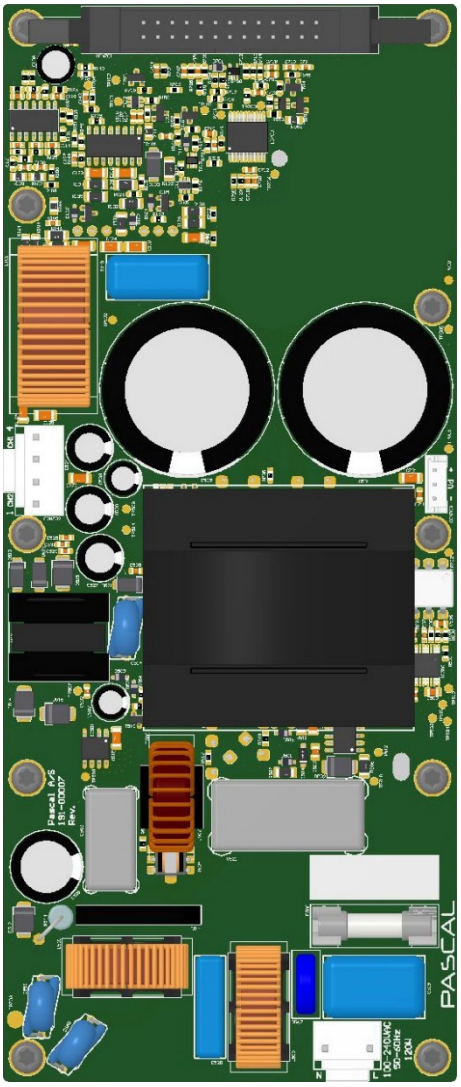
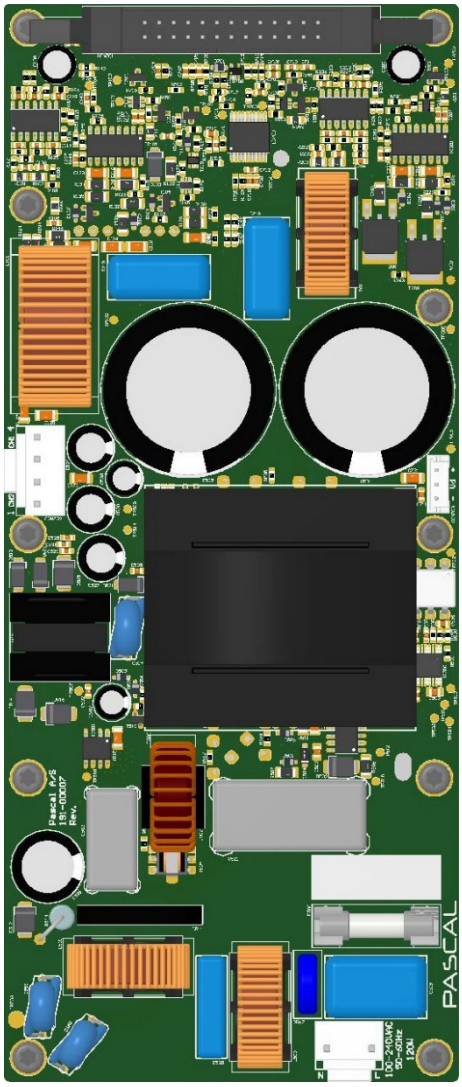
T-PRO Series

Data Sheet



T-PRO1 Amplifier Module



T-PRO2 Amplifier Module

Table of Contents

1 Features and Description

Features

- 1 x 500W (SE) + 1 x 150W (SE) amplifier channels using Pascal's UMAC™ technology for un-matched sonic performance and full power bandwidth up to 25kHz
- Universal mains regulated power supply with PFC using Pascal's UREC™ power supply technology
- Auxiliary power supply for external circuitry like DSP Front End solutions
- ErP (1275/2008/EC) & Energy Star compliant standby consumption < 0.5W
- Wake on Music ready with selectable timing
- Full protection scheme
- Ultra-compact size
- Unmatched total system efficiency
- Multiple readouts (temperature, amplifier output voltage, clip monitor, amplifier protect/mute, V_{AC})
- Safety approved and verified for EMC compliance

Product Summary

Parameter	**Typical Value**
Total Output power (1% THD+N, 1kHz @ 4Ω/8Ω)	500W + 150W
Total system efficiency (T-PRO1: 1 x 250W @ 8Ω)	89 %
Peak output current (CH1)	30 A
THD+N (1kHz @ 1W)	0.003 %
Dynamic range	121 dB(A)
Idle noise	41 µV(A)
Output resistance (1kHz)	12 mΩ
Mains input voltage	$85V_{AC}$ – $265V_{AC}$
Standby consumption	0.2 W

Description

The T-PRO series modules are 1- or 2-channel Class-D amplifiers with integrated universal mains power supply with PFC.

The 2-channel model (T-PRO2) has a high-power channel intended for LF/MF drivers and a low power channel intended for HF drivers.

They offer an ultra-compact size with an un-matched total system efficiency, to ease the integration of the T-PRO modules into any audio solution.

In addition, the T-PRO modules offer a number of readouts and controls, which allow for external DSP control of the modules. The built-in auxiliary power supply makes it easy to supply the DSP Front End.

Typical Applications

- Professional Audio Solutions
- MI Audio Solutions
- Consumer Audio Solutions
- HiFi Audio Solutions
- Self-Powered Loudspeakers
- Installation Systems

2 General specifications

2.1 Audio specifications

Electrical Characteristics @ T_a = 25°C (unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{out,max}$	Peak output voltage Ch1 & Ch2	Unloaded	-	± 70	-	V
$I_{out,peak\_Ch1(LF)}$	Peak output current		-	30	-	A
$I_{out,peak\_Ch2(HF)}$	Peak output current		-	11	-	A
$P_{o,tot}$	Total module output power[1]	230V_{AC} 120V_{AC}	-	520 470	-	W
P_o	Output power @ 1% THD+N, 1kHz[2] Ch1(LF), single channel driven R_L=8Ω	230V_{AC} 120V_{AC}	-	245 245	-	W
P_o	Output power @ 1% THD+N, 1kHz[2] Ch1(LF), single channel driven R_L=4Ω	230V_{AC} 120V_{AC}	-	500 430	-	W
P_o	Output power @ 1% THD+N, 1kHz[2] Ch2(HF), single channel driven R_L=16Ω	230V_{AC} 120V_{AC}	-	120 120	-	W
P_o	Output power @ 1% THD+N, 1kHz[2] Ch2(HF), single channel driven R_L=8Ω	230V_{AC} 120V_{AC}	-	220 220	-	W
THD+N	THD+N @ 1W, 1kHz, R_L = 8Ω[2]		-	0.003	-	%
$V_{noise\ Ch1(LF)}$	Output idle noise - Ch1(LF)	Unweighted A-weighted	-	53 41	-	μV_{RMS}
$V_{noise\ Ch2(HF)}$	Output idle noise – Ch2(HF)	Unweighted A-weighted	-	53 41	-	μV_{RMS}
$DR_{Ch1(LF)}$	Dynamic Range - Ch1(LF)	Unweighted A-weighted	-	118 121	-	dB
$DR_{Ch2(HF)}$	Dynamic Range – Ch2(HF)	Unweighted A-weighted	-	118 121	-	dB
A	Voltage gain @ 1kHz, Ch1 & Ch2	SE	-	26	-	dB
$A_{var\_Ch1(LF)}$	Frequency response variance Ch1(LF) @ 20Hz – 20kHz	Open Load 8Ω 4Ω	-	0.09 0.25 0.44	-	dB
$A_{var\_Ch1(LF)}$	Frequency response variance Ch2(HF) @ 20Hz – 20kHz	Open Load 16Ω 8Ω	-	0.20 0.27 0.36	-	dB
BW_{up}	Upper bandwidth @ -3dB Ch1(LF)	R_L = 8Ω R_L = 4Ω	-	70 60	-	kHz
BW_{up}	Upper bandwidth @ -3dB Ch2(HF)	R_L = 16Ω R_L = 8Ω	-	70 60	-	kHz

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
BW_{low}	Lower bandwidth @ -3dB Ch1 & Ch2	All loads	-	1.6	-	Hz
$R_{o\_Ch1(LF)}$	Output resistance[3]	1 kHz 20 kHz	-	12 140	-	mΩ
$R_{o\_Ch2(HF)}$	Output resistance[3]	1 kHz 20 kHz	-	35 160	-	mΩ
$V_{out,offset}$	Amplifier output DC Offset	4Ω	-	±0.5	-	mV
$IMD_{CCIF\_Ch1(LF)}$	Intermodulation distortion (CCIF), Ch1(LF)	18kHz & 19kHz Po = 10W, 8Ω	-	0.004	-	%
$IMD_{TIM\_Ch1(LF)}$	Transient Intermodulation distortion (TIM), Ch1(LF)	Po = 10W, 8Ω	-	0.002	-	%
$IMD_{CCIF\_Ch2(HF)}$	Intermodulation distortion (CCIF), Ch2(HF)	18kHz & 19kHz Po = 10W, 8Ω	-	0.001	-	%
$IMD_{TIM\_Ch2(HF)}$	Transient Intermodulation distortion (TIM), Ch2(HF)	Po = 10W, 8Ω	-	0.002	-	%

Table 1 Audio Specifications.

Note 1: Maximum total power is limited by the power supply.
Note 2: Measured using the Audio Precision AES-17 filter.
Note 3: Measured using "APx Output Impedance Utility" at the mating part of the output connector, thereby including contact resistance of the connectors.

2.2 Input & Output loading

Electrical Characteristics @ T_a = 25°C (unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Z_{INPUT}	Input impedance	Balanced Unbalanced	-	4.72 2.36	-	kΩ
$Z_{L,Ch1(LF)}$	Loudspeaker nominal impedance range Ch1(LF)	Ch1(LF)	2.7[1]	4	∞	Ω
$Z_{L,Ch2(HF)}$	Loudspeaker nominal impedance range Ch2(HF)	Ch2(HF)	8[1]	16	∞	Ω
$Z_{L,C}$	Maximal purely capacitive loading of amplifier output		-	-	1	µF

Table 2 Input & Output Loading.

Note 1: T-PRO is fully protected for $Z_L < Z_L$ Min. Connection of loads < Z_L Min is not recommended as a low load impedance in combination with the amplifier current limit will limit maxim output power.

2.3 AC Mains & Thermal specification

Electrical Characteristics @ T_a = 25°C (unless otherwise specified)
When values differ between T-PRO1 and T-PRO2, T-PRO2 data is added in parentheses.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{AC} Range	Operational voltage range	45Hz - 65Hz	85	-	265	V_{AC}
$P_{120VAC\ NS}$	Mains power input No signal applied Pascal T-PRO I/O-board attached.	Standby Mute Idle	-	0.37 6.4(7.2) 7.3(9.5)	-	W_{RMS}
$P_{230VAC\ NS}$	Mains power input No signal applied Pascal T-PRO I/O-board attached.	Standby Mute Idle	-	0.43 7.7(8.5) 9.2(11.4)	-	W_{RMS}
$P_{120VAC\ NS}$	Mains power input No signal applied	Standby Mute Idle	-	0.17 4.9(5.7) 6.5(8.7)	-	W_{RMS}
$P_{230VAC\ NS}$	Mains power input No signal applied	Standby Mute Idle	-	0.23 6.2(7.1) 8.4(10.5)	-	W_{RMS}
P_{AC_PN}	Mains power input $230V_{AC}$ TPRO-1. Pink Noise $P_{out,RMS}$ = 1/8th 250W for R_L = 8Ω $P_{out,RMS}$ = 1/8th 500W for R_L = 4Ω	R_L = 8Ω R_L = 4Ω	-	48 88	-	W_{RMS}
P_{AC_PN}	Mains power input $120V_{AC}$ TPRO-1. Pink Noise $P_{out,RMS}$ = 1/8th 250W for R_L = 8Ω $P_{out,RMS}$ = 1/8th 500W for R_L = 4Ω	R_L = 8Ω R_L = 4Ω	-	48 88	-	W_{RMS}
P_{AC_PN}	Mains power input TPRO-2, Pink Noise, Load Ch1: 4Ω / Ch2: 16 Ω $P_{out,RMS}$ = 1/8th 500W for R_L = 4Ω $P_{out,RMS}$ = 1/8th 125W for R_L = 16Ω	$230V_{AC}$ $120V_{AC}$	-	107 108	-	W_{RMS}
P_{Loss}	Module power loss at $230V_{AC}$ T-PRO1. Pink Noise ($P_{out,RMS}$ = 1/8th of rated power)	R_L = 8Ω R_L = 4Ω	-	17 25	-	W_{RMS}
$\eta_{tot,8\Omega}$	System efficiency @ 1 x 8Ω Ch1(LF) T-PRO1, (1x250W_{out})	$230V_{AC}$ $120V_{AC}$	-	89 86	-	%
$\eta_{tot,4\Omega}$	System efficiency @ 1 x 4Ω Ch1(LF) T-PRO1, (1x250W_{out})	$230V_{AC}$ $120V_{AC}$	-	84 81	-	%
$PF_{8\Omega}$	Power Factor @ 1 x 8Ω Ch1(LF) T-PRO1, (1x200W_{out} @ 1kHz)	$230V_{AC}$ $120V_{AC}$	-	0.94 0.97	-	
$PF_{4\Omega}$	Power Factor @ 1 x 4Ω Ch1(LF) T-PRO1, (1x400W_{out} @ 1kHz)	$230V_{AC}$ $120V_{AC}$	-	0.94 0.97	-	
T_{SD}	Temperature @ thermal shutdown Thermal hysteresis = 5°C[1]		-	85	-	°C

Table 3 AC Mains & Thermal specifications.

Note 1: 5°C but minimum 10s.

2.4 Auxiliary power supply specification[1]

Electrical Characteristics @ T_a = 25°C (unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{+7.5V}$	+7.5V voltage			7.7		V
V_{+15V}	+15V voltage			15.5		V
V_{-15V}	-15V voltage			-15.5		V
V_{Drive}	Vdrive voltage	Ref. to -70V		12.4		V
$I_{+7.5V}$	+7.5V current rating[2]		0		800	mA
I_{+15V}	+15V current rating[2]		0		250	mA
I_{-15V}	-15V current rating[2]		-250		0	mA
I_{VDrive}	V_{Drive} current rating[2]		0		200	mA
P_{tot}	Maximum total output power[2]		0		9	W

Table 4 Auxiliary power supply specification

Note 1: For details see T-PRO Application Manual
Note 2: The Auxiliary power supply cannot be loaded with the maximum rated load current for all four outputs simultaneously as this will violate the 9 Watt total output power limit. Use the typical Voltage levels from Table 4 in combination with the actual load currents to calculate the total power consumption. The calculated total power consumption must comply with the 9 Watt total output power limit.

3 Audio measurements

3.1 Frequency response Ch1(LF)

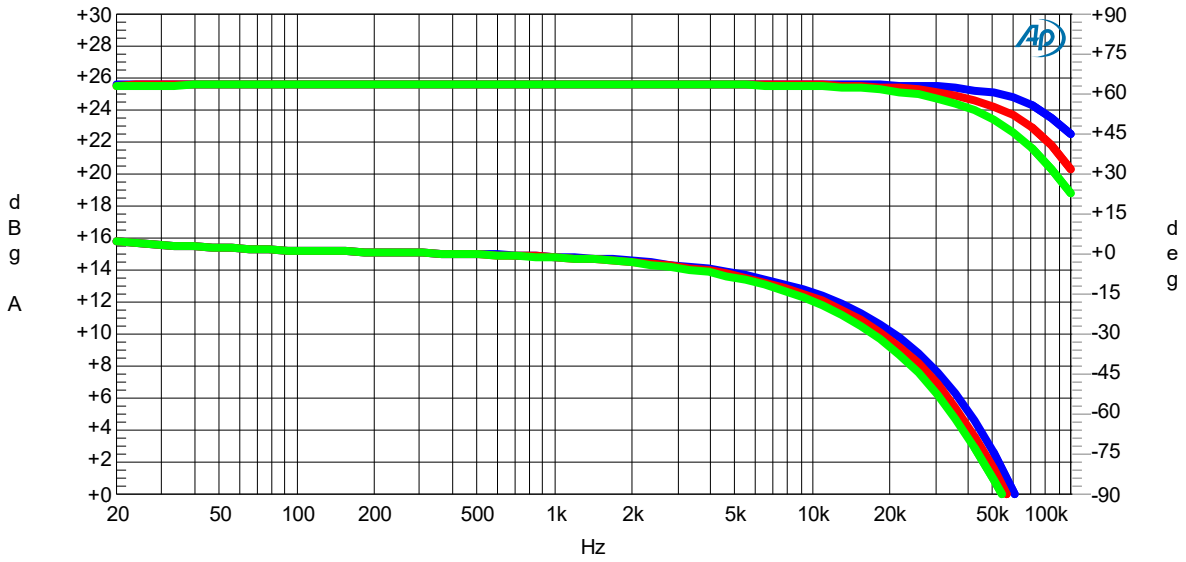


Figure 3-1 Frequency response (Top curves: Amplitude, Bottom curves: Phase)
4Ω (green), 8Ω (red) and Open Load (blue).

3.2 Frequency response Ch2(HF)

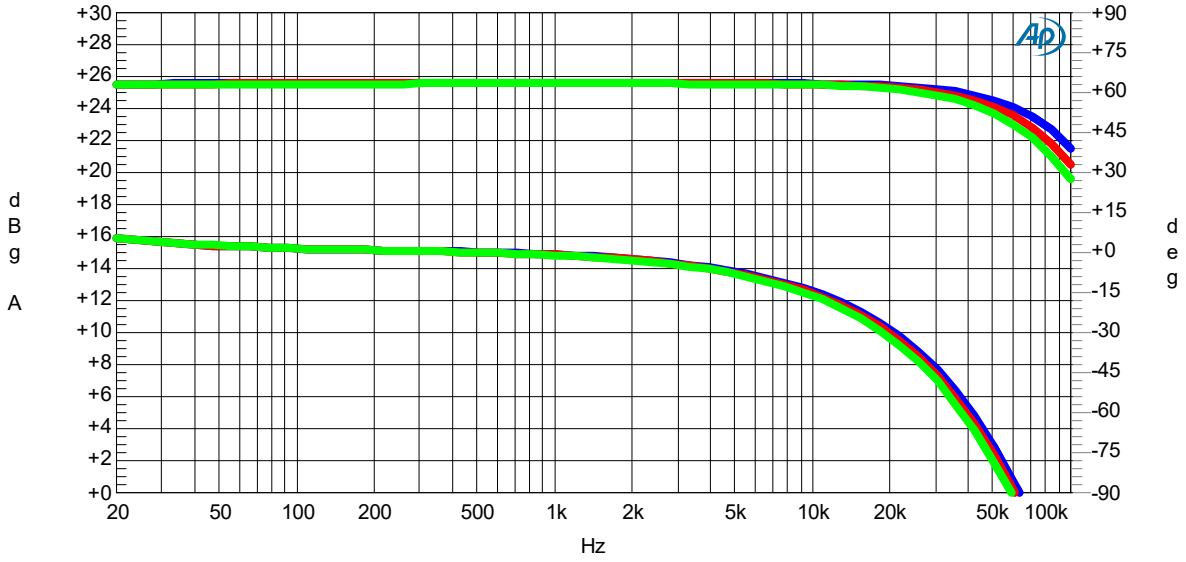


Figure 3-2 Frequency response (Top curves: Amplitude, Bottom curves: Phase)
8Ω (green), 16Ω (red) and Open Load (blue).

3.3 Total Harmonic Distortion + Noise (THD+N) Ch1(LF)

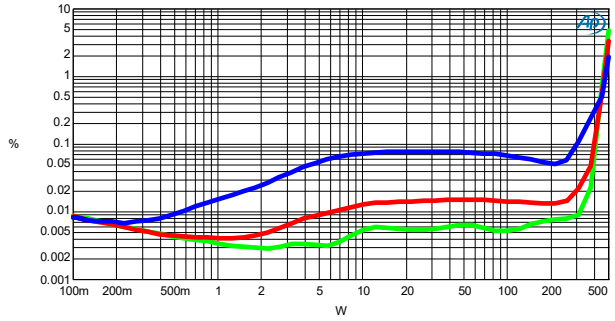


Figure 3-3 THD+N vs. Power @ 4Ω
100Hz (green), 1kHz (red), 6.67kHz (blue).

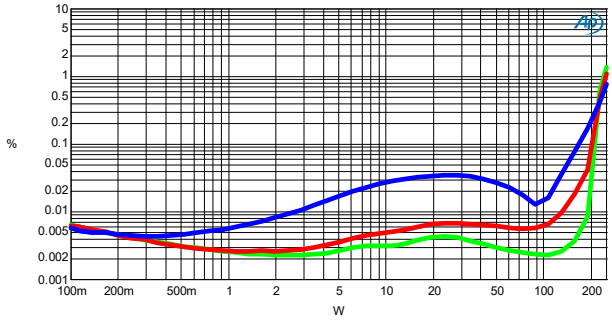


Figure 3-4 THD+N vs. Power @ 8Ω
100Hz (green), 1kHz (red), 6.67kHz (blue).

3.4 Total Harmonic Distortion + Noise (THD+N) Ch2(HF)

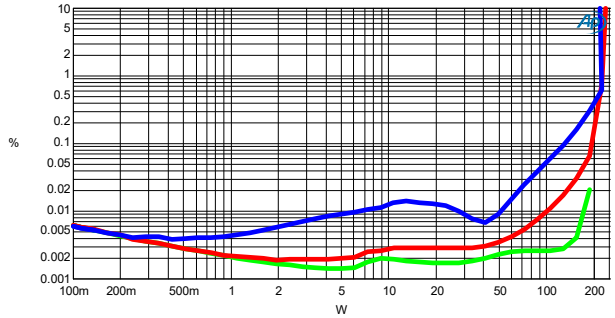


Figure 3-5 THD+N vs. Power @ 8Ω
100Hz (green), 1kHz (red), 6.67kHz (blue).

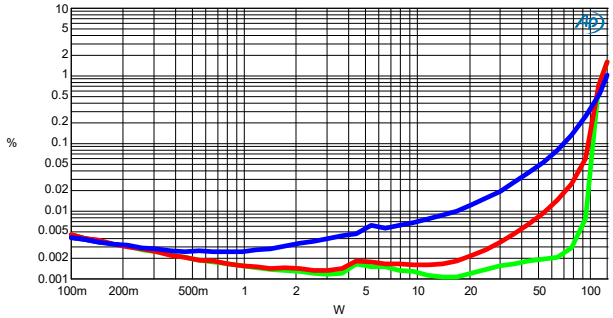


Figure 3-6 THD+N vs. Power @ 16Ω
100Hz (green), 1kHz (red), 6.67kHz (blue).

3.5 Noise Spectrum

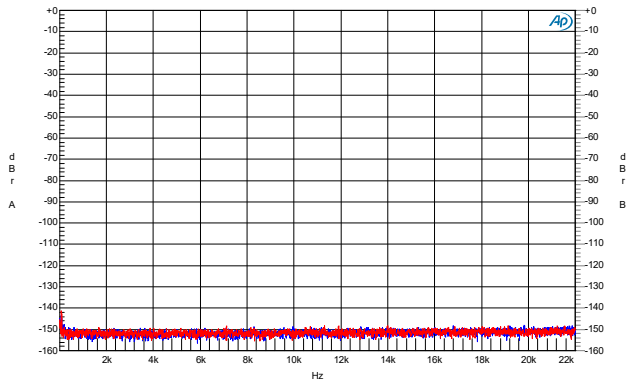


Figure 3-7 FFT idle - 8Ω
Ch1(LF) (blue) & Ch2(HF) (red).

3.6 Intermodulation Distortion (CCIF, TIM) Ch1(LF)

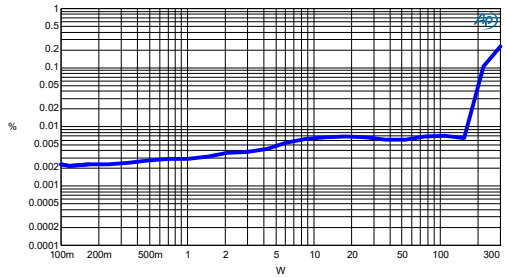


Figure 3-8 CCIF vs. Power - R_L=4Ω
Ch1(LF), f_1=18kHz, f_2 =19kHz.

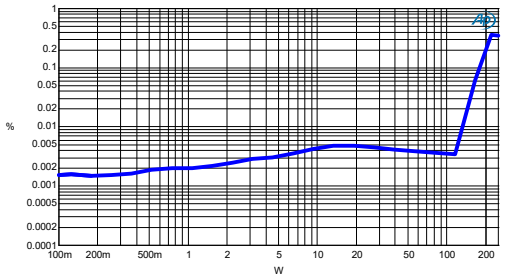


Figure 3-9 CCIF vs. Power - R_L=8Ω
Ch1(LF), f_1=18khz, f_2 =19khz.

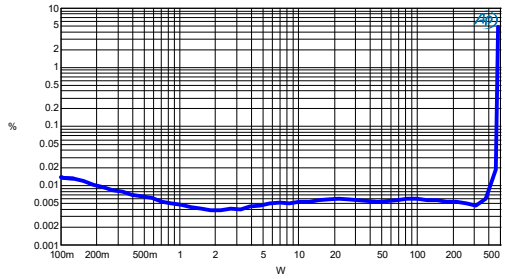


Figure 3-10 TIM vs. Power - R_L=4Ω
Ch1(LF).

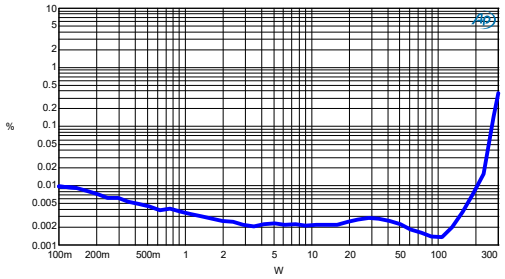


Figure 3-11 TIM vs. Power - R_L=8Ω
Ch1(LF).

3.7 Intermodulation Distortion (CCIF, TIM) Ch2(HF)

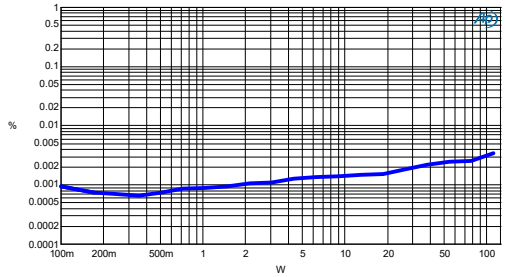


Figure 3-12 CCIF vs. Power - R_L=8Ω
Ch2(HF), f_1=18kHz, f_2 =19kHz.

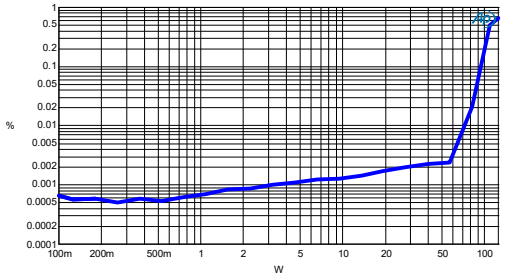


Figure 3-13 CCIF vs. Power - R_L=16Ω
Ch2(HF), f_1=18khz, f_2 =19khz.

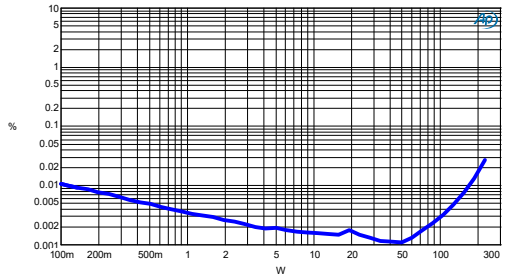


Figure 3-14 TIM vs. Power - R_L=8Ω
Ch2(HF).

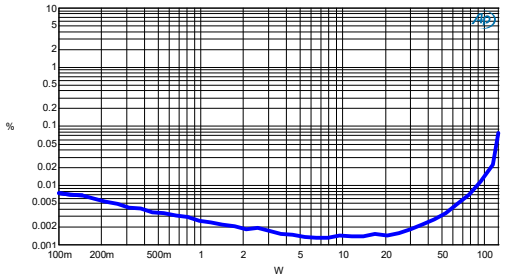


Figure 3-15 TIM vs. Power - R_L=16Ω
Ch2(HF).

3.8 Cross Talk & Output Resistance

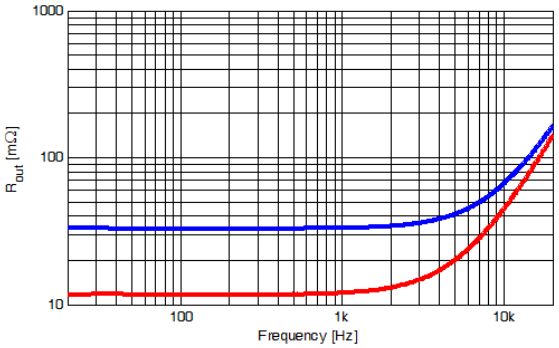


Figure 3-16 Output resistance - Measurement made at the mating part of the output connector. Connector resistance thereby included. Ch1(LF) (red), Ch2(HF) (blue)

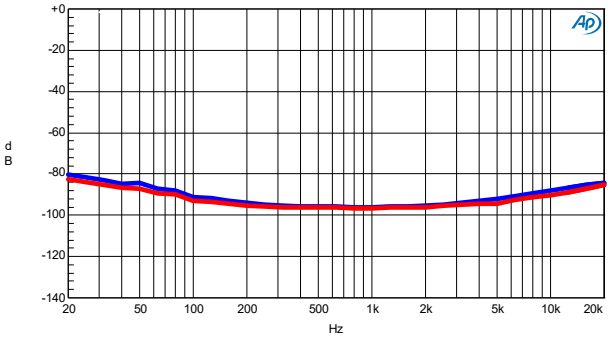


Figure 3-17 Cross talk - Ch.1 @ Po,ch2=50W 8Ω (red), Ch.2 @ Po,ch1=50W 8Ω (blue)

3.9 Output Voltage vs. Frequency

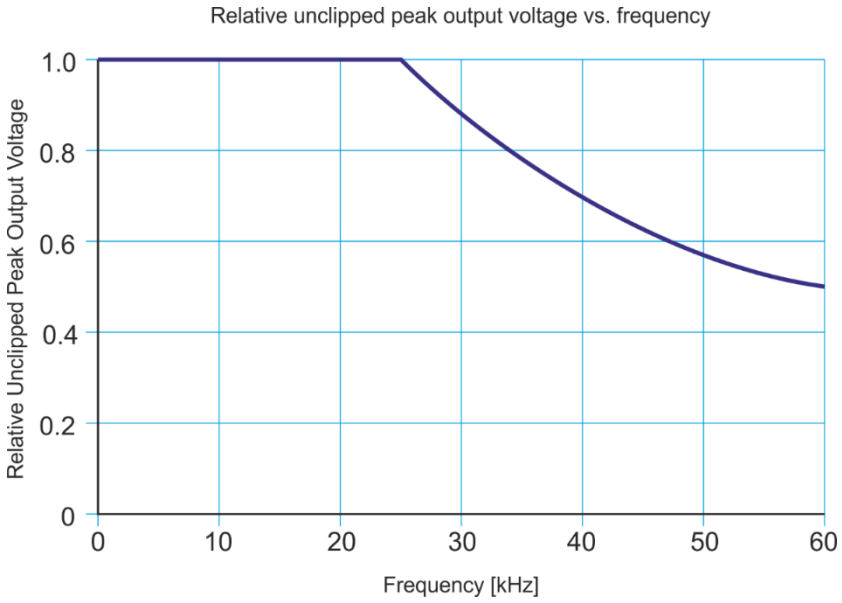


Figure 3-18 Output Peak Voltage vs. Frequency[1]

Note 1: Output available > 5s without activation of HF protection for combinations of frequency and output voltage below the curve.

4 Control and Readout specification

4.1 Control pins

$\overline{\text{Mute}}$ – When muting the T-PRO module, the amplifier outputs will be disabled. It typically takes 0.5ms to disable and only 1ms to enable the amplifier. The mute function may be used with an external wake-on-music circuitry to lower the mains power consumption when the module is unused, but still with the module ready to play in typically 1ms – making it unnoticeable for the user.

$\overline{\text{Standby}}$ – With the T-PRO module in standby the mains power consumption is put to a minimum. In standby it is possible to comply to the ErP (1275/2008/EC) & Energy Star specification with a total power consumption of less than 0.5W. This includes a current draw of up to 25 mA on the +7.5V supply for external standby control circuitry.

Signal_Present – This signal is part of the “Wake on Music” function built into the T-PRO series modules. If left open the signal is internally pulled high and “Wake on Music” is not used. If pulled low continuously for a selectable amount of time set by the “Signal Time Out Select” the amplifiers will first be muted to save power but still be able to un-mute within 1ms. If Signal_Present continues to be low the T-PRO series module will enter standby mode. The T-PRO series module exits standby mode as soon as the signal present signal is released and is ready within typically 660ms.

A suitable circuit for sensing the audio with a sensitivity of $4mV_{RMS}$ and controlling the Signal_Present pin can be found in the T-PRO series application manual.

Signal_Time_Out_Select – This signal is part of the “Wake on Music” function built into the T-PRO series modules. Placing a resistor from this pin to GND makes it possible to choose between 3 different timing settings. See the T-PRO series application manual for details.

Temp/Vac_Set – By toggling the Temp/Vac select pin it is possible to read both the mains voltage and amplifier temperature real-time. By default, the amplifier temperature is selected; if the pin is pulled low the mains voltage is read.

For further details see the T-PRO Application Manual.

4.2 Readouts

The T-PRO has various readouts to monitor the state of the module.

- **Temp/Vac_Mon** – Amplifier temperature or mains voltage readout; by toggling a control-pin, either mains voltage, or amplifier temperature can be read real-time.

    - *Amplifier temperature* – The output stage temperature from 0-100° is expressed as a DC voltage from 0-3.3V. When the module enters thermal protection at 85° equivalent to 2.805V the voltage will jump to 3.3 V indicating thermal protection is active. This makes it possible to both read the live temperature and read when the module is disabled due to thermal protection. The module exits thermal protection when the temperature drops below 80° and the voltage will return to a live readout of the actual module temperature.

    - *Mains voltage* – The AC mains voltage from 85-265V_{AC} is expressed as a DC voltage from 0.213V to 2.925V. This readout may be used to adjust external limiters to match the mains voltage dependent output power.

- **Amplifier Output Voltage readout** – Vout_Monitor_Ch1 and Vout_Monitor_Ch2 are the amplifier output voltage readouts for each channel. These readouts are voltage divisions of the output signals in the range of ±10Vp corresponding to ±70Vp at the output.

- **Amplifier Clip readout** – There is one amplifier clip readout, $\overline{\text{Clip\_1}}$ only. This readout is an open-collector output. The readout pin will be pulled low if the audio output voltage for Ch1 becomes too high, compared to the internal rail voltages, or if the Ch1 amplifier reaches internal current protection. This readouts may be used for signal clip/limiting indications. There is no voltage clip readout for Ch2 since this is an HF channel not normally clipped and if clipped the distortion is less obvious. Current clipping on a HF driver is not normally reached but in case current clipping on Ch2 occurs, this event is shown as clip on the Ch1 clip readout - $\overline{\text{Clip\_1}}$.

- $\overline{\textbf{Dis\_Read/Protect}}$– This readout is an open-collector output which will be pulled low when the module is either muted or has entered an internal protection.

For further details see the T-PRO Application Manual.

5 Protection features

The T-PRO has built-in protection features which protect the module and speaker from malfunctioning.

- **Temperature** – Temperature protection of the power supply and amplifiers is implemented to prevent the module from thermal runaway. When thermal protection is engaged both (for T-PRO2) amplifiers are muted until the temperature has dropped 5°C or for a minimum of 10s.

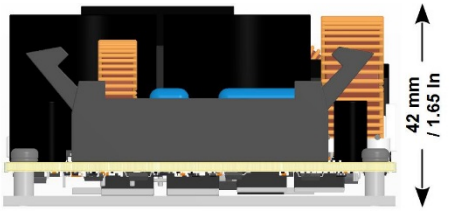
- **Over Current** – If an amplifier output is shorted or reaches its current limit, the clip readout will be activated to allow an external limiter/DSP to limit the input signal. If the limiter is not capable of limiting the signal the module will enter over-current protection and mute both (for T-PRO2) outputs until the internal protection timing allows the module to re-enable the amplifier(s).

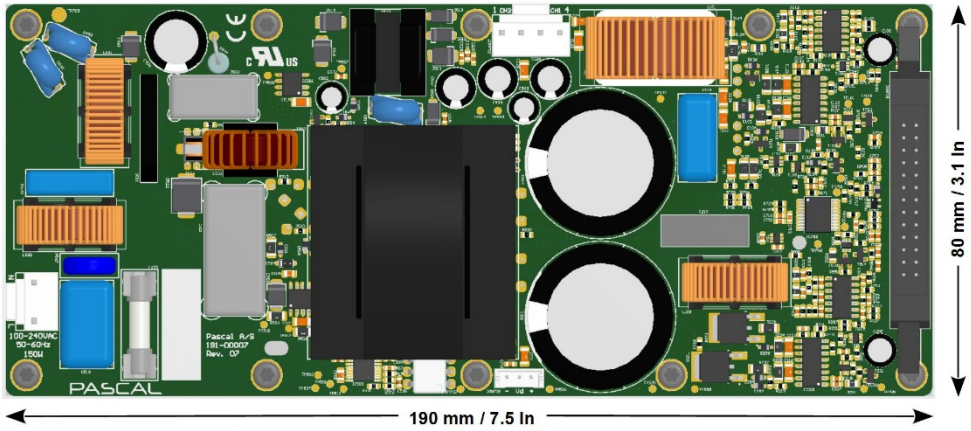
- **DC Protection** – If DC-voltage is detected at one of the amplifier outputs, the T-PRO Series module mutes the outputs. If DC still is present after 3 cycles, the T-PRO Series DC protection circuit switch off the +/-70V power supply. Resetting the latched protection circuit requires cycling of the AC mains.

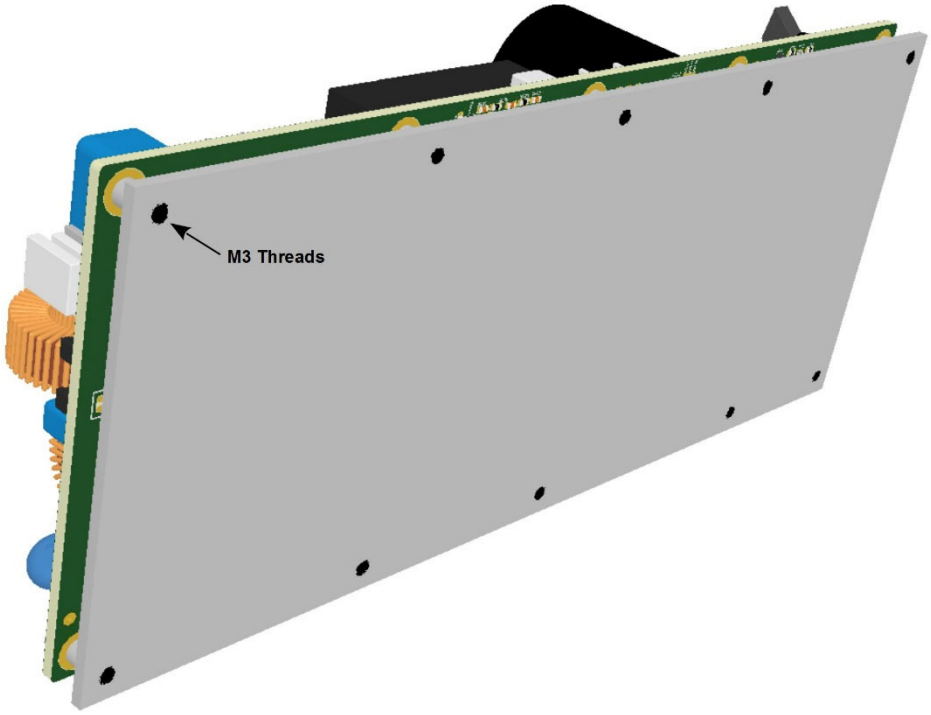
- **HF Protection** – A high frequency protection is implemented in order to protect the amplifier output filter components from overload above 25 kHz. If a high frequency (and high amplitude) signal is present for a longer period of time the module will enter HF protection and mute both outputs (for T-PRO2) until the internal protection timing allows the module to re-enable the amplifier(s).

For further details see the T-PRO Application Manual.

6 Mechanical specifications







Module weight: T-PRO1: 505 g / 1.11 lbs, T-PRO2: 520 g / 1.15 lbs

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