Yamaha LSI Specifications

Device Name: YAS539-PZE2

Specification No.: Reference

Please indicate your receipt by providing the name, position, and signature of the person in charge.

Ref. Mark	Revised On:	Cause for Revision	Approved
-			

Note:

1. We issue * copies of this specification, please return * copies out of them (for Yamaha or Agent) after putting your reception signature.
2. If you would like us to change the contents of the specifications, please contact us within 30 days after the reception.
   We consider a possibility that we can respond.
3. The contents of the specifications may change with notice due to the future improvement.

Yamaha Stamp

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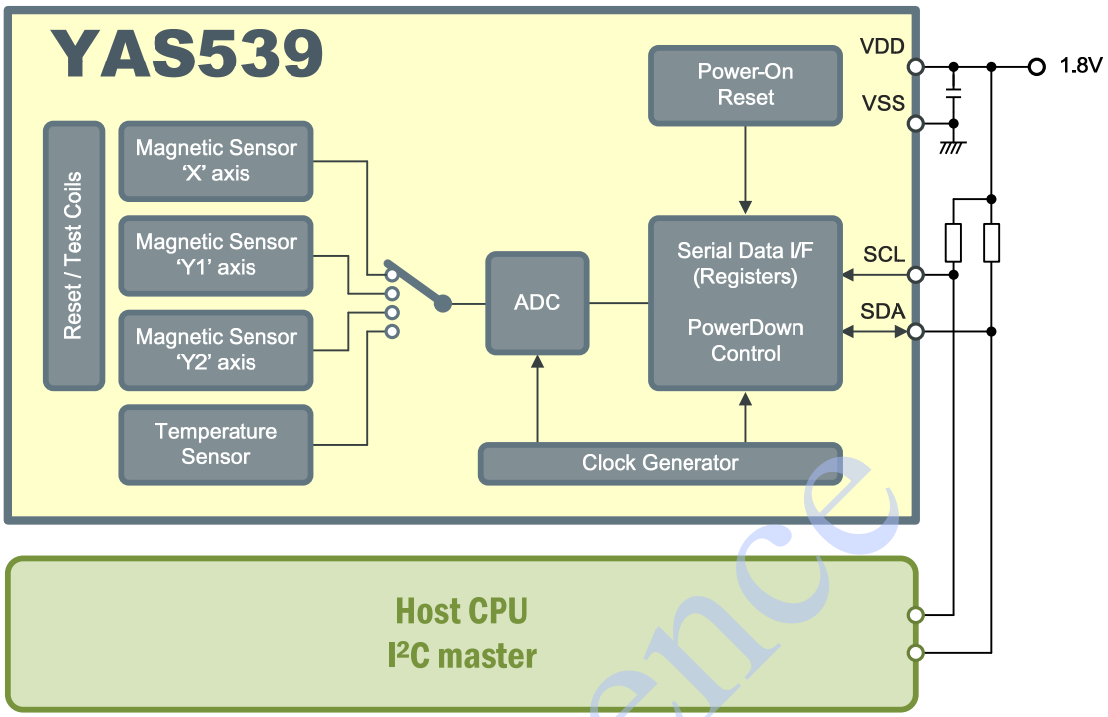
Approved	Checked	Checked

1. Basic Specifications

1. Device Name : YAS539-PZE2
2. Function : YAS539 (MS-3S) chip integrates a three axis magnetometer with processing circuits with I2C bus interface to report processed, ready-to-use geomagnetic field intensity values to the host.
3. Application : Compass for Mobile phone, Portable GPS system, and so on
4. Production process : Si-Gate CMOS process + Magnetic Sensor
5. Package : 4-ball WLCSP package (Lead-free solder ball)

2. Block Diagram



Magnetic Sensor
YAS539 has magnetic sensors.

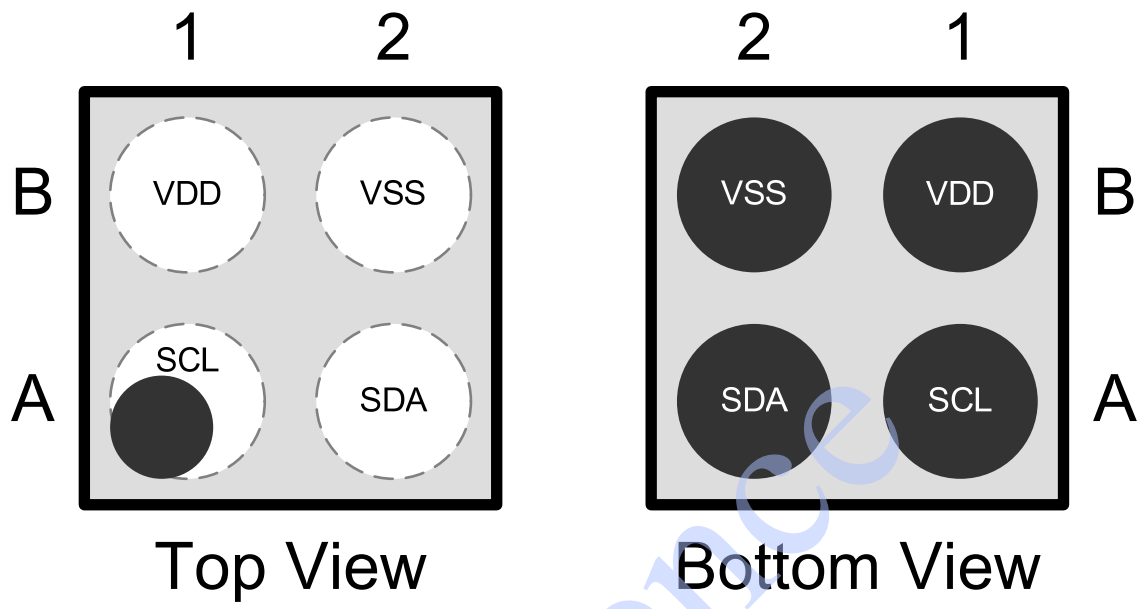
Temperature Sensor
Temperature sensor element is used to correct magnetometer outputs for temperature variations.

A/D Converter
Analog to digital converter digitizes magnetometer and temperature sensor output signals.

Clock Generator
On chip clock generator generates and provides clock signals to internal circuits.

3. Pin Descriptions

Pin Arrangement



4 pin WLCSP

Pin Descriptions

Ball No.	Name	I/O	Description
1A	SCL	Is	I2C serial clock
1B	VDD	-	Power (1.8 V typ.)
2A	SDA	Is/Od	I²C serial data
2B	VSS	-	Ground

Is : Schmitt trigger input
Od : Open-drain outpu

4. Electrical Characteristics

● Absolute Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Unit
Supply Voltage (VDD)	V_{VDD}	−0.3		2.5	V
Digital Input Pin Voltage (SCL, SDA)	V_{IND}	−0.3		2.5	V
Storage Temperature	T_{stg}	−50		125	°C
Maximum Applicable Magnetic Field Intensity	H_{max}			500	mT

● Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Supply Voltage (VDD)	V_{VDD}	1.65	1.8	1.95	V
Operating Ambient Temperature	T_{OP}	−40	25	85	°C

Note: The above operating conditions do not always ensure data sampling accuracy.
In an actual application, the ambient magnetic environment may vary with changes in temperature and affect data sampling accuracy.

● Operating Current

Parameter	Min.	Typ.	Max.	Unit
Standby current(T_{OP} = 25°C, SCL = SDA = VDD = 1.95 V)			1.5	µA
Standby current(T_{OP} = 85°C, SCL = SDA = VDD = 1.95 V)			15	µA
Current drawn during standby (periodic sampling)		10		µA
Current drawn during magnetometer data sampling (See Note 1.)		2.5		mA
Current drawn during temperature data sampling (See Note 1.)		1.5		mA
Current averaged during periodic sampling (Default configuration, VDD = 1.8 V, 100 sample/s)		280		µA
Current averaged during periodic sampling (See Note 2.) (Low current configuration, VDD = 1.8 V, 100 sample/s)		160		µA
Current during activating reset coils		95		mA

Note 1: After data sampling, the device automatically powers down to enter the standby state.
Note 2: See 9.2.6. AVRR: Averaging Filter for further information.

● Magnetic Sensor Characteristics

(Conditions: T_{OP} = 25°C, VDD = 1.8 V)

Parameter		Min.	Typ.	Max.	Unit
Maximum measurable magnetic field intensity	(See Note 1.)	-	2000	-	µT
Magnetic field sensitivity (X, Y, Z)	(See Note 2.)	-	0.15	0.3	µT / LSB
Sensitivity axis deviation	(See Note 3.)	-	-	±5	deg

Note 1: This value assumes Yamaha device driver is used.
Note 2: Y sensitivity is for (Y1 − Y2) / √3 , and Z sensitivity for −Y1 − Y2.
Note 3: The sensitivity axis deviation is for the value corrected with CAL register values without magnetic fields.

4. Electrical Characteristics

● Data Sampling Time

(Conditions: T_{OP} = 25°C, VDD = 1.8 V)

Parameter	Min.	Typ.	Max.	Unit
Data Sampling Time	-	1.10	1.21	ms
On-chip oscillator frequency tolerance			±10	%

* The sampling time assumes registers have initial values, and varies depending on what value registers have.

● DC Characteristics

(For operation under *Recommended Operating Conditions*)

Parameter	Symbol	Min.	Max.	Unit
"L" level input voltage	V_{IL}	−0.3	0.3 × V_{VDD}	V
"H" level input voltage	V_{IH}	0.7 × V_{VDD}	V_{VDD} + 0.3	V
Hysteresis voltage width (SCL, SDA)	V_{SH}	0.1 × V_{VDD}		V
"L" level output voltage (sink current 3 mA)	V_{OL}	0	0.2 × V_{VDD}	V
Input leakage current at the input voltage ranging from 0.1 ×VVDD to 0.9 × VVDD	I_i		±1	µA
I/O pin static capacitance	C_i		10	pF

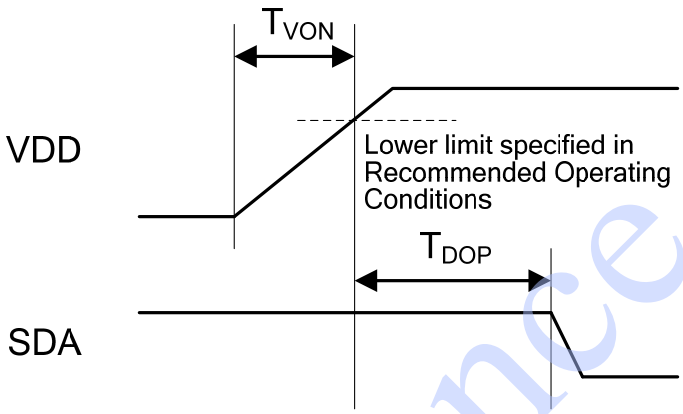
4. Electrical Characteristics

● AC Characteristics

Power Supply Timing

(For operation under *Recommended Operating Conditions*)

Parameter	Symbol	Min.	Max.	Unit
Power supply ramp up time (VDD)	T_{VON}	0.01	50	ms
Time taken from when VDD gets valid to when I2C gets ready	T_{DOP}	-	4	ms



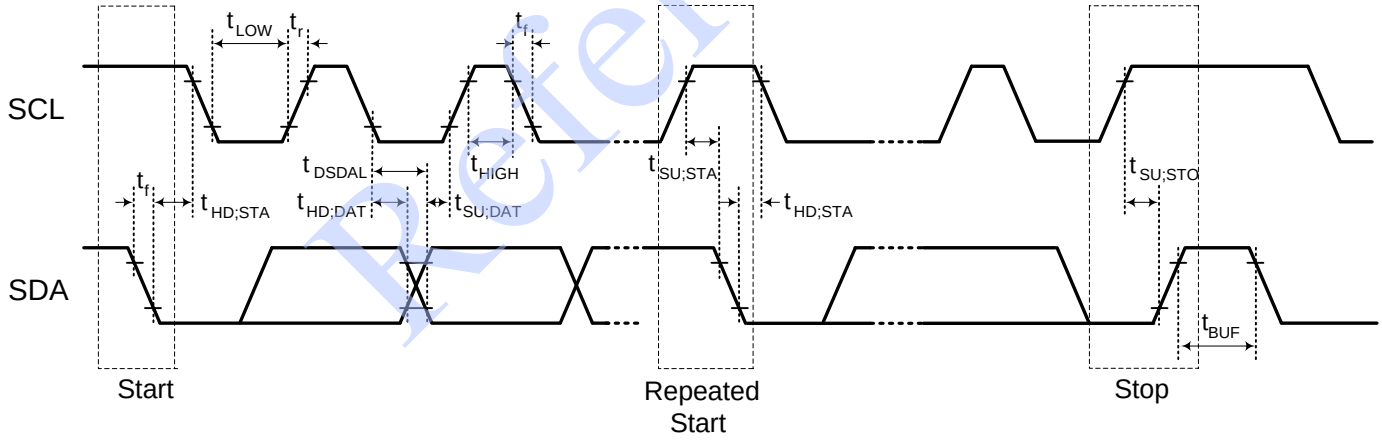
Power-Up Sequence Examples

4. Electrical Characteristics

Serial Data Interface: SCL, SDA

(For operation under *Recommended Operating Conditions*)

Parameter	Symbol	Min.	Max.	Unit
Input Conditions				
SCL clock frequency	f_{SCL}	0	400	kHz
(Repeated) START bit hold time	$t_{HD;STA}$	0.6		µs
SCL clock "L" time	t_{LOW}	1.3		µs
SCL clock "H" time	t_{HIGH}	0.6		µs
Repeated START bit setup time	$t_{SU;STA}$	0.6		µs
Data hold time	$t_{HD;DAT}$	0	0.9	µs
Data setup time	$t_{SU;DAT}$	0.1		µs
SDA or SCL signal rise time	t_r		300	ns
SDA or SCL signal fall time	t_f		300	ns
STOP bit setup time	$t_{SU;STO}$	0.6		µs
Bus free time between STOP and START bits	t_{BUF}	1.3		µs
SDA and SCL capacitive load	C_b		400	pF
Output Conditions				
SDA fall delay time	t_{DSDAL}		1.15	µs
Data output hold time	$t_{HD;DAT}$	0	0.9	µs



Serial Data Interface Timing.

- **YAS539 serial data interface is compliant to I²C as much described in this document.**
- **The circuit tolerates spike noise of up to about 50 ns.**

5. Function Overview

YAS539 (MS-3S) chip integrates a three axis magnetometer with processing circuits with I2C bus interface to report processed, ready-to-use geomagnetic field intensity values to the host.

The chip features high sensitivity, low noise magnetic field sensor elements which works with lower voltage across the sensing bridge circuit, allowing single 1.8 V operation. Like our previous generation devices, the chip samples magnetic field periodically in a short time and then goes into power down state by itself, but when coupled with its lower voltage operation, achieves further power saving compared to them.
Packaged in 0.97 mm × 0.97 mm WLCSP, one of the smallest on the market, and less area required as fewer additional discrete components thanks to the single supply operation, the chip as well improves system footprint over the previous devices.

The chip provides averaging filter for low noise sampling while keeping power consumption low and supports periodic data sampling, allowing flexible configurations for various applications.
On-chip memory contains sensor element errors found at chip factory which can be used to effortlessly reduce errors.
YAS539 chip thus makes a compact, feature-rich electronic compass part with high sensitivity and low power consumption for mobile phone and GPS applications.

- Three-axis magnetometer and processing circuits in one package
- Geomagnetic field sensor elements superior sensitivity and higher S/N ratio
- Small sized package
- 1.8 V single power supply operation with minimum external component counts
- Automatic power-down controls
- Low power consumption
- Autonomous periodic sampling (sampling and processing data at set time intervals)
- Configurable averaging filters for reducing noise level and saving power
- I2C bus interface (100 kbps / 400 kbps, slave mode)

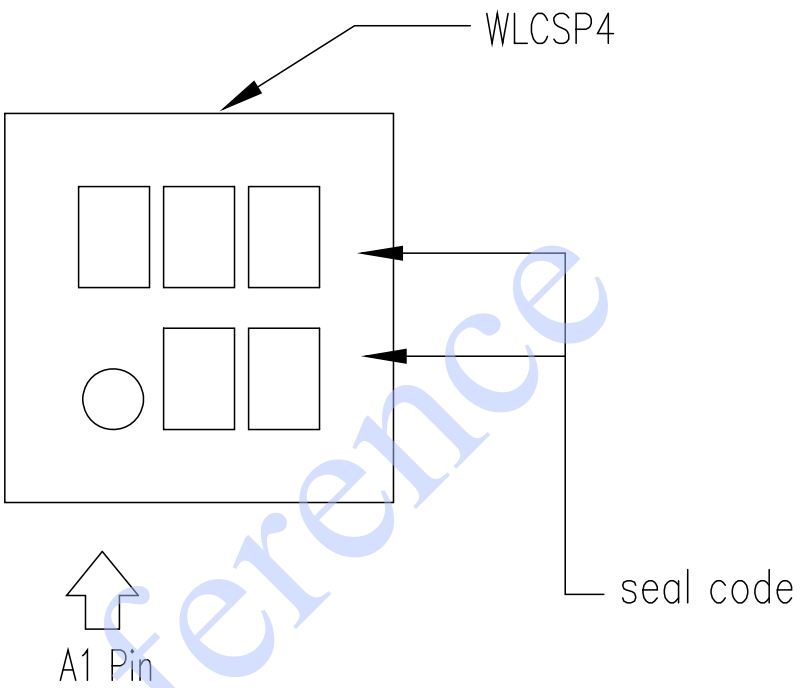
Package	Pb-free 4-ball WLCSP (YAS539-PZ)	
Size	0.97mm × 0.97 mm	
Power Supply (VDD)	1.65 V to 1.95 V	
Operating temperature	−40°C to +85°C	
Averaged current (See Note 1.)	280 µA (Default configuration; 100 sample/s, VDD = 1.8 V)	
	160 µA (Low current mode; 100 sample/s, VDD = 1.8 V)	
Magnetometer		
Manufacturing process	Standard CMOS + Magnetic sensor element process	
Maximum intensity	2000 µT	(See Note 2.)
Sensitivity (X, Y, Z)	0.15 µT / LSB	
Sampling time	1.1ms (magnetic field intensity + temperature sampling)	(See Note 3.)

Note 1: For details of the Low Current Mode
Note 2: With Yamaha-provided device driver used.
Note 3: Different register configuration needs different time to complete one sampling. The value shown is for default configuration.on.

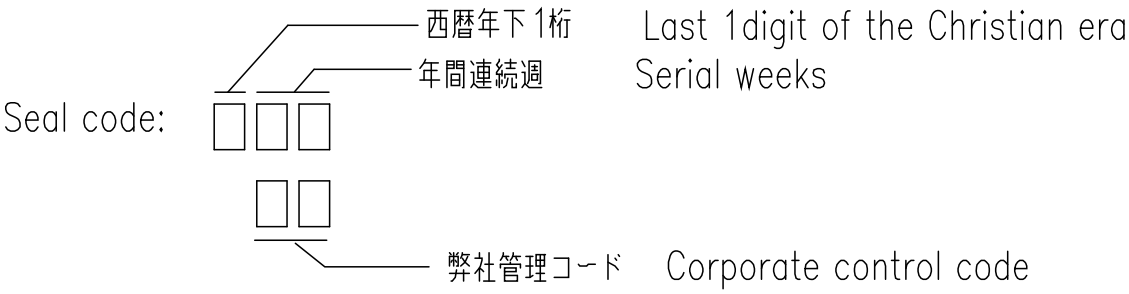
6. Markings

(REG.No. U-M4P-ZG6401-Z*)

U-M4P-ZG6401-Z*



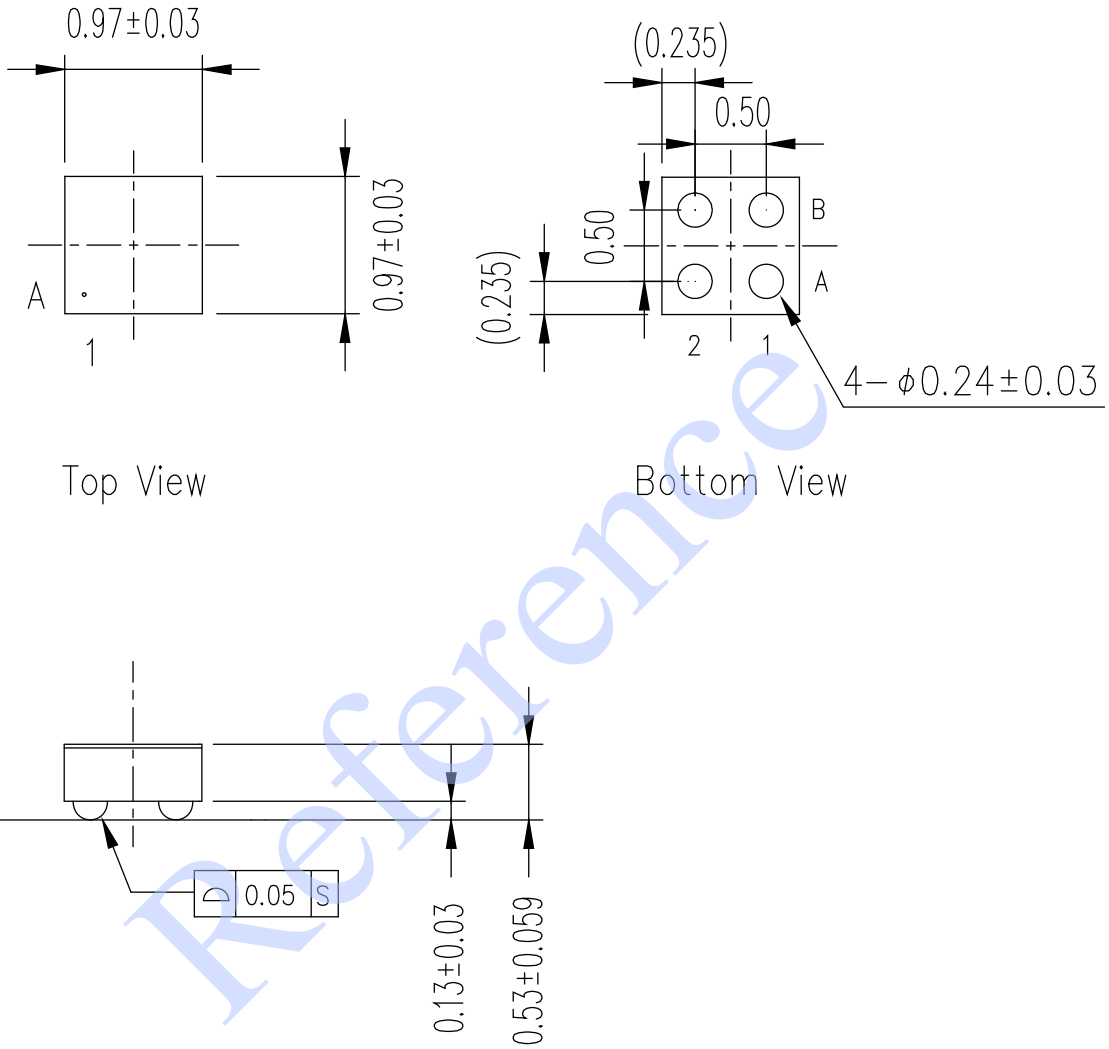
この図は捺印内容を説明するもので、文字形状、捺印位置などの詳細を示すものではありません。
This drawing shows the marking contents
and does not mention the detail of letter form,marking position,etc.



7. Package Outlines

(REG.No. U-PK4PP3-18-2)

U-PK4PP3-18-2



カッコ内の寸法値は参考値とする。
The value parenthesized is not specified.

外形寸法はバリを含みます。
Dimensions include burr.

UNIT: mm

8. Cautions for use of the surface mount package

(REG.No. U-F-260C0-04)

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℃ /5℃ to 30℃
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も上記環境条件下で保管してください。 **（耐湿レベルは J-STD-020 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, store under the conditions described above.

(J-STD-020 : 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℃でリフロー回数は 3 回までとしてください。 (Refer to Fig.1 for an example of recommended temperature profile. *Device surface temp. is allowed Max.260℃ 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.)

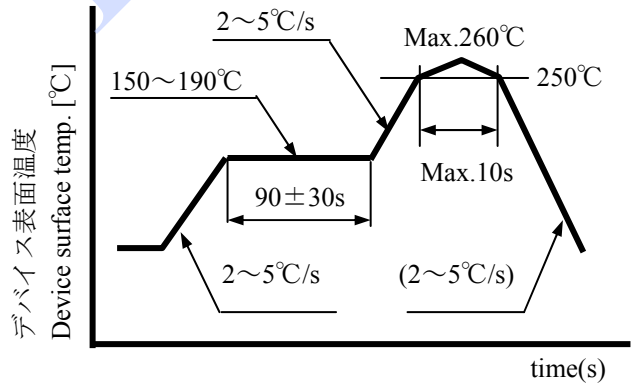


Fig.1 Reflow soldering recommended temperature profile

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ない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.

9. Yamaha LSI Application Notes

Yamaha LSI Application Notes

The most of Yamaha LSIs are manufactured by the C-MOS process technology.
When using these LSIs, please keep the following instructions:

- Fix the unused input to H or L.
  Connect the unused input terminal to the power supply or ground terminal.
  When the terminal voltage becomes the middle potential, both P-gate and N-gate are turned on and flows the penetrating current.
  Even for the terminal internally pulled-up, it should be connected to the power supply terminal for noise immunity.
  On the other hand, the unused output terminal should be remained unconnecting.

- Pay attention to the latch-up
  Any input signal shall not exceed the power supply range.
  When a terminal voltage rises more than the power supply voltage or falls less than the ground voltage, a parasitic thyristor is induced and it causes latch-up.
  This will damage the LSI or will be deteriorated of reliability.
  Especially, note that any signal voltage shall not be previously applied before power supply voltage is supplied.

- Supply the same power voltage to the power supply terminals.
  Use identical power supply to provide to each power supply terminal.
  The potential difference between these terminals causes short-circuits and latch-up, because most of the power supply terminals of the monolithic LSI are connected each other internally.

- Don't shut the clock signals.
  Don't shut the clock signals supplied to the LSI while working.
  Many dynamic circuits are often used for high integration in Yamaha LSIs.
  The dynamic circuits may induce penetrating current by being gone its charge with the shutting the clock signals. The penetrating current causes damage of the LSI.

- Warning for the device which makes sound using speaker
  A speaker radiates heat in a voice-coil by air flow accompanying vibration of a diaphragm. When DC signal (several Hz or less) is input, heat radiation characteristics falls rapidly.
  In addition, even if it is used lower than rated input, it may lead to voice-coil burnout, smoke or ignition of a speaker.
  In order to avoid such situations, be sure to implement one or more preventive measures from the following.
  1. Do not select settings (sound production) which may generate DC signal.
     (Since thoroughness of this preventive measure is generally difficult, we recommend the combined use with the following 2, 3, and 4)
  2. Add the equivalent of DC cut digital filter for cutting DC signal in the digital section.
     (As long as "Built-in" is not mentioned in the manual, there is no such built-in circuit inside of a device).
  3. Add a DC cut capacitor for cutting DC signal in the analog section.
     (When addition is specified in the example of a recommended circuit diagram, be sure to add)
  4. When a latter stage device exists in the signal path from this device to speaker, be sure to realize the DC cut in a latter stage device.
  In addition, the above-mentioned measures are based on the assumption that the device itself, DC cut capacitor, and the latter stage device will be in a normal operation. Therefore, it is also necessary to implement measures based on the assumption of these part failures.

9. Yamaha LSI Application Notes

PRECAUTIONS AND INSTRUCTIONS FOR SAFETY

	WARNING
Prohibited	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.
Prohibited	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. And, do not use the device again that has been improperly mounted and powered once.
Prohibited	Do not short between pins. 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.
Instructions	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.

	CAUTION
Prohibited	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.
Instructions	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.
Instructions	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.
Instructions	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.
Instructions	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.
Instructions	Use a robust power supply. 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.
Instructions	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.
Instructions	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.
Instructions	Electrostatic discharges can damage and destroy semiconductor devices. Pay close attention to static build-up when handling devices.
Instructions	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.

10. Packing specification

(REG.No. U-PC4PP4-03)

WLCSP4　梱包仕様書 / WLCSP4 Packing specifications

No.	Japanese		English	
①	エンボスキャリアテープ	導電性PC製	Embossed carrier tape	Conductive PC
②	カバーテープ	帯電防止フィルム製	Cover tape	Antistatic film
③	リール	導電性PS製	Reel	Conductive PS
④	内袋	透明静電袋	Inner bag	Transparent electrostatic bag
⑤	ラベル	品名・数量を表示	Label	Part name and quantity
⑥	内箱	段ボール製	Inner box	Cardboard
⑦	クッション材	段ボール製	Cushioning material	Cardboard box
⑧	外箱	段ボール製	Outer box	Cardboard

＜収納個数 / Storage quantity＞

リール/Reel	IC 10000 +5/-0 pcs. / reel
外箱/Outer box	Max 5 inner boxes / outer box

＜仕様 / specification＞

(1)部品の欠落数 / Maximum blank pockets

部品の欠落数は、リールの総部品数の0.05%又は1個のいずれか大きい方以下とし、連続2個以上の欠落はないものとする。

Each reel shall contain a maximum of 0.05% or 1 blank pocket, whichever is greater. Two or more successive blank pockets shall not be allowed.

(2)エンボスキャリアテープの引っ張り強度 / Tensile strength of embossed carrier tape

10N以上とする。/ The embossed carrier tape shall have a tensile strength of 10N or greater.

(3)カバーテープの剥離強度 / Peel strength of cover tape

テープ接着面に対し165～180度で毎分300mmの速さで剥離させた時0.1～1.0Nとする。

The cover tape shall have a peel strength of 0.1 to 1.0N when peeled at an angle between 165 to 180 degrees relative to the adhesive face of the tape and at a speed of 300mm per minute.

(4)包装 / Packing

テーピングの終了したリールには、製品名、ロットNo.、梱包日、数量等を記入したラベルを貼り、内袋に入れヒートシールする。

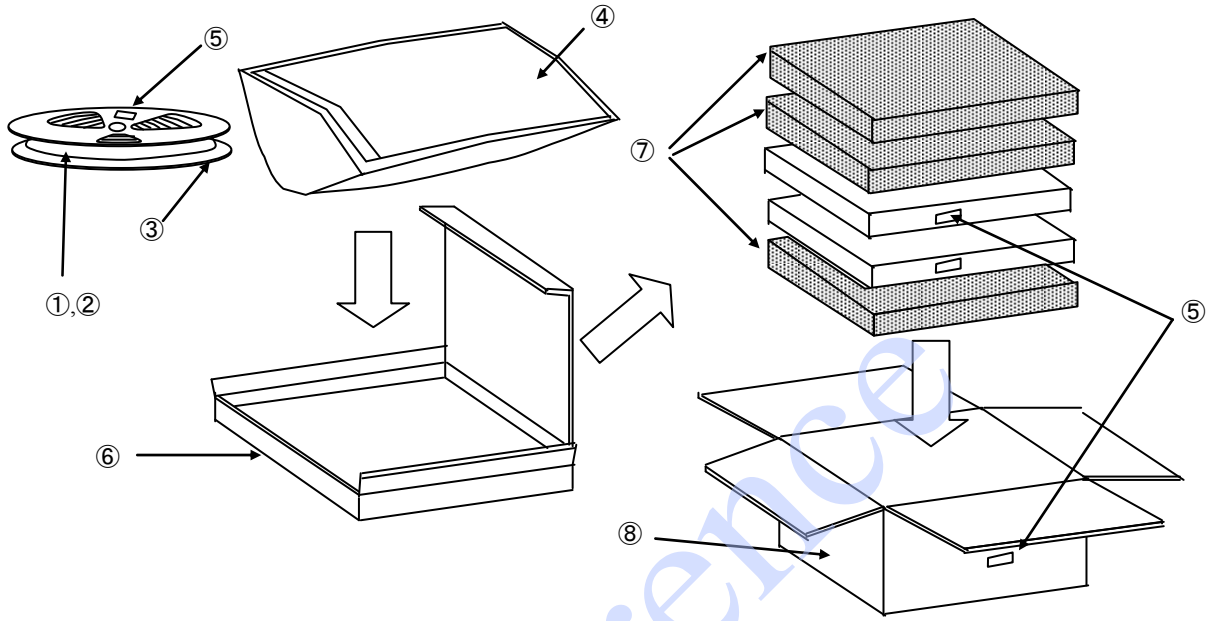
Each reel complete with the taping procedure shall have a marking label posted on it; each label shall have the indications of Product name, quantity, lot number, packing date. The reel shall be put into an inner bag, which shall be heat sealed.

10. Packing specification

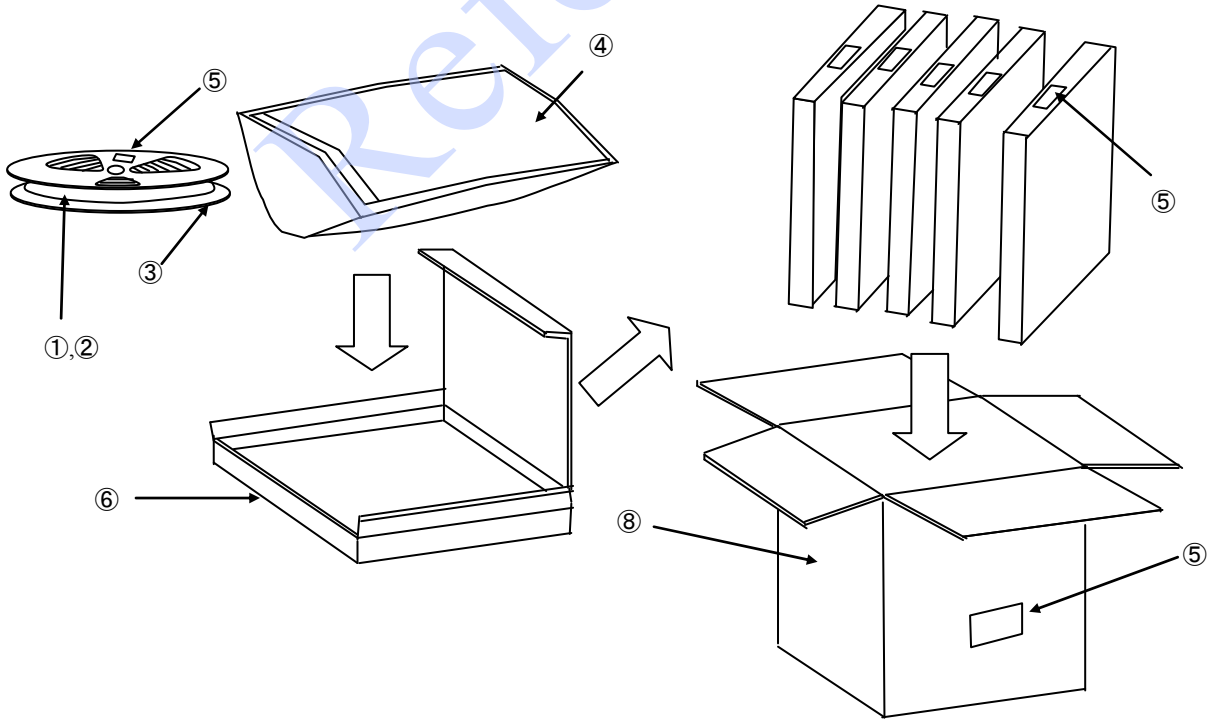
(REG.No. U-PC4PP4-03)

●梱包説明図 ／ Explanatory Drawing for Packing specification

※ 1～2 Inner boxes



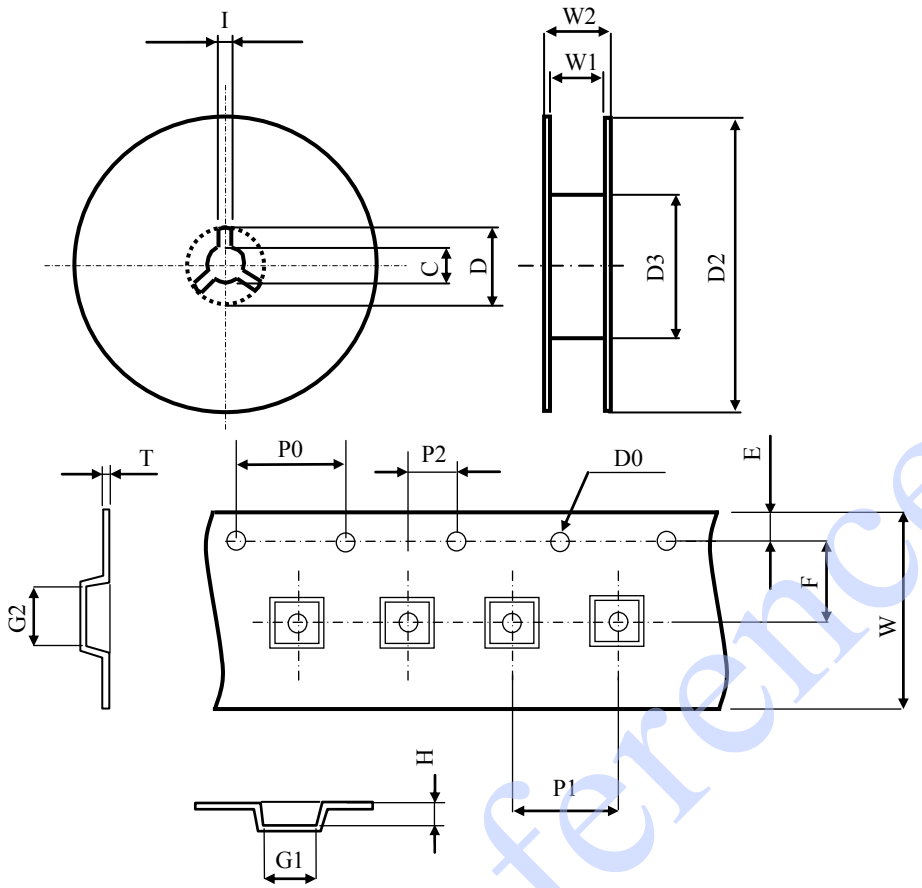
※3～5 Inner boxes



10. Packing specification

(REG.No. U-PC4PP4-03)

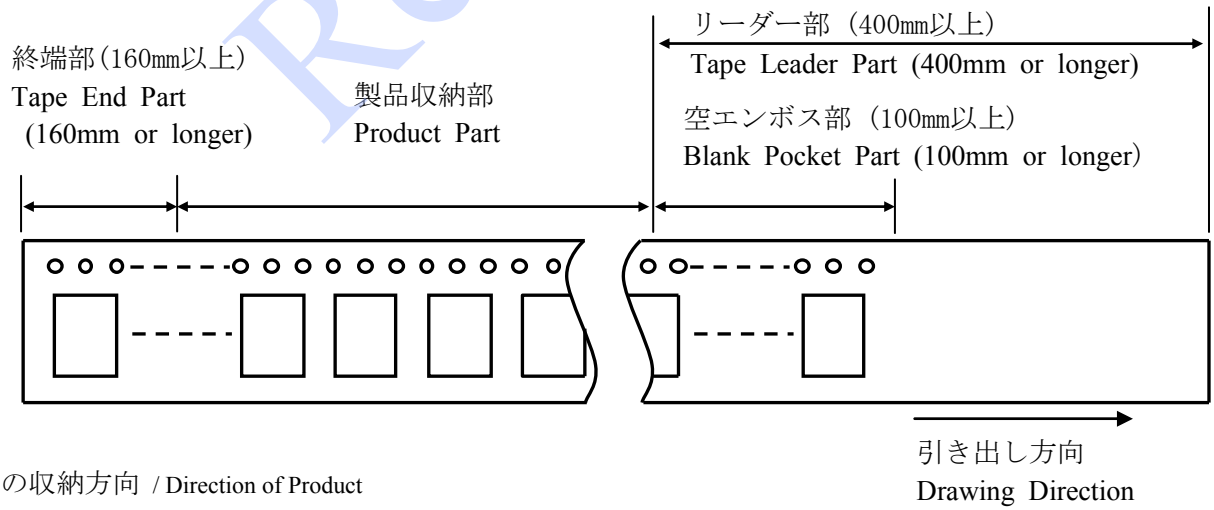
●リール、エンボスキャリアテープ寸法 / Dimensions of Reel and Embossed carrier Tape



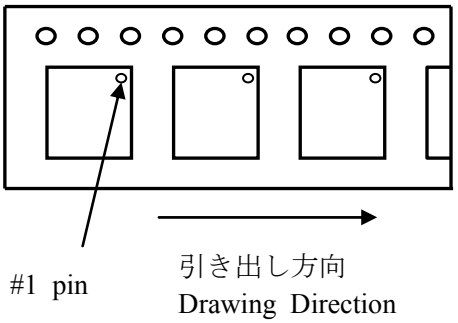
unit: mm

D2	φ254±2
D3	φ100±2
C	φ13±0.2
D	φ21±1.0
I	2±0.5
W1	9.50±1.0
W2	13.50±1.0
P0	4.0±0.1
P1	4.0±0.1
P2	2.0±0.05
D0	φ1.5+0.1/-0
W	8.0+0.3/-0.1
E	1.75±0.1
F	3.50±0.05
G1	1.13±0.05
G2	1.13±0.05
H	0.65±0.03
T	0.20±0.03

●リーダー部、終端部寸法 / Dimensions of Tape Leader Part and Tape End Part



●製品の収納方向 / Direction of Product



信頼性試験結果成績書
Reliability Test Result

製品名 Product Name	YAS539-PZE2
パッケージ Package Type	WLCSP4
試験番号 Test No.	R3279

	試験項目 Test Item	参考規格 Reference Standard	条件 Condition	不良数 / 試験数 Failure / Sample Size
1	高温通電試験 High Temperature Operating	JEITA ED-4701/101 JEDEC JESD22-A108	Ta=125℃, VDD=VDDMAX t=1000h	0/15
2	高温保存試験 High Temperature Storage	JEITA ED-4701/201 JEDEC JESD22-A103	Ta=150℃ t=1000h	0/15
3	はんだ耐熱性試験 Resistance to Soldering Heat	JEITA ED-4701/301 IPC/JEDEC J-STD-020	Precondition : MSL 1 265℃ Peak IR-Reflow 3 times	0/45
4	高温高湿通電試験 （はんだ耐熱性試験後） High Temperature High Humidity Operating (After item Resistance to Soldering Heat)	JEITA ED-4701/102 JEDEC JESD22-A101	Ta=85℃, RH=85%, VDD=VDDMAX t=1000h	0/15
5	プレッシャークッカー試験 （はんだ耐熱性試験後） Pressure Cooker (After item Resistance to Soldering Heat)	JEITA ED-4701/103 JEDEC JESD22-A118	Ta=130℃, RH=85%, 2.3 atm t=96h	0/15
6	温度サイクル試験 （はんだ耐熱性試験後） Temperature Cycling (After item Resistance to Soldering Heat)	JEITA ED-4701/105 JEDEC JESD22-A104	-65℃ / R. T /150℃ (30min / 5min /30min) 500 cycles	0/15
7	静電破壊試験　人体モデル ESD Human Body Model (HBM)	JEITA ED-4701/300 JEDEC JESD-22-A114	C=100pF, R=1.5kΩ, ±2000V, 1time　ground : VDD ground : VSS	0/5 0/5
8	静電破壊試験　マシンモデル ESD Machine Model (MM)	JEITA ED-4701/300 JEDEC JESD-22-A115	C=200pF, R=0Ω, ±200V, 1time　stress (+) stress (-)	0/5 0/5
9	静電破壊試験　デバイス帯電モデル ESD Charged Device Model (CDM)	JEITA ED-4701/300 JEDEC JESD-22-C101	F-CDM ±500V, 1time　stress (+) stress (-)	0/5 0/5
10	ラッチアップ試験 コンデンサディスチャージ法 Latch-up (Condenser discharge)	-	C=500pF, R=470Ω, ±150V　stress (+) stress (-)	0/5 0/5