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ICEpower250A
250W General Purpose ICEpower Amplifier

Version 2.2

General Description

The ICEpower250A is a general purpose amplifier solution. By using patented, state-of-the-art ICEpower $^{®}$ analogue technology, the ICEpower250A achieves extremely high fidelity in a compact package.

The full audio bandwidth and the ability to operate from a variety of power sources means the ICEpower250A can be used in:

- Active speakers and subwoofers
- A/V amplifiers/receivers
- Automotive amplifiers
- Musical instrument amplifiers
- Marine audio products
- Installation audio products

Figure 1: ICEpower250A
Size: 8 x 8 x 2.7cm

True high-end performance is guaranteed by the patented, proprietary COM modulation and MECC control techniques and the integrated, turn-key design reduces design-in cost and shortens Time-to-Market for the end product.

Key Specifications

- 250W @ 0.01% THD+N 1kHz, 2.7Ω
- Peak output current > 25A
- 112dBA dynamic range
- THD = 0.0009% @ 100mW, 5kHz
- THD+N < 0.05%, 0.1W – 170W, 4Ω
- Efficiency = 93% @ 100W /8Ω
- Output impedance < 5mΩ @ 1kHz
- Power Supply Rejection Ratio > 60dB
- Output DC-offset < 25mV

Key Features

- Very rugged design for demanding use
- Soft mute/de-mute
- Stand-by mode for low power consumption
- Under voltage protection
- Monitor output
- Balanced input and output
- Excellent EMI performance
- No heat sink required
- Safety: IEC 60065 ed. 8.

Version	Date	Revised by	Changes
2.2	2017-10-17	DIT	Address updated Legal Notes updated Document History added
2.3	2020-07-03	LBH/NKK	Safety information added

Document History

Block Diagram

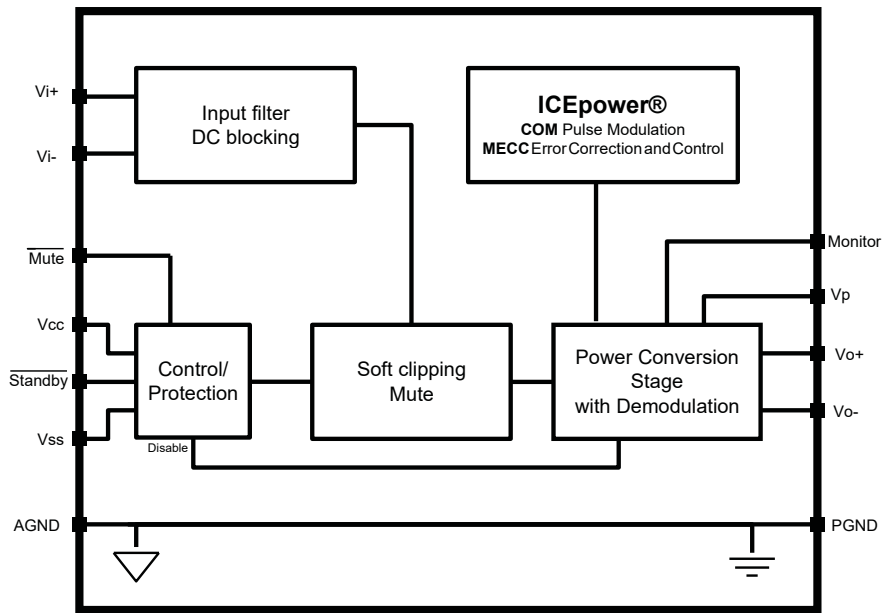Figure 2: ICEpower250A block diagram
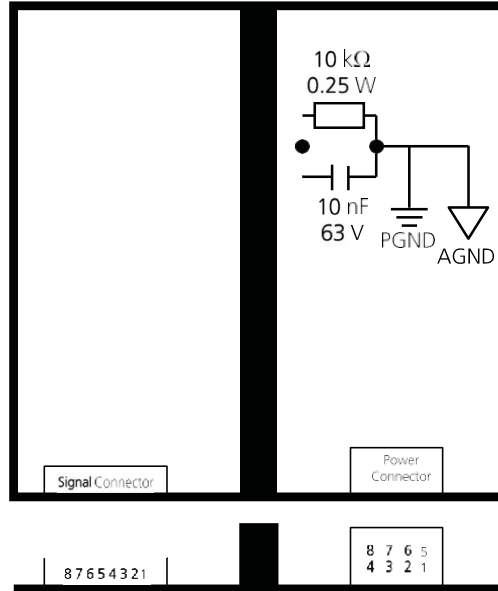
Connection Diagram

Figure 3: ICEpower250A-IC connectors.

The plug interface of the ICEpower250A has two industry standard connectors selected for long-term reliability. The power Molex Micro-Fit™ connector is used for power input and speaker output. The JST PH-connector is used for low level power supply, audio input and the control features.

Power Connector Specification

Pin	Function	Description
7, 8	PGND	Power GND for the single ended power supply input Vp.
3, 4	Vp	Power Supply (single) for the power stage
1, 2	Vo-	" Cold " balanced power output terminals. In phase with Vi -
5, 6	Vo+	" Hot " balanced power output terminals. In phase with Vi+

Table 1: Power Connection Specifications.

Signal Connector Specification

ICEpower* Pin numbering	Function	Description	JST** Pin numbering
1	Vcc	Positive power supply input for the signal section.	8
2	Vss	Negative power supply input for the signal section.	7
3	AGND	Ground terminal for the signal section.	6
4	Monitor	Unbalanced attenuated output signal.	5
5	Vi+	Positive input (balanced input buffer).	4
6	Vi-	Negative input (balanced input buffer).	3
7	Mute	Mute input (Internal pull-up).	2
8	Standby	Control pin for standby control. (Internal pull-up).	1

* This pin numbering is used by ICEpower in all ICEpower documentation
**This pin numbering is used by JST in the specifications for the PHR-08 connector.

Table 2: Signal Connector Specification.

Absolute Maximum Ratings

Absolute maximum ratings indicate limits beyond which damage may occur.

Symbol	Parameter	Value	Unit
Vp	Operating power supply level	55	V
Vcc	Positive analog supply	15	V
Vss	Negative analog supply	−15	V
Vin	Maximum differential input voltage	±12	V
T_{case}	Maximum case temperature	90	°C
T_a	Maximum operating ambient temperature	60	°C
$R_{th,case-rib}$	Thermal resistance, case – rib	2	K/W
T_{ZOBEL} [1]	Maximum duration of 25V_{RMS} output @ 20kHz	30	s
C_L	Maximum pure capacitive loading	470	nF

Table 3: Absolute Maximum ratings.

1) The output RC-Zobel network is designed for music loads. Continuous stress at frequencies above 10 kHz may damage the device.

Electrical Specifications

Unless otherwise specified, f=1kHz, P_o=1W. T_a = 25 °C.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Vp	Power Supply	Operation	29	48	50	V
Vcc	Positive analog supply	Operation	10	12	15	V
Vss	Negative analog supply	Operation	-10	-12	-15	V
P_O	Output power @ 0.09%THD+N 10Hz <f< 20kHz (AES17 measurement filter) [2]	R_L = 2.7Ω, Vp = 50V		250		W
		R_L = 4Ω, Vp = 50V		210		
		R_L = 8Ω, Vp = 50V		110		
THD+N	THD+N in 4Ω (AES17 measurement filter) [2]	f = 1kHz, P_O = 1W		0.015	0.02	%
THD+N	Maximal THD+N in 4Ω (AES17 measurement filter) [2]	10Hz < f < 20kHz 100mW < P_O < 170W		0.05	0.07	%
I_{Vp}	Quiescent current	Vp = 48V	30	40	50	mA
$I_{Vp, standby}$	Standby current	Vp = 48V		2.5		mA
I_{Vcc}	Quiescent current	Vcc = 12V	110	130	160	mA
$I_{Vcc, standby}$	Standby current	Vcc = 12V		60		mA
I_{Vss}	Quiescent current	Vss = -12V	10	20	30	mA
$I_{Vss, standby}$	Standby current	Vss = -12V		25		mA
f_o	Offset switching frequency	Idle	380	440	480	kHz
f_S	Switching frequency range	Idle to full scale variation	60		480	kHz
η	Power stage Efficiency	R_L = 8Ω, P_O = 100W		93		%
PSRR	Power Supply Rejection Ratio of Vp	Voltage ripple @ f = 100 – 120Hz	60			dB
$V_{N,O}$	Output referenced idle noise	A-weighted 10Hz <f <20kHz	70	85	100	μV
$V_{OFF,Diff}$	Differential offset on output terminals	Input terminated.			±25	mV
$V_{OFF,CM}$	Common mode offset on output terminals	Input terminated.		Vp / 2	±10%	V
A_V	Nominal Voltage Gain	f = 1 kHz	27.1	27.4	27.7	dB
f	Frequency response	20Hz - 20kHz, All loads		±0.3	±0.6	dB
f_u	Upper bandwidth limit (-3dB)	R_L = 8Ω		70		kHz
f_i	Lower bandwidth limit (-3dB)	R_L = 8Ω		4		Hz
Z_O	Abs. output impedance	f = 1kHz		5	10	mΩ
Z_L	Load impedance range		2	4	∞	Ω
D	Dynamic range	A-weighted		112		dB
IMD1	Intermodulation (CCIF)	f = 19kHz, 20kHz, P_O = 10W		0.001	0.002	%
IMD2	Intermodulation (SMPTE)	f = 60Hz,7kHz(1:4), P_O =10W		0.01	0.02	%
TIM	Transient intermodulation (TIM)	f_1 = 3.15kHz square, f_2 = 15kHz, P_O =10W		0.003	0.005	%

Table 4: Electrical Specifications.

2) AES17, 22 kHz 7th order Audio Precision measurement filter is used for measurements.

Timing Specifications

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t_{sd}	Switching start up delay	Time from when all power supplies are within operational limits [3]	200	250	300	ms
t_{pdm}	Output delay	Time delay to signal [3]	350	400	500	ms
t_{md}	Mute delay	Time delay to mute [3]	30	50	100	ms
t_{dmd}	De-mute delay	Time to demute [3]	300	350	400	ms
t_{psd}	Shutdown delay	Supply failure or Standby pin [3]		1	5	µs

Table 5: Timing Specifications.
3) For details see Figure 12 and Figure 13.
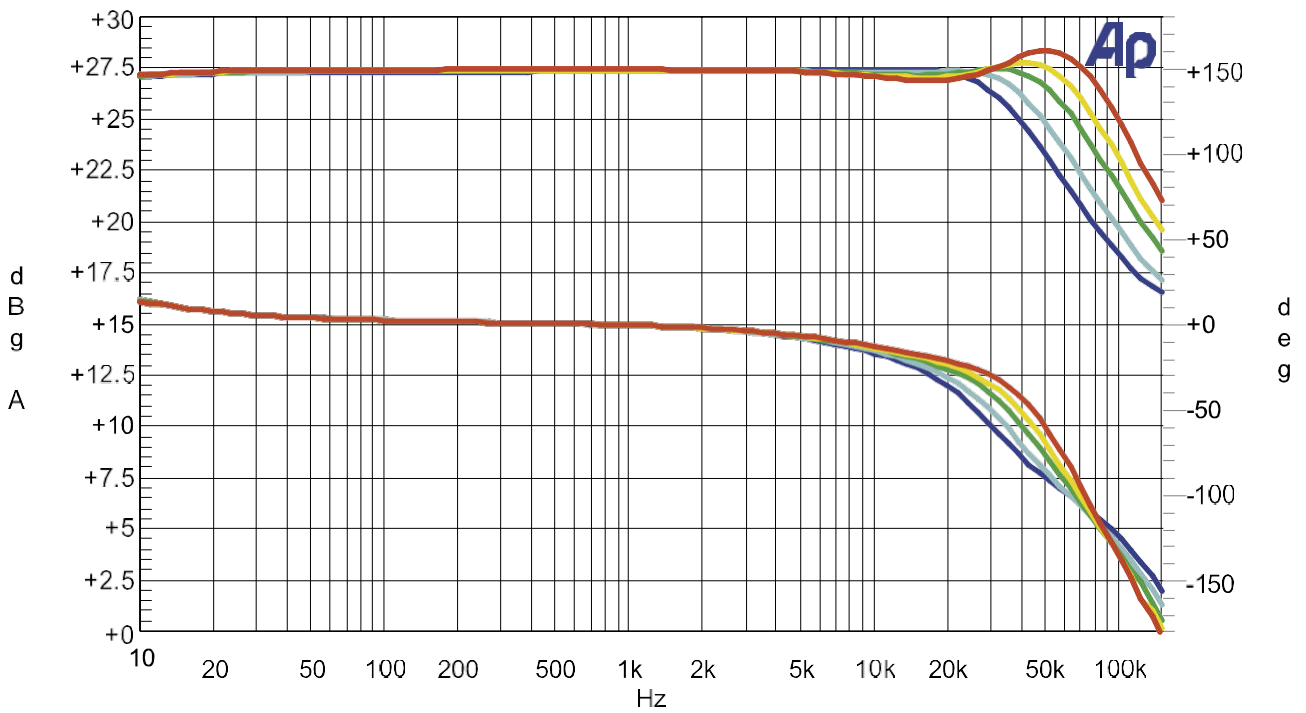
Typical Performance Characteristics

Figure 4: Frequency response in 2.7Ω, 4Ω, 8Ω, 16Ω and open load. Top – amplitude. Bottom – phase.
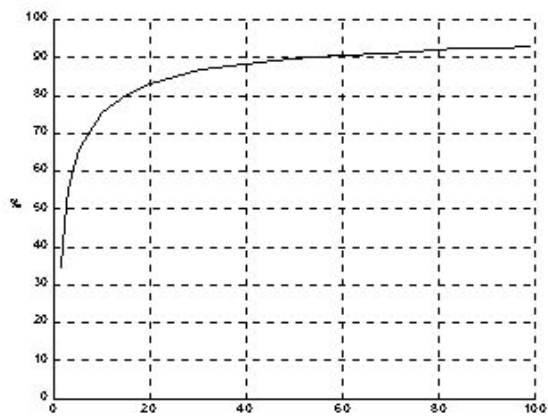
Efficiency vs. Output Power
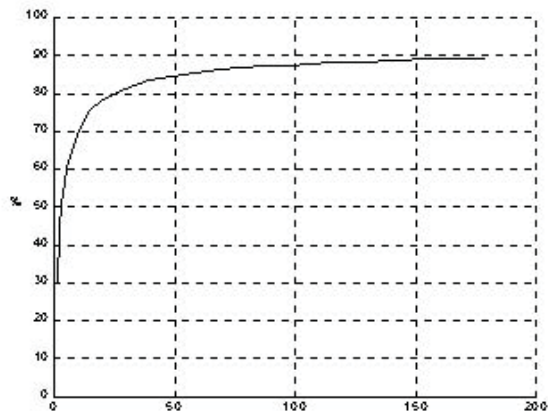
Figure 5: Efficiency vs. output power (8Ω).

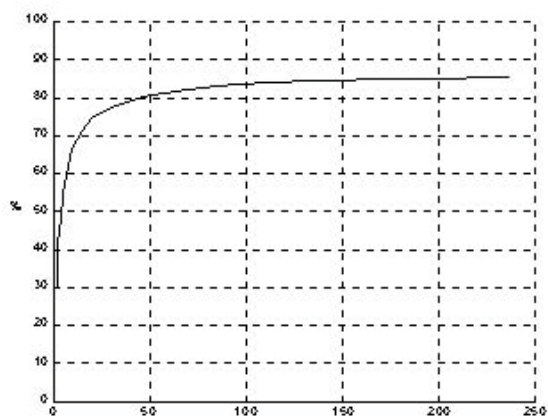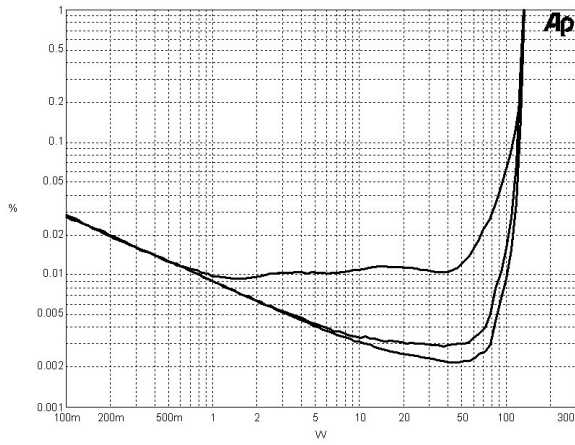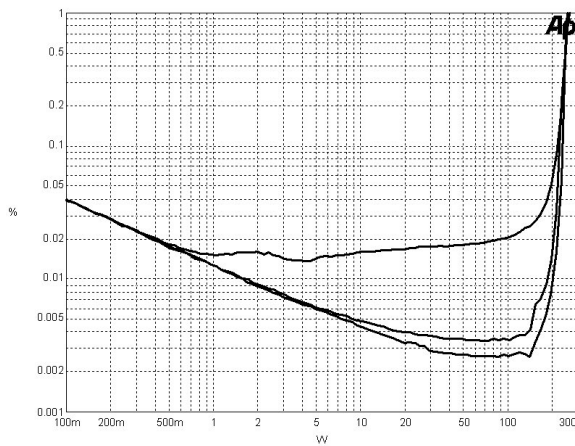Figure 6: Efficiency vs. output power (4Ω).
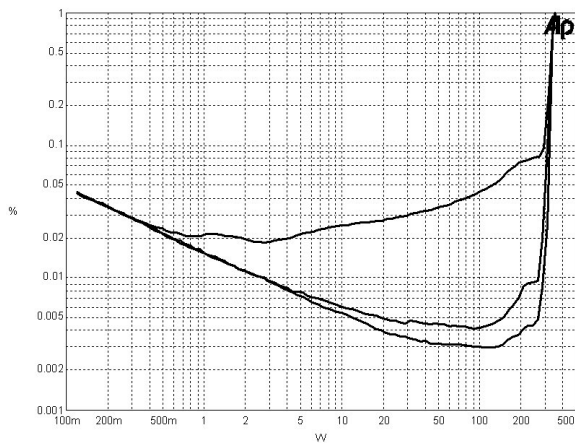
Figure 7: Efficiency vs. output power (2.7Ω).
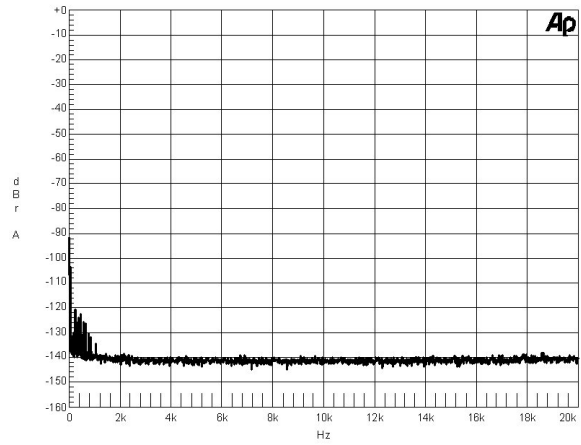
Harmonic Distortion & Noise

THD + N vs. output power at 100Hz, 1kHz and 7kHz [4] (8Ω).

Idle noise (16K FFT). Residual = 80µV(A).

THD + N vs. output power at 100Hz, 1kHz and 7kHz [4] (4Ω).
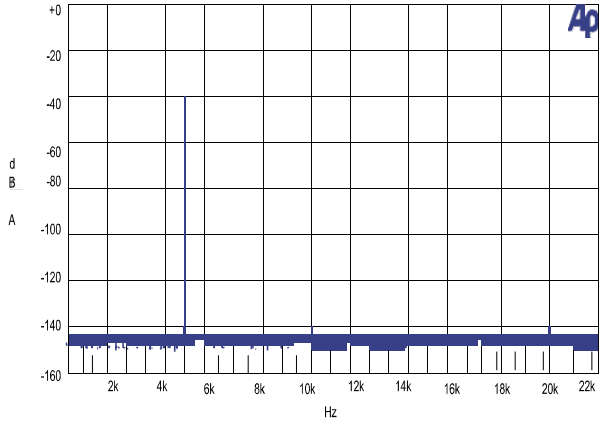
FFT Analysis. f = 5kHz. Po = 100mW 4Ω loading.
THD = -101dB (0.0009%)

THD + N vs. output power at 100Hz, 1kHz and 7kHz [4] (2.7Ω).
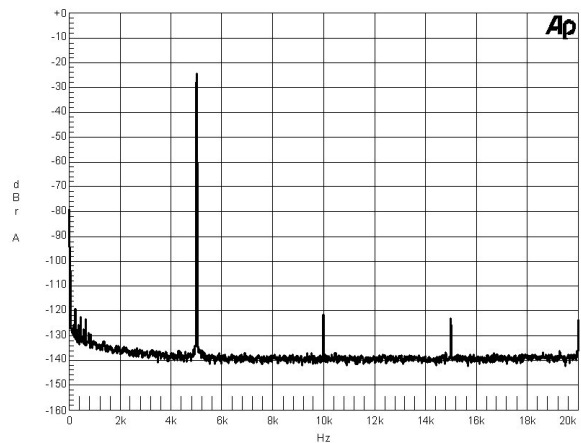
f= 5kHz. P_o = 1W. 4Ω loading. THD = 0.002%.

Figure 8: Harmonic Distortion & Noise.
4) AES17, 22 kHz 7th order Audio Precision measurement filter is used.

Application Information

To simplify product development, the ICEpower250A is designed as a "complete" component electrically and mechanically. A typical ICEpower250A component application is a single channel application (e.g. an active speaker system). An example is shown in Figure 9.

Figure 9: Typical application.

Input/Output Interfaces

The balanced input section provides signal buffering and anti-alias filtering. The balanced configuration helps to avoid hum and noise pick-up. If an unbalanced input be preferred this can be set by shorting Vi- and AGND.

Figure 10: Balanced input buffer / anti-aliasing filter.

The anti-aliasing filter bandwidth is 100 kHz and the filter characteristics are shaped to match the power amplification section. The audio bandwidth is 70 kHz and the input impedance is approximately 8kΩ over the audio bandwidth. This presents an acceptable load for most pre-amps, active crossover outputs etc.

Output Stage

The output stage is a bridge topology with a 2nd order filter. This leads to a balanced power output on the terminals Vo+ and Vo-. The filter design is a part of the proprietary MECC topology and has been chosen as a compromise between demodulation, efficiency and filter volume.
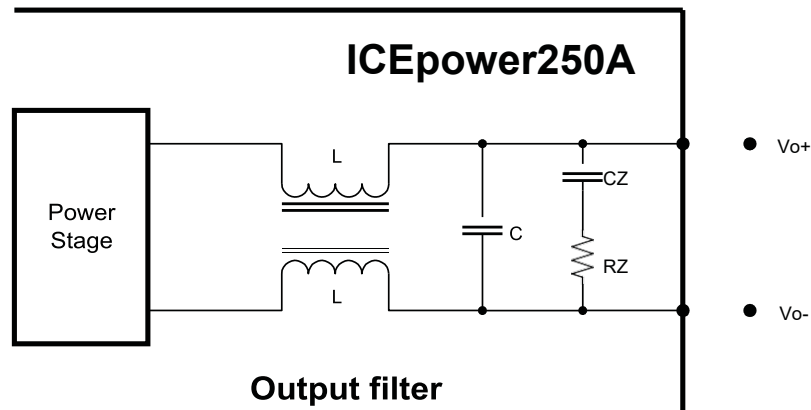

Figure 11: Output filter section with compensating Zobel network.

The essential output characteristics are:

- The output impedance is below 25mΩ @ 20 kHz.
- The output residual basically consists of a single frequency component at the carrier fundamental of approximately 440 kHz. In a standard application set-up, the output characteristics lead to compliance with the EN and FCC directives on EMI.
- The system bandwidth is 70 kHz with an 8Ω load.

The ICEpower250A is designed to have low output impedance at all frequencies (see Figure 4) and thus be unaffected by loading characteristics. Care should however be taken with *purely* capacitive loads. The ICEpower250A is designed to be stable with purely capacitive loads up to 470nF. Higher capacitive loads may compromise stability and thus damage the device.

Warning! The balanced speaker outputs are both "hot" with a common-mode DC level equal to Vp/2. Always use balanced probes for monitoring and measurements. Shorting one of the terminals to ground results in an over current situation. As the module has no internal current limiter even a brief short circuit (phase-to-phase or phase-to-GND) will damage the device beyond repair. Current limiting circuitry must be connected externally.

Operational Timing Diagram

The power supply input pins, the Standby pin and the Mute pin control the ICEpower250A. If the supplies are not above their minimum values the amplifier will enter standby mode. The amplifier can be forced into standby mode by pulling the standby pin low. The Mute pin will not stop the switching of the amplifier, but attenuates the output signal by 60dB when pulled low.
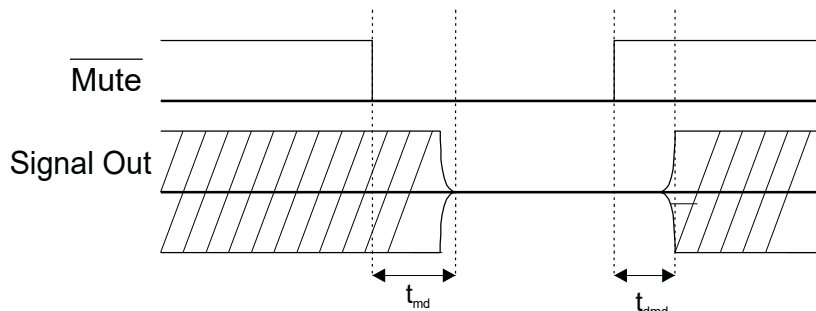

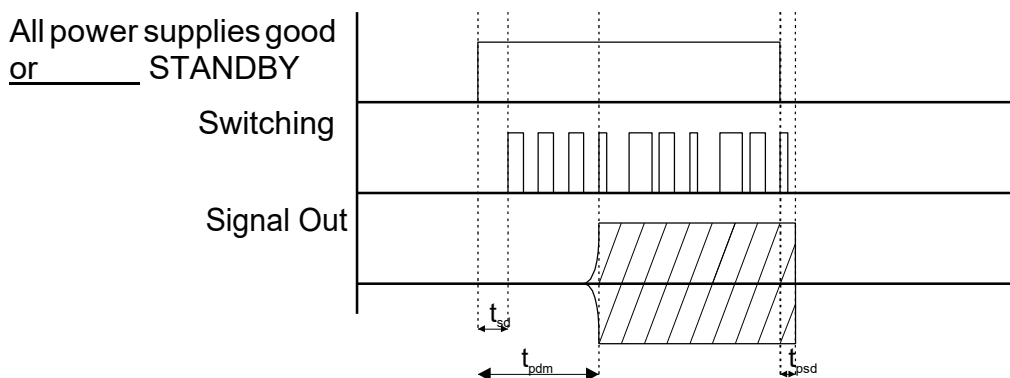Figure 12: Mute and de-mute timing definitions.

Figure 13: Supply startup and shut down timing definitions.

Power-up Sequence

The power supplies control power-up of the ICEpower250A. When the power supplies reach operational power levels the switching output stage is enabled with a 50% duty-cycle (zero modulation). To ensure power supply stability before start-up, a propagation delay of t_{sd} = 250ms (typical value) has been introduced. The built-in mute function subsequently releases the input signal with a timed delay of t_{dmd} = 350ms for a soft, controlled start-up sequence. The total delay from power is applied until full signal amplification is available is thus 600ms.

Power-down Sequence

The module will enter standby mode if:

1. One of the power supplies drops below the minimum acceptable level or falls out completely.
2. The standby pin is pulled low.

In either case the ICEpower250A will shut off instantly (1 μs) by muting the signal and disabling the output stage. After a power-down, meaning when the standby pin is released and/or the power supplies return to nominal values, the ICEpower250A will power up using the standard power-up sequence as described above.

Features

Mute Control

The mute function has been implemented to allow soft mute/de-mute of the module. The recommended external interface circuit for this pin can be seen on Figure 14. Timing specifications are only valid with the interface shown.
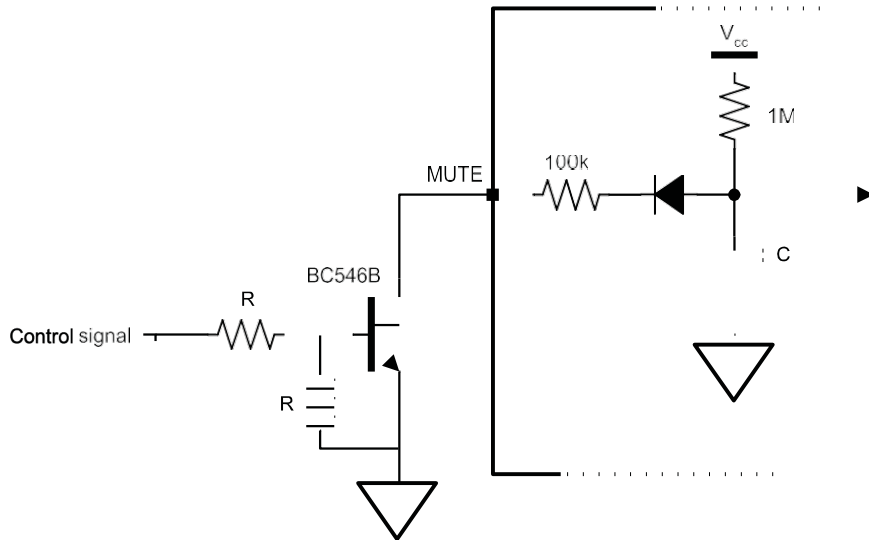
Figure 14: Interface and simplified internal circuit for the MUTE pin.

Standby Control

The Standby pin can be used to put the module in a low power consumption mode. Pulling the standby pin low sets the standby mode. This function allows quick shutdown of the module and can be used for protection of the module. The recommended external circuit is shown in Figure 15. The timing specifications are only valid with the interface circuit shown.
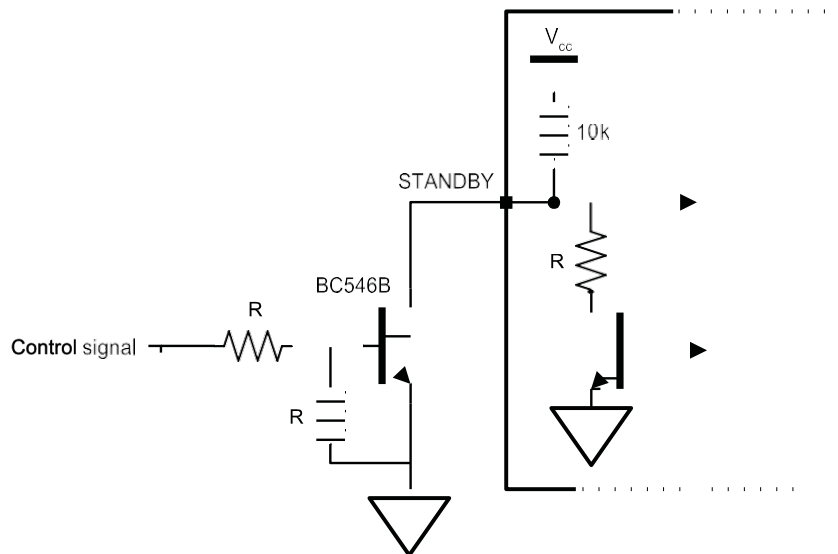
Figure 15: Interface and simplified internal circuit for STANDBY pin.

Monitor Output

The monitor output has been implemented as an attenuated, ground referenced version of the balanced output signal. The internal output circuit of this output is shown in Figure 16. The bandwidth for the monitor output is limited to 45 kHz.
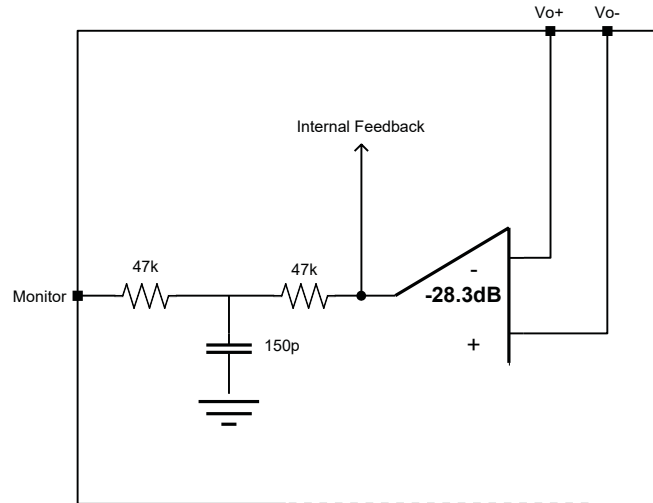
Figure 16: Internal circuitry of the monitor output.

Thermal Design

Thermal design is generally a great challenge in power amplifier systems. Linear amplifier designs operating in class A or AB are normally very inefficient and therefore equipped with extensive heat sinking to keep the transistor junction temperature low. The ICEpower250A is based on highly efficient ICEpower switching technology providing high overall efficiency characteristics at all levels of operation. Refer to the efficiency vs. output power graph in the section "Typical performance characteristics" for more information.

With $R_{th, \text{case-rib}}$ = 2 K/W the heat sink can be designed using normal thermal design considerations. Mounting the ICEpower250A to an aluminum backplane or enclosure is normally sufficient to ensure trouble-free operation even under continuous loading. Please note that the module relies on both the heat sink and the ambient air for cooling and so it must be ensured that neither T_{case} nor T_a is exceeded during operation. The ICEpower250A has no thermal shutdown feature and a suitable thermal monitoring circuit must be connected externally if the application requires protection against thermal overload.

Power Supply

The ICEpower250A has excellent power supply rejection on the main supply line (V_p) due to the use of ICEpower's patented COM modulation, and as such there are no specific requirements for power supply stabilization. The ICEpower250A runs well even on an unstabilized supply, linear or switch-mode, with several volts of ripple. The COM modulation technology also means that power supply bypassing and layout are not critical and that poor layouts will not cause stability problems as can be the case in linear amplifier designs.

The analog V_{cc} and V_{ss} supply lines must be regulated. Noise and ripple on these supplies will directly affect overall system performance and voltages exceeding 15V on either line will damage the device.

Contact

For additional information about the ICEpower® technology from ICEpower a/s, visit our web site or contact us.

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