2.5W Mono Class-D Audio Power Amplifier

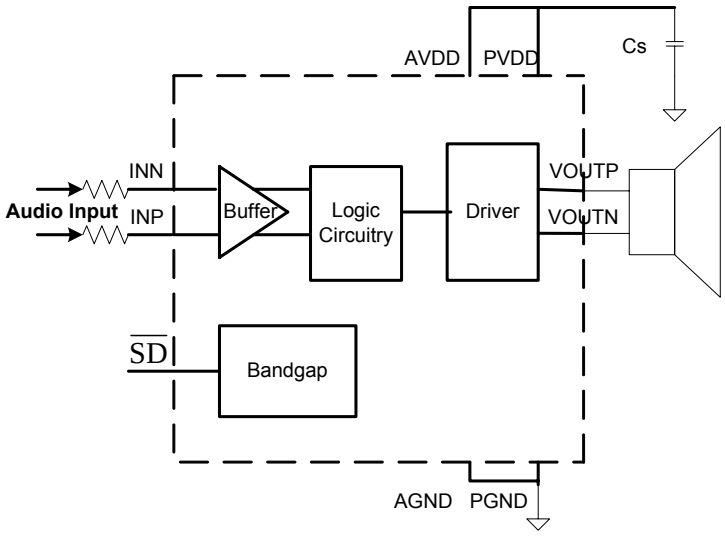
DESCRIPTION

The GSI8010A is a cost effective, low power, low EMI, mono, Class D audio power amplifier. The GSI8010A delivers 2.5W into a 4 Ω load and offers efficiencies above 85%. The device utilize Go2Silicon's proprietary ESF (EMI Suppression Function) technology and architecture. ESF circuitry greatly reduces EMI by controlling the edge rate of the output FET. Advanced dead zone control maintains state-of-the-art efficiency and THD+N performance. The output filter is eliminated and requires only three external components. The GSI8010A features high -70dB PSRR, as low as 0.04% THD+N, and 90dB SNR. Short circuit and thermal protection prevents the devices from being damaged during over current conditions. Click and pop suppression circuitry is also built-in to eliminate click and pop noise.

APPLICATIONS

- Cellular Phones
- MP3 MP4 Players
- Portable Computer
- PDAs

APPLICATION CIRCUIT



FEATURES

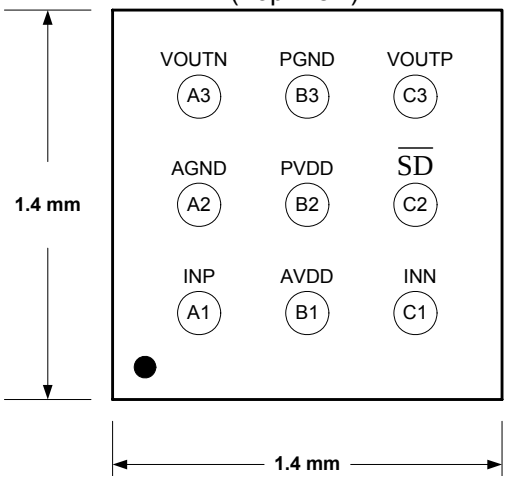
- **Filter less Capability**
- **Large Output Power Capability: 2.5 W into 4 Ω load**
- **Efficiency up to 88% at 400 mW**
- **Low Typical Quiescent Current 2.0 mA**
- **Low EMI Design with ESF technology**
- **Low Shutdown Current of less than 0.05 µA**
- **Wide Supply Voltage Range 2.5V-5.5 V**
- **External Gain Configuration Capability**
- **High PSRR (-70 dB) at 217Hz**
- **Fully Differential Design, Eliminates Two Input Capacitors**
- **Built-in Clock Generators**
- **Internal Thermal Shutdown**
- **Built in Click and Pop Suppression Circuitry**
- **Only Three External Components**
- **9-pin Wafer Chip Scale Package (WCSP)**
- **RoHS Compliant, Lead Free**

ORDERING INFORMATION

Device	TEMP Range	PACKAGE	TOP MARK
GSI8010A	-40 ℃ to 85 ℃	9 pin WCSP	LL

See detailed ordering and shipping information on page 11 of this data sheet.

9-Pin Wafer Chip Scale Package (WCSP)
(Top View)



PIN DESCRIPTION

Pin No.	Symbol	Type	Description
A1	INP	I	Positive Differential Input
A2	AGND	I	Analog Ground
A3	VOUTN	O	Negative BTL Output
B1	AVDD	I	Positive Analog Supply
B2	PVDD	I	Positive Power Analog Supply
B3	PGND	I	Analog Ground
C1	INN	I	Negative Differential Input
C2	$\overline{SD}$	I	When $\overline{SD}$ is inserted, the device is entered into power down mode.
C3	VOUTP	O	Positive BTL Output

MAXIMUM RATINGS

Symbol	Rating	Max	Unit
AVDD PVDD	Supply Voltage	6.0	V
Vin	Input Voltage	Vdd+0.3	V
Tj	Junction Temperature	150	℃
Ta	Operating Ambient Temperature	-40 to 85	℃
	ESD Susceptibility Human Body Model (HBM) Machine Model (MM)	 >2 >200	 kV V
	Latchup Current @ Ta=85 ℃ 9 Pin WCSP 8 Pin QFN	 +-70	 mA

Recommended Operating Condition

	Min	Max	Unit
Supply Voltage, AVDD PVDD	2.5	5.5	V
High Level Input Voltage, VIH	1.5	AVDD	V
Low Level Input Voltage, VIL	0	0.4	V
Input Resistor, Ri	15	150	kΩ
Common Mode Input Voltage Range, Vic	0.5	AVDD-0.8	V
Operating Temperature	-40	80	℃

Electrical Characteristic (Ta=25 ℃, unless otherwise noted)

Symbol	Characteristic	Conditions	Min	Typ	Max	Unit
Vp	Operating Supply Voltage	Ta=-40 ℃ to +85 ℃	2.5		5.5	V
Idd	Supply Quiescent Current	Vp=3.6 V, No Load Vp=5.5 V No Load		1.5 2.0		mA mA
Isd		Vp=2.5 V to 5.5 V Ta=-40 ℃ to 85 ℃		0.02	0.1	μA
A	Gain		$\frac{200k\Omega}{Ri}$		$\frac{315K\Omega}{Ri}$	V/V
Zosd	Output impedence in shutdown mode			20		kΩ
Rsd	Resistance from $\overline{SD}$ to ground		300			kΩ
Voff	Output Offset Voltage				6	mV
Ton	Turn on time	Vp=2.5 V to 5.5 V		6		mS
Toff	Turn off time	Vp=2.5 V to 5.5 V		5		mS
Tsd	Thermal Shut Down Voltage	Vp=2.5 V to 5.5 V		150		℃
Von	Output Noise Voltage	Vp=3.6 V, f=20 Hz to 20 kHz No Weight Filter With Weight Filter		 65 42		μVrms
CMRR	Common Mode Rejection Ratio	Vp=2.5 V to 5.5 V Vic=0.5 V to Vp-0.8 V F=1.0 kHz		-62		dB
PSRR	Power Supply Rejection Ratio	Vp-p ripple=200 mV, Rl=8 Ω Input AC grounded F=1.0 kHz		-70		dB

Electrical Characteristic (Ta=25 ℃, unless otherwise noted)

Symbol	Characteristic	Conditions	Min	Typ	Max	Unit
Po	RMS Output Power	Rl=8 Ω, f=1.0 kHz, THD+N<1%				W
		Vp=2.5 V		0.33		
		Vp=3.0 V		0.46		
		Vp=3.6 V		0.69		
		Vp=4.2 V		0.96		
		Vp=5.0 V		1.36		
		Rl=8 Ω, f=1.0 kHz, THD+N<10%				W
		Vp=2.5 V		0.4		
		Vp=3.0 V		0.6		
		Vp=3.6 V		0.88		
		Vp=4.2 V		1.20		
		Vp=5.0 V		1.70		
		Rl=4 Ω, f=1.0 kHz THD+N<1%				W
		Vp=2.5 V		0.48		
		Vp=3.0 V		0.71		
		Vp=3.6 V		1.05		
		Vp=4.2 V		1.62		
		Vp=5.0 V		2.12		
		Rl=4 Ω, f=1.0 kH, THD+N<10%				W
		Vp=2.5 V		0.6		
		Vp=3.0 V		0.9		
		Vp=3.6 V		1.35		
		Vp=4.2 V		1.98		
		Vp=5.0 V		2.50		
Ed	Efficiency	Rl=8.0 Ω, f=1kHz				%
		Vp=3.6 V, Po=0.6 W		84		
		Vp=5.0 V, Po=1.2 W		85		
		Rl=4.0 Ω，f=1 kHz				%
		Vp=3.6 V, Po=1.0 W		80		
		Vp=5.0 V, Po=2.0 W		81		
THD+N	Total Harmonic Distortion + Noise	Vp=3.6 V, Rl=8 Ω, f=1.0 kHz, Po=0.25 W		0.06		%
		Vp=5.0 V, Rl=8 Ω f=1.0 kHz, Po=0.25 W		0.04		

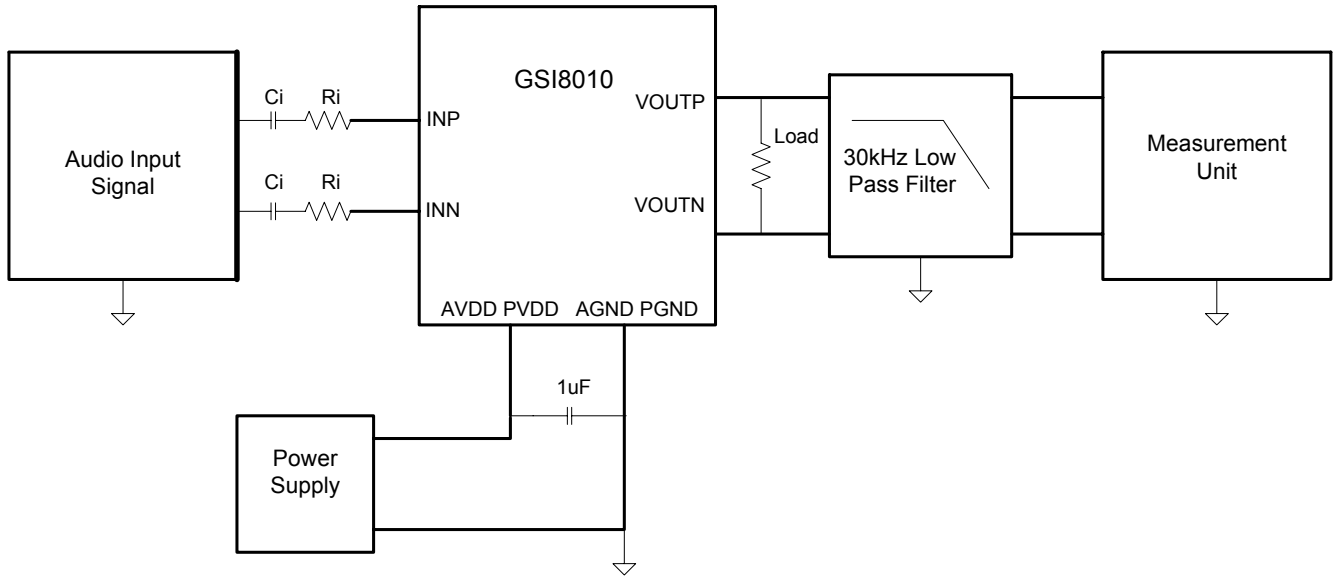


Figure 1. Test Setup for Graphs

Notes:

(1) Ci was shorted for any Common Mode input voltage measurement.
(2) A 33-µH inductor was placed in series with the load resistor to emulate a smaller speaker for efficiency measurements.
(3) The 30kHz low pass filter is required even if the analyzer has an internal low-pass filter. An RC low pass filter (100 Ω, 47 nF) is used on each output for the datasheet graphs.
(4) Unless otherwise noted, Ci=100 nF and Ri=150 kΩ. Thus the cutoff frequency of the input high pass filter is set to 10Hz.

Application Information

Fully Differential Amplifier

The GSI8010A is a fully differential amplifier with differential inputs and outputs. The amplifier consists of a buffered amplifier and a gain stage. The output voltage of the amplifier is equal to the differential input times the gain of the amplifier. The common mode feedback network ensures that the output is biased at the proper voltage of the amplifier regardless of the common mode input voltage at the input. The GSI8010A can also be used with a single-ended input. However, in a noisy environment, fully differential operation is recommended for the best performance.

Component Selection

Figure 2 and Figure 3 shows the GSI8010A typical schematic with differential inputs and Figure 4 shows the GSI8010A with single-ended inputs. Differential inputs should be used whenever possible because the single-ended inputs are much more susceptible to noise.

Table 1. Typical Component Values

REF DES	VALUE
Ri	150 kΩ (±0.5%)
Cs	1uF (+22%, -80%)
Ci(1)	3.3 nF(±10%)

(1) Ci is only needed for single-ended input or if Vicm is not between 0.5V and Vdd-0.8V. Ci=3.3nF (with Ri=150 kΩ) give a high-pass corner frequency of 321 Hz.

Input Resistors(Ri)

The input resistors (Ri) set the gain of the amplifier according to Equation 1.

$$\text{Gain} = \frac{2\times 150k\Omega}{Ri}\quad \left(\frac{V}{V}\right) \tag{1}$$

Resistor matching is very important in full differential amplifiers. Therefore, it is recommended to use 1% tolerance resistors or better to keep the performance optimized. The resistors should be placed very close to the GSI8010A to limit noise on the high impedance nodes.

Decoupling Capacitor (Cs)

The GSI8010 requires adequate power supply decoupling to ensure the efficiency and low total harmonic distortion. A good low equivalent-series-resistance (ESR) ceramic capacitor, typically 1uF should be used. Placing this decoupling capacitor close to the GSI8010A is very importance for the efficiency of the class-D amplifier.

Input Capacitors (Ci)

The GSI8010A does not require input coupling capacitors if the design uses a differential source that biased from 0.5V to VDD-0.8V (Shown is Figure 2). If the input signal is not biased within the recommended common-mode input range, if needing to use the input as a high pass filter, or if using a single-ended source, input coupling capacitors are required. The value of the input capacitor is important to consider as it directly affects the bass performance of the circuit. Speakers in wireless phones can not usually respond well to low frequencies, so the corner frequency can be set to block low frequencies in this application.

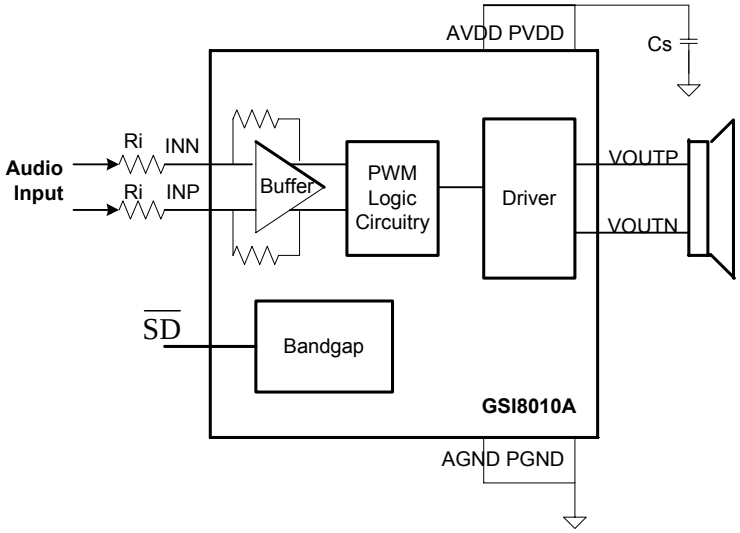


Figure 2. Typical GSI8010A Application Schematic With Differential Input for a Wireless Phone

If the corner frequency is within the audio band, the capacitors should have a tolerance of +-10% or better, because any mismatch in capacitance causes an impedance mismatch at the corner frequency and below.

Larger input capacitors (1μF) can be used for a flat low-frequency response (Shown in Figure 3). However, in a GSM phone the ground signal is fluctuating at 217 Hz. 217 Hz hum can be heard.

Optional Output Filter

This filter is optional due to the capability of the speaker to filter by itself the high frequency signal. Nevertheless, the high frequency is not audible and filtered by the human ear. An optional filter can be used for the filtering high frequency signal before the speaker. In this case, the circuit consists of two inductors (33 μH) and two capacitors (2.2 μF) (Figure 5). The size of the inductors is linked to the output power requested by the application. Cellular phones and portable electronic devices are great applications for Filterless Class-D as the trace length between amplifier and speaker is short, thus, there is usually no need for an EMI filter. However, to lower radiated emissions as much as possible when used in filter less mode, a ferrite filter can often be used (Figure 6).

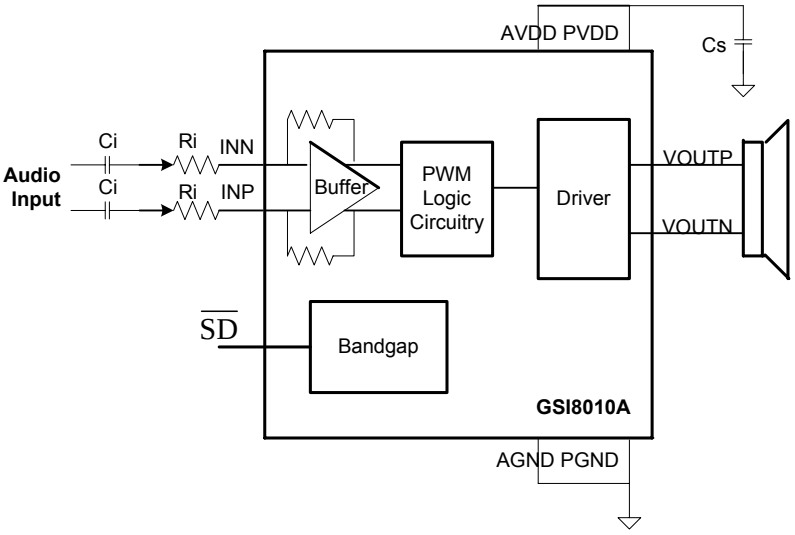


Figure 3. Typical GSI8010A Application Schematic With Differential Input and Input Capacitors

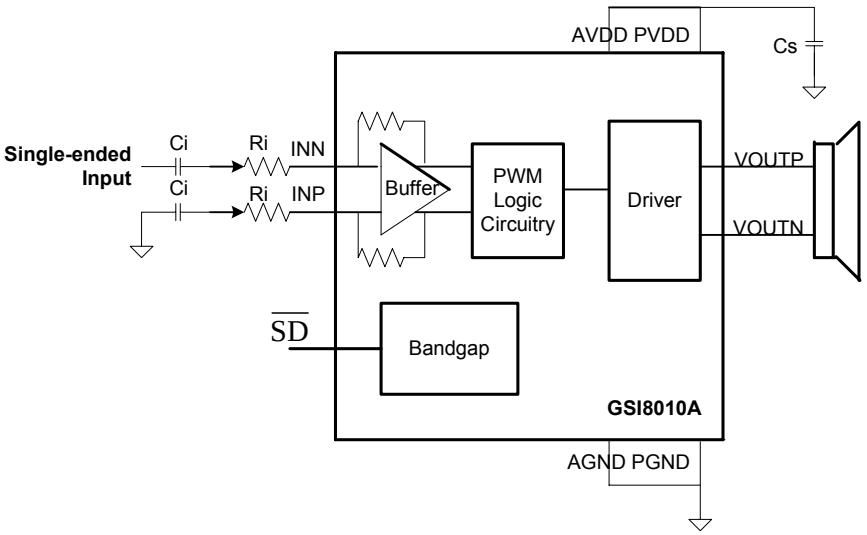


Figure 4. Typical GSI8010A Application Schematic With Single-ended Input

Optimum Equivalent Capacitance at Output Stage

If the optional filter described in the above section isn't selected. Cellular phones and wireless portable devices design normally put several RF filtering capacitors and ESD protection devices between filter less Class D outputs and loudspeaker. Those devices are usually connected between amplifier output and ground. In order to achieve the best sound quality, the optimum value of total equivalent capacitance between each output terminal to the ground should be less than or equal to 150pF. This total equivalent capacitance consists of the RF filtering capacitors and ESD protection device equivalent parasitic capacitance.

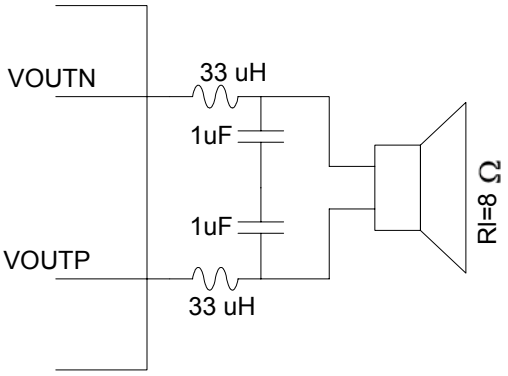


Figure 5. Optional Audio Output Filter

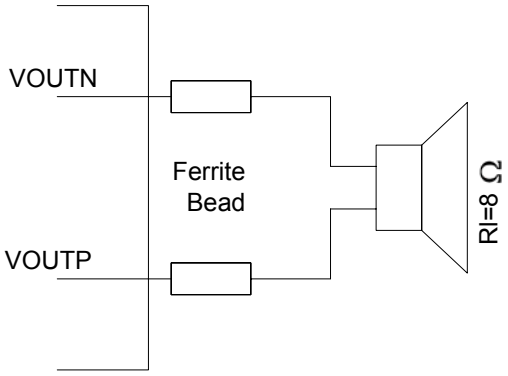


Figure 6. Optional EMI Ferrite Bead Filter

PCB Board

Place all external components very close to the GSI8010A. The input resistors need to be very close to the GSI8010A input pins so noise does not couple on the high impedance nodes between the input resistors and the input amplifier of the GSI8110A. Placing the decoupling capacitor, Cs, close to the GSI8010A is important for the efficiency of the class-D amplifier. Any resistance or inductance in the trace between the device and the capacitor can cause a loss in efficiency.

Recommended trace width at the solder balls is 75um to 100um to prevent solder wicking onto wider PCB traces. For high current pins (PVDD, PGND VOUTP and VOUTN) of the GSI8010A, use 100-um trace widths at the solder balsa and at least 500-um PCB traces to ensure proper performance and output power for the devices.

For input pins (INP INN and $\overline{SD}$) of the GSI8010A, use 75-um to 100-um trace widths at the solder balls. INP and INN pins need to run side-by-side to maximize common-mode noise cancellation. Placing input resistors, Ri as close to the GSI8010A as possible is recommended.

Ordering Information

Order Number	Package Type	Marking	Shipping	Operating Temperature Range
GSI8010AWIT0	9 Pin WCSP	28A0	3000/Tape & Reel T1 Orientation	-40 ℃ to 85 ℃
GSI8010AQIQ0	8 Pin DFN	28B0	3000/Tape & Reel	-40 ℃ to 85 ℃

GSI8010A X X X X

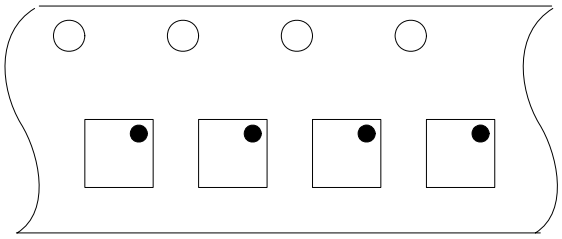
Lead Free Code
1: Lead
0: Lead Free

Packing
T: Tape & Reel

Operating Temperature Range
I: Industry Standard

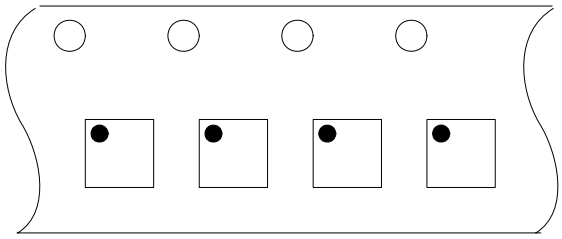
Package Type
Q: QFN
W: WCSP

T1 Orientation



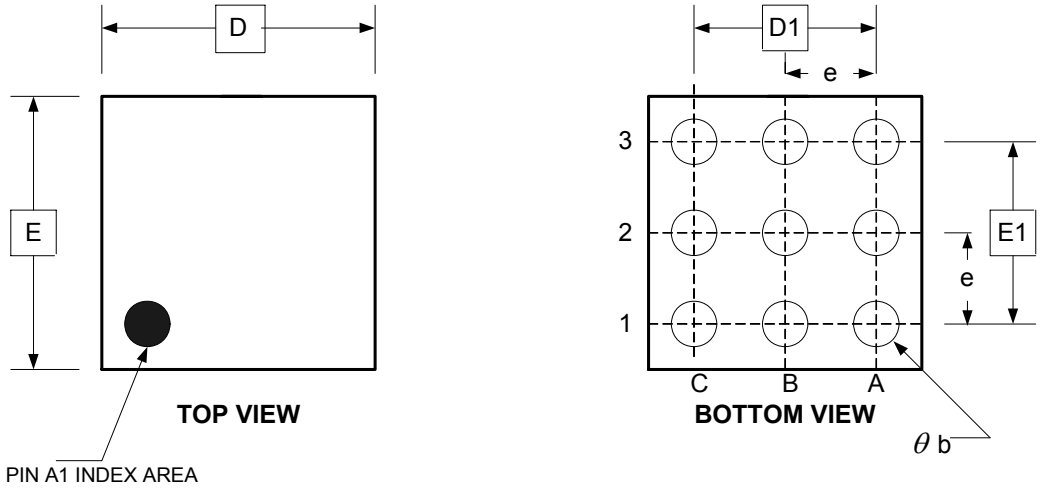
Pin 1 at Upper Right
Die orientation in tape with bumps down

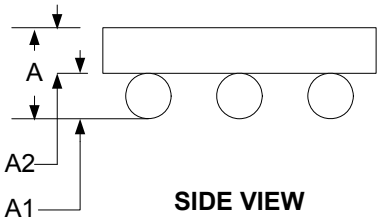
T2 Orientation



Pin 1 at Upper Left
Die orientation in tape with bumps down

Package Dimensions





MIN

DIM	MILLOIMETERS	
	MIN	MAX
A	0.570	0.752
A1	0.180	0.242
A2	0.390	0.510
D	1.360 BSC	
E	1.360 BSC	
b	0.260	
e	0.5 BSC	
D1	1.000 BSC	
E1	1.000 BSC	

Notes:
1. All linear dimensions are in millimeters.
2. This drawing is subject to change without notice.
3. Device in GSI8010A package can have dimension D and E ranging from 1.25 mm to 2.00 mm. Call local sales office for exact package size.
4. This package contains lead-free balls.