



**APPLICATION NOTE**

Understanding VPT's Datasheets

**DC-DC CONVERTERS AND ACCESSORIES**



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## Introduction

VPT offers a large product line for ground, aerospace, and space applications with various power levels, output voltages, and levels of radiation tolerance or hardening. Once the correct products are selected for your application's power distribution needs, the datasheet can be used to learn more about the capabilities and limitations of the units in your design. The purpose of this application note is to help potential customers determine if VPT products are right for their application. Please note that the limits listed in the datasheet have built-in margin, and a statistical analysis of historical testing data reveals that most if not all the performance metrics are tighter than what is listed.

If your application requires tighter tolerance or if you go outside of the datasheet range, please [contact our sales team](#) to get statistical data or to learn more about the effect of going outside the listed limits. For example, many of VPT's customer applications require a larger output capacitance than is listed in the datasheet. This has resulted in a large amount of custom testing at sometimes an order of magnitude more than the datasheet specification. In short, if your application falls outside of the datasheet limits, contact your sales representative and we will help you learn about the effects of exceeding the datasheet limits will have on the converter's performance.

## Performance Specifications

The performance specifications are broken up into multiple sections, which specify static and dynamic limits as well as general information and post radiation limits if the component is radiation tolerant or hardened. Static parameters focus on constant steady state operation, while dynamic parameters are focused on changes in output voltages due to a sudden change in load or input voltage.

Starting in Figure 1, you can see the absolute maximum ratings for the SVFL2805D. This section goes over the maximum temperature during operation and maximum input voltage for normal operation and transient conditions. It's important that the temperature range is measured directly on the baseplate. For the ESD rating, the SVFL2805D is rated to Class 3A per the Human Body Model specified in MIL-STD-883C, TM3015 which is 4000V - 7999V.

### 3.1 ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings			
Input Voltage (Continuous):	-0.5 V to 40 V	Operating Temperature (Full Load):	-55 °C to +125 °C
Input Voltage (Transient, 1 second):	-0.5 V to 50 V	Storage Temperature:	-65 °C to +150 °C
ESD Rating per MIL-PRF-38534:	3A	Lead Solder Temperature (10 seconds):	270 °C

Figure 1: Absolute Maximum Ratings

Below in Figure 2 you can see more information about the input ratings of the device. This goes over the maximum and minimum input voltages, as well as current drawing in both inhibited states and no loading conditions. The best practice for using the inhibit function is pulling the INH pin to Incom through a BJT or FET and letting the pin float when you want it to turn back on. When inhibited, the output is off and a minimal input current is drawn. As you can see from the typical and maximum current draw results in the lowest power dissipation with a maximum input current of 6mA. INH 2, or the out com referenced inhibit pin, will result in less than half of the no load current draw, but will have a much higher power dissipation over using the primary side inhibit. When INH 1 is pulled to in com, the VCC on the primary side will be pulled down as well as the UVLO input, which stops the FET from switching and VCC secondary from being powered. When INH2 is pulled down, the feedback for the PWM is pulled down which prevents the main FET from switching but VCC primary and VCC secondary are in

regulation. During a no load non-inhibited state, the output voltage will be in regulation and there will be zero output current. Turn on delay can be increased by adding capacitance between either of the INH pins and their respective grounds.

The input current consists of two parts, a DC portion that depends on the load current and input voltage and AC current that is a result of the power stage switching. The ripple current is defined as the AC portion of the input. This value will decrease with lower loads and higher input voltages, the specification in the datasheet is taken at nominal input voltage. The last information covered in this section is the under voltage lockout (UVLO) thresholds. Please note that while the turn-on and turn-off voltages have some overlap, there will always be 0.5 V-1 V hysteresis between the two. More specifically, the converter will turn off at 0.5 V-1 V lower than the turn on threshold. This is to prevent the unit from chattering on and off rapidly. This is dependent on the input line resistance from the source to the converter and the power requirements. The turn on voltage drop could cause false triggering of the UVLO circuit.

### 3.2 PERFORMANCE SPECIFICATIONS

T<sub>case</sub> = -55 °C to +125 °C, V<sub>in</sub> = +28 V ± 5%, Full Load<sup>1</sup>, Unless Otherwise Specified

Parameter	Conditions	SVFL2805D			SVFL2812D			Units
		Min	Typ	Max	Min	Typ	Max	
<b>INPUT</b>								
Voltage	Continuous	16	28	40	16	28	40	V
	Transient, 1 sec <sup>4</sup>	-	-	50	-	-	50	V
Current	INH 1 < 1.5 V	-	1	6	-	1	6	mA
	INH 2 < 1 V	-	40	70	-	40	70	mA
	No Load	-	75	160	-	90	160	mA
Ripple Current	20 Hz to 10 MHz	-	30	80	-	35	80	mApp
Undervoltage Lockout	Turn-On	14.5	-	16	14.5	-	16	V
	Turn-Off <sup>4</sup>	13.5	-	15.5	13.5	-	15.5	V

Figure 2: Input

The next section in the datasheet goes over static output parameters and can be seen below in Figure 3. Beginning with the output voltage, acceptable ranges for the positive and negative rail for room temperature and the temperature limits are listed. Please note that these measurements should be taken as close to the pins of the converter as possible. These limits do not include transient conditions or cross-regulation error, caused by uneven loading, and just include the steady state ranges. The power and current sections are broken up into the total or individual output for dual converters. It's important to ensure that your design follows both limits so that either rail is not over loaded.

Just as the input current ripple, the output voltage ripple is broken into two parts, a DC portion that is the voltage model and an AC portion that is a result of the power stage switching. The measurement is limited to frequency components between 20Hz to 10 MHz and specified at a nominal input voltage. The output voltage ripple measurement is difficult to measure because it consists of a fundamental frequency which is the switching frequency and higher harmonics because of the fast switching transitions. For more information on the ripple voltage measurement techniques and how to reduce it, refer to the [VXR Series Output Voltage Ripple Reduction Application Note](#) on VPT's website.

The line and load regulation mentioned in this section are not referring to fast transitions in input voltage or load current, that is covered in the dynamic portion of the datasheet. In this section the line and load regulation is the change in output voltage with slow transitions in input voltage and load current.. The combined line and load regulation account for any error in the DC output voltage regulation due to load current, temperature, and V<sub>in</sub> with margin built into account for difference between components. The

cross-regulation section is stating the error in voltage regulation on the negative rail (-Vout) given an unbalanced load of 30 % on one output and 70 % on the other. Cross regulation will be discussed in detail in the performance curve section of this application note.

The last spec in this section is the load fault power dissipation. This states the maximum power dissipated by the converter in the worst-case load fault condition, a shorted output. In between the max load and short circuit is called overload, and it's defined as when the output voltage drops to 90% of the nominal value. The overload and short circuit conditions are controlled by a current control loop that will take over the voltage control loop when the current hits the set limit. For dual converters the current from both rails are summed, so over current protection will not take over if one of the outputs is overloaded and the other is left open.

OUTPUT STATIC								
Voltage	+Vout, Tcase = 25 °C	4.95	5	5.05	11.88	12	12.12	V
	+Vout, Tcase = -55 °C to +125 °C	4.925	5	5.075	11.82	12	12.18	V
	-Vout, Tcase = 25 °C	4.80	5	5.20	11.8	12	12.20	V
	-Vout, Tcase = -55 °C to +125 °C	4.75	5	5.25	11.52	12	12.48	V
Power <sup>2,6</sup>	Total	0	-	100	0	-	110	W
	Either Output	0	-	70	0	-	77	W
Current <sup>2,6</sup>	Total	0	-	20	0	-	9.17	A
	Either Output	0	-	14	0	-	6.4	A
Ripple Voltage	20 Hz to 10 MHz	-	15	80	-	25	80	mVpp
Line Regulation	+Vout, VIN = 16 V to 40 V	-	2	20	-	2	20	mV
	-Vout, VIN = 16 V to 40 V	-	10	200	-	10	200	mV
Load Regulation <sup>7</sup>	+Vout, No Load to Full Load	-	10	100	-	2	120	mV
	-Vout, No Load to Full Load	-	55	200	-	40	200	mV
Cross Regulation, -Vout	+Vout: 30% load, -Vout: 70% load	-	260	450	-	220	450	mV
	+Vout: 70% load, -Vout: 30% load	-	260	450	-	220	450	mV
Load Fault Power Dissipation	Overload <sup>4</sup>	-	-	50	-	-	50	W
	Short Circuit	-	-	50	-	-	50	W

Figure 3: Output Static

This section of the datasheet is the dynamic conditions of the converter. Below in Figure 4, you can see the maximum output voltage variation caused by different transient conditions. The line step and load step list the limits of the amplitude of the transient in output voltage when given the step change in either input voltage or output current. For the load transient, each output is stepped from half load to full load while the other rail is held at a constant 50% load. Please [contact the sales team](#) if you would like oscilloscope plots of the output voltage transient for your applications. The two main parts of transient response are amplitude, which is the amount that the output voltage varies from its set point, and settling time, which is the amount of time the output voltage is more than 1% from its regulation set point. It should be noted that for VPTs dual output hybrid converters, a load step on one rail, or a line step on the input, will result in a transient on both rails. VPTs dual output VXR products have independently regulated outputs, which means that a load step on one rail will not result in a transient on the other rail, but a line step will still result in a transient on both. The turn on delay is the total time from when the input voltage is above the turn on setpoint and the output is within 1% of its final regulation setpoint. Load current doesn't affect the turn on time but may change the shape of the turn on waveform. Adding output capacitance can slow down the turn on time slightly.

To determine the worst-case voltage regulation in your specific application, you must start with the high or low limits listed in the voltage section plus the line and load regulation plus the worst cross regulation error. This is the worst-case steady state voltage. From here you can add on any kind of voltage transient from the worst-case line or load step. It's important to get an accurate understanding of the slew rate for both steps to make sure your worst-case regulation isn't unrealistically high. It should also

be mentioned that the worst-case line, load, and voltage regulation all at once and all in the same direction is highly improbable.

OUTPUT DYNAMIC								
Load Step, Half to Full Load, Either Output	Output Transient	-	130	400	-	260	500	mVpk
	Recovery <sup>3</sup>	-	200	500	-	140	500	μs
Line Step <sup>4</sup> , Vin = 16V to 40 V	Output Transient	-	300	600	-	600	1200	mVpk
	Recovery <sup>3</sup>	-	300	500	-	300	500	μs
Turn-On, Vin = 0 to 28 V	Delay	-	5	20	-	5	20	ms
	Overshoot	-	0	25	-	0	50	mVpk

Figure 4: Output Dynamic

For dual output converters, load step is tested on one output at a time from 25-50% total load while the other output is held at 50% total load. These percentages represent the total output power of both outputs, and not the maximum output power for each rail. Below in Figure 5, you can see the load step from 50% to 25% on the +Vout and the effect it has on the -Vout. The first spike at roughly 0 ms is from the 2 A-4 A load step and the second spike at roughly 3 ms is from the 4 A-2 A load step. The current and voltage are shown for both rails to make it easier to understand the testing conditions. In these plots, the transients go in the opposite direction and that is because both ground references to the oscilloscope were on Outcom. Two important things to take note of is that the transient is on both the positive and negative outputs, even though only the positive rail is stepped. The differences in the DC settling point are caused by cross regulation. When +Iout is smaller than -Iout, -Vout settles above +Vout where the opposite is true when they are at the same load.

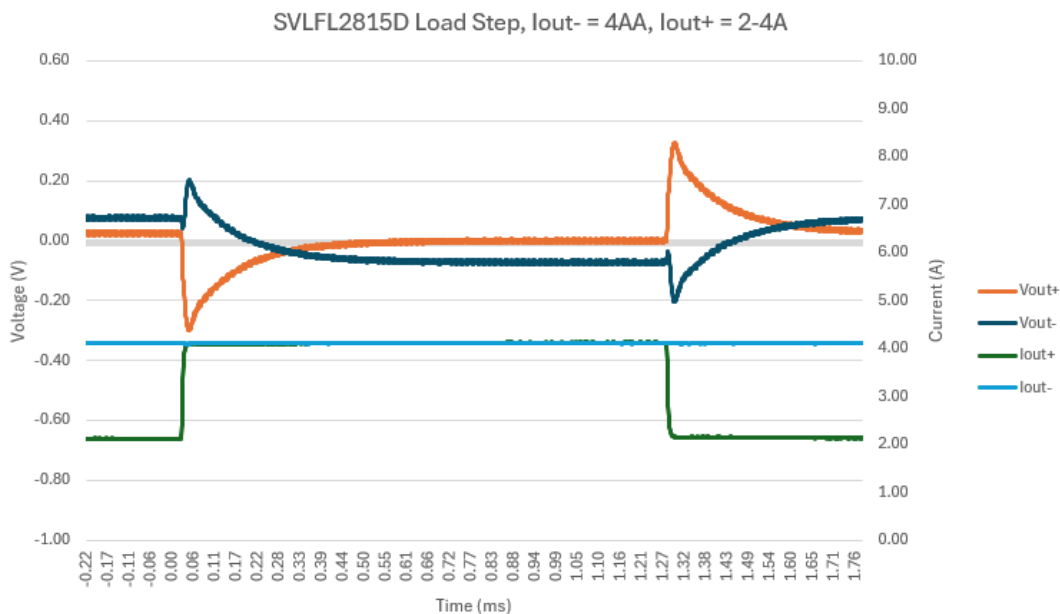


Figure 5: 50% load step on +Vout of a SVLFL2815D, Iout+ = 2-4A, Iout- = 4A

To better examine this response, the same sized load step was tested with different steady state conditions and can be seen below in Figure 6. For this load step, the negative rail was held at 10% and the positive rail stepped from 10-60% load. The voltage transient on the positive rail grew by roughly 10 mV and the transient on the negative output is almost nonexistent. Cross regulation is much more

evident in this example due to a larger percentage difference between loads during the two loading conditions. The cross regulation for this example, which is about 75 mV, accounts for more of the regulation error than the load step transient. This is a good example of how important it is to understand how various loading conditions can completely change the response of the converter to the same load step.

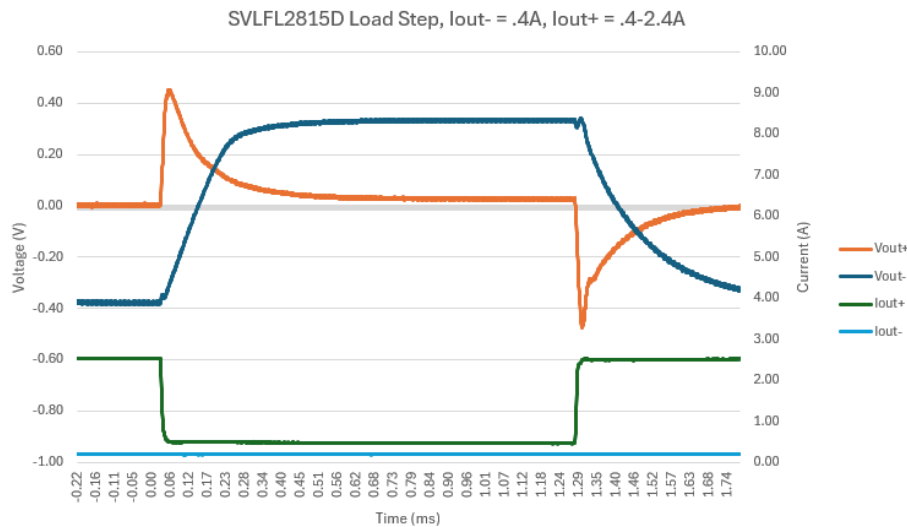


Figure 6: Load step on a SVLFL2815D.

Like load steps, line steps create transients on both outputs. Figure 7 shows the measured output transients on both outputs given a 16 V-40 V input voltage step. The DC offset between the two outputs is not cross regulation, because both rails are under a 2 A load. This offset is caused by the difference in line regulation between the outputs. Please note that the transients in Figures 5-7 were taken with both Vout measurements referenced to outcom. If the rails were stacked and the measurement was taken from +Vout referenced to -Vout, these transients would be in the same direction and add together.

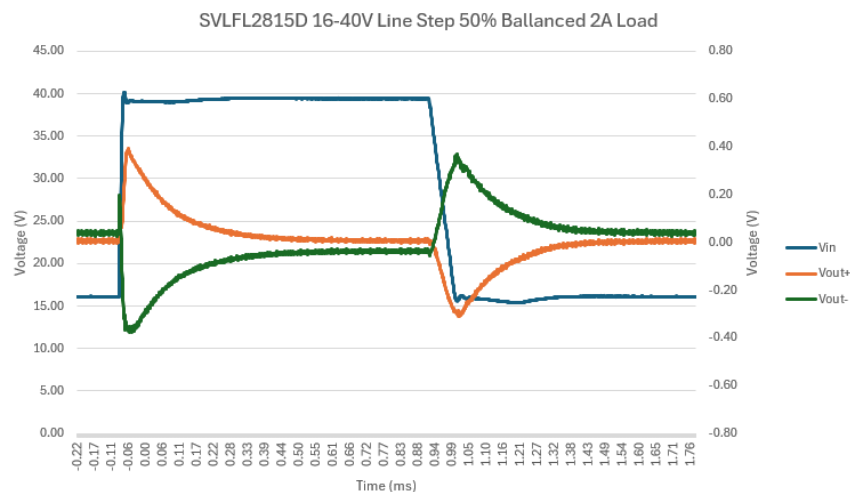


Figure 7: Line step on a SVLFL2815D. (The left y axis is for Vin and the right y axis is for Vout).

The next section covers limits and expected values for the INH, TRIM, SHARE, and SYNC functions. The TRIM function allows the output voltage to be adjusted between -20 % and +10 % of the nominal value. There is a table in every datasheet that goes over what resistor value you need and where to connect it to get the desired output voltage. The SHARE function should be used whenever two converter outputs are connected in parallel to ensure proper load sharing. Lastly, the SYNC function can be used to synchronize the switching frequencies of various DC- DC converters. This is done to remove any beat frequencies, or the result of adding two periodic waveforms with different frequencies, at the cost of increasing the noise spike at the switching frequency.

A specific example of this can be seen in Figure 8. The INH Output Inhibited values let you know how low you must pull the inhibit pin voltage before the converter is fully inhibited. The INH Output Enabled values show you the typical voltage range of the inhibit pins when they are left floating. The voltage trim range and sync frequency range are the maximum limits of these functions, and going outside of these ranges may result in a converter malfunction or failure. Lastly, the Share Pin Voltage shows the normal operating range of this function.

FUNCTION								
INH 1 Pin Input <sup>4</sup>	Output Inhibited	0	-	1.5	0	-	1.5	V
INH 2 Pin Input <sup>4</sup>	Output Inhibited	0	-	1	0	-	1	V
INH 1 Pin Open Circuit Voltage <sup>4</sup>	Output Enabled	10.5	-	15	10.5	-	15	V
INH 2 Pin Open Circuit Voltage <sup>4</sup>	Output Enabled	4	-	12	4	-	12	V
Voltage Trim Range		-20	-	10	-20	-	10	%
SHARE Pin Voltage <sup>4</sup>		2	-	4	2	-	4	V
SYNC Frequency Range		500	-	600	500	-	600	kHz

Figure 8: Function

The performance specifications section goes over some general information about the series, and an example can be seen below in Figure 9. The efficiency varies with temperature, load, and input voltage and will be covered in more detail in the Performance Curves section of this paper, but this provides a good estimate of efficiency at nominal input voltage, full load and over the full temperature range. The capacitive load specification is the maximum amount of capacitance that can be added to the output to guarantee stability. If your program requires more than the maximum output capacitance contact sales. The over-current protection feature will ensure that even if a very large capacitive load is on the output, the converter will not over dissipate and damage itself.

For stability concerns, many customers have requested custom testing at their specific load, capacitance load, input voltage, and sometimes temperature. The higher power units like the DVFL2800S have been tested beyond 5 mF of capacitance load while still maintaining adequate control loop margin, and many of the lower power units have also been tested well above their capacitive load rating while still maintaining a good control loop margin. If your application requires a much higher capacitive load then it is listed in the datasheet, please contact the sales team and request stability plots at your system requirements

The switching frequency of VPT converters are set by internal component values, and variations in those components can cause variations in the switching frequency. Temperature and aging are also factors, because they change the capacitor value. The MTBF, or Mean Time Between Failure, shows how long on average the converter can run before experiencing failure this is calculated from MIL-HDBK-217. A FMECA, Failure Mode Effect and Criticality Analysis, goes into detail about what kind of

failures can occur and how likely the converter is to fail in that state. These failure states are only expected after the unit has operated for the entire MTBF, which in this case is 673,000 hours.

### 3.2 PERFORMANCE SPECIFICATIONS (CONTINUED)

Tcase = -55 °C to +125 °C, Vin = +28 V ± 5%, Full Load<sup>1</sup>, Unless Otherwise Specified

Parameter	Conditions	SVFL2805D			SVFL2812D			Units
		Min	Typ	Max	Min	Typ	Max	
<b>GENERAL</b>								
Efficiency		73	79	-	79	85	-	%
Capacitive Load <sup>4</sup>		-	-	500	-	-	500	µF
Switching Frequency		425	525	600	425	525	600	kHz
Isolation	500 V DC, Tcase = 25 °C	100	-	-	100	-	-	MΩ
Weight	Standard and optional side-flanged	-	-	88	-	-	88	g
MTBF (MIL-HDBK-217F) <sup>8</sup>	SF @ Tcase = 55 °C	-	673	-	-	673	-	kHr

Figure 9: General

The last section in the Performance Specification section of VPT datasheets is the post-rad end of life limits and can be seen in Figure 10. These values will show the worst-case scenario for Total Ionizing Dose, Displacement Damage, and component degradation. If the specific application does not take the unit all the way to its end of life and exposes it to less than the total TID rating of the part, the input ripple and output voltage regulation will be much closer to the desired value.

POST-RAD END-OF-LIFE LIMITS <sup>5</sup>								
Input Ripple Current		-	-	140	-	-	140	mApp
Output Voltage	+Vout, Tcase = -55 °C to +125 °C	4.89	-	5.10	11.66	-	12.28	V
	-Vout, Tcase = -55 °C to +125 °C	4.715	-	5.275	11.36	-	12.58	V

Figure 10: Post-Rad End-Of-Life

## Performance Curves

The two main performance curves in VPT datasheets are efficiency and cross regulation if the converter has multiple outputs with only one being regulated. Efficiency changes over three main variables which are input voltage, output power, and temperature. VPT datasheets show how efficiency changes over output power at three different input voltages for all the output voltages in that family. Requests can be made to do these measurements over temperature as well as input voltage and load. Below in Figure 11 you can see the typical efficiency plots for the [SVRTR2800D](#) series. Typically, a lower input voltage will provide higher efficiency at a lower power output while the ideal input voltage of 28V provides the highest efficiency at maximum load. There are many factors that affect efficiency, but this tradeoff is mostly because there are VI as well as I<sup>2</sup>R losses along with losses that stay constant across input voltage like switching loss. Simply put, some losses will be greater at higher current and lower voltage, and some losses will be greater at higher voltage and lower current and the more the losses are evenly matched the greater the efficiency will be.

#### 4.1.4 SVRTR2815D Efficiency (Typical, 25 °C)

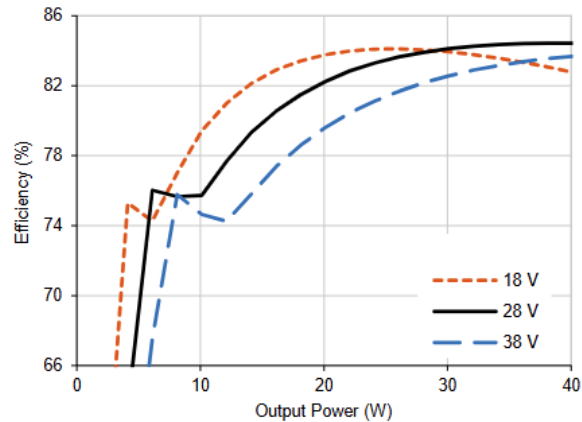


Figure 11: Efficiency curves for the SVRTR2800D

Cross regulation is the result of equal power being delivered to uneven loads. The VXR dual output units do not have cross regulation issues because both outputs are independently regulated. In the dual output hybrid, VSC, and VPT series, only +Vout is regulated, and -Vout will change depending on the loading conditions of the two outputs. This can be seen better below in Figure 12, which shows the cross-regulation curves for the [SVRTR2815D](#). These plots show how the -Vout changes with the load on the negative output for 4 different +Vout loads. Please note that when the -Vout crosses the ideal output voltage the -Vout and the +Vout have matching loads. For example, the black line on the 5V output plot, representing a 3-amp load on +Vout, crosses -5V on the Y axis when -Iout is also 3 amps on the X axis.

#### 4.2.3 SVRTR2815D Cross-Regulation (Typical, 25 °C)

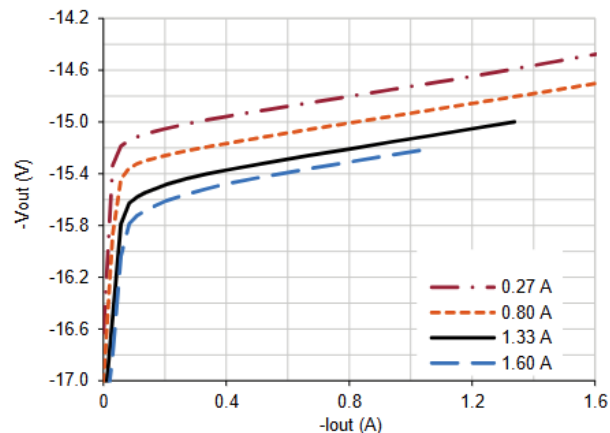


Figure 12: Cross regulation curves for the SVRTR2800D

The SVRTR series uses a flyback topology which is like most others in that, the output voltage is purely determined by the duty cycle and input voltage. Since the output rails are two windings on the same transformer, they should have the same voltage. The main reason they don't is that the losses and voltage drop across the inductors and diodes in the output increase with a larger current flowing out of the output. The main switching FET on the primary side is regulated off the positive rail, so any changes in losses based on the +Vout output power will be accounted for. And if the losses on the -Vout are the same as the losses on the +Vout, the loads are matched and there will be no cross regulation. But if +Iout is at the maximum output current and -Iout is at a very low output current, the duty cycle will

increase to account for the maximum drop in the positive rail which will result in a larger voltage on the negative rail. An example of how to read one of these plots can be seen below in Figures 13 and 14.

#### 4.2.3 SVRTR2815D Cross-Regulation (Typical, 25 °C)

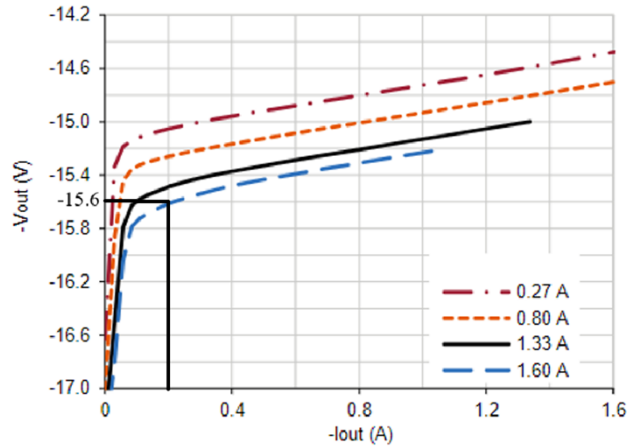


Figure 13: Cross Regulation example 1

For the first example, as seen in the previous page in Figure 12, we will look at a [SVRTR2815D](#) with a -Iout of 2A and a +Iout of 1.6A. The first step is to find the correct dotted line for your +Iout, in this case it's the dashed blue line. From here, find the -Iout on the x axis, and lastly find what corresponding -Vout which is -15.6V.

#### 4.2.2 SVRTR2807D Cross-Regulation (Typical, 25 °C)

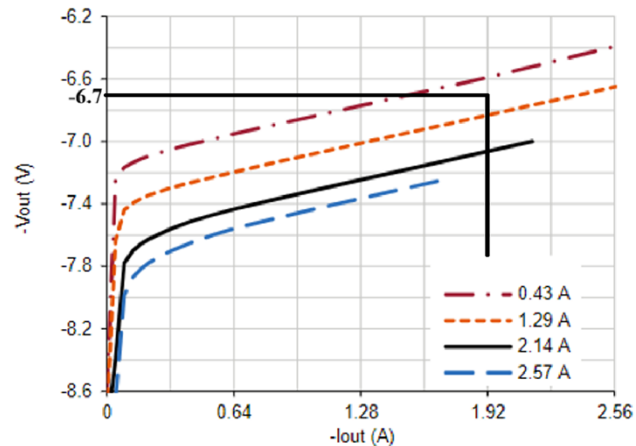


Figure 14: Cross Regulation example 2

The second example, seen above in Figure 14, we will look at a [SVRTR2807D](#) with a -Iout of 1.92 A and a +Iout of .86 A. This one is a bit more difficult because the chosen value is in between two of the dotted lines, but the steps remain the same. First, find the right dotted line for your +Iout, or approximately where the line would be if it's not one of the four listed. Then find the right -Iout on the x axis and finally find the corresponding -Vout which is -6.7 V. If you want to know the exact value of your cross regulation, please contact the sales team. The cross regulation may change slightly from unit to unit, but the main factors will always be the -Iout and +Iout loads.

## Conclusion



Interpreting a datasheet accurately is essential for the successful integration of DC-DC converters into high-reliability applications. Each section, including static and dynamic performance specifications, efficiency, and cross regulation curves, provides critical insight into how the device will behave under different operating conditions. By understanding these parameters and their implications, designers can better predict system performance, ensure compliance with electrical and thermal limits, and avoid common pitfalls during development. For further clarification or application-specific data, VPT's technical and sales teams are available to assist with tailored support and additional documentation. For more information on the General Information, Function Descriptions, and Protection Features, please refer to the [User Guide for VPT DC-DC Converters](#) app note on the VPT website.

## Contact Information

For further information about any of VPT's products, policies, or programs contained herein, or to request a quotation or place orders please contact your sales representative or the VPT Inc. Sales Department at:

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