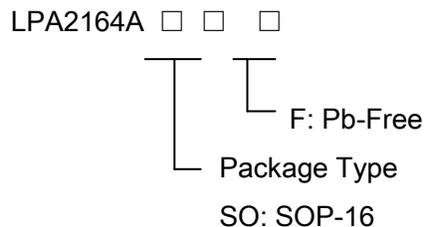


## 6W Class- F Audio Amplifier With Boost Convertor Integrated

### General Description

The LPA2164A is a 6W, class-F audio amplifier with boost convertor integrated. It offers low THD+N, allowing it to achieve high-quality Power Supply sound reproduction. The new filterless architecture allows the device to drive the speaker directly requiring no low-pass output filters, thus to save the system cost and PCB area. With high performance inductor and diode, the boost convertor can offer 3A switch on current for load. It can provide up to 6.0V stable DC voltage for amplifier so that it can display 6W output at 10% THD with a 3Ω load. When it provides 5.0V DC voltage, it can provide 3.1W output at 10% THD with a 4Ω load. The LPA2164A also can work at class-AB mode which make LPA2164A could apply to device with radio receiver. The other character of LPA2164A contact OCP、OTP and high noise suppression for FR signal. The LPA2164A is available in SOP-16.

### Order Information



### Applications

- ✧ Portable Bluetooth Speaker
- ✧ Cellular and Smart mobile phone
- ✧ Square Speaker

### Features

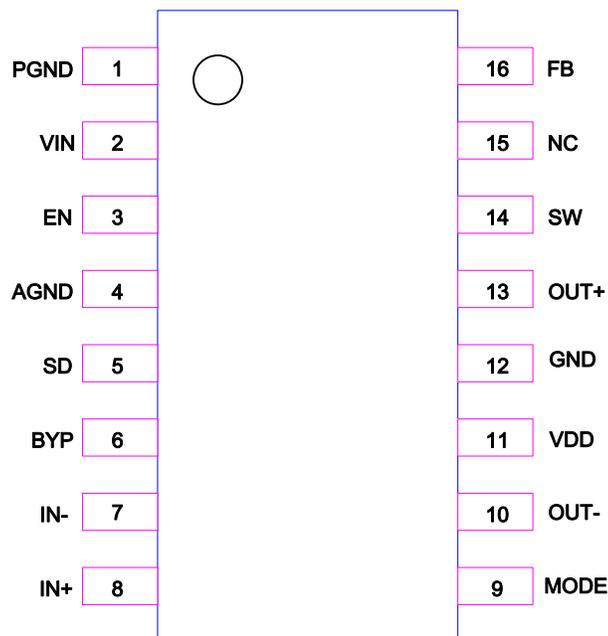
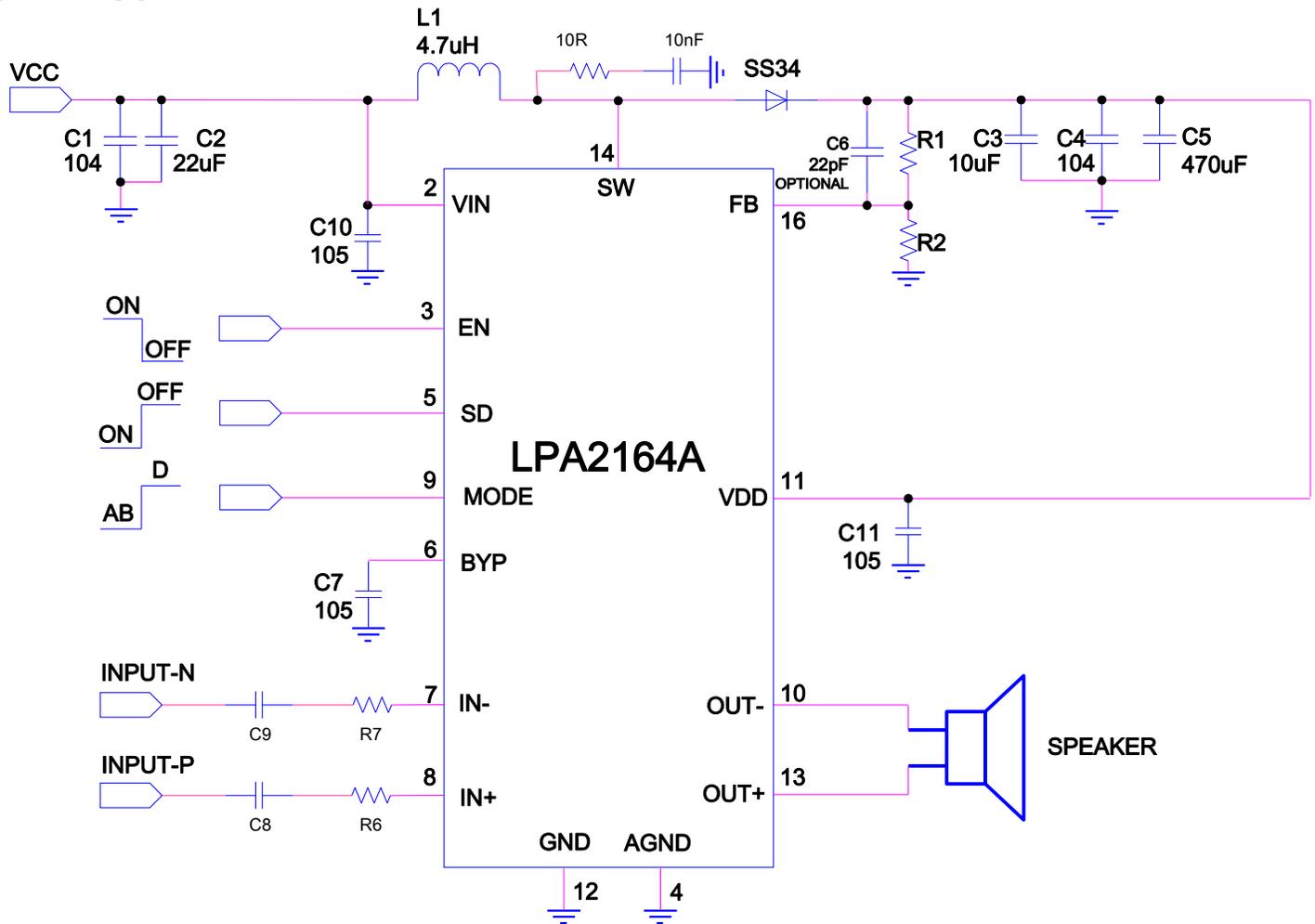
- ◆ Integrated boost convertor
- ◆ Shutdown current:<3uA
- ◆ Switch on current :3.0A
- ◆ Internal Compensation
- ◆ Max duty cycle: 90%
- ◆ 480KHz fixed frequency switching for amplifier work at class\_D mode and 900KHz for step up convertor
- ◆ P<sub>OUT</sub> at 10% THD+N, V<sub>IN</sub>=3.7V for boost convertor  
R<sub>L</sub>=4Ω, P<sub>OUT</sub>=4.8W, boost to 6.0V for amplifier  
R<sub>L</sub>=4Ω, P<sub>OUT</sub>=3.1W, boost to 5.0V for amplifier
- ◆ P<sub>OUT</sub> at 1% THD+N, V<sub>IN</sub>=3.7V for boost convertor  
R<sub>L</sub>=4Ω, P<sub>OUT</sub>=3.6W, boost to 6.0V for amplifier  
R<sub>L</sub>=4Ω, P<sub>OUT</sub>=1.8W, boost to 5.0V for amplifier
- ◆ Filterless, Low Quiescent Current and Low EMI
- ◆ Amplifier Efficiency up to 84%
- ◆ Excellent POP&CLICK rejection
- ◆ OCP, OTP features
- ◆ Few External Components to Save the Space and cost
- ◆ Free LC filter digital modulation, direct-drive speakers
- ◆ Pb-Free Package

### Marking Information

Device	Marking	Package	Shipping
LPA2164ASOF	LPS LPA2164A YWX	SOP-16	3K/REEL

Y: Y is year code. W: W is week code. X: X is series number.

### Typical Application Circuit



## Functional Pin Description

Pin No.	PIN Name	DESCRIPTION
1	PGND	Power ground pin.
2	VIN	Power supply for boost convertor.
3	EN	Enable pin for boost convertor. Active high.
4	AGND	Analog power ground for boost convertor.
5	SD	Amplifier Shutdown pin. Active high.
6	BYP	Bypass pin. Connect a 1uF capacitor to ground.
7	IN-	Negative input of amplifier.
8	IN+	Positive input of amplifier.
9	MODE	Class_AB and class_D mode switch pin. Choice class_D mode with high voltage.
10	OUT-	Negative output of amplifier.
11	VDD	Power supply for amplifier.
12	GND	Ground for amplifier.
13	OUT+	Positive output of amplifier.
14	SW	Switch pin for boost convertor.
15	NC	No connection.
16	FB	Feedback pin.

## Absolute Maximum Ratings

- ◇ Supply voltage for boost convertor ----- -0.3V to 6V
- ◇ Supply voltage for amplifier ----- -0.3V to 6.5V
- ◇ Lead Temperature (Soldering, 10 sec.) ----- 260°C
- ◇ Storage Temperature Range ----- -65°C to 150°C
- ◇ Operation Junction Temperature Range ----- -40°C to 125°C
- ◇ Operation Ambient Temperature Range ----- -40°C to 85°C
- ◇ Maximum Junction Temperature Range ----- 125°C

## Recommended Operating Conditions

- ◇ Supply voltage for boost convertor ----- 2.5V to 5.0V
- ◇ Supply voltage for amplifier ----- 2.5V to 6.0V

## Thermal Information

Parameter	Symbol	Package	Maximum	Units
Thermal resistance (junction to ambient)	$\theta_{JA}$	SOF16	80	°C/W
Thermal resistance (junction to case)	$\theta_{JC}$	SOF16	36	°C/W

## Electrical Characteristics For Amplifier

(T<sub>A</sub> = 25° C, unless otherwise specified)

Parameter	Symbol	Test Conditions		Min	Typ		Max	Units
					Class-D	Class-AB		
Supply power	V <sub>IN</sub>			2.5			6.0	V
Output power	P <sub>O</sub>	THD+N=10%, f=1KHz,RL=4Ω	VDD=6.0V		4.8	4.7		W
			VDD=5.0V		3.2	3.2		
		THD+N=10%, f=1KHz,RL=3Ω	VDD=6.0V		6.0	5.9		
			VDD=5.0V		3.8	3.7		
		THD+N=1%, f=1KHz,RL=4Ω	VDD=6.0V		3.4	3.6		
			VDD=5.0V		2.5	2.6		
THD+N=1%, f=1KHz,RL=3Ω	VDD=6.0V		4.8	4.7				
	VDD=5.0V		3.1	3.2				
Power supply ripple rejection	PSRR	INPUT ac-grounded with C <sub>IN</sub> =0.47uF, VDD=6.0V	f=100HZ		75			dB
			f=1KHz		50			
Signal-to-noise ratio	SNR	V <sub>DD</sub> =5V,P <sub>OUT</sub> =0.5W,RL=2Ω	f=1KHz		90	91		dB
Efficiency	η	R <sub>L</sub> =4Ω,P <sub>O</sub> =0.6W	f=1KHz		88			%
Quiescent current	I <sub>Q</sub>	V <sub>DD</sub> =5.0V	No load		4.65	7		mA
Shutdown current	I <sub>SD</sub>				2			uA
Offset output voltage	V <sub>OS</sub>	VDD=5.0V, V <sub>SD</sub> =0V			1.1	2		mV
Frequency for class_D	f <sub>sw</sub>				480			KHz

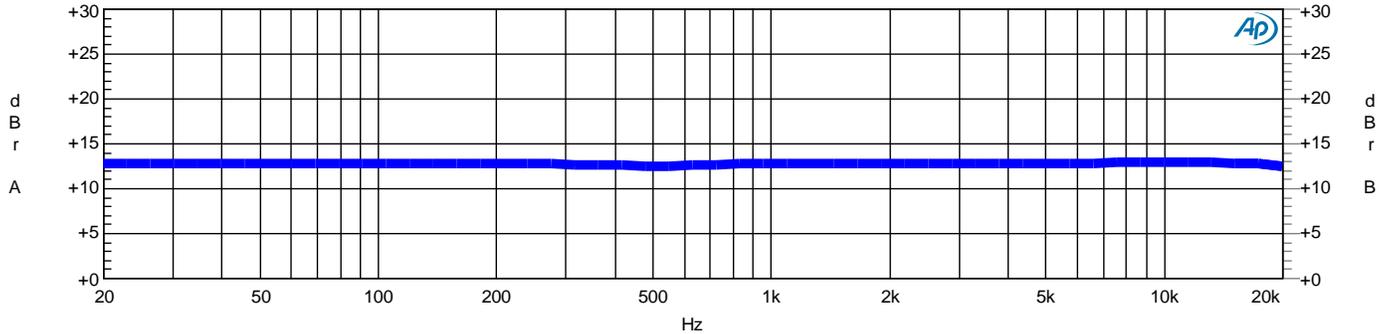
## Electrical Characteristics For Boost Convertor

( $V_{IN}=3.6V, V_{OUT}=5V, C_{IN}=22\mu F, C_{OUT}=22\mu F//10\mu F, L=4.7\mu H$ )

Parameter	Conditions	Boost of LPA2164A			Units
		Min	Typ	Max	
Supply Voltage		2.2		5.5	V
Output Voltage Range			6	6.5	V
Supply Current(Shutdown)	$V_{EN}=V_{OUT}=0V, V_{IN}=5V$			1	$\mu A$
Supply Current	$V_{EN}=V_{IN}=3.6V, V_{FB}=0.6V$			150	$\mu A$
Feedback Voltage		0.588	0.6	0.612	V
Feedback Input Current	$V_{FB}=0.6V$			50	nA
Switching Frequency			900		KHz
Maximum Duty Cycle			90		%
EN Input Low Voltage				0.4	V
EN Input High Voltage		1.4			V
Limit current of power MOSFET			3		A
$R_{DS(ON)}$	$V_{OUT}=3.3V$		100		$m\Omega$

# Typical Operating Characteristic For Amplifier

## Audio Precision

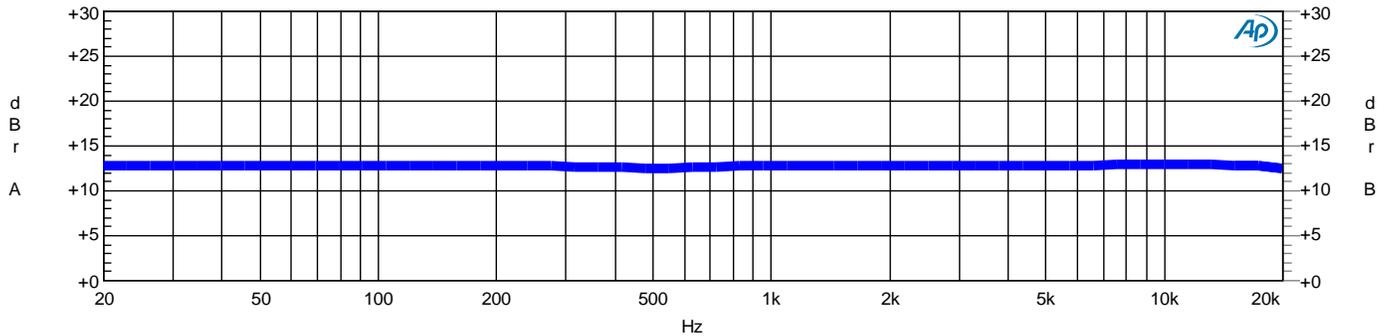


Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Cyan	Solid	1	Analyzer.Level A	Left	
1	2	Blue	Solid	7	Analyzer.Level B	Right	

Rapid (<2 seconds) frequency response measurement.  
 Can be even faster if the lowest frequencies are not included.  
 Press F4 to set the 1kHz dbr A and dBr B reference.  
 Optimize for a detailed view.

A-A FREQ RESP FAST @ 4ohm PO=4.8W CLASS AB VDD=6V.ats2

## Audio Precision



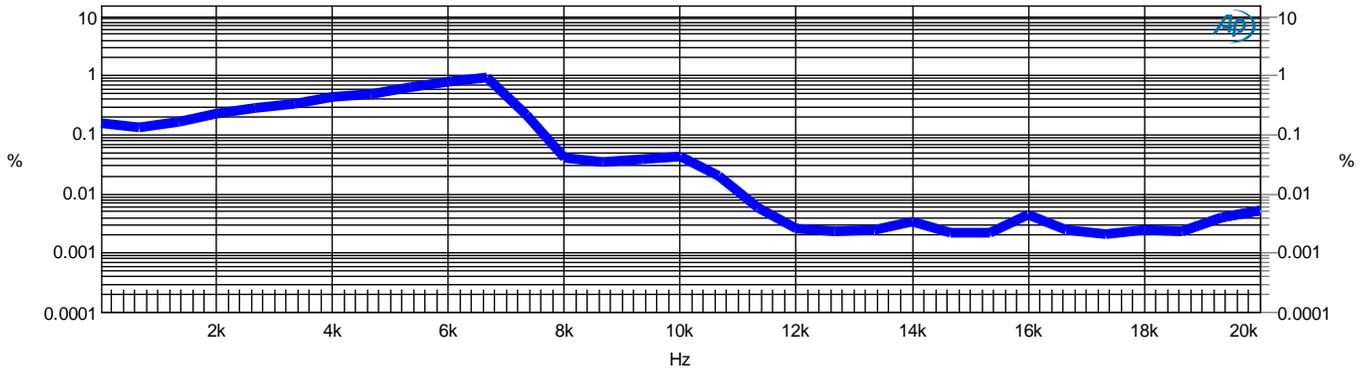
Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Cyan	Solid	1	Analyzer.Level A	Left	
1	2	Blue	Solid	7	Analyzer.Level B	Right	

Rapid (<2 seconds) frequency response measurement.  
 Can be even faster if the lowest frequencies are not included.  
 Press F4 to set the 1kHz dbr A and dBr B reference.  
 Optimize for a detailed view.

A-A FREQ RESP FAST @ 4ohm PO=4.8W CLASS D VDD=6V.ats2

Audio Precision

A-A THD+N vs FREQUENCY



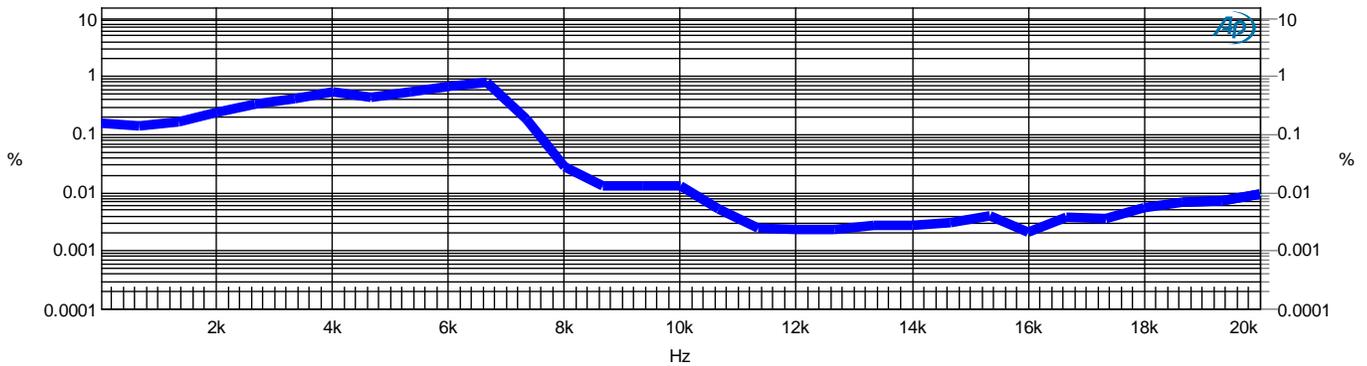
Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Cyan	Solid	1	Analyzer.THd+N Ratio B	Left	
1	2	Blue	Solid	7	Analyzer.THd+N Ratio B	Right	

A single sweeps produces a stereo THD+N sweep of Ch A and Ch B when data 1 is set for THD+N and the Stereo box is checked. The upper Analyzer bandwidth is 20kHz. At a 6kHz fundamental only the 2nd and 3rd harmonics are included, above 10kHz only the noise is included in the measurement bandwidth. For band-limited systems IMD testing is better.

A-A THD+N VS FREQ @4ohm PO=3W CLASS D VDD=6V.ats2

Audio Precision

A-A THD+N vs FREQUENCY

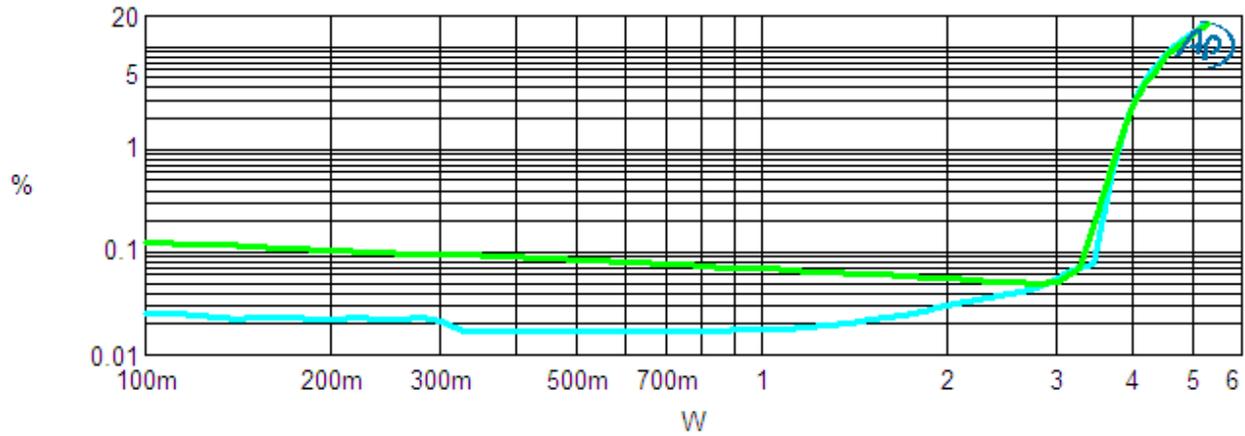


Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Cyan	Solid	1	Analyzer.THd+N Ratio B	Left	
1	2	Blue	Solid	7	Analyzer.THd+N Ratio B	Right	

A single sweeps produces a stereo THD+N sweep of Ch A and Ch B when data 1 is set for THD+N and the Stereo box is checked. The upper Analyzer bandwidth is 20kHz. At a 6kHz fundamental only the 2nd and 3rd harmonics are included, above 10kHz only the noise is included in the measurement bandwidth. For band-limited systems IMD testing is better.

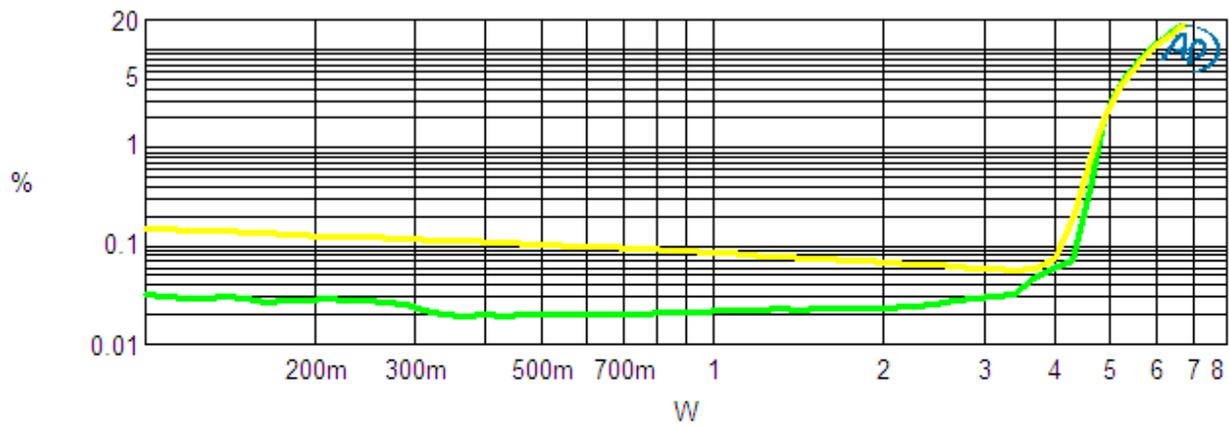
A-A THD+N VS FREQ @4ohm PO=3W CLASS AB VDD=6V.ats2

### Audio Precision



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Cyan	Solid	3	Analyzer.TH+D+N Ratio A	Left	6V 40hm Class D
2	1	Green	Solid	3	Analyzer.TH+D+N Ratio A	Left	6V 40hm Class AB

### Audio Precision



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Green	Solid	3	Analyzer.TH+D+N Ratio A	Left	6V 30hm Class D
2	1	Yellow	Solid	3	Analyzer.TH+D+N Ratio A	Left	6V 30hm Class AB

## Typical Operating Characteristic For Boost Convertor



Vin=3.3V Vout=5V, 0mA



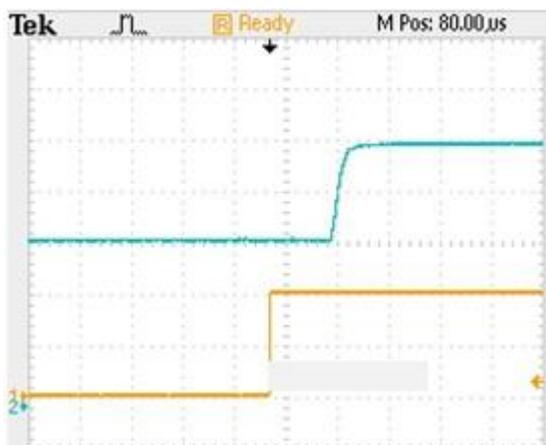
Vin=3.3V Vout=5V, 50mA



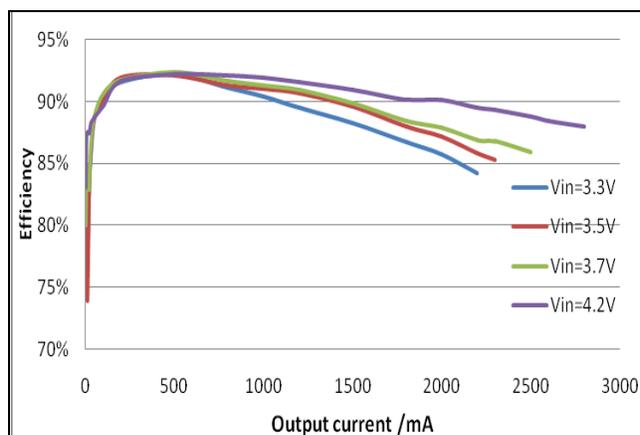
Vin=3.3V Vout=5V, 100mA



Vin=3.3V Vout=5V, 2A



Start up wave



Efficiency VS. Output current

## Applications Information(for Amplifier)

### Maximum Gain

The LPA2164A 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  $R_f$  to  $R_i$  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 amplifiers produce signals identical in magnitude, but different in phase by 180°.

Consequently, the differential gain for the IC is

$$A_v = 20 \cdot \log [2 \cdot (R_f/R_i)]$$

The LPA2164A sets maximum:

$$R_f = 280 \text{ k} \pm 10\% \quad \text{Class-AB}$$

$$R_f = 280 \text{ k} \pm 10\% \quad \text{Class-D}$$

### Shutdown operation

In order to reduce power consumption while not in use, the LPA2164A contains shutdown circuitry to turn off the amplifier's bias circuitry. This shutdown feature turns the amplifier off when logic high is applied to the SD pin. By switching the SD pin connected to high voltage, the LPA2164A supply current draw will be minimized in idle mode.

### Power supply decoupling

The LPA2164A 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-series-resistance (ESR) ceramic capacitor, typically 1.0µF, works best, placing it as close as possible to the device VDD terminal. For filtering lower-frequency noise signals, a large capacitor of 20µF (ceramic) or greater is

recommended, placing it near the audio power amplifier.

### Short Circuit Protection (SCP)

The LPA2164A 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 LPA2164A prevents the device from damage when the internal die temperature exceeds 150°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.

### Analog Reference Bypass Capacitor ( $C_{BYP}$ )

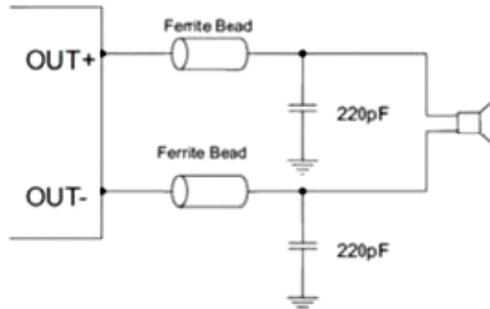
In addition to system cost and size, click and pop performance is affected by the size of the input coupling capacitor,  $C_{BYP}$ . A larger input coupling capacitor requires more charge to reach its quiescent DC voltage (nominally 1/2 VDD). This charge comes from the internal circuit via the feedback 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.

The Analog Reference Bypass Capacitor ( $C_{BYP}$ ) is the most critical capacitor and serves several important functions. During start-up or recovery from shutdown mode,  $C_{BYP}$  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.

#### How to reduce EMI

A simple solution is to put an additional capacitor 220pF at power supply terminal for power line. The traces from amplifier to speakers should design as short as we can.



### Applications Information(for Boost)

The LP2164A integrates a 1200KHz fixed frequency, current-mode regulation architecture to regulate the boost convertor output voltage. The LP2164A measures the output voltage through an external resistive voltage divider and compares that to the internal 0.6V reference to generate the error voltage to the inductor current to regulate the output voltage. The use of current-mode regulation improves transient response and control loop stability.

When the boost convertor is disabled (EN=Low),

both power switches are off. There is no current path from SW to OUT. Therefore, the output voltage discharges to ground. When the boost convertor is enabled (EN=High), a limited start-current charges the output voltage rising to SW, then TH part operates in force PWM mode for regulating the output voltage to the target value. At the beginning of each cycle, the N-channel MOSFET switch is turned on, forcing the inductor current to rise. The current at the source of the switch is internally measured and converted to a voltage by the current sense amplifier. That voltage is compared to the error voltage. When the inductor current rises sufficiently, the PWM comparator turns off the switch, forcing the inductor current to the output capacitor which forces the inductor current to decrease. The peak inductor current is controlled by the error voltage. Thus the output voltage controls the inductor current to satisfy the load.

#### Setting the Output Voltage

Set the output voltage by selecting the resistive voltage divider ratio. The voltage divider drops the output voltage to the 0.6V feedback voltage. Use a 100K resistor for R2 of the voltage divider. Determine the high-side resistor R1 by the equation:

$$V_{out} = (R1/R2 + 1) \times V_{FB}$$

$$V_{out} = (R1/R2 + 1) \times 0.6V$$

## PCB Layout notices

1, In the path of the power supply, plus a 1uF and a 10uF to ground high-frequency filter capacitor. These caps can be connected to the thermal pad directly for an excellent ground connection. Consider adding a small, good quality low ESR ceramic capacitor may achieve better sound effects.

2, Large (470 μF or greater) bulk power supply decoupling capacitors should be placed near the LPA2164A on the VDD supplies. Local, high-frequency bypass capacitors should be placed as close to the VDD pins as possible.

3, The power line, ground line and filter capacitor and bypass capacitors as close to the chip's pins, remember not to put the capacitor on the back of the board, through tiny holes through the jumper even over. Keep the current loop from each of the outputs through the ferrite bead and the small filter cap and back to PGND as small and tight as possible. The size of this current loop determines its effectiveness as an antenna.

4, Power, ground, and a large current line must try to be wide enough, if you want to add vias, the number of through-holes must be at least 6. The thermal pad must be soldered to the PCB for proper thermal performance and optimal reliability.

## PCB LAYOUT

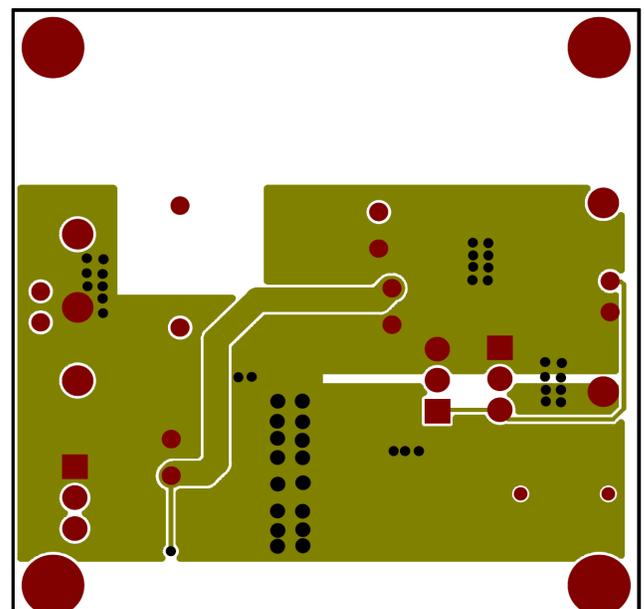
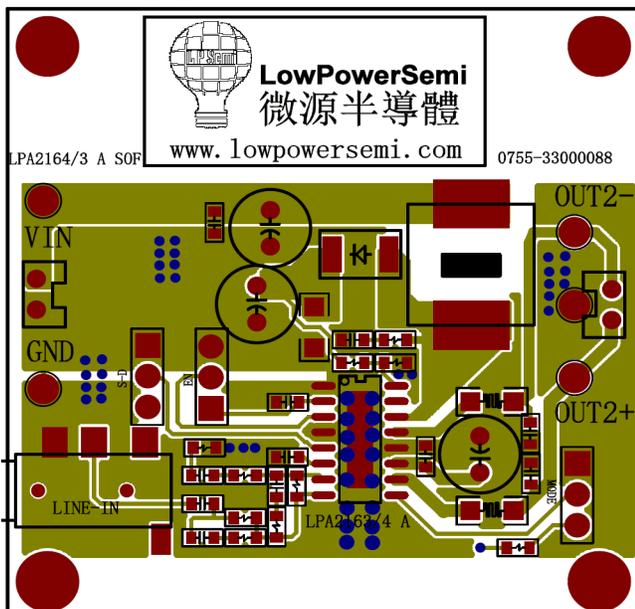
5, GND and VDD should be put independently, high-power signals to avoid interference.

6, If you want to pursue as large as the effect of power, a large selection of speakers or sound chamber with low resistance (such as 3.6Ω) speakers, or added to improve the supply voltage boost circuit.

7, Including the line between large current cell and chip, the inductor should be as close and short as possible to chip for a high performance. Adding a coil to this pin would be helpful for EMI certification. If there is a high standards needed in LPA2164A application, we could add a coil and capacitor between chip and speaker constituting a LC filter which coil would be 100MHz, 100~150Ω and its DCI beyond 3A placing as close as possible to chip, the capacitor should be 1nF connecting the PGND.

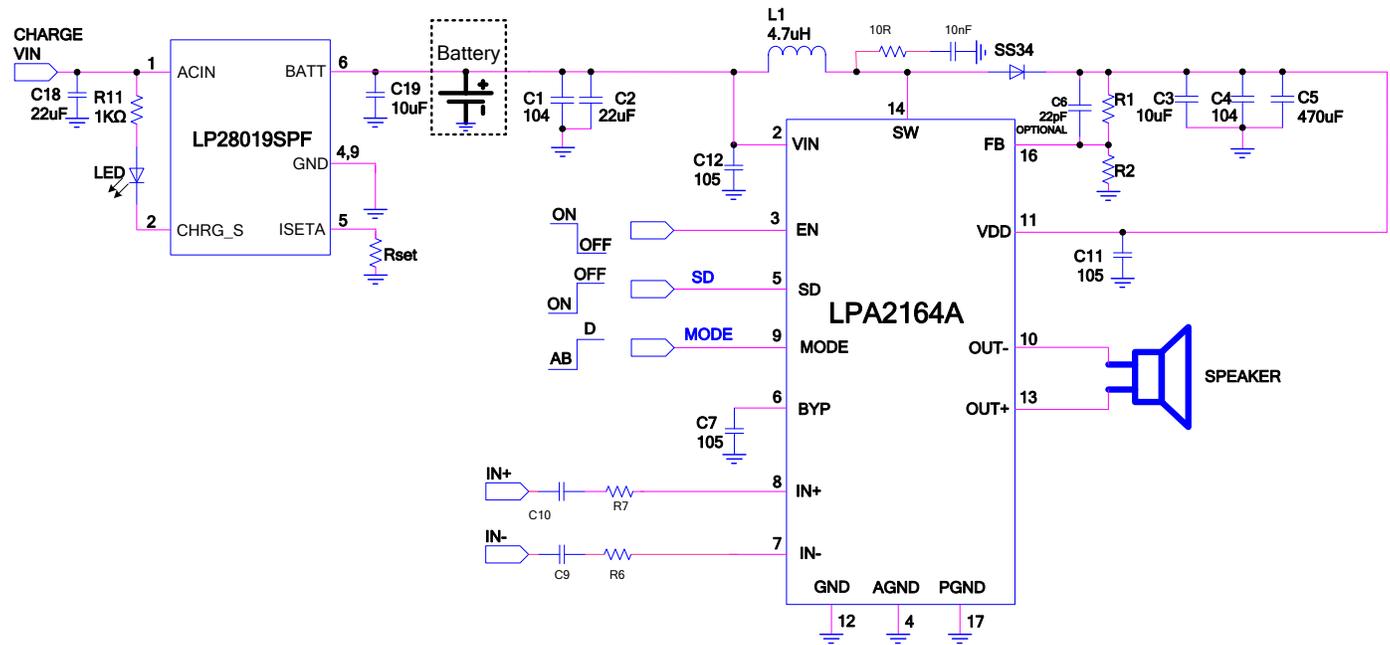
8, The position under the amplifier chip on the board must be added vents and large areas of exposed copper and tin to enhance heat dissipation.

9, In case of fixed gain and meeting demand, it should make  $C_{IN}$  small as possible as we can because it constitute a high through filter with  $R_{in}$  which cutoff frequency is  $1/2 * 3.414 * C_{in} * R_{in}$ . A high capacitance cap could make POP worse.

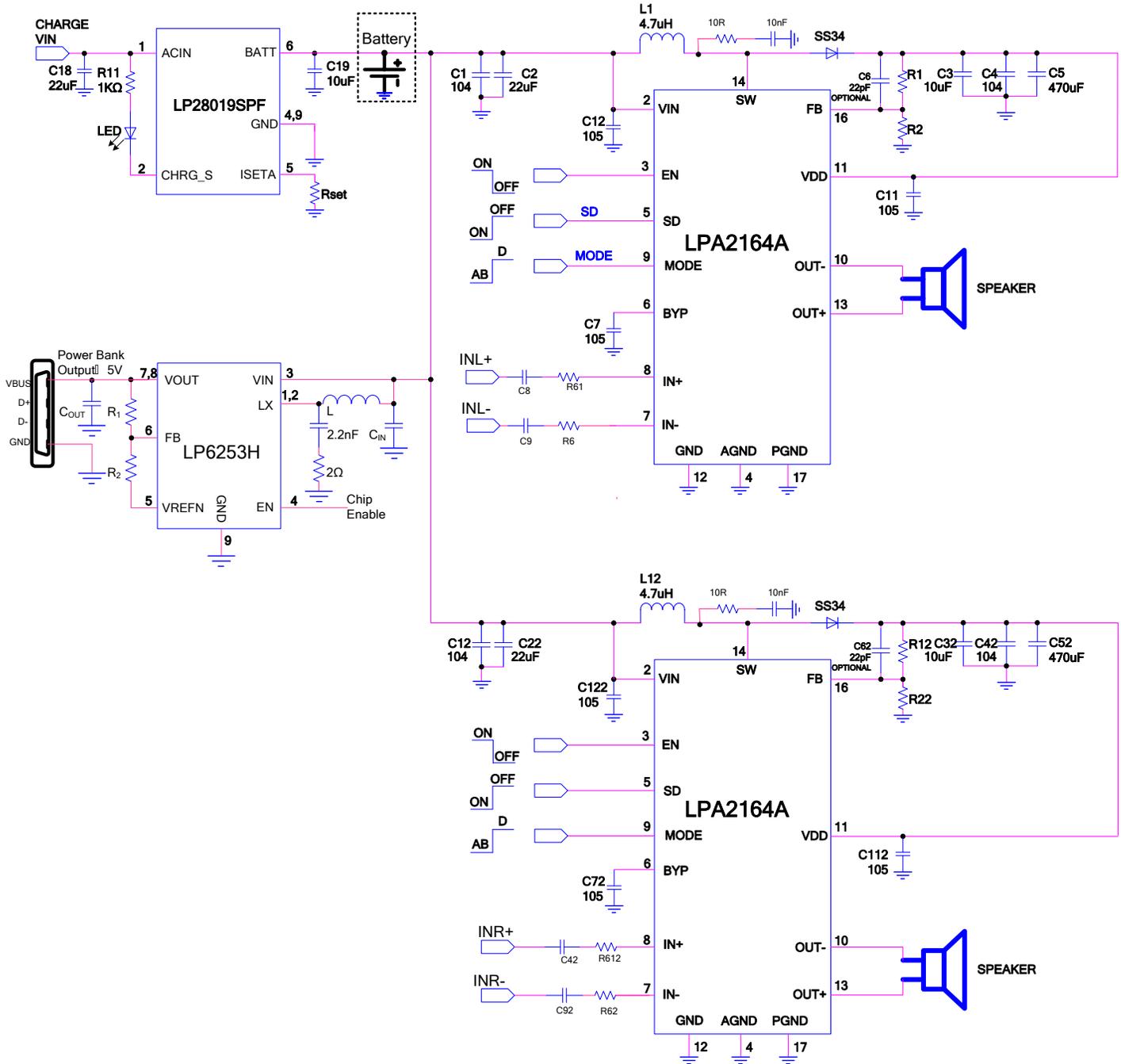


## Recommend Application

### Case1: Bluetooth Speaker Box — Charge(1A) + 5W Class F Amplifier



Case2: Bluetooth Speaker Box with Power Bank— Charge(1A) +Boost(2A) +(2×5W) Class F Amplifier



Classical Application

Charger	Boost	Amplifier
LP28056S(1A Linear Charger, ESOP8)	LP6253H(2.4A Synchronous Boost, ESOP8)	LPA2173(8W Class_F, EQ, ESOP8)
LP28019(1A Linear Charger, ESOP8)	LP6212(2A Boost, ESOP8 & SOT23-6)	LPA2174(8W Differential Input, ESOP8)
LP28301(5A Switch Charger, QFN28)	LP6255(External MOS, Syn, TQFN-20)	LPA2164A(6W Class_F with Boost, EQ, SOP16)

## Packaging Information

SOP-16

