



# BCT8937S

## High efficiency, Low noise Class T Audio Amplifier

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##### GENERAL DESCRIPTION

BCT8937S is specifically designed to enhance smart mobile phone sound quality, which is an innovative high efficiency, low noise, ultra-low distortion, constant large volume, Class T audio amplifier, Using our unique Digital Power Modulation(DPM) audio algorithm, effectively eliminate audio noise, increase signal Dynamic range which will greatly improve sound quality and volume. With an advance TOP power technology, efficiency reach 93%, and power amplifier's overall efficiency is up to 80%, greatly saves the mobile phone power consumption and prolong the mobile phone usage time. The BCT8937S noise floor is as low as to 53 $\mu$ V, with 97dB high signal-to-noise-ratio(SNR). The ultra-low distortion 0.008% and unique Digital Power Modulation technology brings high quality music enjoyment.

BCT8937S has 0.6W, 0.8W, 1.0W and 1.2W four selectable speaker-protection output power levels, which is suitable for different rated power speakers. With Digital Power Modulation audio Algorithms, the music is pure nature and melodious. Within lithium battery voltage range (3.3V--4.35V), output power is constant, preventing the voice becomes smaller and smaller during usage of cell phone.

BCT8937S has built-in over current protection, over-temperature protection and short circuit protection function, effectively protecting the chip from damage.

The BCT8937S uses small 0.4mm pitch 1.58mmx1.63mm WCSP-14L package.


##### FEATURES

- Power amplifier overall efficiency 80%
- Low noise: 53  $\mu$  V
- Ultra-low distortion: 0.008%
- Digital Power Modulation (DPM) technology
- Selectable speaker-guard power level: 0.6w, 0.8W, 1.0W, 1.2W
- Within voltage range(3.3V-4.35V), output power is maintained constant
- One wire pulse control
- High PSRR: -68dB (217Hz)
- Support 6ohm speaker
- Excellent pop-click suppression
- ESD protection:  $\pm$ 6kV (HBM)
- Small 0.4mm pitch 1.58mmx1.63mm WCSP-14L package

##### APPLICATIONS

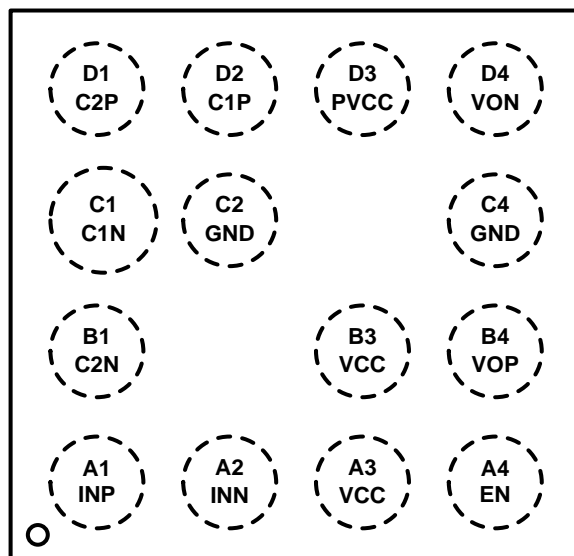
- Cellular Phones
- Portable Audio Devices
- Mini Speakers
- Tablets

### ORDERING INFORMATION

| Order Number   | Package Type | Temperature Range | Marking   | QTY/Reel |
|----------------|--------------|-------------------|---|----------|
| BCT8937SEWD-TR | WCSP-14L     | -40°C to +85°C    | <br>8937S<br>XXXXX | 3000     |

Note: "XXXXX" in Marking will be appeared as the batch code.

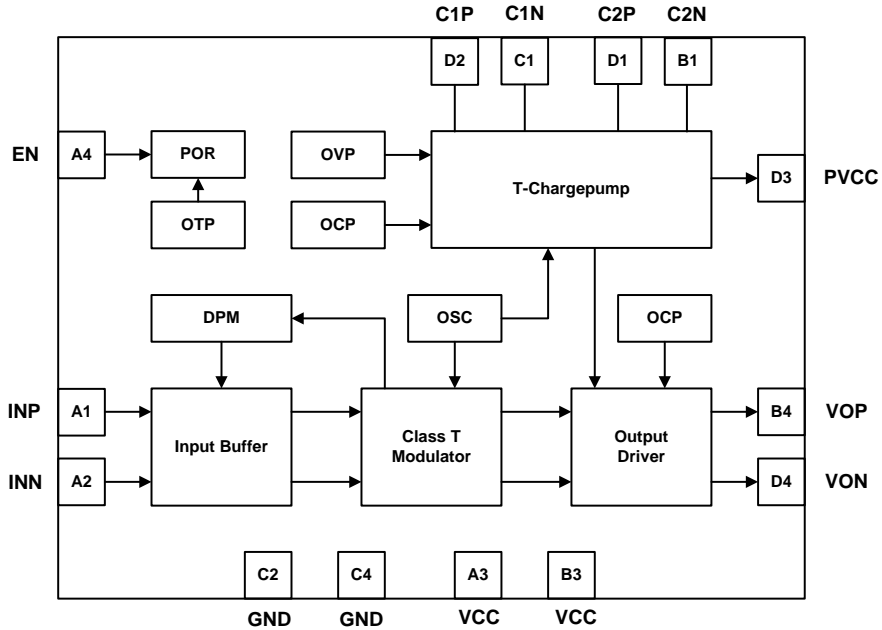
### PIN CONFIGURATION (Top View)



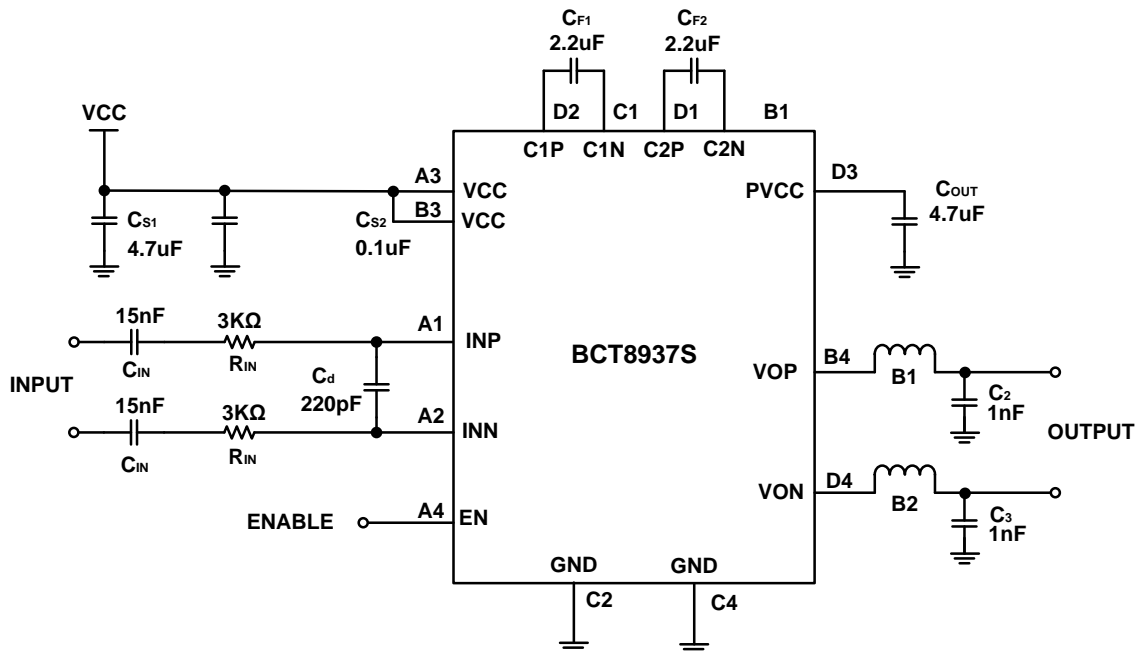
### PIN DESCRIPTION

| PIN    | NAME | FUNCTION  |
|--------|------|---|
| A1     | INP  | Positive audio input pin                                      |
| A2     | INN  | Negative audio input pin                                      |
| A3     | VCC  | Power supply  |
| A4     | EN   | Chip enable pin, active high; one wire pulse control;         |
| B1     | C2N  | Negative side of the external charge pump flying capacitor C2 |
| B3     | VCC  | Power supply  |
| B4     | VOP  | Positive audio output pin                                     |
| C1     | C1N  | Negative side of the external charge pump flying capacitor C1 |
| C2, C4 | GND  | Ground  |
| D1     | C2P  | Positive side of the external charge pump flying capacitor C2 |
| D2     | C1P  | Positive side of the external charge pump flying capacitor C1 |
| D3     | PVCC | 1.5X Boost charge pump output voltage                         |
| D4     | VON  | Negative audio output pin                                     |

### BLOCK DIAGRAM



### TYPICAL APPLICATION CIRCUIT





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### MODE DESCRIPTION

| Mode  | Enable Signal | Gain (V/V)      |                  | DPM Power (W)                 |                               | DPM Function |
|-------|---------------|-----------------|------------------|-------------------------------|-------------------------------|--------------|
|       |               | Rin=3K $\Omega$ | Rin=10K $\Omega$ | RL=8 $\Omega$ +<br>33 $\mu$ H | RL=6 $\Omega$ +<br>33 $\mu$ H |              |
| Mode1 |               | 16.3            | 12               | 1.2                           | 1.6                           | √            |
| Mode2 |               | 16.3            | 12               | 1                             | 1.3                           | √            |
| Mode3 |               | 16.3            | 12               | 0.8                           | 1.0                           | √            |
| Mode4 |               | 16.3            | 12               | 0.6                           | 0.8                           | √            |

### ABSOLUTE MAXIMUM RATINGS

|   |                    |
|---|--------------------|
| V <sub>DD</sub> , Supply Voltage Range..... | -0.3V to 6V        |
| Charge pump output voltage PVCC.....        | -0.3V to 7V        |
| VOP, VON, C1P, C2P Input Voltage Range..... | -0.3V to PVCC+0.3V |
| INP, INN, C1N, C2N Input Voltage Range..... | -0.3V to VDD+0.3V  |
| Package Thermal Resistance $\theta$ JA..... | 85°C/W             |
| Operating Temperature Range.....            | -40°C to +85°C     |
| Junction Temperature.....                   | 150°C              |
| Storage Temperature Range.....              | -65°C to +150°C    |
| Lead Temperature (Soldering, 10sec).....    | 260°C              |
| Lead Temperature (Soldering, 10sec).....    | 260°C              |
| ESD HBM (human body model) .....            | ±6KV               |

#### NOTE:

- Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute Maximum rating conditions for extended periods may affect device reliability.



# BCT8937S

## High efficiency, Low noise Class T Audio Amplifier

### ELECTRICAL CHARACTERISTICS

Test condition: TA=25°C, VDD=3.6V, RL=8Ω+33μH, f=1kHz (unless otherwise noted)

| Parameter                                      |  | Test conditions  | Min  | Typ      | Max             | Units            |
|--|--|--|------|----------|-----------------|------------------|
| V <sub>DD</sub>                                | Power supply voltage                           |  | 3.0  |          | 5.5             | V                |
| V <sub>IH</sub>                                | EN high input voltage                          |  | 1.3  |          | V <sub>DD</sub> | V                |
| V <sub>IL</sub>                                | EN low input voltage                           |  | 0    |          | 0.35            | V                |
| V <sub>OS</sub>                                | Output offset voltage                          | V <sub>in</sub> =0V, V <sub>DD</sub> =3.0V to 5.5V                   | -30  | 0        | 30              | mV               |
| I <sub>SD</sub>                                | Shutdown current                               | V <sub>DD</sub> =3.6V, EN =0V  |      |          | 1               | μA               |
| T <sub>TG</sub>                                | Thermal AGC start temperature threshold        |  |      | 150      |                 | °C               |
| T <sub>TGR</sub>                               | Thermal AGC exit temperature threshold         |  |      | 130      |                 | °C               |
| T <sub>SD</sub>                                | Over temperature protection threshold          |  |      | 160      |                 | °C               |
| T <sub>SDR</sub>                               | Over temperature protection recovery threshold |  |      | 120      |                 | °C               |
| T <sub>ON</sub>                                | Start-up time                                  |  |      | 40       |                 | ms               |
| <b>K-Charge pump</b>                           |  |  |      |          |                 |                  |
| PVCC   | Output voltage                                 | V <sub>DD</sub> =3.0V to 4V  |      | 1.5* VDD |                 | V                |
|  |  | V <sub>DD</sub> >4V  |      | 6.05     |                 | V                |
| V <sub>hys</sub>                               | OVP hysteresis                                 | V <sub>DD</sub> >4V  |      | 50       |                 | mV               |
| F <sub>CP</sub>                                | Charge Pump frequency                          | V <sub>DD</sub> =3.0V to 5.5V  | 0.8  | 1.06     | 1.33            | MHz              |
| η <sub>CP</sub>                                | Charge pump efficiency                         | V <sub>DD</sub> =3.6V, I <sub>load</sub> =200mA                      |      | 93       |                 | %                |
| I <sub>L</sub>                                 | Current limit when PVCC short to ground        |  |      | 300      |                 | mA               |
| <b>Class T power amplifier (Mode1-Mode4)</b>   |  |  |      |          |                 |                  |
| I <sub>q</sub>                                 | Quiescent current                              | V <sub>DD</sub> =4.2V, V <sub>in</sub> =0, no load                   |      | 10       | 15              | mA               |
| η  | Efficiency                                     | V <sub>DD</sub> =3.6V, P <sub>o</sub> =1.0W, R <sub>L</sub> =8Ω+33μH |      | 80       |                 | %                |
| F <sub>osc</sub>                               | Modulation frequency                           | V <sub>DD</sub> =3.0V to 5.5V  | 600  | 800      | 1000            | kHz              |
| A <sub>v</sub>                                 | gain   | external input resistance=3kΩ  |      | 16.3     |                 | V/V              |
| V <sub>in</sub>                                | Recommend input voltage                        | V <sub>DD</sub> =3.0V to 5.5V  |      |          | 1               | V <sub>rms</sub> |
| R <sub>in</sub>                                | Inner input resistance                         | Mode1-Mode4  |      | 16.6     |                 | kΩ               |
| f <sub>HFP</sub>                               | Input high pass filter corner frequency        | C <sub>in</sub> =15nF, external input resistance=3kΩ                 |      | 542      |                 | Hz               |
| PDPM   | Mode1 DPM output power                         | V <sub>DD</sub> =4.2V, R <sub>L</sub> =8Ω+33μH                       | 1.08 | 1.2      | 1.32            | W                |
|  |  | V <sub>DD</sub> =4.2V, R <sub>L</sub> =6Ω+33μH                       | 1.44 | 1.6      | 1.76            | W                |
|  |  | V <sub>DD</sub> =4.2V, R <sub>L</sub> =4Ω+15μH                       | 2.16 | 2.4      | 2.64            | W                |
|  |  | V <sub>DD</sub> =4.2V, R <sub>L</sub> =3Ω+15μH                       | 2.16 | 2.4      | 2.64            | W                |
|  | Mode2 DPM output power                         | V <sub>DD</sub> =4.2V, R <sub>L</sub> =8Ω+33μH                       | 0.9  | 1        | 1.1             | W                |
|  |  | V <sub>DD</sub> =4.2V, R <sub>L</sub> =6Ω+33μH                       | 1.17 | 1.3      | 1.43            | W                |
| V <sub>DD</sub> =4.2V, R <sub>L</sub> =4Ω+15μH |  | 1.8  | 2    | 2.2      | W               |                  |

### ELECTRICAL CHARACTERISTICS

Test condition: TA=25°C, VDD=3.6V, RL=8Ω+33μH, f=1kHz (unless otherwise noted)

| Parameter                          |                                 | Test conditions   | Min         | Typ   | Max  | Units |
|------------------------------------|---------------------------------|---|-------------|-------|------|-------|
|                                    | Mode2 DPM output power          | V <sub>DD</sub> =4.2V, R <sub>L</sub> =3Ω+15μH  | 2.16        | 2.4   | 2.64 | W     |
| PDPM                               | Mode3 DPM output power          | V <sub>DD</sub> =4.2V, R <sub>L</sub> =8Ω+33μH  | 0.72        | 0.8   | 0.88 | W     |
|                                    |                                 | V <sub>DD</sub> =4.2V, R <sub>L</sub> =6Ω+33μH  | 0.9         | 1.0   | 1.1  | W     |
|                                    |                                 | V <sub>DD</sub> =4.2V, R <sub>L</sub> =4Ω+15μH  | 1.44        | 1.6   | 1.76 | W     |
|                                    |                                 | V <sub>DD</sub> =4.2V, R <sub>L</sub> =3Ω+15μH  | 1.8         | 2.0   | 2.2  | W     |
|                                    | Mode4 DPM output power          | V <sub>DD</sub> =4.2V, R <sub>L</sub> =8Ω+33μH  | 0.54        | 0.6   | 0.66 | W     |
|                                    |                                 | V <sub>DD</sub> =4.2V, R <sub>L</sub> =6Ω+33μH  | 0.72        | 0.8   | 0.88 | W     |
|                                    |                                 | V <sub>DD</sub> =4.2V, R <sub>L</sub> =4Ω+15μH  | 1.08        | 1.2   | 1.32 | W     |
|                                    |                                 | V <sub>DD</sub> =4.2V, R <sub>L</sub> =3Ω+15μH  | 1.44        | 1.6   | 1.76 | W     |
| PSRR                               | Power supply rejection ratio    | V <sub>DD</sub> =4.2V, V <sub>p-p_s</sub> =200mV, 217Hz   |             | -68   |      | dB    |
|                                    |                                 | V <sub>DD</sub> =4.2V, V <sub>p-p_s</sub> =200mV, 1kHz  |             | -68   |      | dB    |
| SNR                                | Signal-to-noise ratio           | V <sub>DD</sub> =4.2V, P <sub>O</sub> =1.75W, THD+N=1%, R <sub>L</sub> =8Ω+33μH, A <sub>v</sub> =8V/V |             | 97    |      | dB    |
| V <sub>n</sub>                     | Output noise voltage            | V <sub>DD</sub> =4.2V, f=20Hz to 20kHz, input ac grounded, A <sub>v</sub> =8V/V                       | A-weighting | 53    |      | μVrms |
|                                    |                                 | V <sub>DD</sub> =4.2V, f=20Hz to 20kHz, input ac grounded, 12V/V                                      |             | 58    |      | μVrms |
|                                    |                                 | V <sub>DD</sub> =4.2V, f=20Hz to 20kHz, input ac grounded, 16V/V                                      |             | 68    |      | μVrms |
| THD+N                              | Total harmonic distortion+noise | V <sub>DD</sub> =3.6V, P <sub>O</sub> =1W, R <sub>L</sub> =8Ω+33μH, f=1kHz, Mode1                     |             | 0.008 |      | %     |
|                                    |                                 | V <sub>DD</sub> =3.6V, P <sub>O</sub> =1W, R <sub>L</sub> =6Ω+33μH, f=1kHz, Mode 1                    |             | 0.008 |      | %     |
| <b>One wire pulse control</b>      |                                 |   |             |       |      |       |
| T <sub>H</sub>                     | EN high level duration time     | V <sub>DD</sub> =3.0V to 5.5V   | 0.75        | 2     | 10   | μs    |
| T <sub>L</sub>                     | EN low level duration time      | V <sub>DD</sub> =3.0V to 5.5V   | 0.75        | 2     | 10   | μs    |
| T <sub>LATCH</sub>                 | EN turn on delay time           | V <sub>DD</sub> =3.0V to 5.5V   | 150         |       | 500  | μs    |
| T <sub>OFF</sub>                   | EN turn off delay time          | V <sub>DD</sub> =3.0V to 5.5V   | 150         |       | 500  | μs    |
| <b>DPM</b> <small>(Note 4)</small> |                                 |   |             |       |      |       |
| T <sub>AT</sub>                    | Attack time                     | -13.5dB gain attenuation completed  |             | 40    |      | ms    |
| T <sub>RL</sub>                    | Release time                    | 13.5dB gain release completed   |             | 1.2   |      | s     |
| A <sub>MAX</sub>                   | Maximum attenuation             |   |             | -13.5 |      | dB    |

**Note 4:** Attack time points to 13.5dB gain attenuation time; Release time points to 13.5dB gain recovery time.



# **BCT8937S**

## **High efficiency, Low noise Class T Audio Amplifier**

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### **DETAILED FUNCTIONAL DESCRIPTION**

BCT8937S is designed to enhance smart mobile phone sound quality, which is a new high efficiency, low noise, ultra-low distortion, constant large volume, upgrading seventh generation Class T audio amplifier. Using a new generation K-Charge pump technology, efficiency reach 93%, power amplifier's overall efficiency is up to 80%, greatly prolong the mobile phone usage time. The BCT8937S noise floor is as low as to 53 $\mu$ V, with 94dB high signal-to-noise-ratio (SNR). The ultra-low distortion 0.008% and unique Digital Power Modulation (DPM) technology brings high quality music enjoyment.

BCT8937S has 0.6W, 0.8W, 1W and 1.2W four selectable speaker-guard output power levels, recommended using rated power of 0.5W and above speakers. BCT8937S integrated unique DPM technology, the output power cannot drop along with lithium battery voltage lower down. Within lithium battery voltage range (3.3V--4.35V), output power is constant, preventing the voice becomes smaller and smaller during usage of cell phone.

The BCT8937S built in excellent pop-click noise suppression circuit, effectively avoids pop-click noise during shutdown, wakeup, and power-up/down operation of BCT8937S.

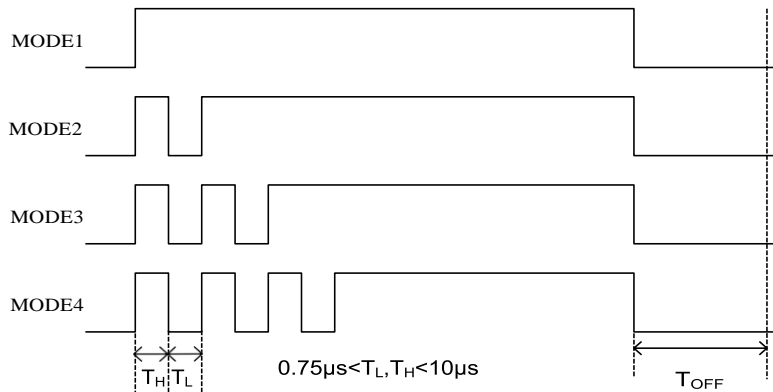
BCT8937S has built-in over current protection, over-temperature protection and short circuit protection function, effectively protect the chip. The BCT8937S uses small 0.4mm pitch 1.58mmx1.63mm WCSP-14L package. The BCT8937S is specified over the industrial temperature range of -40 $^{\circ}$ C to 85 $^{\circ}$ C.

### **CONSTANT OUTPUT POWER**

In the mobile phone audio applications, the DPM function to promote music volume and quality is very attractive, but as the lithium battery voltage drops, general power amplifier output power will reduce gradually, leads to smaller and smaller music volume. So, it is hard to provide high quality music within the battery voltage range. The BCT8937S uses unique second generation DPM technology, within lithium battery voltage range(3.3V--4.35V), output power is constant, the output power cannot drop along with lithium battery voltage lower down. Even if the battery voltage drops, BCT8937S can still provide high quality large volume music enjoyment. BCT8937S has seven operation modes, first four modes have DPM function, the output power level is 1.2W,1W,0.8W,0.6W, respectively.

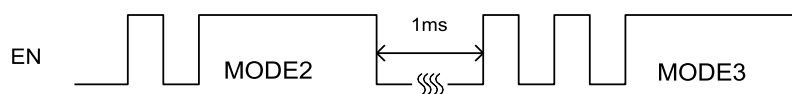
### One Wire Pulse Control

BCT8937S select each mode through the detection of number of the pulse signal rising edge of EN pin, as shown in figure 14: When EN pin pull high from shutdown mode, there is only a rising edge, BCT8937S enter into mode 1, DPM output power is 1.2W; When high-low-high signal set to EN pin, there are two rising edges, BCT8937S enter into mode 2, DPM output power is 1W; When there are three rising edges, BCT8937S enter into mode 3, DPM output power is 0.8W; When there are four rising edges, BCT8937S enter into mode 4, DPM function is turned off; BCT8937S has four operation modes, the number of the rising edges does not allow more than four.



**Figure 14 One Wire Pulse Control**

When BCT8937S needs to work in different mode, PIN EN should be pull low longer than  $T_{OFF}$  first(recommended 1ms) which make the BCT8937S shut down, Then send series pulse make the BCT8937S enter into right mode, as shown in figure 15.



**Figure 15 One Wire Pulse Control Switching Sequence**



### APPLICATION INFORMATION

#### External Input Resistor- $R_{ine}$ (Gain setting)

The BCT8937S is a differential audio amplifier. The IC integrates two internal input resistors, which is  $R_{ini}=16.6k\Omega$ . Take external input resistor  $R_{ine}=3k\Omega$  for an example, gain setting as follows:

Class T mode:

$$A_V = \frac{319.5k\Omega}{R_{ine} + R_{ini}} = \frac{319.5k\Omega}{3k\Omega + 16.6k\Omega} = 16.3V/V$$

#### Input Capacitor- $C_{in}$ (input high-pass cutoff frequency)

The input coupling capacitor blocks the DC voltage at the amplifier input terminal. The input capacitors and input resistors form a high-pass filter with the corner frequency:

$$f_H(-3dB) = \frac{1}{2 * \pi * R_{in} * C_{in}} \text{ (Hz)}$$

Setting the high-pass filter point high can block the 217Hz GSM noise coupled to inputs. Better matching of the input capacitors improves performance of the circuit and also helps to suppress pop-click noise.

Take typical application in Figure 1 as an example:

$$f_H(-3dB) = \frac{1}{2 * \pi * R_{in} * C_{in}} \text{ (Hz)} = \frac{1}{2 * \pi * 19.6k\Omega * 15nF} = 542\text{Hz}$$

#### Differential input filter capacitor $C_d$ (input low-pass cutoff frequency)

Input differential input filter capacitor and input resistor together to form a low-pass filter, could be used to attenuate high frequency components of the input signal. When the musical sounds screechy, this low-pass filter can be appropriately attenuate the high frequency part of the input signal, so that the music signal sounds soft and comfortable. -3dB cutoff frequency of the low-pass filter is as follows:

$$f_H(-3dB) = \frac{1}{2 * \pi * (R_{ini} // R_{ine}) * C_d} \text{ (Hz)}$$

With input resistance  $R_{ine} = 3k\Omega$ , differential capacitance 220pF, for example, the low-pass cutoff frequency is as follows:

$$f_H(-3dB) = \frac{1}{2 * \pi * (R_{ini} // R_{ine}) * C_d} \text{ (Hz)} = \frac{1}{2 * \pi * 2.54k\Omega * 2 * 220pF} \text{ (Hz)} = 142.5kHz$$

### Supply Decoupling Capacitor ( $C_S$ )

The BCT8937S is a high-performance audio amplifier that requires adequate power supply decoupling. Place a low equivalent-series-resistance (ESR) ceramic capacitor, typically  $0.1\mu\text{F}$ . This choice of capacitor and placement helps with higher frequency transients, spikes, or digital hash on the line. Additionally, placing this decoupling capacitor close to the BCT8937S is important, as any parasitic resistance or inductance between the device and the capacitor causes efficiency loss. In addition to the  $0.1\mu\text{F}$  ceramic capacitor, place a  $10\mu\text{F}$  capacitor on the VBAT supply trace. This larger capacitor acts as a charge reservoir, providing energy faster than the board supply, thus helping to prevent any droop in the supply voltage.

### Flying Capacitor ( $C_F$ )

The value of the flying capacitor ( $C_F$ ) affects the load regulation and output resistance of the charge pump. A  $C_F$  value that is too small degrades the device's ability to provide sufficient current drive. Increasing the value of  $C_F$  improves load regulation and reduces the charge pump output resistance to an extent. A  $2.2\mu\text{F}@6.3\text{V}$  upper capacitor is recommended.

### Output Capacitor ( $C_{OUT}$ )

The output capacitor value and ESR directly affect the ripple at PVCC. Increasing  $C_{OUT}$  reduces output ripple. Likewise, decreasing the ESR of  $C_{OUT}$  reduces both ripple and output resistance. A  $4.7\mu\text{F}@10\text{V}$  capacitor is recommended.

### Optional Ferrite Bead Filter

The BCT8937S passed FCC and CE radiated emissions with no ferrite chip beads and capacitors. Use ferrite chip beads and capacitors if device near the EMI sensitive circuits and/or there are long leads from amplifier to speaker, placed as close as possible to the output pin.

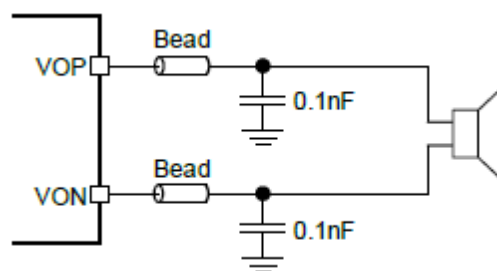
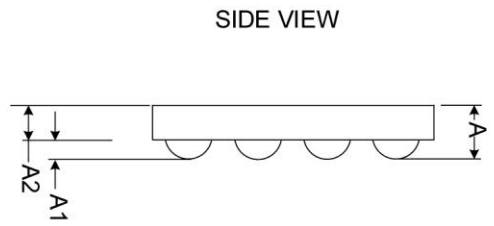
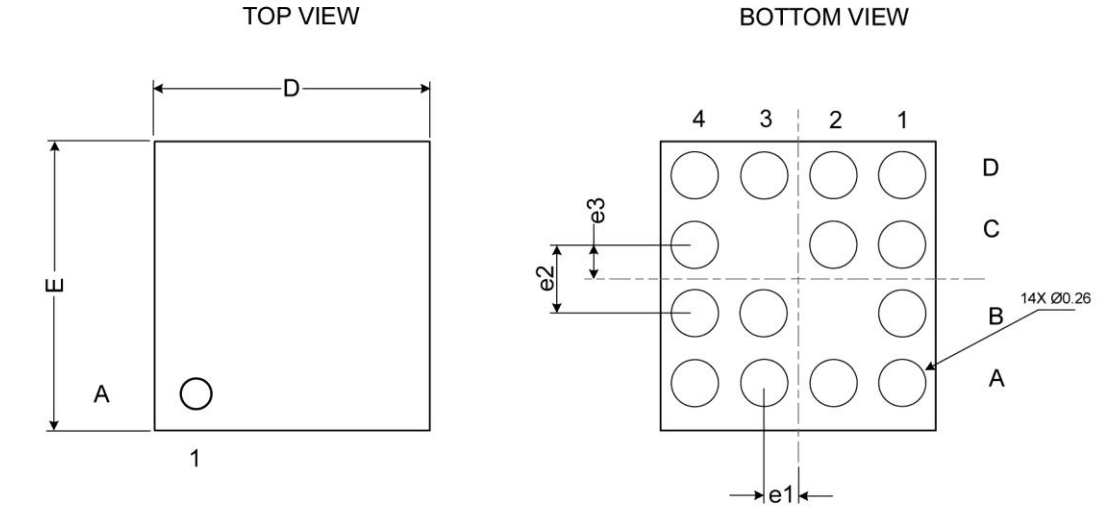


Figure 17 Ferrite Chip Bead and capacitor

### PACKAGE OUTLINE DIMENSIONS

WCSP-14L



| Symbol | Min   | Typ   | Max   |
|--------|-------|-------|-------|
| A      | 0.515 | 0.546 | 0.576 |
| A1     | 0.186 | 0.206 | 0.226 |
| A2     | 0.327 | 0.340 | 0.353 |
| D      | 1.61  | 1.63  | 1.65  |
| E      | 1.56  | 1.58  | 1.60  |
| e1     |       | 0.200 |       |
| e2     |       | 0.400 |       |
| e3     |       | 0.200 |       |

Unit: mm

