



# YAS530

PRELIMINARY
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## MS-3E

### Magnetic Field Sensor Type 3E

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#### ■ Overview

The YAS530 is the 3-axis geomagnetic sensor device with the following circuits integrated on one chip: a buffer amplifier, an AD converter, a clock generator circuit, and a serial data interface circuit (compliant with I<sup>2</sup>C bus interface).

The YAS530 allows a compact electronic compass with high sensitivity and low power consumption in mobile phones or mobile GPS systems.

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# YAMAHA CORPORATION

YAS530 Catalog
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CATALOG No. LSI-4AS530A01
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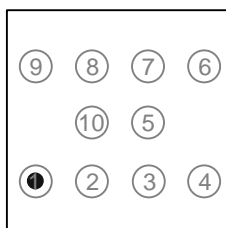
## ■ Features

- 3-axis magnetic sensors and peripheral circuits integrated on one chip
- High sensitivity geomagnetic sensors
- Supports the I<sup>2</sup>C bus interface (100kbps/400kbps, slave mode)
- Small footprint with the small-sized package
- Automatic power-down control after the acquisition, and low-power consumption
- Reduced communication load with a host controller via deferred acquisition and interrupt outputs

Package	10-ball WLCSP (YAS530-PZ)	
Size	2mm × 2mm	
Power Supply	Core supply voltage (VDD)	2.5V to 3.6V
	Digital interface supply voltage (IOVDD)	1.65V to VDD
Operating temperature	-40°C to +95°C	
Consumption current	4mA (VDD=3.0 V, during the acquisition)	
Magnetic Sensor	Manufacturing process	CMOS + Magnetic Sensor
	Measurable magnetic field range	±800 μT
	Magnetic field sensitivity (X, Y)	0.15 μT/count
	Magnetic field sensitivity (Z)	0.3 μT/count
	Acquisition Time	1.5 ms (Magnetic sensor acquisition + Temperature acquisition)

## ■ Pin Assignments

The figure below shows the pin assignment and its description:



< 10-pin WLCSP Top View >

Pin No.	Pin Name	I/O	Function
1	INT	O	Interrupt output pin
2	VSS	-	GND
3	TEST1	I	Be sure to connect to VSS.
4	TEST2	I	Be sure to connect to VSS.
5	TEST3	I	Be sure to connect to VSS.
6	VDD	-	Core power supply (Typ. 3V)
7	SDA	I/Od	Serial data
8	SCL	I	Serial clock
9	IOVDD	-	Interface power supply (Typ. 1.8V)
10	RSTN	Is	Device initialization

I : Digital input

Is : Schmitt trigger input

Od : Open-drain output

O : Output

## ■ Pin Descriptions

- Power supply pins (VDD, IOVDD, VSS)

These are power supply pins:

- VDD : Core power supply (Typ. 3.0V)
- IOVDD : Interface power supply (Typ. 1.8V)
- VSS : GND

- Interface pins (SCL, SDA, RSTN, INT)

SCL : Serial clock input pin

Pull up this pin externally.

SDA : Serial data input and output pin

Pull up this pin externally.

RSTN : Device initialization pin

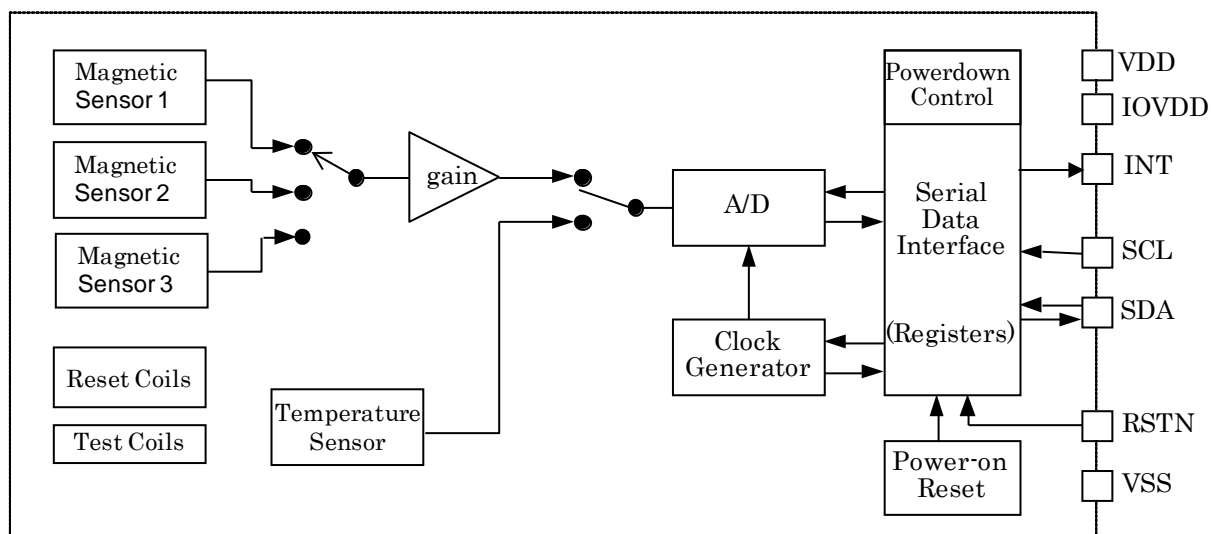
A low level releases the I<sup>2</sup>C bus and resets the internal circuit.

Connect to IOVDD pin when not used.

INT : Interrupt output pin. An interrupt signal is sent through this output pin when the acquisition is completed. The config register can select either a high or low output level.

Leave this pin open when not used.

## ■ Block Diagram



YAS530 Block Diagram

- **Magnetic Sensor**

Three magnetic sensors are on the chip.

The supply voltage is supplied to only the sensor corresponding to the axis to be measured.

- **Buffer Amplifier**

The buffer amplifier, operating only when measuring the magnetic field, amplifies the magnetic sensor output.

- **Temperature Sensor**

The temperature sensor, operating only when measuring the temperature, can be used to compensate for the temperature characteristics of the sensor.

- **A/D Converter (ADC)**

The ADC, operating only when measuring the magnetic field, transforms the magnetic sensor output amplified with the buffer amplifier or the temperature sensor output, to the digital form.

- **Clock Generator**

The clock generator, operating only when measuring the magnetic field or the temperature, supplies clocks to the ADC and the digital circuits.

- **Power-on Reset Circuit**

The power-on reset circuit detects the ramp-up of the core supply voltage and resets the internal circuit.

- **Reset Coils**

The Reset coils are used to restore the function of a damaged magnetic sensor because of the high magnetic field received.

Generating magnetic field with the reset coils restores the magnetic sensor characteristics.

- **Serial Data Interface**

The YAS530 serial data interface is compliant with I<sup>2</sup>C bus interface and operates in slave mode.

Data are transferred via the following pins:

SCL— Serial clock input pin

SDA— Serial data input and output pin

## ■ Electrical Characteristics

### ● Absolute Maximum Ratings

Item	Symbol	Min.	Typ.	Max.	Unit
Core Supply Voltage	VDD	-0.3		4.2	V
Interface Supply Voltage	IOVDD	-0.3		4.2	V
Digital Input Pin Voltage (SCL, SDA, RSTN)	VIND	-0.3		IOVDD+0.3	V
Storage Temperature	Tstg	-50		125	°C
Maximum Applicable Magnetic Field	Hmax			400	mT

### ● Recommended Operating Conditions

Item	Symbol	Min.	Typ.	Max.	Unit
Core Supply Voltage	VDD	2.5	3.0	3.6	V
Interface Supply Voltage	IOVDD	1.65	1.8	VDD	V
Operating Ambient Temperature	Top	-40	25	95	°C

### ● Consumption Current

Item	Min.	Typ.	Max.	Unit
Standby Current (TOP=25°C, SCL=SDA= IOVDD=VDD=3.6V,RSTN=VDD)			1	μA
Standby Current (TOP=95°C, SCL=SDA= IOVDD=VDD=3.6V,RSTN=VDD)			10	μA
IOVDD Current Consumption during communication		TBD		μA
VDD Current Consumption during magnetic field acquisition * See Note.		4.0		mA
VDD Current Consumption during temperature acquisition * See Note.		1.6		mA
VDD Current Consumption (reset coil is ON)		50		mA

Note) After the acquisition the device automatically powers down to enter the standby state.

- **Magnetic Sensor Characteristics**

(Conditions: TOP = 25°C, VDD = 3.0 V)

Item	Min.	Typ.	Max.	Unit
Maximum Measurable Magnetic Field		±800		μT
Magnetic Field Sensitivity (X,Y)		0.15	0.3	μT/count
Magnetic Field Sensitivity (Z)		0.3	0.5	μT/count
Sensitivity Axis Deviation			±5	deg

Note) Y and Z sensitivities are for Y1-Y2 and Y1+Y2, respectively. And, the sensitivity axis deviation is for the value corrected with CAL register values. For details, see the application manual.

- **Temperature Sensor Characteristics**

(Conditions: VDD = 3.0 V)

Item	Min.	Typ.	Max.	Unit
Temperature Acquisition Range	-40		95	°C
Temperature Resolution		0.45		°C/count

- **Acquisition Time**

(Conditions: see "Recommended Operating Conditions")

Item	Min.	Typ.	Max.	Unit
Acquisition Time		1.5	2	ms



## ● DC Characteristics

### Serial Data Interface SCL, SDA

(Conditions: see “Recommended Operating Conditions”)

Item	Symbol	Min.	Max.	Unit
“L” level input voltage	$V_{IL}$	-0.3	$0.3 \times IOVDD$	V
“H” level input voltage	$V_{IH}$	$0.7 \times IOVDD$	$IOVDD + 0.3$	V
“L” level output voltage (sink current 3mA)	$V_{OL}$	0	$0.2 \times IOVDD$	V
Output Falling Time (from $V_{IHmin}$ to $V_{ILmax}$ )	$t_{of}$	$20 + 0.1 \times C_b$	250	ns
Input Current of each I/O pin at input voltage of $0.1 \times IOVDD - 0.9 \times IOVDD$	$I_i$	-1	1	$\mu A$
Capacitance of each I/O pin	$C_i$		10	pF

$C_b$ : capacitance of one bus line (pF)

### Reset Circuit RSTN

(Conditions: see “Recommended Operating Conditions”)

Item	Symbol	Min.	Typ.	Max.	Unit
“L” level input voltage	$V_{IL}$	-0.3		$0.2 \times IOVDD$	V
“H” level input voltage	$V_{IH}$	$0.8 \times IOVDD$		$IOVDD + 0.3$	V
Schmitt Width	$V_{SH}$		$0.1 \times IOVDD$		V
Input Leakage Current	$I_i$	-1		1	$\mu A$
Input Capacitance	$C_i$			10	pF

### Interrupt Output INT

(Conditions: see “Recommended Operating Conditions”)

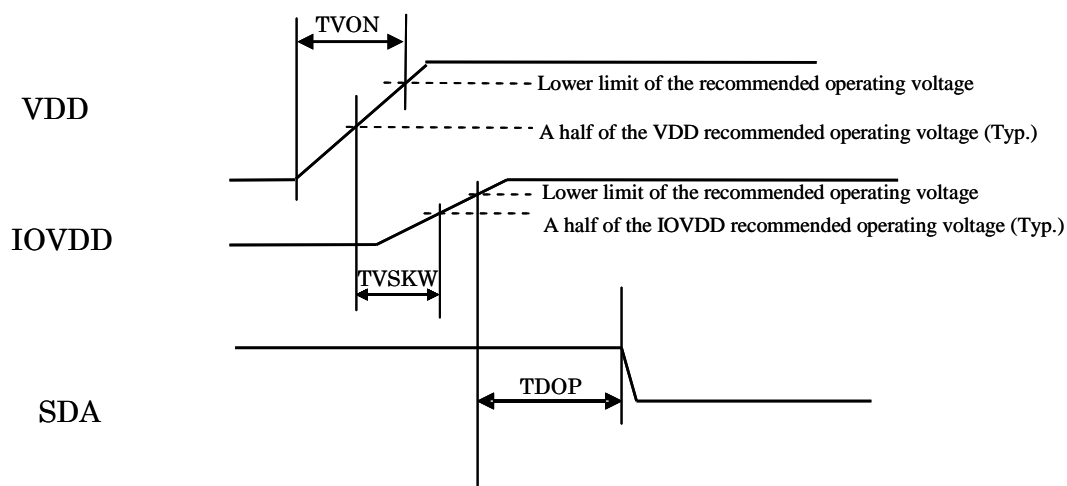
Item	Symbol	Min.	Typ.	Max.	Unit
“L” level output voltage ( $I_{OL} = 1\text{mA}$ )	$V_{OL}$			$0.2 \times IOVDD$	V
“H” level output voltage ( $I_{OH} = -1\text{mA}$ )	$V_{OH}$	$0.8 \times IOVDD$			V

## ● AC Characteristics

The table below shows the rules on the power supply power-on sequence.

(Conditions: see “Recommended Operating Conditions”)

Item	Symbol	Min.	Max.	Unit
Power Supply Ramp Up Time	TVON		0.5	ms
Time from when VDD reaches a half of its recommended operating voltage (Typ.) till when IOVDD reaches a half of its recommended operating voltage (Typ.)	TVSKW	0	30	ms
Time from when all the power supplies are completely powered up till when the device circuitry is initialized	TDOP	1		ms

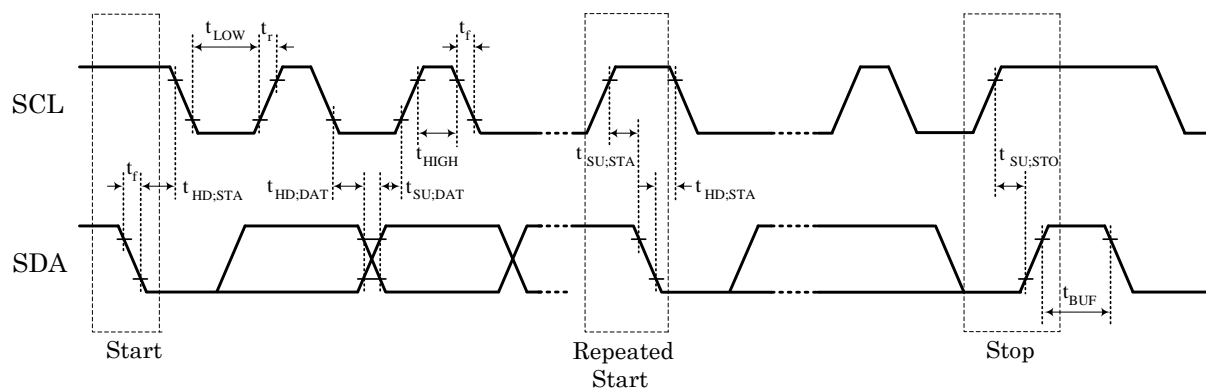


**Initialization Sequence**

## Serial Data Interface SCL, SDA

(Conditions: see “Recommended Operating Conditions”)

Item	Symbol	Min.	Max.	Unit
SCL Clock Frequency	$f_{SCL}$	0	400	kHz
Hold Time (repeat) Start Condition	$t_{HD:STA}$	0.6		$\mu$ s
SCL Clock “L” Time	$t_{LOW}$	1.3		$\mu$ s
SCL Clock “H” Time	$t_{HIGH}$	0.6		$\mu$ s
Setup Time of the repeat start conditions	$t_{SU:STA}$	0.6		$\mu$ s
Data Hold Time	$t_{HD:DAT}$	0	0.9	$\mu$ s
Data Setup Time	$t_{SU:DAT}$	0.1		$\mu$ s
SDA and SCL signals rise time (input)	$t_r$		300	ns
SDA and SCL signals fall time (input)	$t_f$		300	ns
SDA signal fall time (output)	$t_f$	$20+0.1 \times C_b$	300	ns
Stop Condition Setup Time	$t_{SU:STO}$	0.6		$\mu$ s
Bus Free Time between stop and start conditions	$t_{BUF}$	1.3		$\mu$ s
SDA and SCL Capacitive Load	$C_b$		400	pF



## Serial Data Interface Timing Specification

## [Notes]

- YAS530 serial data interface is compliant to I<sup>2</sup>C bus as far as described in this document.
- No schmitt trigger circuits are used.
- Spike noise with the width of about 50ns can be suppressed.

Reset Circuit RSTN

(Conditions: see "Recommended Operating Conditions")

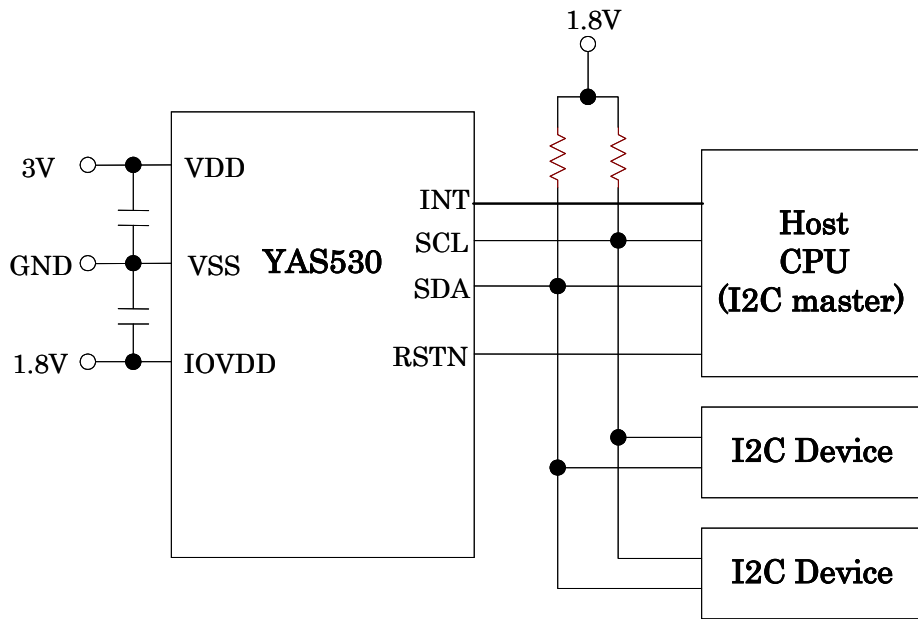
Item	Symbol	Min.	Max.	Unit
Reset "L" pulse width	$t_{RSTW}$	2.5		$\mu\text{s}$

## ■ System Configuration Examples

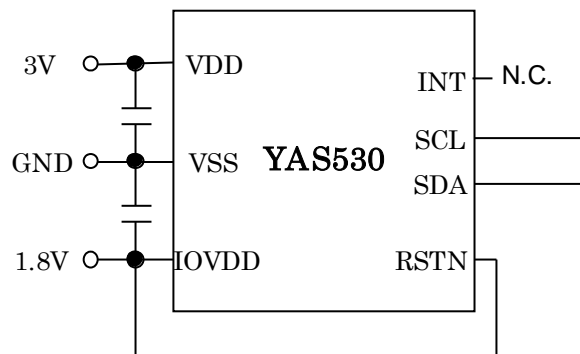
The figures below show examples of the system configuration.

When the RSTN pin is not used, connect the pin to the IOVDD pin.

When the INT pin is not used, leave it open.



Example 1 (RSTN and INT pins used)



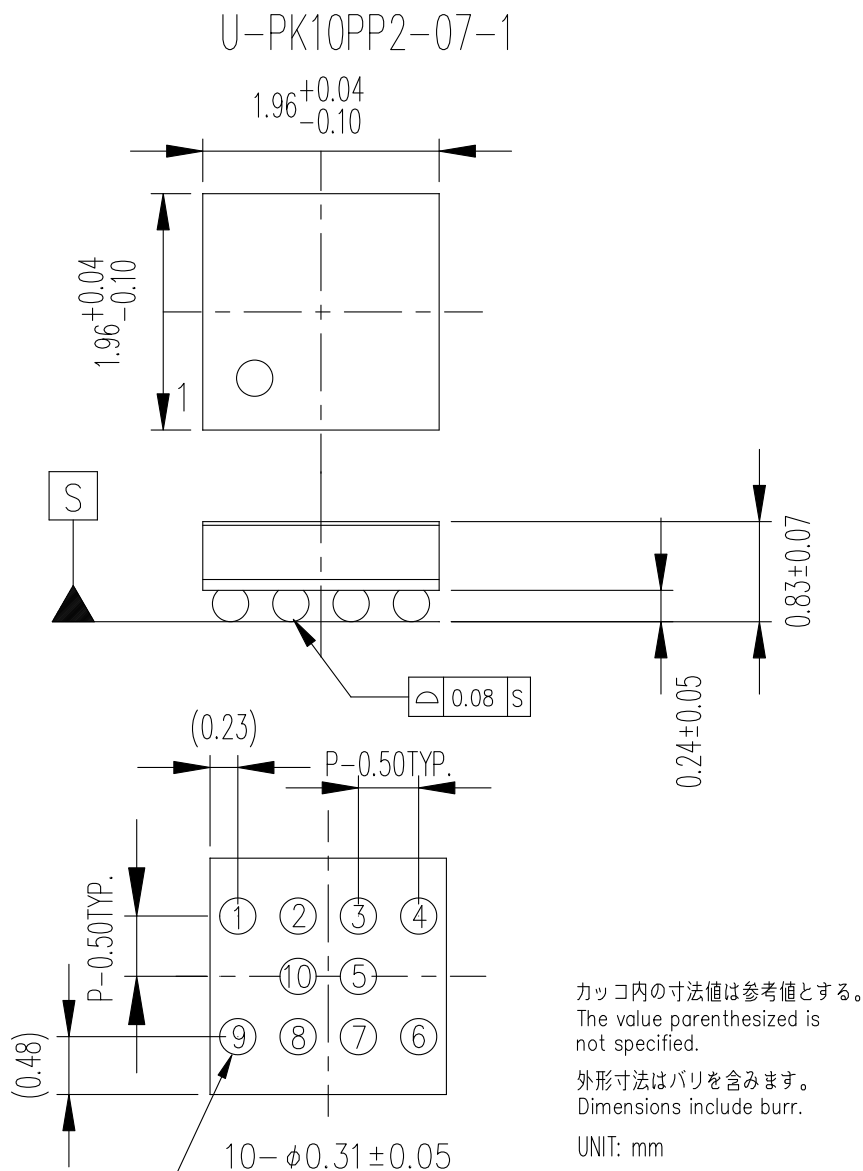
Example 2 (RSTN and INT pins not used)

## ■ Package Information

### Caution

The product of the WLCSP package should be used under light-shielded conditions.

Since the WLCSP package has a structure that a silicon wafer is exposed, if light (such as sunlight) hits the wafer, the device may malfunction (leak current increase etc.) due to electric charge internally generated by the photoelectric effect.



- 注) 1. 表面実装LSIは、保管条件、および、半田付けについての特別な配慮が必要です。  
2. 組立工場により、寸法や形状などが異なる場合があります。  
詳しくはヤマハ代理店までお問い合わせください。

- Note: 1. Special attention needs to be paid to the storage conditions and soldering method of the surface mount IC.  
2. Dimension, form, etc. may differ depending on assembly plants.  
For details, please contact your local Yamaha agent.

## ■ Cautions for use of the surface mount package

### 使用上の注意 / Precaution for soldering

WLCSP パッケージ下面の半田端子(ボール)を溶融して、半田付け実装してください。また、製品耐熱性を考慮して、パッケージ本体の表面温度管理を行ってください。具体的な使用条件は下記をご参照ください。

Dissolve the solder terminal (ball) of WLCSP package undersurface and carry out solder mounting. Moreover, control the temperature of package surface in consideration of product heat resistance. Refer to the following for the concrete handling condition.

### 1. 実装までの保管 / Storage before soldering

吸湿及び端子の酸化を避けるため、実装するまでは出来るだけ乾燥した雰囲気中に保管してください。推奨条件は下記のとおりです。

Store the products in the environment which is as dry as possible to prevent moisture absorption and oxidation of terminal, until soldering. We recommend the following conditions.

温度 / Temperature	5~30° C / 5° C to 30° C
湿度 / Humidity	70%RH.以下 / Less than 70% RH.

### 2. 防湿梱包開封後の取り扱い / Handling after the dry packing bag is opened

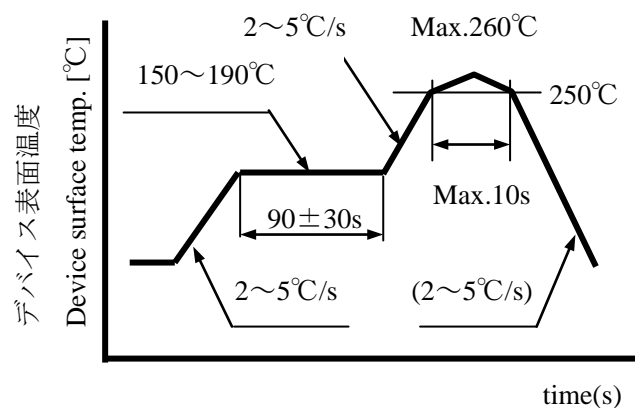
開封後は吸湿および端子底面の酸化を避けるため、上記環境条件下にて保管し、リフロー半田付け実装してください。

開封後に再保管される場合、シリカゲルを入れ再度密封の上、上記環境条件下で保管くださるか、またはドライボックスで保管ください。(耐湿レベルは J-STD-020A LEVEL1 を有しております。)

Store in accordance with the condition described above to avoid moisture absorption and the oxidation of terminal after opening the dry packing, and carry out reflow soldering. If stored again after opening, insert silica gel and seal it once more and store under the conditions described above, or in a dry box. (J-STD-020A : MSL LEVEL1)

### 3. 半田付け条件 / Soldering conditions

(1)フローソルダリング Wave soldering	当該パッケージはフロー半田（ディップ）法に適応していません。 (This package is not suitable for wave soldering. (Dipping) )
(2)リフローソルダリング Reflow soldering	推奨温度プロファイル例（fig.1）参照願います。 *デバイス表面温度はMax.260° Cでリフロー回数は3回までとしてください。 (Refer to Fig1 for an example of recommended temperature profile. *Device surface temp. is allowed Max.260° C and 3 times. )
(3)手半田付け Manual soldering	当該製品は手半田付けに適応していません。 高温な半田ごてが近づくと特性に影響を与える可能性があります。 (This product is not suitable for manual soldering. Since hot solder iron is close to this product, the performance may change. )



**Fig.1 Reflow soldering recommended temperature profile**






### 4. アンダーフィル / Underfill










アンダーフィルを行うと温度補正が正常に行われず可能性がありますのでアンダーフィル無しで実装してください。

Since temperature compensation may not be performed normally when under-fill is made while mounting WLCSP on a board, please mount it without under-fill.



**PRECAUTIONS AND INSTRUCTIONS FOR SAFETY**

 <b>WARNING</b>	
 Prohibited	<p>Do not use the device under stresses beyond those listed in Absolute Maximum Ratings. Such stresses may become causes of breakdown, damages, or deterioration, causing explosion or ignition, and this may lead to fire or personal injury.</p>
 Prohibited	<p>Do not mount the device reversely or improperly and also do not connect a supply voltage in wrong polarity. Otherwise, this may cause current and/or power-consumption to exceed the absolute maximum ratings, causing personal injury due to explosion or ignition as well as causing breakdown, damages, or deterioration.</p> <p>And, do not use the device again that has been improperly mounted and powered once.</p>
 Prohibited	<p>Do not short between pins.</p> <p>In particular, when different power supply pins, such as between high-voltage and low-voltage pins, are shorted, smoke, fire, or explosion may take place.</p>
 Instructions	<p>As to devices capable of generating sound from its speaker outputs, please design with safety of your products and system in mind, such as the consequences of unusual speaker output due to a malfunction or failure. A speaker dissipates heat in a voice-coil by air flow accompanying vibration of a diaphragm. When a DC signal (several Hz or less) is input due to device failure, heat dissipation characteristics degrade rapidly, thereby leading to voice-coil burnout, smoking or ignition of the speaker even if it is used within the rated input value.</p>

 <b>CAUTION</b>	
 Prohibited	<p>Do not use Yamaha products in close proximity to burning materials, combustible substances, or inflammable materials, in order to prevent the spread of the fire caused by Yamaha products, and to prevent the smoke or fire of Yamaha products due to peripheral components.</p>
 Instructions	<p>Generally, semiconductor products may malfunction and break down due to aging, degradation, etc. It is the responsibility of the designer to take actions such as safety design of products and the entire system and also fail-safe design according to applications, so as not to cause property damage and/or bodily injury due to malfunction and/or failure of semiconductor products.</p>
 Instructions	<p>The built-in DSP may output the maximum amplitude waveform suddenly due to malfunction from disturbances etc. and this may cause damage to headphones, external amplifiers, and human body (the ear). Please pay attention to safety measures for device malfunction and failure both in product and system design.</p>
 Instructions	<p>As semiconductor devices are not nonflammable, overcurrent or failure may cause smoke or fire. Therefore, products should be designed with safety in mind such as using overcurrent protection circuits to control the amount of current during operation and to shut off on failure.</p>
 Instructions	<p>Products should be designed with fail safe in mind in case of malfunction of the built-in protection circuits. Note that the built-in protection circuits such as overcurrent protection circuit and high-temperature protection circuit do not always protect the internal circuits. In some cases, depending on usage or situations, such protection circuit may not work properly or the device itself may break down before the protection circuit kicks in.</p>
 Instructions	<p>Use a robust power supply.</p> <p>The use of an unrobust power supply may lead to malfunctions of the protection circuit, causing device breakdown, personal injury due to explosion, or smoke or fire.</p>
 Instructions	<p>Product's housing should be designed with the considerations of short-circuiting between pins of the mounted device due to foreign conductive substances (such as metal pins etc.). Moreover, the housing should be designed with spatter prevention etc. due to explosion or burning. Otherwise, the spattered substance may cause bodily injury.</p>
 Instructions	<p>The device may be heated to a high temperature due to internal heat generation during operation. Therefore, please take care not to touch an operating device directly.</p>

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