BCT89317A

High efficiency, Low noise Class T Audio Amplifier

GENERAL DESCRIPTION

BCT89317A 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 BCT89317A noise floor is as low as to 53μV, with 97dB high signal-to-noise-ratio (SNR). The ultra-low distortion 0.08% and unique Digital Power Modulation technology brings high quality music enjoyment.

BCT89317A 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.

BCT89317A supports the special speaker and receiver two-in-one application. In receiver mode, the output noise floor is as low as 22μV, amplifier is in Class D mode, powered by VCC.

BCT89317A has built-in over current protection, over-temperature protection and short circuit protection function, effectively protecting the chip from damage. The BCT89317A uses small 0.4mm pitch FCQFN1.6x1.6-16L package.

FEATURES

- Power amplifier overall efficiency 80%
- Low noise：53μV
- Ultra-low distortion：0.08%
- Speaker and Receiver two-in-one application
  Receiver：1V/V, Vn=22μV, THD+N=0.02%
  Receiver：3V/V, Vn=26μV, THD+N=0.01%
- 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：±6kV (HBM)
- Small 0.4mm pitch FCQFN1.6x1.6-16L package

APPLICATIONS

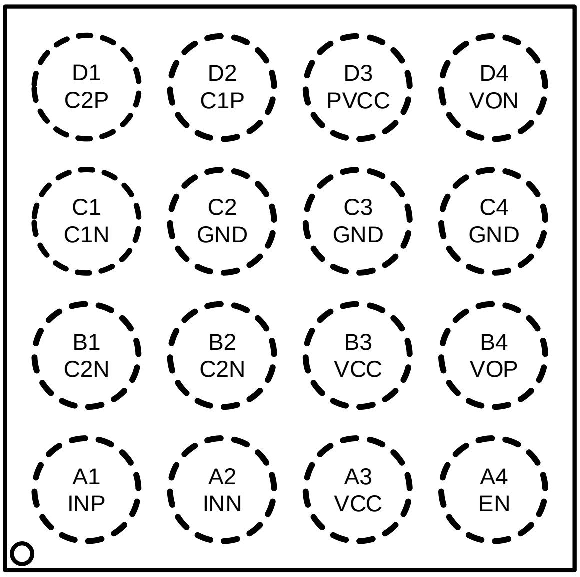
- Cellular Phones
- Portable Audio Devices
- Mini Speakers
- Tablets

ORDERING INFORMATION

Order Number	Package Type	Temperature Range	Marking	QTY/Reel
BCT89317AEZE-TR	FCQFN1.6x1.6-16L	-40°C to +85°C	DQLA XXXX	3000

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

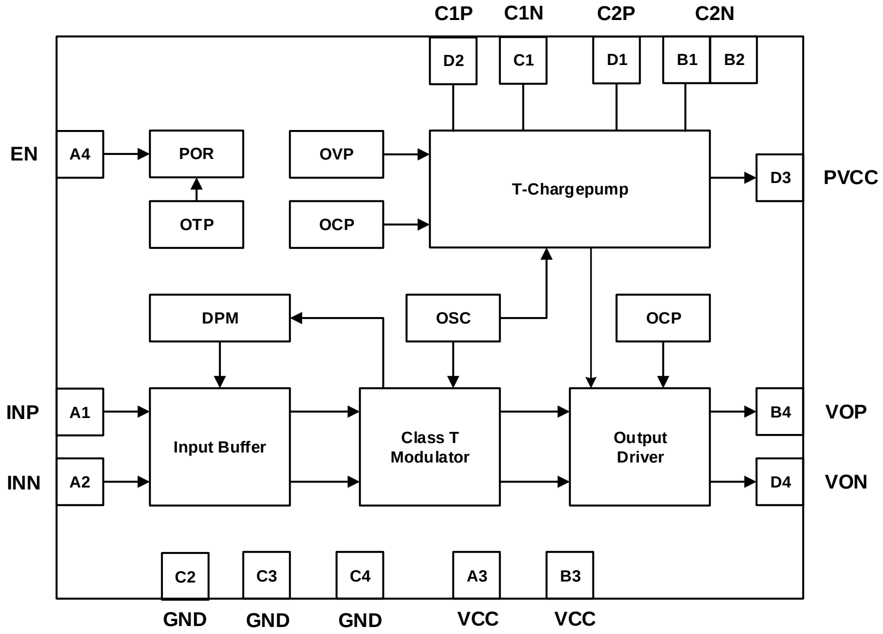
PIN CONFIGURATION (Top View)



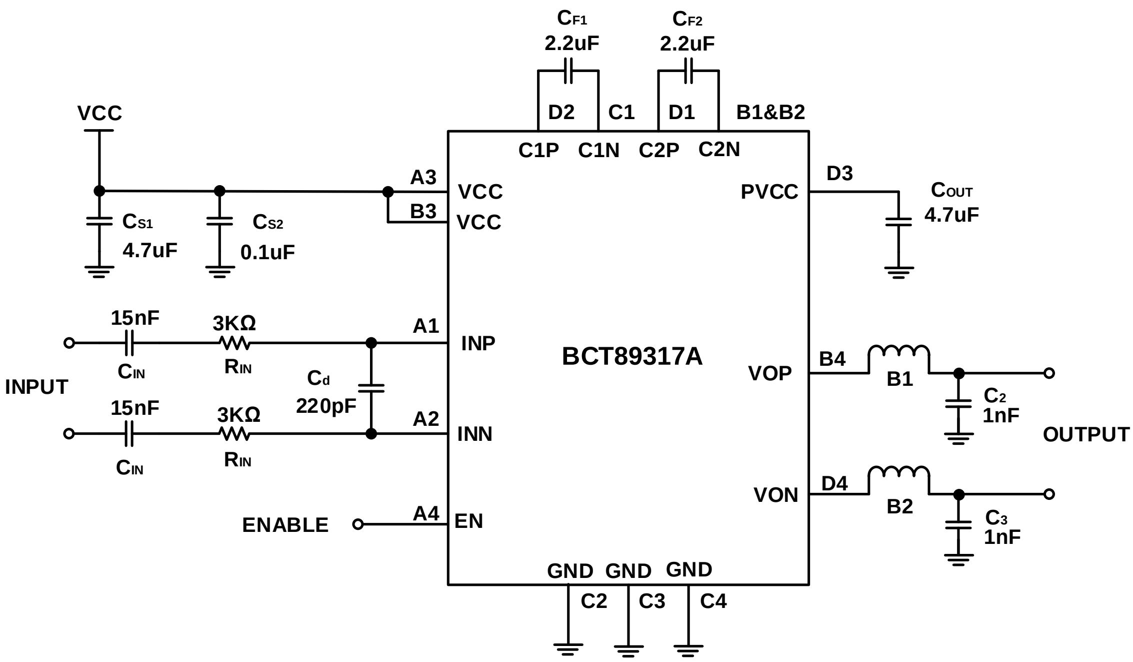
PIN DESCRIPTION

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,B2	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,C3,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

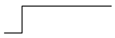
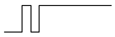
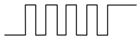
BLOCK DIAGRAM



TYPICAL APPLICATION CIRCUIT



MODE DESCRIPTION

Mode	Enable Signal	Gain(V/V)		DPM Power(W)		DPM Function	Receiver Mode
		Rin=3KΩ	Rin=10KΩ	RL=8Ω+33μH	RL=6Ω+33μH		
Mode1		16.3	12	1.2	1.6	√	
Mode2		16.3	12	1.0	1.3	√	
Mode3		16.3	12	0.8	1.0	√	
Mode4		16.3	12	0.6	0.8	√	
Mode5		1	1				√
Mode6		3	3				√
Mode7		16.3	12	1.75W@ THD=1%	2.05W@ THD=1%		

ABSOLUTE MAXIMUM RATINGS

VCC, 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 VCC+0.3V
Package Thermal Resistance θJA.. 85℃/W
Operating Temperature Range.. -40℃ to +85℃
Junction Temperature.. 150℃
Storage Temperature Range.. -65℃ to +150℃
Lead Temperature (Soldering, 10sec) .... 260℃
ESD HBM (Human body model) .... ±6KV

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℃, VCC=3.6V,RL=8Ω+33μH,f=1kHz(unless otherwise noted)

Parameter		Test conditions	Min	Typ	Max	Units
VCC	Power supply voltage		3.0		5.5	V
V_{IH}	EN high input voltage		1.3		VCC	V
V_{IL}	EN low input voltage		0		0.35	V
V_{OS}	Output offset voltage	Vin=0V, VCC=3.0V to 5.5V	-30	0	30	mV
I_{SD}	Shutdown current	VCC=3.6V, EN =0V			1	μA
T_{TG}	Thermal AGC start temperature threshold			150		℃
T_{TGR}	Thermal AGC exit temperature threshold			130		℃
T_{SD}	Over temperature protection threshold			160		℃
T_{SDR}	Over temperature protection recovery threshold			120		℃
T_{ON}	Start-up time			40		ms
T-Charge pump						
PVCC	Output voltage	VCC =3.0V to 4.0V		1.5* VCC		V
		VCC >4.0V		6.05		V
Vhys	OVP hysteresis	VCC >4.0V		50		mV
F_{CP}	Charge Pump frequency	VCC=3.0V to 5.5V	0.80	1.06	1.33	MHz
η_{CP}	Charge pump efficiency	VCC=3.6V, I_{load}=200mA		93		%
I_L	Current limit when PVCC short to ground			300		mA
Class T power amplifier (Mode1-Mode4,Mode7)						
I_q	Quiescent current	VCC=4.2V,Vin=0,no load		10	15	mA
η	Efficiency	VCC=3.6V, Po=1.0W, RL=8Ω+33μH		80		%
Fosc	Modulation frequency	VCC=3.0V to 5.5V	600	800	1000	kHz
Av	Gain	External input resistance=3kΩ		16.3		V/V
Vin	Recommend input voltage	VCC=3.0V to 5.5V			1	Vrms
Rini	Inner input resistance	Mode1~Mode4,Mode7		16.6		kΩ
f_{HPF}	Input high pass filter corner frequency	Cin=15nF, External input resistance=3kΩ		542		Hz
P_{DPM}	Mode1 DPM output power	VCC=4.2V, R_L=8Ω+33μH	1.08	1.20	1.32	W
		VCC=4.2V, R_L=6Ω+33μH	1.44	1.60	1.76	W
		VCC=4.2V, R_L=4Ω+15μH	2.16	2.40	2.64	W
	Mode2 DPM output power	VCC=4.2V, R_L=8Ω+33μH	0.90	1.00	1.10	W
		VCC=4.2V, R_L=6Ω+33μH	1.17	1.30	1.43	W
		VCC=4.2V, R_L=4Ω+15μH	1.80	2.00	2.20	W

ELECTRICAL CHARACTERISTICS (continued)

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

Parameter		Test conditions		Min	Typ	Max	Units
P_{DPM}	Mode3 DPM output power	VCC=4.2V, R_L=8Ω+33μH		0.72	0.80	0.88	W
		VCC=4.2V, R_L=6Ω+33μH		0.90	1.00	1.10	W
		VCC=4.2V, R_L=4Ω+15μH		1.44	1.60	1.76	W
	Mode4 DPM output power	VCC=4.2V, R_L=8Ω+33μH		0.54	0.60	0.66	W
		VCC=4.2V, R_L=6Ω+33μH		0.72	0.80	0.88	W
		VCC=4.2V, R_L=4Ω+15μH		1.08	1.20	1.32	W
PSRR	Power supply rejection ratio	VCC=4.2V, Vp-p_sin=200mV	217Hz		-68		dB
		VCC=4.2V, Vp-p_sin=200mV	1kHz		-68		dB
SNR	Signal-to-noise ratio	VCC=4.2V, Po=1.75W, THD+N=1%, RL=8Ω+33μH,Av=8V/V			97		dB
V_n	Output noise voltage	VCC=4.2V, f=20Hz to 20kHz, input ac grounded, Av=8V/V	A-weighting		53		μVrms
		VCC=4.2V, f=20Hz to 20kHz, input ac grounded, Av=12V/V	A-weighting		58		μVrms
		VCC=4.2V, f=20Hz to 20kHz, input ac grounded, Av=16V/V	A-weighting		68		μVrms
THD+N	Total harmonic distortion+noise	VCC=3.6V,Po=1W,R_L=8Ω+33μH,f=1kHz, Mode1			0.08		%
		VCC=3.6V,Po=1W,R_L=6Ω+33μH,f=1kHz,Mode7			0.08		%
PO	Mode7 output power	THD+N=10%, f=1kHz, R_L=8Ω+33μH, VCC=4.2V			2.15		W
		THD+N=1%, f=1kHz, R_L=8Ω+33μH, VCC=4.2V			1.75		W
		THD+N=10%, f=1kHz, R_L=8Ω+33μH, VCC=3.6V			1.60		W
		THD+N=1%, f=1kHz, R_L=8Ω+33μH, VCC=3.6V			1.28		W
		THD+N=10%, f=1kHz, R_L=6Ω+33μH, VCC=4.2V			2.52		W
		THD+N=1%, f=1kHz, R_L=6Ω+33μH, VCC=4.2V			2.05		W
		THD+N=10%, f=1kHz, R_L=6Ω+33μH, VCC=3.6V			1.82		W
		THD+N=1%, f=1kHz, R_L=6Ω+33μH, VCC=3.6V			1.50		W
		THD+N=10%, f=1kHz, R_L=4Ω+15μH, VCC=4.2V			2.45		W
		THD+N=1%, f=1kHz, R_L=4Ω+15μH, VCC=4.2V			2.10		W
		THD+N=10%, f=1kHz,R_L=4Ω+15μH, VCC=3.6V			1.85		W
		THD+N=1%, f=1kHz, R_L=4Ω+15μH, VCC=3.6V			1.55		W

ELECTRICAL CHARACTERISTICS (continued)

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

Parameter		Test conditions	Min	Typ	Max	Units
Receiver (Mode5-Mode6)						
I_q	Quiescent current	VCC=4.2V,Vin=0,no load		5	7.5	mA
η	Efficiency	VCC=3.6V, Po=0.8W, RL=8Ω+33μH,Mode6		86		%
Fosc	Modulation frequency	VCC=3.0V to 5.5V	600	800	1000	kHz
Av	gain	External input resistance=3kΩ,Mode5		1		V/V
		External input resistance=3kΩ,Mode6		3		V/V
Rini	Inner input resistance	Mode5		186.6		kΩ
		Mode6		56.6		kΩ
f_{HPF}	Input high pass filter corner frequency	Cin=15nF, external input resistance=3kΩ,Mode5		56		Hz
		Cin=15nF, external input resistance=3kΩ,Mode6		178		Hz
Vn	Output noise voltage	VCC=4.2V, f=20Hz to 20kHz, input ac grounded, Av=1V/V, A-weighting		22		μVrms
		VCC=4.2V, f=20Hz to 20kHz, input ac grounded, Av=3V/V, A-weighting		25		μVrms
THD+N	Total harmonic distortion+noise	VCC=4.2V, Po=0.1W, R_L=8Ω+33μH, f=1kHz, Mode5		0.02		%
		VCC=4.2V, Po=0.4W, R_L=8Ω+33μH, f=1kHz, Mode6		0.01		%
One wire pulse control						
T_H	EN high level duration time	VCC=3.0V to 5.5V	0.75	2	10	μs
T_L	EN low level duration time	VCC=3.0V to 5.5V	0.75	2	10	μs
T_{LATCH}	EN turn on delay time	VCC=3.0V to 5.5V	90		500	μs
T_{OFF}	EN turn off delay time	VCC=3.0V to 5.5V	90		500	μs
DPM(Note)						
T_{AT}	Attack time	-13.5dB gain attenuation completed		40		ms
T_{RL}	Release time	13.5dB gain release completed		1.2		s
A_{MAX}	Maximum attenuation			-13.5		dB

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

DETAILED FUNCTIONAL DESCRIPTION

BCT89317A 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 T-Chargepump technology, efficiency reach 93%, power amplifier's overall efficiency is up to 80%, greatly prolong the mobile phone usage time. The BCT89317A noise floor is as low as to 53μV, with 94dB high signal-to-noise-ratio (SNR). The ultra-low distortion 0.08% and unique Digital Power Modulation (DPM) technology brings high quality music enjoyment.

BCT89317A 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. BCT89317A 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.

BCT89317A supports speaker and receiver two-in-one application. In receiver mode, the output noise is as low as to 22μV, amplifier is in Class D mode, powered by VCC.

The BCT89317A built in excellent pop-click noise suppression circuit, effectively avoids pop-click noise during shutdown, wakeup, and power-up/down operation of BCT89317A.

BCT89317A has built-in over current protection, over-temperature protection and short circuit protection function, effectively protect the chip. The BCT89317A uses small 0.4mm pitch FCQFN1.6x1.6-16L package. The BCT89317A is specified over the industrial temperature range of -40℃ to 85℃.

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 BCT89317A 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, BCT89317A can still provide high quality large volume music enjoyment. BCT89317A has seven operation modes, first four modes have DPM function, the output power level is 1.2W,1W,0.8W,0.6W, respectively.

DETAILED FUNCTIONAL DESCRIPTION (continued)

One Wire Pulse Control

BCT89317A select each mode through the detection of number of the pulse signal rising edge of EN pin, as shown in figure: When EN pin pull high from shutdown mode, there is only a rising edge, BCT89317A enter into mode 1,DPM output power is 1.2W; When high-low-high signal set to EN pin, there are two rising edges, BCT89317A enter into mode 2, DPM output power is 1W; When there are three rising edges, BCT89317A enter into mode 3, DPM output power is 0.8W; When there are four rising edges, BCT89317A enter into mode 4, DPM output power is 0.6W…… BCT89317A has seven operation modes, the number of the rising edges does not allow more than seven.

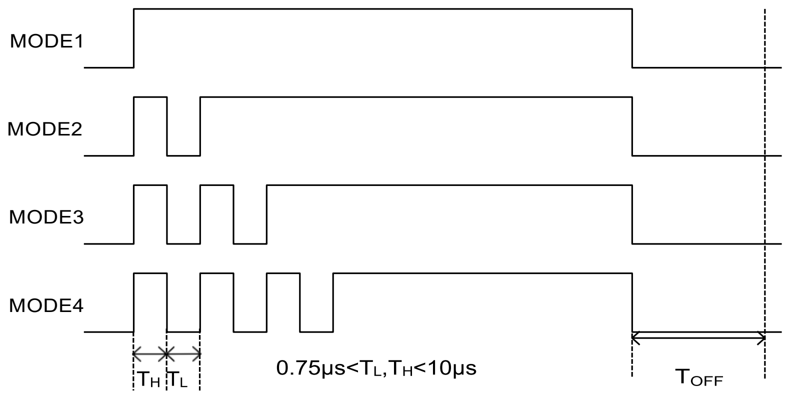


Figure. One Wire Pulse Control

When BCT89317A needs to work in different mode, PIN EN should be pull low longer than TOFF first (recommended 1ms) which make the BCT89317A shut down, then send series pulse make the BCT89317A enter into right mode, as shown in figure.

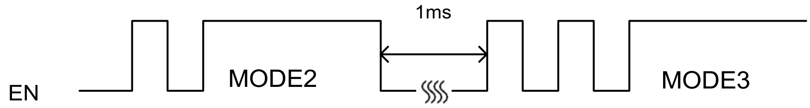


Figure. One Wire Pulse Control Switching Sequence

APPLICATION INFORMATION

External Input Resistor-Rine (Gain setting)

The BCT89317A is a differential audio amplifier. The IC integrates two internal input resistors, which is Rini=16.6kΩ. Take external input resistor Rine=3kΩ for an example, gain setting as follows：

Class T mode：

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

Receiver 1V/V mode：

$$A_V = \frac{190k\Omega}{R_{ine} + R_{ini}} = \frac{190k\Omega}{3k\Omega + 186.6k\Omega} = 1V/V$$

Receiver 3V/V mode：

$$A_V = \frac{190k\Omega}{R_{ine} + R_{ini}} = \frac{190k\Omega}{3k\Omega + 56.6k\Omega} = 3.2V/V$$

Input Capacitor-Cin（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:

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

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 as an example:

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

Take 1V/V receiver mode application as example, the input high-pass corner frequency is：

$$f_H(-3dB) = \frac{1}{2 * \pi * R_{in} * C_{in}} (Hz) = \frac{1}{2 * \pi * 186.6k\Omega * 15nF} = 56Hz$$

Differential input filter capacitor Cd (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:

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

With input resistance Rine = 3kΩ, differential capacitance 220pF, for example, the low-pass cutoff frequency is as follows:

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

APPLICATION INFORMATION (continued)

Supply Decoupling Capacitor (C_S)

The BCT89317A is a high-performance audio amplifier that requires adequate power supply decoupling. Place a low equivalent-series-resistance (ESR) ceramic capacitor, typically 0.1µF. 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 BCT89317A is important, as any parasitic resistance or inductance between the device and the capacitor causes efficiency loss. In addition to the 0.1µF ceramic capacitor, place a 10µF capacitor on the VCC 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 (CF) affects the load regulation and output resistance of the charge pump. A CF value that is too small degrades the device's ability to provide sufficient current drive. Increasing the value of CF improves load regulation and reduces the charge pump output resistance to an extent. A 2.2µF@6.3V upper capacitor is recommended.

Output Capacitor (C_{OUT})

The output capacitor value and ESR directly affect the ripple at PVCC. Increasing COUT reduces output ripple. Likewise, decreasing the ESR of COUT reduces both ripple and output resistance. A 4.7µF@10V capacitor is recommended.

Optional Ferrite Bead Filter

The BCT89317A 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.

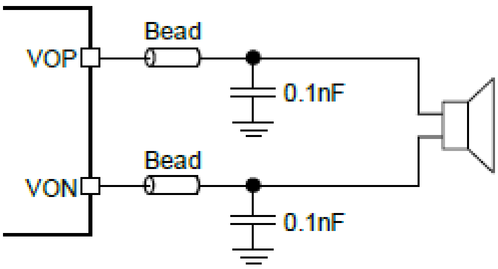
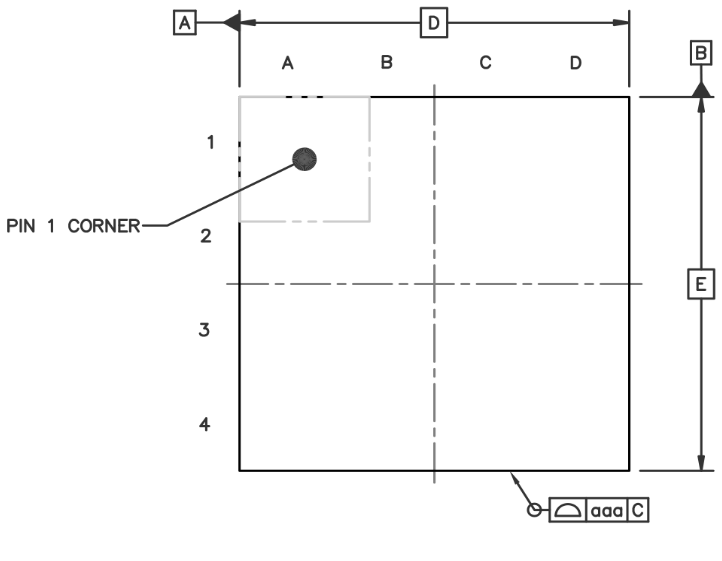


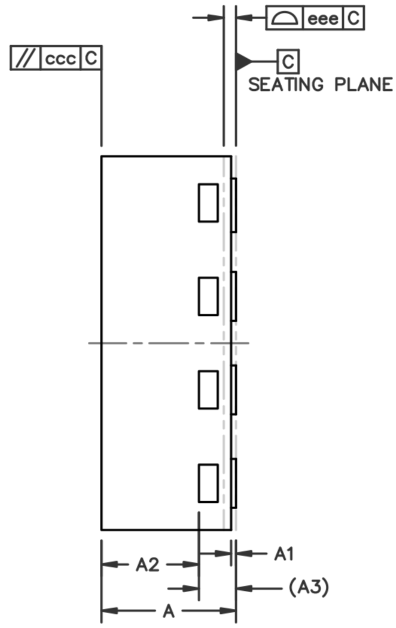
Figure. Ferrite Chip Bead and capacitor

PACKAGE OUTLINE DIMENSIONS

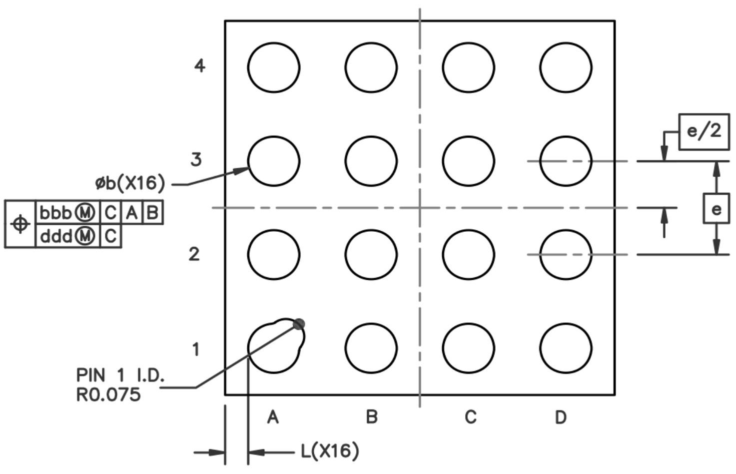
FCQFN1.6x1.6-16L



TOP VIEW



SIDE VIEW



BOTTOM VIEW

Symbol	Min.	Typ.	Max.
A	0.5	0.55	0.6
A1	0	0.02	0.05
A2	---	0.4	---
A3		0.152 REF	
b	0.16	0.21	0.26
D		1.6 BSC	
E		1.6 BSC	
e		0.4 BSC	
L		0.095 REF	
aaa		0.1	
ccc		0.1	
eee		0.05	
bbb		0.07	
ddd		0.05	

Unit: mm