

BCT8933B

High Power, Low THD+N Class T Audio Amplifier

GENERAL DESCRIPTION

The BCT8933B is a powerful 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.

The BCT8933B includes a built-in 2X charge pump converter which generates a 6.3V supply voltage. This can provide a wider audio signal output range than a Traditional class D amplifier directly connected to the battery. The BCT8933B can provide 2W output power (10% THD+N) into 8Ω load from the 4.2V battery voltage.

The BCT8933B features the DPM function, which adjusts the system gain and output power automatically, protects the speaker from damage at high power levels and brings the most comfortable listening experience to the customers.

The BCT8933B is available in a small 3mmx3mm 20-Pin QFN Package. It is specified over the extended -40°C to +85°C temperature range.


FEATURES

- Digital Power Modulation audio algorithm
- 2.0W into 8Ω at 4.2V(10% THD+N)
- Ultra-Low THD+N:0.06%
- 4 Mode selected by one-wire pulse
- 4 Selectable Gain,12dB,16dB,24dB, 27.5dB
- Short-Circuit and Thermal Protection
- ±8KV HBM ESD
- Small 3mmx3mm 20-Pin TQFN Package

APPLICATIONS

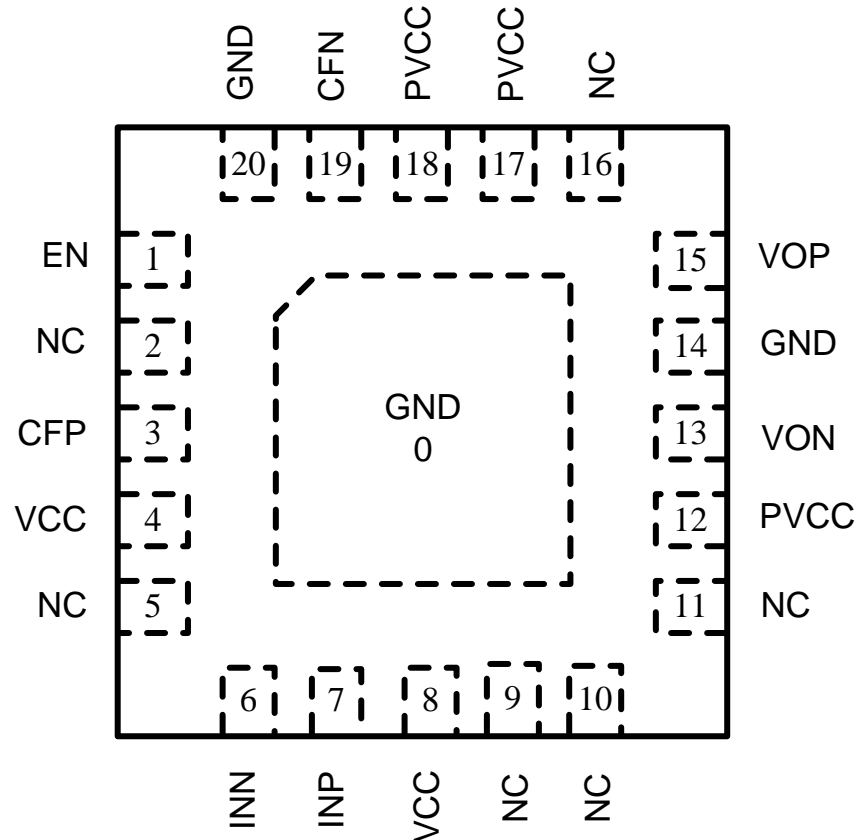
- Smart phone
- Portable Audio Devices
- Mini Speakers

ORDERING INFORMATION

| Order Number | Package Type | Temperature Range | Marking | QTY/Reel |
|----------------|--------------|-------------------|---|----------|
| BCT8933BEGP-TR | QFN3x3-20L | -40°C to +85°C |  XGDDB XXXXX | 6000 |

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

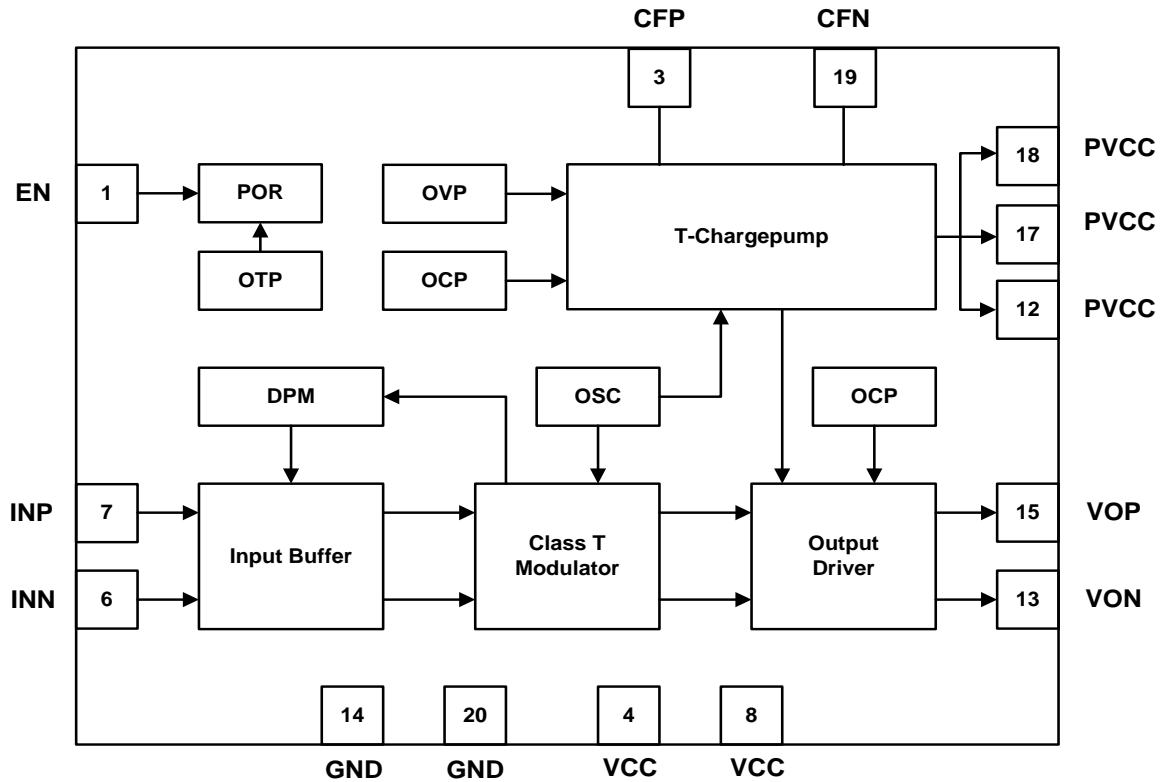
PIN CONFIGURATION (Top View)



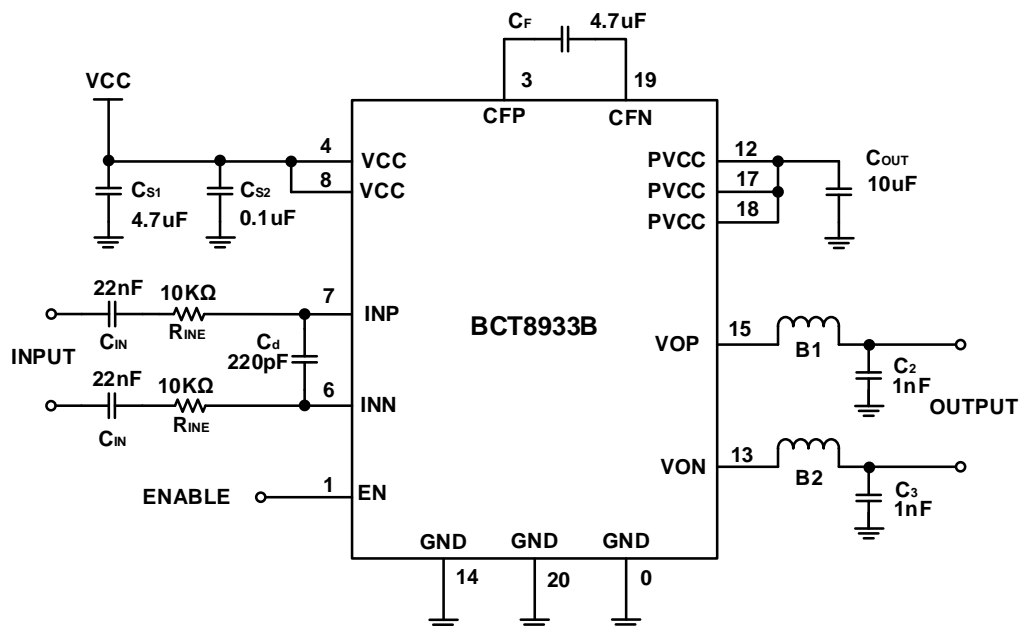
PIN DESCRIPTION

| PIN | NAME | FUNCTION |
|----------------|------|--|
| 1 | EN | Enable and one-wire control pin |
| 2,5,9,10,11,16 | NC | No Connect |
| 3 | CFP | Positive Terminal of Flying capacitor |
| 4,8 | VCC | Supply Voltage. |
| 6 | INN | Negative Amplifier Input |
| 7 | INP | Positive Amplifier Input |
| 12,17,18 | PVCC | 2x Charge-Pump Output. |
| 13 | VON | Negative Amplifier output |
| 14,20,21 | GND | Ground |
| 15 | VOP | Positive Amplifier Output |
| 19 | CFN | Negative Terminal of Flying capacitor. |

BLOCK DIAGRAM



TYPICAL APPLICATION CIRCUIT





BCT8933B

High Power, Low THD+N

Class T Audio Amplifier

ABSOLUTE MAXIMUM RATINGS

| | |
|--|-------------------|
| VCC, Supply Voltage Range..... | -0.3V to 6V |
| Charge pump output voltage PVCC..... | -0.3V to 7V |
| INP, INN, EN Input Voltage Range..... | -0.3V to VCC+0.3V |
| Package Thermal Resistance θ_{JA} | 54°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 |
| ESD HBM (human body model) | ±8KV |

NOTE:

1. 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.

ELECTRICAL CHARACTERISTICS

Test condition: $T_A=25^{\circ}\text{C}$, $V_{CC}=3.6\text{V}$, $R_L=8\Omega+33\mu\text{H}$, $f=1\text{kHz}$ (unless otherwise noted)

| Parameter | | Conditions | | Min | TYP | Max | Units |
|------------------------|--------------------------------------|--|-------|------|-----|------|-------|
| VCC | Power Supply | | | 2.5 | | 5.5 | V |
| I _q | Quiescent current | | | 10 | | | mA |
| I _{SD} | Shutdown current | VCC=3.6V, EN=0V | | 0.1 | | | μA |
| V _{IH} | EN high-level input | | | 1.2 | | VCC | V |
| V _{IL} | EN low-level input | | | 0 | | 0.35 | V |
| I _{IH} | EN high-level input current | VCC=5.5V,V _{EN} =5.8V | | 100 | | | μA |
| I _{IL} | EN low-level input current | VCC=5.5V,V _{EN} =-0.3V | | 5 | | | μA |
| T _{SD} | Thermal Protect level | | | 160 | | | °C |
| T _{SDH} | Thermal Hysteresis | | | 40 | | | °C |
| Charge Pump | | | | | | | |
| PVCC | Output Voltage | VCC =3.3V to 5.5V,no load | | 5.8 | 6.3 | 7 | V |
| F1 | Switching Frequency | VCC=3V to 5.5V | | 600 | | | kHz |
| T _{ST} | Soft-start time | No load, COUT=10uF | | 0.5 | | | ms |
| I _L | PVCC short to GND current limit | | | 300 | | | mA |
| Class T | | | | | | | |
| V _{OS} | Output offset voltage | V _{IN} =0V, no load | | | 0 | 30 | mV |
| R _{ini} | Internal impedance | Mode1 and Mode2 | | 30 | | | kΩ |
| | | Mode3 and Mode4 | | 5 | | | |
| F _{osc} | Modulation Frequency | VCC=2.5V to 5.5V | | 370 | | | kHz |
| PSRR | Power supply rejection ratio | VCC=4.2V,V _{p-p_s} _{in} =200mV | 217Hz | -70 | | | dB |
| | | | 1kHz | -68 | | | dB |
| T _{ON} | Start-up time | | | 28 | | | ms |
| THD+N | Total harmonic distortion plus noise | VCC=4.2V,P _o =1W,f=1kHz | | 0.06 | | | % |
| | | VCC=3.6V,P _o =0.5W,f=1kHz | | 0.07 | | | % |
| P _O | Output power | THD+N=10%,f=1kHz,VCC=4.2V | | 2 | | | W |
| | | THD+N=1%,f=1kHz,VCC=4.2V | | 1.7 | | | W |
| One-wire Pulse Control | | | | | | | |
| T _H | EN high level hold time | VCC=2.5V to 5.5V | | 0.75 | 2 | 10 | μs |
| T _L | EN low level hold time | VCC=2.5V to 5.5V | | 0.75 | 2 | 10 | μs |
| T _{OFF} | EN delay time | VCC=2.5V to 5.5V | | | | 500 | μs |
| DPM | | | | | | | |
| T _{AT} | Attack time | f _{sin} =1kHz | | 40 | | | ms |
| T _{RL} | Release time | | | 1.2 | | | s |
| A _{MAX} | Maximum attenuation gain | | | -13 | | | dB |

DETAILED FUNCTIONAL DESCRIPTION

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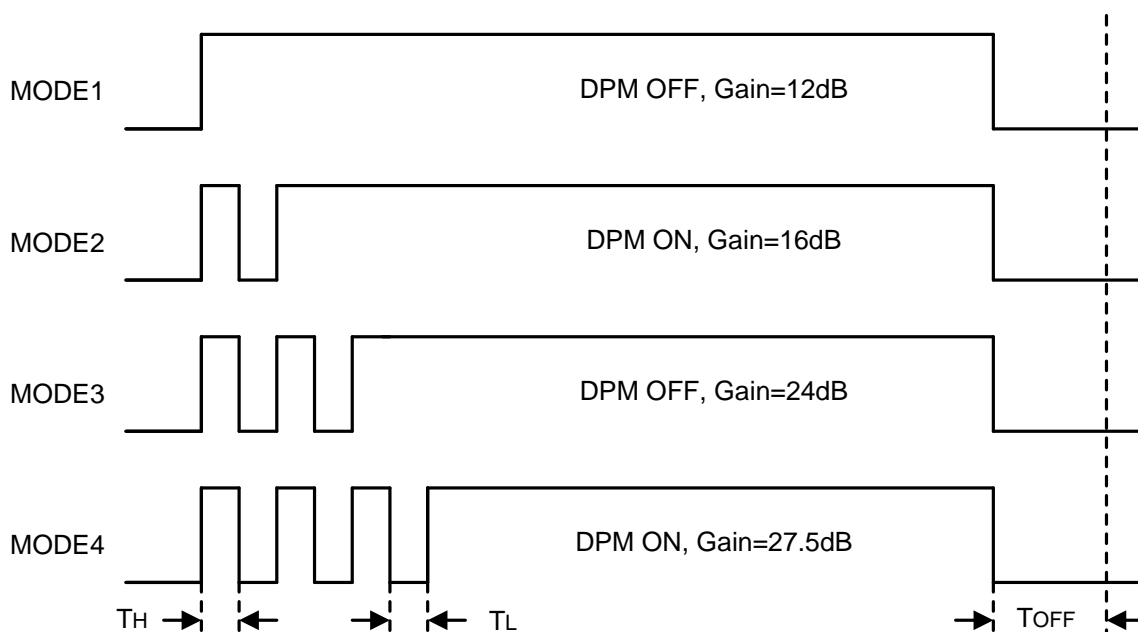
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One Wire Pulse Control

BCT8933B select each mode by one-wire pulse control, When EN pin pull high from shutdown mode, there is one rising edge, BCT8933B start to work and set Gain=12dB. When high-low-high signal set to EN pin, there are two rising edges, BCT8933B open DPM function and set Gain=16dB. When there are three rising edges, BCT8933B close DPM function and set Gain=24dB. When there are four rising edges, BCT8933B open DPM function and set Gain=27.5dB.

When EN pull down above 500μs, BCT8933B will enter shutdown mode.



APPLICATION INFORMATION

External Input Resistor-R_{in} (Gain setting)

The BCT8933B is a differential audio amplifier. The IC integrates two internal input resistors, which 30kΩ in mode1 and mode2, 5kΩ in mode3 and mode4. Take external input resistor R_{ine}=10kΩ for an example,

$$\text{Mode 1 : } A_V = \frac{160k\Omega}{R_{ine}+R_{ini}} = \frac{160k\Omega}{10k\Omega+30k\Omega} = 4V/V$$

$$\text{Mode 2 : } A_V = \frac{240k\Omega}{R_{ine}+R_{ini}} = \frac{240k\Omega}{10k\Omega+30k\Omega} = 6V/V$$

$$\text{Mode 3 : } A_V = \frac{240k\Omega}{R_{ine}+R_{ini}} = \frac{240k\Omega}{10k\Omega+5k\Omega} = 16V/V$$

$$\text{Mode 4 : } A_V = \frac{360k\Omega}{R_{ine}+R_{ini}} = \frac{360k\Omega}{10k\Omega+5k\Omega} = 24V/V$$

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:

Mode 1, Mode 2:

$$f_H(-3dB) = \frac{1}{2 * \pi * R_{in} * C_{in}} \text{ (Hz)} = \frac{1}{2 * \pi * 40k\Omega * 22nF} = 181\text{Hz}$$

Mode 3, Mode 4:

$$f_H(-3dB) = \frac{1}{2 * \pi * R_{in} * C_{in}} \text{ (Hz)} = \frac{1}{2 * \pi * 15k\Omega * 22nF} = 482\text{Hz}$$

APPLICATION INFORMATION (Continued)

Supply Decoupling Capacitor (C_S)

The BCT8933B 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 BCT8933B 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)

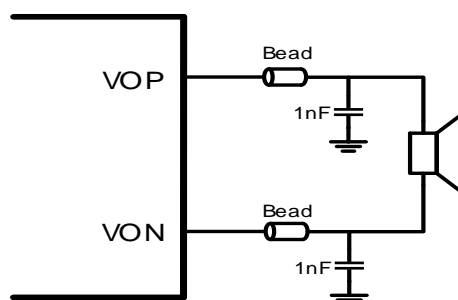
The value of the flying capacitor (C_F) affects the load regulation and output resistance of the charge pump. A C_F value that is too small degrades the device's ability to provide sufficient current drive. Increasing the value of C_F improves load regulation and reduces the charge pump output resistance to an extent. A $4.7\mu\text{F}$ 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 $10\mu\text{F}@10\text{V}$ capacitor is recommended.

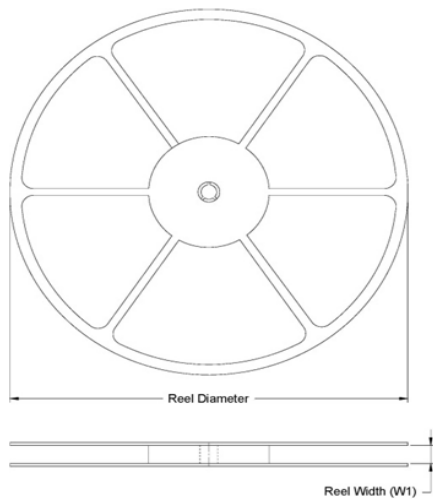
Optional Ferrite Bead Filter

The BCT8933B 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.

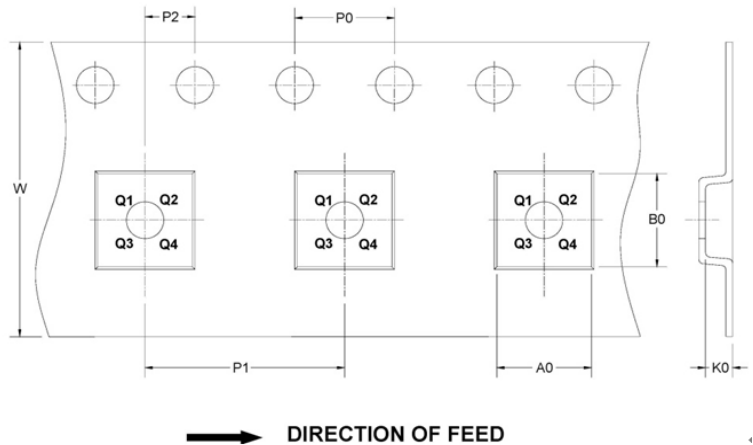


TAPE AND REEL INFORMATION

REEL DIMENSIONS



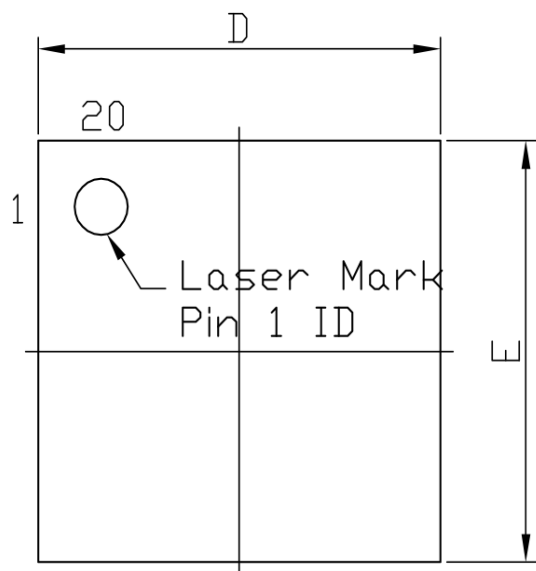
DIMENSIONS



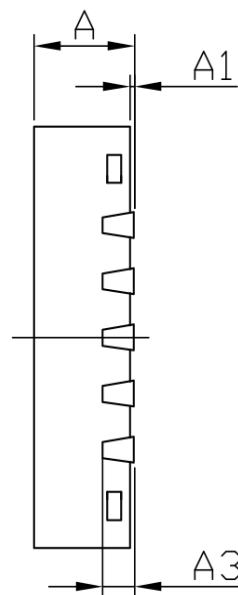
| Device Name | Package Type | Reel Diameter | Unit: mm | | | | | | | | Pin 1 Quadrant | Reel QTY |
|----------------|--------------|---------------|---------------|-----|-----|-----|----|----|----|----|----------------|----------|
| | | | Reel Width W1 | A0 | B0 | K0 | P0 | P1 | P2 | W | | |
| BCT8933BEGP-TR | QFN3x3-20L | 13" | 12 | 3.3 | 3.3 | 1.1 | 4 | 4 | 2 | 12 | Q1 | 6000 |

PACKAGE OUTLINE DIMENSIONS

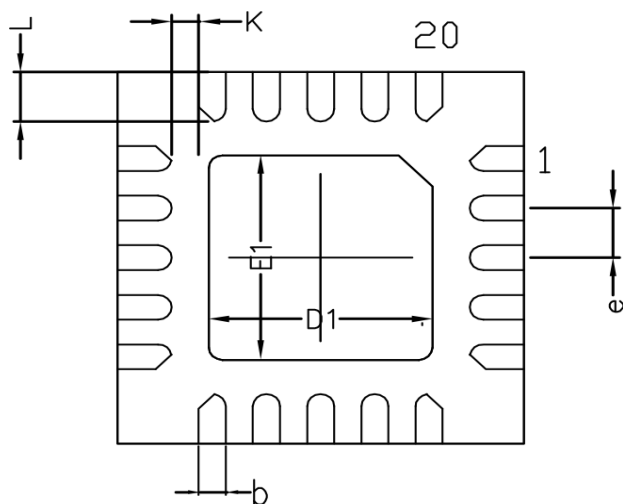
QFN3x3-20L



Top View



Side View



bottom View

| Symbol | Dimensions In Millimeters | | |
|--------|---------------------------|------|------|
| | Min | Nom | Max |
| A | 0.70 | 0.75 | 0.80 |
| A1 | 0.00 | -- | 0.05 |
| A3 | 0.203REF | | |
| b | 0.15 | -- | 0.25 |
| D | 2.90 | 3.00 | 3.10 |
| E | 2.90 | 3.00 | 3.10 |
| D1 | 1.55 | 1.65 | 1.75 |
| E1 | 1.55 | 1.65 | 1.75 |
| e | 0.40TYP | | |
| K | 0.20 | -- | -- |
| L | 0.30 | 0.40 | 0.50 |