3W Class-D Stereo Audio Amplifier

General Description

The HM8403 is a 3W, class-D audio amplifier. It offers low THD+N, allowing it to achieve high-quality sound reproduction. The new filterless rchitecture allows the device to drive the speaker directly, requiring no low-pass output filters,thus to save the system cost and PCB area. With the same numbers of external components, the efficiency of the HM8403 is much better than that of class-AB cousins. It can extend the battery life, ideal for portable applications.

Features

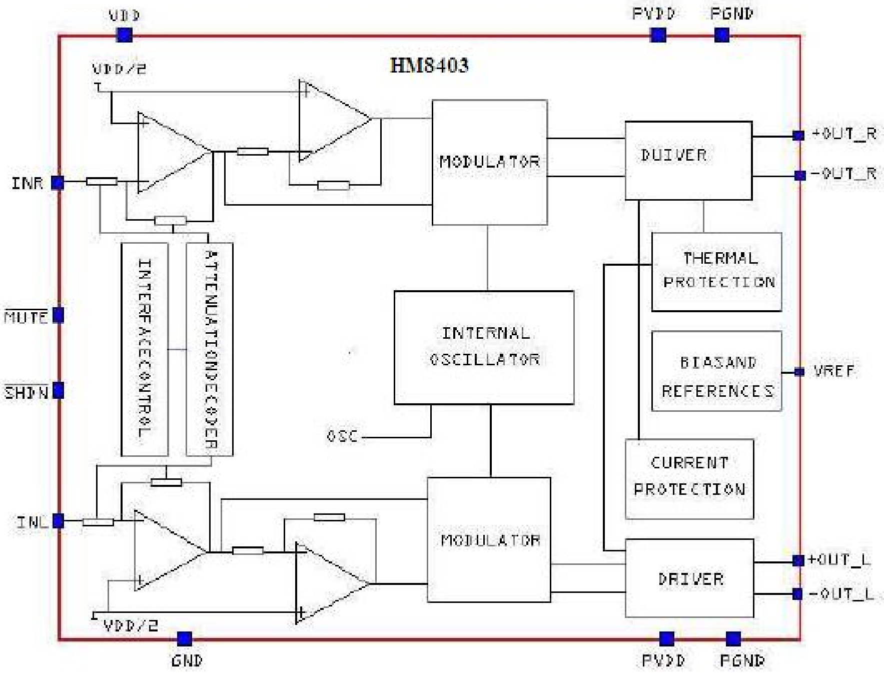
- 3W output at 10% THD with a 4ΩLoad and 5V Power Supply
- Filterless, Low Quiescent Current and Low EMI
- Low THD+N
- Superior Low Noise
- Efficiency up to 90%
- Short Circuit Protection
- Thermal Shutdown
- Few External Components to Save the Space and Cost
- Pb-Free

Physical Map

Applications

- LCD Monitors 1 TV Projectors
- Notebook Computers
- Portable Speakers
- Portable DVD Players, Game Machines
- Cellular Phones1Speaker Phones

Block Diagram



Ordering Information

Part Number	Package Type	Shipping Type	Note
HM8403S	SOP16	50 Units/Tube	
HM8403Q	QFN4X4	3000 Units/Reel	
HM8403QF	QFN3X3	3000 Units/Reel	

Typical Application

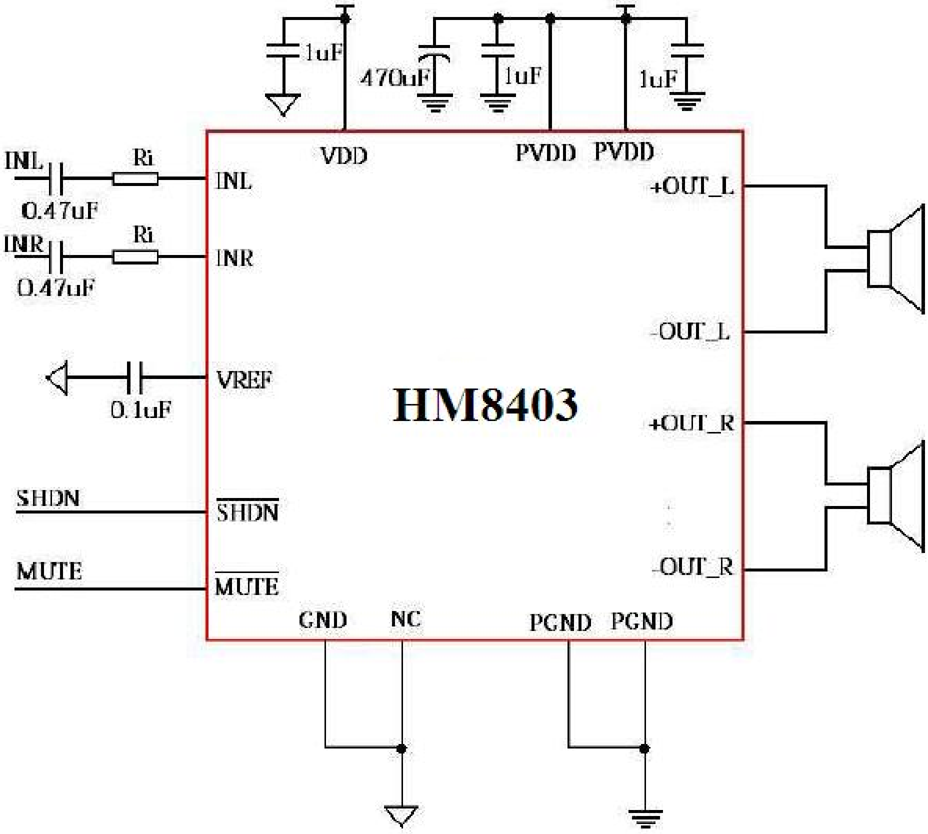


FIGURE 1. Typical Audio Amplifier Application Circuit

Connetction Diagrams

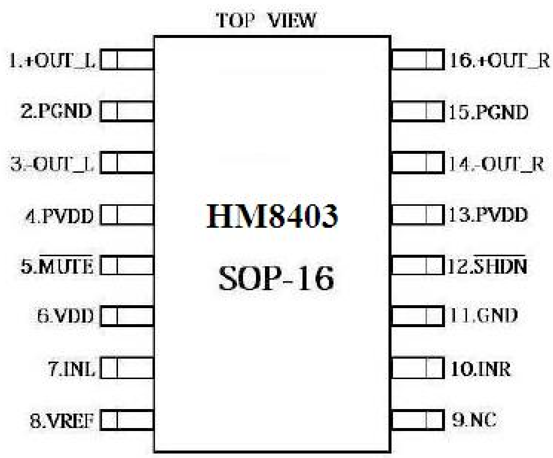


FIGURE2. SOP-16 Package

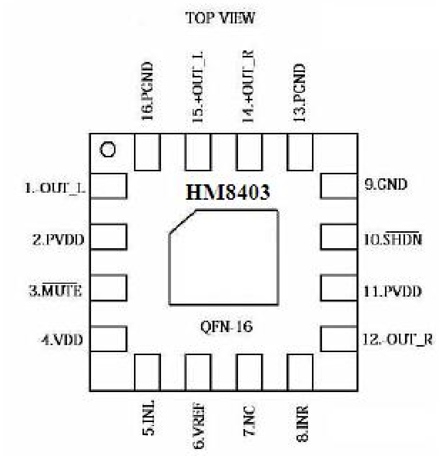


FIGURE3. QFN-16 Package

Terminal Functions

Pin Number		Pin Name	Discription
15	1	+out_L	Left Channel Positive output
16	2	PGND	Power GND
1	3	-out_L	Left Channel Negative output
2	4	PVDD	Power VDD
3	5	MUTE	Mute Control Input（active low）
4	6	VDD	Analog VDD
5	7	INL	Left Channel Input
6	8	VREF	Internal analog reference, connect a bypass capacitor from VREF to GND
7	9	NC	No connect
8	10	INR	Right Channel Input
9	11	GND	Analog GND
10	12	SHDN	Shutdown Control Input (active low)
11	13	PVDD	Power VDD
12	14	-out_R	Right Channel Negative output
13	15	PGND	Power GND
14	16	+out_R	Right Channel Positive output

Absolute Maximum Ratings

These are stress ratings only and functional operation is not implied Exposure to absolute maximum ratings for prolonged time periods may affect device reliability All voltages are with respect to ground.

Supply Voltage	6.0V
Input Voltage	-0.3V to VDD+0.3V
Operation Temperature Range	-40℃ to 85℃
Maximum Junction Temperature	150℃
Operatio Junction Temperature	-40℃ to 125℃
Storage Temperture	-65℃ to 150℃
Soldering temperature	300℃,5sec

Recommended Operating Conditions

Supply voltage Range........................ 2.5V to 5.5V
Operation Temperature Range...........-40 to 85
Junction Temperature Range.............-40 to 125

Thermal Information

Parameter	Symbol	Package	Maximum	Unit
Thermal Resis tance (Junction to Ambient)	θJ	SoP-16	110	°C1
Thermal Resis tance (Junction to Case)	θJ	SoP-16	23	°C1

Electrical Characteristics

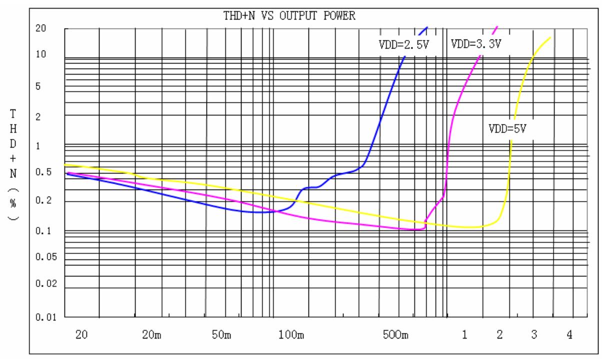
V_{DD}=5V, Gain=24dB, R_L=8ο, T_A=25°C, unless otherwise noted.

Sym	Parameter	Test Conditions	MI	TYP	M	U

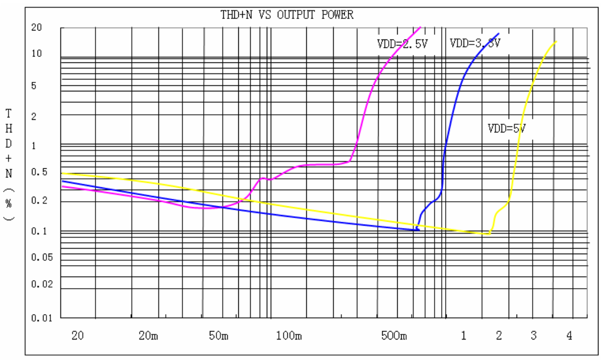
VIN	Supply Power			2.5		5.5	V
Po	output Power	THD+N=10%,f=1kHz, RL=4 Ω	VDD=5.0V		3.2		W
			VDD=3.6V		1.6		
			VDD=3.		1.3		
		THD+N=1%,f=1kHz,	VDD=5.		2.5		W
			VDD=3.6V		1.3		
			VDD=3.		0.85		
		THD+N=10%,f=1kHz,	VDD=5.		1.8		W
			VDD=3.6V		0.9		
			VDD=3.		0.6		
		THD+N=1%,f=1kHz,	VDD=5.		1.4		W
			VDD=3.6V		0.72		
			VDD=3.		0.45		
THD	Total Harmonic Distortion Plus	VDD=5.0V,Po=0.5W,RL	f=1kHz		0.15		%
		VDD=3.6V,Po=0.5W,RL=8			0.11		
		VDD=5.0V,Po=1W,RL=	f=1kHz		0.15		%
		VDD=3.6V,Po=1W,RL=4 Ω			0.11		
Gv	Gain				24		dB
PSR	Power Supply Ripple	VDD=5.0V, Inputs ac-grounded with	f=100H		-59		d
			f=1kHz		-58		
Cs	Crosstalk	VDD=5V,Po=0.5W,RL=8	F=1kHz		-95		dB
SNR	Signal-to-noise ratio	VDD=5V,	f=1kHz		80		dB
V	output noise	VDD=5V, Inputs ac-grounded with	A-weighti		100		μ
			No		150		
Dyn	Dynamic range	VDD=5.0V, THD=1%	f=1kHz		90		dB
η	Efficie	RL=8 Ω, THD=10%	f=1kHz		8		%
		RL=4 Ω, THD=10%			83		
I	Quiescent Current	VDD	No load		16		m
		VDD=3.6V			10		
		VDD			8		
Sym	Parame	Test		MI	TY	M	UNI

IMUT	Muting Current	VDD=5.0V	VMUTE		3.5		mA
ISD	Shutdown Current	VDD=2.5V to 5.5V	Vsd=0.3V		<1		μA
Rds	Static Drain-to-source on-state	IDS =500mA,Vgs=5V	PMoS		18		mo
			NMoS		140		
fsw	Switching Frequency	VDD=3V to 5V			260		kHz
Vos	output offset Voltage	Vin=0V, VDD=5V			10		mV
VIH	Enable Input High Voltage	VDD=5.0V		1.5	1.4		V
VIL	Enable Input Low	VDD=5.0V			0.7	0.4	
VIH	MUTE Input High Voltage	VDD=5.0V		1.5	1.4		V
VIL	MUTE Input Low Voltage	VDD=5.0V			0.7	0.4	
oTP	over Temperature	No Load, Junction	VDD=5V		140		°C
oTH	over Temperature				30		

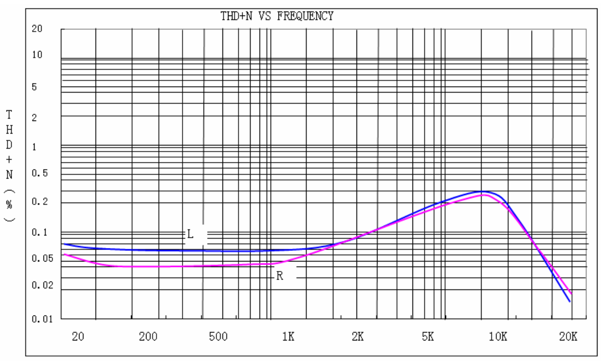
Operating Characteristics



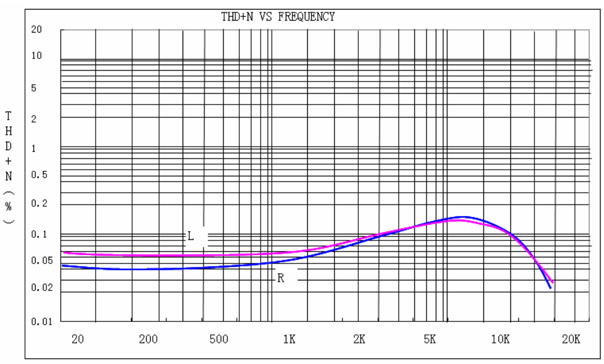
RL=4Ω, GAIN=24dB, F=1kHz



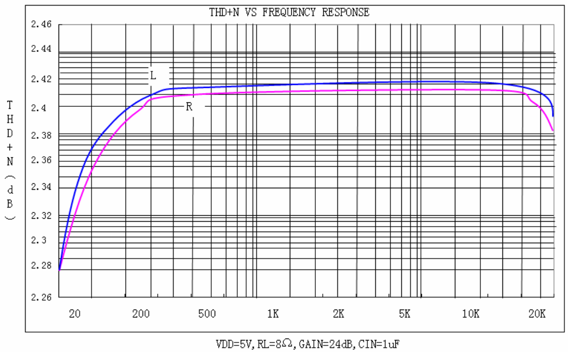
RL=4Ω, GAIN=24dB, F=1kHz

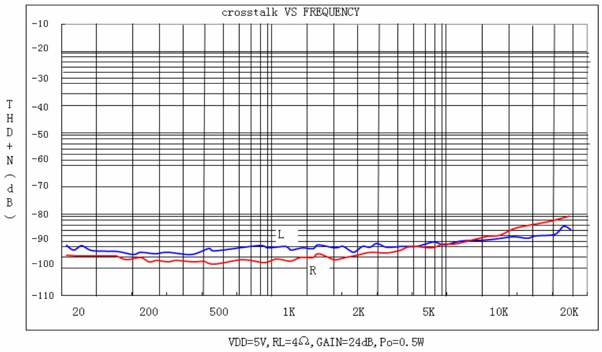


VDD=5V, RL=4Ω, GAIN=24dB, CIN=1uF



VDD=5V, RL=8Ω, GAIN=24dB, CIN=1uF





Application Notes

1. When the HM8403 works with LC filters, it should be connected with the speaker before it's powered on, otherwise it will be damaged easily.
2. When the HM8403 works without LC filters, it's better to add a ferrite chip bead at the outgoing line of speaker for suppressing the possible electromagnetic interference.
3. The recommended operating voltage is 5.5V. When the HM8403 is powered with 4 battery cells, it should be noted that the voltage of 4 new dry or alkaline batteries is over 6.0V, higher than its operation voltage, which will probably damage the device. Therefore, it's recommended to use either 4 Ni-MH(Nickel Metal Hydride) rechargeable batteries or 3 dry or alkaline batteries.
4. one should not make the input signal too large. Large signal can cause the clipping of output signal when increasing the volume. This will damage the device because of big gain of the HM8403.
5. When testing the HM8403without LC filters by using resistor instead of speaker as the output load, the test results, e.g. THD or efficiency, will be worse than those of using speaker as load.

Test Setup for Performance Testing

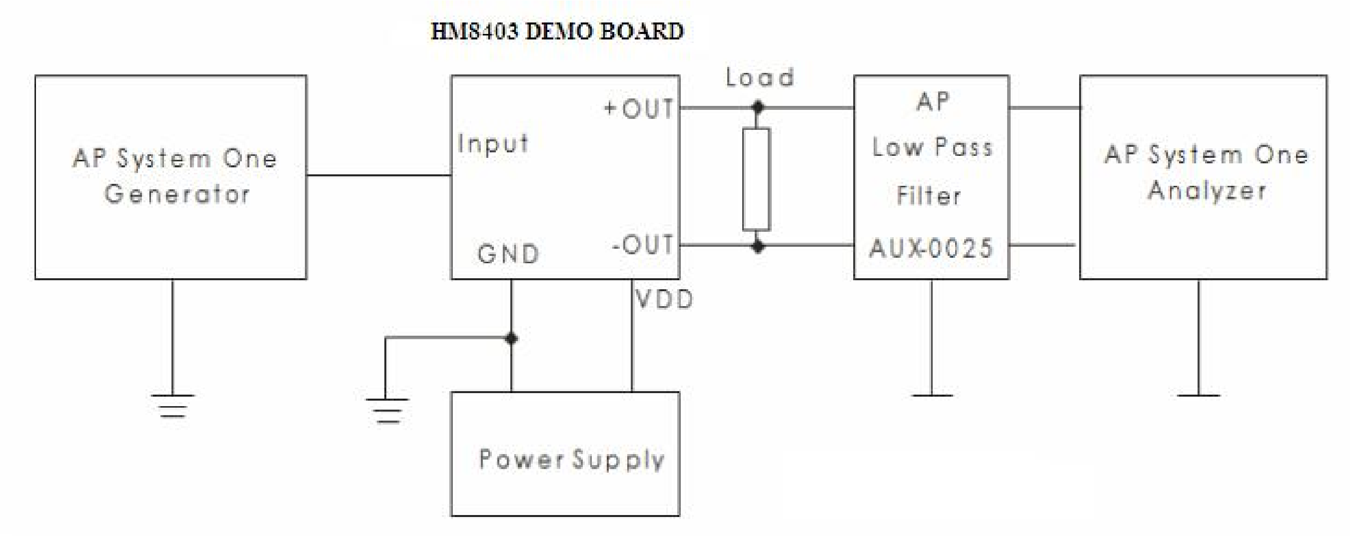


FIGURE 6. Test Set-Up For Graphs

Notes

1. The AP AUX-0025 low pass filter is necessary for class-D amplifier measurement with AP analyzer.
2. Two 22μH inductors are used in series with load resistor to emulate the small speaker for efficiency
measurement.

Application Information

Maximum Gain

As shown in block diagram (page 2), the HM8403 has two internal amplifier stages. The first stage's gain is externally configurable, while the second stage's is internally fixed. The closed-loop gain of the first stage is set by selecting the ratio of R to R while the second stage's gain is fixed at 2x.The output of amplifier 1 serves as the input to amplifier 2, thus the two a m p l i f i e r s produce si g n a l s i d e n t i c a l i n magnitude, but different in phase by 180°. Consequently, the differential gain for the IC is

A =20*log [2*(R /R)]

The HM8403 sets maximum R =142k , minimum R =18k , so the maximum closed-gain is 24dB.

Mute Operation

The pin is an input for controlling the output state of the HM8403. A logic low on this pin disables the outputs, and a logic high on this pin enables the outputs. This pin may be used as a quick disable or enable of the outputs without a volume fade. Quiescent current is listed in the electrical characteristic table. The pin can be left floating due to the internal pull-up.

Shutdown operation

In order to reduce power consumption while not in use, the HM8403 contains shutdown circuitry to turn off the amplifier's bias circuitry. This shutdown feature turns the amplifier off when logic low is applied to the pin. By switching the pin connected to GND, the HM8403 supply current draw will be minimized in idle mode. The pin can be left floating due to the internal pull-up.

Power supply decoupling

The HM8403 is a high performance CMOS audio amplifier that requires adequate power supply decoupling to ensure the output THD and PSRR as low as possible. Power supply decoupling affects low frequency response. Optimum decoupling is achieved by using two capacitors of different types targeting to different types of noise on the power supply leads. For higher frequency transients, spikes, or digital hash on the line, a good low equivalent-seriesresistance (ESR) ceramic capacitor, typically 1.0μF, works best, placing it as close as possible to the device V terminal. For filtering lowerfrequency noise signals, a large capacitor of 20μF (ceramic) or greater is recommended, placing it near the audio power amplifier.

Input Capacitor (Ci)

Large input capacitors are both expensive and space hungry for portable designs. Clearly, a certain sized capacitor is needed to couple in low frequencies without severe attenuation. But in many cases the speakers used in portable systems, whether internal or external, have little ability to reproduce signals below 100Hz to 150Hz. Thus, using a large input capacitor may not increase actual system performance. In this case, input capacitor (Ci) and input resistance (R i) of the amplifier form a high-pass filter with the corner frequency determined by equation below,

$$f_c = \frac{1}{2\pi R_i C_i}$$

In addition to system cost and size, click and pop performance is affected by the size of the input coupling capacitor, C . A larger input coupling capacitor requires more charge to reach its quiescent DC voltage (nominally 1/2 V). This charge comes from the internal circuit via the feedback and is apt to create pops upon device enable. Thus, by minimizing the capacitor size based on necessary low frequency response, turn-on pops can be minimized.

Analog Reference Bypass Capacitor (CBYP)

The Analog Reference Bypass Capacitor (CBYP) is the most critical capacitor and serves several important functions. During start-up or recovery from shutdown mode, C determines the rate at which the amplifier starts up. The second function is to reduce noise caused by the power supply coupling into the output drive signal. This noise is from the internal analog reference to the amplifier, which appears as degraded PSRR and THD+N.

A ceramic bypass capacitor (CBYP) with values of 0.47μF to 1.0μF is recommended for the best THD and noise performance. Increasing the bypass capacitor reduces clicking and popping noise from power on/off and entering and leaving shutdown.

Under Voltage Lock-out (UVLO)

The HM8403 incorporates circuitry designed to detect low supply voltage. When the supply voltage drops to 2.0V or below, the HM8403 outputs are disabled, and the device comes out of this state and starts to normal function when Vdd>=2.2V.

Short Circuit Protection (SCP)

The HM8403 has short circuit protection circuitry on the outputs to prevent damage to the device when output-to-output or output-to-GND short occurs. When a short circuit is detected on the outputs, the outputs are disabled immediately. If the short was removed, the device activates again.

Over Temperature Protection

Thermal protection on the HM8403 prevents the device from damage when the internal die temperature exceeds 140°C. There is a 15 degree tolerance on this trip point from device to device. Once the die temperature exceeds the thermal set point, the device outputs are disabled. This is not a latched fault. The thermal fault is cleared

once the temperature of the die is reduced by 30°C. This large hysteresis will prevent motor boating sound well and the device begins normal operation at this point without external system intervention.

How to Reduce EMI (Electro Magnetic Interference)

A simple solution is to put an additional capacitor 1000 F at power supply terminal for power line coupling if the traces from amplifier to speakers are short (<20cm).

Most applications require a ferrite bead filter as shown in Figure 2. The ferrite filter reduces EMI of around 1 MHz and higher. When selecting a ferrite bead, choose one with high impedance at high frequencies, and low impedance at low frequencies.

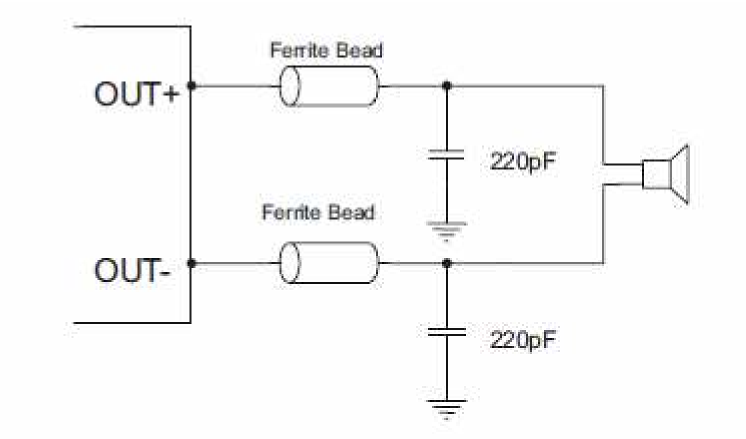
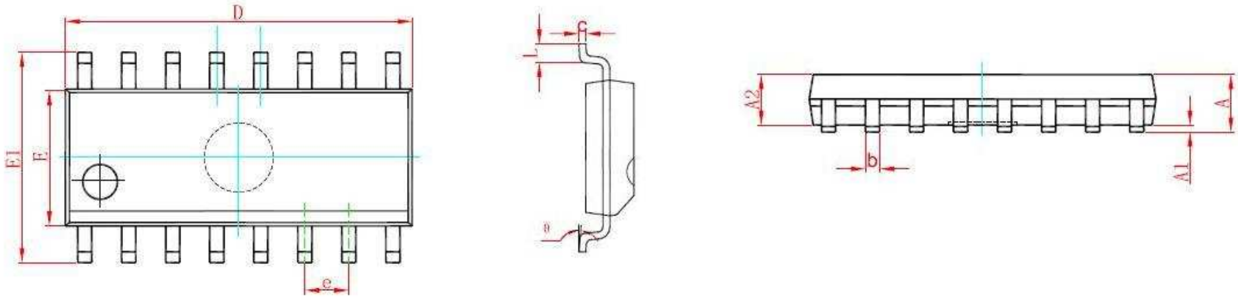


Figure 2: Ferrite Bead Filter to reduce EMI

Package Information

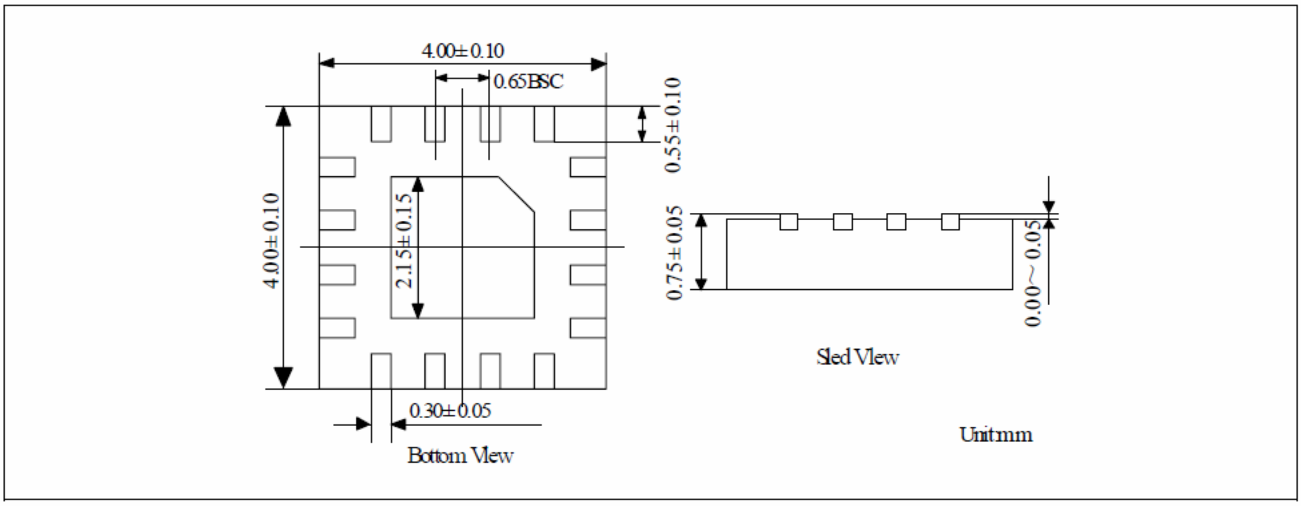
1、 SOP16



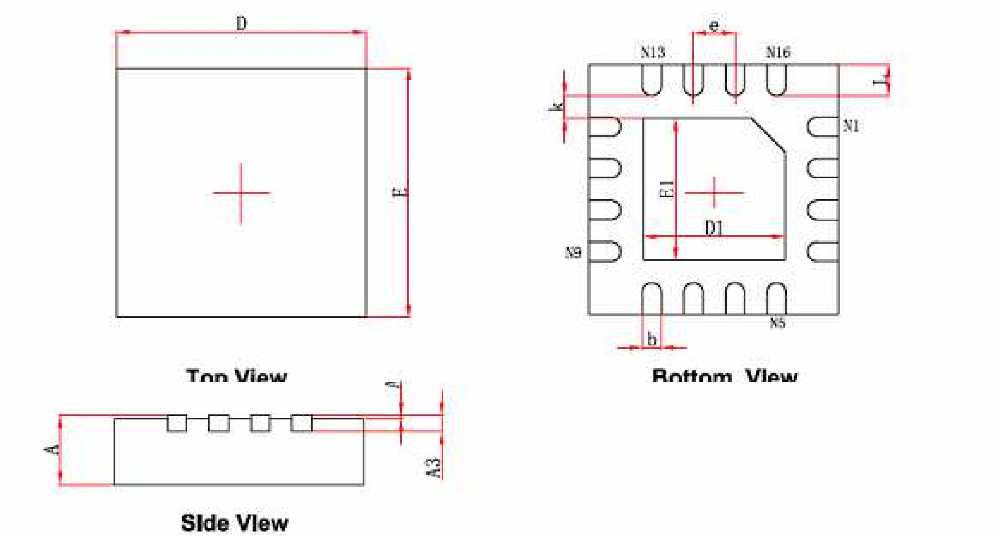
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	9.800	10.200	0.386	0.402
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

2.QFN4X4

QFN16(4mm*4mm*0.75mm)



3.QFN3X3



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700/0.800	0.800/0.900	0.028/0.031	0.031/0.035
A1	0.000	0.050	0.000	0.002
A3	0.203REF.		0.008REF.	
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
D1	1.600	1.800	0.063	0.071
E1	1.600	1.800	0.063	0.071
k	0.200MIN.		0.008MIN.	
b	0.180	0.300	0.007	0.012
e	0.500TYP.		0.020TYP.	
L	0.300	0.500	0.012	0.020