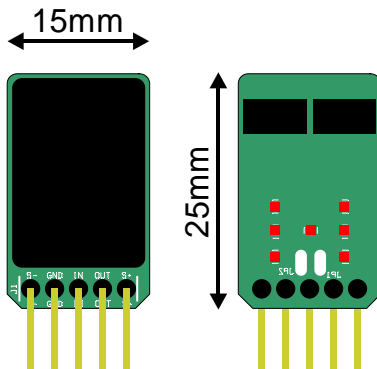


High-Performance Voltage Regulators



Features

- Ultra-low noise
- Wide bandwidth
- Excellent ripple rejection
- Low, load-independent output impedance
- Kelvin sense connections
- Size and pin compatible with TO-220 style regulators

Applications

- Preamplifiers and buffers
- RIAA input stages
- Playback head amplifiers
- Performance upgrade for existing products

Description

The HPR12/HNR12 are high performance voltage regulators targeted at performance-critical audio applications. Key performance parameters exceed that of industry-standard integrated circuits by several orders of magnitude. Kelvin sense connections provide point-of-load (local) regulation without requiring physical proximity.

Performance data

$V_i=18V$, $I_o=10mA$, $T_j=25^{\circ}C$, unless otherwise noted

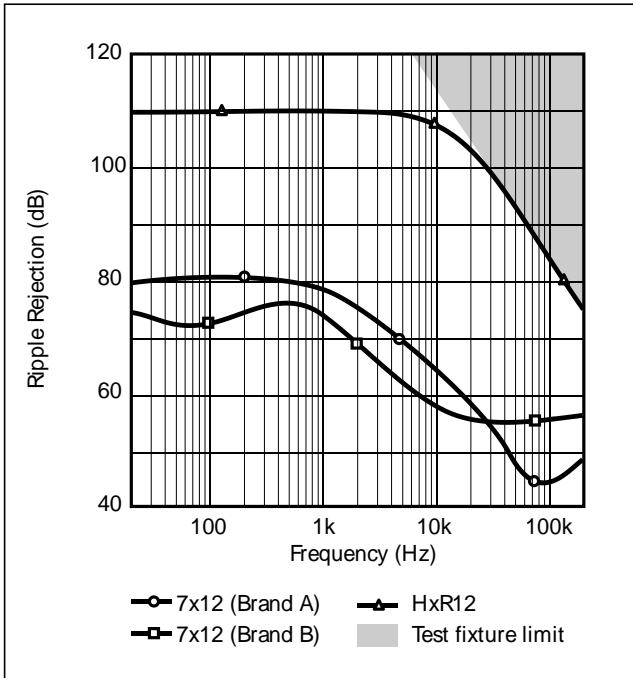
Item	Symbol	Min	Typ	Max	Unit	Notes
Output Voltage	V_o	11.5	12	12.5	V	
Output Impedance	Z_o	-	50	70	$m\Omega$	
Ripple Rejection	PSRR	105	110	-	dB	
Output Noise Voltage	V_N	-	290	400	nV	MBW=10Hz to 20kHz
Dropout Voltage	V_D	-	-	3	V	
Quiescent Current	I_o	-	14	20	mA	
Output Current Range	I_{PK}	0	-	100	mA	
Short-Circuit Current	I_{SC}	-	500	-	mA	
Optimum Load Capacitance Range	C_L	2.2	-	∞	μF	Stability below $1\mu F$ not guaranteed.

Absolute maximum ratings

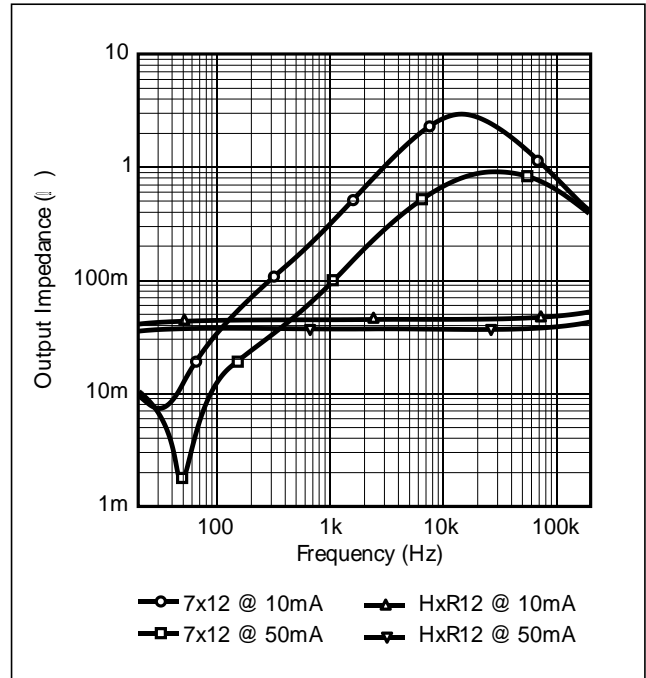
Correct operation at these limits is not guaranteed. Operation beyond these limits may result in irreversible damage.

Item	Symbol	Rating	Unit	Notes
Input Voltage	V_i	60	V	
Output Current	I_o	600	mA	
Power Dissipation	P_D	2	W	
Operating Temperature	T_{OPR}	0 ~ 125	$^{\circ}C$	
Storage Temperature	T_{STG}	0 ~ 150	$^{\circ}C$	

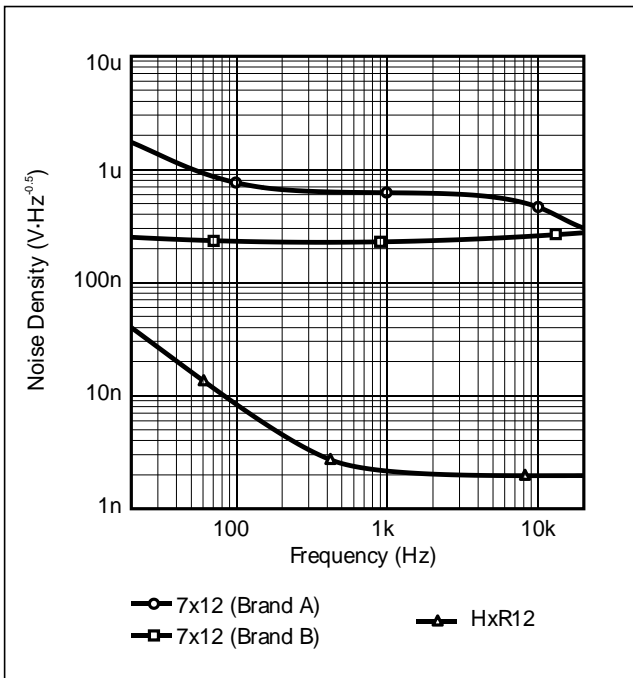
Typical Performance Graphs



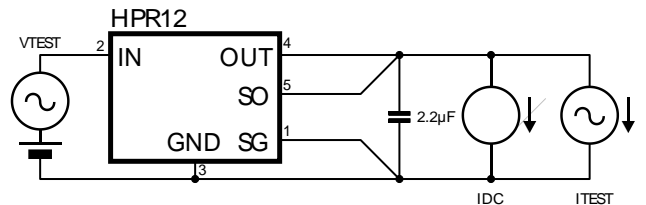
Ripple Rejection. HF ripple rejection is dominated entirely by magnetic coupling in the test fixture.



Output impedance at two load currents.



Output noise density. Even though the internal reference has no filtering at all, noise is as low as the Johnson noise of a 250Ω resistor.



An audio analyser with a typical 40Ω output impedance may be used both as the voltage source at the input or as the current source at the output, since 40Ω is low compared to the input impedance of the regulator and high compared to its output impedance. In that case, the input circuit is rearranged for the analyser output to be capacitively coupled to the circuit input.

Test circuit.

Theory of operation

The HxR12 series pass regulators are externally compensated transconductance amplifiers. The load decoupling capacitor thereby doubles as compensation capacitor.

In a traditional emitter-output regulator, a constant-gain amplifier is placed around an emitter follower whose output impedance is low and scales inversely with load current. The dominant pole is set inside the voltage amplifier with any load capacitance adding an unwanted pole, reducing phase margin. As output impedance becomes highly current-dependent, so does phase margin.

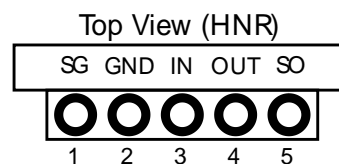
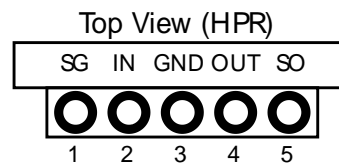
This contrasts with a transconductance regulator where the error voltage controls the output current. Dominant-pole compensation is effected by the decoupling capacitor across the load. **Stability requires a minimum load capacitance** and increasing it improves phase margin further. Output impedance works out as the inverse of transconductance which in turn is given by the transconductance of the difference amplifier and the hfe of the pass device, all of which are nearly constant with load. The advantage of linear output impedance plays out most directly in power supply sensitive audio applications, where a non-linear response from the power supply adds distortion.

Because of the extreme bandwidth of the HxR12 regulators, care should be taken to take the sense connections directly at the decoupling capacitor.

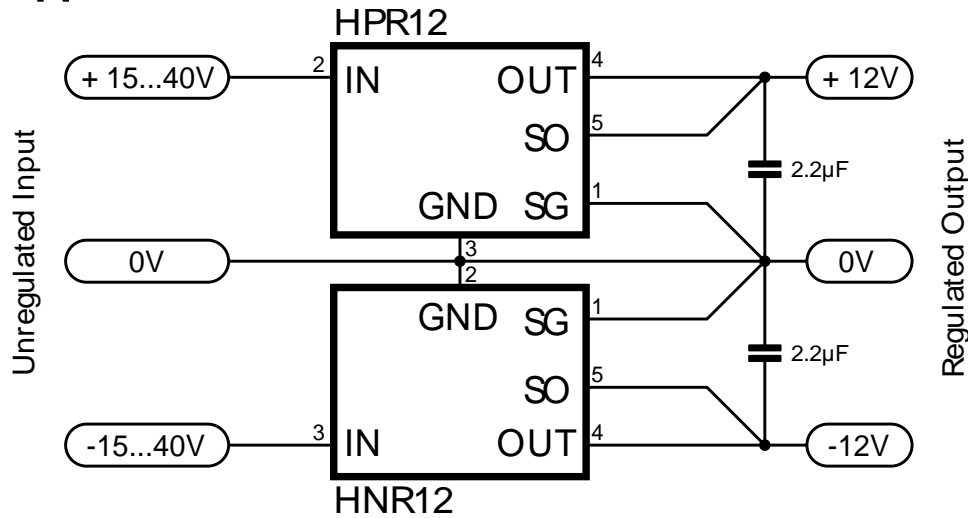
Connections

The middle three pins on the HxR12 modules match the pin-out of the standard LM7812CT/LM7912CT devices. If the decoupling capacitor is placed very close to the regulator, full pin-compatibility can be achieved by shorting the two solder jumpers on the back of the module and clipping the two outer pins. This adversely affects all performance parameters so this should only be done when retrofitting pre-existing equipment. In case of doubt, run two wires from the decoupling capacitor to the kelvin sense connections.

HPR12		
Pin	Name	Function
1	SG	Ground Sense input
2	IN	Unregulated input
3	GND	Ground connection
4	OUT	Regulated Output
5	SO	Output Sense input
HNR12		
Pin	Name	Function
1	SG	Ground Sense input
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3	IN	Unregulated input
4	OUT	Regulated Output
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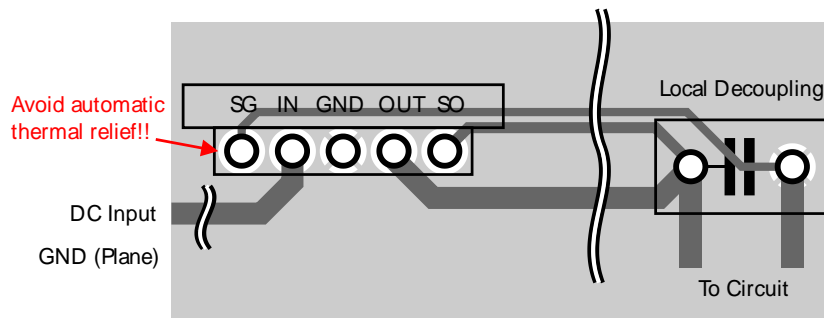


Typical Application Schematic



PCB Layout Considerations

The HxR12 regulators are fast, high-performance circuits. Care must be taken not to degrade performance by lay-out oversights. Most CAD tools automatically assign the output and sense pins to the same net. The sense traces must be routed manually from the decoupling capacitor to the regulator. When using a ground plane, special care should be taken to keep the layout program from drawing a thermal relief star straight to the ground plane. If necessary, use "0 ohm" jumpers to forcibly separate the negative kelvin sense from the GND net. Sense traces should be treated like a differential signal connection. Run them parallel and close to **each other**, not necessarily parallel to the output traces. The regulator has minimal decoupling internally. If the power traces from the unregulated supply to the regulator are particularly long, some extra decoupling in the form of a series resistor and a small electrolytic capacitor might be added.



Upgrading UcD/HG modules

The new High Grade UcD modules have a stuffing option to easily allow users to upgrade their amplifier modules with these regulators. The use of these regulators in combination with the HG UcD amplifier modules further improves the sound quality. Following Jumpers need to be removed in order to use these regulators:

- UCD180HG → R68 & R69.
- UCD400HG → R85 & R86.
- UCD700HG → R111 & R112.

Document Revision	PCB Version	Description	Date
R1	HxR12V1	Initial draft.	26.06.2007
R2	HxR12V2	Current source altered. Functionality has not changed.	03.01.2008
R3	HxR12V3	Instructions for UcD180HG changed	21.02.2011