

ICEpower400A2

Two Channel 400W ICEpower Amplifier
Version 1.0

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2. General Description

ICEpower400A2 is designed for outstanding audio quality in a compact size. The 400A2 incorporates the latest in state of the art custom ICEpower patented ICEedge Chipset technology, enabling superior sound quality with an ultra-low noise floor, of typical 34 μ V for a Signal To Noise ratio of 121.5 dB, despite the high nominal voltage gain. It is an efficient two/one-channel audio power amplifier intended for driving two 4 Ω loudspeakers or one 8 Ω speaker in BTL mode.

The ICEpower400A2 provides comprehensive protection and monitoring functions with an easy-to-use control interface. Additionally, dedicated monitor outputs for loudspeaker connector output voltage enables real time protection system of the loudspeaker.

ICEpower400A2 is designed for high output power, making it ideal for applications requiring sustained output power and high output voltage not only for home hi-fi, but also for demanding studio monitor and high performance amplifier for PRO audio speakers as well. The integrated aluminum heatsink enables easy extended heat transfer to external heatsink so improved long term output power can be achieved

The ICEpower400A2 is designed to comply with EMC and safety enabling fast design-in and minimum time to market.

Features

Can be configured as a two channel SE amplifier or a single channel BTL amplifier

Designed for flexible mounting and, if needed, easy mechanical interface to external heatsink for even higher continuous power capability

Designed as hanger module for 1500S-69V

Thermal, over-current and over- and under- voltage rail protection

Suitable for 1U products

Fully differential audio inputs

Amplifier Disable function

Clip detect signals for both channels

Real time voltage monitor output for both channels

2.1 Key Specifications

- 2 channel 400 W @ 1 % THD+N, 20 Hz – 20 kHz, 4 Ω or
1 channel 800 W @ 1 % THD+N, 20 Hz – 20 kHz 8 Ω
- 121.5 dB(A) dynamic range SE
- 124.5 dB(A) dynamic range BTL
- THD+N = 0.001 % @ 10 W (4 Ω , 100 Hz) SE
- THD+N = 0.0015 % @ 50 W (4 Ω , 100 Hz) SE
- Load independent frequency response
- Very low THD+N in the entire audio band
- Very low IM distortion
- <35uVrms A-weighted idle noise SE
- <50uVrms A-weighted idle noise BTL
- Dimensions (L x W x H): 100 x 60 x 35 mm, (3.93 x 2.36 x 1.38 inch)

3. Release Notes

| Data Sheet Version | Date | Revised by | Description |
|---------------------------|-------------|-------------------|--------------------|
| 1.0 | 2021-03-02 | JAP/LBH/ASP | Release version |
| | | | |

4. Getting Started

ICEpower400A2 is a fully self-contained amplifier module and requires no interaction nor control to operate.

For first time use, please connect an audio source to the analog input and loudspeakers to the loudspeaker output connectors before applying power to the power rail supply connectors, auxiliary supplies and Vdrive. ICEpower400A2 will start after all supply voltages are applied.

The ICEpower400A2 is a two-channel single ended output Class D audio amplifier utilizing ICEpower patented technology. Each channel comprises a high impedance fully balanced input buffer for high suppression of hum and noise in a multi-channel application. The two-channel amplifier module can easily be bridged creating a single channel of higher output power by connecting the two balanced inputs with inverted polarity and activating BTLselect by pulling it high.

Important: The module should only be supplied by either DVDD/DVSS or VDD/VSS.

5. Block Diagram

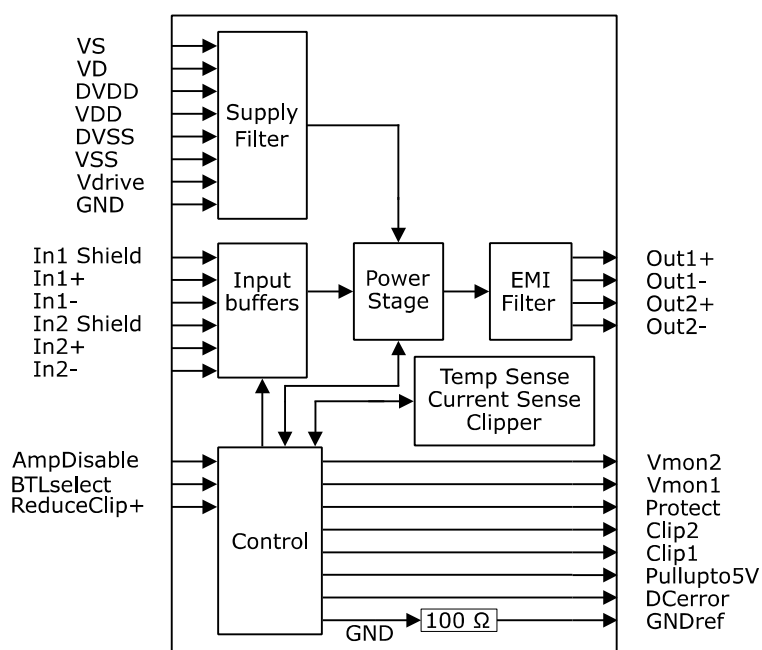


Figure 1: ICEpower400A2 block diagram

6. Connectors

The ICEpower400A2 module comes with industry standard connectors selected for long-term reliability.

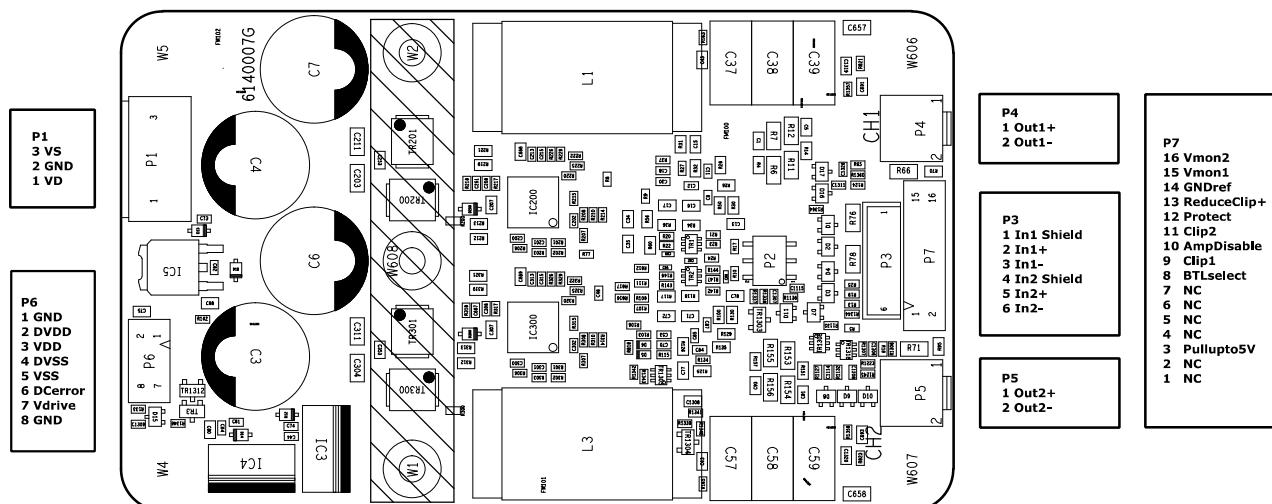


Figure 2: ICEpower400A2 connector overview

6.1 P1: Power Rail Supply Connector

| Type: JST, B03P-NV (LF)(SN) | | | | |
|-----------------------------|----------|-----------------------------------|-------------|-----------|
| PIN | Function | Description | Type | Reference |
| 1 | VD | Positive amplifier DC rail supply | Power input | GND |
| 2 | GND | Ground | Power GND | |
| 3 | VS | Negative amplifier DC rail supply | Power input | GND |

Table 1: Power rail connector

6.2 P6: Auxiliary Supply Connector

| Type: JST, B8B-PHDSS (LF)(SN) | | | | |
|-------------------------------|----------|--------------------------------------|---------------------------------------|-----------|
| PIN | Function | Description | Type | Reference |
| 1 | GND | Ground | GND | |
| 2 | DVDD | Positive supply for control circuit | Input | GND |
| 3 | VDD | Positive supply for analog circuit | Input | GND |
| 4 | DVSS | Negative supply for control circuit | Input | GND |
| 5 | VSS | Negative supply for analog circuit | Input | GND |
| 6 | DCError | DC error for the supply to shut down | Status output, open drain, active low | GND |
| 7 | Vdrive | Vdrive voltage for the power stage | Input | VS |
| 8 | GND | Ground | GND | |

Table 2: Auxiliary Supply connector

The module should only be supplied by either DVDD/DVSS or VDD/VSS

6.3 P7: Basic+ Control Connector

| Type: JST, B16B-PHDSS (LF)(SN) | | | | |
|--------------------------------|-------------|--|---------------------------------------|-----------------|
| PIN | Function | Description | Type | Reference |
| 1 | NC | | NC | |
| 2 | NC | | | |
| 3 | Pullupto5V | Coupled to 5V via a 47k resistor | Output | GND |
| 4 | NC | | NC | |
| 5 | NC | | NC | |
| 6 | NC | | NC | |
| 7 | NC | | NC | |
| 8 | BTLselect | Select BTL mode, active high | Control input, active high | GND |
| 9 | Clip1 | Voltage clip indicator, channel 1 | Status output, open drain, active low | GND |
| 10 | AmpDisable | Disable amplifier (mute) | Control input, active high | GND |
| 11 | Clip2 | Voltage clip indicator, channel 2 | Status output, open drain, active low | GND |
| 12 | Protect | Protect signal | Status output, open drain, active low | GND |
| 13 | ReduceClip+ | Reduce clip level | Control input, active high | GND |
| 14 | GNDref | Ground ref, (terminated through 100 Ω to GND) | GND | Resistor to GND |
| 15 | Vmon1 | Voltage monitor, channel 1 | Analog Output | GND |
| 16 | Vmon2 | Voltage monitor, channel 2 | Analog Output | GND |

Table 3: Basic Control Connector

6.4 P3: Audio Input Connector

| Type: JST, B6B-PH-K-S (LF)(SN) | | | | |
|--------------------------------|------------|---|-------|-----------------|
| PIN | Function | Description | Type | Reference |
| 1 | In1 Shield | Analog audio input shield | Input | Resistor to GND |
| 2 | In1+ | Non-Inverting analog audio input signal | Input | GND |
| 3 | In1- | Inverting analog audio input signal | Input | GND |
| 4 | In2 Shield | Analog audio input shield | Input | Resistor to GND |
| 5 | In2+ | Non-Inverting analog audio input signal | Input | GND |
| 6 | In2- | Inverting analog audio input signal | Input | GND |

Table 4: Audio Input connector

6.5 P4: Channel 1 Loudspeaker Output Connector

| Type: JST, B2P-VH (LF)(SN) | | | |
|----------------------------|----------|---|--------------------|
| PIN | Function | Description | Type |
| 1 | Out1+ | Amplifier output, channel 1 | Audio power Output |
| 2 | Out1- | Amplifier GND output, channel 1 ¹⁾ | Audio power Output |

Table 5: Channel 1 Loudspeaker Output connector

¹⁾Do not connect this to normal GND.

6.6 P5: Channel 2 Loudspeaker Output Connector

| Type: JST, B2P-VH (LF)(SN) | | | |
|----------------------------|----------|---|--------------------|
| PIN | Function | Description | Type |
| 1 | Out2+ | Amplifier output, channel 2 | Audio power Output |
| 2 | Out2- | Amplifier GND output, channel 2 ¹⁾ | Audio power Output |

Table 6: Channel 2 Loudspeaker Output connector

¹⁾Do not connect this to normal GND.

7. Absolute Maximum Rating

Absolute maximum ratings indicate limits beyond which damage may occur.

7.1 Power Rail Supply Section

| Pin | Parameter | MIN | MAX | Unit |
|---------|-----------------------------------|-----|-----|------|
| P1: 2,1 | Positive amplifier DC rail supply | +45 | +75 | Vdc |
| P1: 2,3 | Negative amplifier DC rail supply | -75 | -45 | Vdc |

Table 7: Absolute maximum ratings, power supply section

7.2 Auxiliary Supply Section

| Pin | Parameter | MIN | MAX | Unit |
|----------------|---------------------------------------|------|------|------|
| P6: 1,2 | Positive analog control supply (DVDD) | +4.5 | +5.5 | Vdc |
| P6: 1,4 | Negative analog control supply (DVSS) | -4.5 | -5.5 | Vdc |
| P6: 1,3 | Positive analog supply (VDD) | 7 | 17 | Vdc |
| P6: 1,5 | Negative analog supply (VSS) | -7 | -17 | Vdc |
| P6: 7 to P1: 1 | Vdrive supply (referenced to VS) | +12 | +17 | Vdc |

Table 8: Absolute maximum ratings, auxiliary supplies

7.3 Control pin section P7

| Pin | Parameter | MIN | MAX | Unit |
|----------------|------------------------------|------|-----|------|
| 8 BTLselect | Voltage range on control pin | -0.3 | +20 | Vdc |
| 10 AmpDisable | Voltage range on control pin | -0.3 | +20 | Vdc |
| 13 ReduceClip+ | Voltage range on control pin | 0 | 5 | Vdc |

Table 9: Absolute maximum ratings, control pin section

7.4 Amplifier Signal Input Section

| Pin | Parameter | Value | Unit |
|------------------------------------|---|-------|----------------|
| P3: 4, 5 4, 6 P3: 1, 2 1, 3 | Maximum voltage range on audio input pins | ± 5 | V _p |

Table 10: Absolute maximum ratings, input section

7.5 Output Section

| Pin | Parameter | Value | Unit |
|--------------------------------------|---|-------|------|
| P4: (1+2), (3+4) P5: (1+2), (3+4) | Minimum amplifier load resistance SE | 3.5 | Ω |
| | Maximum current draw from amplifier output | 20 | A |
| P7: 3,9,11,12,15,16 | Maximum amplifier pure capacitive load | 330 | nF |
| | Maximum current draw from basic control connector | 20 | mA |

Table 11: Absolute maximum ratings, output section

8. Electrical Specifications

Unless otherwise specified:

- $f = 1 \text{ kHz}$, $T_a = 25 \text{ }^\circ\text{C}$, $R_L = 4\Omega$, $V_D/V_S = \pm 69\text{V}$, $V_{DD}/V_{SS} = \pm 12\text{V}$, $V_{drive} = V_S + 12$.
- Audio Precision AUX0025 passive class-D filter and AES17 20 kHz 7th order measurement filter.
- ICEpower400A2 mounted on standoffs horizontal on plain surface, no additional heatsink or fan.

8.1 General

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|----------|---|---|-----|------------|---------|----------------|
| f_{sw} | Switching frequency | Idle | 450 | 500 | 550 | kHz |
| f_{sw} | Switching frequency range | Idle to full scale | 150 | | 560 | kHz |
| | V_{mon1} , V_{mon2} output voltage range | Idle to 1% THD+N Output power (56.6Vp@400W,4 Ω) | 0 | | ± 5 | V _p |
| | Voltage monitor gain, speaker output to V_{mon} outputs | $\pm 69 V_D/V_S$ | | ± 0.07 | | - |
| | Voltage monitor frequency response | $f = 20 \text{ Hz} - 20 \text{ kHz}$ | | ± 0.1 | | dB |
| | Voltage monitor phase response | $f = 20 \text{ Hz} - 20 \text{ kHz}$ | | ± 0.15 | | Deg |
| | Monitor output impedance | | | 100 | | Ω |
| | Monitor output impedance, ground sense wire | | | 100 | | Ω |

Table 12: Electrical specifications

8.2 Power specification

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-------------|---|---|------------|---|------------|------|
| V_D | Normal operating DC supply voltage | | +45 | +69 | +71 | V |
| V_S | Normal operating DC supply voltage | | -71 | -69 | -45 | V |
| VDD | Normal operating pos. analog supply | | +11 | +12 | +14 | V |
| VSS | Normal operating neg. analog supply | | -14 | -12 | -11 | V |
| V_{drive} | Normal operating drive analog supply | | $V_S + 12$ | $V_S + 15$ | $V_S + 17$ | V |
| DVDD | Normal operating pos. analog supply | | 4,5 | 5 | 5,5 | V |
| DVSS | Normal operating neg. analog supply | | -4,5 | -5 | -5,5 | V |
| t_{Pmax} | Duration of power burst at full power, one channel driven | $P_o = 400 \text{ W}$ | | 95 | | S |
| t_{Pmax} | Duration of power burst at full power, both channels driven | $P_o = 2 \times 400 \text{ W}$ | | 50 | | S |
| P_{o-con} | Continuous output power without thermal shutdown, one channel driven | THD+N < 1 % | | 85 | | W |
| P_{o-con} | Continuous combined output power without thermal shutdown, both channels driven ¹⁾ | THD+N < 1 % | | 90 | | W |
| I_q | Idle current consumption | V_D V_S VDD VSS V_{drive} DVDD DVSS | | 26 26 86 70 100 85 70 | | mA |
| P_q | Total idle power consumption | | | 6.7 | | W |

| | | | | | | |
|-----------------------|---|---|--|-------------------------------------|--|----|
| I _{disabled} | Disabled current consumption | VD VS VDD VSS V _{drive} DVDD DVSS | | 3 3 28 12 9 27 11 | | mA |
| P _{disabled} | Disabled power consumption | | | 1.0 | | W |
| η | Module power efficiency both channels driven | P _o = 2x400W, 4 Ω P _o = 2x200W, 4 Ω P _o = 2x100W, 4 Ω P _o = 2x50W, 4 Ω | | 91 89 87 83 | | % |

Table 13: Power specifications

¹⁾The continuous combined output power is the sum of the power of the driven channels. This available output power can be distributed evenly or asymmetrically across the channels.

8.3 Audio

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------------------|--|--------------------------------------|-----|------------|-----|------|
| P _o | Output power @ 1 % THD+N f = 1 kHz, 1ch driven f = 1 kHz, 2ch driven | R _L = 4 Ω | | 440 410 | | W |
| P _o | Output power @ 10 % THD+N f = 1 kHz, 2ch driven | R _L = 4 Ω | | 500 | | W |
| P _o | Output power @ 1 % THD+N 20 Hz < f < 20 kHz, 1ch driven 20 Hz < f < 20 kHz, 2ch driven | R _L = 4 Ω | | 425 400 | | W |
| P _o | Output power @ 1 % THD+N 20 Hz < f < 20 kHz, 1ch driven 20 Hz < f < 20 kHz, 2ch driven | R _L = 8 Ω | | 220 205 | | W |
| P _{o_BTL} | Output power BTL @ 1 % THD+N f = 1 kHz | R _L = 8 Ω | | 835 | | W |
| P _{o_BTL} | Output power BTL @ 1 % THD+N 20 Hz < f < 20 kHz | R _L = 8 Ω | | 815 | | W |
| THD+N | THD+N in 4 Ω SE | f = 100 Hz, P _o = 10 W | | 0.001 | | % |
| THD+N | THD+N in 8 Ω BTL | f = 100 Hz, P _o = 10 W | | 0.0008 | | % |

| | | | | | | |
|-------------------|--|--|-----|--------------|----------|---------------|
| N | Output referenced idle noise (SE) 20 Hz < f < 20 kHz | A-weighted Unweighted | | 34 45 | | μV |
| N | Output referenced idle noise (BTL) 20 Hz < f < 20 kHz | A-weighted Unweighted | | 48 64 | | μV |
| A_v | Nominal Voltage Gain (SE) | $f = 1 \text{ kHz}, P_o = 1 \text{ W}$ | | 29.4 | | dB |
| A_v | Nominal Voltage Gain (BTL) ¹⁾ | $f = 1 \text{ kHz}, P_o = 1 \text{ W}$ | | 35.4 | | dB |
| f | Frequency response (SE) 20 Hz < f < 20 kHz | $R_L = 4 \Omega - \text{infinity } \Omega$ $f_{\text{ref}} = 1 \text{ kHz},$ $P_o = 1 \text{ W}$ | | +0.0 -0.5 | | dB |
| f | Frequency response (BTL) 20 Hz < f < 20 kHz | $R_L = 8 \Omega - \text{infinity } \Omega$ $f_{\text{ref}} = 1 \text{ kHz},$ $P_o = 1 \text{ W}$ | | +0.0 -0.5 | | dB |
| f_{U_SE} | Upper bandwidth limit (-3 dB) (SE) | $R_L = 4 \Omega, P_o = 1 \text{ W}$ | | 70 | | kHz |
| f_{U_BTL} | Upper bandwidth limit (-3 dB) (BTL) | $R_L = 8 \Omega, P_o = 1 \text{ W}$ | | 80 | | kHz |
| f_L | Lower bandwidth (-3dB) | $R_L = \text{all loads},$ $P_o = 10 \text{ W},$ no measurement filters | | 3 | | Hz |
| f_{L_power} | Lower bandwidth at nominal power | $R_L = 4 \Omega,$ $P_o = 400 \text{ W},$ no measurement filters | | 20 | | Hz |
| Z_{in_signal} | Input impedance, Signal IN+ and IN- | $f = 1 \text{ kHz}$ | | 38 | | $k\Omega$ |
| Z_o | Abs. output impedance | $f = 1 \text{ kHz}$ | | 9 | | $m\Omega$ |
| R_L | Load impedance range 2-channel mode | | 3.5 | 4 | ∞ | Ω |
| R_L | Load impedance range BTL mode | | 7 | 8 | ∞ | Ω |
| $V_{O_max_SE}$ | Maximum output voltage | $R_L = 4 \Omega$ | | 59 | | Vp |
| $V_{O_max_BTL}$ | Maximum output voltage | $R_L = 8 \Omega$ | | 116 | | Vp |
| C_{load} | Capacitive load | | | | 330 | nF |
| DNR | Dynamic range SE | A-weighted 400 W @ 4 Ω | | 121.5 | | dB |
| DNR | Dynamic range BTL | A-weighted 800 W @ 8 Ω | | 124.5 | | dB |

Table 14: General audio specifications

¹⁾With configuration shown in Figure 28

8.3.1 Asymmetrical Loading

It is also possible to load one channel with for example 4 Ω or 3.5 Ω and the other channel with 8 Ω . This can be used to provide power to a low/midrange driver while still having enough power to drive a high frequency driver.

8.4 Control and Status

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---------------------------|--|---------------------------------|-----|------|-----|------|
| V _{control} | Control input voltage range | AmpDisable, BTL select | 0 | | 20 | V |
| | | Reduce Clip+ | 0 | | 5 | |
| V _{control_low} | Control input low signal | | | | 0.8 | V |
| V _{control_high} | Control input high signal | | 3 | | | V |
| Z _{control} | Control input impedance | Internal pull down | | 50 | | k Ω |
| V _{status} | Status output voltage range | Open drain, external pull up | 0 | | 5 | V |
| V _{status_low} | Status output low | I _{out} = 1mA | | 0.5 | | V |
| V _{status_high} | Status output high ¹⁾ | I _{out} = 1mA | | DVDD | | V |
| I _{status} | Status output sink current | | 0 | | 20 | mA |
| Z _{status} | Status output series impedance | | | 240 | | |
| T _{heatsink} | Heatsink temperature when Amplifier outputs start clipping and activates Clip signal CH1/CH2 outputs | 2 x 100W | | ~87 | | °C |
| T _{heatsink} | Heatsink temperature when Amplifier outputs start clipping and activates Clip signal CH1/CH2 outputs | 2 x 75W | | ~92 | | °C |
| T _{heatsink} | Heatsink temperature when Amplifier outputs start clipping and activates Clip signal CH1/CH2 outputs | 2 x 50W | | ~96 | | °C |

Table 15: Control and Status specifications

¹⁾If pull-up resistor connected to DVDD

8.5 Timing

For detailed description of the below listed timing values, please consult Section 12 in this datasheet.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-----------------------------------|--|------------------------------------|-----|-----|-----|------|
| t _{Supply-Audio-set} | Time from all supplies ¹⁾ are good to amplifier output starts switching | P _o = 2 x 150W / 8 Ω | | 415 | | ms |
| t _{Supply-Audio-hold} | Supply input – audio output hold time | P _o = 2 x 19W / 8 Ω | | 130 | | ms |
| t _{Amp-Disable-set} | Time from AmpDisable is pulled High (active) to amplifier output is disabled | P _o = 2 x 0W / 8 Ω | | 530 | | ms |
| t _{Amp-Enable-release} | Time from AmpDisable is pulled low (not active) to amplifier output is enabled | P _o = 2 x 150W / 8 Ω | | 415 | | ms |
| t _{Amp-Protect-recovery} | Amplifier Protect Recovery | | | 9 | | s |
| t _{clip-out} | Clip indication pulse duration | | | 1 | | ms |

Table 16: Timing specifications

¹⁾ VD/VS, VDD/VSS then Vdrive

9. Mechanical Specification

9.1 Dimensions

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|--------|---------------------------------|--------------------------------------|-----|-----|-----|------|
| L | Module length | | | 100 | | mm |
| W | Module width | | | 60 | | mm |
| H | Module height | | | | 35 | mm |
| Mass | Weight | | | 133 | | g |
| H | Mounting hole depth Heatsink | M3 threads on heatsink | | 4.0 | 20 | mm |
| T | Mounting torque | M3 threads on mounting base plate | | 0.5 | | Nm |

Table 17: Mechanical dimensions

9.2 3D-View

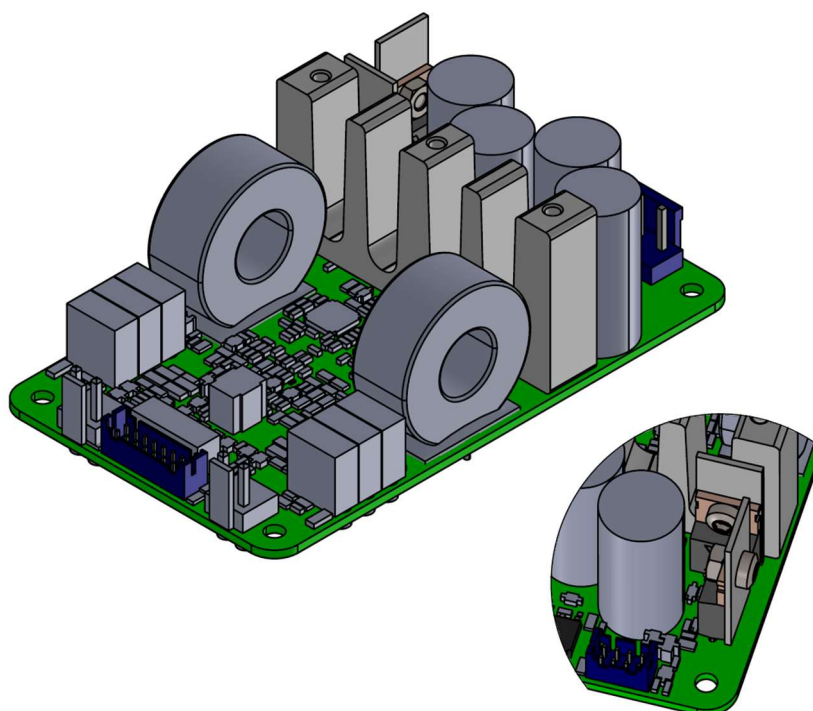


Figure 3: ICEpower400A2 D3-View

9.3 Mounting holes

The ICEpower400A2 module is designed for flexible mounting either on bottom side spacers or by the top side heatsink for easy mechanical interface to external heatsink for even higher continuous power capability.

When choosing screws for mounting, the depth of the threaded holes must be observed as well as the specified mounting torque, both specified in Section 9.1

9.3.1 Mounting on bottom side Spacers

The module is mounted by means of 3.5 mm holes in the board. The holes are indicated in Figure 4

12 mm spacers are recommended for mounting on the bottom side in order to ensure good ventilation around the module. To ensure proper safety a clearance of 8mm between module and chassis is necessary.

Drill Pattern (all dimensions are in mm):

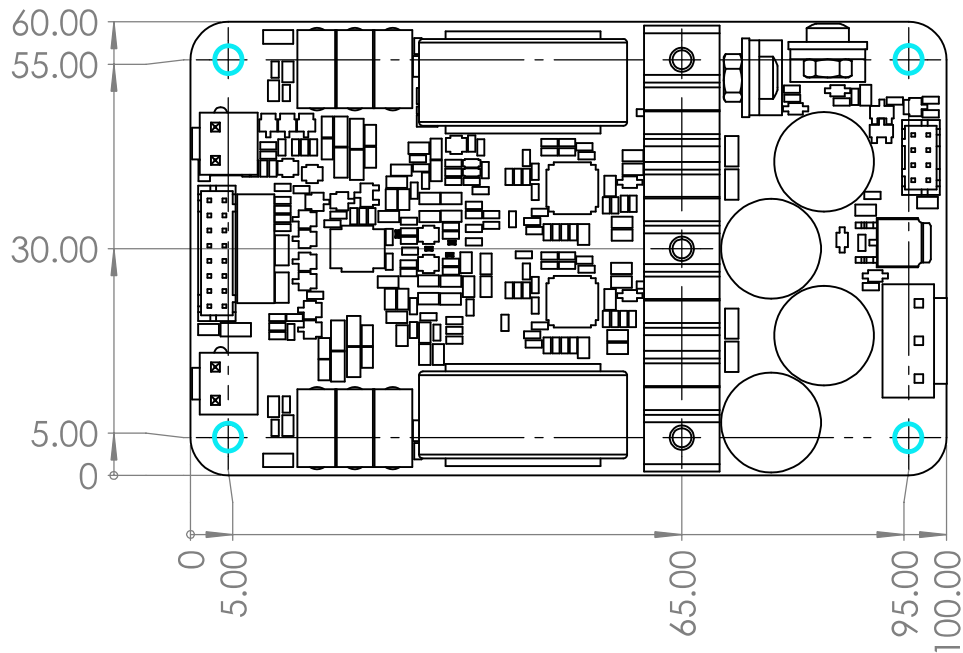


Figure 4: ICEpower400A2 Top view bottom side spacers mounting holes.

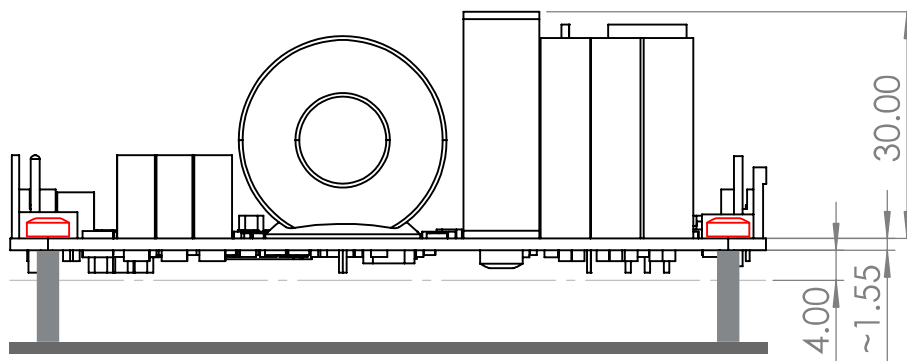


Figure 5: ICEpower400A2 Side view bottom side spacers mounting example with 12 mm spacers.

9.3.2 Mounting on top side Heatsink

The module should not be mounted solely by the top side heatsink. Use 30 mm spacers for support in the positions marked in Figure 6 with cyan circles. Use bolts for support in the positions marked with cyan squares. Electrically conductive spacers must be used to comply with the EMC regulations.

Remember to ensure good airflow and ventilation above the ICEpower400A2 module.

Finally, thermal conductive compound can be used in the mechanical interface between top side heatsink and additional chassis/heatsink if required. Please follow the instructions provided by the thermal compound manufacturer as incorrect use can result in non-optimal performance.

Drill Pattern:

All dimensions are in mm.

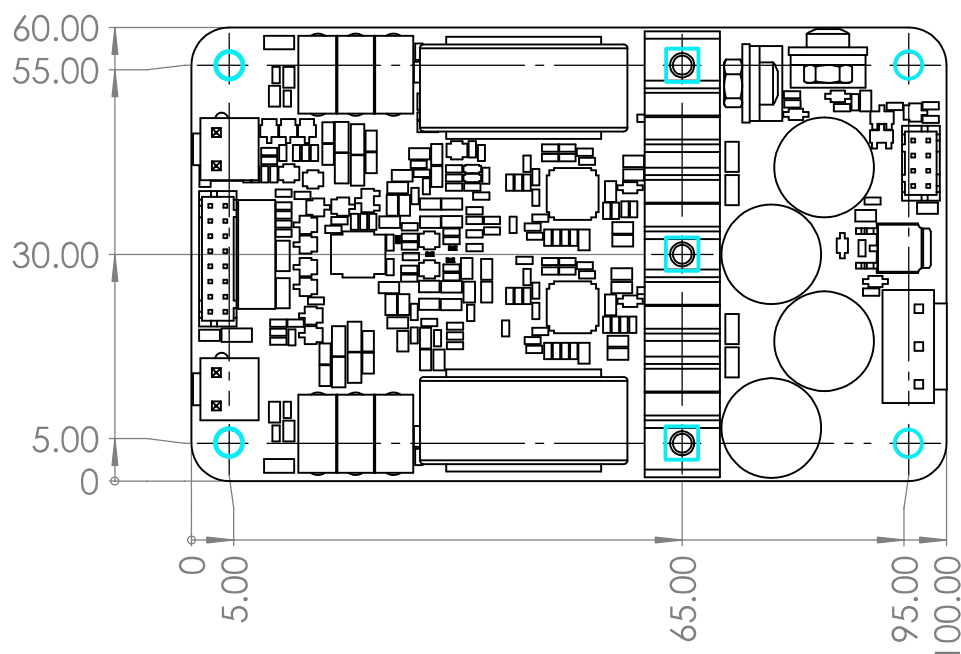


Figure 6: ICEpower400A2 Top view Heatsink mounting holes.

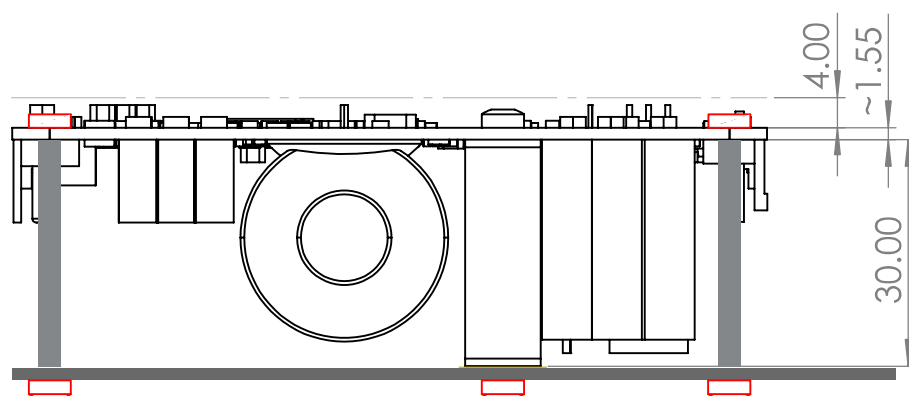


Figure 7: ICEpower400A2 Side view Heatsink mounting example with 30 mm spacers.

9.4 Environmental Specifications

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|------------------------|--------------------------------|---|-----|-----|------------------|-------|
| T _{operating} | Ambient temperature, operating | End-customer use cases | -10 | | 55 ¹⁾ | °C |
| T _{storage} | Ambient temperature, storage | End-customer use cases | -40 | | 70 | °C |
| T _{shelf} | Ambient temperature, shelf | Storage before goods sold to end-customer | 0 | | 60 | °C |
| RH | Relative humidity | Non-condensing Operating and storage | | | 85 | % |
| | Altitude, operating | | | | 2000 | m |

Table 18: Environment specifications

¹⁾For safety test at 55 °C ambient with 1/8 power, the module might require additional cooling in terms of forced air with a fan or a larger heatsink.

10. Typical Performance Characteristics SE

Unless otherwise specified:

- One channel driven, all channels enabled.
- $f = 1 \text{ kHz}$, $T_a = 25 \text{ }^\circ\text{C}$, $R_L = 4\Omega$, $V_D/V_S = \pm 69\text{V}$, $V_{DD}/V_{SS} = \pm 12\text{V}$, $V_{drive} = V_S + 12\text{V}$.
- Audio Precision AUX0025 passive class-D filter and AES17 20 kHz 7th order measurement filter.
- ICEpower400A2 mounted on standoffs horizontal on plain surface, no additional heatsink or fan.

10.1 Frequency Response

Conditions: Measurement bandwidth 500 kHz, $V_o = 2\text{V}_{rms}$ ($1\text{W}_{rms}@4\Omega$)

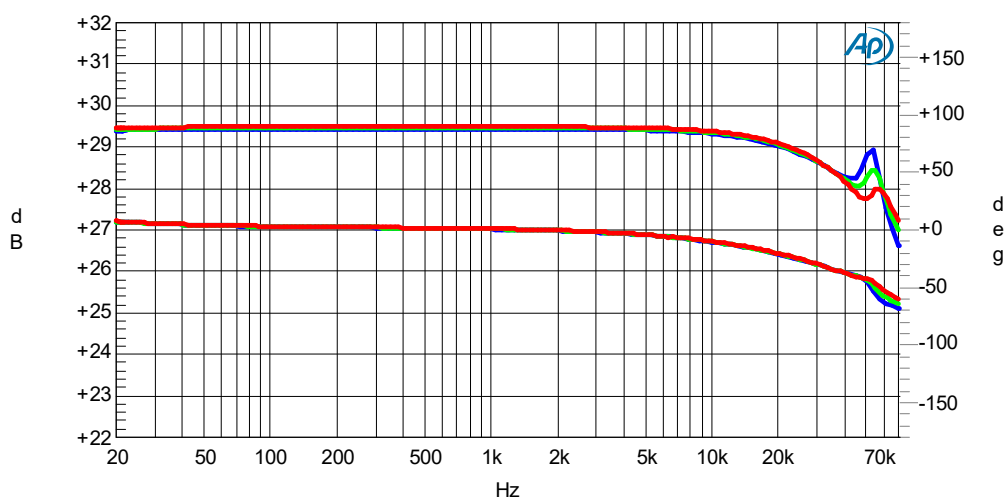


Figure 8: Frequency response in 4 Ω (blue), 8 Ω (green) and open load (red). Top – amplitude. Bottom – phase

10.2 Total Harmonic Distortion + Noise

Conditions: The frequency 6.67 kHz corresponds to the worst-case scenario where both 2nd and 3rd harmonics are within the audio band. 100Hz (blue), 1kHz (green) and 6.67kHz (red).

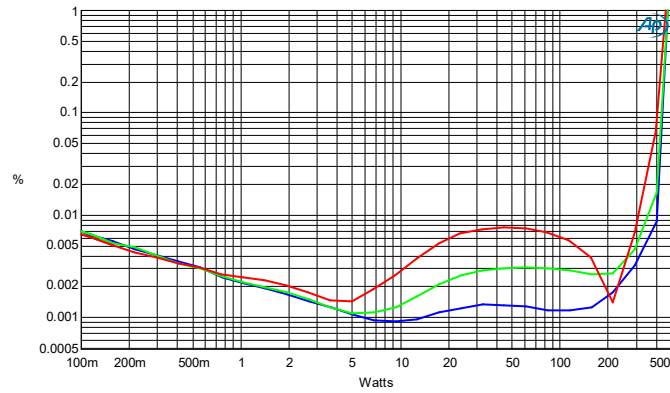


Figure 9: THD+N vs. Po @ 100Hz, 1kHz, 6.67kHz, RL=4Ω

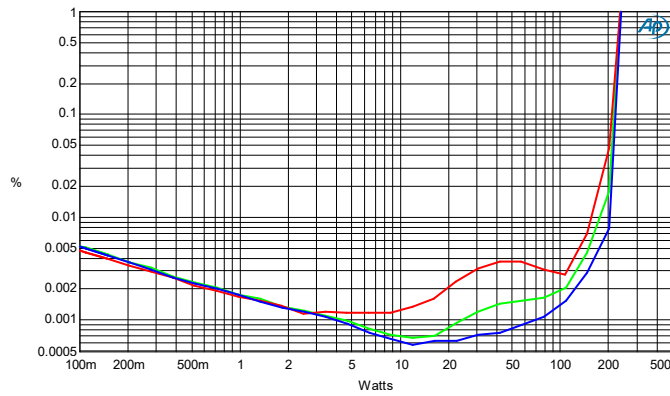


Figure 10: THD+N vs. Po @ 100Hz, 1kHz, 6.67kHz, RL=8Ω

10.3 Idle Noise

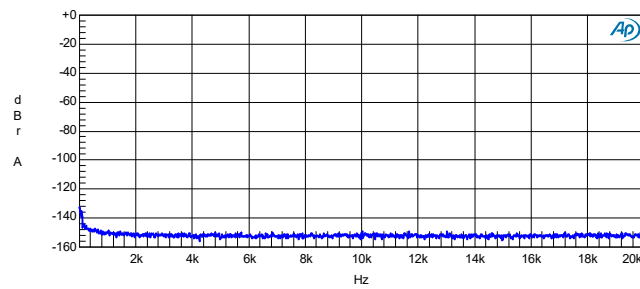


Figure 11: Idle noise (64K FFT), RL = 4 Ω (Relative to 400 W)

10.4 Intermodulation Distortion

Conditions: The selected CCIF signal is equal amplitude 18 kHz and 19 kHz. The difference tone at 1 kHz is detected. Dual tone intermodulation spectrum, 0 – 20 kHz @ 0 dB = 400 W / 4 Ω

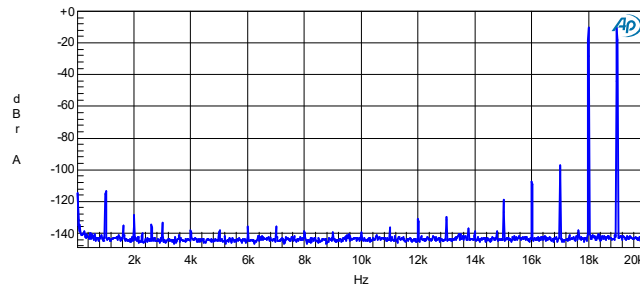


Figure 12: CCIF vs. P_0 , $R_L=4 \Omega$, $f_1=18 \text{ kHz}$, $f_2=19 \text{ kHz}$

10.5 Crosstalk

Conditions: $P_0=50 \text{ W}$, $R_L=4 \Omega$ and wide bandwidth measurement.

Both channels active/enabled during all measurements, only input signal is switched.

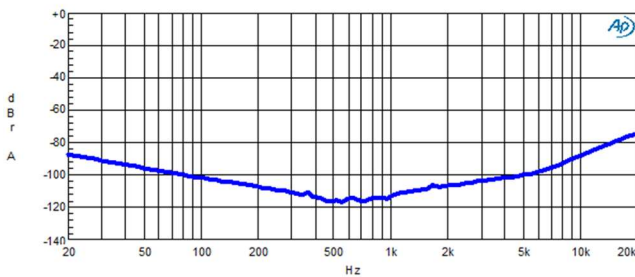


Figure 13: Cross talk, Ch1 vs Ch2. $1/8 P_{max} = 50 \text{ W} @ 4 \Omega$

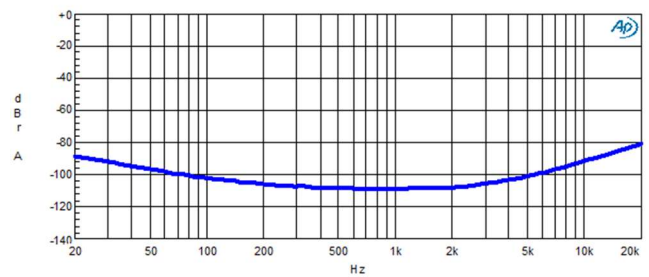


Figure 14: Cross talk, Ch2 vs Ch1. $1/8 P_{max} = 50 \text{ W} @ 4 \Omega$

10.6 Output Impedance

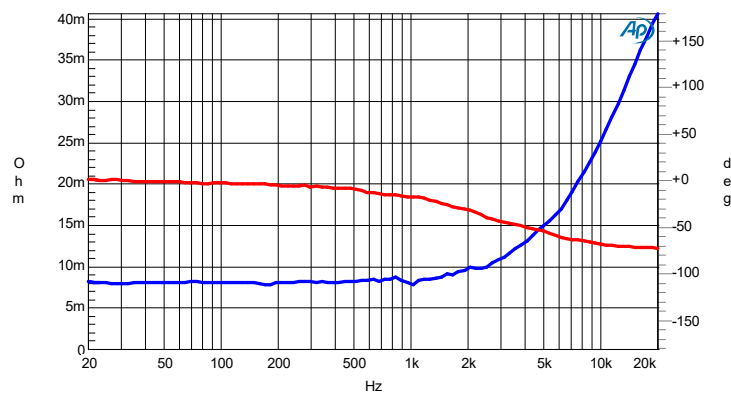


Figure 15: Output Impedance Amplitude (Blue), and Phase (Red)

10.7 Damping Factor

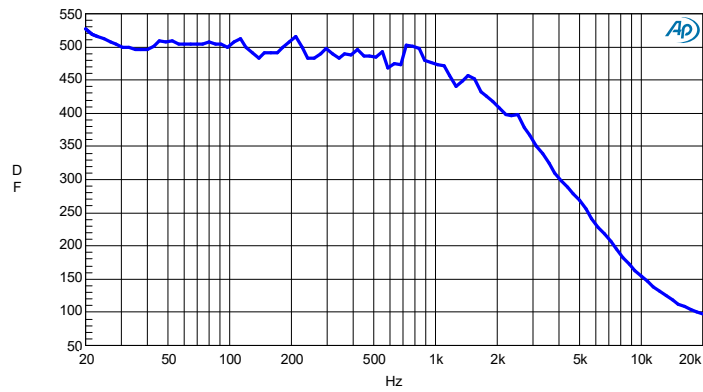


Figure 16: Damping factor in 4 Ω

10.8 Output Power vs. Rail Voltage supplies

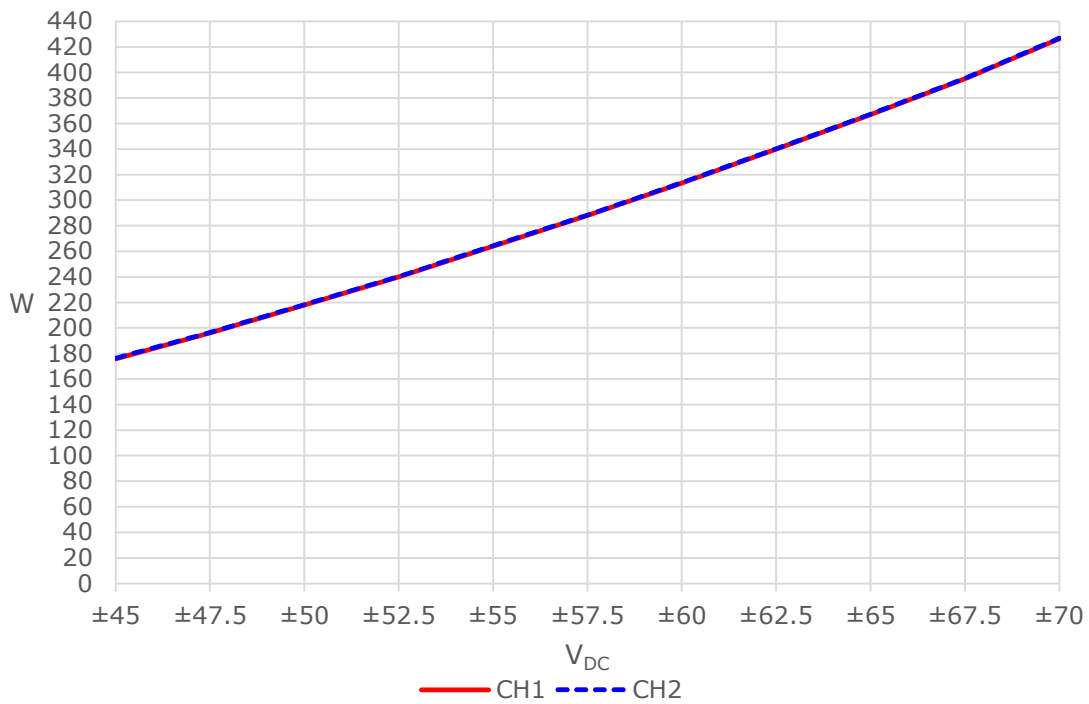


Figure 17: Output power @ 4 Ω and 1 % THD+N vs. rail Voltage, 2 ch driven, CH1 (red) CH2 (blue-dashed), 1kHz

10.9 Power Efficiency

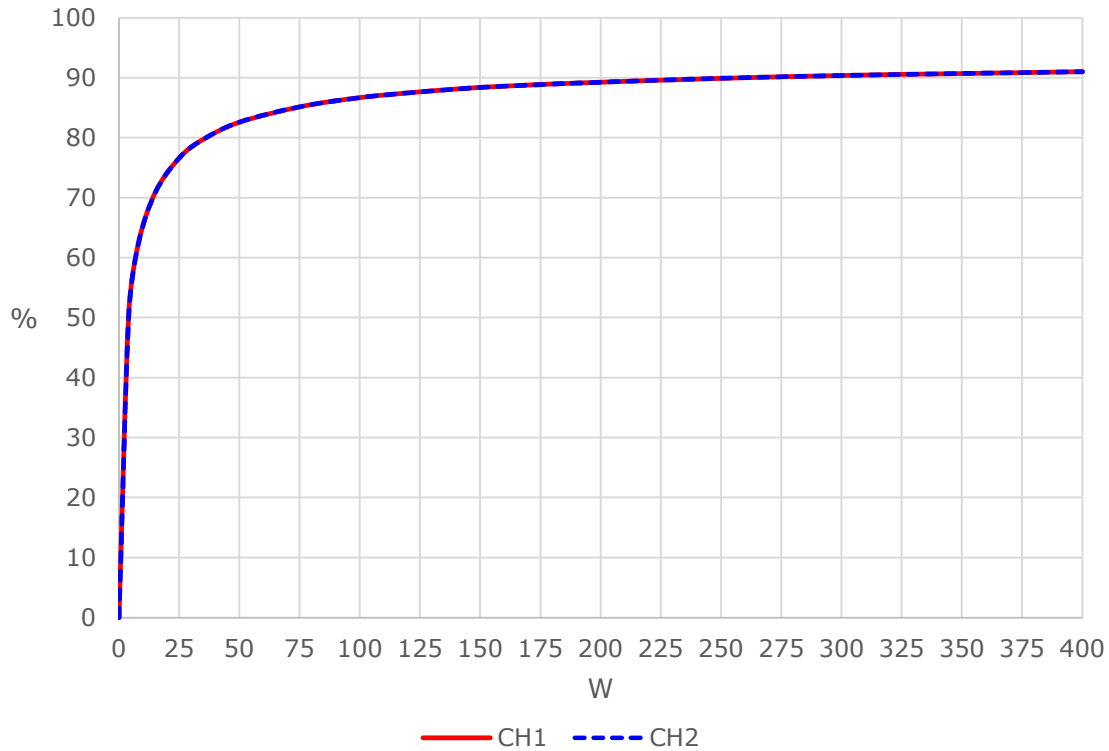


Figure 18: Power efficiency vs. output power per channel @ 4 Ω , 2 ch driven, CH1 (red) CH2 (blue-dashed)

10.10 Dissipated Power

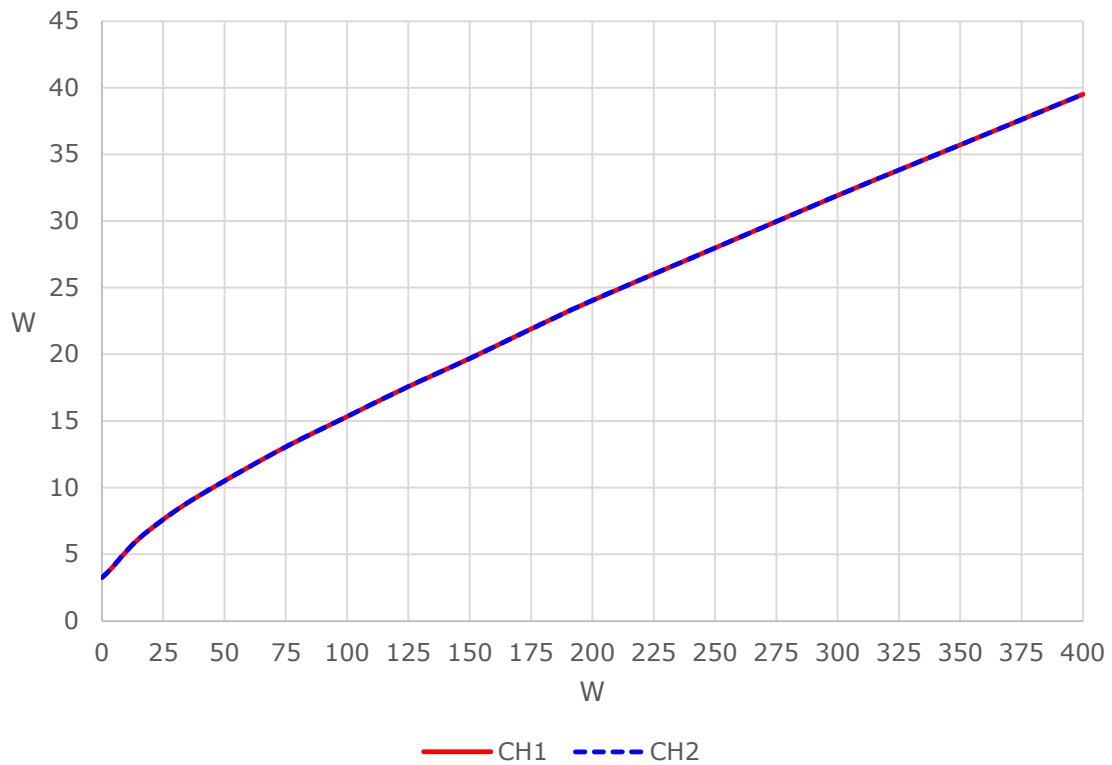


Figure 19: Dissipated power per channel vs. output power per channel @ 4 Ω , 2 CH driven, CH1 (red) CH2 (blue-dashed)

11. Typical Performance Characteristics BTL

Unless otherwise specified:

- One channel driven, all channels enabled.
- $f = 1 \text{ kHz}$, $T_a = 25 \text{ }^\circ\text{C}$, $R_L = 8\Omega$, $V_D/V_S = \pm 69\text{V}$, $V_{DD}/V_{SS} = \pm 12\text{V}$, $V_{drive} = V_S + 12$.
- Audio Precision AUX0025 passive class-D filter and AES17 20 kHz 7th order measurement filter.
- ICEpower400A2 mounted on standoffs horizontal on plain surface, no additional heatsink or fan.

11.1 Frequency Response

Conditions: Measurement bandwidth 500 kHz, $V_o = 2.83\text{V}_{rms}$ ($1\text{W}_{rms}@8\Omega$)

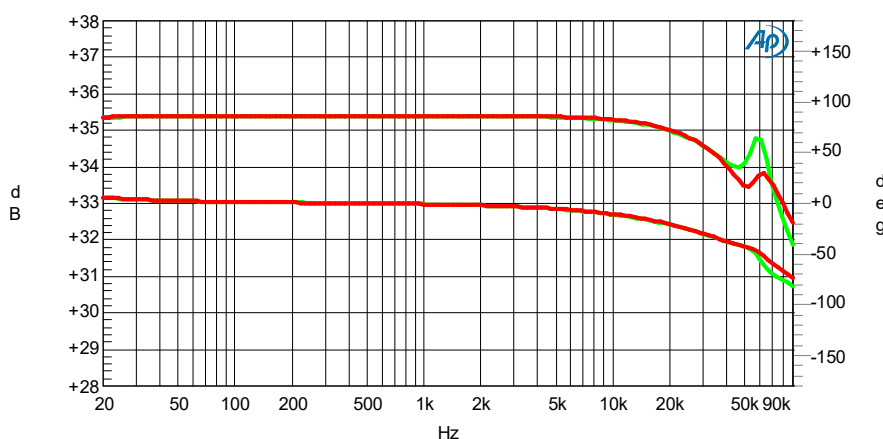


Figure 20: Frequency response in 8 Ω (green) and open load (red). Top – amplitude. Bottom – phase

11.2 Total Harmonic Distortion + Noise

Conditions: The frequency 6.67 kHz corresponds to the worst-case scenario where both 2nd and 3rd harmonics are within the audio band. 100Hz (blue), 1kHz (green) and 6.67kHz (red).

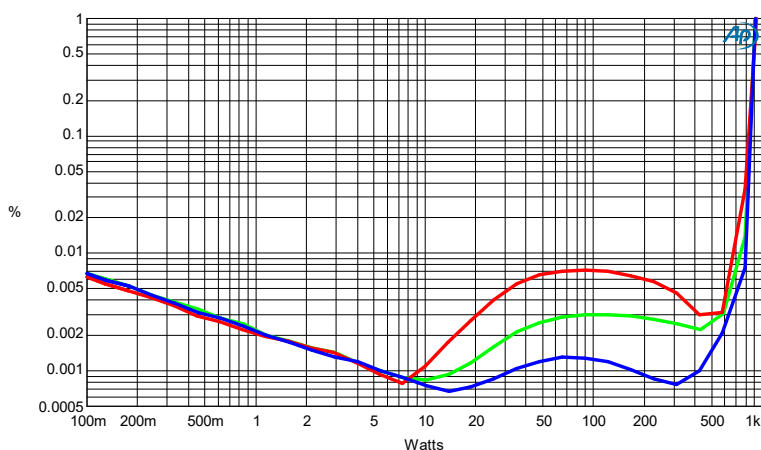


Figure 21: THD+N vs. P_o @ 100Hz, 1kHz, 6.67kHz, $R_L = 8\Omega$

11.3 Idle Noise and Low Power spectrum

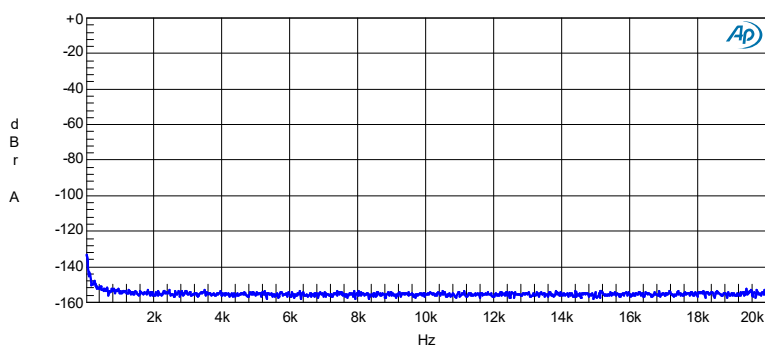


Figure 22: Idle noise (64K FFT). $R_L = 8 \Omega$ (Relative to 800 W into 8Ω)

11.4 Intermodulation Distortion

Conditions: The selected CCIF signal is equal amplitude 18 kHz and 19 kHz. The difference tone at 1 kHz is detected. Dual tone intermodulation spectrum, 0 – 20 kHz @ 0 dB = 800 W / 8Ω

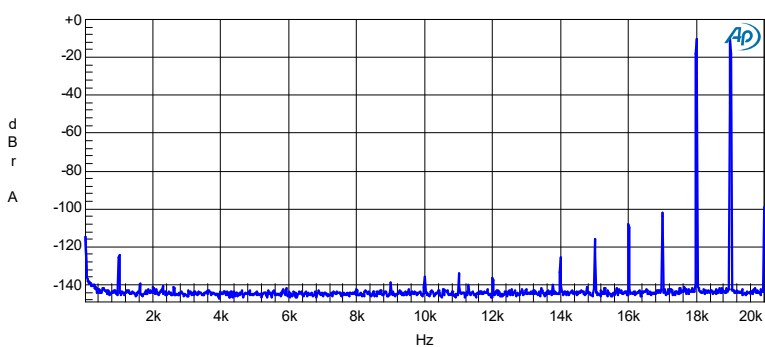


Figure 23: CCIF vs. P_o , $R_L=8 \Omega$, $f_1=18 \text{ kHz}$, $f_2=19 \text{ kHz}$

11.5 Output Impedance

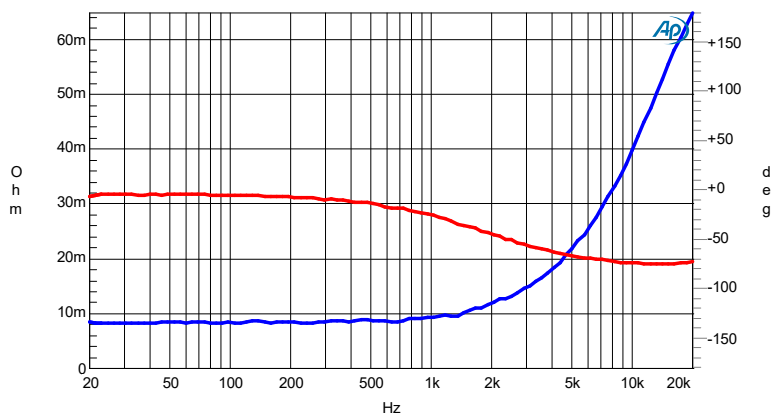


Figure 24: Output Impedance BTL (Blue), and Phase (Red)

11.6 Damping Factor

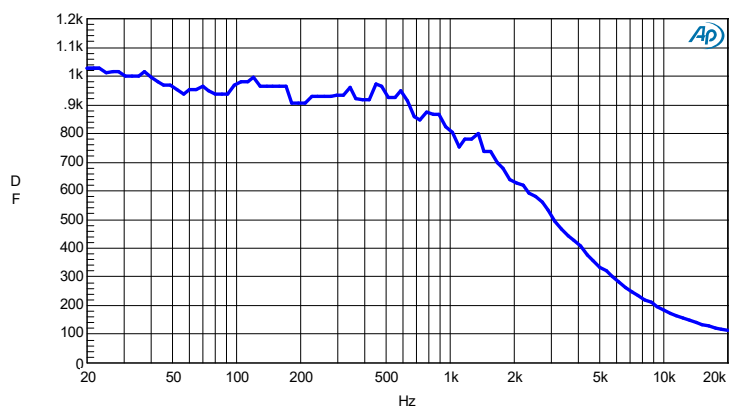


Figure 25: Damping factor in 8 Ω BTL

12. Functional Description

ICEpower400A2 will start operating when power is applied to the module and therefore no special control is needed for simple applications. For more advanced applications, a wide set of control, status and monitoring inputs and outputs are available all through a connector following the ICEpower standard interface definition.

Following ICEpower's "Music at All Times" philosophy, the module will operate under all conditions except for potentially destructive situations. At power-up, the 400A2 module performs comprehensive checks to verify operation conditions and to check for errors. If an error is detected, the module will try to reboot after a short delay. As part of the effort to keep music playing, the module monitors numerous internal parameters during operation and reacts proactively if required.

In three distinct situations, the module will initiate a progressive clipping of the audio signal to limit the loading of the module. These situations are:

- Temperature conditions close to thermal shutdown
- Excess super-sonic audio content
- Over current

Should the progressive limitation of the output power be insufficient to maintain safe operation or if a potentially destructive error should occur, the 400A2 module will shut down and automatically restart after the overload situation is removed.

In the following subsections, a description is given for all ICEpower400A2 features organized by the connector in which the corresponding input or output is located.

12.1 Audio Input

The audio inputs of the 400A2 are high impedance fully differential audio input including a non-inverting signal input, inverting signal input and a shield ground reference.

The audio inputs can be used in both a semi-balanced input configuration and in a fully balanced configuration. In semi-balanced configuration, it is recommended to connect the non-inverting input to a single ended signal source and use the inverting input as ground sense on the signal source ground reference. In both semi-balanced and in fully balanced configuration, the signal ground should be connected to ground on the front-end PCB.

To prevent ground loop related noise and hum problems, the signal ground is fitted with low value series resistors on the module i.e., the signal ground wire must not carry any additional current. The recommended connection to the audio input is shown on Figure 33 in Section 13.

The two audio signal inputs share the same connector on the 400A2 module.

12.2 Loudspeaker Outputs

The loudspeaker output of the 400A2 is an unbalanced output capable of driving complex speaker loads.

The loudspeaker output is fully overload and short circuit protected. In case of an overload or short circuit event, the module will shut down and resume operation when the overload or short circuit has been removed.

The loudspeaker output is in an unbalanced configuration, bridging of the two channels is possible.

12.3 Power Supply Input

All power lines should be connected before powering the ICEpower400A2. First VD/VS and VDD/VSS then Vdrive. After all power supplies are applied to the 400A2, the module will read the control inputs and start operating accordingly. If the module controls are left unconnected, the module will start normal operation without further action.

Important: The module should only be supplied by either DVDD/DVSS or VDD/VSS.

The power up and power down timing is shown in Figure 26 and specific timing values are available in Section 8.5

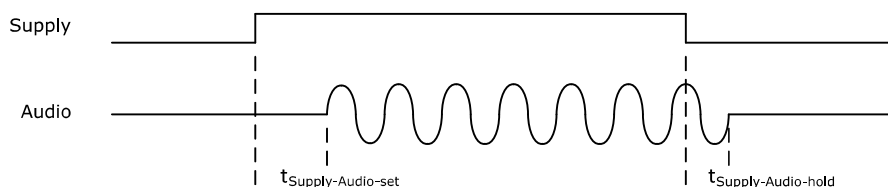


Figure 26: Power up timing after all supplies (VD, VS, and all aux supplies) are good to amplifier starts switching

12.4 Basic Control and Status

The Basic Control connector and Auxiliary Supply connector for e.g., a signal front-end PCB and the following features:

- AmpDisable
- BTLselect
- ReduceClip+
- Vmon1 and Vmon2
- Protect
- Clip1 and Clip2
- Pullupto5V
- DCerror

The recommended connection to the control input and status outputs are shown on Figure 35 and Figure 36 in Section 13.

12.4.1 AmpDisable Input

The AmpDisable input shuts down the ICEpower400A2 amplifier section when pulled high. An internal pull down ensures normal operation if the AmpDisable input is left unconnected.

This feature can be used in e.g., applications where a front-end needs time to boot a DSP based system at power up before enabling the amplifier.

Timing of the AmpDisable inputs shown in Figure 27 and specific timing values are available in Section 8.5.



Figure 27: Standby and AmpDisable timing

Advanced pop and click reduction mechanisms are built into the 400A2 leaving almost no audible artifacts when the AmpDisable input is used.

12.4.2 BTLselect input

The BTL mode synchronizes the two SE channels to avoid idle tones and to improve the performance when driving the two channels in BTL. To enable the BTL mode the BTLselect, pin 8 on connector P7, needs to be pulled high. In BTL mode invert the polarity of channel 2 relative to channel 1, as illustrated in Figure 28.

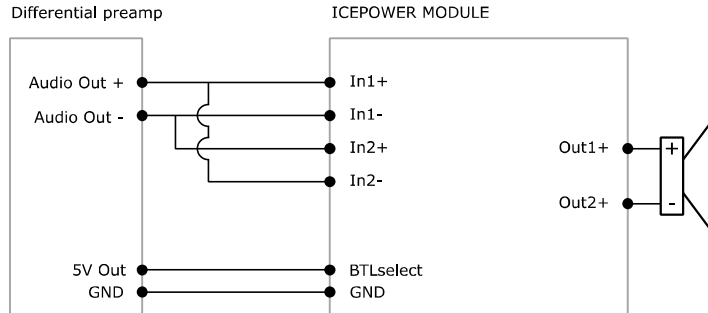


Figure 28: ICEpower400A2 BTL block diagram

The BTL output is taken between the two positive outputs, this means pin 1 on connector P4 and P5. Figure 29 indicates pins related to BTL functionality.

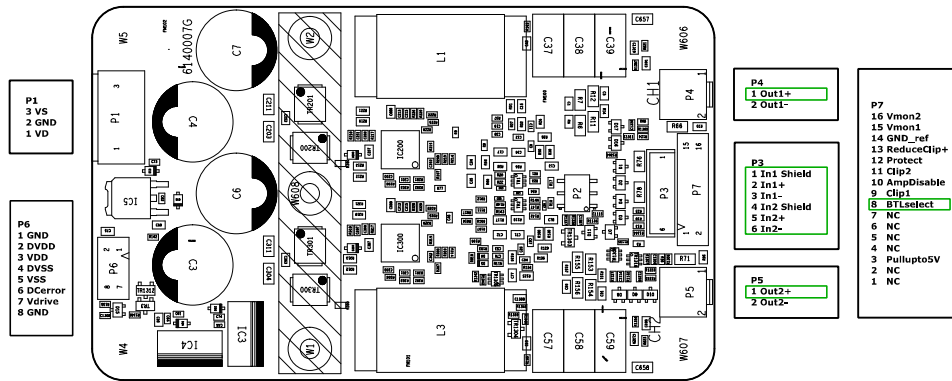


Figure 29: ICEpower400A2 connector overview in BTL mode¹⁾

¹⁾Pull up to 5V can be used to enable BTL select, for simple testing or permanent BTL configuration.

12.4.3 Reduce Clip+ input

The Reduce Clip+ input is an analog DC input used to reduce the clip level of the input buffer.

Can be used to send an analog signal to reduce the clipping level, this can reduce the maximum output power if the supply gets hot.

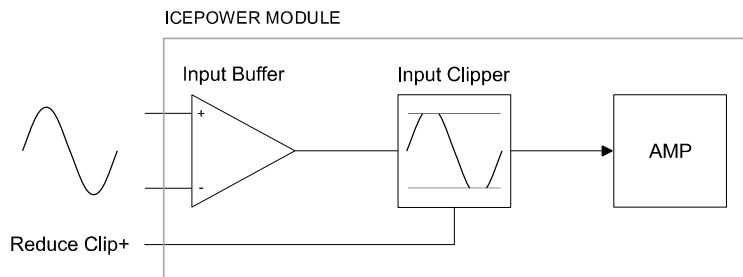


Figure 30: Clip reduce block diagram.

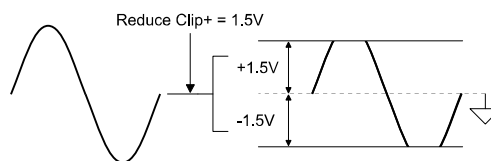


Figure 31: Example of Reduce Clip set to 1.5V

12.4.4 Vmon1 and Vmon2 output

Analog voltage divider high impedance output

Analog voltage divider connected to the output of the power stage. This serves as a high impedance output to monitor the output voltage.

12.4.5 Protect output

In case of potentially destructive overload situations, the 400A2 will shut down and resume operation after a short delay or after the overload-condition has been removed. These events are reported by a low level on the Protect output.

Events that will trigger the Protect output are:

- Severe amplifier overcurrent conditions and short circuit in the amplifier section.
- Over-temperature errors in the module.
- DC error
- Supply voltages are out of normal operating conditions
- Excess sub-sonic or super-sonic audio content

In the first two cases, the 400A2 module will resume operation shortly after the error condition has been removed. For the over-temperature case, it is also required that the module temperature is brought below the temperature reset threshold.

The Protect output is an open-drain output pulled high by external pull-up resistors. Interface schematics can be found in Section 13.3

Timing of the protection events are shown in Figure 32 and specific timing values are available in Section 8.5.

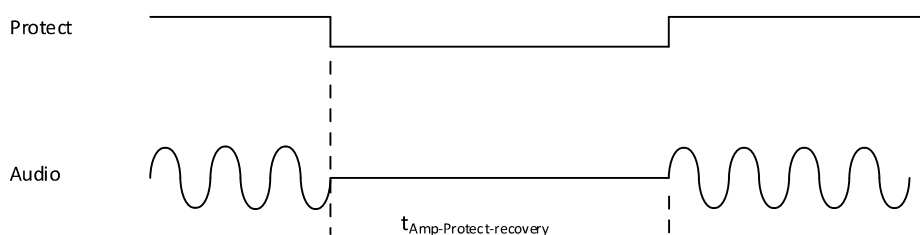


Figure 32: Amplifier Protect recovery

12.4.6 Clip1 and Clip2 output

The Clip output is a multi-purpose output indicating:

- Audio signal voltage clipping

The Clip1 and Clip2 outputs are audio signal clipping indicators, one per channel. Clipping is indicated by a low on the Clip1 and Clip2 for channel 1 and 2 respectively. The clipping outputs stay low for the full duration of clipping in the audio signal, but to make it easier to detect very short clipping event and in cases where the clip signals are directly connected to a LED, the clipping signals on Clip1 and Clip2 have a minimum duration $t_{\text{Clip-out}}$.

The Clip output is an open drain output pulled high by external pull-up resistors. Interface schematics can be found in Section 13.3

12.4.7 Pullupto5V output

Used exclusively for BTL select and LED output identification.

12.4.8 DCerror output

The DC Error is an output indicating DC on the output. The module will shut down and send a shutdown signal to the power supply.

The DC Error output is an open drain output pulled high by external pull-up resistors. Interface schematics can be found in Section 13.3

13. Interface Schematics

In the following sub-sections, proposed interface schematics are shown. These schematics should be considered an assistance to the design process, and they represent the recommended interface to the 400A2 module.

13.1 Audio Input

Generic interface for fully differential use of analog inputs.

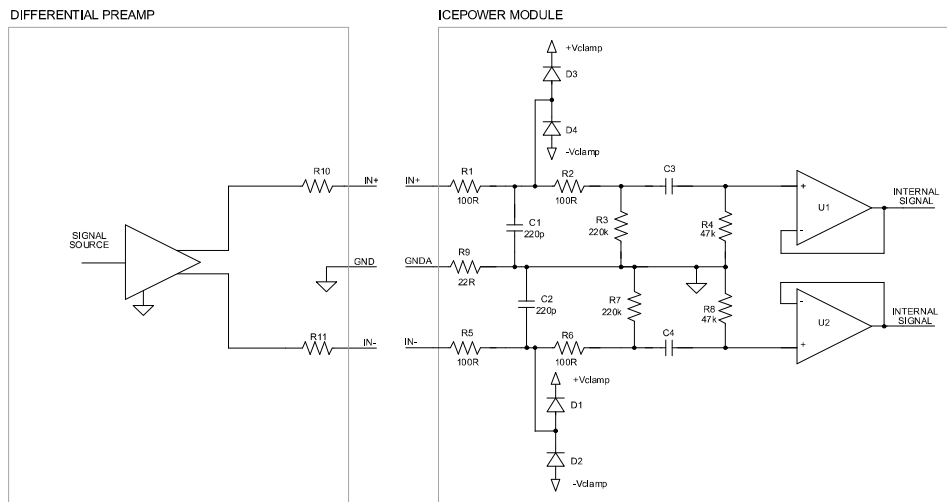


Figure 33: Fully balanced audio input interface schematics

Generic interface for semi-balanced use of the analog input.

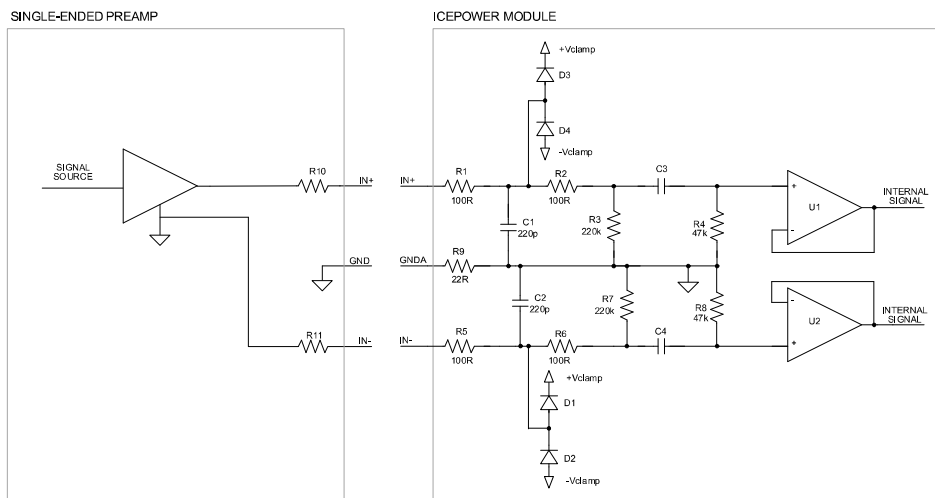


Figure 34: Semi-balanced audio input interface schematics

13.2 Control Input

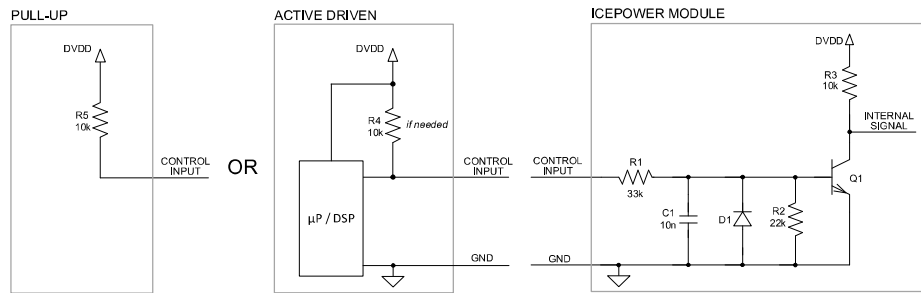


Figure 35: Recommended control input interface schematics DVDD¹⁾

¹⁾External DVDD for PULL-UP can be selected from 5V to 20V

13.3 Status Output

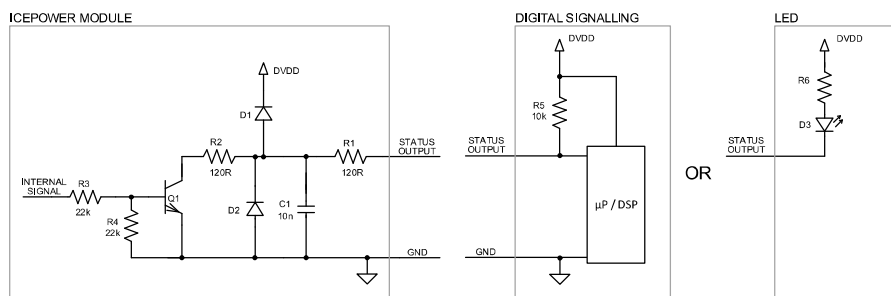


Figure 36: Recommended status output interface schematics

14. Integration Guidelines

The 400A2 module is designed with ease of integration in mind. This includes both electrical, EMC, thermal and mechanical integration. In the following sub-sections, recommendations will be given to assist the end-product design process.

14.1 Grounding Scheme

Depending on the complexity of the end-product several grounding schemes can be used. On Figure 37: Grounding scheme an example of the grounding scheme usable on the 400A2 module is shown for a simple setup including a front-end PCB and PSU.

The low value series resistor included in the signal shield connection prevents ground loops between the 400A2 module and the front-end PCB. To prevent similar ground loops between the PCBs and the chassis, it is recommended not to connect the audio input connector to the chassis but to have them grounded on the front-end PCB.

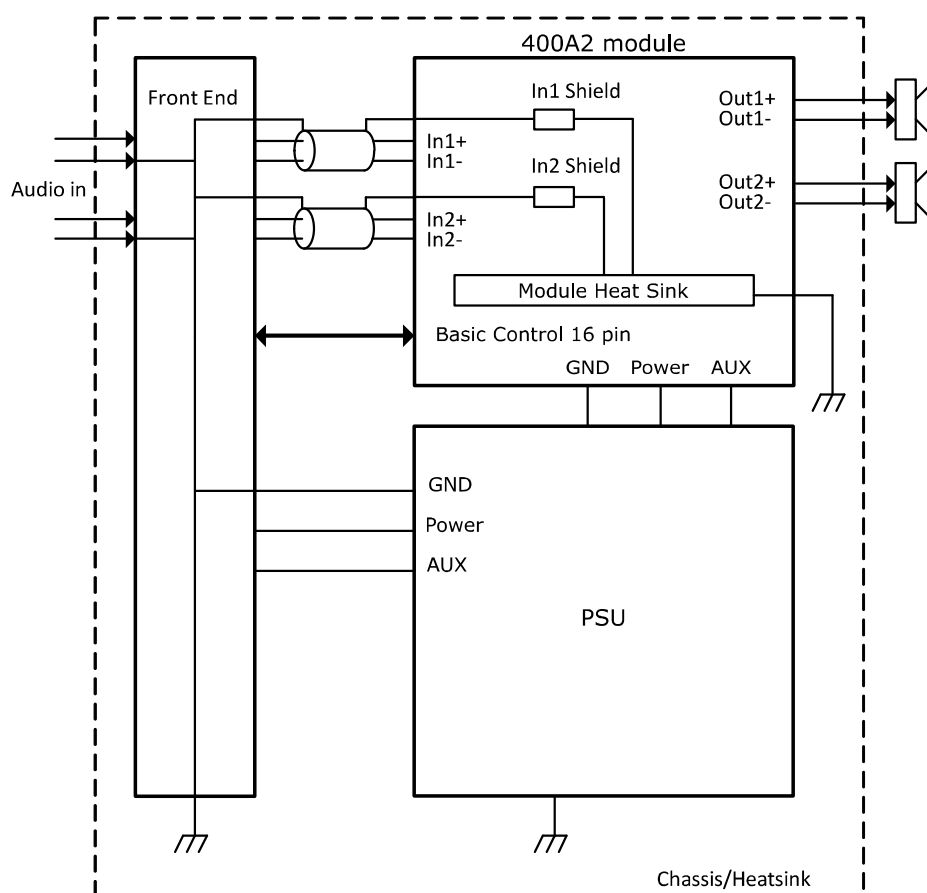


Figure 37: Grounding scheme

14.2 EMC Management

As described in Section 1, the ICEpower400A2 module is EMC pre-approved as is when mounted on a standard aluminum open back plate. However, because of the high-power switching electronics included in the module, some EMC precautions are required to ensure an EMC approvable end-product design.

- Connect the module mounting holes to the chassis as described in section 9.3 . Mounting of the module isolated from the chassis may cause increased HF radiation.

Do not use cable/wires between module and other PCBs that are longer than necessary. Avoid wire loops on the speaker output wires. Use wires closely paired side by side or if required use twisted or shielded cables.

- Do not route cables near magnetic components on the module e.g., inductors and transformers.
- Do not bundle amplifier DC rail supply wires together with other cables.
- Do not bundle speaker wires together with other cables (Figure 39).

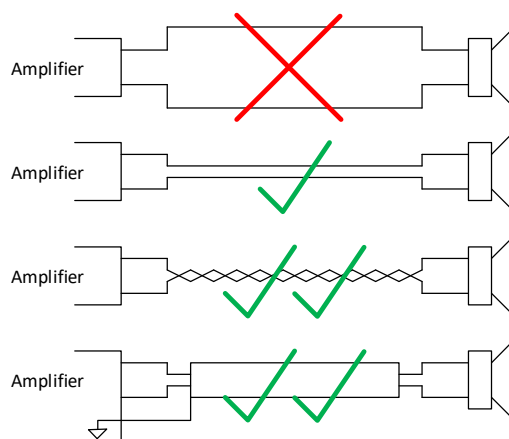


Figure 38: Speaker wire routing

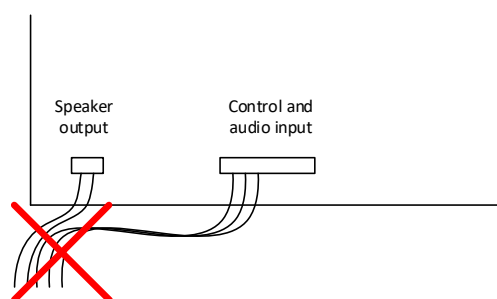


Figure 39: Wire bundling

Depending on the end-product application, additional EMC initiatives and filtering may be required to have the entire product EMC approved. The reason for this could be, among others, insufficient cable routing within the application or DSP/microprocessor based front-end systems.

To improve on EMC performance, it is often advisable to revisit the used grounding scheme and cable routing and add EMC filters on some or all the connectors on the end-product.

15. Safety and EMC Standards

ICEpower400A2 is design to comply with EMC directives and safety standards.

16. ESD Warning

ICEpower products are manufactured according to the following ESD precautions:

ANSI/ESD-S20.20-2014: Protection of Electrical and Electronic Parts, Assemblies and Equipment.

Further handling of the products should comply with the same standard.

The general warranty policy of ICEpower a/s does not cover ESD damaged products due to improper handling.

17. Ordering, Packaging and Storage

All ICEpower modules are packaged in ESD safe bubble wrap bags and cardboard boxes.

17.1 Ordering Information

| Order Codes | Description | Part Number |
|---------------|--------------------------------------|-------------|
| ICEpower400A2 | Two channel 400 W ICEpower amplifier | 8008204 |

17.2 Shipping Dimensions and Weight

| Package | Quantity | Dimensions (w × d × h) [mm] | Gross Weight [kg] |
|---------|----------|-----------------------------|-------------------|
| Carton | 24 | 390 × 290 × 230 | 4.3 |

17.3 Storage Conditions

Storage Humidity and Temperature:

Please find storage humidity and temperature information in Section 8.3, Environmental Specifications.

Stacking

A maximum of 4 cartons must be stacked on top of each other.

Pallets may not be stacked on top of each other.

18. Legal Notes

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Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labelling, can be reasonably expected to result in a significant injury to the user.

A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

19. Contact

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