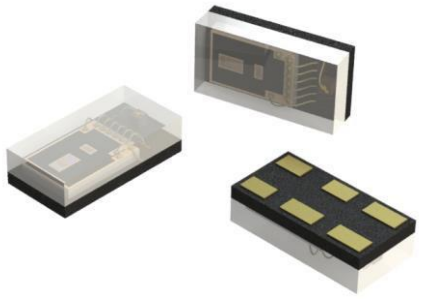
Digital Proximity Sensor

WHE0146UC



RoHS Compliant

Halogen Free

Features

- I²C interface (Fast Speed Mode at 400kHz/s)
- Dedicated Interrupt Pin
- Supply Voltage Range from 1.7V to 3.6V
- Operating temperature from -40°C to +85°C
- Proximity Sensor
  - Auto calibration cross-talk
  - Selectable gain and resolution (up to 12-bit).
  - 4 Programmable VSCEL Current Output, up to 20mA
  - Pulse Width Selection, PGA Gain Selection and Pulse Count Selection

Description

The WHE0146UC is a light to digital converter which combines an advanced proximity sensor and a high efficiency infrared VCSEL. The pitch of proximity sensor and VCSEL is only 1.0 mm

Proximity sensor (PS) built-in an 940nm optical filter for ambient light immunity, so PS can detect reflected IR light with high precision and excellent rejection.

WHE0146UC detects the human or object approach by reflection of IR light. It built in algorithm auto to calibrate the crosstalk between the sensor and optical cover.

Applications

- Handset device
  - TWS, tablet, PDA, mobile POS

Ordering Information

Ordering Code	Packaging	MOQ
WHE0146UC	Tape and reel	TBD

Block Diagram

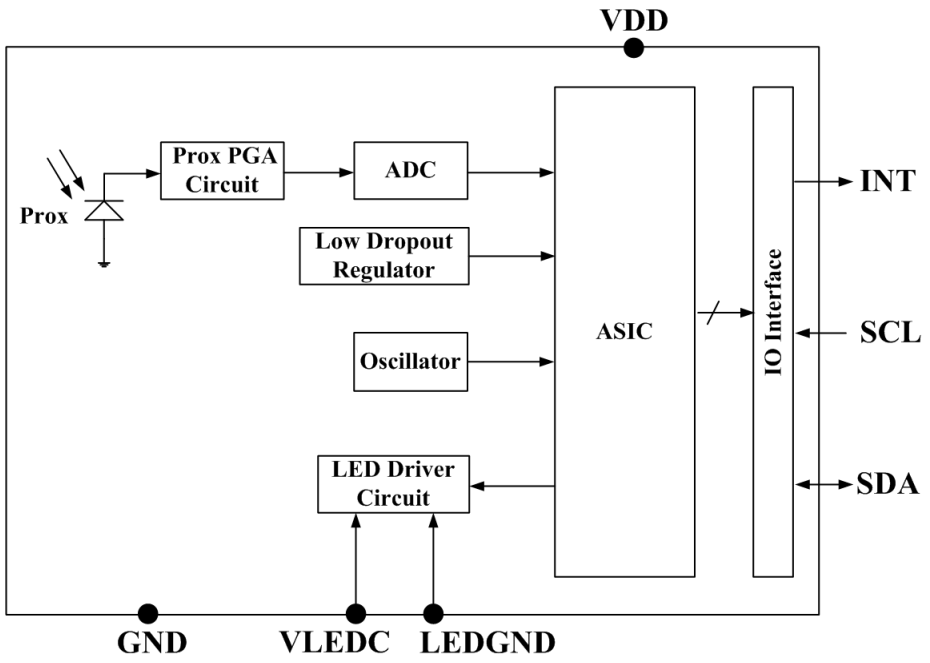
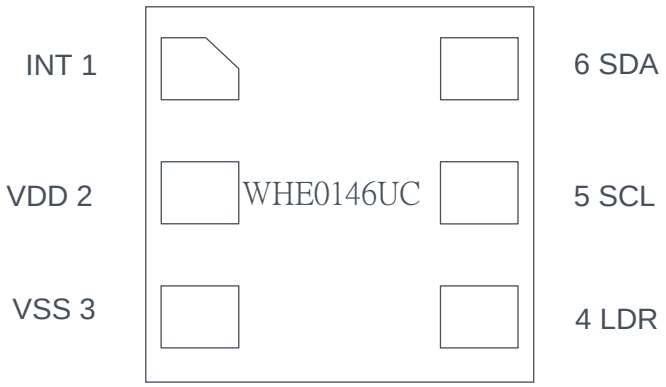


Fig. 1 Block Diagram

I/O Pins Configuration



Pin	I/O Type	Pin Name	Description
1	I	INT	Interrupt pin
2	P	VDD	Power Supply
3	P	GND	Ground
4	P	LDR	VCSEL anode
5	I	SCL	I2C serial clock line
6	I/O	SDA	I^2C serial data line

Absolute Maximum Ratings*

Parameter	Symbol	Value	Unit
Supply Voltage	VDD	4.5	V
I^2C Bus Pin Voltage	SCL, SDA, INT	-0.2 to 4.5	V
I^2C Bus Pin Current	SCL, SDA, INT	10	mA
LDR Pin Voltage	VLEDC	-0.2V to VDD + 0.5V	V
Operating Temperature	Tope	-40 to +85	˚C
Storage Temperature	Tstg	-45 to +100	˚C
ESD Rating	Human Body Model	2	KV

*Note: Exceeding these ratings could cause damage to the device. All voltages are with respect to ground. Currents are positive into, negative out of the specified terminal.

Recommended Operation Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Supply Voltage Note1	V_{DD}	1.7		3.6	V	
I^2C Bus Pin Voltage	V_{Bus}	1.62	1.8	VDD	V	$V_{Bus} \leq V_{DD}$
Operating Temperature	T_{ope}	-40		+85	˚C	
I^2C Bus Input High Voltage Note2	V_{IH_SCL}, V_{IH_SDA}	1.4			V	
I^2C Bus Input Low Voltage Note2	V_{IL_SCL}, V_{IL_SDA}			0.5	V	
SDA Output Low Voltage	V_{OL_SDA}	0		0.4	V	3mA sinking current
		0		0.6	V	6mA sinking current
INT Output Low Voltage	V_{OL_INT}	0		0.4	V	3mA sinking current

Notes:

1. The power supply need to make sure the VDD slew rate at least 0.5 V/ms. WHE0146UC have power on reset function. When VDD drops below 1.2V under room temp, the IC will be reset automatically. Then power back up at the requirement slew rate, and write registers to the desired values.
2. The specs are defined under VDD=3.3V, T=25°C

Electrical & Optical Specifications

Unless otherwise specified, the following specifications apply over the operating ambient temperature T = 25˚C, VDD = 3.3V.

Electrical Characteristics	Symbol	MIN	TYP	MAX	Notes	Unit
Active Supply Current	I_{DD}		35		Ev=0, **Note1**	μA
	I_{PD}		1		Sleep mode,Ev=0,**Note2**	uA

Waiting Characteristics	Symbol	MIN	TYP	MAX	Notes	Unit
Wait time unit	**WTIME**	6.5		1664	unit=6.5ms	ms

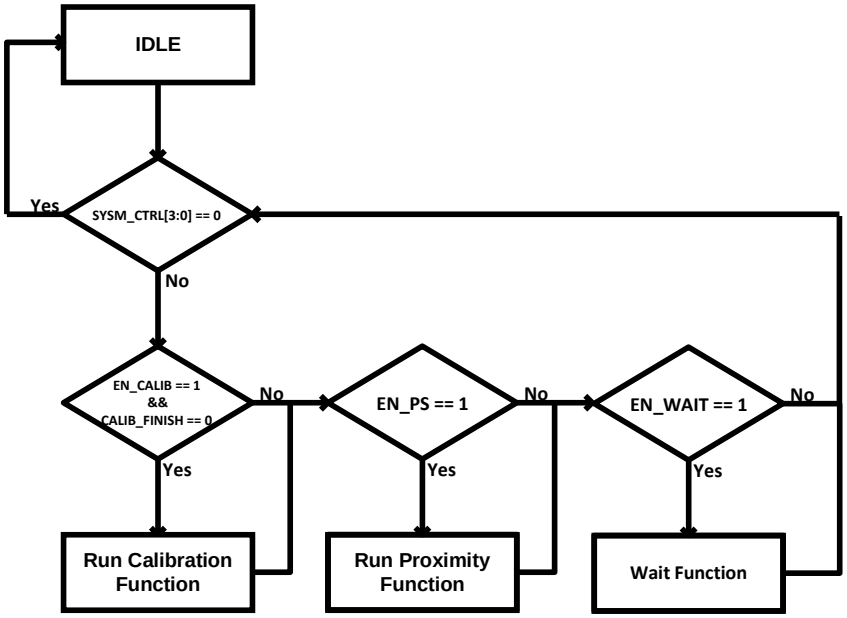
PS Characteristics	Symbol	MIN	TYP	MAX	Notes	Unit
Sensing Gain, relative to x1 setting	**PGA_PS**		2			
			4			
PS ADC integration time step size	**PStep**		0.256			ms
PS ADC number of integration unit	**PSCONV**	1		16		Unit
Full ADC counts per step		0		255	PSCONV=1	count
Full scale ADC counts value		0		4095	PSCONV=16	count
LED pulse period	**ITW_PS**	0.016		0.256		ms
LED pulse count	**ITC_PS**	1		16		pulse
LED Driving Current	**PLDR**		5			mA
			10			
			15			
			20			
IR Peak Wavelength	**λp**		940			nm

Notes :

1. EN_WAIT=1, EN_PS=1, NUM_AVG=0, WTIME=8
2. Setting EN_FRST=1

State Machine

There are two operation mode, PS and Calibration mode. The state machine is shown below:



Typical Characteristics Curves

Unless otherwise specified, the following specifications apply over the operating ambient temperature T = 25˚C, VDD = 3.3V.

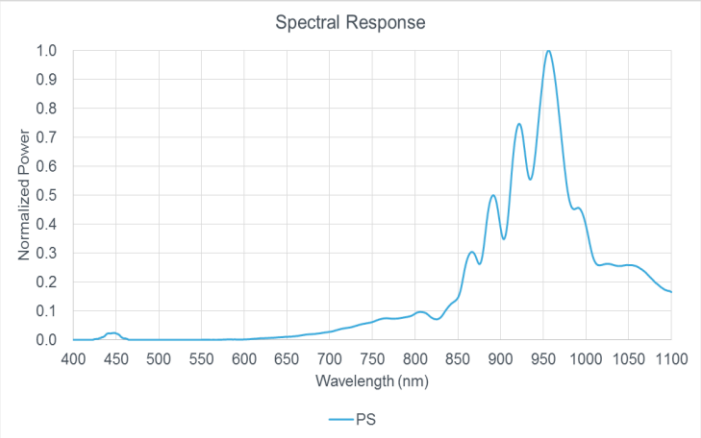


Fig. 2 PS Spectral Response

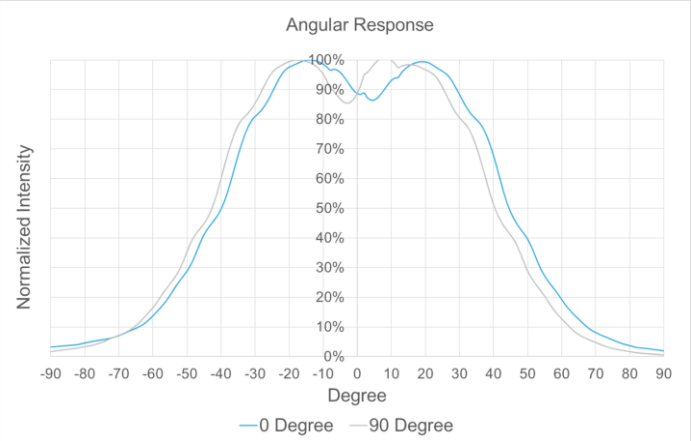


Fig.3 PS Angular Response

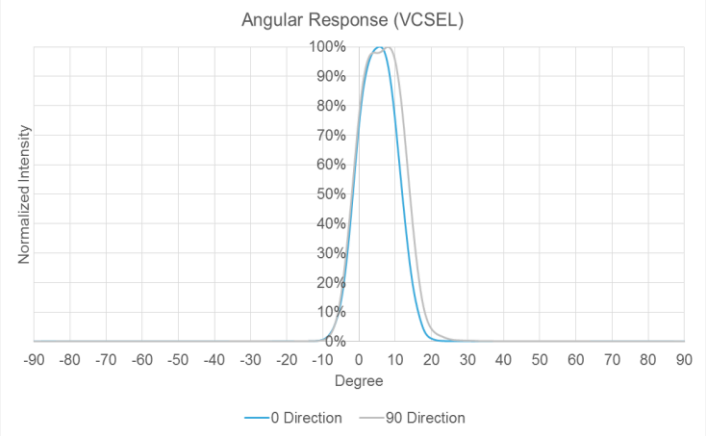
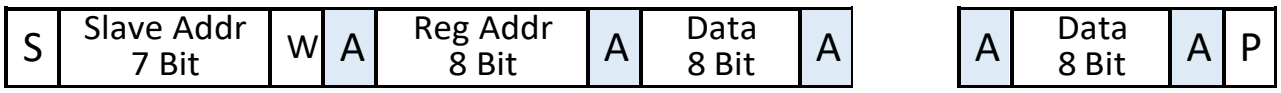


Fig.4 VCSEL Angular Response

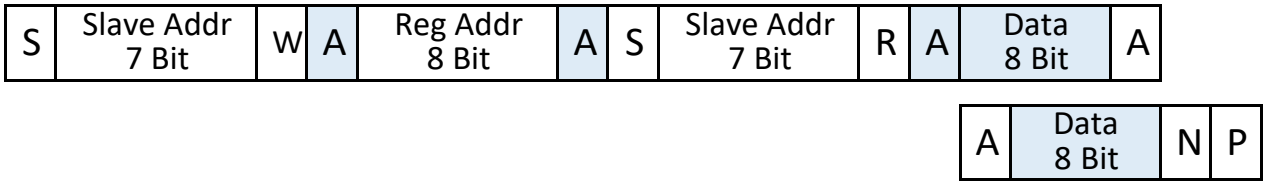
I²C Write Format

I²C Block Write Format



I²C Read Format

I²C Block Read Format



Master to Slave

Slave to Master

S Start Condition, 1 Bit

P Stop Condition, 1 Bit

W Write, Set 0 for write, 1 Bit

R Read, Set 1 for read, 1 Bit

A Acknowledge(ACK), Set 0, 1 Bit

N Non acknowledge(NACK), Set 1, 1 Bit

I²C Slave Address and R/W bit

This address is seven bits long followed by an eighth bit which is a data direction bit (R/W). A '0' indicates a transmission (WRITE), a '1' indicates a request for data (READ). The slave address of this device is 0x38.

Register Set

The WHE0146UC is operated over the I2C bus with registers that contain configuration, status, and result information. All registers are 8 bits long.

Address	Name	Type	Default value	Description
0x00	SYSM_CTRL	R/W	0x00	PS/CALIB operation mode control, waiting mode control, SW reset
0x01	INT_CTRL	R/W	0x07	Interrupt pin control, interrupt persist control
0x02	INT_FLAG	R/W	0x80	Interrupt flag, error flag, power on reset(POR) flag
0x03	WAIT_TIME	R/W	0x00	Waiting time setting
0x06	PS_GAIN	R/W	0x00	LED setting, PS analog gain setting
0x07	PS_PULSE	R/W	0x00	PS number of LED pulse
0x08	PSPD_CONFIG	R/W	0x02	PS PD setting
0x09	PS_TIME	R/W	0x00	PS integrated time setting
0x0A	PS_FILTER	R/W	0xBF	PS filter setting
0x0B	PERSISTENCE	R/W	0x11	PS persistence setting
0x10	PS_THRES_LL	R/W	0x00	PS low interrupt threshold - LSB
0x11	PS_THRES_LH	R/W	0x00	PS low interrupt threshold - MSB
0x12	PS_THRES_HL	R/W	0xFF	PS high interrupt threshold - LSB
0x13	PS_THRES_HH	R/W	0xFF	PS high interrupt threshold - MSB
0x14	PS_OFFSET_L	R/W	0x00	PS offset level - LSB
0x15	PS_OFFSET_H	R/W	0x00	PS offset level - MSB
0x17	ERROR_FLAG	R	0x00	Error flag
0x1A	PS_DATA_L	R	0x00	PS output data - LSB
0x1B	PS_DATA_H	R	0x00	PS output data - MSB
0x26	CALIB_CTRL	R/W	0x0F	PS calibration control
0x28	CALIB_STAT	R	0x00	PS calibration status
0x2A	MANU_CDAT_L	R/W	0x00	Manual calibration data - LSB
0x2B	MANU_CDAT_H	R/W	0x00	Manual calibration data - MSB
0x2C	AUTO_CDAT_L	R	0x00	Automatic calibration data - LSB
0x2D	AUTO_CDAT_H	R	0x00	Automatic calibration data - MSB
0xBC	PROD_ID_L	R	0x11	Product ID - LSB
0xBD	PROD_ID_H	R	0x42	Product ID - MSB

SYSM_CTRL

0x00	SYSM_CTRL, System Control (Default = 0x00)							
BIT	7	6	5	4	3	2	1	0
R/W	SWRST	EN_WAIT	EN_FRST	0	0	EN_CALIB	EN_PS	0

SWRST： Software reset. Reset all register to default value.

0: (Default)

1: Reset will be triggered.

EN_WAIT： Waiting time will be inserted between two measurements.

0: Disable waiting function. (Default)

1: Enable waiting function.

EN_FRST：

0: Enable (Brown out Reset circuit enable). (Default)

1: Disable (Brown out Reset circuit disable).

EN_CALIB： Enables calibration (CALIB) function.

0: Disable CALIB function. (Default)

1: Enable CALIB function.

EN_PS： Enables PS function.

0: Disable PS function. (Default)

1: Enable PS function.

INT_CTRL

0x01	INT_CTRL, interrupt pin control (Default = 0x07)							
BIT	7	6	5	4	3	2	1	0
R/W	0	0	PS_ SYNC	0	0	EN_ CALIBINT	EN_ PINT	1

PS_SYNC： Measurement is pended when PS interrupt is triggered. Until clear the interrupt then start the next measurement.

0: Disable pending PS function. (Default)

1: Enable pending PS function.

EN_CALIBINT： The CALIB interrupt (INT_CALIB) flag can trigger the INT pin to low.

0: Disable INT_CALIB effect INT pin.

1: Enable INT_ CALIB effect INT pin. (Default)

EN_PINT： The PS interrupt (INT_PS) flag can trigger the INT pin to low.

0: Disable INT_PS effect INT pin.

1: Enable INT_PS effect INT pin. (Default)

INT_FLAG

0x02	INT_FLAG, interrupt flag (Default = 0x80)							
BIT	7	6	5	4	3	2	1	0
R/W	INT_POR	DATA_ FLAG	OBJ	0	0	INT_ CALIB	INT_PS	0

INT_POR： Power-On-Reset Interrupt flag trigger the INT pin when the flag sets to one. Write zero to clear the flag.

0:

1: This bit will be set to one when it satisfy one of the following conditions:

- Power On
- VDD < 1.2V
- SWRST

DATA_FLAG： It shows if any data is invalid after completion of each conversion cycle. This bit is read-only.

0: Data valid.

1: Data invalid.

OBJ： Object Detection Bit. It shows the position of the object. This bit is read only.

0: Object disappear.

1: Object appear.

INT_CALIB： CALIB interrupt flag. Write zero to clear the flag.

0: CALIB Interrupt not triggered or be cleared.

1: CALIB Interrupt triggered.

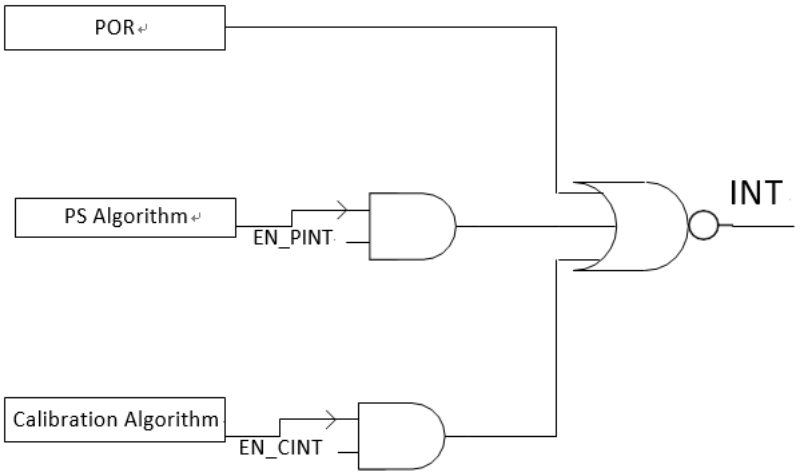
INT_PS： PS interrupt flag. It correlation with PS_DATA and PS high/low threshold. Write zero to

clear the flag.

0: PS Interrupt not triggered or be cleared.

1: PS Interrupt triggered.

PS Behavior:



Correlative register:

The PS Interrupt (**INT_PS**, register 0x02, bit1),

The PS Persistence (**PRS_PS,** register 0x0B, bit4 to bit7),

The PS Data (**PS_DATA**, register 0x1A to 0x1B),

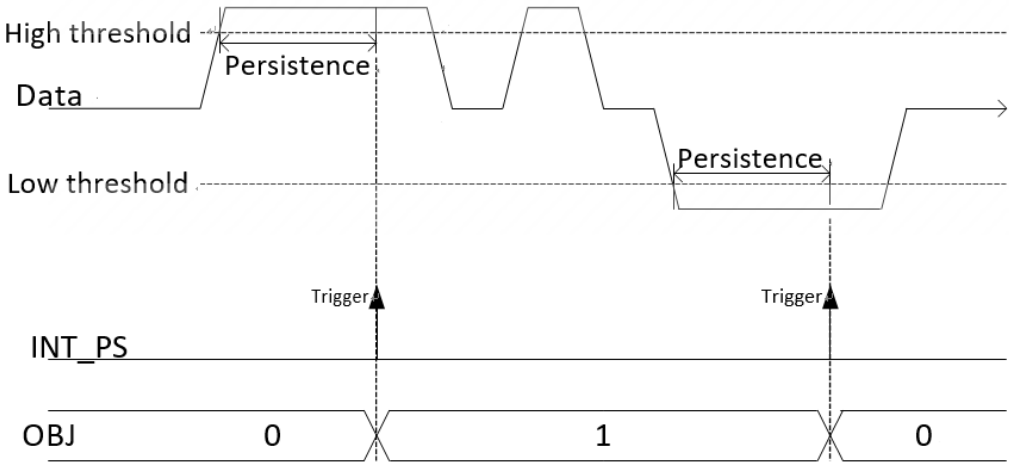
The PS Low Threshold (**PS_THRES_L**, register 0x10 to 0x11),

The PS High Threshold (**PS_THRES_H**, register 0x12 to 0x13).

INT_PS triggered condition:

1. Rule of active interrupt:
   i. **When OBJ** is zero, **PS_DATA** > **PS_THRES_H**.
   ii. **When OBJ** is one, **PS_DATA** < **PS_THRES_L**.
2. If **PS_DATA** meets the rule, the interrupt **counter** increases one.
   If **PS_DATA** fails in the rule, the interrupt counter will be cleared.
3. When the counter value equal to **PRS_PS**, the **OBJ** flag will be inverted, **INT_PS** will be triggered, and clear interrupt counter.

If **PRS_PS is** set to zero, **the threshold** setting will be ignored and **DATA** will meets the active interrupt rule forcibly



WAIT_TIME

0x03	WAIT_TIME, waiting time (Default = 0x00)							
BIT	7	6	5	4	3	2	1	0
R/W	WTIME							

WTIME： This register controls the time unit of waiting state which is inserted between any two measurements. It is 6.5 ms per time unit.

0x00: 1 time unit. (Default)

0x01: 2 time units

……

0xFF: 256 time units

PS_GAIN

0x06	PS_GAIN, PS analog gain and LED control (Default = 0x00)							
BIT	7	6	5	4	3	2	1	0
R/W	0	0	IRDR_SEL		0	0	PGA_PS	

IRDR_SEL： It configures the peak current of the internal LED driver.

0x0: 5mA (Default)

0x1: 10mA

0x2: 15mA

0x3: 20mA

PGA_PS：PS sensing gain.

0x0: x1 (Default)
0x1: x2
0x2: x4

PS_PULSE

0x07	PS_PULSE, PS integration pulse configure(Default = 0x00)							
BIT	7	6	5	4	3	2	1	0
R/W	0	0	0	0	ITW_PS			

ITW_PS：It controls LED pulse width in PS function mode. Pulse width is 16us per unit.

0x00: 1T (default).
0x01: 2T
……
0x0F: 16T

PSPD_CONFIG

0x08	**PS_PULSE, PS pulse count control(Default = 0x00)**							
BIT	7	6	5	4	3	2	1	0
R/W	0	0	0	0	0	EN_PSPD		0

EN_PSPD： PS PD select 0x0：

None
0x1：Select PD1 (Default)
0x2：Select PD2 0x3：
Select PD1 and PD2

PS_TIME

0x09	PS_TIME, PS integrated time (Default = 0x00)							
BIT	7	6	5	4	3	2	1	0
R/W	ITC_PS				PSCONV			

ITC_PS：It controls the number of LED pulse in PS function mode.

0x0： 1 pulse (Default)

0x1： 2 pulses

0x2： 3 pulses

……

0xF： 16 pulses

PSCONV：This register controls the conversion time of AD converter at PS mode (TPS), and the resolution of output data (PS_DATA, IR_DATA).

0x0: The maximum count of **output data is** 255, 1 time unit (default).

0x1: The maximum count of **output data is** 511, 2 time units.

……

0xF: The maximum count of **output data is** 4095, 16 time unit.

The maximum count of **output data is** (256 x time unit) -1.

The conversion time of PS function (TPS) is decided by **ITW_PS, ITC_PS** and **PSCONV.**

TPS = 1.251 + 0.0005 x **(ITC_PS + 1)** x [144 + 64 x **(ITW_PS+1)**] + 0.256 x **(PSCONV+1)** (ms)

PS_FILTER

0x0A	PS_FILTER, PS integrated time (Default = 0xBF)							
BIT	7	6	5	4	3	2	1	0
R/W	1	0	1	1	NUM_AVG			

NUM_AVG：This register sets the numbers of data to do average before output.

0x0: The output data is the average data of one time.

0x1: The output data is the average data of two times.

……

0xF: The output data is the average data of sixteen times. (Default)

The total conversion time (TTOTAL) of device is decided by TPS, and **NUM_AVG**.

TTOTAL = (**NUM_AVG** + 1) * T_{PS} (ms)

PERSISTENCE

0x0B	PERSISTENCE, PS persistence setting (Default = 0x11)							
BIT	7	6	5	4	3	2	1	0
R/W	PRS_PS				0	0	0	1

PRS_PS：This register sets the numbers of similar consecutive PS interrupt events before the interrupt pin is triggered.

0x0: Every PS conversion is done.

0x1: 1 PS interrupt event is asserted. (Default)

……

0xF: 15 consecutive PS interrupt events are asserted

PS_THRES_L

0x10 0x11	PS_THRES_L, PS low interrupt threshold (Default = 0x0000)							
BIT	7	6	5	4	3	2	1	0
R/W	PS_THRE_LL							
R/W	PS_THRE_LH							

This register sets the lower threshold value of PS interrupt. The interrupt algorithm compares the selected PS data and PS threshold value.

PS_THRE_LL：PS lower interrupt threshold value, LSB. (Reg. 0x10)

PS_THRE_LH：PS lower interrupt threshold value, MSB. (Reg. 0x11)

PS_THRES_H

0x12 0x13	PS_THRES_H, PS high interrupt threshold (Default = 0xFFFF)							
BIT	7	6	5	4	3	2	1	0
R/W	PS_THRE_HL							
R/W	PS_THRE_HH							

This register sets the high threshold value of PS interrupt. The interrupt algorithm compares the selected PS data and PS threshold value.

PS_THRE_HL：PS high interrupt threshold value, LSB. (Reg. 0x12)
PS_THRE_HH：PS high interrupt threshold value, MSB. (Reg. 0x13)

PS_OFFSET

0x14 0x15	ERROR_FLAG, Error flag status							
BIT	7	6	5	4	3	2	1	0
R/W	PS_OFFSET_L							
R/W	PS_OFFSET_H							

This register used to calibrate the device's cross talk. The **PS_DATA** should be closed to zero with no object. The PS_OFFSET is subtracted from the measured data before it output to. **PS_DATA**.

PS_OFFSET_L：PS low offset value, LSB. (Reg. 0x14)
PS_OFFSET_H：PS high offset value, MSB. (Reg. 0x15)

ERROR_FLAG

0x17	ERROR_FLAG, Error flag status.							
BIT	7	6	5	4	3	2	1	0
R	PS_ REDY	0	0	ERR_ PSD	ERR_ PSL	0	0	0

This register indicates the PS data status. If the PS data is outside of measurable range, the corresponding error flag will set to one. That also means the data is invalid.
Every PS conversion is done, the PS_REDY flag will set to 1. It notifies the user that the sensor data is updated.

PS_DATA

0x1A 0x1B	PS_DATA, PS output data..							
BIT	7	6	5	4	3	2	1	0
R	PS_DATA _L							
R	PS_DATA_H							

The PS conversion result is written into PS_DATA.

For insuring the data in the register comes the same measurement, the high byte data will be latched when the low byte data has being accessed until the high byte data has be read.

CALIB_CTRL

0x26	CALIB_CTRL, PS calibration control (Default = 0x0F)..							
BIT	7	6	5	4	3	2	1	0
R/W	0	0	0	CALIB_ BIN_SEL	1	1	1	1

CALIB_BIN_SEL：It select calibration bin-search source.

0x0: Automatic calibration (Default)

0x1: Manual

CALIB_STAT

0x28	CALIB_STAT, PS calibration status (Default = 0x00.							
BIT	7	6	5	4	3	2	1	0
R/W	0	0	0	0	0	0	ERR_ CALIB	CALIB_ FINSH

PS_CALIB_SAT： It shows if calibration bin-search result equal to 0xFF.

CALIB_FINSH： It shows the calibration function is done. Write zero to clear the flag.

MANU_CDAT

0x2A 0x2B	MANU_CDAT, Manual calibration data. (Default = 0x0000)							
BIT	7	6	5	4	3	2	1	0
R	MANU_CDAT_L							
R	0							MANU_ CDAT_H

The manual calibration data is setting by user to do crosstalk calibration

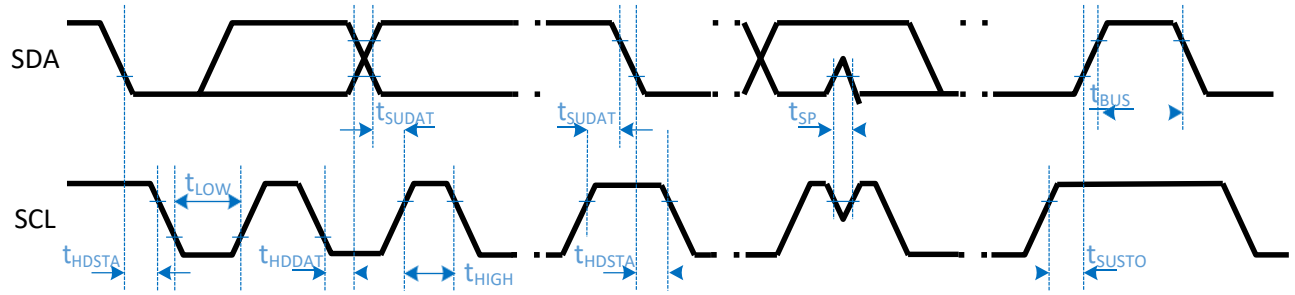
AUTO_CDAT

0x2C 0x2D	AUTO_CDAT, Automatic calibration data.							
BIT	7	6	5	4	3	2	1	0
R	AUTO_CDAT_L							
R	0							AUTO_CDAT_H

The automatic calibration data is setting by chip to do crosstalk calibration. When calibration function is finished, the calibration data will show on this register

I²C Interface Timing Characteristics

This section will describe the protocol of the I²C bus. For more details and timing diagrams please refer to the I²C specification.



Parameter (*)	Symbol	Fast mode		Unit
		Min	Max	
SCL clock frequency	f_{SCL}	100	400	kHz
Bus free time between STOP condition and START condition	t_{BUS}	1.3	--	μs
LOW period of the SCL clock	t_{LOW}	1.3	--	μs
HIGH period of the SCL clock	t_{HIGH}	0.6	--	μs
Hold time (repeated) START condition	t_{HDSTA}	0.6	--	μs
Set-up time (repeated) START condition	t_{SUSTA}	0.6	--	μs
Set-up time for STOP condition	t_{SUSTO}	0.6	--	μs
Data hold time	t_{HDDAT}	50	--	ns
Data set-up time	t_{SUDAT}	100	--	ns
Pulse width of spikes which must be suppressed by the input filter	t_{SP}	0	50	ns
Rise time of both SDA and SCL signals		20 x VDD/5.5	300	ns
Fall time of both SDA and SCL signals		20 x VDD/5.5	300	ns

(*) Specified by design and characterization; not production tested.

(**) All specifications are at V_{Bus} = 3.3V, T_{ope}=25ºC, unless otherwise noted.

Note:

I²CBus Clear

In the unlikely event where the clock (SCL) is stuck LOW, the preferential procedure is to reset the bus using the HW reset signal if your I2C devices have HW reset inputs. If theI2C devices do not have HW reset inputs, cycle power to the devices to activate the mandatory Internal Power-On Reset (POR) circuit.

If the data line (SDA) is stuck LOW, the master should send nine clock pulses. The device that held the bus LOW should release it sometime within those nine clocks.

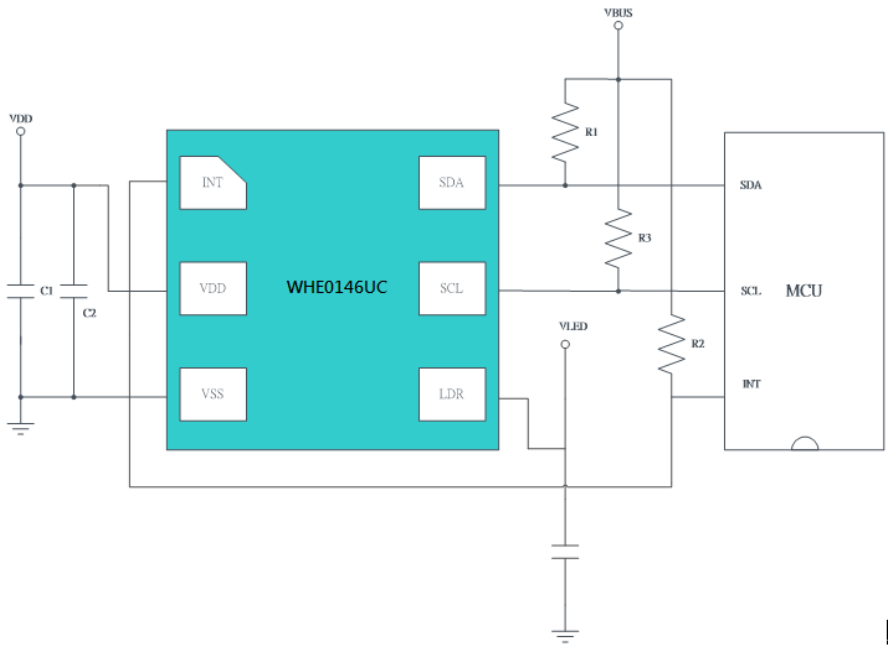
I²C General Call Software Reset

Following a General Call, (0000 0000), sending 0000 0110 (06h) as the second byte causes software reset. This feature is optional and not all devices will respond to this command. On receiving this 2-byte sequence, all devices designed to respond to the general call address will reset and take in the programmable part of their address.

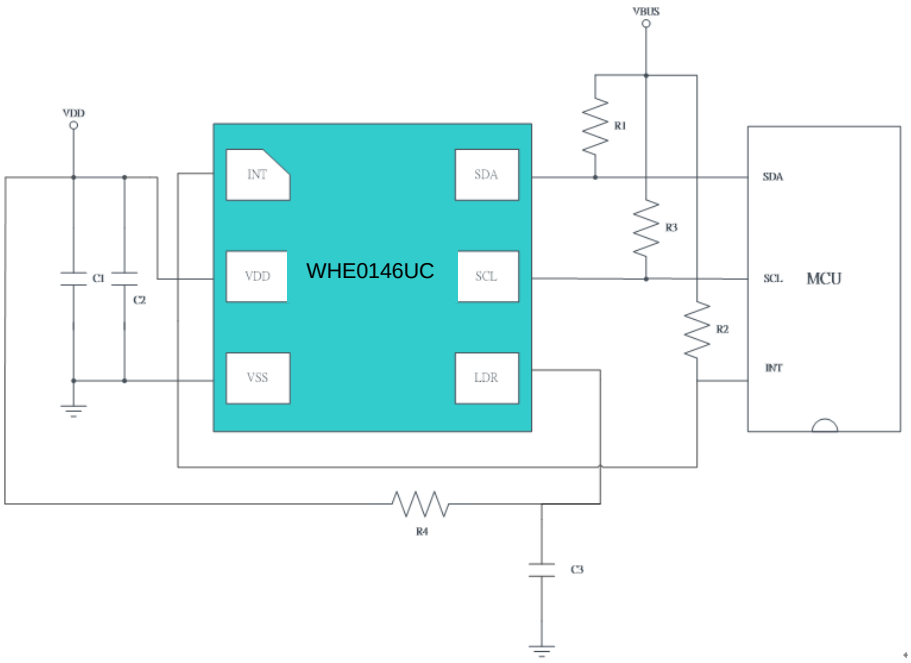
Precautions have to be taken to ensure that a device is not pulling down the SDA or SCL line after applying the supply voltage, since these low levels would block the bus.

Application Circuit

Separate Power Supplies



Single Power Supply



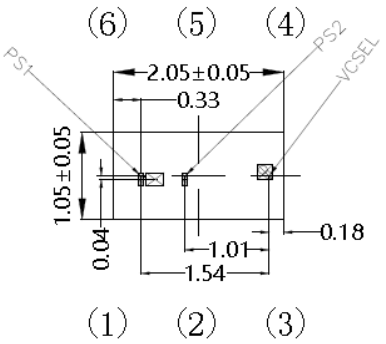
The capacitors (C1, C2) are required for sensor power supply. The capacitors should be placed as close as possible to the device. The high frequency AC noises can be shunted to the ground by the capacitors. The transient current caused by digital circuit switching also can be handled by the capacitors. A typical value 0.1 / 1 μF can be used.

The capacitors (C3) is required for LED power supply. A typical value 2.2μF is used. The extra resistor (R4) is required when using single power supply. A typical value 22Ω is used.

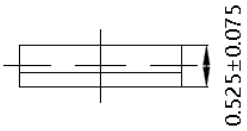
The pull-up resistors (R1, R2) are required for I^2C communication. At fast speed mode (400kHz/s) and VBUS = 3V, 1.5kΩ resistors can be used. The pull-up resistor (R3) is also required for the interrupt, a typical value between 10 kΩ and 100 kΩ can be used.

Package Outline Dimensions

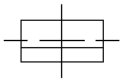
Top View



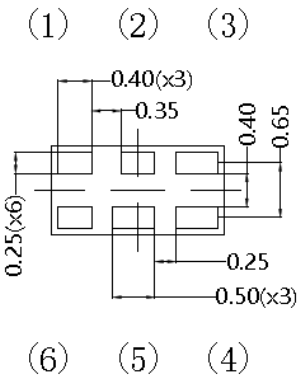
Front View



Right Side View

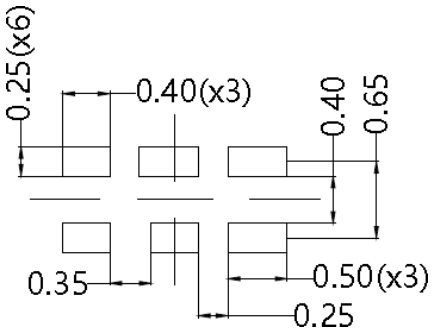


Bottom View

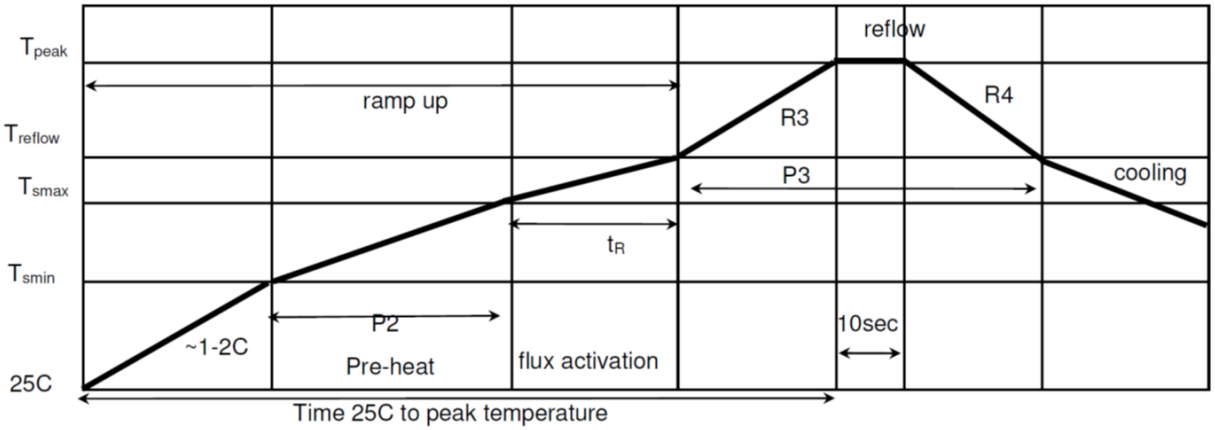


Pin-out	Name
(1)	INT
(2)	VDD
(3)	VSS
(4)	LDR
(5)	SCL
(6)	SDA

Recommended Land Pattern



Recommended Reflow Profile



	Peak temperature (Tpeak)	255-260C (max) ; 10sec
Pre-Heat	Temperature min (Tsmin) Temperature max (Tsmax) P2: (Ts min to Ts max)	150C 2C/sec 150C-217C 100s to 180s 90-110s
Time maintain above	Temperature (T_{reflow}) Time (P3) R3 slope (from 217C -> peak) R4 slope (from peak -> 217C)	217C 60-90sec 2C/sec [typ] -> 2.5C/sec (max) -1.5C/sec [typ]-> -4C/sec (max)
	Time to peak temperature	480s max
	Cooling down slope (peak to 217C)	2-4C/ sec