ft2811

2.4W Charge Pump Class-G Audio Amplifier

GENERAL DESCRIPTION

The ft2811 is a Class-G audio power amplifier with battery-tracking AGC technology. It integrates a charge pump and drives up to 2.4W into an 8 Ω speaker (10%THD). With 74% efficiency, the ft2811 helps extend battery life when playing audio.

The built-in charge pump generates a 6V supply voltage for the Class-G amplifier. This provides a louder audio output than a stand-alone amplifier directly connected to the battery. The AGC technology helps to adjust Class-G gain automatically.

The ft2811 has an integrated lowpass filter. It helps you get lower EMI noise and increase SNR.

The ft2811 is available in QFN3x3-20L and QFN4x4-28L Package

FEATURES

- Wide Supply Voltage Range from 2.7V to 5.5V
- Class-G Audio Amplifier with Integrated ChargePump
- Constant Output Power at 2.4W into 8Ω Load from 4.0V Supply
- Automatic Gain Control for Battery Tracking
- Integrated Lowpass Filter for Out-of-Band Noise Rejection
- Four Gain Settings: 12/16/24/28dB
- One-Wire Pulse adjust Gain Control
- Short-Circuit Protection with Hiccup Mode
- Low EMI noise
- High Power Efficiency up to 74%.
- Available in QFN3x3-20L and QFN4x4-28L Package

APPLICATIONS

- Cell Phones
- Smart phones
- MP3/PMP
- GPS

APPLICATION CIRCUIT

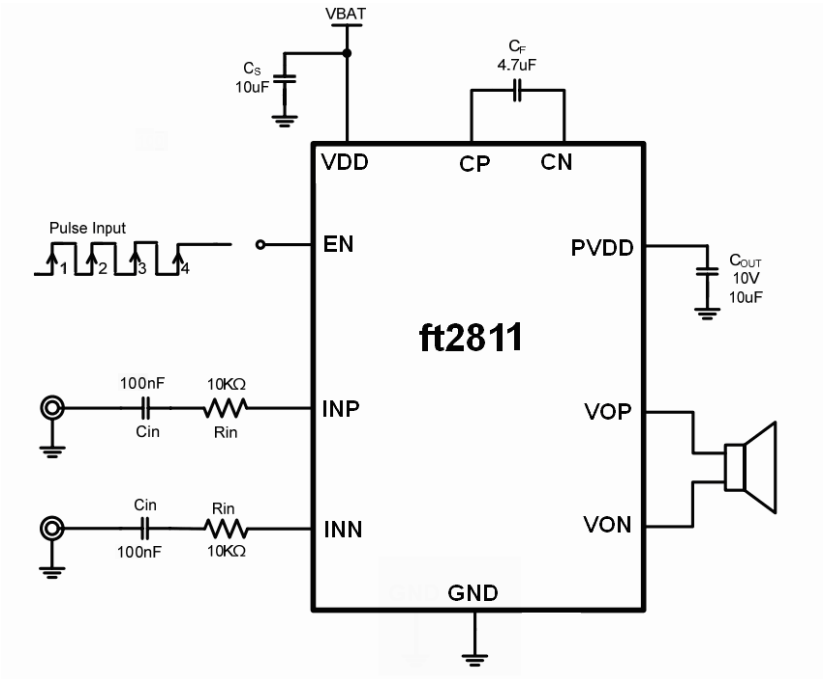
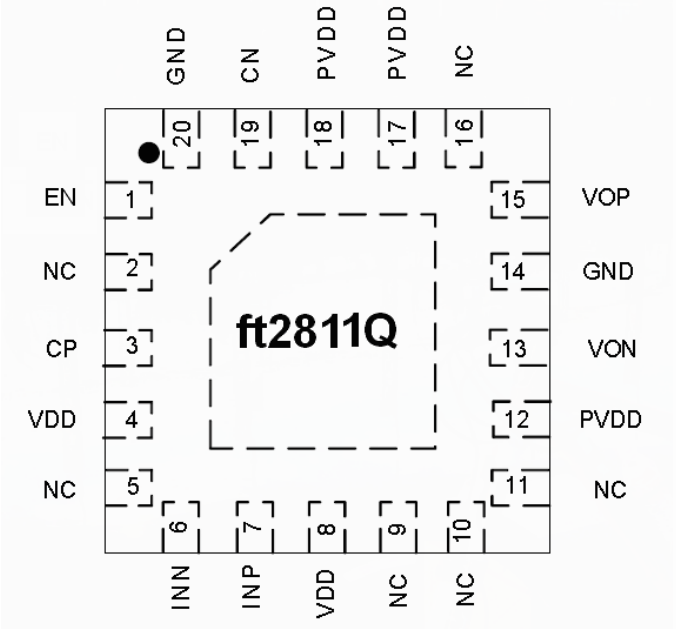
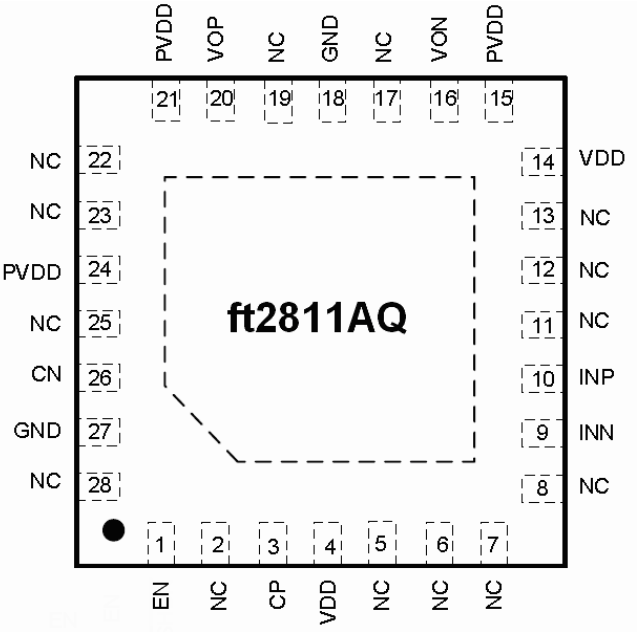


Figure 1: Typical Audio Amplifier Application Circuit

PIN CONFIGURATION AND DESCRIPTION



Top View



Top View

Symbol	QFN3x3-20L	QFN4X4-28L	I/O	Description
EN	1	1	I	Chip enable
NC	2,5,9,10, 11,16	2,5,6,7,8, 11,12,13 17,19,22, 23,25,28	-	NC
CP	3	3	O	Flying capacitor positive terminal.
VDD	4,8	14	P	Power supply
INN	6	9	I	Negative audio input terminal (differential -).
INP	7	10	I	Positive audio input terminal (differential +).
PVDD	12,17,18	15,21,24	P	Class-G Audio power amplifier voltage supply
VON	13	16	O	Negative audio output
VOP	15	20	O	Positive audio output
CN	19	26	O	Flying capacitor negative terminal.
GND	14,20	18,27	G	Ground

ORDERING INFORMATION

PART NUMBER	TEMPERATURE RANGE	PIN-PACKAGE
ft2811Q	-40°C to +85°C	QFN3x3-20L
ft2811AQ	-40°C to +85°C	QFN4x4-28L

ABSOLUTE MAXIMUM RATINGS

Parameter	Value
Supply voltage, VDD	-0.3V to 6.0 V
Storage Temperature	−65°C to +150°C
Input Voltage EN	−0.3V to VDD +0.3V
Power Dissipation	Internally Limited
ESD Ratings-Human Body Model (HBM)	2000V
Junction Temperature	150°C
θ_{JA} (A)	48°C/W
Maximum Soldering Temperature (@10 sec duration)	260°C

Note 1: Stresses beyond those listed under absolute maximun 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 under recommended operating conditions is not implied.Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

Parameter	Conditions	MIN	TYP	MAX	UNIT
Supply voltage，VDD		2.7		5.5	V
Operating free-air temperature, T_A		-40		85	°C
Load impedance, Z_L		7.6	8		Ω

FUNCTIONAL BLOCK DIAGRAM

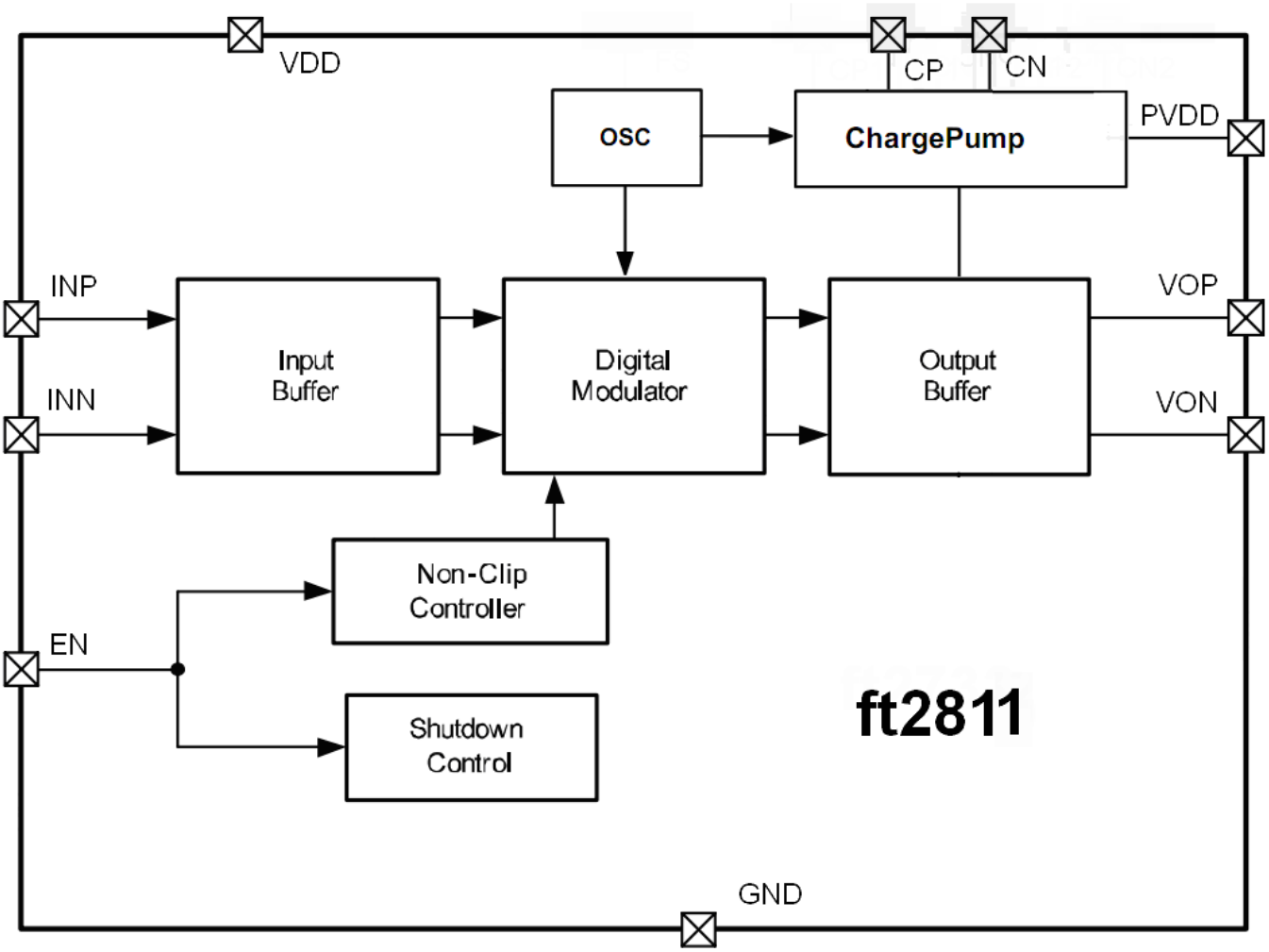


Figure 2: Functional Block Diagram

ELECTRICAL CHARACTERISTICS

VDD = 3.6 V, Gain = 12 dB, CS = 10 µF, COUT = 10µF, CF = 4.7µF, CIN=0.1µF, RIN=10KΩ, Load = 8 Ω + 33 µH, TA = 25°C, unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
VDD	VDD supply voltage range		2.7		5.5	V
UVLO	Under voltage lockout			2.2		V
IQ	Operating quiescent current	EN = VDD, RL=8Ω+33µH,VIN=0		2.5	5	mA
ISD	Shutdown quiescent current	VDD = 2.7V to 5.5V, EN = GND		0.1	1	µA
VIH	High–level input voltage, EN		1.5			V
VIL	Low–level input voltage, EN				0.4	V
	Thermal Shutdown			160		°C
	Thermal Hysteresis			20		°C
η	Power Efficiency	POUT = 1W, f = 1kHz		74		%
CHARGE PUMP						
PVDD	Charge pump output voltage range, PVOUT	IBOOST = 500 mA		6.2		V
IOUT	Max. Output Current				1	A
tSTART	Soft start time	COUT=10uF		0.5		ms
Fpump	Charge pump working frequency	VDD=2.7V to 5.5V		0.8		MHz
CLASS-G AMPLIFIER						
Po	Output power (NCN OFF Mode)	THD = 10%, VDD = 4 V, f = 1 kHz		2.4		W
		THD = 1%, VDD = 4 V, f = 1 kHz		1.8		
$f_{CLASS-G}$	Switching frequency	VDD=2.7V to 5.5V		800		KHz
VOS	Output peak voltage	No load		5	20	mV
TON	Start-up time	VDD=2.7V to 5.5V		5		ms
RIN	Input impedance (per input pin)	A_V = 12/16 dB		30		Ω
		A_V = 24/28 dB		5		
Vn	Output voltage noise	f=20Hz to 20KHz, Inputs AC- Grounded.		45		µVrms
ZO	Output impedance in shutdown	END = 0 V		3		KΩ
THD+N	Total harmonic distortion plus noise	PO =300 mW, f = 1 KHz		0.08		%
		PO = 1000 mW, f = 1 KHz		0.08		
PSRR	Power supply ripple rejection	200 mVPP ripple, f = 217 Hz		75		dB
		200 mVPP ripple, f = 1 KHz		70		
NCN						

	AGC gain range			6		dB
	AGC attack time			20		ms
	AGC release time			1600		ms
EN CONTROL						
TLO	Time of EN low		0.5		10	μs
THI	Time of EN high		0.5			μs
TRST	Mode Reset Time			32		μs
TSHDN	Time of shutdown			4		ms

(1) The 1 μF input capacitors (CI) were shorted for input common-mode voltage measurements.

(2) A 33 mH inductor was placed in series with the load resistor to emulate a small speaker for efficiency measurements.

(3) The 30 kHz low-pass filter is required even if the analyzer has an internal low-pass filter. An R-C low pass filter (100 Ω, 47 nF) is used on each output for the data sheet graphs.

TYPICAL PERFORMANCE CHARACTERISTICS

VDD = 3.6 V, Gain = 12 dB, CS = 10 µF, COUT = 10µF, CF = 4.7µF, CIN=0.1µF, RIN=10KΩ, Load = 8 Ω + 33 µH, TA = 25°C, unless otherwise specified.

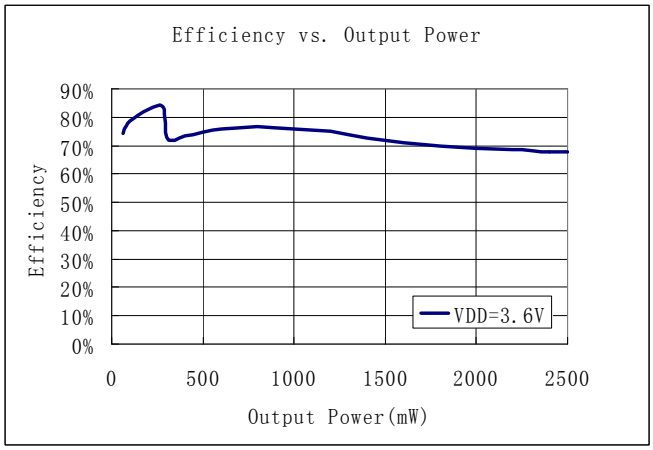


Figure 3: Efficiency vs. Output Power

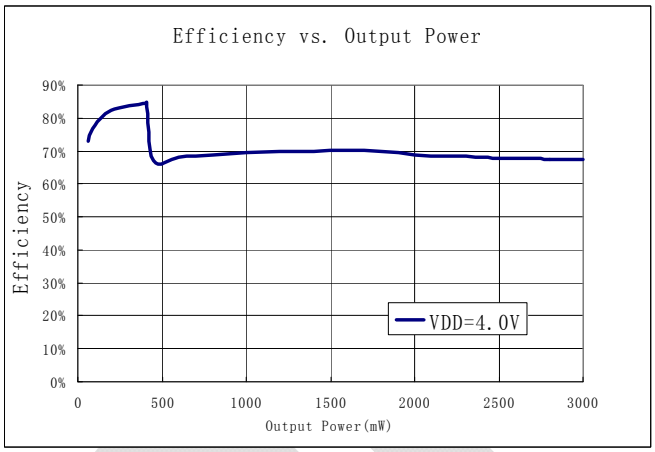


Figure 4: Efficiency vs. Output Power

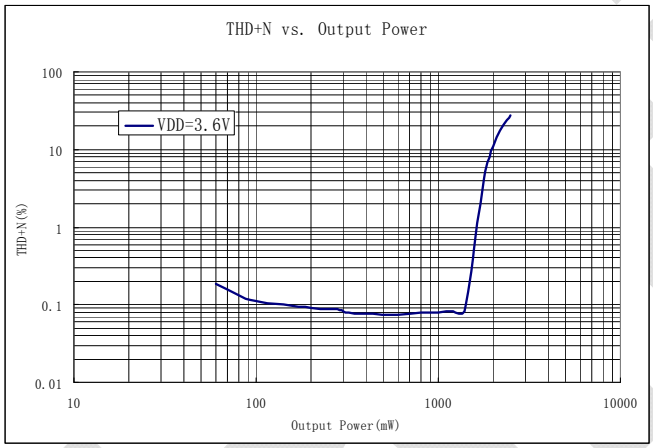


Figure 5: THD+N vs. Output Power

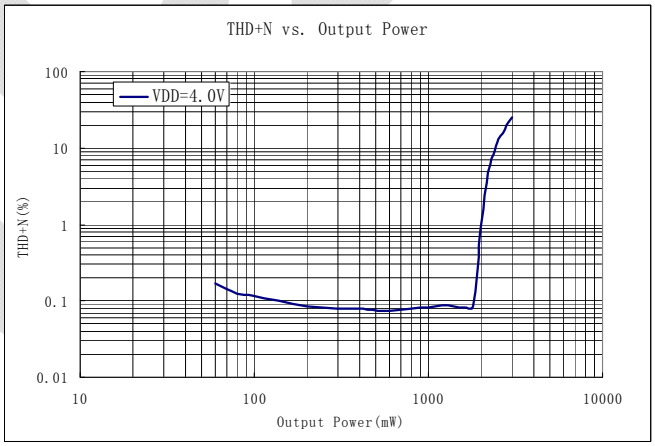


Figure 6: THD+N vs. Output Power

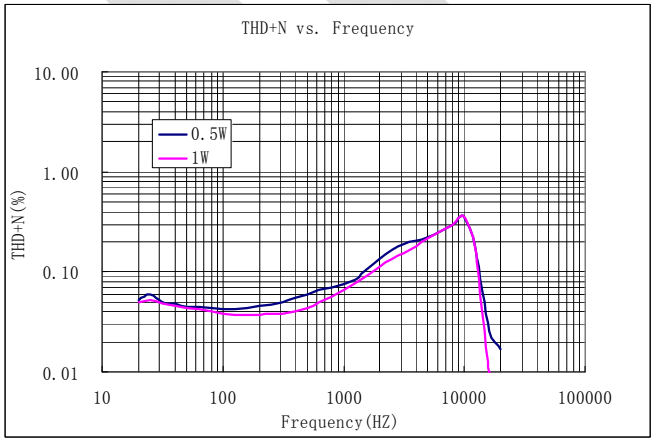


Figure 7: THD+N vs. Frequency

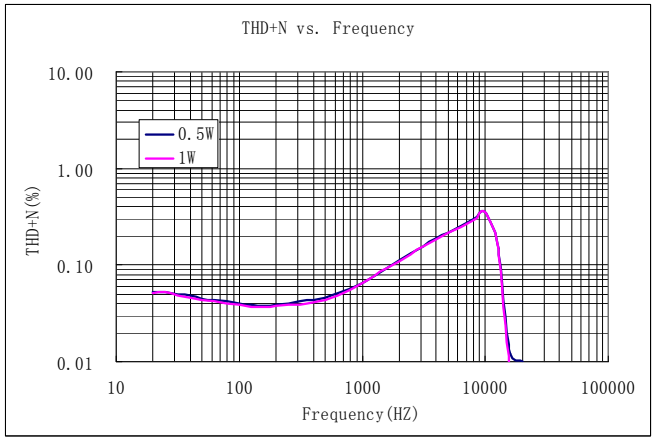


Figure 8: THD+N vs. Frequency

TYPICAL PERFORMANCE CHARACTERISTICS （Cont.）

VDD = 3.6 V, Gain = 12 dB, CS = 10 μF, COUT = 10μF, CF = 4.7μF, CIN=0.1μF, RIN=10KΩ, Load = 8 Ω + 33 μH, TA = 25°C, unless otherwise specified.

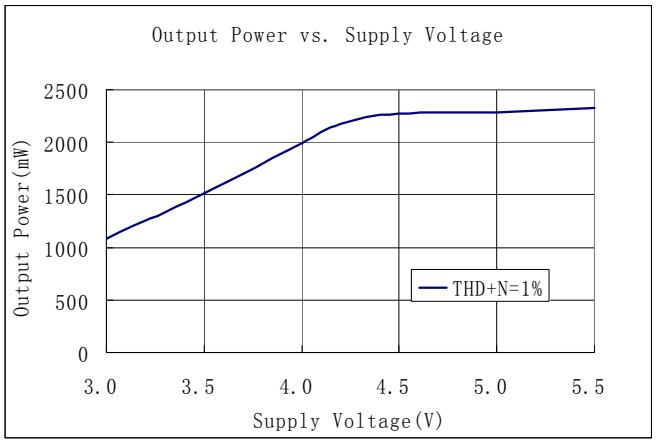


Figure 9: Output Power vs. Supply Voltage

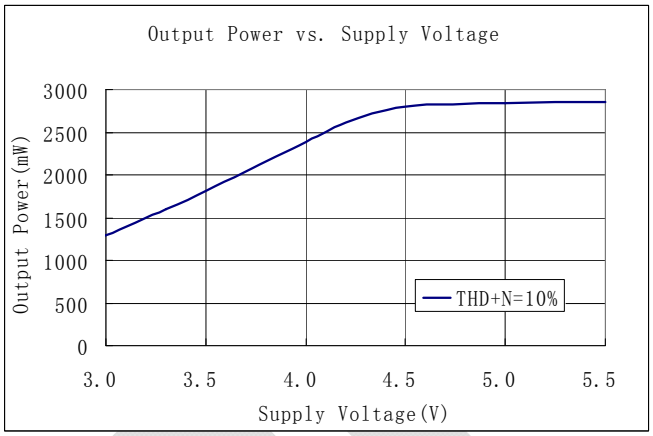


Figure 10: Output Power vs. Supply Voltage

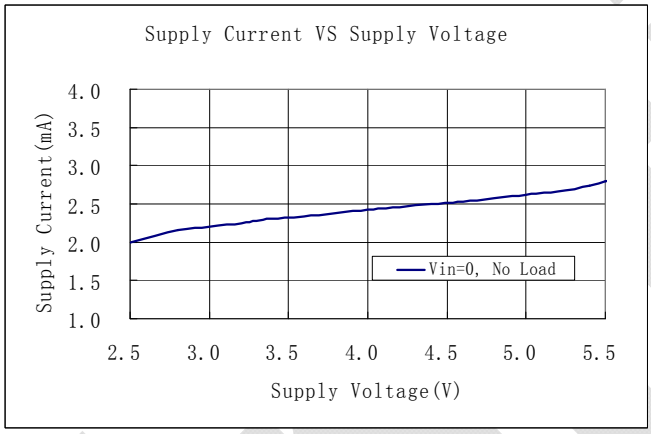


Figure 11: Output Power vs. Supply Voltage

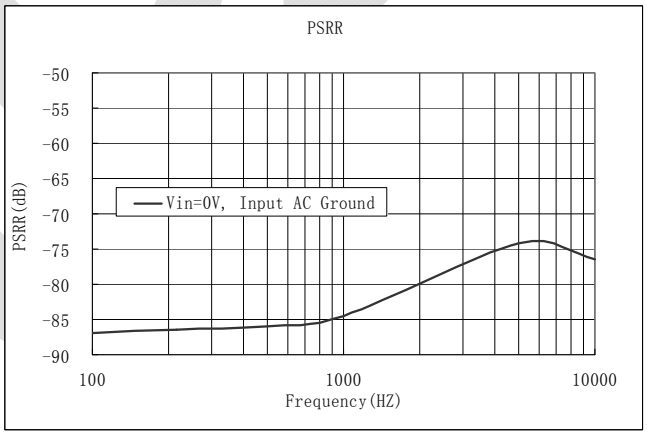


Figure 12: Output Power vs. Supply Voltage

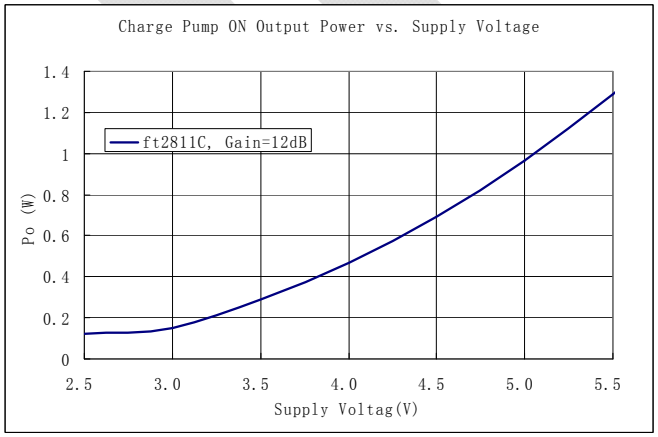


Figure 13: Charge Pump On Output Power vs. Supply Voltage

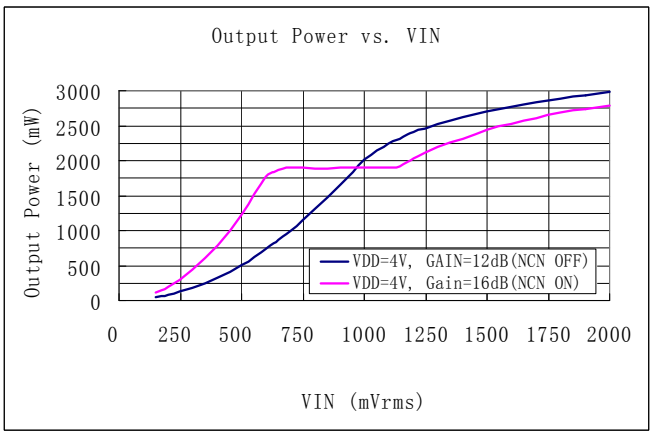


Figure 14: Output Power vs. VIN

APPLICATION INFORMATION

The ft2811 is a Class-G audio power amplifier with battery-tracking AGC technology. It integrates a charge pump and drives up to 2.4W into an 8 Ω speaker (10%THD). With 74% efficiency, the ft2811 helps extend battery life when playing audio.

The built-in charge pump generates a 6V supply voltage for the Class-G amplifier. This provides a louder audio output than a stand-alone amplifier directly connected to the battery. The AGC technology helps to adjust Class-G gain automatically.

The ft2811 has an integrated lowpass filter. It helps you get lower EMI noise and increase SNR

Adaptive Charge-Pump control

The ft2811 integrates an adaptive charge pump. The adaptive charge pump detects and qualifies the input signal.

When the input signal amplitude is smaller than the pre-set voltage level and keeps 128mS, the charge pump will enter into standby mode. At this mode, the Class-G output stage is powered by battery directly through charge pump switches; this increases system efficiency and extends battery life at low output power.

When the input signal amplitude is larger than the pre-set voltage level and keeps 16uS, the charge pump exits from standby mode into active mode. At this mode, the PVDD is regulated up to 6.25V, the ft2811 can output up to 2.4W power into an 8 Ω speaker at non-clip-off mode with 10%THD or 2.0W at non-clip mode with little distortion.

Working Mode Control and Gain Setting

ft2811 implements a pulse method to control the working mode. Users can easily use a low to high plus to change mode. The detail operation of mode control is showed as figure 15.

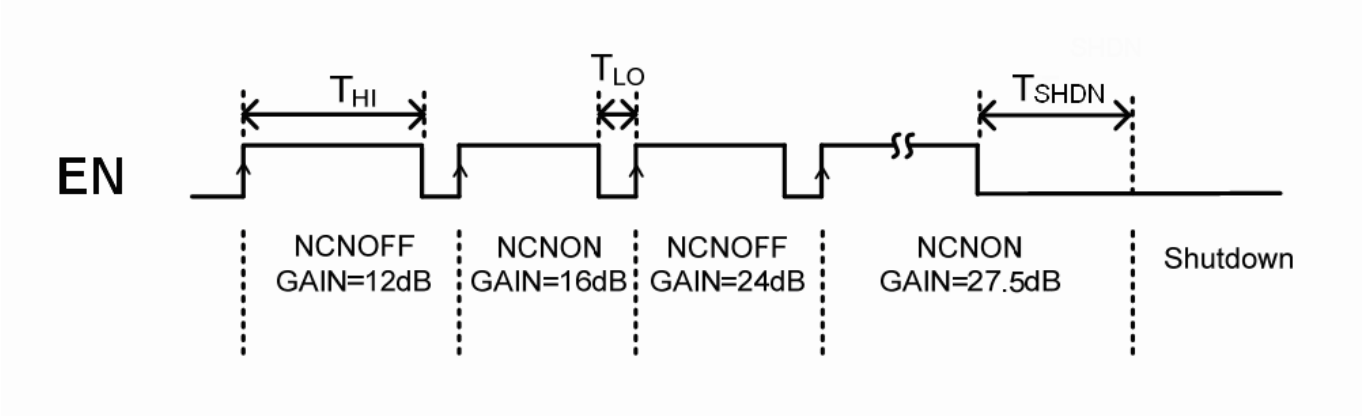


Figure 15: Gain Setting

MODE RESET

When EN PIN is held low for 32μs (typical) or more, ft2811's internal state will be reset, the chip will enter into mode1 (GAIN=12dB, NCN OFF) when input a low to high plus to EN pin, .

SHUTDOWN

When EN PIN is held low for 4ms (typical) or more, ft2811 will enter into shutdown mode, the supply current will be less than 1μA.

Non-Clip control Function

This is the function to control the output in order to obtain a maximum output level without distortion when an excessive input which causes clipping at the differential signal output is applied. That is, with the Non-Clip function, ft2811 lowers the Gain of the digital amplifier to an appropriate value so as not to cause the clipping at the differential signal out put. And, ft2811 follows also to the clip of the output wave form due to the decrease in the power-supply voltage.

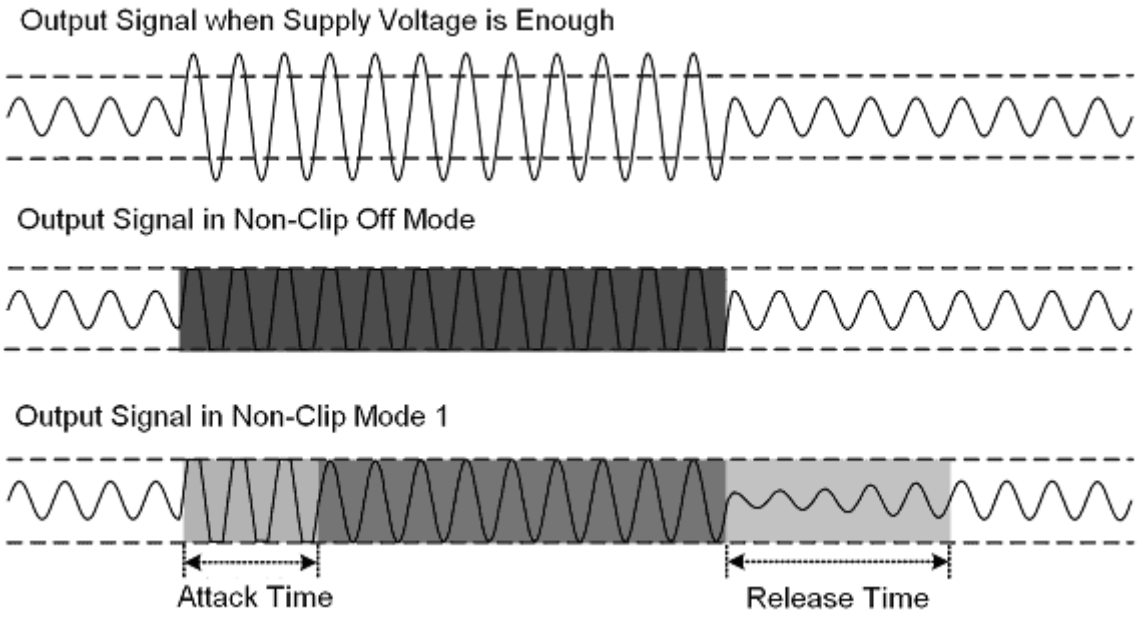


Figure 16: Non-Clip Function Diagram

The attack time and the release time of Non-Clip control are fixation two levels, and selects with the CTRL terminal. The attack time is a time interval until gain fails to target attenuation gain-3dB with a big signal input enough. And, the Release Time is a time from target attenuation gain to not working of Non-Clip Mode.

Click-and-Pop Suppression

The ft2811 speaker amplifier features Maxim's comprehensive click-and-pop suppression. During startup, the click-and-pop suppression circuitry reduces any audible transient sources internal to the device. When entering shutdown, the differential speaker outputs ramp down to SPKPGND quickly and simultaneously.

Protection Function

ft2810 incorporates Class D Over-current and short circuit Protection function, Thermal Protection function, and Under Voltage Lock-out (UVLO) function.

Class D amplifier over current and short circuit protection

The output of Class D amplifier detects and qualifies over current and short circuit event at operating state.

When a short circuit event between two differential output, differential output to battery, PVDD or Ground happened, the cycle by cycle over current protection function activates, and the four switches of output stage are put into high impedance state at corresponding cycle.

If above event appears four times continuously and uninterruptedly, ft2810 goes into shutdown state and keeps the state for 200mS. At this state, the switches of charge pump are all switched off, and the PVDD is discharged by a resistor through PVDD to Ground. When the voltage level at PVDD is discharged to 100mV lower than VDD, the charge pump is converted to standby mode.

When the shutdown state time out, the ft2810 precede another try again to validate if the short circuit event is removed. At the same time, the charge pump is starting to pump PVDD to preset voltage again. If the validation result is not, the ft2810 repeated above procedure, qualifies four times and then goes into shutdown state and keeps the state for 200mS again. This is so called hic-cup operating mode. If the validation result is yes, ft2810 restores into normal operating state.

The over current threshold is 1.65A at 4V (standby mode), 2.75A at 6.25V (charge pump active mode).

Thermal Protection function

This is the function to establish the thermal protection mode when detected excessive high temperature of ft2810 itself. In the thermal protection mode, the differential output terminal becomes Weak Low state (a state grounded through high resistivity). And, when ft2810 gets out of such condition, the protection mode is cancelled.

Under Voltage Lock-out (UVLO) function

The ft2810 incorporates circuitry designed to detect low supply voltage. When the supply voltage drops to 2.0V or below, the ft2810 goes into a state of mute, and the device comes out of its mute state and restore to normal function when the power supply voltage is higher than 2.2V.

PSRR enhancement

Compare to standard Class-G amplifier, the ft2810 is not provide common mode terminal in PIN configuration and external capacitor for PSRR improvement, but the PSRR of ft2810 is good enough thanks to fangtek proprietary intellectual circuitry.

Class D Speaker Amplifier

The ft2811 filter-less Class-G amplifier offers much higher efficiency than Class AB amplifiers. The high efficiency of a Class D amplifier is due to the switching operation of the output stage transistors. Any power loss associated with the Class D output stage is mostly due to the I2R loss of the MOSFET on-resistance and quiescent current overhead.

Fully Differential Amplifier

The ft2811 is a fully differential amplifier with differential inputs and outputs. The fully differential amplifier

consists of a differential amplifier and a common-mode amplifier. The differential amplifier ensures that the amplifier outputs a differential voltage on the output that is equal to the differential input times the gain. The common-mode feedback ensures that the common-mode voltage at the output is biased around VDD/2 regardless of the common-mode voltage at the input. The fully differential ft2811 can still be used with a single-ended input; however, the ft2811 should be used with differential inputs when in a noisy environment, like a wireless handset, to ensure maximum noise rejection.

Low-EMI Filter-less Output Stage

Traditional Class-G amplifiers require the use of external LC filters, or shielding, to meet EN55022B electromagnetic-interference (EMI) regulation standards. Fangtek use edge-rate control circuitry to reduce EMI emissions, while maintaining up to 92% efficiency (speaker only). Above 10MHz, the wideband spectrum looks like noise for EMI purposes.

Filter-less Design

Traditional Class D amplifiers require an output filter to recover the audio signal from the amplifier's output. The filter adds cost, increases the solution size of the amplifier, and can decrease efficiency and THD+N performance. The traditional PWM scheme uses large differential output swings (2 x supply voltage peak-to-peak) and causes large ripple currents. Any parasitic resistance in the filter components results in a loss of power and lowers the efficiency.

The ft2811 does not require an output filter. The device relies on the inherent inductance of the speaker coil and the natural filtering of both the speaker and the human ear to recover the audio component of the square-wave output. Eliminating the output filter results in a smaller, less costly, and more efficient solution.

Because the frequency of the ft2811 output is well beyond the bandwidth of most speakers, voice coil movement due to the square-wave frequency is very small. Although this movement is small, a speaker not designed to handle the additional power can be dam- aged. For optimum results, use a speaker with a series inductance > 10uH. Typical 8Ω speakers exhibit series inductances in the 20uH to 100uH range.

How to Reduce EMI

Additional EMI suppression can be achieved using a filter constructed from a ferrite bead and a capacitor to ground (Figure 17). Use a ferrite bead with low DC resistance, high-frequency (>100MHz) impedance between 100Ω and 600Ω, and rated for at least 1A. The capacitor value varies based on the ferrite bead chosen and the actual speaker lead length. Select a capacitor less than 1nF based on EMI performance.

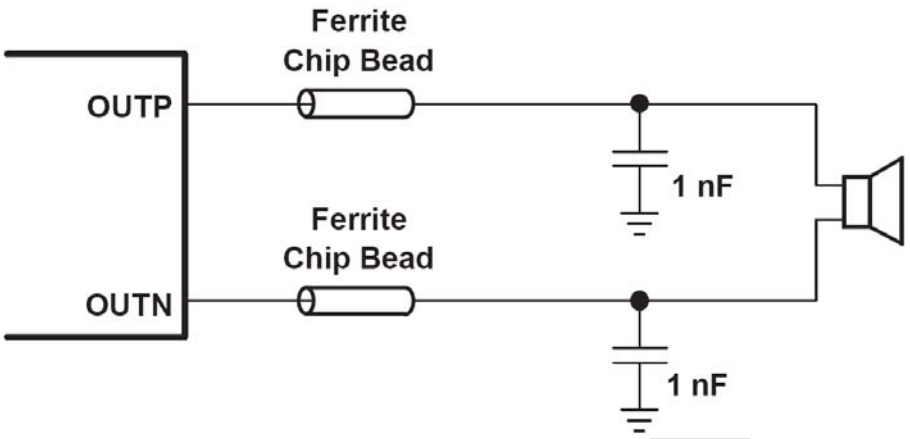


Figure 17: Ferrite Bead Filter to Reduce EMI

Decoupling Capacitor (CS)

The ft2811 is a high-performance Class-G audio amplifier that requires adequate power supply decoupling. Adequate power supply decoupling to ensures that the efficiency is high and total harmonic distortion (THD) is low.

Place a low equivalent-series-resistance (ESR) ceramic capacitor (X7R or X5R), typically 1μF, within 2mm of the VDD pin. 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 ft2811 is important, as any parasitic resistance or inductance between the device and the capacitor causes efficiency loss. In addition to the 1μF ceramic capacitor, place a 10μF to 47μF capacitor on the VDD 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.

Input Capacitors (Cin)

Input audio DC decoupling capacitors are recommended. The input audio DC decoupling capacitors prevents the AGC from changing the gain due to audio DAC output offset. The input capacitors and ft2811 input impedance form a high-pass filter with the corner frequency, fC, determined in Equation 4.

Any mismatch in capacitance between the two inputs will cause a mismatch in the corner frequencies. Severe mismatch may also cause turn-on pop noise. Choose capacitors with a tolerance of ±5% or better.

$$fc=1/(2 \times \pi \times Rin \times Cin) \qquad (4)$$

Flying Capacitor Selection (CF)

Select a LOW ESR 4.7uF/10V capacitor for flying capacitor is recommended.

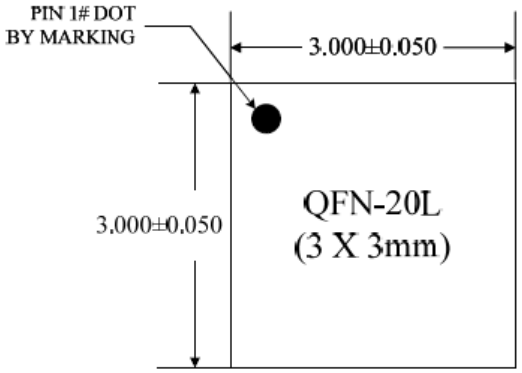
Typically, a capacitor value of4.7μF should be used for flying capacitors (CF). The low equivalent-series-resistance (ESR) ceramic capacitors, such as X7R or X5R ceramic capacitor is recommended.

Output Capacitor Selection (COUT)

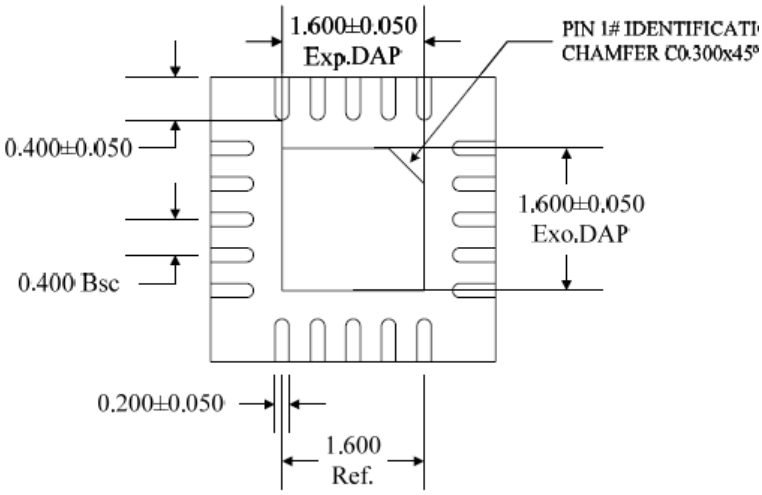
Typically, a capacitor value of 10μF should be used for COUT. The X7R or X5R ceramic capacitor is recommended.

PHYSICAL DIMENSIONS

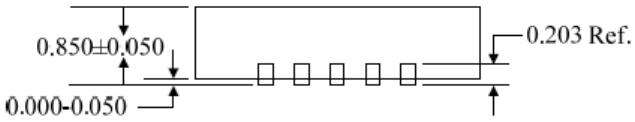
QFN3x3-20L Package



TOP VIEW



BOTTOM VIEW

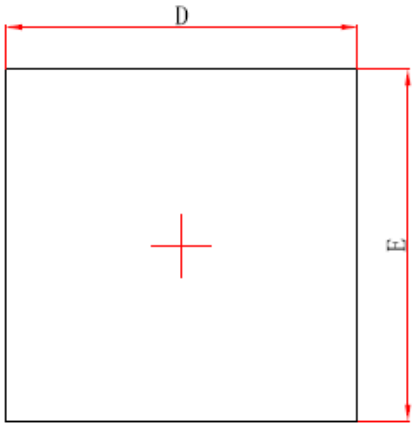


SIDE VIEW

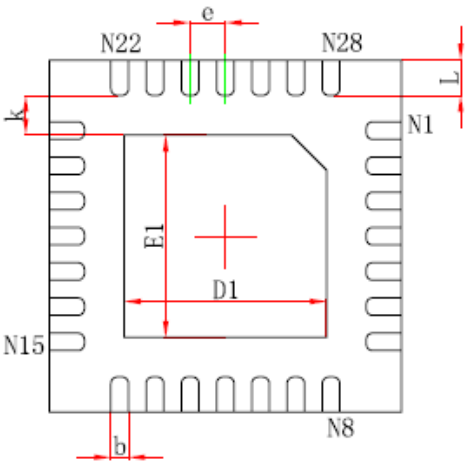
Unit: millimeters.

QFN4x4-28L Package

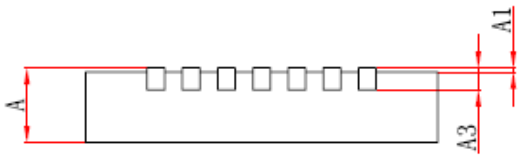
QFNWB4×4-28L(P0.40T0.75/0.85) PACKAGE OUTLINE DIMENSIONS



Top View



Bottom View



Side View

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	3.950	4.050	0.156	0.159
E	3.950	4.050	0.156	0.159
D1	2.200	2.400	0.087	0.094
E1	2.200	2.400	0.087	0.094
k	0.200MIN.		0.008MIN.	
b	0.150	0.250	0.006	0.010
e	0.400TYP.		0.016TYP.	
L	0.324	0.476	0.013	0.019

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