sales@calex.com +1 (925) 687-4411

EBM Series, 120 Watt

1/8-Brick DC/DC Converter with 4:1 Input

The EBM Series of isolated DC-DC converters feature a single 120W isolated output, from an input voltage range of 9V – 36Vdc in an industry standard eighth-brick package. Two baseplate options are available including “flanged with slots” for mechanical fixing to a heatsink surface and “without flange” for minimal board space consumption. Positive and Negative on/off logic variants are also available.

The EBM Series is designed for applications in the Industrial/ Transportation area, and ideally suited to accept the input from a 12V or 24V battery. The output voltage can be trimmed +/-10% via external resistor. The EBM series deliver fast settling to transient step loads and demonstrate no adverse effects from higher capacitive loads. The EBM also incorporates a full set of self-protection features including under-voltage lockout, over-temperature shutdown, current limit and short circuit protection.

Features

- Ideal for Industrial, Railway and Transportation applications
- Input voltage 9-36Vdc with 5V, 12V or 24Vout
- High efficiency up to 92%
- 2000VAC I/O Isolation, Basic Insulation
- Standard 1/8 brick package, DOSA footprint
- Overload Protection
- Over-temperature Protection
- Under Voltage Shutdown
- Remote On/Off, Voltage sense compensation
- Two baseplate options, with or w/o flange
- -40 to 85°C Operating temperature range
- Safety approvals, RoHS compliant

Table of Contents

Part Number Selection Table

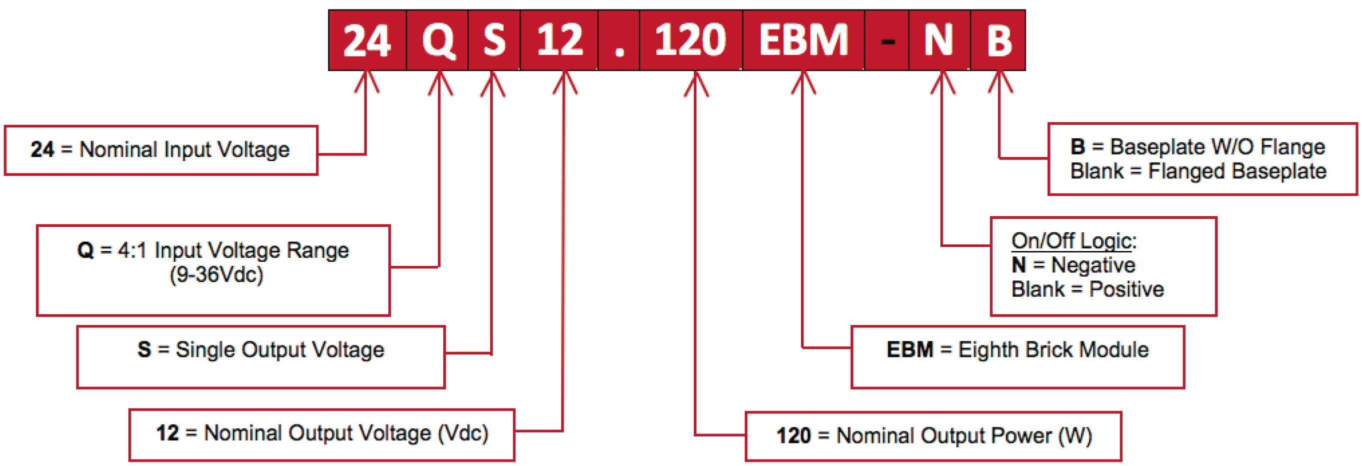
All specifications are at full load with nominal input and output voltage and Ta +25°C unless otherwise noted. Output capacitors are 1μF ceramic multilayer in parallel with 10μF and minimum requested input capacitor. I/O caps are necessary for our test equipment and may not be required for your application. See detailed specifications.

Voltage (Vdc)			Current			Efficiency	Ripple & Noise	Regulation	Capacitive Load	Root Model
Input		Output	Input		Output					
Vin Nom	Vin Range	Vout Nom	No Load (mA)	Max Load (A)	Io Max (A)	Typical at Max Load (%)	Typical (mVp-p)	Line / Load Max (%)	Max. C external (μF)	Basic Model without option
12	9 – 36	5	0.4	10.87	24	92	100	±0.4 / ±0.4	4700	24QS5.120EBM
		12	0.4	10.87	10	92	115	±0.3 / ±0.3	4700	24QS12.120EBM
		24	0.08	10.87	5	92	150	±0.4 / ±0.4	1000	24QS24.120EBM

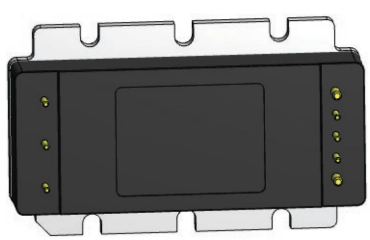
Part Number Description

Root models have positive on/off control logic and flanged, slotted baseplate.

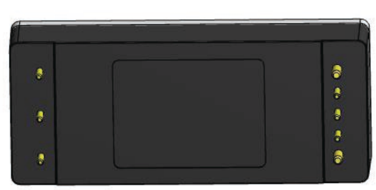
For ordering optional control logic or non-flanged baseplate, add –N, -B or -NB to part number when ordering as shown below.



Standard Flanged Baseplate:



Optional Baseplate W/O Flange:



General Data (all Models)

All specifications are at full load with nominal input and output voltage and Ta +25°C unless otherwise noted. Output capacitors are 1μF ceramic multilayer in parallel with 10μF and minimum requested input capacitor. I/O caps are necessary for our test equipment and may not be required for your application. See detailed specifications.

Absolute Maximum Ratings	Conditions	Min.	Typ.	Max.	Unit
Input Voltage	Continuous	-0.3		36	Vdc
Input Transient	100ms max., Operating			50	Vdc
Storage Temperature		-55		125	°C
Input to Output Isolation	60 sec. (equivalent to factory test)			2000	VAC
Voltage at ON/OFF control pin		-2		18	Vdc

Isolation Data	Conditions	Min.	Typ.	Max.	Unit
Input to Output Isolation Voltage	Dielectric Strength (basic insulation)	2000			Vrms
	Actual Factory Test	2828			Vdc
Isolation Voltage Input/Output to Baseplate	Input and Output to Baseplate Test	1500			Vdc
Insulation Resistance	500Vdc	30M			Ohm
Insulation Capacitance			1000		pF

Safety, Reliability		
Safety Approvals	Certified to UL 60950-1, CSA-C22.2 No.60950-1, IEC60950-1, 2nd Edition	Yes
Calculated MTBF	Belcore, Telcordia SR-332, Issue 3, Method 1, Case 1, Gf	1.7M hrs.

Mean Time Before Failure (MTBF) is calculated using the Telcordia (Belcore) SR-332 Issue, Case 3, ground benign controlled conditions. Operating temperature = +40°C, full output load, natural air convection.

Mechanical Specifications			
Outline Dimensions – (L x W x H)	Without Flanged Baseplate	2.41 x 1.01 x 0.50 / 61.2 x 25.7 x 12.7	Inches/mm
	With Flanged Baseplate	2.41 x 1.45 x 0.50 / 61.2 x 36.8 x 12.7	Inches/mm
Weight	Flanged Baseplate	1.84 / 52.16	Ounces/Grams
Baseplate Material		Aluminum	-
Case Material		Plastic	-
Pin Diameter (Power & Signal)	Through Hole	0.062 & 0.040 / 1.57 & 1.02	Inches/mm
Pin Material	Through Hole	Copper alloy	-
Pin Plating Metal and Thickness	Nickel sub-plate	50μ	inches
	Gold over-plate	5μ	inches

On/Off Control, Remote Sense, Output Voltage Trim, Switching Frequency

Feature Specifications	Conditions	Min.	Typ.	Max.	Unit
Positive ON/OFF Control (Blank, no suffix)					
Off-State Voltage	Pull LOW to Disable Output	0		1	V
On-State Voltage	ON/OFF High/Open, Output = ON	3.5		15	V
Negative ON/OFF Control (N suffix)					
Off-State Voltage	ON/OFF High/Open, Output = OFF	2.5		15	V
On-State Voltage	Pull LOW to Enable Output	-0.1		0.8	V
ON/OFF Control Current (Either Logic)					
Current thru ON/OFF pin	ON/OFF pin Voltage = 0V		1	2	mA
Current thru ON/OFF pin	ON/OFF pin Voltage = 15V			50	µA
Remote Sense Compensation	Ext. connected to respective V_O pin		10		%
Output Voltage Trim Range	Pout <= Max rated power	-10		+10	%Vout
Trim Up/ Trim Down Equations	Please see technical notes: Output Voltage Adjustment (TRIM)				
Switching Frequency		220	240	260	kHz

The On/Off pin is normally driven by an open-collector/open-drain drive circuit. External logic may be used if voltage levels are fully compliant to specifications.

Environmental Data

Temperature	Conditions	Min.	Typ.	Max.	Units
Operating Temperature Natural convection, Vin nom, Full Load, Power derating see derating curves.					
Thermal Impedance Natural Convection	Without (With) heatsink		TBD		ºC / W
Operating Temperature	Baseplate	-40		+115	ºC
Over Temperature Protection	Baseplate	115	125	130	ºC
Over Temperature Restart Hysteresis			10		ºC
Storage Temperature		-50		+125	ºC
Humidity (Operating)		5		95	%
Cooling	Free Air Convection				

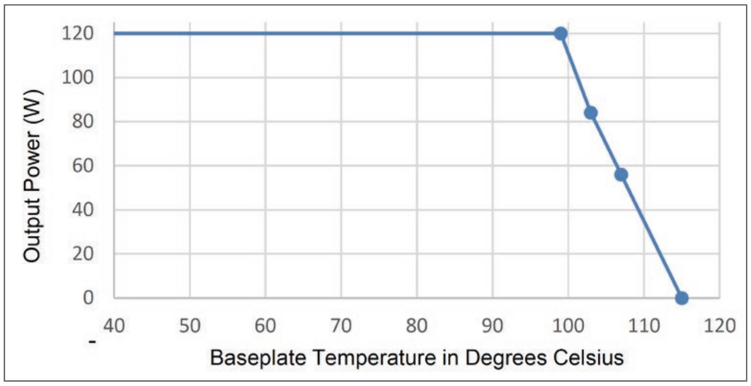


Fig. A-1: Derating Max Baseplate (115ºC) Temperature, Vin = 24V (Tested on 10x10 inch PCB)

Electromagnetic Compatibility (EMC)

Electromagnetic Emissions		
Conducted Emissions	External filter is required, see technical notes	EN55022/CISPR22 Class A

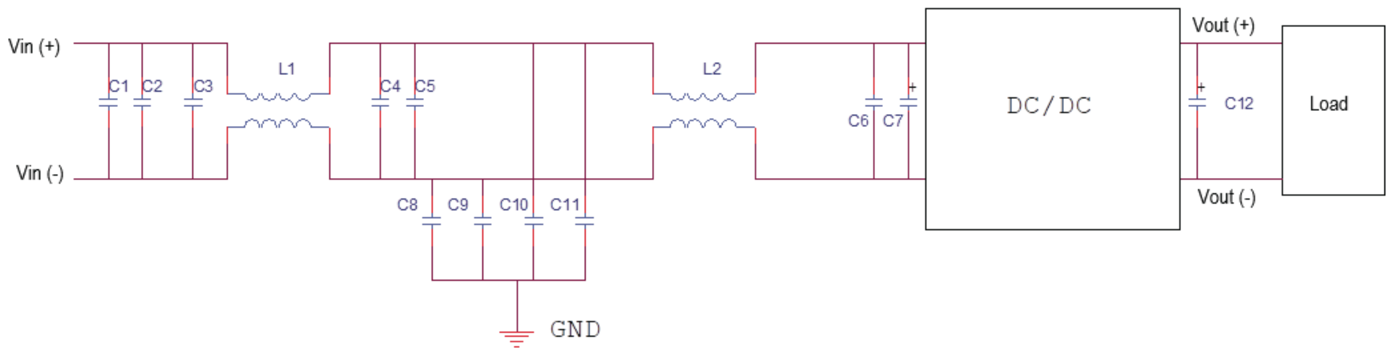


Fig. A-2: EMI Filter for Conducted Emissions Measurement with external components table

Item	Reference	Part Number	Description	Vendor
1	C1, C2, C3, C4, C5	GRM32ER72A105KA01L	SMD CERAMIC-100V-1000nF-X7R-1210	Murata
2	C6	GRM319R72A104KA01D	SMD CERAMIC 100V-100nF-±10%-X7R-1206	Murata
3	L1, L2	PO502NL	COMMON MODE-473uH-±25%-14A	Pulse
4	C8, C9, C10, C12	GRM55DR72J224KW01L	SMD CERAMIC 630V-0.22uF-±10%-X7R-2220	Murata
5	C7	UHE2A221MHD	Aluminum 100V-220uF -±10%-long lead	Nichicon
6	C12	NA		

Qualification Testing

Parameters	Test conditions	Operating
Vibration	EN 61373:1999 Category I, Class B, Body mounted	Yes
Mechanical Shock	EN 61373:1999 Category I, Class B, Body mounted	Yes
DMTBF (Life Test)	Vin nom, units at derating point, 101days	Yes
Temperature Cycling Test (TCT)	-40°C to 125°C, unit temp. ramp 15°C/min., 500cycles	Yes
Power and Temperature Cycling Test (PTCT)	Temperature operating = min to max, Vin = min to max, Load=50% of max., 100cycles	Yes
Temperature, Humidity and Bias (THB)	85°C, 85RH, Vin=max, Load=min load, 1072Hour (72hours with a pre-conditioning soak, unpowered)	No
Damp heat test, cyclic	EN60068-2-30: Temperature +55°C and +25°C; Number of cycles 2 (respiration effect); Time 2 x 24 hours; Relative Humidity 95%	No
Dry heat test	EN60068-2-2, Vin=nom, Full load, 85°C for 6 hours.	Yes
High Temperature Operating Bias (HTOB)	Vin=min to max, 95% rated load, units at derating point, 500hours	Yes
Low Temperature operating	Vin=nom, Full load, -40°C for 2 hours.	Yes
Highly Accelerated Life Test (HALT)	High temperature limits, low temperature limits, Vibration limits, Combined Environmental Tests.	Yes
EMI	CISSPR 22 Class A, or IEC62236-3-2 (GB/T 24338.4)	Yes
ESD	IEC6100-4-2: ±8kV contact discharge / ±15kV air discharge	Yes
Surge Protection	EN50121-3-2	Yes
Solderability	MIL-STD-883, method 2003 (IPC/EIA/JEDEC J-SID-002B)	No

Electrical Input Data

All specifications are at full load with nominal input and output voltage and Ta +25°C unless otherwise noted. Output capacitors are 1µF ceramic multilayer in parallel with 10µF and minimum requested input capacitor. I/O caps are necessary for our test equipment and may not be required for your application. See detailed specifications.

Input Data	Conditions	Min.	Typ.	Max.	Unit
Input Voltage Range, Continuous Operation	Io = 0 – Io max, Tb min – Tb max	9	12	36	Vdc
Input Voltage, Short Term	100ms transient			50	Vdc
Input Under-Voltage Lockout					
Turn-On Voltage Threshold		8.1	8.8	8.95	Vdc
Turn-Off Voltage Threshold		7.8	8.4	8.8	Vdc
Lockout Voltage Hysteresis			0.4	1.0	Vdc
Input Current	Full Load, Vin = 9V,		14.5	14.96	A
	Full Load, Vin = 12V,		10.9	11.22	A
	No-Load, Vin = 12V,: 5V/12Vout 24Vout		400 80	600 120	mA
	Shut-Down Mode, Either Logic		15	20	mA
	Inrush Current (I^2t)		0.1	0.2	A^2sec
External Input Fuse (recommended)	Fast acting fuse recommended			20	A
External Input Capacitance (recommended)	Low ESR	220	330		µF
Reverse Polarity Protection			External		

If reverse polarity is accidentally applied to the input, to ensure reverse input protection, always connect an external fast blow fuse in series with the +Vin input.

5V Output: Electrical Specification for 24QS5.120EBM

All specifications are at full load with nominal input and output voltage and Ta +25°C unless otherwise noted.

Output Data	Conditions	Min.	Typ.	Max.	Unit
Total Output Power	Tcase min-max. See also thermal derating.	0		120	W
Output Voltage Set Point	Nominal Vin, 50% Load	4.95	5	5.05	Vdc
Output Over-Voltage Protection	Hiccup mode; auto-recovery over full temp range	6.0	7.0	8.5	Vdc
Output Voltage Regulation					
Over Load	Vin = 12V, Iout from 0 to 100%		±0.2	±0.4	%
Over Line	Iout = 100%, Vin from Min to Max.		±0.2	±0.4	%
Over Temperature	Vin = 12V, Ta = -40°C to 85°C		0.008	0.02	%/°C
Output Voltage Ripple & Noise	20MHz bandwidth, All conditions,				
Peak-to-Peak Deviation	1μF ceramic, 10μF tantalum & 330μF E-Cap		100	150	mVp-p
Output Current Range		0		24	A
Output Current-Limit Inception	Output Voltage 10% Low	26	30	36	A
Short Circuit Current	Continuous, Hiccup technique with auto recovery		2.0	4.5	A
Output Capacitance	Vout Nominal, 0 to Full Load	330		4700	μF

Do not exceed maximum power ratings if adjusting output trim values.

Output noise may be further reduced by installing an external filter. Larger caps (especially low-ESR ceramic types) may slow transient response and degrade dynamic performance. Thoroughly test your application with all components installed. See Application Notes for additional information.

Dynamic Characteristics	Conditions	Min.	Typ.	Max.	Unit
Load Step Transient	1A/μS, 1μF parallel to 10μF output capacitors				
Peak Deviation	50% - 75% - 50% Iout max 25% - 75% - 25% Iout max		±200 ±350	±300 ±450	mV
Settling Time	To within 1% Vout nom		70	120	μS
Turn-On Transient					
Input on Start-up Time	To Vout=90% nominal		30	60	mS
On/Off Control Startup Time	To Vout=90% nominal		30	60	mS
Rise Time	Time from 10% to 90% of nominal output voltage		20	40	mS
Output Voltage Overshoot				2	%

Regulation specifications describe the deviation as the input line voltage or output load current is varied from a nominal midpoint value to either extreme.

External capacitance: 1μF multilayer ceramic in parallel with 10μF electrolytic output and a 220μF/100V input capacitor. All caps described are low ESR. These capacitors are necessary for our test equipment and may not be needed in your application. All models are stable and regulate within spec without external capacitance. Testing must be kept short enough that the converter does not appreciably heat up during testing. For extended testing, use plenty of cooling.

Efficiency	Conditions	Min.	Typ.	Max.	Unit
	Vin = 9V	90	91.5		%
Efficiency at Full Load	Vin = 12V	90	92		%
	Vin = 24V	89	90.5		%

5V Output: Typical Performance Curves (24QS5.120EBM)

Fig. 5-1: Efficiency vs. Line and Load @ 25°C

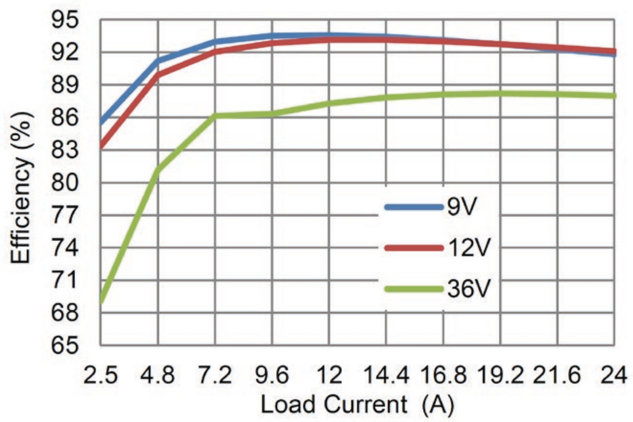


Fig. 5-2: Power Dissipation vs. Load @ 25°C

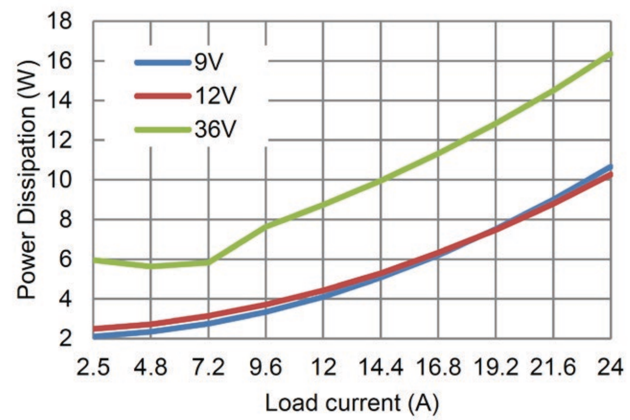


Fig. 5-3: On/Off Enable Delay (Green: Vout; Red: Enable)

Ta=+25°C, Vin = 12V, Iout = 0A, Cload = 330µF

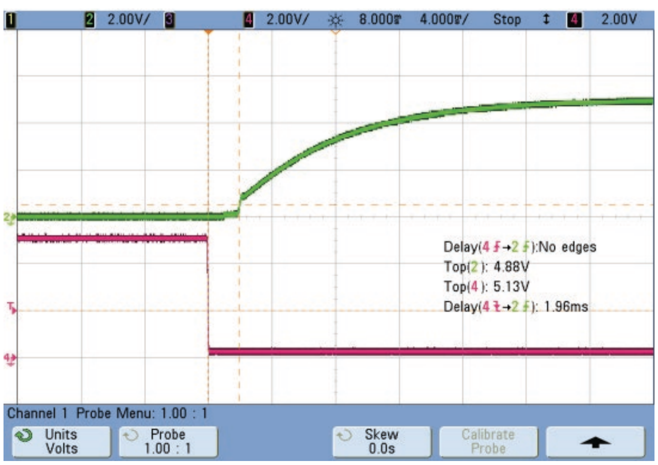


Fig. 5-4: On/Off Enable Delay (Green: Vout; Red: Enable)

Ta=+25°C, Vin = 12V, Iout = 24A, Cload = 4700µF

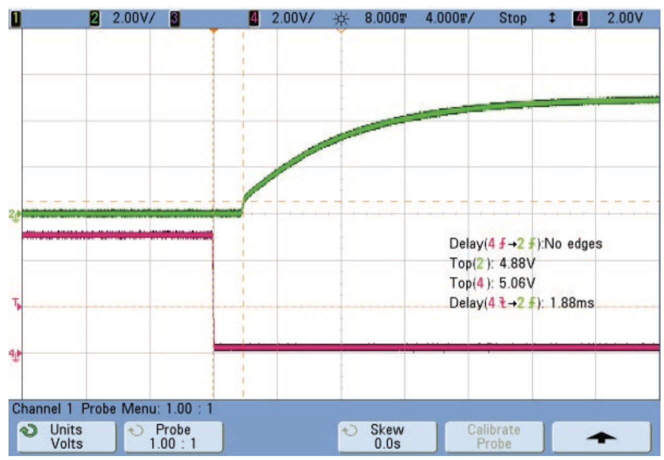


Fig. 5-5: Output Ripple and Noise (Scope BW = 20MHz)

Iout = 24A, Ta = 25°C

Vin =12V; Cload = 1µF ceramic||10µF tantalum||; 330µF Ecap

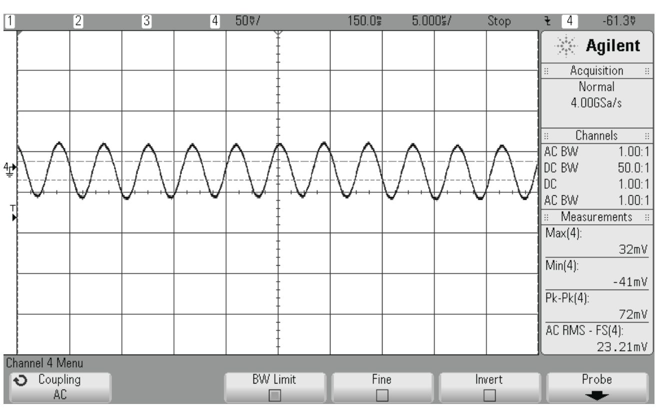
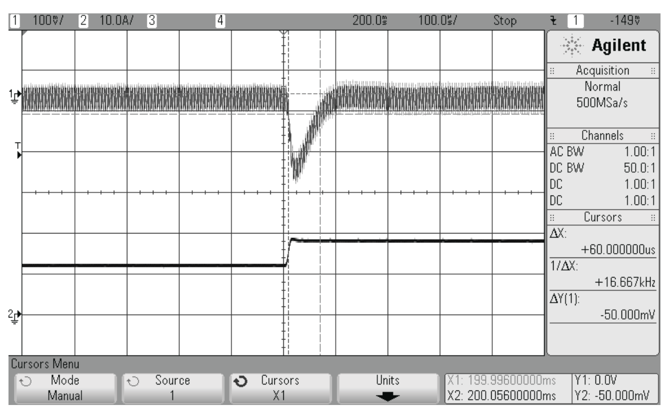


Fig. 5-6: Transient response, Vout = Nom,

Iout = 50-75% Step

Slew Rate = 1A/µs, Ta = 25°C

Vin =12V; Cload = 1µF ceramic||10µF tantalum||; 330µF Ecap



12V Output: Electrical Specification (24QS12.10EBM)

All specifications are at full load with nominal input and output voltage and Ta +25°C unless otherwise noted.

Output Data	Conditions	Min.	Typ.	Max.	Unit
Total Output Power	Tcase min-max. See also thermal derating.	0		120	W
Output Voltage Set Point	Nominal Vin, 50% Load	11.88	12	12.12	Vdc
Output Over-Voltage Protection	Hiccup mode; auto-recovery over full temp range	13.8	15.0	16.0	Vdc
Output Voltage Regulation					
Over Load	Vin = 12V, Iout from 0 to 100%		±0.15	±0.3	%
Over Line	Iout = 100%, Vin from Min to Max.		±0.15	±0.3	%
Over Temperature	Vin = 12V, Ta = -40°C to 85°C		0.008	0.02	%/°C
Output Voltage Ripple & Noise	20MHz bandwidth, All conditions,				
Peak-to-Peak Ripple & Noise	1µF ceramic, 10µF tantalum & 200µF E-Cap		115	200	mVp-p
Output Current Range		0		10	A
Output Current-Limit Inception	Output Voltage 10% Low	11	14.5	18.2	A
Short Circuit Current	Continuous, Hiccup technique with auto recovery		1.0	2.3	A
Output Capacitance	Vout Nominal, 0 to Full Load	200		4700	µF

Do not exceed maximum power ratings if adjusting output trim values.

Output noise may be further reduced by installing an external filter. Larger caps (especially low-ESR ceramic types) may slow transient response and degrade dynamic performance. Thoroughly test your application with all components installed. See Application Notes for additional information.

Dynamic Characteristics	Conditions	Min.	Typ.	Max.	Unit
Load Step Transient	1A/μS, 1μF parallel to 10μF output capacitors				
Peak Deviation	50% - 75% - 50% Iout max 25% - 75% - 25% Iout max		±200 ±450	±300 ±600	mV
Settling Time	To within 1% Vout nom		150	200	μS
Turn-On Transient					
Input on Start-up Time	To Vout=90% nominal		25	40	mS
On/Off Control Startup Time	To Vout=90% nominal		25	40	mS
Rise Time	Time from 10% to 90% of nominal output voltage		20	60	mS
Output Voltage Overshoot				2	%

Regulation specifications describe the deviation as the input line voltage or output load current is varied from a nominal midpoint value to either extreme.

External capacitance: 1μF multilayer ceramic in parallel with 10μF electrolytic output and a 220μF/100V input capacitor. All caps described are low ESR. These capacitors are necessary for our test equipment and may not be needed in your application. All models are stable and regulate within spec without external capacitance. Testing must be kept short enough that the converter does not appreciably heat up during testing. For extended testing, use plenty of cooling.

Efficiency	Conditions	Min.	Typ.	Max.	Unit
	Vin = 9V	90	92		%
Efficiency at 100% Load	Vin = 12V	90	92		%
	Vin = 24V	88	92		%

12V Output: Typical Performance Curves (24QS12.10EBM)

Fig. 12-1: Efficiency vs. Line and Load @ 25°C

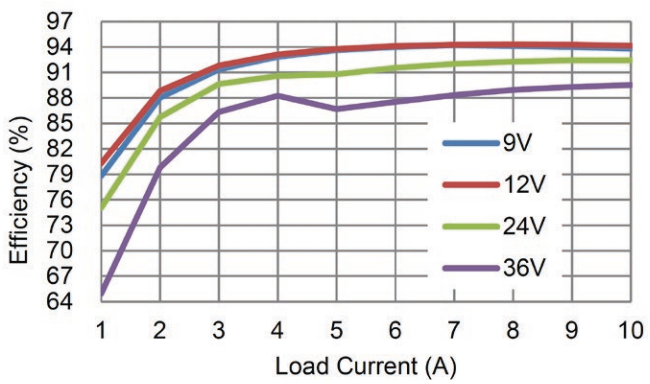


Fig. 12-2: Power Dissipation vs. Load @ 25°C

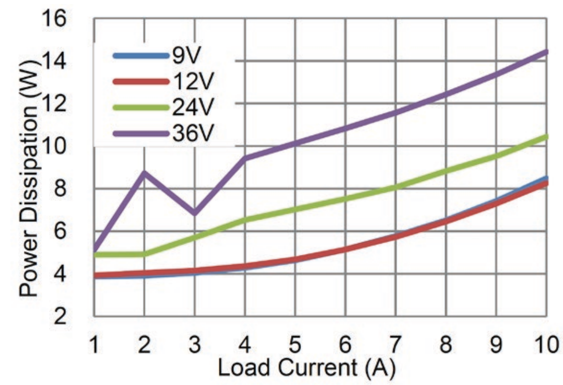


Fig. 12-3: On/Off Enable Delay (CH2: Vout; CH4: Enable)

Ta=+25°C, Vin = 12V, Iout = 0A, Cload = 200µF

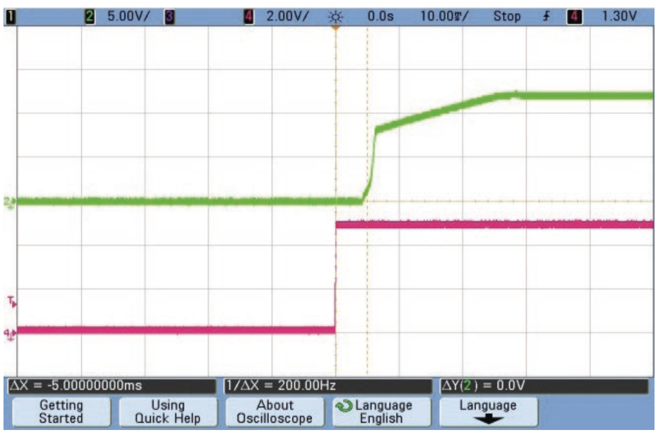


Fig. 12-4: On/Off Enable Delay (CH2: Vout; CH4: Enable)

Ta=+25°C, Vin = 12V, Iload = 10A, Cload = 4700µF

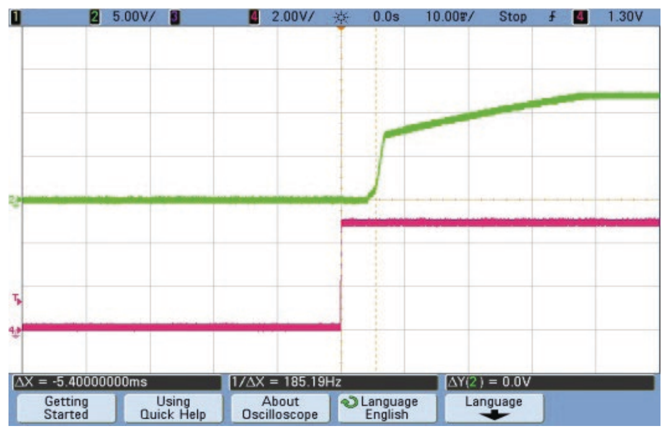


Fig. 12-5: Output Ripple and Noise (Scope BW = 20MHz)

Iout = 10A, Ta = 25°C

Vin =12V; Cload = 1µF ceramic||10µF tantalum||; 200µF Ecap

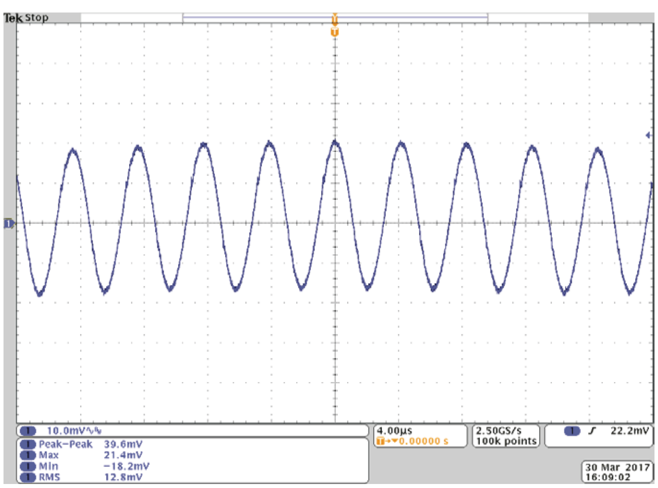
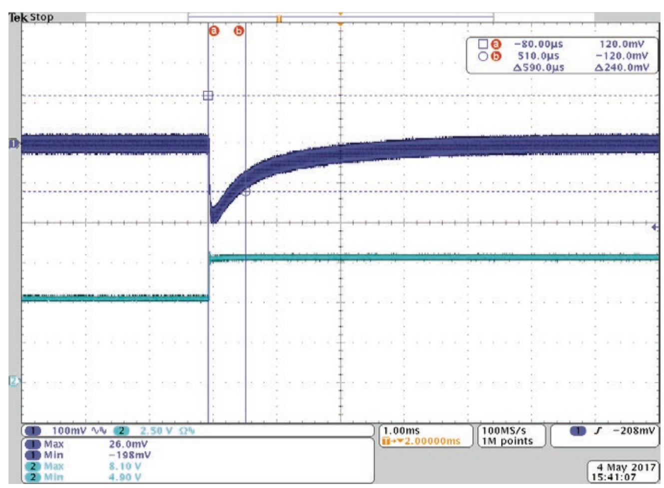


Fig. 12-6: Transient response, Vout = Nom,

Iout = 50-75% Step

Slew Rate = 1A/µs, Ta = 25°C

Vin =12V; Cload = 1µF ceramic||10µF tantalum||; 200µF Ecap



24V Output: Electrical Specification (24QS24.5EBM)

All specifications are at full load with nominal input and output voltage and Ta +25°C unless otherwise noted.

Output Data	Conditions	Min.	Typ.	Max.	Unit
Total Output Power	Tcase min-max. See also thermal derating.			120	W
Output Voltage Set Point	Nominal Vin, 50% Load	23.76	24	24.24	Vdc
Output Over-Voltage Protection	Hiccup mode; over full temp range	28	30	35	Vdc
Output Voltage Regulation					
Over Load	Vin = 12V, Iout from 0 to 100%		±0.2	±0.4	%
Over Line	Iout = 100%, Vin from Min to Max.		±0.2	±0.4	%
Over Temperature	Vin = 12V, Ta = -40°C to 85°C		0.008	0.02	%/°C
Output Voltage Ripple & Noise	20MHz bandwidth All conditions,				
Peak-to-Peak Deviation	1μF ceramic, 10μF tantalum & 330μF E-Cap		150	240	mVp-p
Output Current Range		0		5	A
Output Current-Limit Inception	Output Voltage 10% Low	6	7	8.5	A
Short Circuit Current	Continuous, Hiccup technique with auto recovery		1.0	2.0	A
Output Capacitance	Vout Nominal, 0 to Full Load	100		1000	μF

Do not exceed maximum power ratings if adjusting output trim values.

Output noise may be further reduced by installing an external filter. Larger caps (especially low-ESR ceramic types) may slow transient response and degrade dynamic performance. Thoroughly test your application with all components installed. See Application Notes for additional information.

Dynamic Characteristics	Conditions	Min.	Typ.	Max.	Unit
Load Step Transient	1A/μS, 1μF parallel to 10μF output capacitors				
Peak Deviation	50% - 75% - 50% Iout max 25% - 75% - 25% Iout max		±250 ±350	±350 ±500	mV
Settling Time	To within 1% Vout nom		200	500	μS
Turn-On Transient					
Input on Start-up Time	To Vout=90% nominal		25	40	mS
On/Off Control Startup Time	To Vout=90% nominal		25	40	mS
Rise Time	Time from 10% to 90% of nominal output voltage		25	60	mS
Output Voltage Overshoot				2	%

Regulation specifications describe the deviation as the input line voltage or output load current is varied from a nominal midpoint value to either extreme.

External capacitance: 1μF multilayer ceramic in parallel with 10μF electrolytic output and a 220μF/100V input capacitor. All caps described are low ESR. These capacitors are necessary for our test equipment and may not be needed in your application. All models are stable and regulate within spec without external capacitance. Testing must be kept short enough that the converter does not appreciably heat up during testing. For extended testing, use plenty of cooling.

Efficiency and Frequency	Conditions	Min.	Typ.	Max.	
	Vin = 9V	90	91.5		%
Efficiency at 100% Load	Vin = 12V	90	92		%
	Vin = 24V	88	91		%

24V Output: Typical Performance Curves (24QS24.5EBM)

Fig. 24-1: Efficiency vs. Line and Load @ 25°C

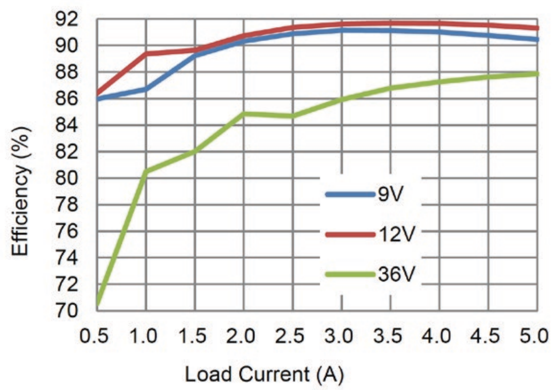


Fig. 24-2: Power Dissipation vs. Load @ 25°C

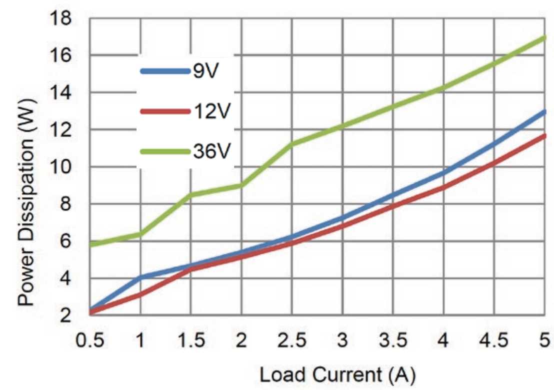


Fig. 24-4: On/Off Enable Delay (CH2: Vout; CH4: Enable)

Ta=+25°C Vin = 12V, Iout = 0A, Cload = 100µF

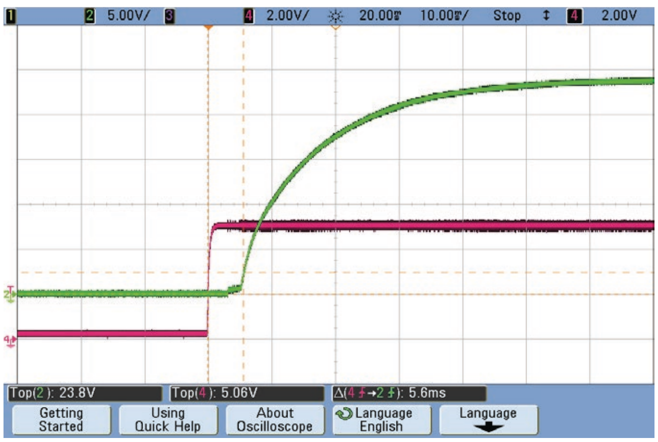


Fig. 24-4: On/Off Enable Delay (CH2: Vout; CH4: Enable)

Ta=+25°C Vin = 12V, Iout = 5A, Cload = 1000µF

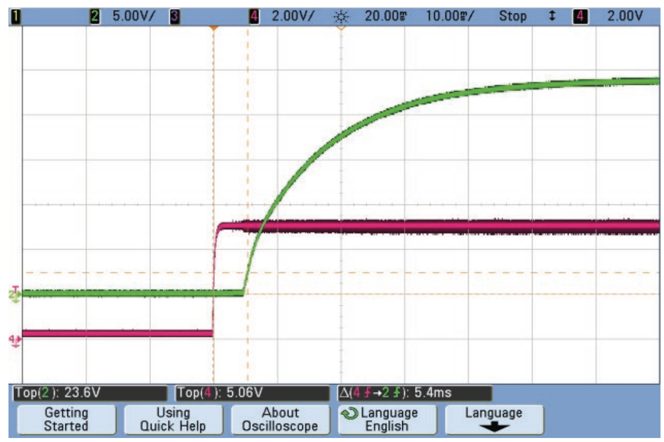


Fig. 24-5: Output Ripple and Noise (Scope BW = 20MHz)

Iout = 5A, Ta = 25°C

Vin =12V Cload = 1µF ceramic||10µF tantalum|| 100µF Ecap

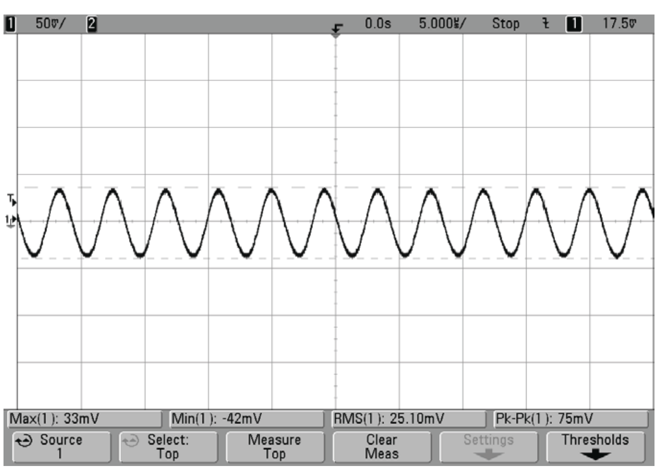
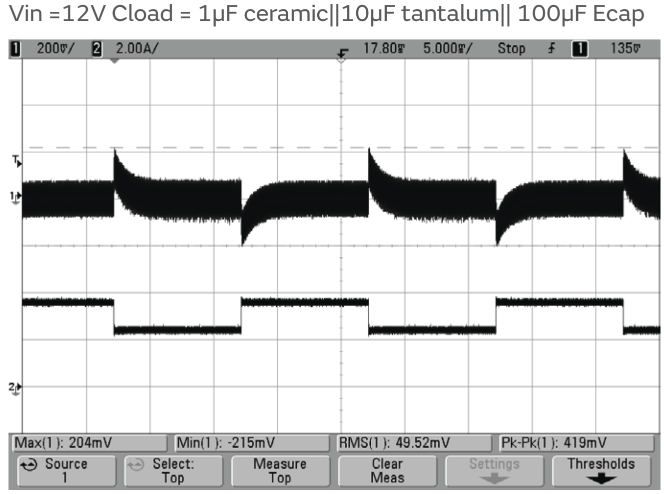


Fig. 24-6: Transient response, Vout = Nom,
Iout = 50-75% Step

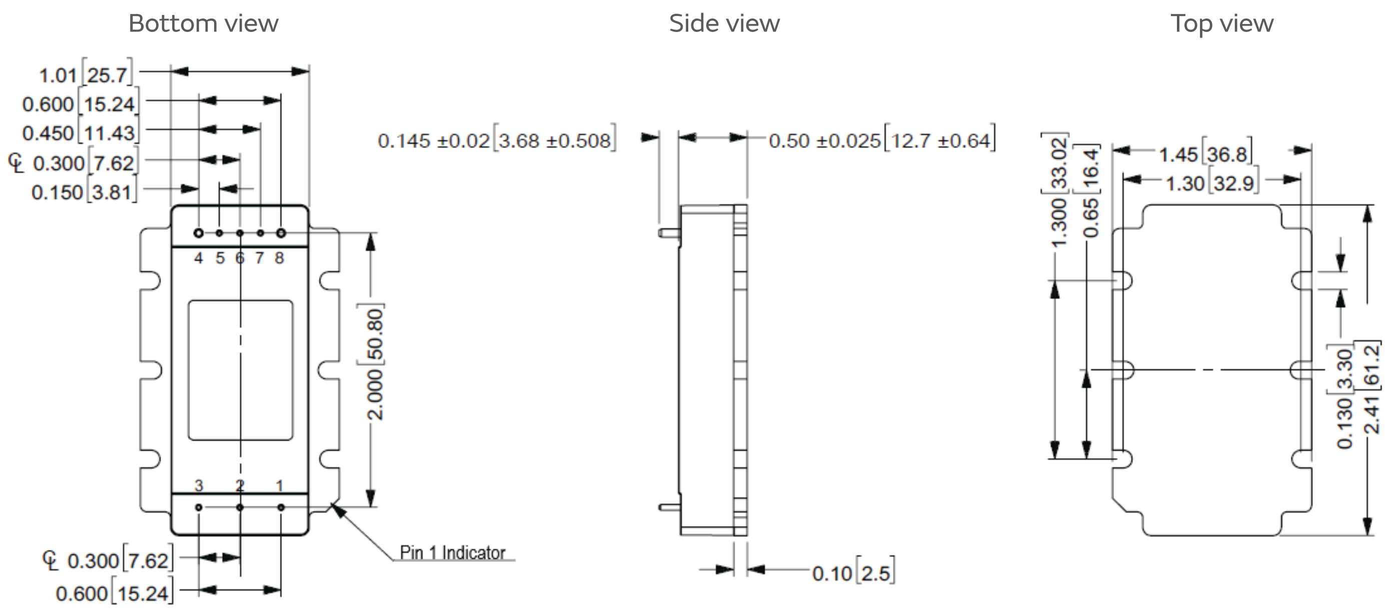
Slew Rate = 1A/µs, Ta = 25°C

Vin =12V Cload = 1µF ceramic||10µF tantalum|| 100µF Ecap

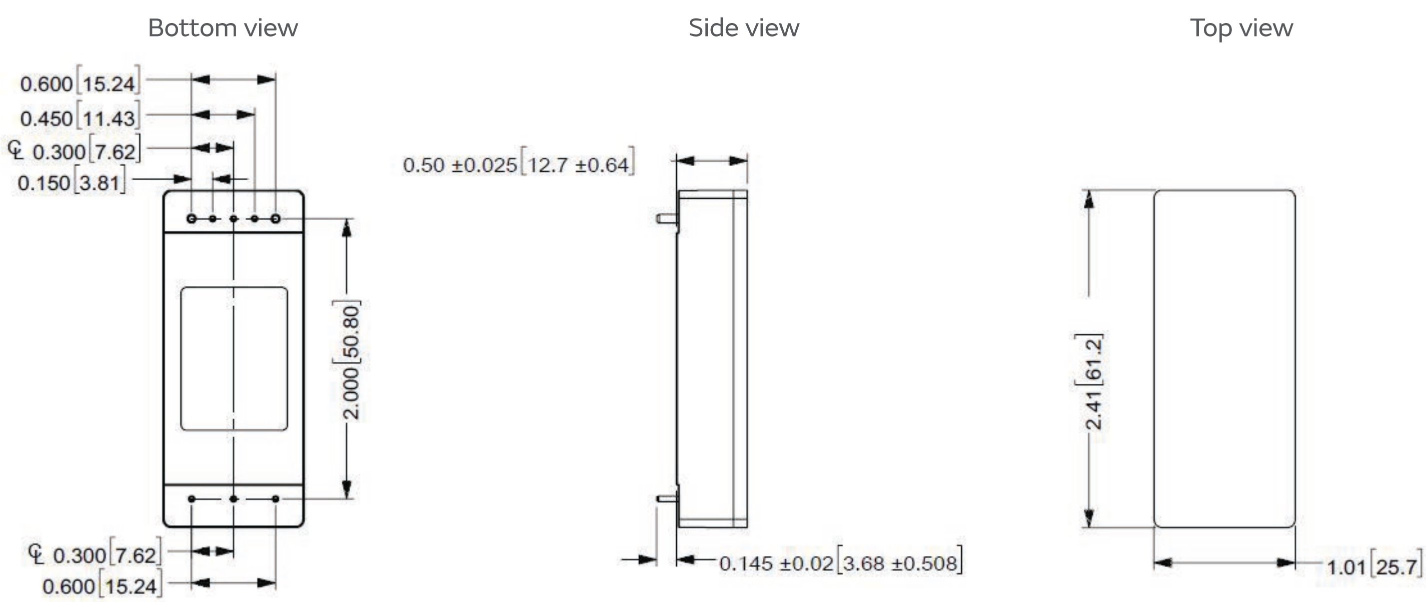


Mechanical Data

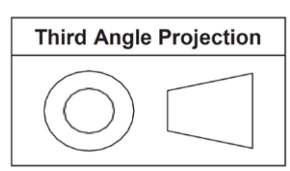
Standard Baseplate (flanged):



Optional Baseplate (Non-flanged):

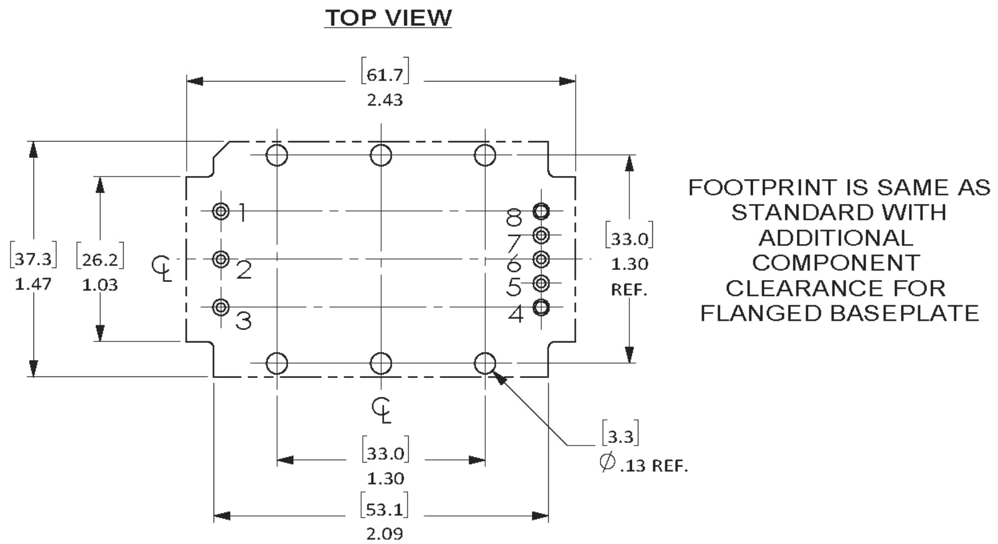


Notes:
All dimensions are in Inches [Millimeter].
Tolerance: x.xx in, ±0.02 (x.x mm, ±0.5).
x.xxx in, ±0.01 (x.xx mm, ±0.25).
Pin diameter: 0.04in for Pin no. 1-3 and 5-7
0.062in for Pin no. 4 and 8
Pin material: See General Data, Mechanical Specifications

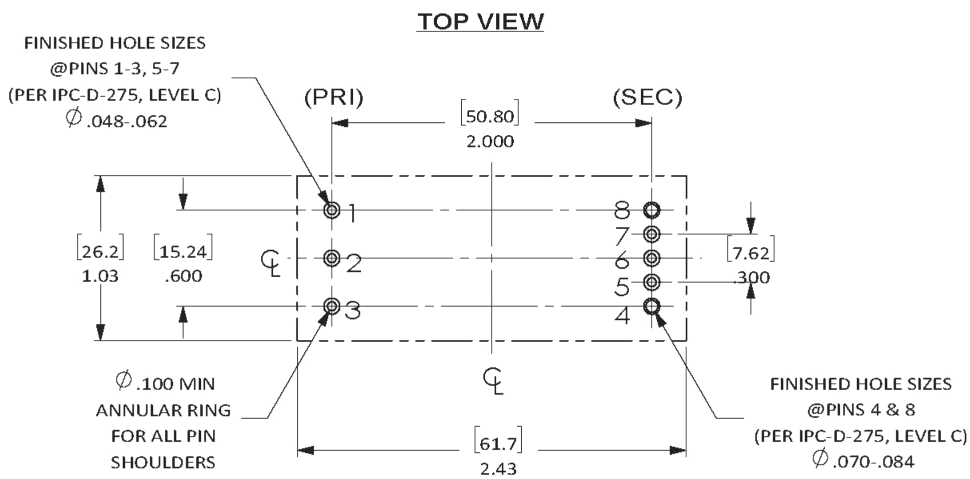


Standard Baseplate: Recommended Footprint with Flange

INPUT/OUTPUT CONNECTIONS			
Pin No.	**Function**	**Pin No.**	**Function**
1	Vin (+)	5	Sense(-)
2	On/Off	6	Trim
3	Vin	7	Sense(+)
4	Vout(-)	8	Vout(+)

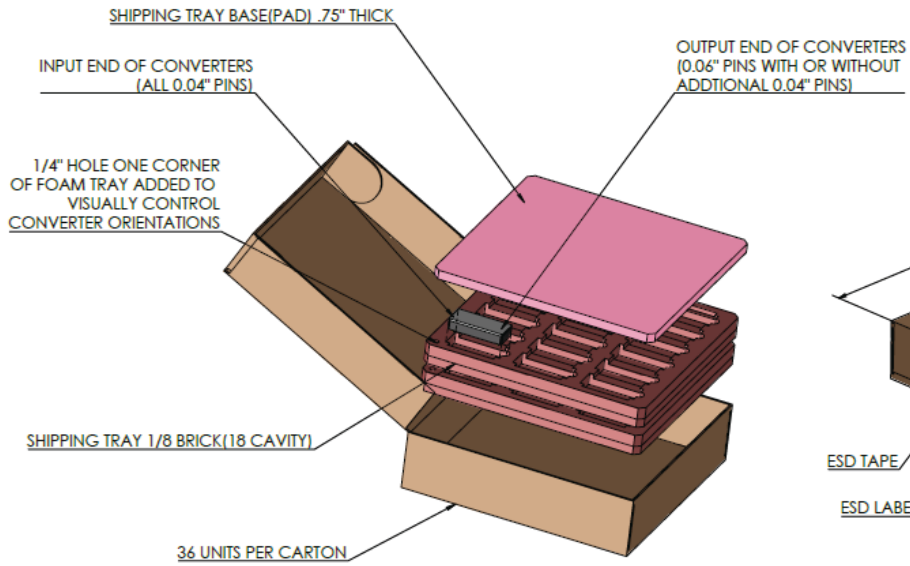


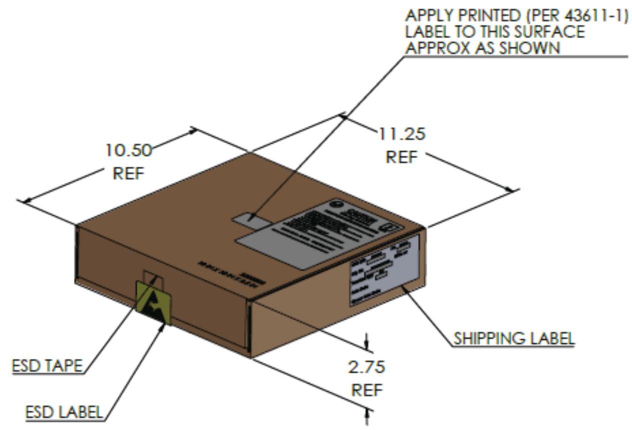
Optional Baseplate: Recommended Footprint without Flange



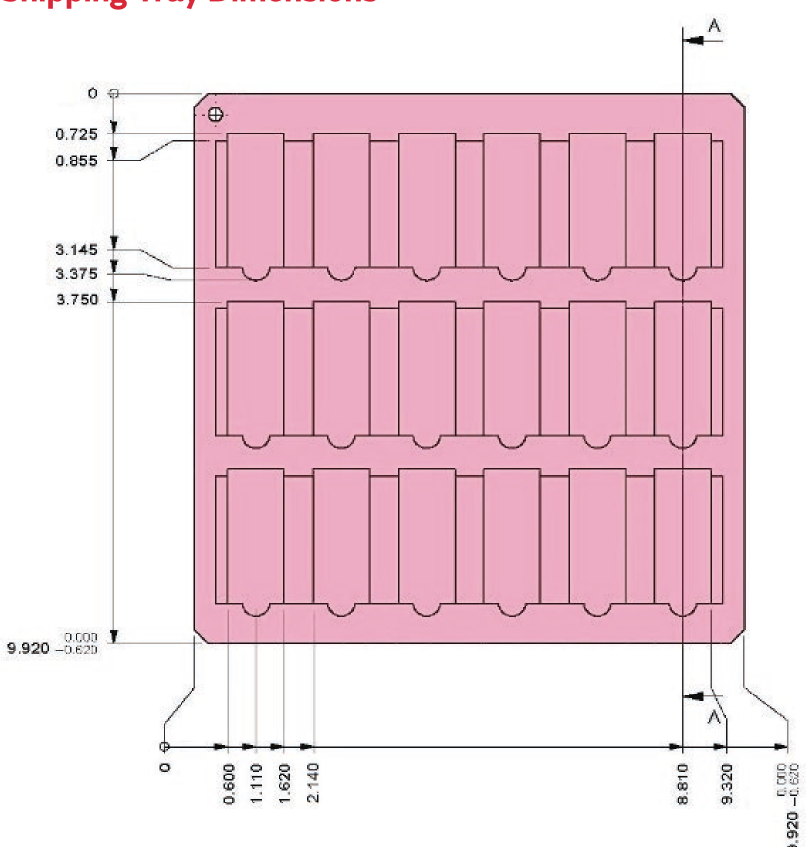
Notes:
All dimensions are in Inches [Millimeter].
Tolerance: x.xx in, ±0.02 (x.x mm, ±0.5).
x.xxx in, ±0.01 (x.xx mm, ±0.25).

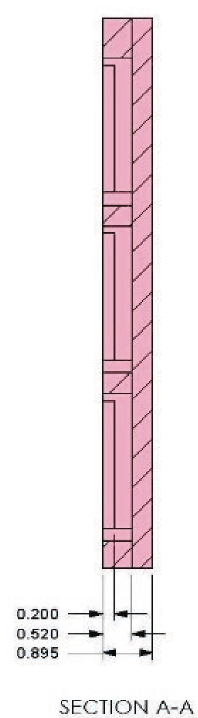
Shipping Box Content and Dimensions





Shipping Tray Dimensions





Tray material: Low density closed cell polyethylene static dissipative foam.

Technical and Application Notes

Input Fusing

Most if not all applications and/or safety agencies will require the installation of an external input fuse for power conversion components to meet specific safety agency requirements. For the EBM series DC-DC converters, we recommend the use of a fast blow fuse, installed in the ungrounded input supply line. See recommended fuse value specified for each module.

All relevant national and international safety standards and regulations must be observed by the installer. For system safety agency approvals, the converters must be installed in compliance with the requirements of the end use safety standard, i.e. IEC/UL60950-1.

Input Reverse-Polarity Protection

If the input voltage polarity is accidentally reversed, an internal diode will become forward biased and likely draw excessive current from the power source. If this source is not current limited or the circuit appropriately fused, it could cause permanent damage to the converter.

There is no Input reverse-Polarity Protection. An external circuit must be added.

Input Under-Voltage Shutdown and Start-Up Thresh-old

Under normal start-up conditions, devices will not begin to regulate properly until the ramping-up input voltage exceeds the Start-Up Threshold Voltage. Once operating, devices will not turn off until the input voltage drops below the Under-Voltage Shutdown limit. Subsequent re-start will not occur until the input is brought back up to the Start-Up Threshold. This built in hysteresis prevents any unstable on/off situations from occurring at a single input voltage.

Start-Up Time

The Vin to Vout Start-Up Time is the time interval between the points at which the ramping input voltage crosses the Start-Up Threshold and the fully loaded output voltage reaches and remains above 90% of its specified output voltage.

Actual measured time will vary with input source impedance, external input capacitance, and the slew rate and final value of the input voltage as it appears at the converter. The EBM Series implements a soft start circuit to limit the duty cycle of its PWM controller at power up, thereby limiting the input inrush current.

The On/Off Control to Vout start-up time assumes the converter has its nominal input voltage applied but is turned off via the On/Off Control pin. The specification defines the interval between the points at which the converter is turned on (released) and the fully loaded output voltage reaches and remains above 90% of its specified output voltage. Similar to the Vin to Vout start-up, the On/Off Control to Vout start-up time is also governed by the internal soft start circuitry and external load capacitance. The difference in start-up time from Vin to Vout and from On/Off Control to Vout is therefore insignificant.

Input Source Impedance

The input of a dc-dc converter acts like a negative resistance and must be compensated by providing a low impedance input source to insure the system will be stable. The dc-dc converter performance and stability will be compromised if the source is not compensated properly.

A low ESR Cbus in the input circuit shown below is a practical solution that can be used to minimize the effects of inductance in the input traces. For optimum performance, components should be mounted as close to the DC-DC converter as possible.

There are several papers that have been written regarding this topic and we suggest that that the power systems engineer review for further information:

References:

1) Middlebrook, R.D. "Input Filter Considerations in Design and Application of Switching Regulators" IEE IAS Annual Meeting, 1976

2) Feng, X. et al, "individual Load Impedance Specification for a Stable DC

I/O Filtering, Input Ripple Current, and Output Noise

All models in the EBM Series are tested/specified for input reflected ripple current, input terminal ripple current and output noise using the specified external input/output components/circuits and layout as shown in the following figures. External input capacitors (Cbus in Figure 1 Measuring Input Ripple Current and Output Noise) serve primarily as energy-storage elements, minimizing line voltage variations caused by transient IR drops in conductors from backplane to the DC-DC. Input caps should be selected for bulk capacitance (at appropriate frequencies), low ESR, and high RMS-ripple-current ratings. The switching nature of DC-DC converters requires that dc voltage sources have low ac impedance as highly inductive source impedance can affect system stability. The input ripple is measured with simulated source impedance Ls. Capacitor Cs to offset possible battery impedance. Your specific system configuration may necessitate additional considerations.

In critical applications, output ripple/noise (Fig. T1: Measurement Input Ripple and Output Noise Circuit) may be reduced below specified limits using filtering techniques, the simplest of which is the installation of additional external output capacitors. They function as true filter elements and should be selected for bulk capacitance, low ESR and appropriate frequency response. Care must be taken not to exceed the maximum rated Cout specification as this can cause system instability and possible failure of the dc-dc module.

All external capacitors should have appropriate voltage ratings and be located as close to the converter as possible. Temperature variations for all relevant parameters should also be taken carefully into consideration. The most effective combination of external I/O capacitors will be a function of line voltage and source impedance, as well as particular load and layout conditions.

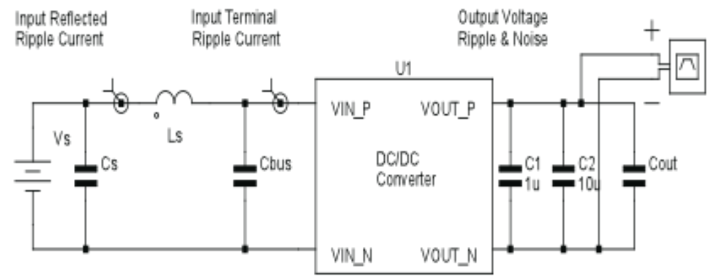


Fig. T1: Measurement Input Ripple and Output Noise Circuit

Floating Outputs

Since these are isolated DC-DC converters, their outputs are “floating” with respect to their input. Designers will normally use the –Output as the ground/ return of the load circuit. You can however, use the +Output as ground/return to effectively reverse the output polarity.

Thermal Shutdown

The EBM-series converters are equipped with thermal-shutdown circuitry. If environmental conditions cause the temperature of the DC-DC converter to rise above the designed operating temperature, a precision temperature sensor will power down the unit. When the internal temperature decreases below the threshold of the temperature sensor, the unit will self-start.

The thermal shutdown is set to a point where the semiconductors should never exceed their “maximum ratings”. The thermal shutdown is set to avoid “nuisance” shutdown under fault conditions. i.e. if the air conditioning goes down in the data center, the module can run at a higher temperature for some time. We do not recommend that you run the module continuously above the thermal derating curve recommendations.

It is recommended that you fully understand the “recommended operating temperature” and verify that under normal operating conditions the module temperature is not exceeded in your application.

See Performance/Functional Specifications.

Output Over-Voltage Protection

Vout is controlled via a closed loop system and monitored for fault conditions (over voltage, over current) such as an over-voltage condition. If Vout for any reason rises above the specified OVP set point the converter will shut down causing Vout to decrease rapidly (depending on load conditions). Following a time-out period the module will restart causing Vout to ramp to its specified set-point. If the fault condition persists and Vout again exceeds the OVP set point the converter will again enter the shutdown cycle. This on/off cycling is referred to as “hiccup” mode. When the fault condition has been corrected the module will return to normal operations.

Current Limiting

As soon as the output current increases to approximately 130% of its rated value, the DC-DC converter will go into a current-limiting mode. In this condition, the output voltage will decrease proportionately with increases in output current, thereby maintaining somewhat constant power dissipation. This is commonly referred to as power limiting. Current limit inception is defined as the point at which the full-power output voltage falls below the specified tolerance. See Performance/Functional Specifications. If the load current, being drawn from the converter, is significant enough, the unit will go into a short circuit condition as described below.

Short Circuit Condition

When a converter is in current-limit mode, the output voltage will drop as the output current demand increases. If the output voltage drops too low, the magnetically coupled voltage used to develop primary side voltages will also drop, thereby shutting down the PWM controller. Following a time-out period, the PWM will restart causing the output voltage to begin ramping to their appropriate value. If the short-circuit condition persists, another shutdown cycle will be initiated. This on/off cycling is referred to as “hiccup” mode. The hiccup cycling reduces the average output current, thereby preventing internal temperatures from rising to excessive levels. The EBM Series is capable of enduring an indefinite short circuit output condition.

On/Off Control

The input-side, remote On/Off Control function can be ordered to operate with Positive (“P” suffix) logic models are enabled when the On/Off pin is left open or is pulled high (see specifications) with respect to the –Input.

Positive-logic devices are disabled when the on/off pin is pulled low with respect to the –Input.

Negative (“N” suffix) logic devices are off when the On/Off pin is left open or is pulled high (see specifications), and on when the pin is pulled low with respect to the –Input. See specifications.

Dynamic control of the remote on/off function is best accomplished with a mechanical relay or an open-collector/open-drain drive circuit (optically isolated if appropriate). The drive circuit should be able to sink appropriate current (see Performance Specifications) when activated and withstand appropriate voltage when deactivated.

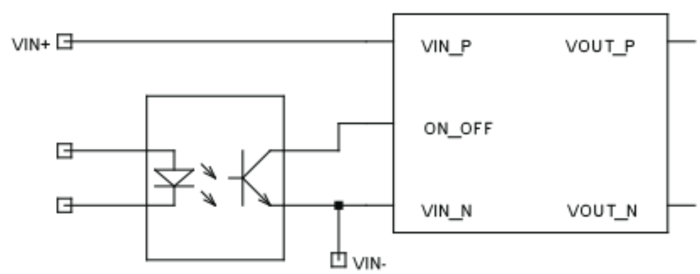


Fig. T2: ON/OFF Control Circuit

Remote Sense

Note: The Sense and Vout lines are internally connected through low-value resistors. Nevertheless, if the sense function is not used for remote regulation, the user should connect the +Sense to +Vout and –Sense to –Vout directly at the DC-DC converter pins. EBM series converters employ a sense feature to provide point of use regulation, thereby overcoming moderate IR drops in PCB conductors or cabling. The remote sense lines carry very little current and therefore require minimal cross-sectional-area conductors. The sense lines, which are coupled to their respective output lines, are used by the feedback control-loop to regulate the output. As such, they are not low impedance points and must be treated with care in layouts and cabling. Sense lines on a PCB should be run adjacent to dc signals, preferably ground.

$$[Vout(+) - Vout(-)] - [Sense(+) - Sense(-)] \leq 10\% \times Vout$$

In cables and discrete wiring applications, twisted pair or other techniques should be used. Output over-voltage protection is monitored at the output voltage pin, not the Sense pin. Therefore, excessive voltage differences between Vout and Sense in conjunction with trim adjustment of the output voltage can cause the over-voltage protection circuitry to activate (see Performance Specifications for over-voltage limits).

Power derating is based on maximum output current and voltage at the converter’s output pins. Use of trim and sense functions can cause output voltages to increase, thereby increasing output power beyond the converter’s specified rating, or cause output voltages to climb into the output over-voltage region. Therefore, the designer must ensure:

(Vout at pins) × (Iout) ≤ rated output power

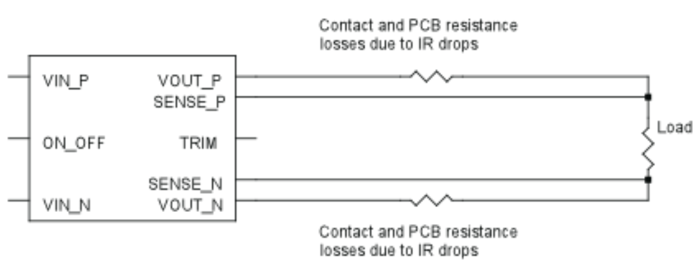


Fig. T3: Remote Sense Circuit

Output Voltage Adjustment (TRIM)

The TRIM input permits the user to adjust the output voltage across the sense leads up or down according to the trim range specifications.

To decrease the output voltage, the user should connect a resistor between TRIM pin and SENSE (–) pin. For a desired decrease of the nominal output voltage, the value of the resistor should be:

$$R_{trimdown} = \frac{5.11}{\Delta\%} - 10.22\ (k\Omega)$$

Where:

$$\Delta\% = \left|\frac{V_{nominal} - V_{desired}}{V_{nominal}}\right|$$

To increase the output voltage, the user should connect a resistor between TRIM pin and SENSE (+) pin. For a desired increase of the nominal output voltage, the value of the resistor should be:

$$R_{trimup} = \frac{5.11 \times V_{nominal} \times (1 + \Delta\%)}{1.225 \times \Delta\%} - \frac{5.11}{\Delta\%} - 10.22\ (k\Omega)$$

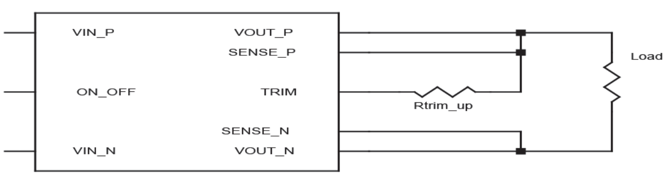


Figure 1. Trim Up connections to increase Vout

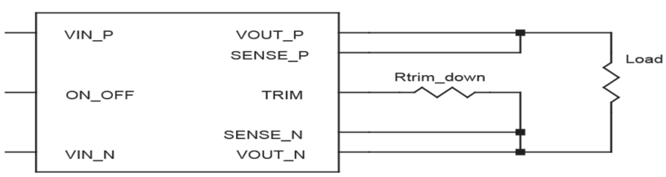


Figure 2. Trim Down connections to decrease Vout

Through-Hole Soldering Guidelines

Calex recommends the TH soldering specifications below when installing these converters. These specifications vary depending on the solder type. Exceeding these specifications may cause damage to the product. Your production environment may differ; therefore please thoroughly review these guidelines with your process engineers.

Wave Solder Operations for through-hole mounted products (THMT)		
For Solder based on:	**Sn/Ag/Cu**	**Sn/Pb**
Maximum Preheat Temperature	115° C.	105° C.
Maximum Pot Temperature	270° C.	250° C.
Maximum Solder Dwell Time	7 seconds	6 seconds

Some detailed trim resistance values are listed in the below table:

	Trim Up Resistance		Trim Down Resistance	
PN	**Vout(V)**	**Rtrim_up (kΩ)**	**Vout (V)**	**Rtrim_ down (kΩ)**
24QS5.120EBM	5.05	1585	4.9	245.3
	5.1	798	4.8	117.5
	5.2	404	4.6	53.7
	5.3	273	4.4	32.4
	5.4	207	4.2	21.7
	5.5	168	4	15.3
24QS12.120EBM	12.12	4535	11.76	245.3
	12.36	1538	11.28	74.9
	12.6	939	10.8	40.9
	12.84	682	10.32	26.3
	13.08	539	9.84	18.2
	13.2	489	9.6	15.3
24QS24.120EBM	24.24	9590	23.52	245.3
	24.48	4840	23.04	117.5
	24.96	2465	22.08	53.7
	25.44	1673	21.12	32.4
	25.92	1277	20.16	21.7
	26.4	1040	19.2	15.3

Note: The Trim feature does not affect the voltage at which the output over-voltage protection (OVP) circuit is triggered. Trimming the output voltage too high may cause the over-voltage protection circuit to trigger, particularly during load transients. For the converter to meet its rated specifications the maximum variation of the dc value of Vout, due to both trimming and remote load voltage drop should not exceed the output voltage trim range.