ft2010

2.7W Mono Filter-free Class-D Audio Power Amplifier

General Description

The ft2010 is a 2.7W high efficiency filter-free class-D audio power amplifier. The ft2010 can operate from 2.7 to 5.5V supply. When powered with
5V voltage, the ft2010 can deliver 2.7W to a 4Ω load at 10% THD+N.

As a Class D audio power amplifier, the ft2010
features 90% high efficiency and -75dB PSRR at
217Hz which make the device ideal for battery-supplied, high quality audio applications. The ft2010 also features the minimized click-and-pop noise during the turn-on and shutdown.

The ft2010 is manufactured in space-saving WCSP-9 package (1.46mm x 1.46mm) Applications

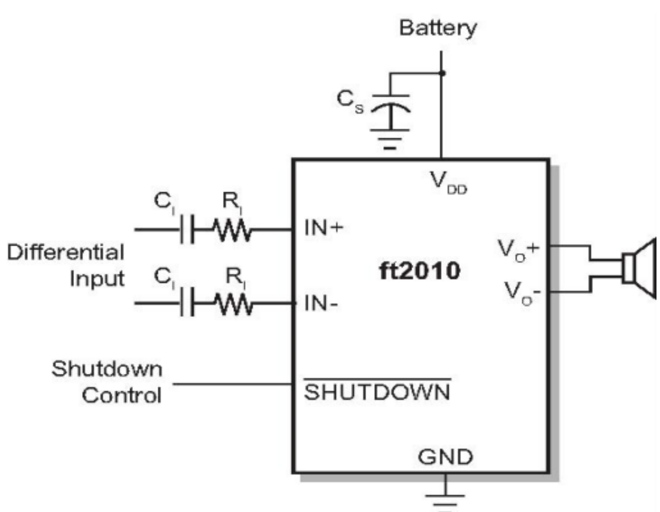
Applications

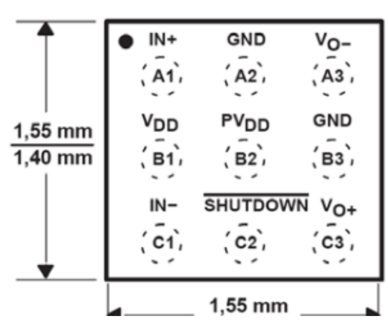
- Mobile phone
- Personal Digital Assistant (PDA)
- Portable gaming device
- Powered speakers
- Notebook computer

Features

- Output power at 5V supply
  - 2.7W (4Ω load, 10% THD+N)
  - 1.65W (8Ω load, 10% THD+N)
- Quiescent current: 3.0mA @ 3.6V supply (8Ω load)
- Shutdown current: 0.1μA (typical)
- PSRR: -75dB (typical)
- CMRR: -65dB (typical)
- Efficiency up to 90%
- Short circuit protection
- Packaging: WCSP-9 (1.46mm x 1.46mm)

Application Circuit





9 Ball WCSP (TOP VIEW)

Absolute Maximum Ratings

Operating Junction Temperature (T_J) -40°C to +125°C

Storage Temperature (T_{STG}) -65°C to +150°C

Lead Temperature (Solding, 10sec.) 260°C

Operation Ratings

Supply Voltage (V_{DD}) 2.7V to 5.5V

High Level Input Voltage (V_{IH}) 1.5V to VDD

Low Level Input Voltage (V_{IL}) 0 to 0.35V

Operating Temperature (T_A) -40°C to +85°C

Electrical Characteristics

Note: The following electrical characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. But note that specifications are not guaranteed for parameters where no limit is given. The typical value however, is a good indication of device performance.

All voltages in the following tables are specified at 25°C which is generally taken as parametric norm.

T_A=25°C

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$\lvert V_{OS} \rvert$	Output offset voltage (measured	V_I=0V, A_V=2V/V, V_{DD}=2.7V to 5.5V		1	25	mV
PSRR	Power supply rejection ratio	V_{DD}=2.7V to 5.5V		-75	-55	dB
CMRR	Common mode rejection ratio	V_{DD}=2.7V to 5.5V		-65	-50	dB
$\lvert I_{IH} \rvert$	High-level input current	V_{DD}=5.5V, V_I=5.5V			50	μA
$\lvert I_{IL} \rvert$	Low-level input current	V_{DD}=5.5V, V_I=-0.3V			5	μA
$I_{(Q)}$	Quiescent current	V_{DD}=5.5V, no load		3.8	5	mA
		V_{DD}=3.6V, no load		3.0		
$I_{(SD)}$	Shutdown current	$V_{(\overline{SHOUTDOWN})}$=0.35V, V_{DD}=2.7V to		0.1	2	μA
$r_{DS(ON)}$	Static Drain-source On-state Resistance	V_{DD}=3.6V		400		mΩ
		V_{DD}=5.5V		350		
	Output impedance in $\overline{\text{SHUTDOWN}}$	$V_{(\overline{SHOUTDOWN})}$=0.35V		2		kΩ
$f_{(SW)}$	Switching frequency	V_{DD}=2.7V to 5.5V	200	250	300	kHZ
	Gain	V_{DD}=2.7V to 5.5V	$\frac{280k\Omega}{RI}$	$\frac{300k\Omega}{R_I}$	$\frac{320k\Omega}{R_I}$	$\frac{V}{V}$
	Resistance from shutdown to GND			300		kΩ

Operating Characteristics

Note: The following electrical characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. But note that specifications are not guaranteed for parameters where no limit is given. The typical value however, is a good indication of device performance.

All voltages in the following tables are specified at 25°C which is generally taken as parametric norm.

T_A=25°C, R_L=8Ω

Symbol	Parameter	Test Conditions		Min	Typ	Max	Unit
P_O	Output power	THD+N=10%, f=1kHz, R_L=4Ω	V_{DD}=5V		2.7		W
			V_{DD}=3.6V		1.35		
		THD+N=1%, f=1kHz, R_L=4Ω	V_{DD}=5V		2.2		W
			V_{DD}=3.6V		1.10		
		THD+N=10%, f=1kHz, R_L=8Ω	V_{DD}=5V		1.65		W
			V_{DD}=3.6V		0.83		
		THD+N=1%, f=1kHz, R_L=8Ω	V_{DD}=5V		1.32		W
			V_{DD}=3.6V		0.68		
THD+N	Total harmonic distortion plus noise	V_{DD}=5V, P_O=1W, R_L=8Ω, f=1kHz			0.15%		
		V_{DD}=3.6V, P_O=0.5W, R_L=8Ω, f=1kHz			0.12%		
k_{SVR}	Supply ripple rejection ratio	V_{DD}=3.6V, Inputs ac-grounded	f=217Hz, $V_{(RIPPLE)}$=200mV_{pp}		-65		dB
SNR	Signal-to-noise ration	V_{DD}=5V, P_O=1W, R_L=8Ω			95		dB
Vn	Output voltage noise	V_{DD}=5V, Inputs ac-grounded	No weightind		46		μV_{RMS}
CMRR	Common mode rejection	V_{DD}=3.6V, V_{IC}=1V_{pp}	f=217Hz		-65		dB
Z_I	Input impedance			142	150	158	kΩ
	Start-up time from shutdown	V_{DD}=3.6V			32		ms

Terminal Functions

Terminal		I/O	Description
Name	WCSP		
IN-	C1	I	Negative differential input
IN+	A1	I	Positive differential input
V_{DD}	B1	I	Power supply
V_{O+}	C3	O	Positive BTL output
GND	A2, B3	I	High-current ground
V_{O-}	A3	O	Negative BTL output
SHUTDOWN	C2	I	Shutdown terminal (active low logic)
PVDD	B2	I	Power supply

Application Information

Fully Differential Amplifier

The ft2010 is a fully differential amplifier which can receive and transmit differential signals to ensure signal quality with few external components. The ft2010 consists of one amplifier and one common mode amplifier. The former produces output signal equals input times the gain and the later keep the common mode voltage at half V_{DD} so that the output signals are biased at mid-supply (1/2 V_{DD}).

Filter-less Design

In traditional Class D amplifier design, the differential outputs changes from ground to supply voltage and are in anti-phase. Therefore, the voltage at the load (speaker) varies between positive and negative supply voltage. Thus, even a duty cycle of 50% yields 0V voltage across the load, the current on the load is quite high which results in high power loss and low efficiency. In this case, LC filter is introduced at the output ends to store the ripple current.

The ft2010 outputs switch from ground to supply voltage but are in phase with each other. That is to say, when the duty cycle is 50%, there will be almost no voltage across the load. When the positive output duty cycle is greater than 50% and the negative less than 50%, the voltage across the load equals OUT+ minus OUT-, which switches from 0V to V_{DD} and mostly sits at 0V. This greatly reduces the switching current, reduces the power loss over the load resistance and save the LC filter.

However, LC filter is required when the trace between the ft2010 and the speaker exceeds 50mm. Long trace acts like tiny antenna and causes EMI emissions which may result in FCC and CE certification failure.

Components

Input Resistors (R_I)

The input resistors (R_I) set the gain of the amplifier according to equation (1).

$$\text{Gain} = \frac{2 \times 150\text{k}\Omega}{R_I}\left(\frac{V}{V}\right) \qquad (1)$$

Input resistor selection is critical for balancing the output in a fully differential amplifier and influences the CMRR, PSRR and the cancellation of the second harmonic distortion. Therefore, resistors of 1% tolerance or of better performance are recommended for ft2010 application.

Decoupling Capacitor (C_S)

Decoupling capacitor helps to stabilize voltage of power supply and thus reduce the total harmonic distortion (THD). It can also be applied to prevent oscillations over long leads. A Low Equivalent-Series-Resistance (ESR) capacitor of 1μF is required for decoupling and should be placed close to the ft2010 to reduce the resistance and inductance on the trace between the amplifier and the capacitor.

For filtering lower-frequency noise signals, a 10μF capacitor could be placed near the audio power amplifier.

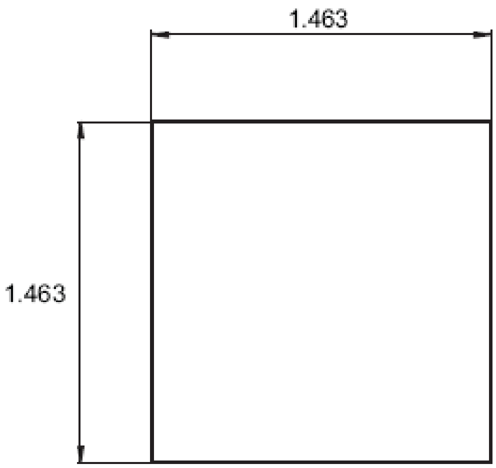
Input Capacitors (C_I)

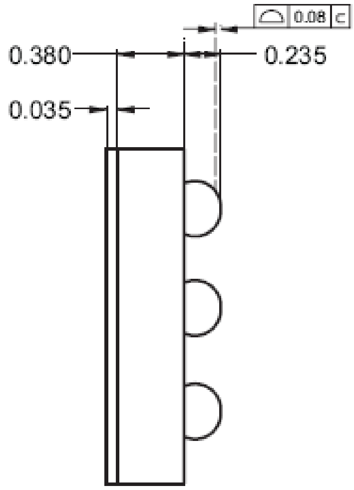
The input capacitor and input resistor determine the corner frequency of the high pass filter. The corner frequency (fC) is calculated with the Equation (2) below.

$$f_C = \frac{1}{(2\pi R_I C_I)} \qquad (2)$$

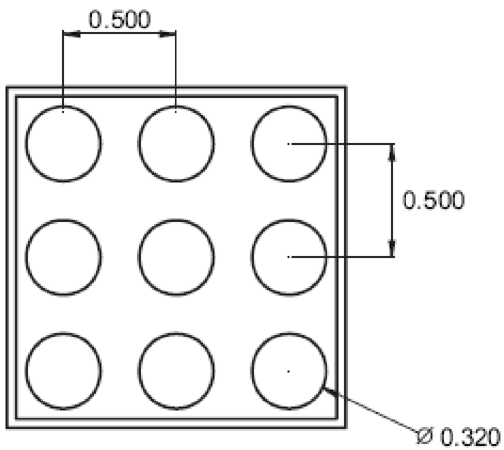
The corner frequency directly influences the low frequency signals and consequently determines output bass quality.

Mechanical Data





TOP VIEW



BOTTOM VIEW

Note: All Dimensions Are in Millimeters.

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