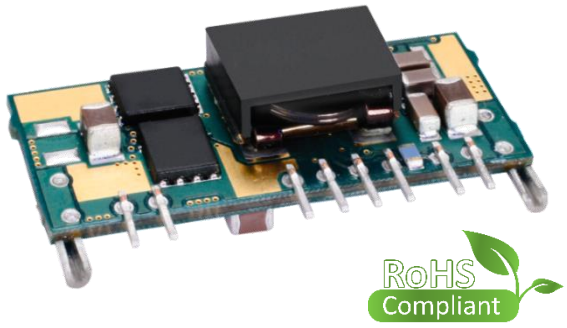
YEV09T20

20 A DC-DC POL Converter

4.5 - 13.8 V Input; 0.59 - 5.1 V Output



Bel Power Solutions point-of-load converters are recommended for use with regulated bus converters in an Intermediate Bus Architecture (IBA). The YEV09T20-0 non-isolated DC-DC point of load (POL) converter delivers up to 20A of output current in an industry-standard single-in-line (SIP) through-hole package. The YEV09T20-0 POL converter is an ideal choice for Intermediate Bus Architectures where point of load conversion is a requirement.

Operating from a 4.5-13.8V input the POL converter provides an extremely tightly regulated programmable output voltage of 0.59V to 5.1V. The POL converter offers exceptional thermal performance, even in high temperature environments with minimal airflow. This performance is accomplished through the use of advanced circuit solutions, packaging and processing techniques. The resulting design possesses ultra-high efficiency, excellent thermal management, and a slim body profile that minimizes impedance to system airflow, thus enhancing cooling for both upstream and downstream devices. The use of automation for assembly, coupled with advanced power electronics and thermal design, results in a product with extremely high reliability.

Key Features

- RoHS lead free and lead-solder-exempt products are available
- High efficiency synchronous buck topology
- Low noise fixed frequency operation
- Wide input voltage range: 4.5V–13.8V
- High continuous output current: 20A
- Programmable output voltage range: 0.59V–5.1V
- Overcurrent, and output overvoltage protections with automatic restart
- Remote differential output voltage sense
- Power Good signal
- Enable input
- Start up into prebiased load
- No minimum load requirements
- High MTBF of 64 million hours
- Industry standard size through-hole single-in-line package and pinout: 1.45 x 0.61 x 0.425 inches (36.8 x 15.5 x 6.08 mm)
- Wide operating temperature range: 0 to 70°C
- UL94 V-0 flammability rating
- Safety approved to UL/CSA 62368-1 and EN/IEC 62368-1

Applications

- Low voltage, high density systems with Intermediate Bus Architectures (IBA)
- Point-of-load regulators for high performance DSP, FPGA, ASIC, and microprocessors
- Desktops, servers, and portable computing
- Broadband, networking, optical, and communications systems

Benefits

- One part that covers many applications
- Reduces board space, system cost and complexity, and time to market

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1. ABSOLUTE MAXIMUM RATINGS

Stresses in excess of the absolute maximum ratings may cause performance degradation, adversely affect long-term reliability, and cause permanent damage to the converter.

PARAMETER	CONDITIONS / DESCRIPTION	MIN	MAX	UNITS
Input Voltage	Continuous	-0.3	15	VDC
Ambient Temperature Range	Operating	0	70	°C
Storage Temperature (Ts)		-55	125	°C
Case Temperature (Tc)	Measured on MOSFETs Q107/Q120		125	°C

2. ENVIRONMENTAL AND MECHANICAL SPECIFICATIONS

PARAMETER	CONDITIONS / DESCRIPTION	MIN	NOM	MAX	UNITS
Weight			7		grams
MTBF	Calculated Per Telcordia Technologies SR-332, Method I Case 1, 50% electrical stress, 40°C ambient temperature		64		MHrs
Lead Plating	YEV09T20-0 and YEV09T20-0G		100% Matte Tin		

3. ELECTRICAL SPECIFICATIONS

Specifications apply at the input voltage from 4.5V to 13.8V, output load from 0 to 20A, output voltage from 0.59V to 5.1V, 22µF external output capacitor, and ambient temperature from 0°C to 70°C unless otherwise noted.

3.1 INPUT SPECIFICATIONS

PARAMETER	CONDITIONS / DESCRIPTION	MIN	NOM	MAX	UNITS
Input voltage (V_{IN})	0.59 V ≤ V_{OUT} ≤ 3.63 V 3.64 V ≤ V_{OUT} ≤ 5.1 V	4.5 6.5	12 12	13.8 13.8	VDC
Undervoltage Lockout Turn On Threshold	Input Voltage Ramping Up	4.1	4.3	4.5	VDC
Undervoltage Lockout Turn Off Threshold	Input Voltage Ramping Down	3.9	4.1	4.3	VDC
Standby Input Current	V_{IN} = 12 V, POL is disabled via ON/OFF		20		mADC
Input Reflected Ripple Current Peak-to-Peak	BW = 5 MHz to 20 MHz, L_{SOURCE} = 1 µH, See Figure 21 for setup		60		mA

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3.2 OUTPUT SPECIFICATIONS

PARAMETER	CONDITIONS / DESCRIPTION	MIN	NOM	MAX	UNITS
Output Voltage Range (V_{OUT})	Programmable with a resistor between TRIM & GND pins	0.59		5.1	VDC
Output Voltage Setpoint Accuracy, $V_{OUT} \geq 1$ V	V_{IN} = 12 V, I_{OUT} = $I_{OUT\ MAX}$, 0.1% trim resistor, room temperature	-1.0		1.0	%V_{OUT}
Output Voltage Setpoint Accuracy, $V_{OUT} < 1$ V	V_{IN} = 12 V, I_{OUT} = $I_{OUT\ MAX}$, 0.1% trim resistor, room temperature	-10		10	mVDC
Line Regulation, $V_{OUT} \geq 2.5$ V	$V_{IN\ MIN}$ to $V_{IN\ MAX}$			0.2	%V_{OUT}
Load Regulation, $V_{OUT} \geq 2.5$ V	0 to $I_{OUT\ MAX}$			0.4	%V_{OUT}
Line Regulation, $V_{OUT} < 2.5$ V	$V_{IN\ MIN}$ to $V_{IN\ MAX}$			5	mVDC
Load Regulation, $V_{OUT} < 2.5$ V	0 to $I_{OUT\ MAX}$			10	mVDC
Output Voltage Regulation	Over operating input voltage, resistive load, and temperature conditions until the end of life	-2.0		2.0	%V_{OUT}
Output Voltage Peak-to-Peak Ripple & Noise, BW = 20 MHz, Full Load	V_{IN} = 12 V, V_{OUT} = 1.2 V V_{IN} = 12 V, V_{OUT} = 3.3 V V_{IN} = 12 V, V_{OUT} = 5.0 V		10 15 20	25 40 50	mV mV mV
Dynamic Regulation Peak Deviation Settling Time	V_{IN} = 12 V, V_{OUT} = 3.3 V 50 - 10% load step, Slew rate 1A/µs, to 10% of peak deviation		 200 50	 250 200	 mV µs
Efficiency V_{IN} = 12 V Full Load Room temperature	V_{OUT} = 0.6 V V_{OUT} = 0.8 V V_{OUT} = 1.2 V V_{OUT} = 1.5 V V_{OUT} = 1.8 V V_{OUT} = 2.5 V V_{OUT} = 3.3 V V_{OUT} = 5.0 V		74 80 84 85 87 91 93 94		% % % % % % % %
Switching Frequency			500		kHz
Output Current (I_{OUT})	$V_{IN\ MIN}$ to $V_{IN\ MAX}$	0		20	ADC
Turn-On Delay Time[1] POL is Enabled	ON/OFF pin is pulled high From V_{IN} = $V_{IN\ MIN}$ to V_{OUT} = 0.1*$V_{OUT.SET}$		0.9		ms
Turn-On Delay Time[2] POL is Disabled. V_{IN} = 12 V	From ON/OFF pin changing its state from low to high until V_{OUT}=0.1*$V_{OUT.SET}$		0.5		ms
Rise Time[2] C_{OUT} = 0 µF, Resistive Load	From V_{OUT} = 0.1*$V_{OUT.SET}$ to V_{OUT} = 0.9*$V_{OUT.SET}$		1.0		ms
Admissible Output Capacitance	I_{OUT}=$I_{OUT\ MAX}$, Resistive load, ESR>1mΩ			2800	µF

3.3 PROTECTION SPECIFICATIONS

PARAMETER	CONDITIONS/DESCRIPTION	MIN	NOM	MAX	UNITS
Output Overcurrent Protection					
Type			Auto-Restart		
Inception Point		120	170	200	%I_{OUT}
Output Short Circuit Current (RMS value)	V_{OUT} = 3.3 V, R_{OUT} < 0.01 Ω		5		A
Output Overvoltage Protection					
Type			Auto-Restart		
Threshold	I_{OUT} = $I_{OUT\ MAX}$, room temperature	112	115	118	%$V_{O.SET}$
Power Good Signal (PGOOD pin)					
Logic	V_{OUT} is inside the PG window V_{OUT} is outside the PG window		High Low		N/A
Low Output Voltage	I_{SINK} = 5 mA			0.35	VDC
High Output Voltage	I_{SOURCE} = 2 mA	2.4		6	VDC
Sink Current	PGOOD is low			10	mADC

[1] Total start-up time is the sum of the turn-on delay time and the rise time

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3.4 FEATURE SPECIFICATIONS

PARAMETER	CONDITIONS / DESCRIPTION	MIN	NOM	MAX	UNITS
Enable (ON/OFF pin)					
ON/OFF Logic	Positive (enables the output when ON/OFF pin is open or pulled high)				
ON/OFF High Input Voltage	POL is ON	2.4		5.5	VDC
ON/OFF High Input Current	POL is ON			1.0	mADC
ON/OFF Low Input Voltage	POL is OFF	-0.3		0.4	VDC
ON/OFF Low Input Current	POL is OFF			0.55	mADC
Remote Voltage Sense (+VS and –VS pins)					
Voltage Drop Compensation[2]				200	mV

4. TYPICAL PERFORMANCE CHARACTERISTICS

4.1 EFFICIENCY CURVES

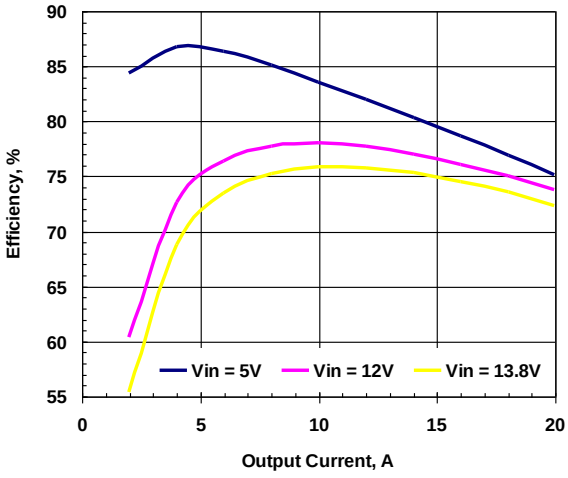


Figure 1. Efficiency vs. Load. Vout=0.6V

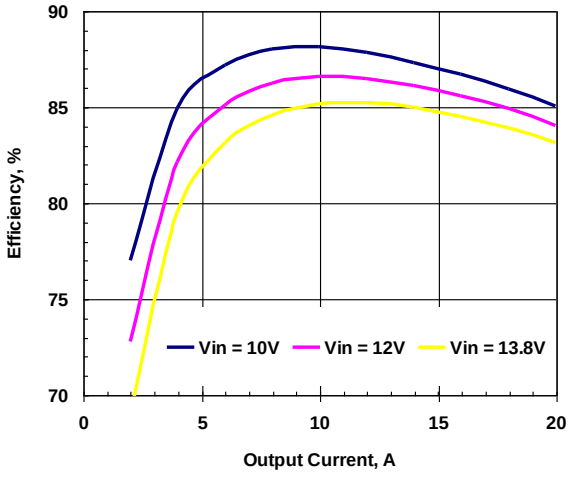


Figure 2. Efficiency vs. Load. Vout=1.2V

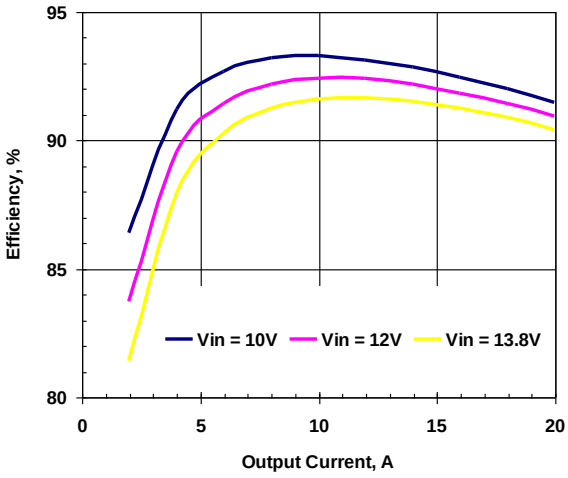


Figure 3. Efficiency vs. Load. Vout=2.5

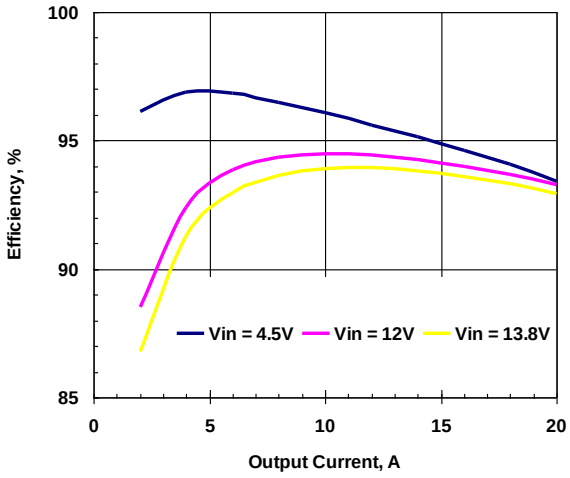


Figure 4. Efficiency vs. Load. Vout=3.3V

[2] The output voltage measured directly between Vout and GND pins shall never exceed 5.1V

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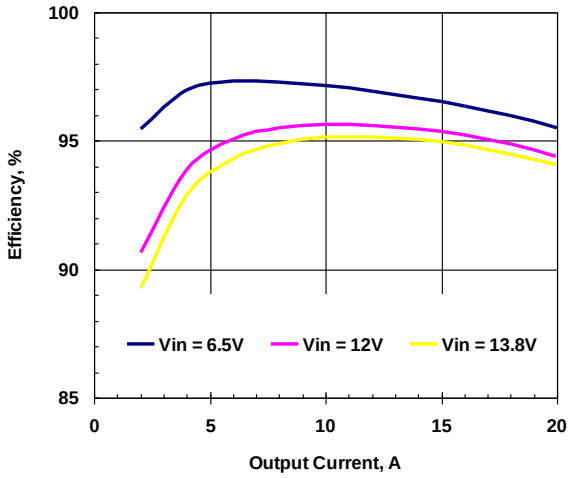


Figure 5. Efficiency vs. Load. Vout=5.0V

4.2 TURN-ON CHARACTERISTICS

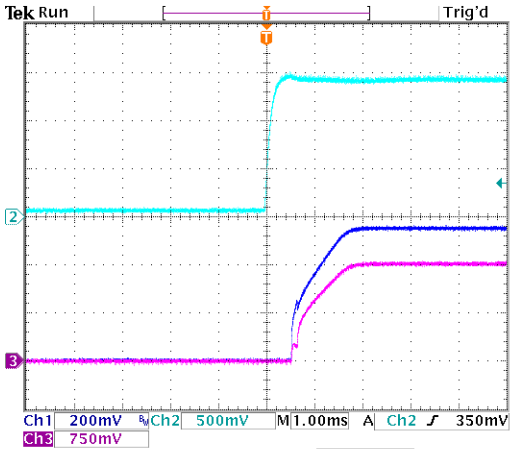


Figure 6. Typical Start-Up Using Remote On/Off (Vo = 0.6Vdc, Io=20A). Ch1 – Vout, Ch2 – ON/OFF, Ch3 - Iout

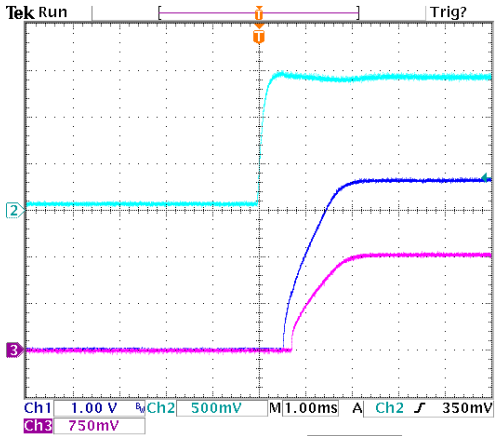


Figure 7. Typical Start-Up Using Remote On/Off (Vo = 3.3 Vdc, Io=20A). Ch1 – Vout, Ch2 – ON/OFF, Ch3 - Iout

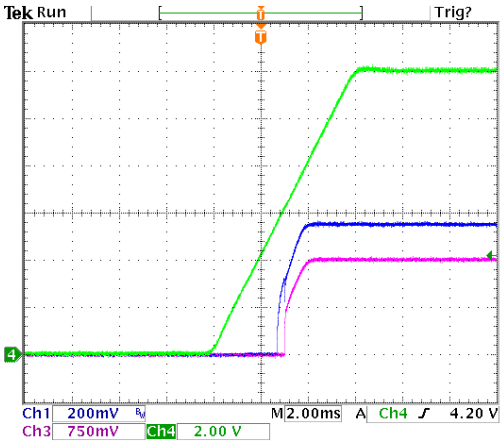


Figure 8. Typical Start-Up with application of Vin (Vo = 0.6Vdc, Io = 20A). Ch1 – Vout, Ch3 – Iout, Ch4 – Vin.

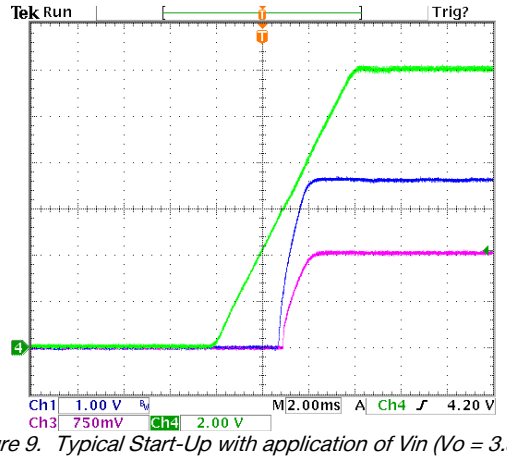


Figure 9. Typical Start-Up with application of Vin (Vo = 3.3Vdc, Io = 20A). Ch1 – Vout, Ch3 – Iout, Ch4 – Vin,

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4.3 TRANSIENT RESPONSE

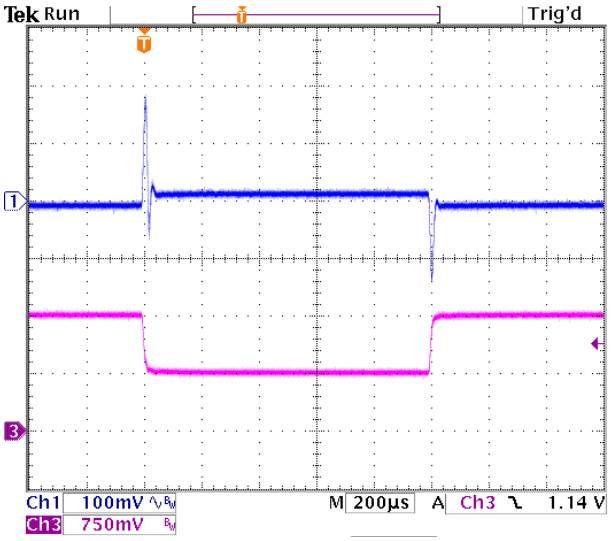


Figure 10. Transient Response to Dynamic Load Change from 50% to 100% of full load (Vin=12V, Vo=0.6Vdc). Ch3 – Iout. Scale=10A/div

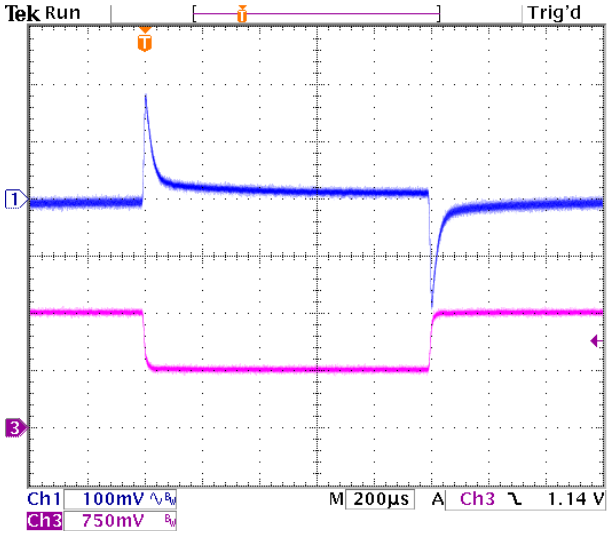


Figure 11. Transient Response to Dynamic Load Change from 50% to 100% of full load (Vin=12V, Vo=3.3Vdc). Ch3 – Iout. Scale=10A/div

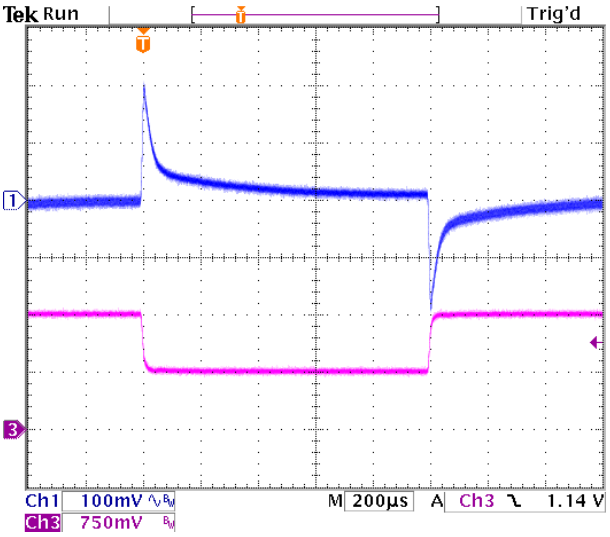


Figure 12. Transient Response to Dynamic Load Change from 50% to 100% of full load (Vin=12V, Vo=5.0Vdc). Ch3 – Iout. Scale=10A/div

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4.4 DERATING CURVES

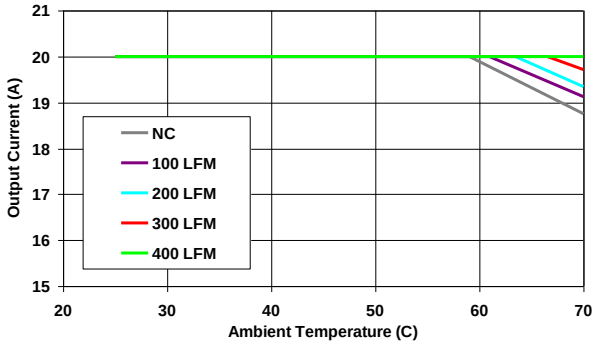


Figure 13. Derating Curves at Vo=0.9Vdc

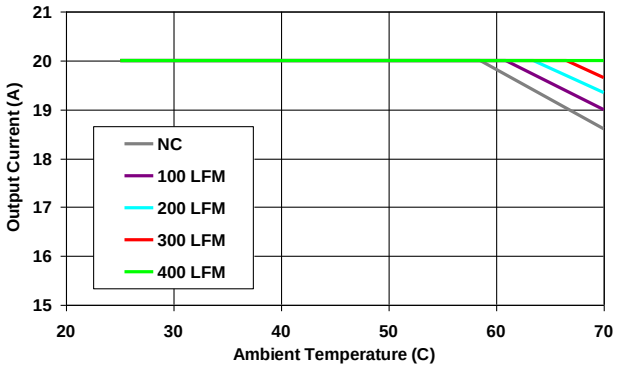


Figure 14. Derating Curves at Vo=1.2Vdc

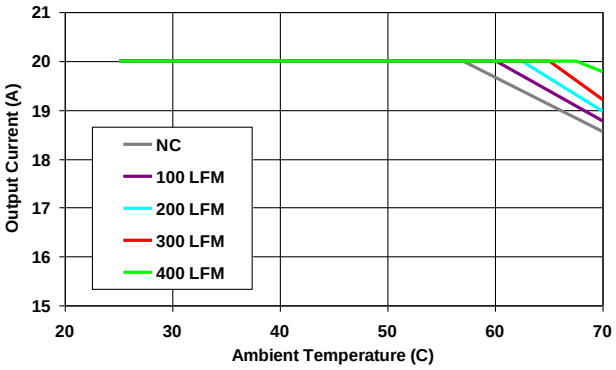


Figure 15. Derating Curves at Vo=1.8Vdc

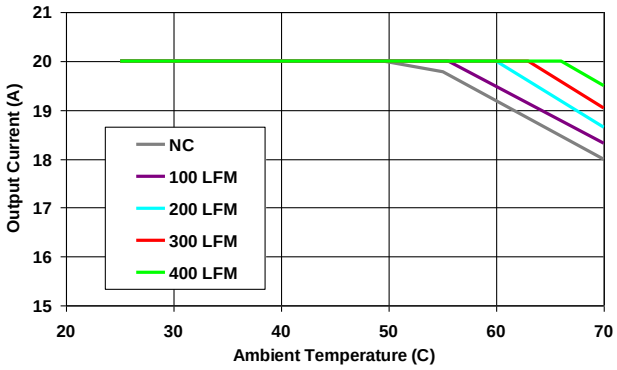


Figure 16. Derating Curves at Vo=2.5Vdc

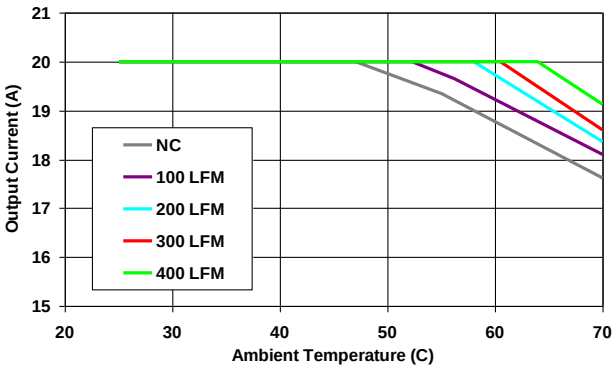


Figure 17. Derating Curves at Vo=3.3Vdc

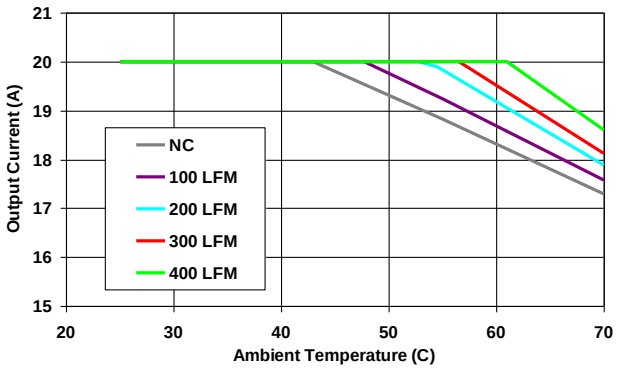


Figure 18. Derating Curves at Vo=5.0Vdc

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5. APPLICATION INFORMATION

5.1 INPUT AND OUTPUT IMPEDANCE

The POL converter should be connected to the DC power source via low impedance. In many applications, the inductance associated with the distribution from the power source to the input of the converter can affect the stability of the converter. Internally, the converter includes 30 µF (low ESR ceramics) of input capacitance which eliminates the need for external input capacitance. However, if the distribution of the input voltage to the POL converter contains high inductance, it is recommended to add a 47-100 µF decoupling capacitor placed as close as possible to the converter input pins. A low-ESR tantalum or POS capacitor connected across the input pins help ensuring stability of the POL converter and reduce input ripple voltage.

The converter has been designed for stable operation with or without external capacitance. A 22 µF ceramic output capacitor is recommended to improve output ripple and dynamic response.

It is important to keep low resistance and low inductance of PCB traces for connecting load to the output pins of the converter in order to maintain good load regulation.

5.2 OUTPUT VOLTAGE PROGRAMMING

The output voltage can be programmed from 0.59V to 5.1V by connecting an external resistor R_{TRIM} between TRIM pin (Pin 2) and SENSE- pin (Pin 8), as shown in Figure 19.

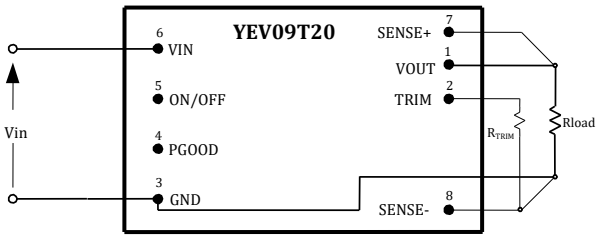


Figure 19. Programming Output Voltage with a Resistor

The trim resistor R_{TRIM} for a desired output voltage can be calculated using the following equation:

$$R_{TRIM} = \frac{1.182}{V_{OUT} - 0.591}, \text{ kΩ}$$

where:

V_{OUT} = Desired (trimmed) value of output voltage V

R_{TRIM} = Required value of the trim resistor in kΩ

If the R_{TRIM} is not used, the output voltage of the POL converter will be 0.591V.

Note that the trim resistor tolerance directly affects the output voltage accuracy. It is recommended to use ±0.1% trim resistors to meet the output voltage setpoint accuracy specified in p. 1.1.

V_{OUT}, V	Calculated R_{TRIM}, kΩ	Standard Value of 0.1% Resistor, kΩ
0.8	5.65	5.62
1.2	1.94	1.93
1.5	1.3	1.30
1.8	0.98	0.976
2.5	0.62	0.619
3.3	0.44	0.437
5.0	0.27	0.267

Table 1. Trim Resistor Values

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5.3 ON/OFF (PIN 5)

The ON/OFF pin is used to turn the power converter on or off remotely via a system signal. Internal impedance of ON/OFF pin to ground is typically 4.32kΩ. The ON/OFF signal is referenced to ground. The converter is ON when the ON/OFF pin is at a logic high (1V min) or left OPEN and OFF when the ON/OFF pin is at a logic low (0.4V max) or connected to GND. This model has internal pull-up resistor 30.1kΩ from ON/OFF pin to Vin.

The typical connections are shown in Figure 20.

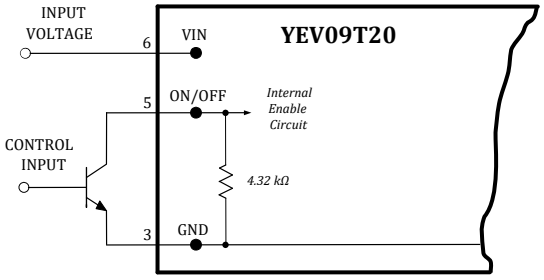


Figure 20. Circuit Configuration For ON/OFF Function

5.4 REMOTE SENSE (PINS 7 AND 8)

The remote sense feature compensates for the voltage drop between the output pins of the POL converter and the load. The SENSE- (Pin 8) and SENSE+ (Pin 7) pins should be connected at the load or at the point where regulation is required (refer to Figure 21).

If remote sensing is not required, the SENSE pins must be connected to the VOUT and GND pins directly at the output of the POL converter.

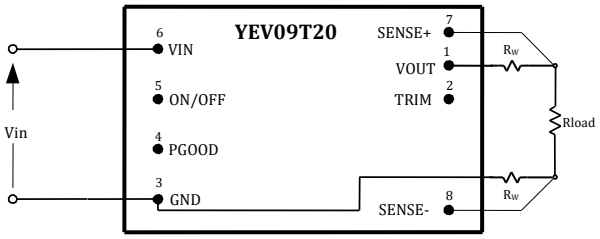


Figure 21. Remote Sense Circuit Configuration

Because the sense leads carry minimal current, large traces on the end-user board are not required. The voltage sense traces should be located close to a ground plane to minimize system noise.

When using remote sense, the output voltage at the converter can be increased by up to 0.2V in order to maintain the required voltage at the load. However, the maximum output voltage measured directly between the VOUT and GND pins shall not exceed 5.0V. In addition, it is the user's responsibility to ensure the POL converter's actual output power always remains at or below the maximum allowable output power obtained from the derating curves.

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5.5 PROTECTIONS

5.5.1 POWER GOOD (PIN 4)

Power Good pin (Pin 4) is an open drain output. The Power Good pin is high when the output voltage is within the regulation band. The Power Good pin is at logic low during start-up, undervoltage, overvoltage or overcurrent conditions, or when the POL converter is disabled via the ON/OFF signal.

5.5.2 INPUT UNDERVOLTAGE LOCKOUT

The POL converter will shut down when the input voltage drops below a predetermined voltage. It will start automatically when the input voltage exceeds the specified threshold.

5.5.3 OUTPUT OVERCURRENT PROTECTION

The POL converter is protected against overcurrent and short circuit conditions. Upon sensing an overcurrent condition, the POL converter will enter hiccup mode of operation. Once the overload or short circuit condition is removed, the POL converter will automatically restart and Vout will return to its nominal value.

5.5.4 OUTPUT OVERVOLTAGE PROTECTION

The POL converter is protected against overvoltage on the output. If the output voltage is higher than 115% of its nominal value set by the R_{TRIM}, the high side MOSFET will be immediately turned off and the low side MOSFET will be turned on. The POL converter will remain in the state until the output voltage reduces below 115% of its nominal value. At that point the POL converter will automatically restart.

6. CHARACTERIZATION

6.1 RIPPLE AND NOISE

The output voltage ripple and input reflected ripple current waveforms are measured using the test setup shown in Figure 22.

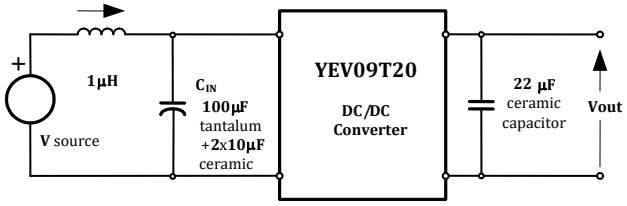


Figure 22. Test Setup for Measuring Input Reflected-Ripple Current and Output Voltage Ripple

7. SAFETY

The YEV09T20-0 POL converters **do not provide isolation** from input to output. The input devices powering YEV09T20-0 must provide relevant isolation requirements according to all IEC 62368-1 based standards. Nevertheless, if the system using the converter needs to receive safety agency approval, certain rules must be followed in the design of the system. In particular, all of the creepage and clearance requirements of the end-use safety requirements must be observed. These requirements are included in CSA/UL 62368-1 and EN 62368-1, although specific applications may have other or additional requirements.

The YEV09T20-0 POL converters have no internal fuse. If required, the external fuse needs to be provided to protect the converter from catastrophic failure. Refer to the "Input Fuse Selection for DC/DC converters" application note on belfuse.com/power-solutions proper selection of the input fuse. Both input traces and the chassis ground trace (if applicable) must be capable of conducting a current of 1.5 times the value of the fuse without opening.

To comply with safety agencies' requirements, a recognized fuse must be used in series with the input line. The fuse must not be placed in the grounded input line. Abnormal and component failure tests were conducted with the POL input protected by a fast-acting 25 A fuse. If a fuse rated greater than 25 A is used, additional testing may be required.

The maximum DC voltage between any two pins is Vin under all operating conditions. In order for the output of the YEV09T20-0 POL converter to be considered as ES1 according to all IEC 62368-1 based standards, the input to the POL needs to be supplied by an isolated secondary source providing a ES1 also.

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8. PIN ASSIGNMENTS AND DESCRIPTION

PIN NAME	PIN NUMBER	PIN TYPE	BUFFER TYPE	PIN DESCRIPTION	NOTES
VOUT	1	P		Output Voltage	
TRIM	2	I	A	Output Voltage Trim	Connect a high accuracy resistor between TRIM and GND pins to set the output voltage
GND	3	P		Power Ground	
PGOOD	4	I/O	PU	Power Good	Open drain pin indicating status of the output voltage
ON/OFF	5	I	PU	Enable	Pull high to turn ON the POL
VIN	6	P		Input Voltage	
SENSE+	7	I	A	Positive Voltage Sense	Connect to the positive point close to the load
SENSE-	8	I	A	Negative Voltage Sense	Connect to the negative point close to the load

Legend: I=input, O=output, I/O=input/output, P=power, A=analog, PU=internal pull-up

9. MECHANICAL DRAWINGS

NOTE: All Dimensions are in inches. Tolerances: X.XX: ±0.02” X.XXX: ±0.01”

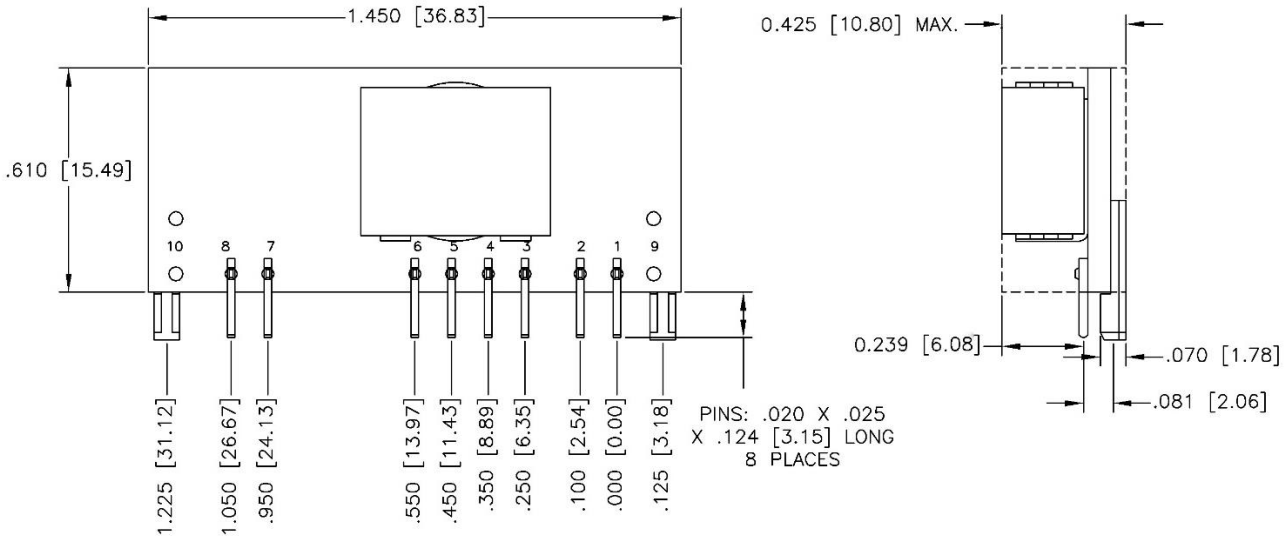


Figure 23. Mechanical Drawing

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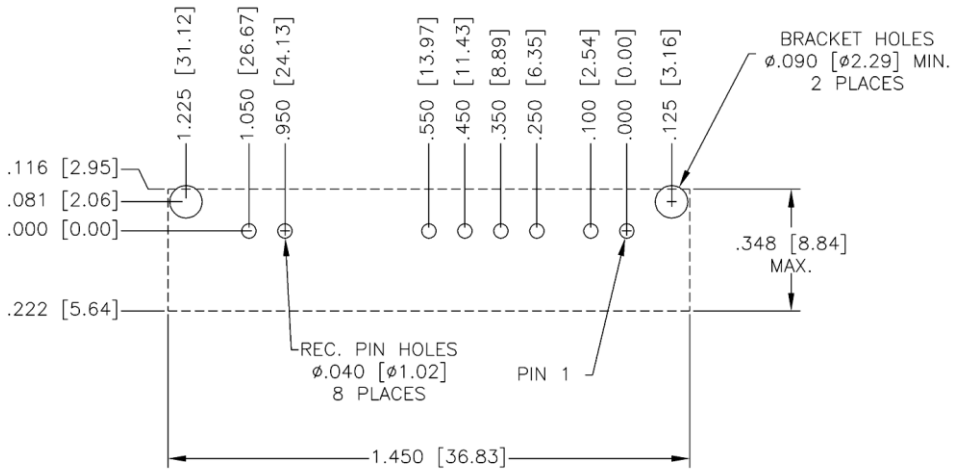


Figure 24. Recommended Footprint – Top View

10. ORDERING INFORMATION

YE	V	09	T	20	–	0	z
PRODUCT FAMILY	**PROFILE**	**INPUT VOLTAGE**	**PCB MOUNTING**	**OUTPUT CURRENT**	**DASH**	**ON/OFF LOGIC**	**ROHS COMPLIANCE**
POL Converter	Vertical	4.5 V to 13.8 V	Through-hole	20 A		**True High Logic**: POL is ON when the ON/OFF pin is high	**No suffix** - RoHS compliant with Pb solder exemption [3] **G** - RoHS compliant for all six substances

Example: **YEV09T20-0G**: YEV09T20-0 POL converter with lead-free solder.

For more information on these products consult: tech.support@psbel.com

NUCLEAR AND MEDICAL APPLICATIONS - Products are not designed or intended for use as critical components in life support systems, equipment used in hazardous environments, or nuclear control systems.
TECHNICAL REVISIONS - The appearance of products, including safety agency certifications pictured on labels, may change depending on the date manufactured. Specifications are subject to change without notice.

[3] The solder exemption refers to all the restricted materials except lead in solder. These materials are Cadmium (Cd), Hexavalent chromium (Cr6+), Mercury (Hg), Polybrominated biphenyls (PBB), Polybrominated diphenylethers (PBDE), and Lead (Pb) used anywhere except in solder.

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