

BCT8933

High Power, Low THD+N Class T Audio Amplifier

GENERAL DESCRIPTION

The BCT8933 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 BCT8933 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 BCT8933 can provide 2W output power (10% THD+N) into 8Ω load from the 4.2V battery voltage.

The BCT8933 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 BCT8933 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:0.03%
- 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

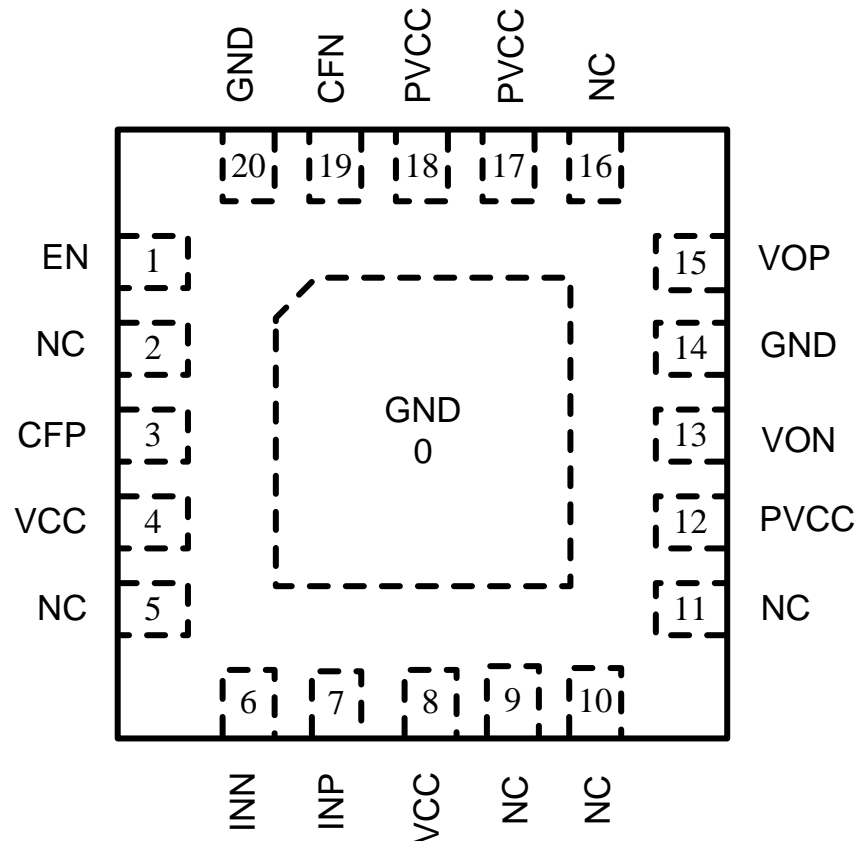
- Smart phone
- Portable Audio Devices
- Mini Speakers

ORDERING INFORMATION

Order Number	Package Type	Temperature Range	Marking	QTY/Reel
BCT8933EGP-TR	QFN3x3-20L	-40°C to +85°C	 8933 XXXXX	6000

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

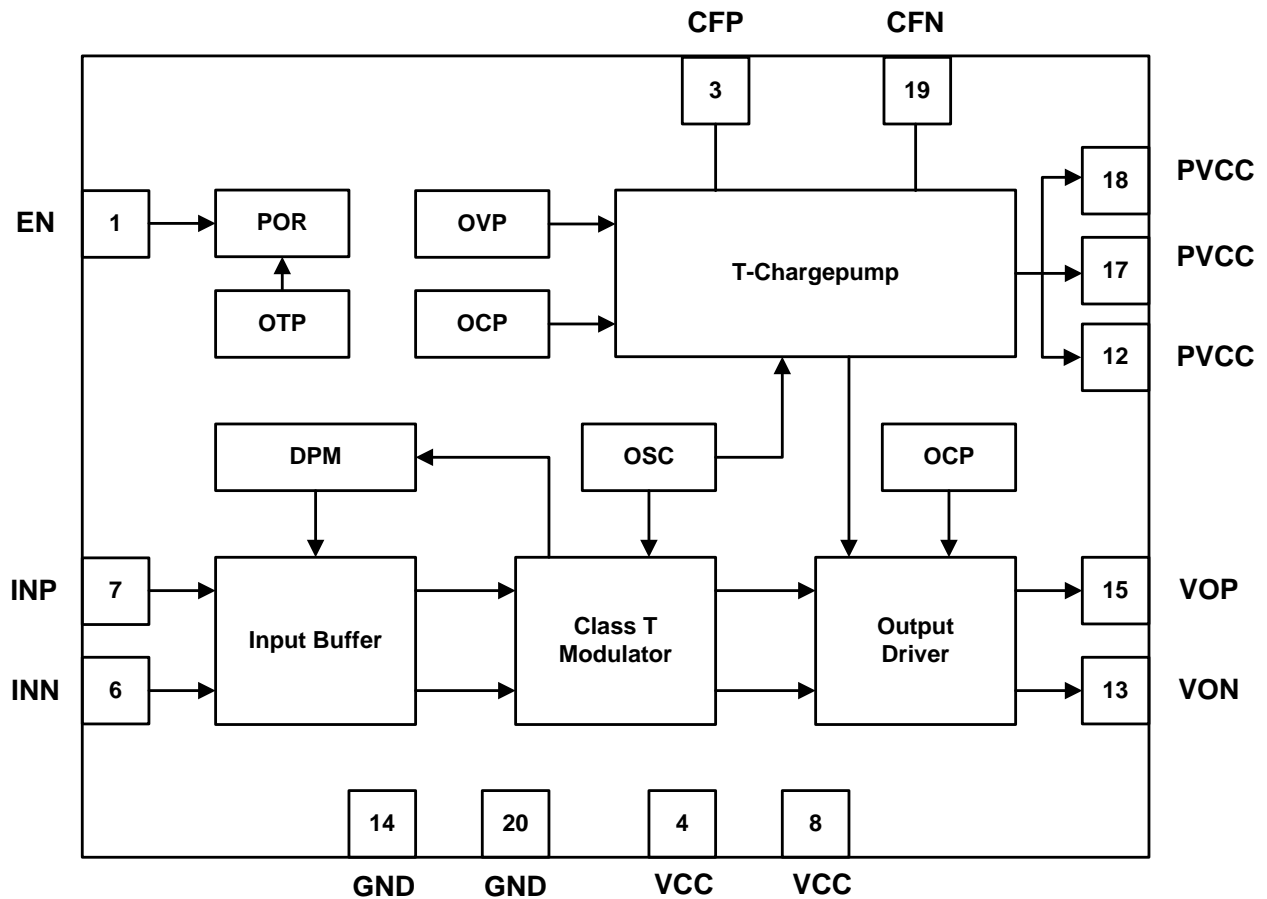
PIN CONFIGURATION (Top View)



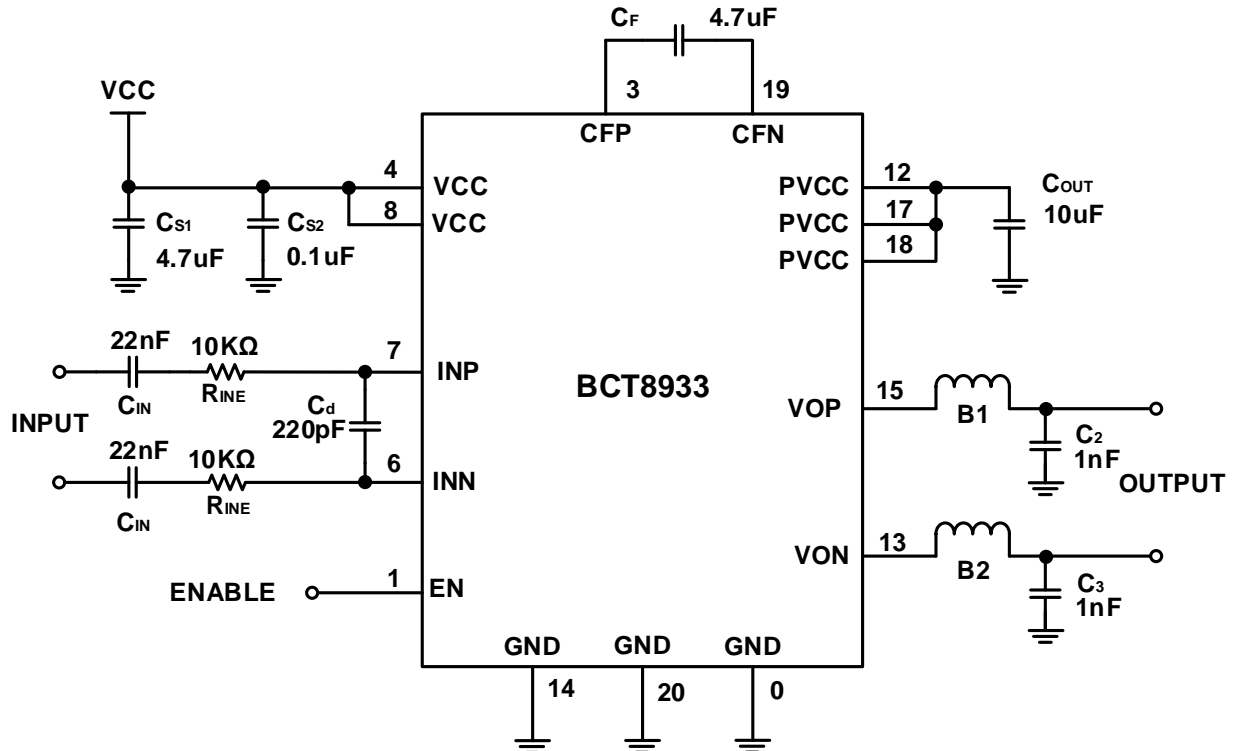
PIN DESCRIPTION

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





BCT8933

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: TA=25°C, VCC=3.6V, RL=8Ω+33μH, f=1kHz (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		800			kHz
PSRR	Power supply rejection ratio	VCC=4.2V,V _{p-p} _{sin} =200mV	217Hz	-70			dB
			1kHz	-68			dB
T _{ON}	Start-up time			28			ms
THD+N	Total harmonic distortion plus noise	VCC=4.2V,Po=1W,f=1kHz		0.03			%
		VCC=3.6V,Po=0.5W,f=1kHz		0.035			%
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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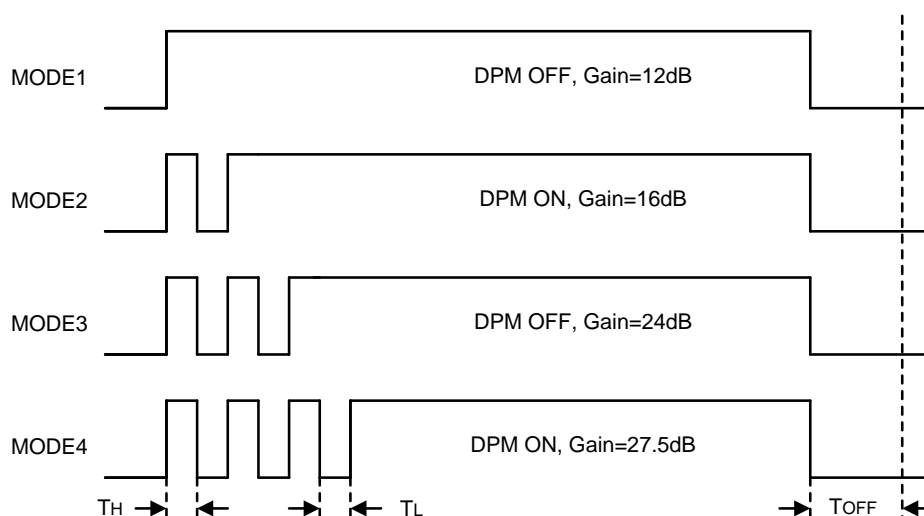
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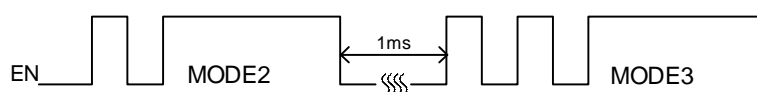
One Wire Pulse Control

BCT8933 select each mode by one-wire pulse control, When EN pin pull high from shutdown mode, there is one rising edge, BCT8933 start to work and set Gain=12dB. When high-low-high signal set to EN pin, there are two rising edges, BCT8933 open DPM function and set Gain=16dB. When there are three rising edges, BCT8933 close DPM function and set Gain=24dB. When there are four rising edges, BCT8933 open DPM function and set Gain=27.5dB.

When EN pull down above 500μs, BCT8933 will enter shutdown mode.



When BCT8933 needs to work in different mode, PIN EN should be pull low longer than T_{OFF} first (recommended 1ms) which make the BCT8933 shut down, then send series pulse make the BCT8933 enter into right mode.



APPLICATION INFORMATION

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

The BCT8933 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:

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

Supply Decoupling Capacitor(C_s)

The BCT8933 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 BCT8933 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)

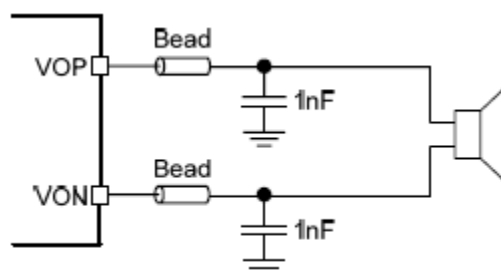
The value of the flying capacitor (C_F) affects the load regulation and output resistance of the charge pump. A C_F value that is too small degrades the device's ability to provide sufficient current drive. Increasing the value of C_F improves load regulation and reduces the charge pump output resistance 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.

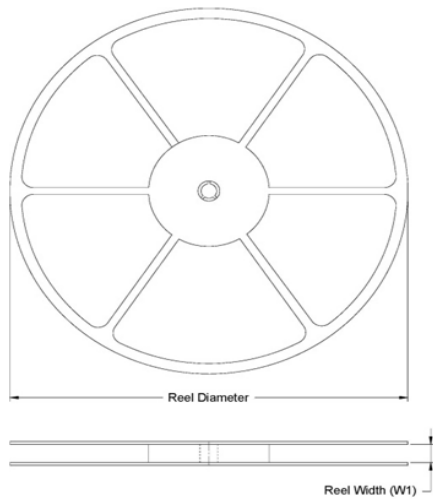
Optional Ferrite Bead Filter

The BCT8933 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.

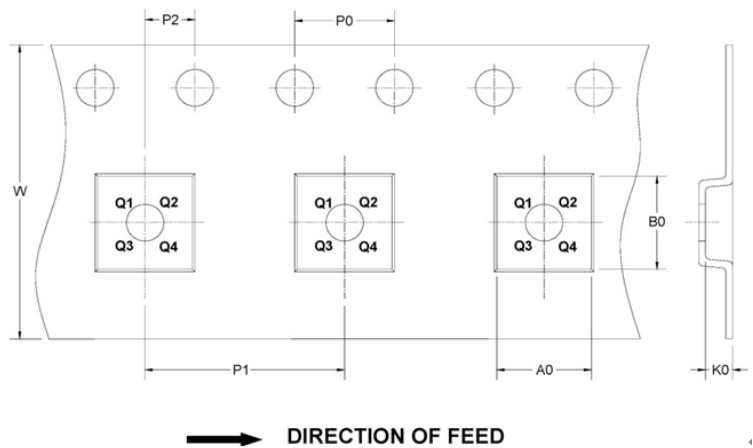


TAPE AND REEL INFORMATION

REEL DIMENSIONS



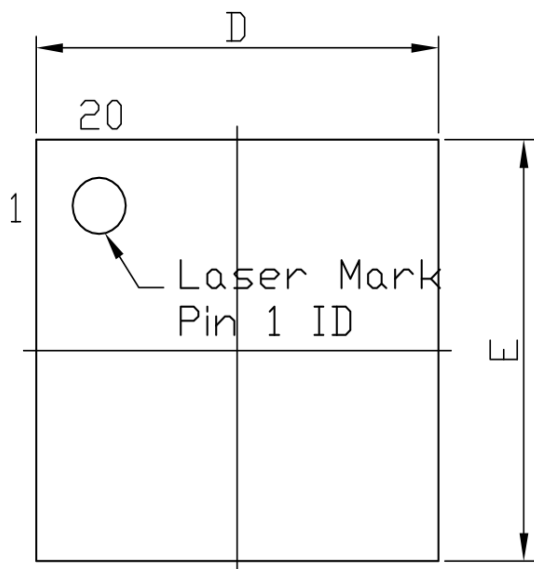
TAPE DIMENSIONS



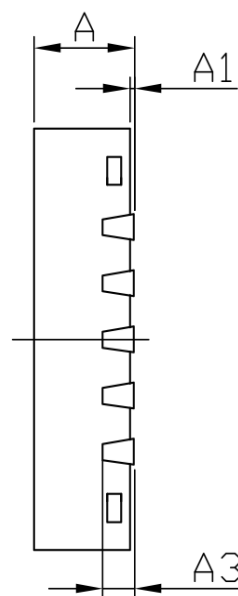
Device Name	Package Type	Reel Diameter	Unit: mm								Pin 1 Quadrant	Reel QTY
			Reel Width W1	A0	B0	K0	P0	P1	P2	W		
BCT8933EGP-TR	QFN3x3-20L	13"	12	3.3	3.3	1.1	4	4	2	12	Q1	6000

PACKAGE OUTLINE DIMENSIONS

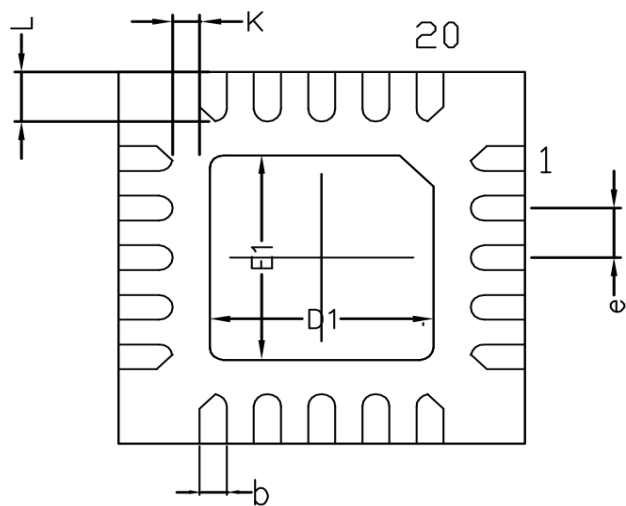
QFN3x3-20L



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