



VXR250-2800S SERIES

HIGH RELIABILITY COTS DC-DC CONVERTERS

Models Available

Input: 11 V to 60 V continuous, 9 V to 80 V transient
250 W, single output of 3.3 V, 5 V, 12 V, 15 V, 28 V
-55 °C to 105 °C Operation



1.0 DESCRIPTION

The VXR series of isolated DC-DC converters is the latest and most advanced offering in VPT's extensive line of high reliability COTS products. Building on a proven design heritage, the VXR series features high efficiency, an ultra-wide input voltage range, and next-generation packaging. Providing a wide 11 V to 60 V input, along with VPT's standard full feature set and industry-leading performance, the VXR family is optimized for a broad range of applications from military ground vehicles to commercial and military aircraft.

The VXR250 utilizes a low noise, fixed frequency, wide input voltage range topology with extended high and low input transient capability to simplify overall power system design and compliance. Precision controlled synchronous rectification achieves high efficiency over a wide input range, reducing power dissipation and minimizing external heatsink requirements. A proprietary control loop design provides fast transient response without the use of optoisolators.

The VXR Series patent-pending epoxy-encapsulated V-SHIELD® packaging is highly resistant to chemical, solvent and salt environments and is fully compatible with high volume manufacturing processes including wave solder, cleaning solvents, high pressure sprays and aqueous wash processes. A unique integral six-sided metalized shield improves system EMI compatibility. Dual sided conduction cooling coupled with reduced power dissipation simplifies system thermal design.

The VXR series is intended for harsh environments including severe vibration, shock and temperature cycling. Testing is to JESD22, MIL-STD-810, and MIL-STD-883.

1.1 FEATURES

- Wide input voltage range: 11 V to 60 V
- 9 V to 80 V transient operation
- High efficiency up to 94%
- Rugged epoxy encapsulated V-SHIELD® package
- Fully compatible with aqueous cleaning processes
- Integral six-sided metalized EMI shield
- Dual-sided thermal conduction
- 2000 V isolation
- Fixed frequency
- Low noise
- Output voltage trim (+10% / -20%)
- Output current limit protection
- Short circuit protection
- Parallel up to 5 units with current sharing

1.2 COMPLIANCE

- MIL-STD-1275 A-E
- RTCA / DO-160-Section 16
- MIL-STD-704 A-F
- MIL-STD-461 C-F when used with an appropriate VXR EMI filter
- RTCA / DO-160-section 18 and 21 when used with an appropriate VXR EMI filter

1.3 PACKAGING

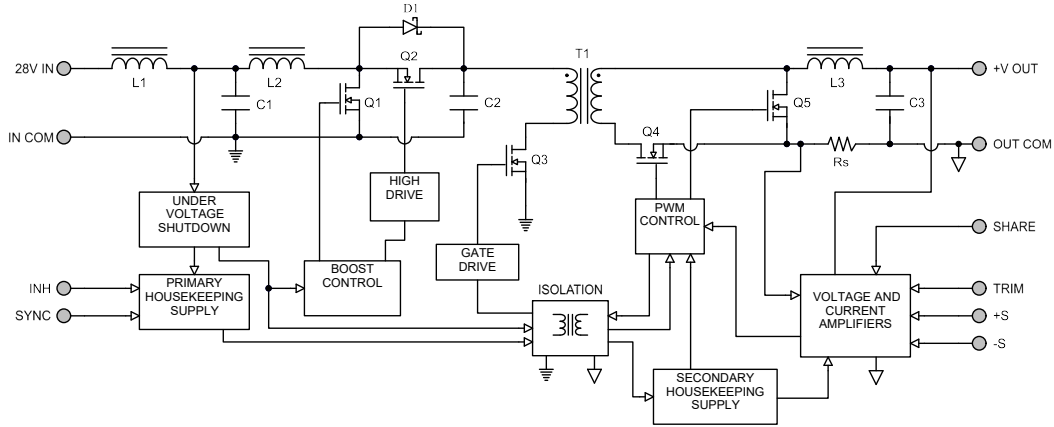
- Low-profile: 2.29" x 2.41" x 0.490"
- Max weight: 139 g

1.4 SIMILAR PRODUCTS AND ACCESSORIES

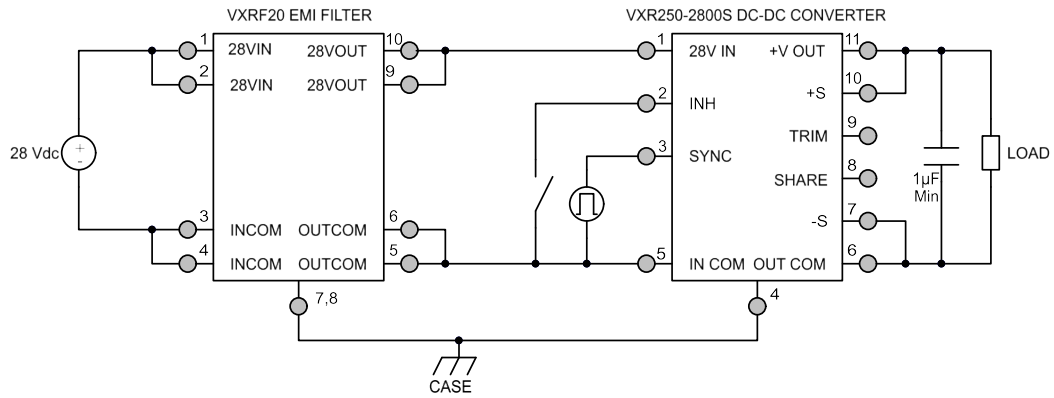
- [VPT250](#) 250 W single output Military Qualified DC-DC Converter
- [DVFL](#) 120 W single output Military Qualified DC-DC Converter
- [EMI filters, Thermal Pads, Front-End Modules and Accessories](#)

2.0 DESCRIPTION

2.1 BLOCK DIAGRAM



2.2 CONNECTION DIAGRAM



3.0 SPECIFICATIONS

3.1 ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings			
Input Voltage (Continuous):	60 V	Operating Temperature (Full Load):	-55 °C to + 105 °C
Input Voltage (Transient, 1 sec):	80 V	Storage Temperature:	-55 °C to + 125 °C
		Lead Solder Temperature (10 seconds):	300 °C

3.2 PERFORMANCE SPECIFICATIONS

Tcase = -55 °C to +105 °C, Vin = +28 V ± 5%, Full Load, Unless Otherwise Specified

Parameter	Conditions	VXR250-283R3S			VXR250-2805S			Units
		Min	Typ	Max	Min	Typ	Max	
INPUT								
Voltage	Continuous	11	28	60	11	28	60	V
	Transient, 1 sec ³	9	-	80	9	-	80	V
Current	INH < 1 V	-	11	18	-	11	18	mA
	No Load	-	250	500	-	280	500	mA
Ripple Current	20 Hz to 10 MHz	-	38	90	-	38	90	mApp
Undervoltage Lockout	Turn-On	-	-	10.9	-	-	10.9	V
	Turn-Off ³	-	-	8.9	-	-	8.9	V
OUTPUT STATIC								
Voltage	+Vout, Tcase = 25 °C	3.25	3.3	3.35	4.92	5	5.08	V
	+Vout, Tcase = -55 °C to +105 °C	3.22	3.3	3.38	4.87	5	5.13	V
Power ²		0	-	165	0	-	250	W
Current ²		0	-	50	0	-	50	A
Ripple Voltage ⁴	20 Hz to 10 MHz	-	140	300	-	170	300	mVpp
Line Regulation	V _{IN} = 11 V to 60 V	-	3	20	-	3	20	mV
Load Regulation	No Load to Full Load	-	1	20	-	1	20	mV
Load Fault Power Dissipation	Overload ³	-	17	30	-	20	35	W
	Short Circuit ³	-	3	6	-	3	6	W
OUTPUT DYNAMIC								
Load Step, Half to Full Load	Output Transient	-	150	300	-	250	350	mVpk
	Recovery ¹	-	100	200	-	65	120	µs
Line Step ³ , Vin = 16 V to 40 V	Output Transient	-	250	400	-	200	350	mVpk
	Recovery ¹	-	50	120	-	60	150	µs
Turn-On, Vin = 0 to 28 V	Delay	-	32	45	-	32	45	ms
	Overshoot	-	0	15	-	0	25	mVpk
FUNCTION								
INH Pin Input ³	Output Inhibited	0	-	1	0	-	1	V
INH Pin Open Circuit Voltage ³	Output Enabled	-	5	6	-	5	6	V
Voltage Trim Range		-12	-	10	-20	-	10	%
SHARE Pin Voltage ³		1	-	5	1	-	5	V
Current Share Accuracy ³		-	5	-	-	5	-	%
SYNC Frequency Range		450	-	550	450	-	550	kHz
GENERAL								
Efficiency		90	92	-	91	93	-	%
Capacitive Load ³		-	-	8000	-	-	8000	µF
Switching Frequency		375	450	525	375	450	525	kHz
Isolation	2000 V DC, Tcase = 25 °C	100	-	-	100	-	-	MΩ
Weight		-	-	139	-	-	139	g
MTBF (MIL-HDBK-217F)	GM @ Tcase = 55 °C	-	398	-	-	398	-	kHr

1. Time for output voltage to settle within 1% of steady-state value

2. Derate linearly to 0 at 115°C

3. Verified by qualification testing

4. With additional 1µF ceramic capacitor from VOUT to OUTCOM

3.2 PERFORMANCE SPECIFICATIONS (CONTINUED)

T_{case} = -55 °C to +105 °C, V_{in} = +28 V ± 5%, Full Load, Unless Otherwise Specified

Parameter	Conditions	VXR250-2812S			VXR250-2815S			Units
		Min	Typ	Max	Min	Typ	Max	
INPUT								
Voltage	Continuous	11	28	60	11	28	60	V
	Transient, 1 sec ³	9	-	80	9	-	80	V
Current	INH < 1 V	-	11	18	-	11	18	mA
	No Load	-	320	550	-	350	550	mA
Ripple Current	20 Hz to 10 MHz	-	55	120	-	55	120	mApp
Undervoltage Lockout	Turn-On	-	-	10.9	-	-	10.9	V
	Turn-Off ³	-	-	8.9	-	-	8.9	V
OUTPUT STATIC								
Voltage	+V _{out} , T _{case} = 25 °C	11.82	12	12.18	14.77	15	15.23	V
	+V _{out} , T _{case} = -55 °C to +105 °C	11.7	12	12.3	14.62	15	15.38	V
Power ²		0	-	250	0	-	250	W
Current ²		0	-	20.8	0	-	16.67	A
Ripple Voltage ⁴	20 Hz to 10 MHz	-	60	150	-	60	150	mVpp
Line Regulation	V _{in} = 11 V to 60 V	-	10	40	-	10	40	mV
Load Regulation	No Load to Full Load	-	1	20	-	1	20	mV
Load Fault Power Dissipation	Overload ³	-	17	30	-	17	30	W
	Short Circuit ³	-	3	6	-	3	6	W
OUTPUT DYNAMIC								
Load Step, Half to Full Load	Output Transient	-	750	1200	-	650	1100	mVpk
	Recovery ¹	-	60	120	-	50	110	µs
Line Step ³ , V _{in} = 16 V to 40 V	Output Transient	-	300	600	-	300	600	mVpk
	Recovery ¹	-	50	120	-	80	180	µs
Turn-On, V _{in} = 0 to 28 V	Delay	-	32	45	-	32	45	ms
	Overshoot	-	20	75	-	50	100	mVpk
FUNCTION								
INH Pin Input ³	Output Inhibited	0	-	1	0	-	1	V
INH Pin Open Circuit Voltage ³	Output Enabled	-	5	6	-	5	6	V
Voltage Trim Range		-20	-	10	-20	-	10	%
SHARE Pin Voltage ³		1	-	5	1	-	5	V
Current Share Accuracy ³		-	5	-	-	5	-	%
SYNC Frequency Range		450	-	550	450	-	550	kHz
GENERAL								
Efficiency		91	93	-	92	94		%
Capacitive Load ³		-	-	1500	-	-	1500	µF
Switching Frequency		375	450	525	375	450	525	kHz
Isolation	2000 V DC, T _{case} = 25 °C	100	-	-	100	-	-	MΩ
Weight		-	-	139	-	-	139	g
MTBF (MIL-HDBK-217F)	GM @ T _{case} = 55 °C	-	398	-	-	398	-	kHr

1. Time for output voltage to settle within 1% of steady-state value

2. Derate linearly to 0 at 115°C

3. Verified by qualification testing

4. With additional 1µF ceramic capacitor from VOUT to OUTCOM

3.2 PERFORMANCE SPECIFICATIONS (CONTINUED)

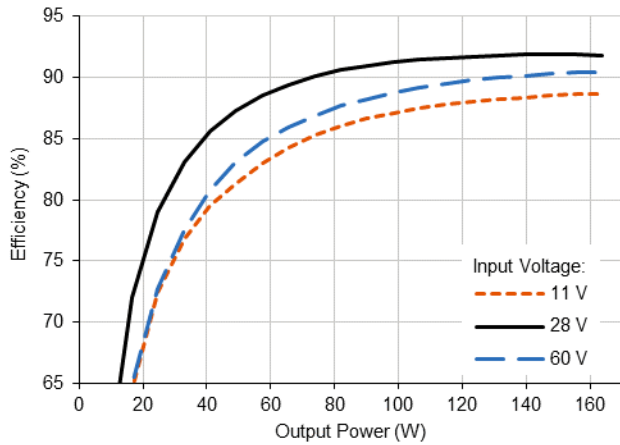
Tcase = -55 °C to +105 °C, Vin = +28 V ± 5%, Full Load, Unless Otherwise Specified

VXR250-2828S					
Parameter	Conditions	Min	Typ	Max	Units
INPUT					
Voltage	Continuous	11	28	60	V
	Transient, 1 sec ³	9	-	80	V
Current	INH < 1 V	-	11	18	mA
	No Load	-	350	550	mA
Ripple Current	20 Hz to 10 MHz	-	55	120	mApp
Undervoltage Lockout	Turn-On	-	-	10.9	V
	Turn-Off ³	-	-	8.9	V
OUTPUT STATIC					
Voltage	+Vout, Tcase = 25 °C	27.58	28	28.42	V
	+Vout, Tcase = -55 °C to +105 °C	27.3	28	28.7	V
Power ²		0	-	250	W
Current ²		0	-	8.92	A
Ripple Voltage ⁴	20 Hz to 10 MHz	-	60	150	mVpp
Line Regulation	V _{IN} = 11 V to 60 V	-	10	40	mV
Load Regulation	No Load to Full Load	-	1	20	mV
Load Fault Power Dissipation	Overload ³	-	17	30	W
	Short Circuit ³	-	3	6	W
OUTPUT DYNAMIC					
Load Step, Half to Full Load	Output Transient	-	1100	1760	mVpk
	Recovery ¹	-	50	110	µs
Line Step ³ , Vin = 16 V to 40 V	Output Transient	-	400	800	mVpk
	Recovery ¹	-	100	200	µs
Turn-On, Vin = 0 to 28 V	Delay	-	32	45	ms
	Overshoot	-	80	150	mVpk
FUNCTION					
INH Pin Input ³	Output Inhibited	0	-	1	V
INH Pin Open Circuit Voltage ³	Output Enabled	-	5	6	V
Voltage Trim Range		-20	-	10	%
SHARE Pin Voltage ³		1	-	5	V
Current Share Accuracy ³		-	5	-	%
SYNC Frequency Range		450	-	550	kHz
GENERAL					
Efficiency		91	93	-	%
Capacitive Load ³		-	-	1500	µF
Switching Frequency		375	450	525	kHz
Isolation	2000 V DC, Tcase = 25 °C	100	-	-	MΩ
Weight		-	-	139	g
MTBF (MIL-HDBK-217F)	GM @ Tcase = 55 °C	-	398	-	kHr

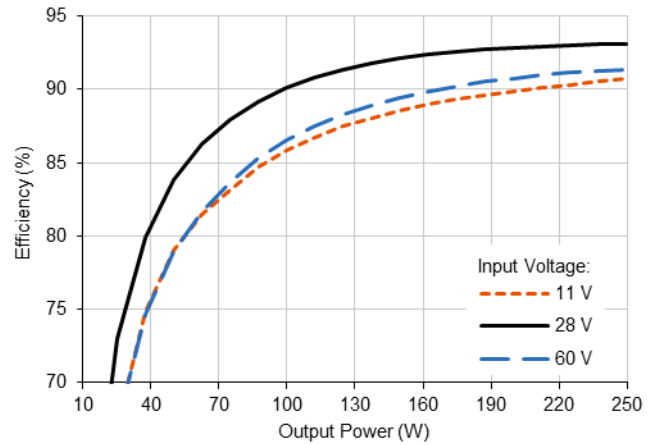
1. Time for output voltage to settle within 1% of steady-state value
2. Derate linearly to 0 at 115°C
3. Verified by qualification testing
4. With additional 1µF ceramic capacitor from VOUT to OUTCOM

4.0 PERFORMANCE CURVES

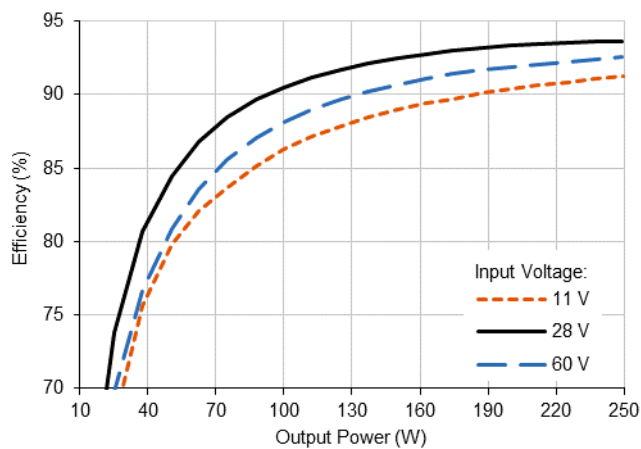
4.1.1 VXR250-283R3S Efficiency (Typical, 25 °C)



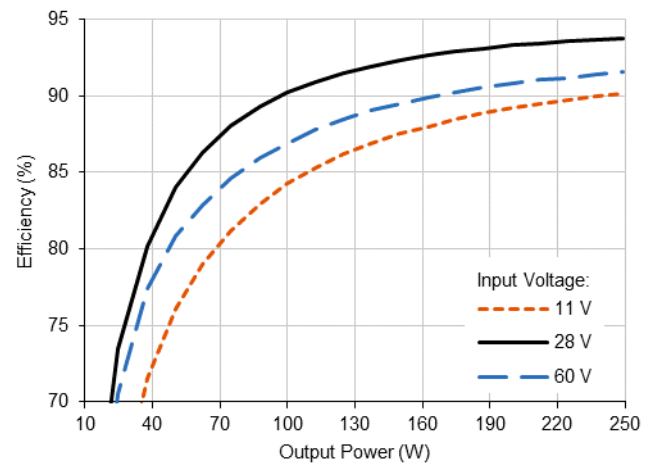
4.1.2 VXR250-2805S Efficiency (Typical, 25 °C)



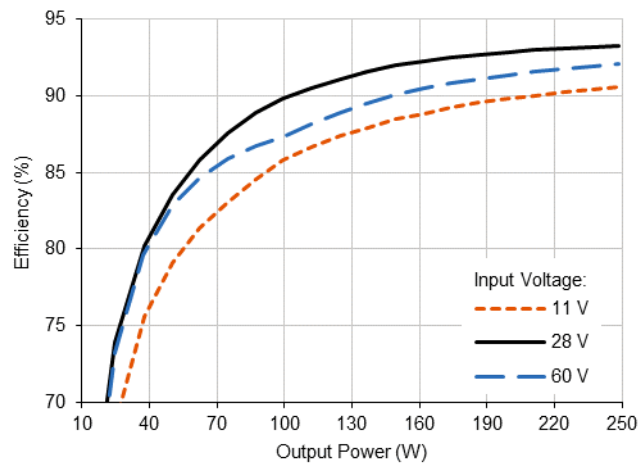
4.1.3 VXR250-2812S Efficiency (Typical, 25 °C)



4.1.4 VXR250-2815S Efficiency (Typical, 25 °C)

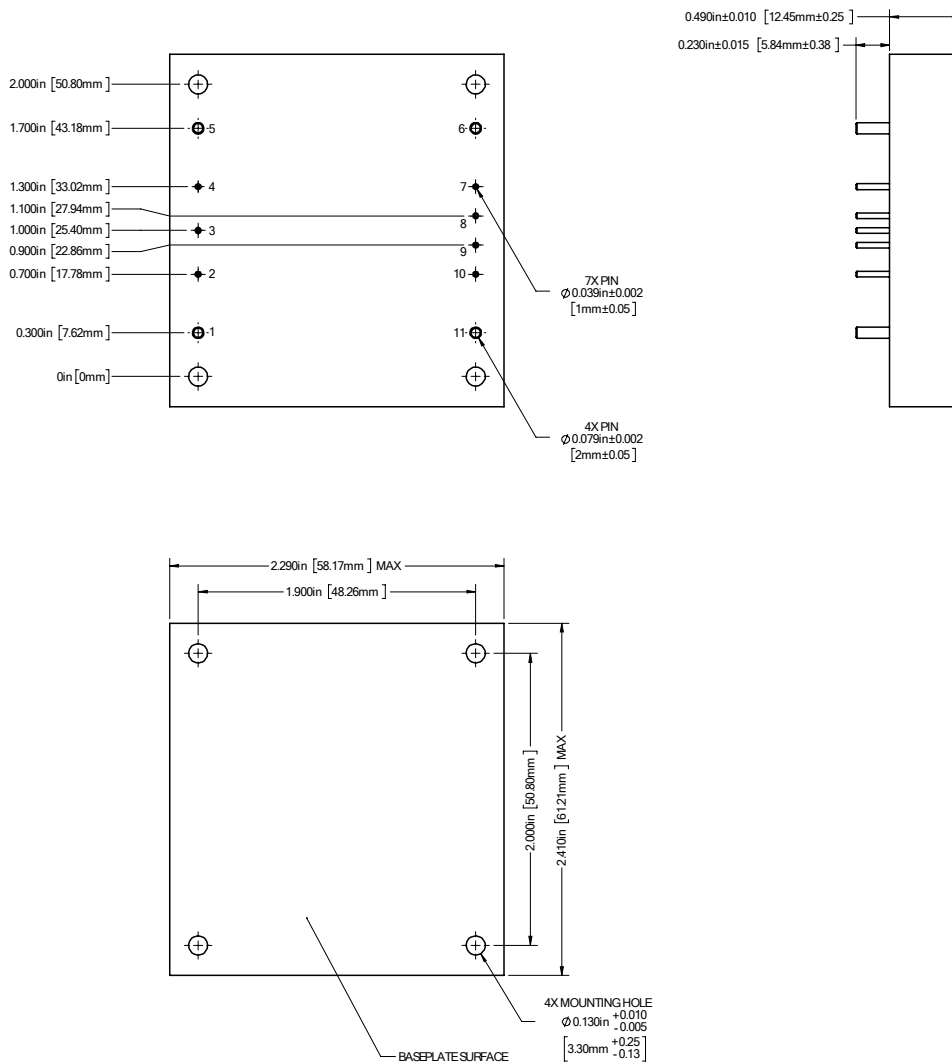


4.1.5 VXR250-2828S Efficiency (Typical, 25 °C)



5.0 MECHANICAL OUTLINES AND PINOUT

Standard Package:



1. Tolerances are ± 0.005 " unless otherwise stated
2. Case temperature is measured on the center of the baseplate surface
3. Mounting holes are not threaded. Recommended fastener is 4-40
4. Materials: Body (Epoxy with integral metalized EMI shield); Pin (Tellurium Copper, alloy 145, gold over nickel plating)

Pin	Function	Pin	Function	Pin	Function	Pin	Function
1	28VIN	4	CASE	7	-SENSE	10	+SENSE
2	INH	5	INCOM	8	SHARE	11	+VOUT
3	SYNC	6	OUTCOM	9	TRIM		

6.0 TECHNICAL NOTES



Please note that many of these functions are also demonstrated in detail on the VPT website in the form of [technical video labs](#).



6.1 GENERAL INFORMATION

6.1.1 Topology Description

The VXR250-2800S Series is an isolated single-output cascade boost and forward topology. This two stage topology allows the VXR250 to operate over a very wide input range and achieve high efficiency. The proprietary secondary side digital control provides a tightly regulated positive output voltage with fast transient response while eliminating analog feedback isolation.

6.1.2 External Components

The VXR250-2800S Series is designed to operate stand-alone and does not require external components for proper operation. An additional $1\mu\text{F}$ capacitor from +VOUT to OUTCOM reduces the output voltage ripple and is required to meet datasheet specifications. Input and output L-C filters are provided internally for low ripple and noise. To further reduce output ripple and noise for more sensitive applications, a small ceramic capacitor, $1\mu\text{F}$ to $10\mu\text{F}$, can be added to the output. Most application specific ripple requirements can be met with the addition of output capacitors alone. External output capacitance can be added up to the maximum listed in Section 3.2.

6.1.3 Source Impedance

The impedance of the 28 V input source can interact with the DC-DC converter and may affect performance. High source impedance is often caused by a long input cable or components added in series with the input. Source resistance will cause a DC voltage drop as the converter draws DC input current. This voltage drop is determined by multiplying the cable resistance by the input current at low line. The voltage drop and the actual voltage at the input to the converter will determine the minimum source voltage at which the converter will operate. A high source inductance can interact with the feedback control loop of the converter. VPT's EMI filters will typically isolate the source and eliminate this problem. In some cases, additional input capacitance may be needed to stabilize the system.

6.1.4 Output Configurations

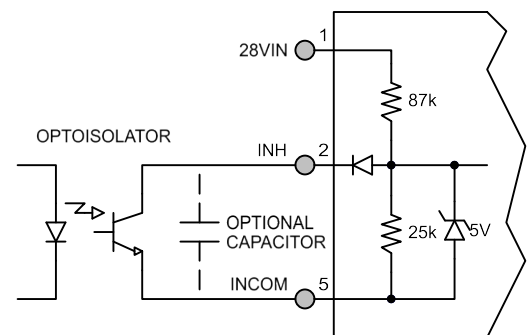
Since the converter is isolated, the output can be configured as a positive or negative voltage. For example, the VXR250-2812S can provide +12 V DC referenced to OUTCOM or -12 V DC referenced to +VOUT.

The outputs of multiple converters can be stacked in series to provide higher voltages. When outputs of multiple modules are stacked, they naturally share the load. For example, two VXR250-2812S converters can be stacked to provide a 24 V DC output at 500 W.

6.2 FUNCTION DESCRIPTIONS

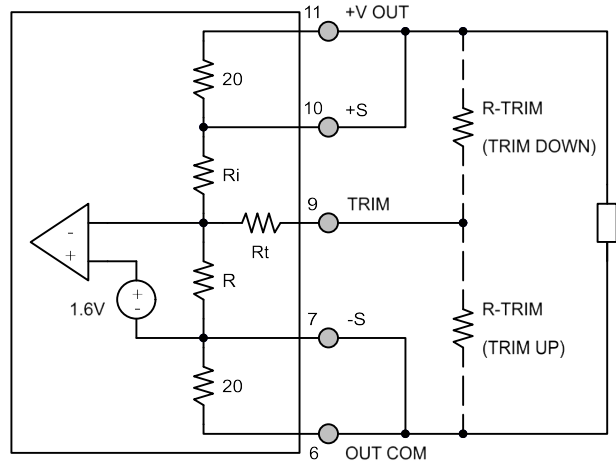
6.2.1 On/Off Control (Inhibit)

The INH (Inhibit) pin is a primary-side control pin referenced to INCOM. The INH pin must be driven using an open collector or open drain configuration. Pulling the INH pin low disables the converter output, removes bias voltage from internal control circuitry, and puts the converter in a state of minimum input current draw. Leaving INH open enables the output, allowing the converter to operate normally. The pin must be pulled below 1.0 V to disable the output. An optional capacitor from INH to INCOM may be used to delay turn-on. The INH pin should be left open if not used.



6.2.2 Adjusting the Output Voltage (TRIM)

The output voltage set point of the converter can be adjusted using the TRIM pin. To adjust the output up, connect the trim resistor from TRIM to OUTCOM. To adjust the output down, connect the trim resistor from TRIM to +VOUT. The maximum trim range is -20% and +10% from nominal. The appropriate resistor values versus the output voltage are given in the table below. Because the TRIM pin can be sensitive to external noise, the trim resistor should be physically located close to the VXR250 converter with short interconnects. The TRIM pin should be left open if not used. When adjusting the output voltage, do not exceed the rated total output power or output current.



VXR250-283R3S		VXR250-2805S		VXR250-2812S		VXR250-2815S		VXR250-2828S	
+Vout (V)	Rtrim (Ω)	+ Vout (V)	Rtrim (Ω)	+ Vout (V)	Rtrim (Ω)	+ Vout (V)	Rtrim (Ω)	+ Vout (V)	Rtrim (Ω)
3.6	24.4k	5.5	10.8k	13.2	9.42k	16.5	8.0k	30.5	9.6k
3.55	30.9k	5.4	15.6k	13	11.49k	16.25	9.8k	30	12.2k
3.5	40.7k	5.3	23.5k	12.8	14.6k	16	12.5k	29.5	16.6k
3.45	57.0k	5.2	39.4k	12.6	19.7k	15.75	17.1k	29	25.4k
3.4	90k	5.1	87k	12.4	29.9k	15.5	26.3k	28.5	51.8k
3.35	188k	5		12.2	59.9k	15.25	54.4k	28	
3.3		4.9	188k	12		15		27.5	854k
3.25	194k	4.8	87k	11.8	414k	14.75	426k	27	418k
3.2	90k	4.7	53k	11.6	199k	14.5	212k	26.5	273k
3.15	55k	4.6	36.4k	11.4	129k	14.25	139k	26	200k
3.1	37.7k	4.5	26.3k	11.2	94k	14	102k	25.5	157k
3.05	27.2k	4.4	19.5k	11	73k	13.75	79.9k	24.5	107k
3	20.3k	4.3	14.7k	10.8	60k	13.5	65.1k	24	91k
2.95	15.4k	4.2	11.1k	10.6	50k	13.25	54.5k	23.5	79k
2.9	11.6k	4.1	8.3k	10.4	42k	13	46.6k	23	70k
		4	6.0k	10.2	37k	12.75	40.4k	22.5	62k
				10	32k	12.5	35.4k		
				9.8	28k	12.25	31.4k		
				9.6	25k	12	28.0k		

6.2.3 Remote Sense (+S, -S)

Remote sensing compensates for voltage drops in the output pins and traces by sensing and regulating directly at the load. The remote sense function can compensate for up to a 10% voltage drop (5% in the positive lead and 5% in the negative lead). The sum of the TRIM up and remote sense compensation cannot exceed 10% such that the voltage at the output terminals of the converter does not exceed 110% of the nominal output voltage. If not used, the user should connect +S to +VOUT and -S to OUTCOM at the pins of the converter.

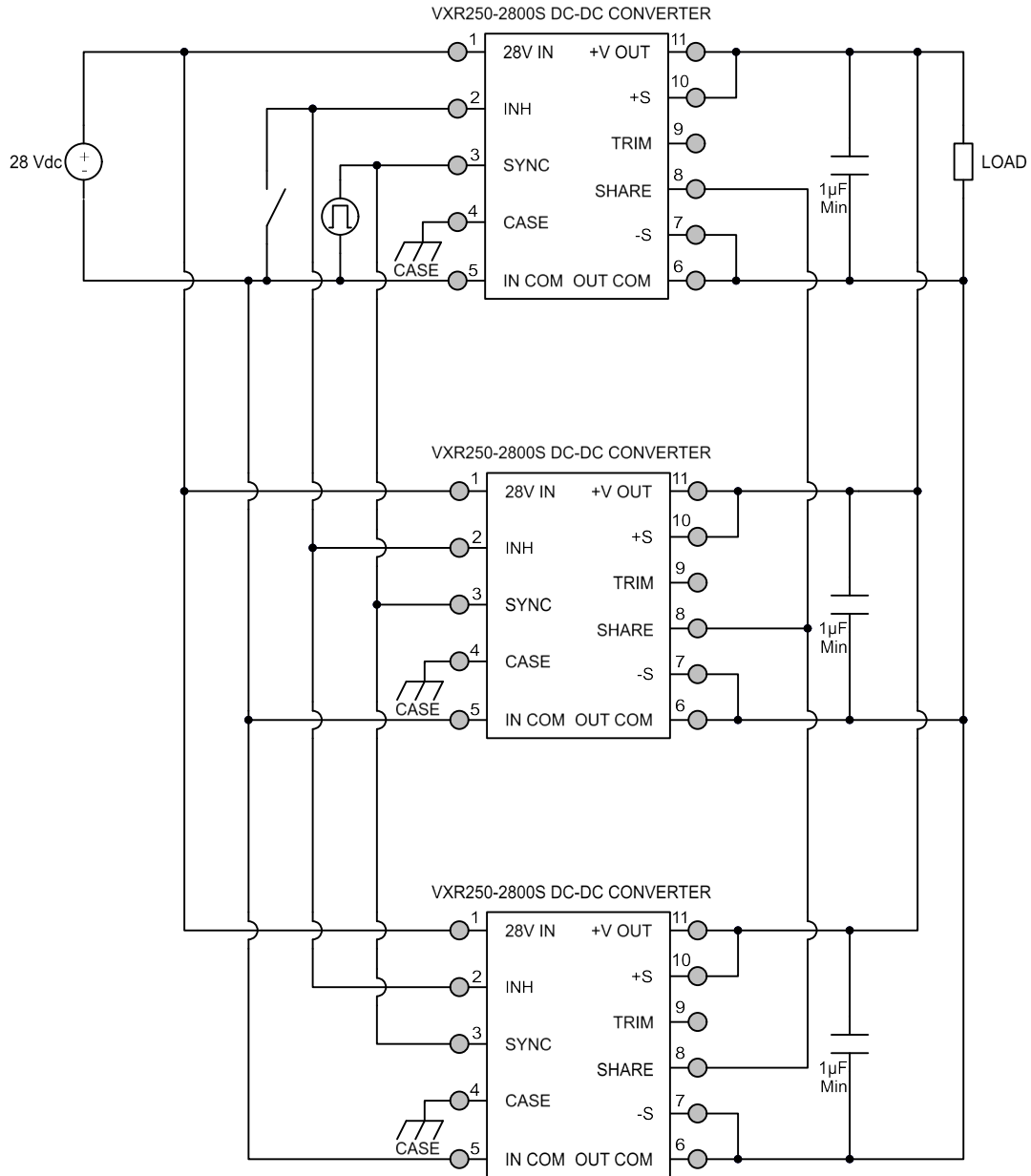
6.2.4 Frequency Synchronization (SYNC)

The VXR250-2800S Series will free run at a switching frequency of approximately 450 kHz, which has been set for optimum converter performance. Frequency synchronization is not necessary unless required by system constraints. The VXR250-2800S Series provides a frequency synchronization input (SYNC) referenced to INCOM.

The SYNC pin can be driven by an external clock. The internal clock and internal power train will operate at the frequency applied to the SYNC pin. The SYNC pin should be driven with a TTL type 5 V square wave signal. The duty cycle of the square wave should be between 40% and 60%. Proper layout and circuit techniques are necessary to prevent noise from being injected into this pin. Synchronized converters should be located physically close together and share a low impedance INCOM connection. The SYNC pin should be connected to INCOM if not used.

6.2.5 Parallel Operation (SHARE)

The VXR250-2800S Series provides a SHARE function for active current sharing among paralleled modules. To enable load sharing, connect a single wire between the SHARE pins of all parallel modules. The SHARE pin can be noise sensitive. Paralleled converters should be located physically close to one another and share a low impedance OUTCOM connection. A symmetrical layout of the output traces will improve share accuracy. Frequency synchronization is not required for parallel operation. The SHARE pin should be left open if not used.



6.3 PROTECTION FEATURES

6.3.1 Input Undervoltage Lockout

The VXR250-2800S Series provides input undervoltage lockout protection. For input voltages below the turn-on voltage, the converter will remain off, drawing minimal current from the source. When the input voltage exceeds the turn-on voltage, the converter will start. The lockout circuit is designed to accept slow ramping input voltage waveforms. The VXR250-2800S circuit provides bias voltage to all secondary control circuits and control amplifiers before the output starts, ensuring a well-controlled start up sequence.

6.3.2 Output Soft Start

The VXR250-2800S Series utilizes an output soft-start function to ramp the output in a controlled manner, eliminating output voltage overshoot and limiting inrush current at turn on. A voltage-mode soft-start ensures the output waveform remains consistent regardless of changes in the load current. The output rise time is approximately 6 ms. The soft-start function is active whether the module is turned on with an application of input voltage or from release of the inhibit pin. Under normal conditions, current drawn from the source during turn-on will not exceed the full-load input current. The turn-on delay time is specified from the application of input voltage (or release of the inhibit pin) until the output reaches 90% of its final value.

6.3.3 Output Overcurrent Protection

The VXR250-2800S Series provides output overcurrent and output short circuit protection. During a load fault condition, a constant output current control circuit reduces the converter duty cycle to limit the output current to approximately 130% of its rated value. The converter will continue to provide constant current into any overload condition. When the output voltage drops below 10% of its nominal value the VXR250 will start a hiccup mode operation. The output will turn on and off at a frequency of approximately 1.6 Hz. This feature reduces the short circuit power dissipation. Recovery is automatic and immediate upon removal of the fault condition. Sustained overload operation can cause excessive power dissipation. Care should be taken to control the operating temperature of the converter in this condition.

6.4 PACKAGE

6.4.1 Package Description

The VXR250-2800S is constructed with an epoxy encapsulated V-SHIELD® package that includes integral metallization for enhanced EMI shielding. The ruggedized package is highly resistant to chemical, solvent and salt environments and is fully compatible with high volume manufacturing processes including wave solder, cleaning solvents, high pressure sprays and aqueous wash processes. The encapsulated converter allows for superior shock and vibration performance in a low-weight package.

6.4.2 Thermal Performance

The VXR250-2800S Series is rated for full power operation at 105 °C. Operation above 105 °C is allowed at reduced power. Specifically, the output power should be derated linearly from full power at 105 °C to half power at 110 °C and to zero power at 115 °C. The operating temperature of the converter is specified on the baseplate or top plate of the converter. The converter is designed to be conduction-cooled, with either the baseplate or top plate mounted to a heat sink, chassis, PCB or other thermal surface.

The DC-DC converter contains many semiconductor components. The maximum temperature rise from junction to case is 20 °C at full load.



7.0 ENVIRONMENTAL SCREENING

Test	Condition
Internal Visual	IPC-A-610, Class 3
Stabilization Bake	MIL-STD-883, Method 1008, Condition B, 125 °C, 24 hours
Temperature Cycling	MIL-STD-883, Method 1010, Condition B, -55 °C to +125 °C, 10 Cycles
Burn In	96 hours at +105 °C
Final Electrical	100% at 25 °C
External Visual	Internal Procedure

8.0 ORDERING INFORMATION

VXR250-	28	05	S
1	2	3	4

(1) Product Series	(2) Nominal Input Voltage	(3) Output Voltage	(4) Number of Outputs
VXR250-	28 28 Volts	3R3 3.3 Volts 05 05 Volts 12 12 Volts 15 15 Volts 28 28 Volts	S Single

Please contact your sales representative or the VPT Inc. Sales Department for more information concerning additional environmental screening and testing, different input voltage, output voltage, power requirements, and source inspection.

9.0 CONTACT INFORMATION

To request a quotation or place orders please contact your sales representative or the VPT, Inc. Sales Department at:

Phone: (425) 353-3010
Fax: (425) 353-4030
E-mail: vptsales@vptpower.com

All information contained in this datasheet is believed to be accurate, however, no responsibility is assumed for possible errors or omissions. The products or specifications contained herein are subject to change without notice. VPT, its logo and tagline are registered trademarks in the U.S. Patent and Trademark Office.

10.0 ADDITIONAL INFORMATION

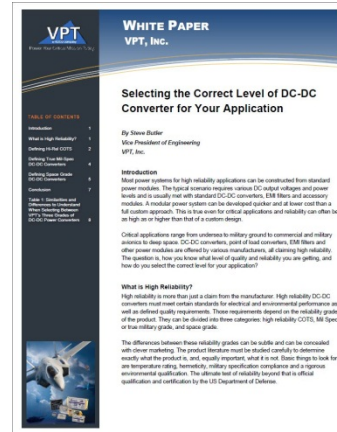
Visit the [VPT website](http://www.vpt-inc.com) for additional technical resources, including:
[Product Catalogs](#)



[Technical Video Labs](#)



[Application Notes and White Papers](#)



Additional Products For [Avionics/Military](#), [Hi-Rel COTS](#), and [Space Applications](#)

