GH300 Datasheet

Rev: 1.3

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Contents

1 Overview

1.1 Brief Introduction

GH300 is a heart rate sensor that integrates two LEDs, one photodiode (PD) and one analog front-end, featuring ultra-compact size and ultra-low power consumption. It is applicable to the devices with harsh requirements on size and power consumption, such as smart headphones and smart rings.

As for smart headphone application, GH300 is capable of in-ear detection (IED) and supports the connection with an external photodiode (PD) and LED module to address the need for higher IED precision.

1.2 Features

- Ultra-Compact Size
  - Package Size: 4.3 mm × 2.6 mm × 0.9 mm
  - Two LEDs, one PD and one AFE embedded
- Ultra-Low Power consumption
  - Average current consumption in Heart Rate Detection mode (typical value): 25 μA @25 Hz Heart Rate Sampling Frequency (excluding the current consumption of LED)
  - Average current consumption in Heart Rate Detection mode (typical value for yellow skin): 40 μA @25 Hz Heart Rate Sampling Frequency (including the current consumption of LED)
  - Average current consumption in In-Ear Detection mode (typical value): 10 μA (including the current consumption of LED)
- Excellent Performance
  - 24-bit highly accurate ADC
  - Dynamic range: 96 dB
- Light Transmitter Block
  - Two internal LEDs and one external LED
  - Three independent LED drivers
  - 8-bit programmable current controller
  - Automatic dimming, self-adaptive to environment changes in optical path for optimal SNR output
- Light Receiver Block
  - One internal photodiode (PD) and one external photodiode (PD)
  - Two receiving channels
  - Up to 1 kHz heart rate sampling frequency for each channel
- Operating Voltage: 2.1 V-3.3 V
- Communication Interface: IIC

- Functions: HR , HRV, In-Ear Detection (IED)
- Application: Smart Headphones, Smart Rings, Smart Wristbands, etc.

1.3 Technical Specifications

Table 1-1 GH300 Technical Specifications

Parameter	Description	Value	Unit
Dimensions	LGA Package Dimensions	4.3×2.6	mm
	Thickness	0.90	mm
Sleep Mode Power Consumption	Sleep Mode Current (Typ.)	3	μA
Average Power Consumption in HBD Mode	@25 Hz Heart Rate Sampling Frequency (LED power consumption excluded)	25	μA
Heart Rate Detection	PPG data refresh rate	25	Hz
	Detection range	30 - 200	Bpm
Power Supply	VCC	2.1 - 3.3	V
	VLED[1]	2.5 - 4.5	V
	VDDIO	1.62 - VCC	V

[1] When green LED is used, the minimum power supply voltage of VLED should be 3.3V

2 Application

2.1 Overview

As shown in Figure 2-1, GH300 heart rate sensor mainly consists of the following parts:

- HBD analog front end: HBD Sensor, LED Driver, TIA, ADC, etc.;
- Communication interface: IIC;
- Basic circuit units: PMU, Clock System, Reset, Interrupt, etc.;
- Digital and logic control units: Data Buffer, Logic Control, etc.

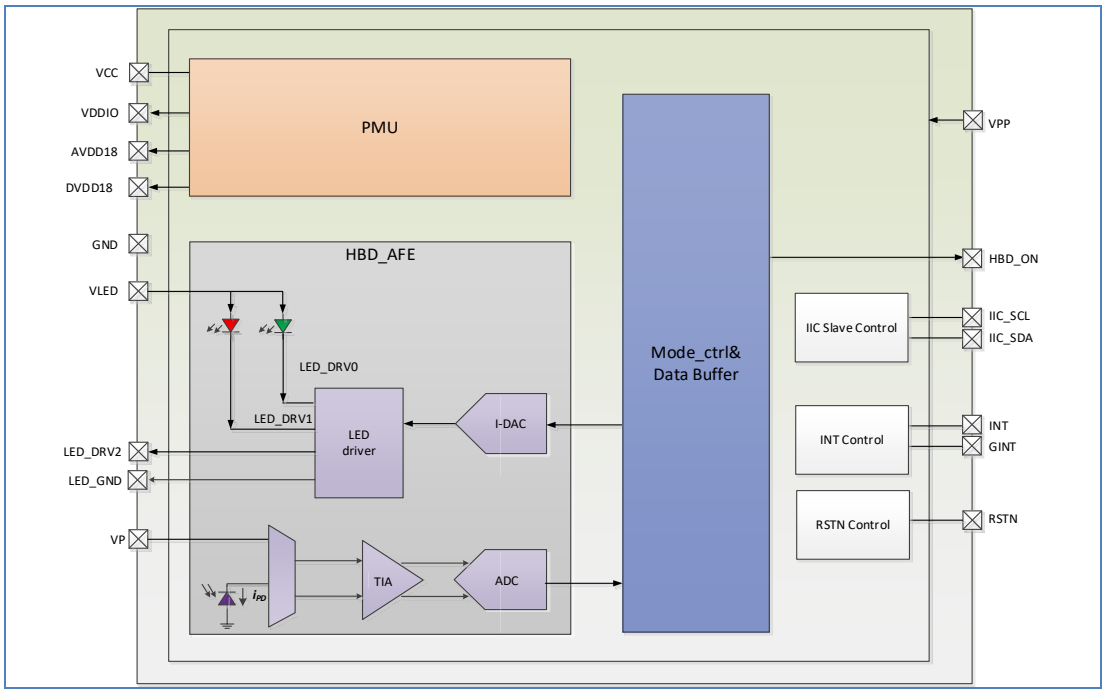


Figure 2-1 GH300 IC Block Diagram

Note:

TIA (Trans-Impedance Amplifier) is used to convert the photocurrent into voltage which serves as the input of ADC.

GH300 can be regarded as a smart sensor responsible for capturing heart rate data; the MCU on the smart devices such as headphone is responsible for data pre-processing and calculation in the exercising algorithm module; the cellphone serves as the control and signal processing center. The dynamic integration of GH300, G-Sensor and exercising heart rate algorithm enables users to track their heart rate more accurately when exercising.

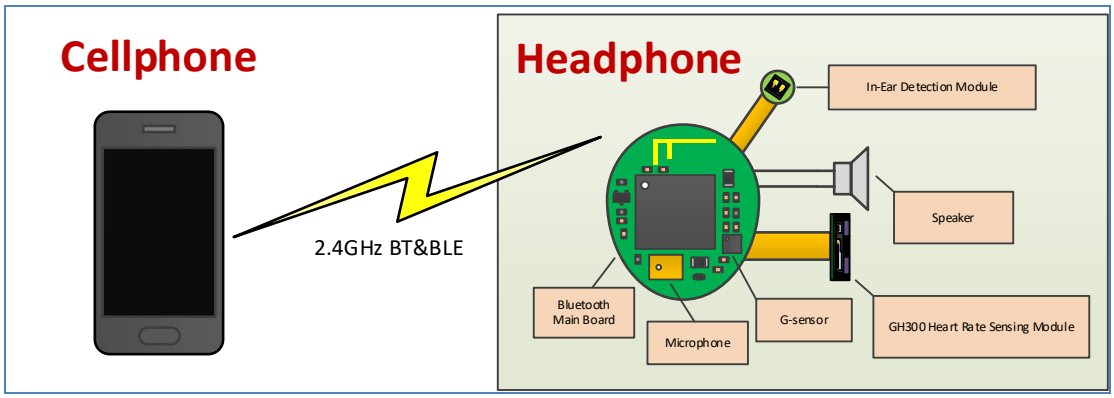


Figure 2-2 GH300 Typical Application in Headphone

2.2 Pin Definition

2.2.1 Pin Assignment

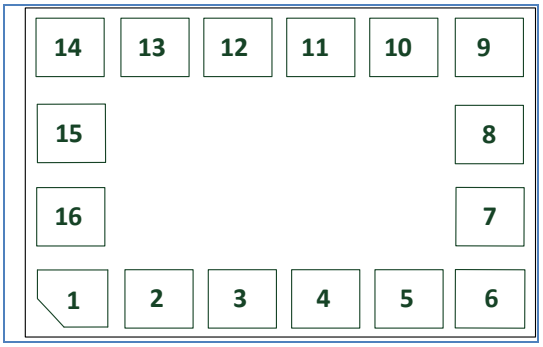


Figure 2-3 GH300 Pin Assignment (Top View)

2.2.2 Pin Definition

Table 2-1 Pin Definition

Pin No.	Name	Type	Description
1	AVDD18	PWR	Analog power domain for GH300, internal LDO integrated, must be connected to external 1 μF decoupling capacitor
2	VP	Analog	External PD input
3	GINT	I/O	Wake-up interrupt input in In-Ear Detection mode; can be connected to the interrupt output pin of G-sensor
4	GND	PWR	System ground
5	LED_GND	PWR	GND of the LED driver , connected to the GND of GH300 when applied
6	VCC	PWR	GH300 system power supply
7	VLED	PWR	Power supply of the internal IR LED and green LED (The LEDs are integrated with the die)
8	LED_DRV2	Analog	Driver for external LED, connected to the cathode of external LED
9	VPP	PWR	For internal use only; left floating during application
10	IIC_SDA	I/O	IIC data signal
11	IIC_SCL	I/O	IIC Clock signal

Pin No.	Name	Type	Description
12	HBD_ON	I/O	HBD working flag, active-high, left floating if unused
13	RSTN	I/O	Hardware reset, active-low
14	INT	I/O	Interrupt signal output
15	VDDIO	PWR	Digital IO power domain, powered by external power supply
16	DVDD18	PWR	Digital power domain, internal LDO integrated; must be connected to external 1 µF decoupling capacitor

2.3 Sample Schematic

Headphone application is taken as example herein.

GH300 module applied in headphone consists of GH300 heart rate sensor, G-sensor, LED, PD and other components as shown in Figure 2-4. VCC and VLED can share the same power supply. When the VLED is 3.3 V, the driving current of green LED cannot exceed 40 mA.

The supply voltage of VDDIO ranges from 1.62 V to VCC. Generally, VDDIO is shorted to VCC. Alternatively, VDDIO can be powered by DVDD18 (fixed to 1.8 V) of GH300. Pay attention to the match among the communication logic levels of G-Sensor, GH300 and MCU during the system design. When the logic level for communication on the host side is not VCC or 1.8 V, the main board should supply power to the VDDIO pin of GH300 module to ensure that the logic level on host side is identical with that on the module side.

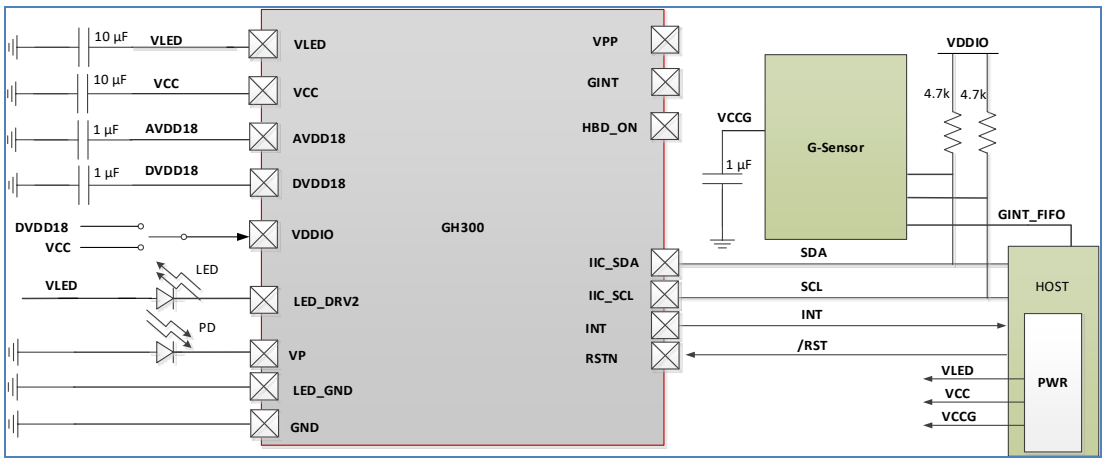


Figure 2-4 Sample Schematic for GH300 Application in Headphone

2.4 LED Application Guidelines

Two LEDs (one IR LED and one green LED) are embedded in GH300; the two embedded LEDs, are driven by two LED drivers respectively, so that users can configure and use the LEDs flexibly. Generally, the IR LED (850 nm) is used for ear presence detection and heart rate detection and the green LED (525 nm) is use for heart rate detection. It is recommended that the green LED should be applied in the projects that require high performance.

In addition, a third LED driver (LED_DRV2) can be used by the external ear presence detection module if required by the customer.

3 Power Management and Reset

3.1 Power-On Timing

Once VCC reaches the threshold voltage (Vpor) preset by GH300, the PMU will start to work and output Vpor signal to notify the other modules inside the sensor to operate. After power-on reset is completed, GH300 starts initialization; after initialization is completed, it enters Idle mode.

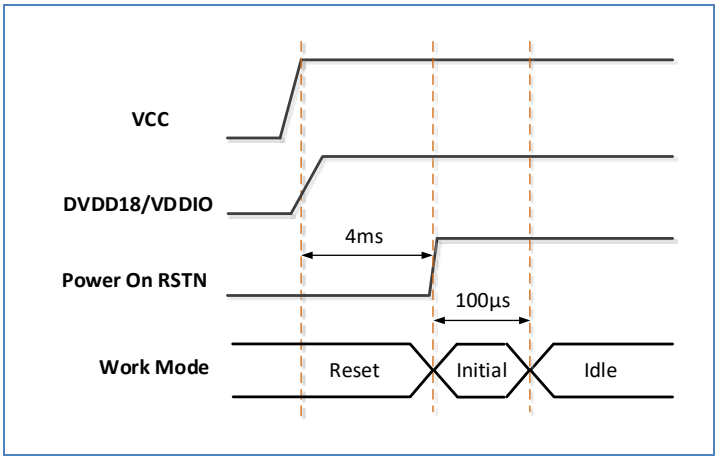


Figure 3-1 Power-On Timing

Follow the timing sequence below during system application.

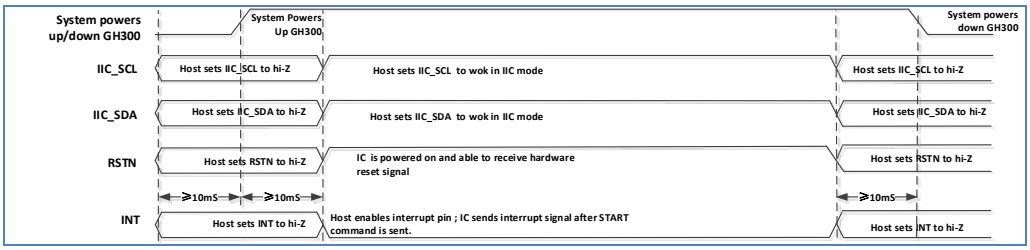


Figure 3-2 System Control Timing Sequence

3.2 Reset

There are 3 reset sources for GH300, namely, Power-On Reset (POR), Hardware Reset and Software Reset.

Table 3-1 Reset Sources

No.	Reset Source Type	Description
1	POR	GH300 will start working when VCC voltage rises to the POR threshold (Vpor) preset by GH300
2	Hardware RSTN	Reset GH300 by pulling RSTN pin low through hardware
3	Software	Reset GH300 by sending RSTN command through the communication interface

4 Communication Interface

4.1 IIC

The MCU can access the resources inside GH300, such as registers and FIFO, through IIC interface. Meanwhile, both single and burst read and write operations are supported. In addition, GH300 is capable of receiving and parsing the specified commands sent by MCU, so as to control the transition of the internal state machine.

The address, command and data in this protocol will be sent based on the bit order “Most Significant Bit” first; the register address where read/write operation starts and the data are 16-bit wide and will be transmitted in bytes, most significant bit first.

4.1.1 IIC Write Operation Protocol

The data format of the write operation is as follows:

start + 8(addr (7’b0010100 + W)) + 8(reg_high) + 8(reg_low) + 8(data_high) + 8(data_low) + …… + stop;

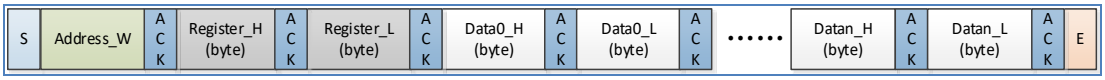


Figure 4-1 IIC Write Operation Data Format

4.1.2 IIC Read Operation Protocol

There are two kinds of data formats when reading from slave:

- Data Format A:

start + 8(addr (7’b0010100 + W)) + 8(reg_high) + 8(reg_low) + stop;

start + 8(addr (7’b0010100 + R)) + 8(data_high) + 8(data_low) + …… + stop;

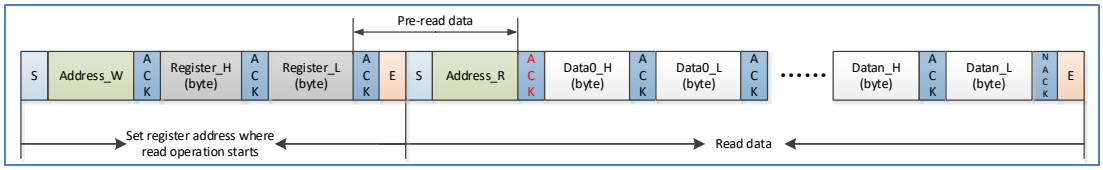


Figure 4-2 Data Format A of IIC Read Operation

- Data Format B:

start + 8(addr (7’b0010100 + W)) + 8(reg_high) + 8(reg_low) + start + 8(addr (7’b0010100 + R)) + 8(data_high) + 8(data_low) + …… + stop;

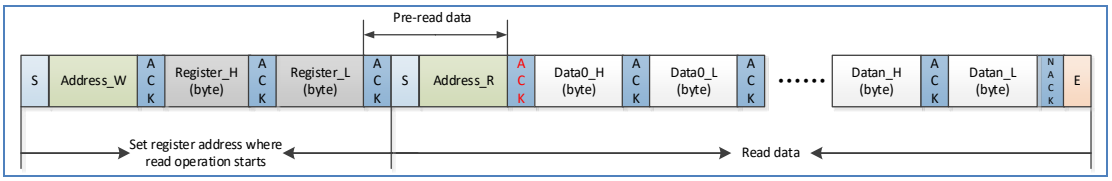


Figure 4-3 Data Format B of IIC Read Operation

Constraint on Read operation: after the reading is completed, if it is necessary to operate IIC bus continuously, the interval between two adjacent read operations should be longer than 10 μs.

4.1.3 IIC Command Issuance Protocol

The data format of the write operation is as follows:

start + 8(addr (7'b0010100 + W)) + 8(reg_high 8'hDD) + 8(reg_low 8'hDD) + 8(Cmd) + stop;

Figure 4-4 Data Format for IIC Command Issuance

4.1.4 IIC Timing

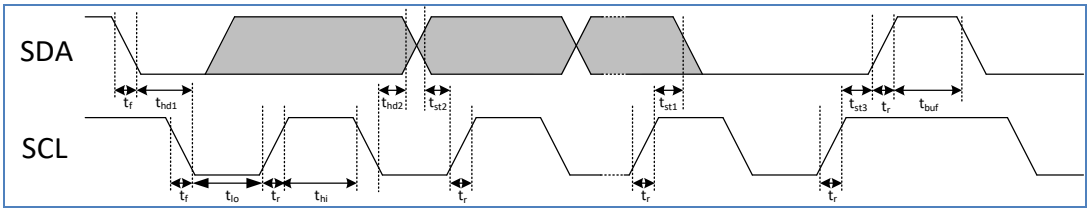


Figure 4-5 IIC Timing Diagram

Table 4-1 IIC Timing Parameters

Parameter	Symbol	Min.	Max.	Unit
Clock Frequency	f_{SCL}	-	400	KHz
SCL low period	t_{lo}	0.4	-	μs
SCL high period	t_{hi}	0.4	-	μs
SCL setup time for START condition	t_{st1}	0.1	-	μs
SCL setup time for STOP condition	t_{st3}	0.1	-	μs
SCL hold time for START condition	t_{hd1}	0.1	-	μs
SDA setup time	t_{st2}	0.1	-	μs
SDA hold time	t_{hd2}	0.1	-	μs
Time before a new transmission can start	t_{buf}	10		μs

4.2 Communication Interface Verification Guidelines

Follow the steps below if the user wants to verify whether the communication succeeds.

When there is no Goodix driver library, follow the steps below:

1. Implement IIC interface function;
2. Send command "0XC0" according to the IIC command sending protocol; delay for 1 ms and then read 2 bytes from the register whose address is 0x0028 according to the IIC read operation protocol; if the read-out value is 0x0031, the communication interface passes the verification.

When there is Goodix driver library, follow the steps below:

1. Implement IIC interface function;

2. Invoke HBD_SetIICRW function in Goodix driver library to register the IIC interface into the library;
3. Invoke HBD_CommunicationInterfaceConfirm interface in Goodix driver library; if the returned value is "HBD_RET_OK", the communication interface passes the verification.

Note:

As for the details of the interfaces in the driver library, please refer to the file *GH30x Heart Rate Sensor Application Note*.

5 Operating Modes

GH300 can operate in three modes: Sleep Mode, HBD Mode and ADT Mode.

5.1 Sleep Mode

GH300 enters Sleep mode after power-on initialization. In Sleep mode, the blocks which are not required will be turned off and the system consumes the least power.

5.2 HBD Mode

After heart rate detection is enabled, GH300 will enter HBD Mode. The Raw Data can be read through IIC interface.

5.3 ADT Mode

After the in-ear detection is enabled, the system will enter into ADT mode and GH300 starts the in-ear detection. The in-ear detection result will be returned by triggering interrupt.

5.4 Mode Transition

GH300 can switch between Sleep Mode and HBD Mode by invoking the HBD_HbStart and HBD_Stop functions, and switch between Sleep mode and ADT mode by invoking the HBD_AdtStart and HBD_Stop functions.

The transition diagram is shown below:

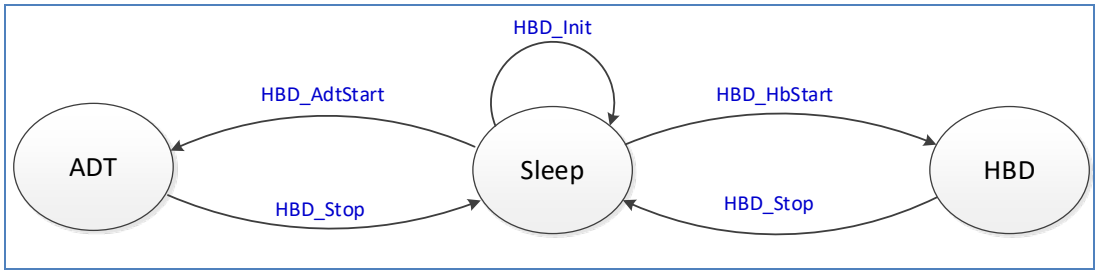


Figure 5-1 System Operating State Transition

Note:

As for details of invoking functions for the operating mode transition, please refer to the file “GH30x Heart Rate Sensor Application Note”.

6 Electrical Characteristics

6.1 Absolute Maximum Ratings

Table 6-1 GH300 Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VCC	-0.3	3.6	V
VLED	-0.3	4.6	V
VDDIO	-0.3	3.6	V
Voltage on digital I/O	-0.3	VDDIO+0.3	V
Storage temperature	-40	+125	°C
ESD susceptibility (HBM)	±2		kV

Note:

- Stresses above these ratings may cause permanent damage.
- These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.
- Exposure to absolute maximum conditions for extended periods may degrade device reliability.

6.2 Recommended Operating Conditions

Table 6-2 Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Unit	Remark
VCC	2.1	-	3.3	V	Power Supply Noise < 50mVpp (White Noise 1 MHz)
VLED	2.5	3.3	4.5	V	1. When green LED is used, VLED supply voltage should be no less than 3.3 V; 2. When VLED is 3.3V, the drive current for green LED cannot exceed 40 mA. If 100 mA drive current needs to be supported, VLED should be greater than 4.0 V; 4.2 V is recommended.
VDDIO	1.62	1.8	VCC	V	Digital IO power domain; voltage on VDDIO cannot exceed voltage on VCC
Operating temperature	-20	+25	+50	°C	-

6.3 DC Electrical Characteristics

Operating Conditions: VCC = 3.3 V, VLED = 3.3 V, Ambient temperature: 25°C

Table 6-3 DC Electrical Characteristics

Parameter	Min.	Typ.	Max.	Unit	Remark
HBD Mode Average current @25Hz	-	25	-	μA	Power consumption of G-sensor(about 20 μA) is excluded; The LED drive current is excluded; the power consumption will be increased by about 1 μA

Parameter	Min.	Typ.	Max.	Unit	Remark
					due to each 1mA LED drive current.
ADT Mode Current	-	10	-	μA	-
Sleep Mode Current	-	3	-	μA	-
Digital input low voltage/V_{IL}	-	-	0.25*VDDIO	V	-
Digital input high voltage/V_{IH}	0.75*VDDIO	-	-	V	-
Digital output low voltage/V_{OL}	-	-	0.15*VDDIO	V	-
Digital Output High Voltage/V_{OH}	0.85*VDDIO	-	-	V	-

7 Package

7.1 LGA Package Drawing

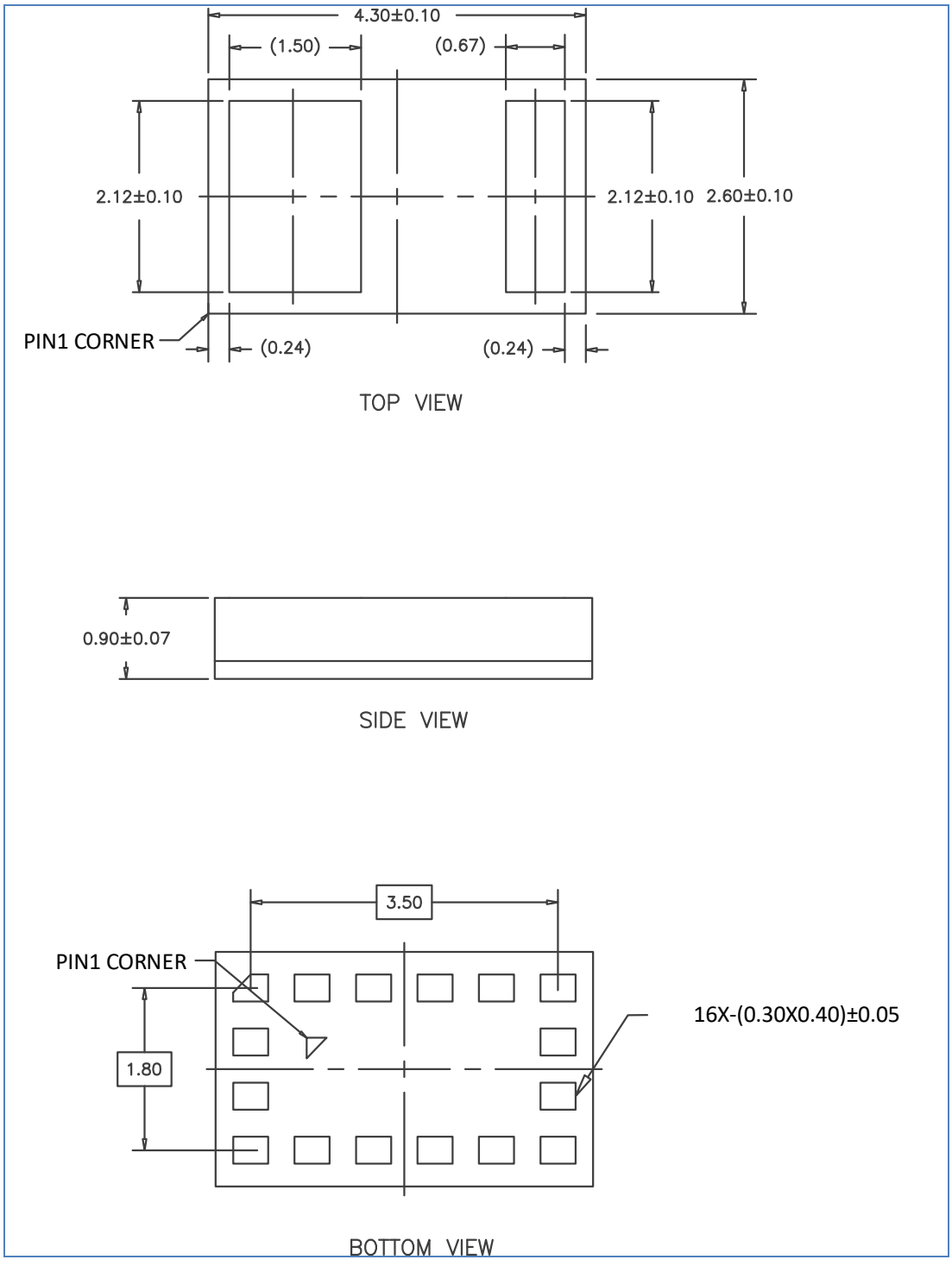


Figure 7-1 LGA Package Drawing (Unit: mm)

7.2 Recommended Package Design on PCB/FPC

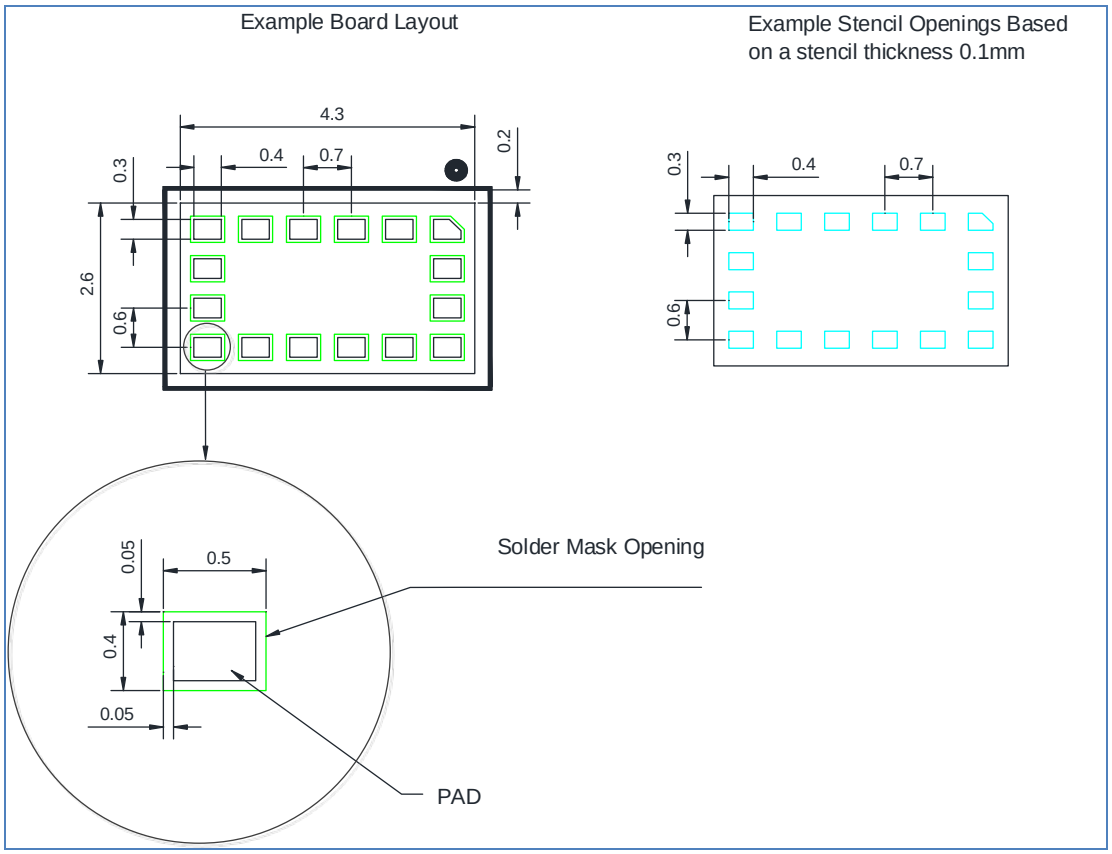


Figure 7-2 Package Design on PCB/FPC

Note:

- All dimensions are in millimeter (mm);
- The size of the pad on PCB/FPC should be identical with that on IC package; the solder mask openings on PCB/FPC should be larger than the pad for 0.05mm on each side, that is, Cu pad size=0.3 mm×0.4 mm and SR opening size=0.4 mm×0.5 mm;
- The precision of solder mask opening is required to be less than 50 μm(that is, single-side tolerance <50 μm);
- The recommended stencil opening size is 0.3 mm×0.4 mm (tolerance for length/width: ±0.02 mm); stencil thickness can range from 0.08 mm to 0.12 mm and should be adjusted according to SMT yield;
- There should be silk screen printing on PCB to mark the chip outline for the convenience of position alignment and visual inspection; the silk screen printed outline should be 0.2 mm larger than the actual chip size on each side; the PCB area right below the chip should be smooth, without any silk screen printing, in case that it affects SMT.

7.3 Package Marking

The products of the same batch feature the same marking information. The definition of the marking information is shown below.

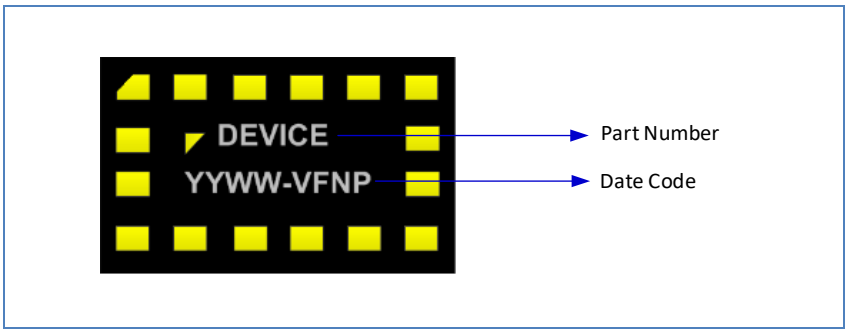


Figure 7-3 GH300 Package Marking Sample

8 Moisture Sensitivity Level (MSL)

GH300 is classified as MSL3. The detailed requirements are listed below:

1. Calculated shelf life in sealed Moisture-Barrier Bag: 12 months at <40°C and < 90% relative humidity (RH)
2. After the bag is opened, devices that will be subjected to IR reflow solder or other high temperature process (<260°C) must be
   (1) Mounted within: 168 hours of factory conditions ≤30°C/60% RH, OR
   (2) Stored at ≤10% RH (such as a dry cabinet)
3. Devices require baking before mounting, if:
   (1) Humidity indicator card is >20% when read at 23±5°C
   (2) 2(1) or 2(2) not met
4. If baking is required:
   (1) Devices shipped in low temperature carriers (such as Tape and Reel) can be baked in carriers for 192 hours at 40°C+5°C/-0°C and <5% RH.
   (2) Devices shipped in high temperature carriers (such as Tray) can be baked in carriers for 8 hours at 125°C +5/-0°C.
   (3) After baking, device should be put into the Moisture-Barrier Bag right after it cools down. Device shipped in low temperature carriers (such as Tape and Reel) should be packed inside the bag along with at least 5g desiccant and a six-spot humidity indicator card; Device shipped in high temperature carriers (such as Tray) should be packed inside the bag along with at least 10g desiccant and a six-spot humidity indicator card. Each bag should be vacuumized and sealed

9 SMT Requirements

9.1 Pb-Free Reflow Temperature Profile

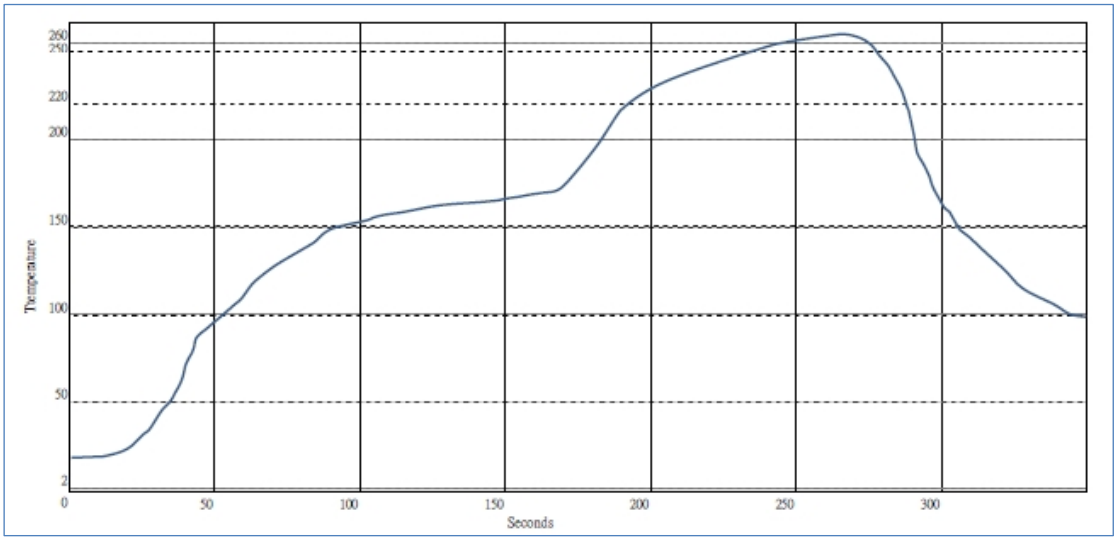


Figure 9-1 Pb-Free Reflow Temperature Profile

GH300 follows the standard J-STD-020D-01 and more particularly these parameters:

Table 9-1 Pb-Free Reflow Temperature Profile Parameters

Zone	**Pb-Free Assembly (For reference)**		
A. Pre-heating zone (25°C - 150°C)	Pre-Heating Duration	80s -120s	The IC cannot stay in the oven for more than 8 minutes.
	Ramp Up Rate	<3°C/s	
B. Constant-Temperature zone (150°C - 200°C)	Constant-Temperature Duration	60s - 120s (100s is recommended)	
	Ramp Up Rate	<1°C/s	
C. Reflow Zone	Reflow Temperature	>217°C	
	Reflow Duration	60s - 150s	
	Ramp Up Rate	<3°C/s	
	Peak Temperature	230 - 255°C	
D. Cooling Zone	Ramp Down Rate 1（~217°C）	<6°C/s	
	Ramp Down Rate 2（<217°C）	1°C/s - 3°C/s	

Please follow the standard “J-STD-020D-01”.

Caution:

- The peak temperature in the oven cannot exceed 260°C (please refer to the reflow temperature profile of the specific solder paste) ; the temperature tolerance of the IC package material is less than 260°C, therefore , the SMT temperature must be lower than 260°C;
- Rework is not recommended; if rework is inevitable, please do not use heat gun or soldering iron; rework station is recommended and please make sure the temperature is lower than 260°C;
- Number of Thermal shocks: Number of soldering (Reflow solder + Wave Solder +Rework) passes: ≤ 3

9.2 Requirements on SMT Equipment

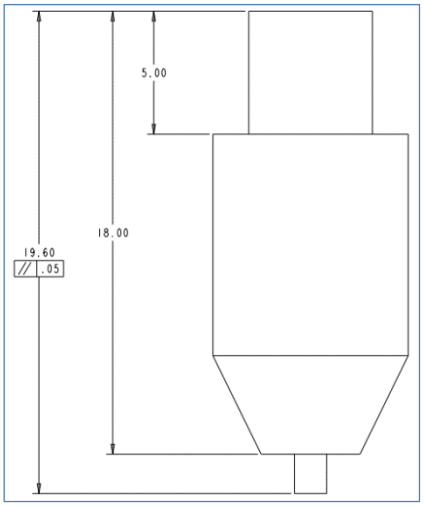
1. The chip mounter should be able to identify the pad location and offset tolerance (generally, the offset tolerance should be less than 50 μm; the chip must be located by identifying the pads on the bottom of the chip instead of identifying the chip outline); X-Ray inspection equipment is used to check the component's height after surface mount (relative to the PCB/FPC surface) and alignment accuracy.
2. It is recommended that specialized fixture should be adopted to ensure the flatness of FPC (magnetic fixture is preferred);
3. Manual printer is not recommended (fully-automatic printer is recommended and the automatic printer should be able to identify the mark on PCB/FPC); first piece inspection is required in printing.

9.3 Requirements on Solder Paste

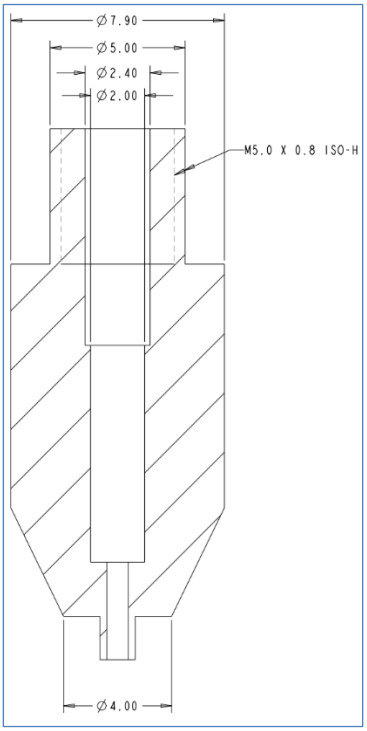
The solder paste is unspecified. Any Pb-free solder paste that has been used in successful mass production is applicable (SAC305 is recommended).

9.4 Requirements on Nozzle

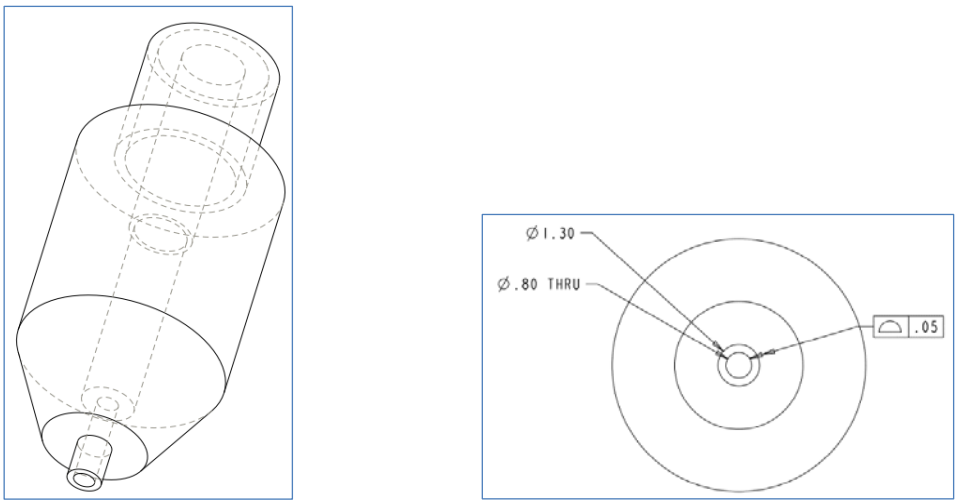
It is recommended that circular nozzle should be adopted. The parameters of the nozzle are shown below (the nozzle is made of anti-static rigid material). Please refer to the figure below for the specific dimensions.



TOP VIEW



SIDE VIEW (SECTION S-S)



TOP ISO VIEW FRONT VIEW

Figure 9-2 Reference Design of Nozzle

Picking position: Please refer to the figure below; the nozzle should pick the lid (in the center).

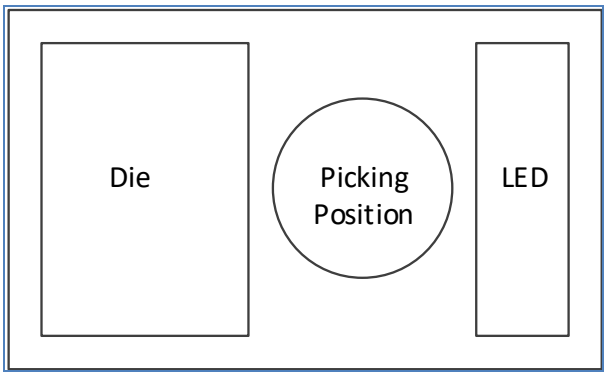


Figure 9-3 Picking Position

Caution：

The nozzle may be contaminated after picking the lid; therefore, the nozzle should be checked or replaced periodically.

10 Legal and Contact Information

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11 Revision History

Version	Date	Description
0.1	2018-07-04	Preliminary version
0.2	2018-08-01	Preliminary version • Updated IC system block diagram; • Added description on LED in section 2.4; • Added section 3 “Power Management and Reset” ; • Updated electrical characteristics.
0.3	2018-9-28	Preliminary version • Updated pin definition; • Updated communication interface verification guidelines; • Updated DC characteristics.
1.0	2019-01-10	Initial Release • Modified pin definition; • Added Sleep mode power consumption and SPI/IIC timing parameters; • Updated system block diagram; • Updated electrical characteristics; • Added requirement on green LED drive current; • Added requirement on power supply noise; • Optimized some descriptions.
1.1	2019-03-20	• Modified tolerance of chip thickness; • Deleted description on Bluetooth.
1.2	2019-05-17	• Added requirements on pad design and SMT design; • Modified Overview and Features.
1.3	2020-03-06	Updated the document format as required