 67, 70, 72, 73, 75. Above 75dB, the ASM will report in 1dB increments.

This C code snippet shows the conversion:

```
audio_dB = (read_data[7]*256 + read_data[8]);                    //
```

Battery Voltage is the sixth value, communicated as two bytes which need to be assembled into a 16-bit integer. This C code snippet shows the conversion:

```
bat_val = ((double)(read_data[9]*256 +read_data[10]) / 1024.0) * 
(3.3 / 0.330);
```

Gas (CO2) PPM is the seventh value, communicated as two bytes which need to be assembled into a 16-bit integer. This C code snippet shows the conversion:

```
gas_val = (read_data[11]*256 +read_data[12]);
```

VOC intensity if the eigth (and last) value, communicated as two bytes which need to be assembled into a 16-bit integer. This C code snippet shows the conversion:

```
voc_val= (read_data[13]*256 +read_data[14]);
```

When communicated from the byte stream is terminated with a Carriage Return (CR read_data[15]) and Line Feed (LF read_data[16]) bytes which can be ignored.

4 PHYSICAL LAYER DESIGN GUIDANCE

4.1 Environmental Sealing

The ASM is a PCB assembly that is not environmentally sealed.

4.2 Mounting Location and Orientation

The ASM can be mounted in any orientation and can be fit into multiple applications. Note that mounting the ASM into any enclosure can alter the performance of the sensors on the ASM. The enclosure design must be optimized to reduce undesired effects to the sensors' accuracy. It is important that the enclosure is designed to promote air circulation across the ASM to improve the accuracy. TE offers options for creating two-piece separable connections and cable assemblies for connection to a remotely mounted ASM. Please contact the TE Product Information Number on the 1st page of this document for further assistance.

4.3 Soldering

The ASM may be soldered to the Host PCBA. See the customer drawings for the recommend pad layout.

Manual soldering
The through hole versions of the ASM should be soldered using acceptable industry standard through hole soldering techniques via the installed connector headers. The castellated version of the ASM can be soldered to a host PCBA using industry standard surface mount soldering techniques as described in IPC-J-STD-020 with a maximum temperature which should not exceed 260 °C following the guidelines of the Pb-Free Assembly. All solder joints should conform to the Workmanship Specification IPC-A-610, “Acceptability of Electronic Assemblies” and IPC J-STD-001, “Requirements for Soldering Electrical and Electronic Assemblies End Item Standards”.

Reflow soldering profile

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Average Ramp-Up Rate (Ts_{max} to Tp)	3 °C/second max.	3° C/second max.
Preheat – Temperature Min (Ts_{min}) – Temperature Max (Ts_{max}) – Time (ts_{min} to ts_{max})	100 °C 150 °C 60-120 seconds	150 °C 200 °C 60-180 seconds
Time maintained above: – Temperature (T_L) – Time (t_L)	183 °C 60-150 seconds	217 °C 60-150 seconds
Peak/Classification Temperature (Tp)	See Table 4.1	See Table 4.2
Time within 5 °C of actual Peak Temperature (tp)	10-30 seconds	20-40 seconds
Ramp-Down Rate	6 °C/second max.	6 °C/second max.
Time 25 °C to Peak Temperature	6 minutes max.	8 minutes max.

Note 1: All temperatures refer to topside of the package, measured on the package body surface.

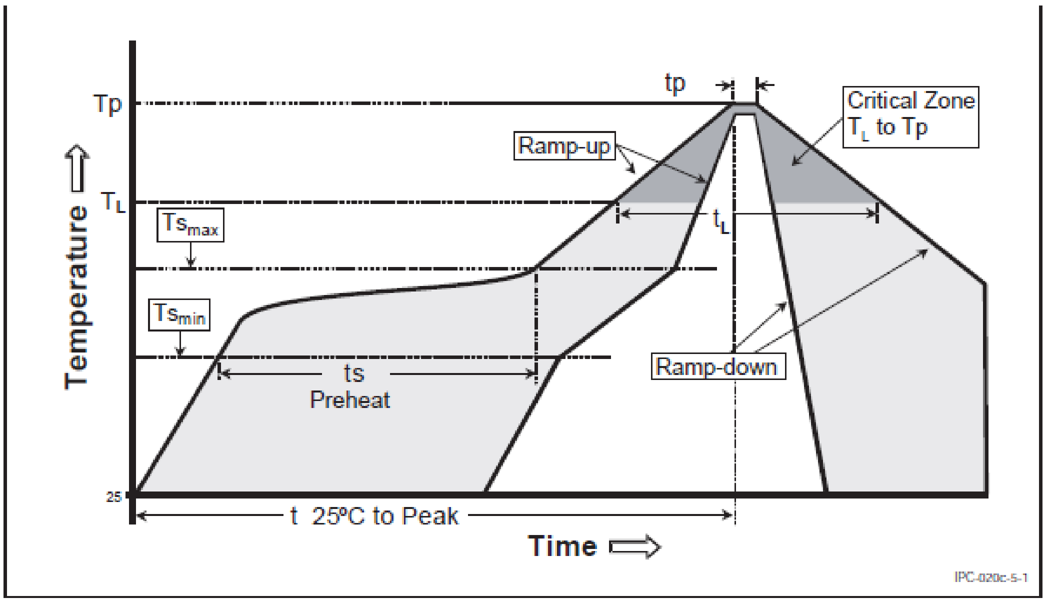


Figure 3: Reflow profile

4.4 Fresnel Lens

Optional Fresnel Lens, TE Part Number 2317697-1 is available for installation over the PIR sensor. Use care when installing the lens to prevent damage to the PIR sensor or the lens.

4.5 Motion Event LED

When a motion event is detected by the ASM, the motion event LED indicator illuminates on the lower right corner for the module (see Figure 1). If needed for the host application, a light pipe can be utilized to allow the motion event indicator to be visible in the final application.

5 QUALIFICATION

To Be Determined