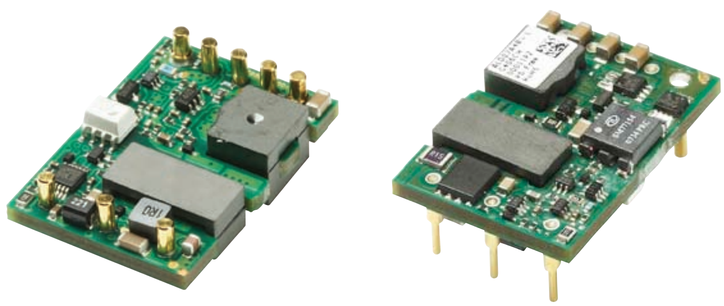
Technical Reference Note

Embedded Power for
Business-Critical Continuity

ALD15 Series

Sixteenth Brick Converter
Single Output Low Power

Total Power: 35 Watts
Input Voltage: 36 - 75 V



Special Features

- Industry standard sixteenth brick footprint
- Low ripple and noise
- Regulation to zero load
- High capacitive load start-up
- Fixed switching frequency
- Industry standard features: Input UVLO, Enable, Non-Latching OVP, OCP and OTP, Output trim, Differential remote sense
- Open-frame low-profile construction
- Through hole or surface mount termination
- Meets basic insulation

Safety

UL+cUL 60950-1, Recognized
EN60950-1 through TUB-PS

Product Description

The ALD15 Series is the latest addition to the Sixteenth brick product offering. It operates from an input range of 36 to 75 V and provides fully regulated output voltages of: 1.2 V, 1.5 V, 1.8 V, 2.5 V, 3.3 V, 5.0 V and 12.0 V rated up to 35 W. It comes with industry standard features such as Input UVLO; Output Enable; non-latching OCP, OVP and OTP; Output Trim; Differential Remote Sense pins. It's an open frame low profile design which comes either through-hole or surface mount termination.

Electrical Specifications

Input	
Input range:	36 - 75 Vdc
Input surge:	100 Vdc / 100 ms
Control	
Enable:	TTL compatible
Positive or Negative Logic Enable Options	
Output	
Load current:	Up to 15 A max.
Line/Load regulation	0.1% V_0
Ripple and noise:	40 mV_{p-p} typical
Adjust range	± 10% V_0
Transient response:	3% Typical deviation 50% to 75% Load Change 80 µs settling time (Typ)
Remote sense:	+10% V_0
Over current protection:	125% Io, max
Over voltage protection:	125% Vo, nom
Over temperature protection:	115 °C

Environmental Specifications

Operating temperature:	-40 °C to +85 °C
Storage temperature:	-40 °C to 125 °C
MTBF:	1 million hours

EMERSON
Network Power

Electrical Specifications

Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause permanent damage to the converter. Functional operation of the device is converter is not implied at these or any other conditions in excess of those given in the operational section of the specs. Exposure to absolute maximum ratings for extended period can adversely affect device reliability.

Parameter	Device	Symbol	Min	Typ	Max	Unit
Input voltage: Continuous Transient (100 ms)	All	V_{IN} $V_{IN, trans}$	-0.3 -	- -	75 100	Vdc
Isolation Voltage: Input to Output	All	-	1500	-	-	Vdc
Operating Temperature:	All	Ta	-40	-	85	°C
Storage Temperature:	All	T_{STG}	-40	-	125	°C
Operating Humidity:	All	-	10	-	85	%
Max Voltage at Enable Pin:	All		-0.6	-	25	Vdc
Max Output Power:	All	$P_{0, MAX}$	-	-	35	W

Input Specifications

Parameter	Device	Symbol	Min	Typ	Max	Unit
Operating Input Voltage Range	All	V_{IN}	36	48	75	Vdc
Input Under-Voltage Lock-out: T_ON Threshold T_OFF Threshold	All		34 31	34.8 32.5	36.0 33.5	Vdc
Max Input Current[1]:	12V0 (B) 5V0 (A) 3V3 (F) 2V5 (G) 1V8 (Y) 1V5 (M) 1V2 (K)	Iin_{MAX}	- - - -	- - - -	1.30 1.10 1.18 1.00 0.90 0.90 0.70	A
Max P_{diss} @ I_o = 0 A: $V_{IN} = V_{in, nom}$ $T_A \geq 25$ °C	12V0 (B) 5V0 (A) 3V3 (F) 2V5 (G) 1V8 (Y) 1V5 (M) 1V2 (K)		- - - -	- - - -	2.9 3.0 2.9 2.7 1.9 1.6 1.6	W
Input Ripple Current[2]:	All	I_{I1}	-	-	10	mAp-p
External Input Capacitor: (100 V cap / ESR < 0.7 ohm)	All	C_{iN}		3.3		µF

Note:

1. Module is not internally fused. External fuse is recommended (e.g. Littlefuse® 465 Series / 1.5 x $I_{IN\ max}$ typical).
2. See Figure 1 for the input ripple current test setup.

Electrical Specifications (continued)

Output Specifications

Parameter	Device	Symbol	Min	Typ	Max	Unit
Output Voltage Set point: $V_{IN} = V_{in, min}$ to $V_{in, max}$ $I_o = I_{o, max}$	12V0 (B) 5V0 (A) 3V3 (F) 2V5 (G) 1V8 (Y) 1V5 (M) 1V2 (K)	$V_{o, set}$	11.820 4.930 3.260 2.465 1.770 1.470 1.180	12.00 5.00 3.30 2.500 1.800 1.500 1.200	12.180 5.070 3.340 2.535 1.830 1.530 1.220	Vdc
Output Regulation:	All					%
Line $V_{IN} = V_{in, min}$ to $V_{in, max}$		-	-	0.1	0.4	
Load $V_{IN} = V_{in, nom}$ $I_o = I_{o, min}$ to $I_{o, max}$		-	-	0.1	0.4	
Temp $V_{IN} = V_{in, nom}$; $I_o = I_{o, max}$ T_a = -40 °C to 85 °C		-	-	0.3	0.8	
Output Ripple and Noise[3]: *Peak-Peak* $I_o = I_{o, max}$; $V_{IN} = V_{in, nom}$ BWL = 20 MHz; T_A = 25 °C	All	-	-	40	100	mVp-p
Output Current[4]:	12V0 (B) 5V0 (A) 3V3 (F) 2V5 (G) 1V8 (Y) 1V5 (M) 1V2 (K)	I_o	0 0 0 0 0 0 0	- - - - - - -	2.75 7 10 11 13 15 15	A
External Load Capacitance: Capacitor ESR	Vo ≤ 5 V	-	- 4	- -	10,000	µF mΩ
	12V (B)		- - 4	- - -	2000 @ 25 °C 470 @ 85 °C	µF µF mΩ
Output Current-limit Inception[5]: V_{out} = 90% $V_{o,set}$ Vin = 36/48/75V	12V0 (B) 5V0 (A) 3V3 (F) 2V5 (G) 1V8 (Y) 1V5 (M) 1V2 (K)		105	- - - - - - -	145	% of Io
Output Over Voltage Protection[5]: *Non-latching / auto-recovery*	12V0 (B) 5V0 (A) 3V3 (F) 2V5 (G) 1V8 (Y) 1V5 (M) 1V2 (K)		14.10 5.9 3.9 3.0 2.1 1.8 1.4	14.9 6.2 4.1 3.2 2.4 2.1 1.6	16.2 6.9 4.9 3.9 2.9 2.5 2.1	V
Overtemperature Protection: *Auto-recovery*	All		105	-	125	°C

Electrical Specifications (continued)

Output Specifications (continued)

Parameter	Device	Symbol	Min	Typ	Max	Unit
Efficiency: $V_{in} = V_{in\ nom}$; $I_o = I_{o,\ max}$ $T_A = 25\ °C$	12V0 (B) 5V0 (A) 3V3 (F) 2V5 (G) 1V8 (Y) 1V5 (M) 1V2 (K)	η η η η η η η	90 89 87.5 86.5 85 83 82	90.5 91 90 89 87 85 84		%
Input to Output Turn-On Delay: $V_{IN} = V_{in,\ nom}$; $I_o = I_{o,\ max}$	All	-	-	-	20	ms
Turn-On Response Time: $V_{IN} = V_{in,\ min}$ to $V_{in,\ max}$	All	-	-	5	15	ms
Enable to Output Turn-On Delay: $V_{IN} = V_{in,\ min}$ to $V_{in,\ max}$ $I_o = I_{o,\ min}$ to $I_{o,\ max}$	All	-	0	-	20	ms
+Vin to Output Turn-On Delay: Enable Pin: Active $V_{IN} = V_{in,\ min}$ to $V_{in,\ max}$ $I_o = I_{o,\ min}$ to $I_{o,\ max}$	All	-	0	-	20	ms
Switching Frequency:	12V0 (B) 5V0 (A) 3V3 (F) 2V5 (G) 1V8 (Y) 1V5 (M) 1V2 (K)	-	630 670 470 700 640 550 410	700 750 530 780 715 615 460	770 830 590 860 790 680 510	kHz
Dynamic Response: C_o = use Appendix A3 test setup	$\Delta I_o/\Delta t$	-		0.1		A/µs
Peak Deviation for Load Step Change from: I_o = 50% to 75% of Io $_{max}$	Vo > 1.2 V Vo < 1.2V	- -		3 3	5 7	% Vo
Settling Time to within 1% of output set point voltage - Vo,set	All	-		80	200	uS
Peak Deviation for Load Step Change from: I_o = 50% to 25% of Io $_{max}$	Vo > 1.2 V Vo < 1.2V	- -		3 3	5 7	% Vo
Settling Time to within 1% of output set point voltage - Vo,set	All	-		80	200	uS
Output Overshoot at Turn-on Passive Resistive Full Load	Vo ≤ 1V8 Vo > 1V8	- -	- -	0 0	5 4	% Vo

Electrical Specifications (continued)

Output Specifications (continued)

Parameter	Device	Symbol	Min	Typ	Max	Unit
Output Enable ON/OFF[8]:						
Enable Signal Slew Rate	All	-	0.01	-	-	V/ms
Negative Enable ("N" Suffix)	N suffix					
Enable Pin Voltage: Mod-ON		-	-0.5	-	1.2	V
Mod-OFF		-	2.95	-	20	V
Positive Enable (No suffix)	No suffix					
Enable Pin Voltage: Mod-ON		-	2.95	-	20	V
Mod-OFF		-	-0.5	-	1.2	V
Output Voltage Remote Sensing[6]:	All	-	-	-	10	% Vo
Output Voltage Trim Range[7]:	All		90		110	%Vo

Note:

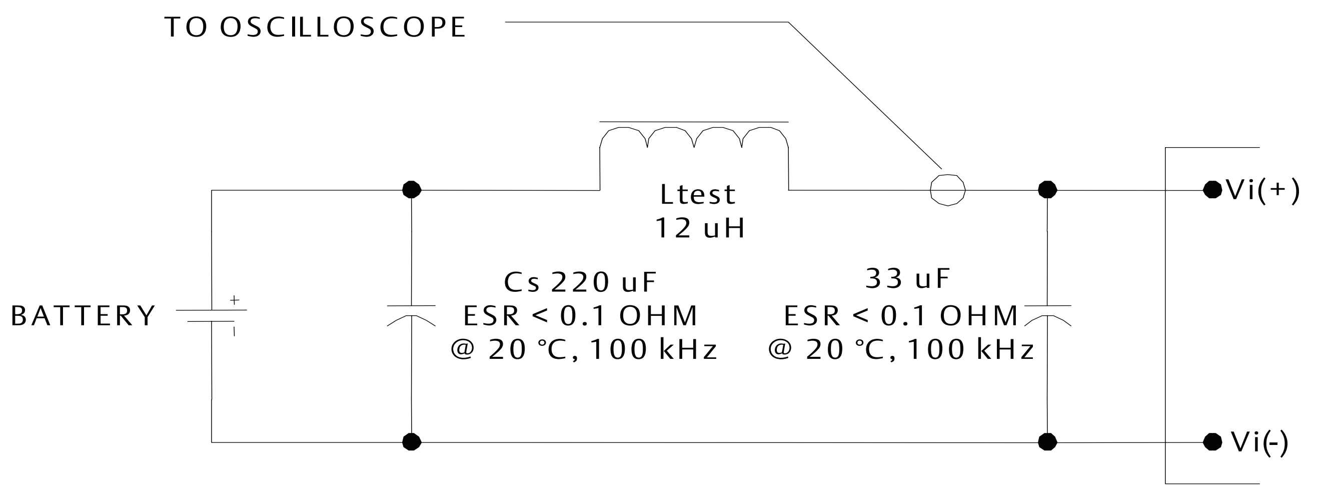
3. See Figure 2 for the Output Ripple and Noise Test Measurement Setup.
4. Output derating applies at elevated temperature. See Figure 10.
5. OCP and OVP are both auto-recovery. The converter will shutdown and attempt to restart until the fault is removed. There is a 25ms lockout period between restart attempts. Note also that the OCP threshold will be reduced proportionally with output voltage trim up and/or remote sense compensation. The percent rise in output voltage will be proportional to the reduction in OCP current limit inception.
6. The sense pins can be used to compensate for any voltage drops (per indicated max limits) that may occur along the connection between the output pins to the load. Pin 7 (+Sense) and Pin 5 (-Sense) should be connected to Pin 8 (+Vout) and Pin 4 (Return) respectively at the point where regulation is desired.
7. See Equation 1 and 2 for the output trim function. The combination of remote sense and trim adjust cannot exceed 100% Vo. Whenever the output voltage is increased, the output current must be derated so as not to exceed the maximum output power.
8. Minimum Enable pin disable time is 100ms. Shorter disable durations may cause output to overshoot beyond specification upon restart (Enable On).

Safety Agency / Material Rating / Isolation

Parameter	Device	
Safety Approval:	All	UL/cUL 60950-1, 3rd Edition - Recognized
	All	EN 60950-1 through TUV
Material Flammability Rating:	All	UL94V-0

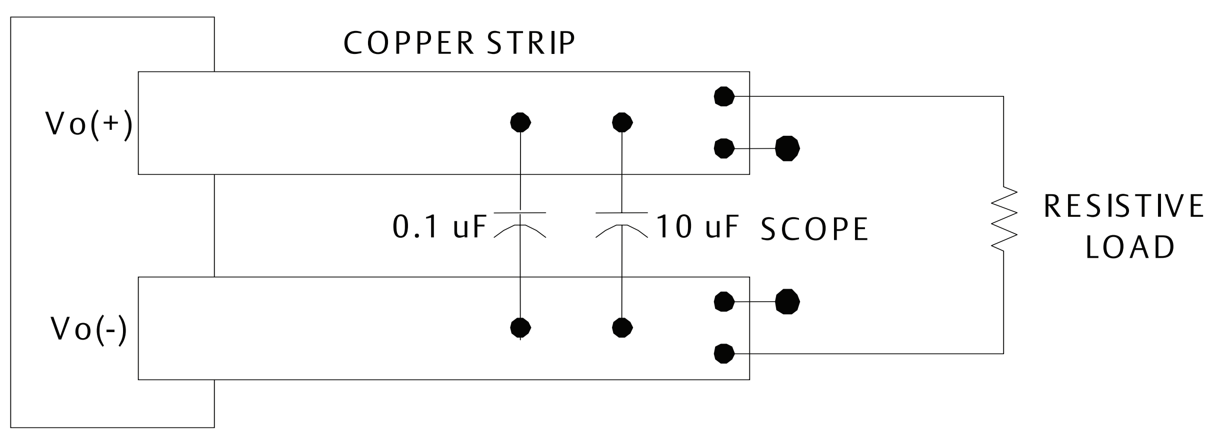
Parameter	Device	Symbol	Min	Typical	Max	Unit
Input to Output Capacitance:	All		-	1000	-	pF
Input to Output Resistance:	All		-	10	-	Mohms
Input to Output Insulation Type:	All		-	Basic	-	-

Electrical Specifications (continued)



Measure input reflected-ripple current with a simulated source inductance (Ltest) of 12 uH. Capacitor Cs offsets possible battery impedance. Measure current as shown above.

Figure 1. Input Reflected Ripple Current Measurement Setup



Use a 0.1 µF @50V X7R ceramic capacitor (connected an inch away from the output terminals of the UUT) and a 10 µF @ 25V tantalum capacitor (2 inches away from the output terminals of the UUT). Scope measurement should be made using a BNC socket, positioned 3 inches away from output terminals of the converter.

Figure 2. Peak to Peak Output Noise Measurement Setup

Basic Operation and Features

Input Under Voltage Lockout

To prevent any instability to the converter, which may affect the end system, the converter have been designed to turn-on once VIN is in the voltage range of 34.0-36.0 Vdc. Likewise, it has also been programmed to turn-off when VIN drops down to 31.0-33.5 Vdc.

Output Voltage Adjust/Trim

The converter comes with a TRIM pin (PIN 6), which is used to adjust the output by as much as 90% to 110% of its set point. This is achieved by connecting an external resistor as described below.

To **INCREASE** the output, external Radj_up resistor should be connected between TRIM PIN (Pin6) and +SENSE PIN (Pin 7). Please refer to Equation (1) for the required external resistance and output adjust relationship.

Equation (1):

$$R_{adj\_up} = \left[\frac{5.1 \times Vo_{set} \times (100 + \Delta\%)}{1.225 \times \Delta\%} - \frac{510}{\Delta\%} - 10.2\right] K\Omega$$

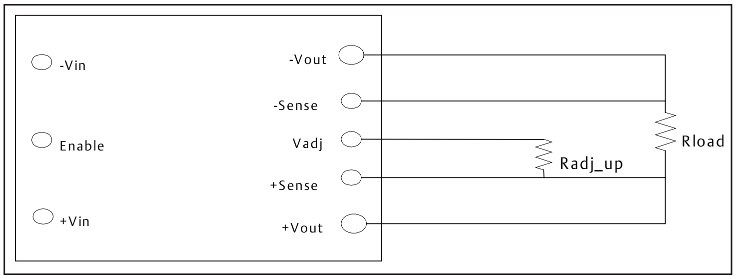


Figure 3. External resistor configuration to increase the outputs

To **DECREASE** the output, external Radj_up resistor should be connected between TRIM PIN (Pin6) and -SENSE PIN (Pin 5). Please refer to Equation (2) for the required external resistance and output adjust relationship.

Equation (2):

$$Radj\_down = \left(\frac{510}{\Delta\%} - 10.2\right) \cdot k\Omega$$

Where Δ% = percent change in output voltage

$$\Delta\% = \left(\frac{Vo_{desired} - Vo_{set}}{Vo_{set}}\right) \times 100$$

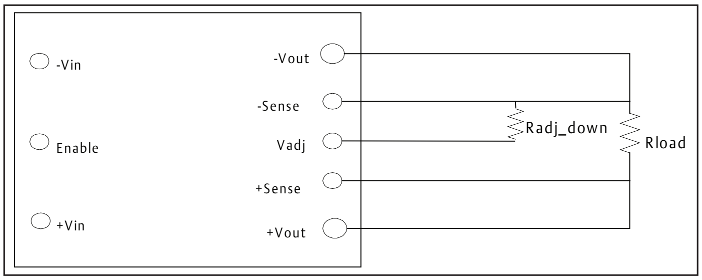


Figure 4. External resistor configuration to decrease the outputs

Output Enable

The converter comes with an Enable pin (PIN 2), which is primarily used to turn ON/OFF the converter. Both a Positive (no "N" suffix required) and a Negative (suffix "N" required) Enable Logic options are being offered. Please refer to Table 2 for the Part Numbering Scheme.

For Positive Enable, the converter is turned on when the Enable pin is at logic HIGH or left open. The unit turns off when the Enable pin is at logic LOW or directly connected to -VIN. On the other hand, the Negative Enable version turns unit on when the Enable pin is at logic LOW or directly connected to -VIN. The unit turns off when the Enable pin is at Logic HIGH.

Basic Operation and Features (continued)

Output Over Voltage Protection (OVP)

The Over Voltage Protection circuit is non-latching - auto recovery mode. The output of the converter is terminated under an OVP fault condition (Vo > OVP threshold). The converter will attempt to restart until the fault is removed. There is a 25ms lockout period between restart attempts.

Over Current Protection (OCP)

The Over Current Protection is non-latching - auto recovery mode. The converter shuts down once the output current reaches the OCP range. The converter will attempt to restart until the fault is removed. There is a 25ms lockout period between restart attempts.

Output Temperature Protection (OTP)

The Over Temperature Protection circuit will shutdown the converter once the average PCB reaches the OTP range. This feature prevents the unit from overheating and consequently going into thermal runaway, which may further damage the converter and the end system. Such overheating may be an effect of operation outside the given power thermal derating conditions. Restart is possible once the temperature of the sensed location drops to less than 110 °C.

Remote Sense

The remote sense pins can be used to compensate for any voltage drops (per indicated max limits) that may occur along the connection between the output pins to the load. Pin 7 (+Sense) and Pin 5 (-Sense) should be connected to Pin 8 (+Vout) and Pin 4 (Return) respectively at the point where regulation is desired. The combination of remote sense and trim adjust cannot exceed 110% of VO. When output voltage is trimmed up (through remote sensing and/or trim pin), output current must be derated and maximum output power must not be exceeded.

Performance Curves (2.5 V Version)

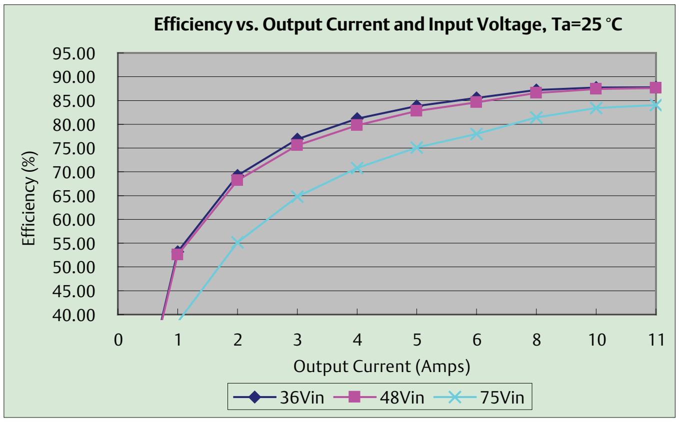


Figure 5. 2.5V Efficiency vs. Output Current at Various Input Line Conditions, Ta = 25 °C

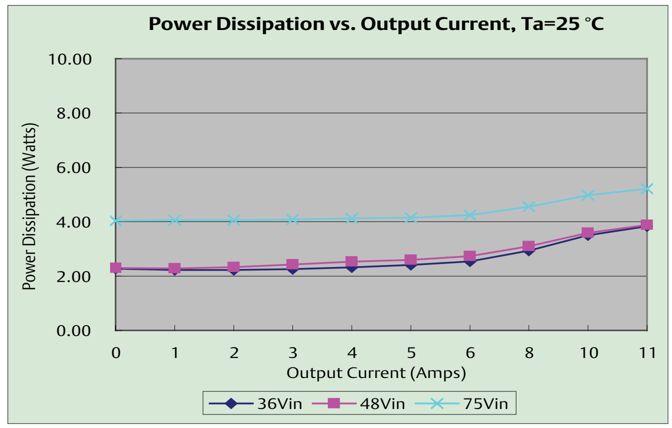


Figure 6. 2.5V Power Dissipation vs. Load Current at Various Input Line Conditions, Ta = 25 °C

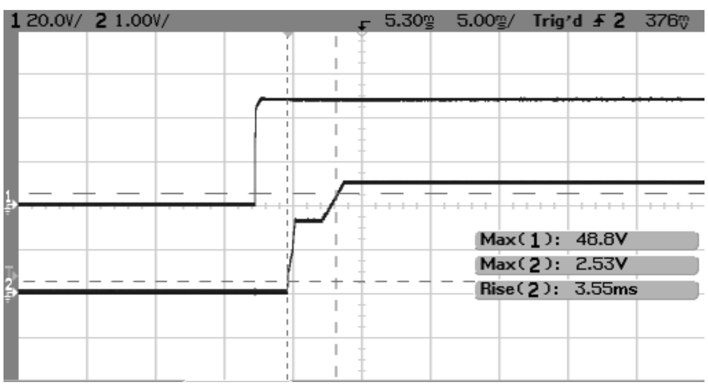


Figure 7. 2.5V Startup Characteristic at Vin = 48Vdc, Io = Full Load, Ta = 25 °C

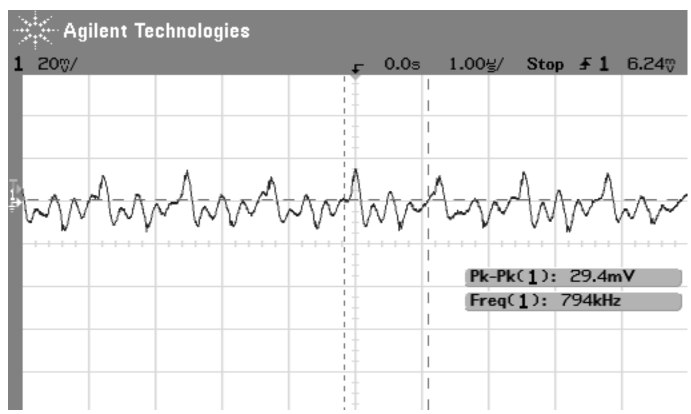


Figure 8. 2.5V Output Ripple at Vin = 48 Vdc, Io = Full Load, Ta = 25 °C

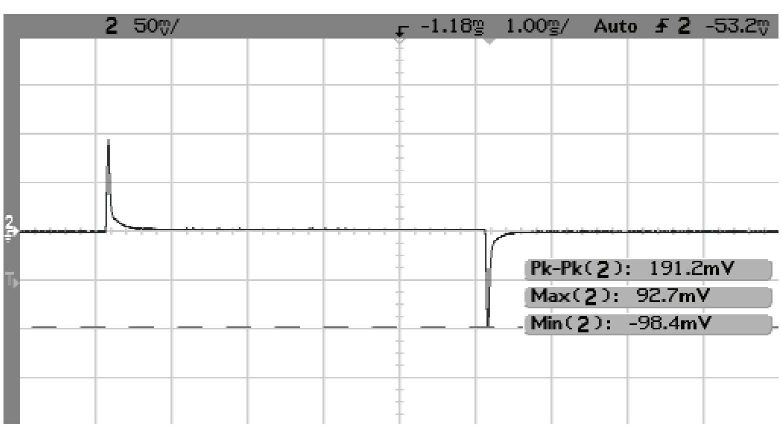


Figure 9. 2.5V Transient Response 50% to 75% step at Vin = 48Vdc, Ta = 25 °C, di/dt = 0.1 A/us, Co = 10 uF

Performance Curves (3.3 V Version)

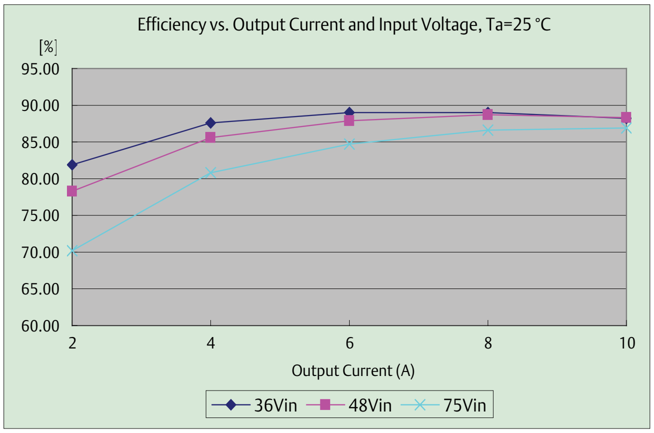


Figure 10. 3.3V Efficiency vs. Output Current at Various Input Line Conditions, Ta = 25 °C

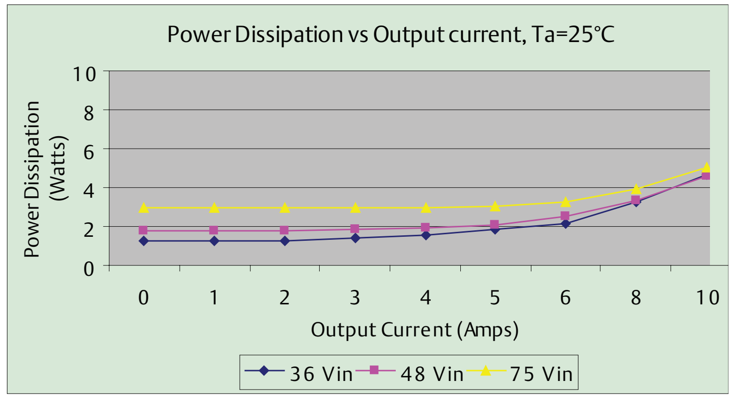


Figure 11. 3.3V Power Dissipation vs. Load Current at Various Input Line Conditions, Ta = 25 °C

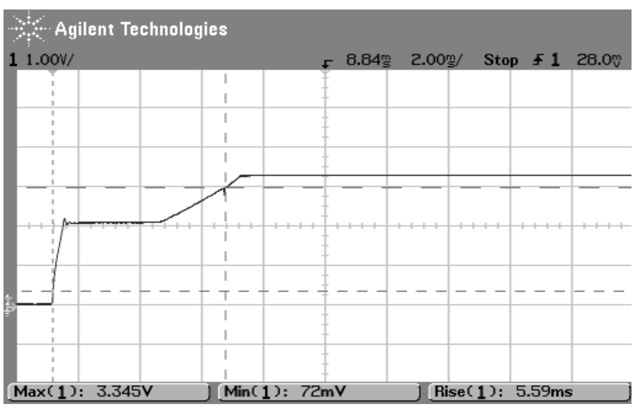


Figure 12. 3.3V Startup Characteristic at Vin = 48Vdc, Io = Full Load, Ta = 25 °C (Channel 1 = VIN)

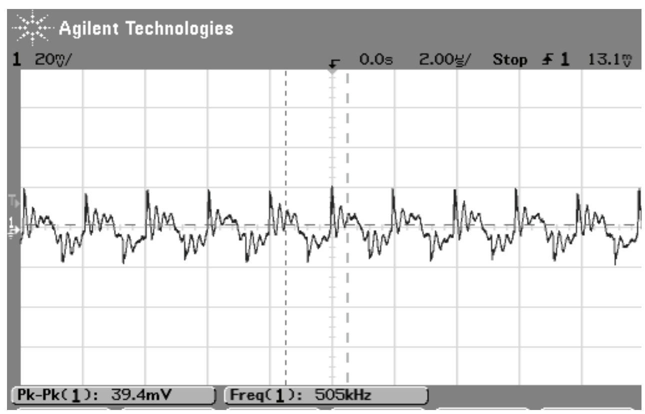


Figure 13. 3.3V Output Ripple at Vin = 48 Vdc, Io = Full Load, Ta = 25 °C

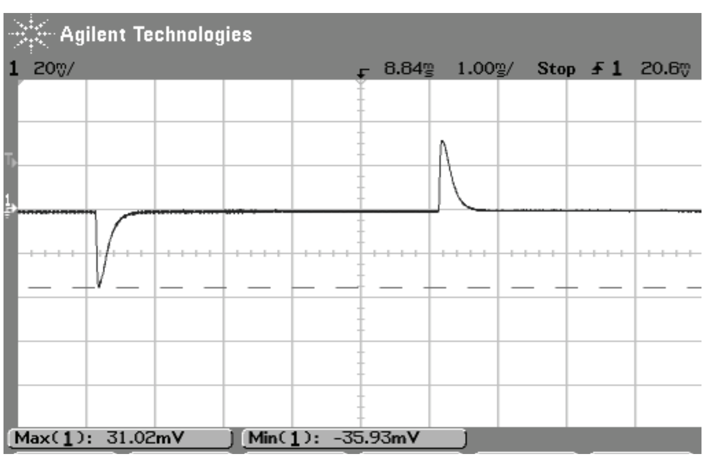


Figure 14. 3.3V Transient Response 50% to 75% step at Vin = 48Vdc, Ta = 25 °C, di/dt = 0.1 A/us, Co = 10 uF

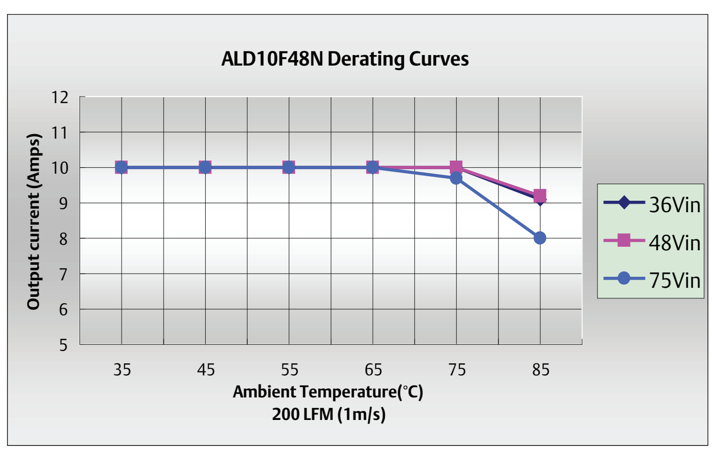


Figure 15. 3.3V Output Load Current vs. Ambient Temperature at Vin = 48Vdc

Performance Curves (5.0 V Version)

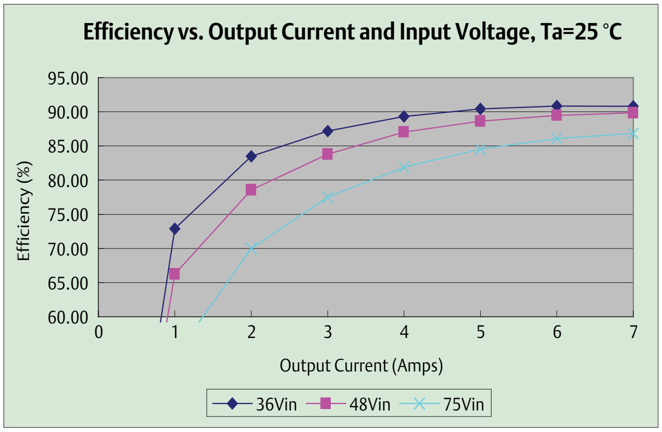


Figure 16. 5.0V Efficiency vs. Output Current at Various Input Line Conditions, Ta = 25 °C

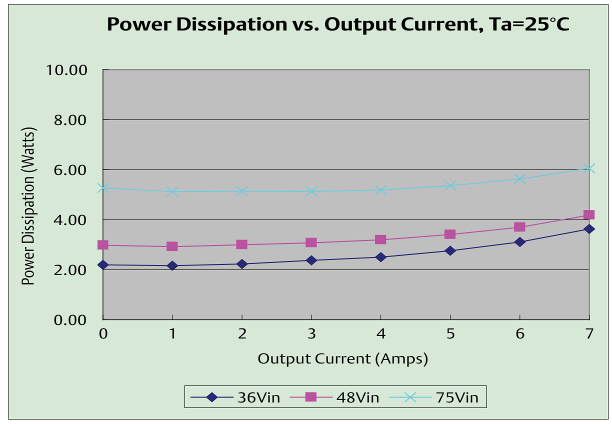


Figure 17. 5.0V Power Dissipation vs. Load Current at Various Input Line Conditions, Ta = 25 °C

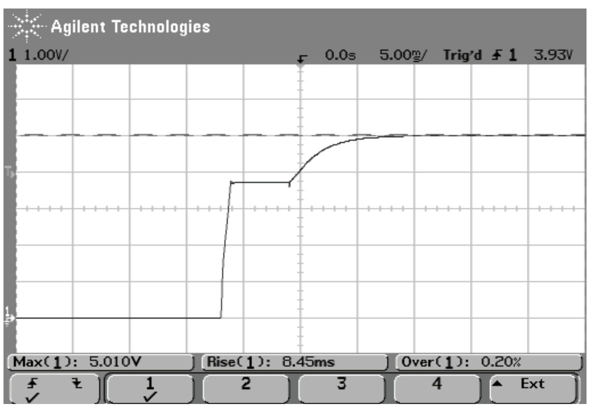


Figure 18. 5.0V Startup Characteristic at Vin = 48Vdc, Io = Full Load, Ta = 25 °C (Channel 1 = VIN)

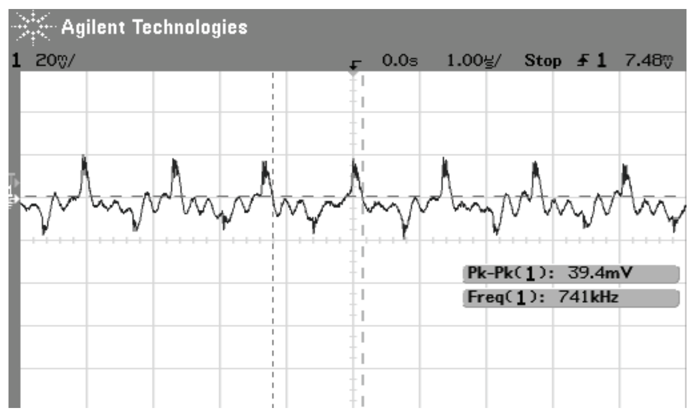


Figure 19. 5.0V Output Ripple at Vin = 48 Vdc, Io = Full Load, Ta = 25 °C

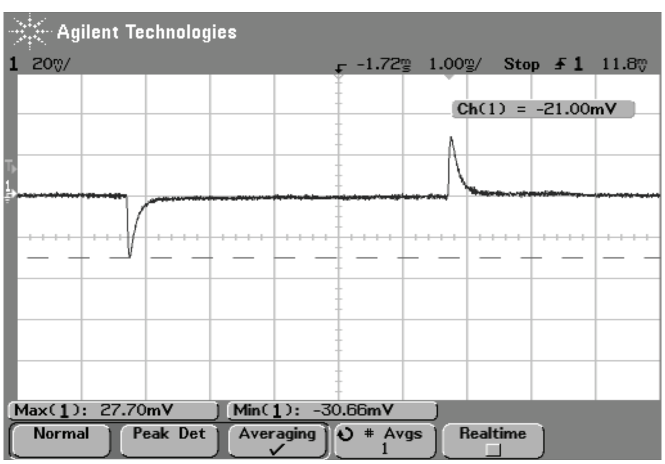


Figure 20. 5.0V Transient Response 50% to 75% step at Vin = 48Vdc, Ta = 25 °C, di/dt = 0.1 A/us, Co = 10 uF

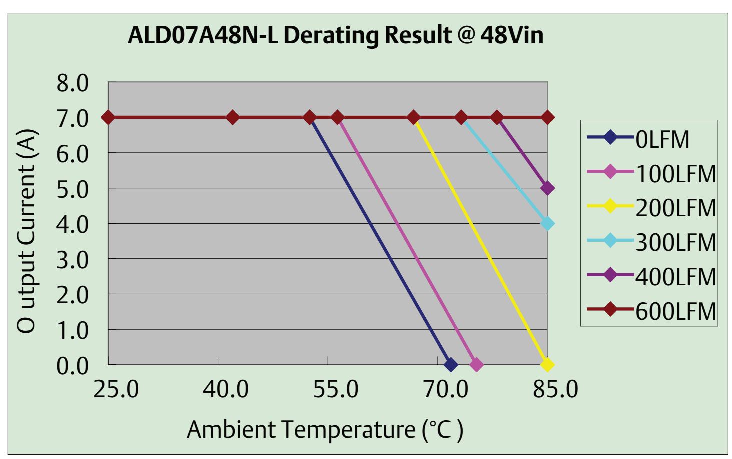


Figure 21. 5.0V Output Load Current vs. Ambient Temperature at Vin = 48Vdc

Performance Curves (12.0 V Version)

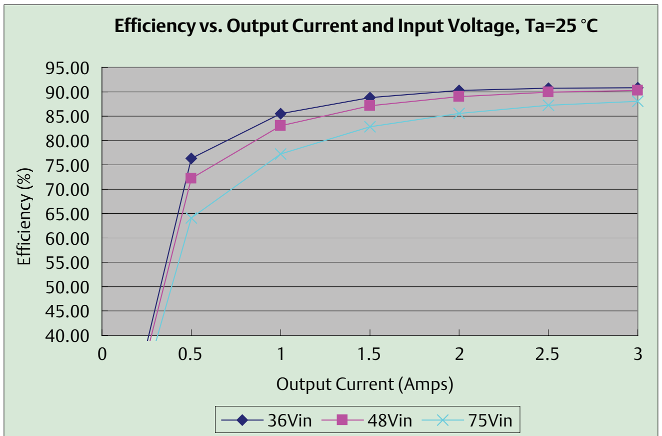


Figure 22. 12.0V Efficiency vs. Output Current at Various Input Line Conditions, Ta = 25 °C

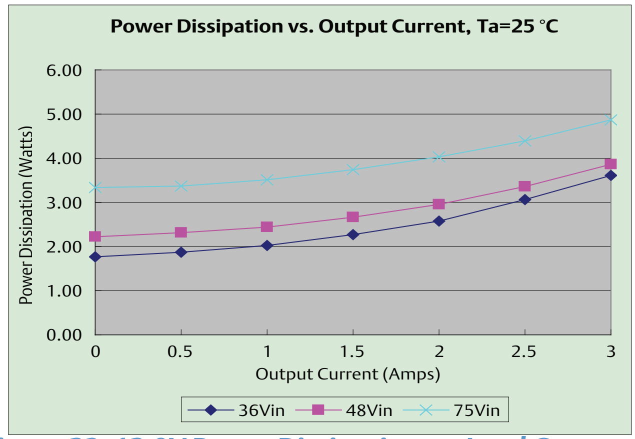


Figure 23. 12.0V Power Dissipation vs. Load Current at Various Input Line Conditions, Ta = 25 °C

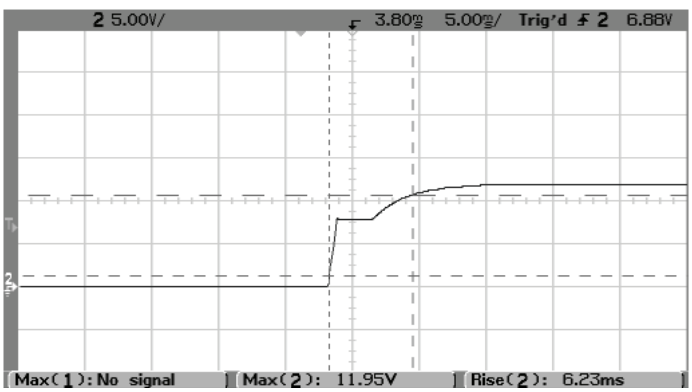


Figure 24. 12.0V Startup Characteristic at Vin = 48Vdc, Io = Full Load, Ta = 25 °C (Channel 1 = VIN)

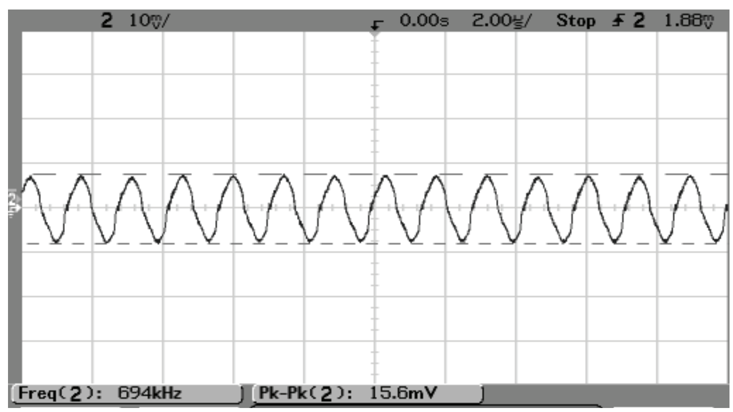


Figure 25. 12.0V Output Ripple at Vin = 48 Vdc, Io = Full Load, Ta = 25 °C

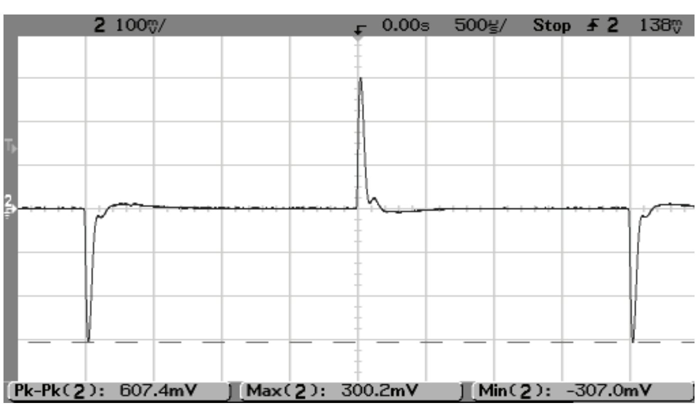


Figure 26. 12.0V Transient Response 50% to 75% step at Vin = 48Vdc, Ta = 25 °C, di/dt = 0.1 A/us, Co = 10 uF

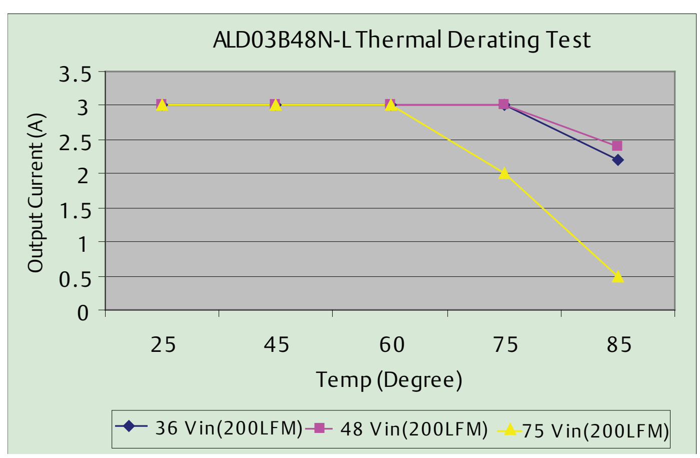


Figure 27. 12.0V Output Load Current vs. Ambient Temperature at Vin = 48Vdc

Input Filter for FCC Class B Conducted Noise

A reference design for an input filter that can provide FCC Class B conducted noise levels is shown below (See Figure 28). A common mode choke is used in the circuit along with balanced bypass capacitors to shunt common mode currents into the ground plane. Shunting noise current back to the converter reduces the amount of energy reaching the input LISN for measurement.

The application circuit shown has an earth ground (frame ground) connected to the converter output (-) terminal. Such a configuration is common practice to accommodate safety agency requirements. Grounding an output terminal results in much higher conducted emissions as measured at the input LISN because a hard path for common mode current back to the LISN is created by the frame ground. "Floating" loads generally result in much lower measured emissions. The electrical equivalent of a floating load, for EMI measurement purposes, can be created by grounding the converter output (load) through a suitably sized inductor(s) while maintaining the necessary safety bonding.

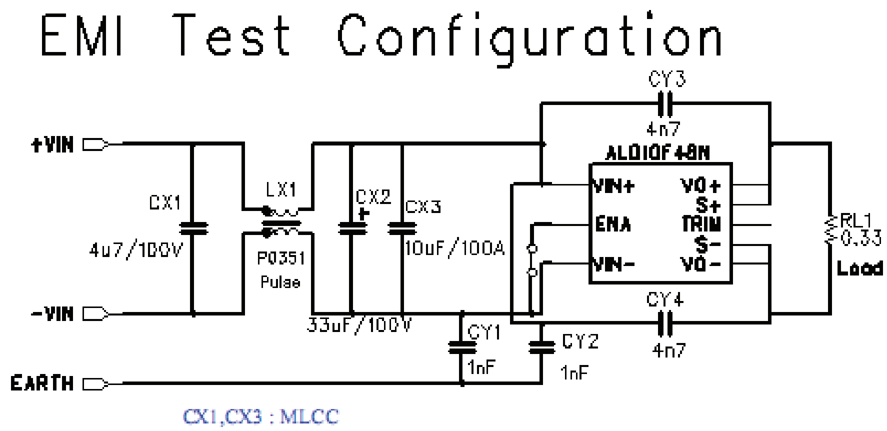
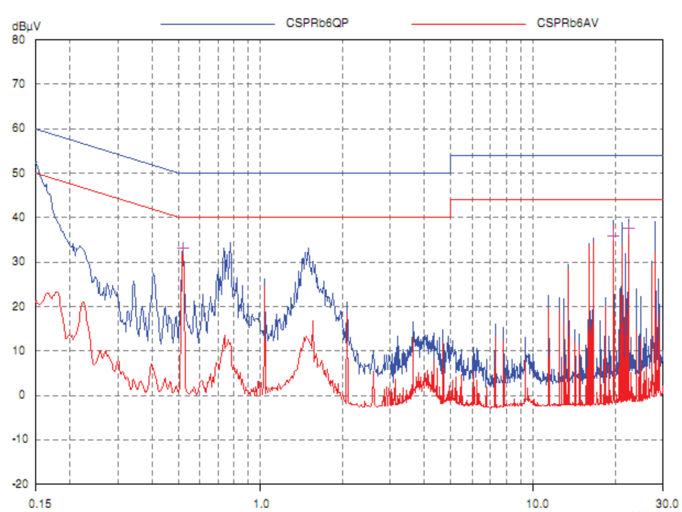
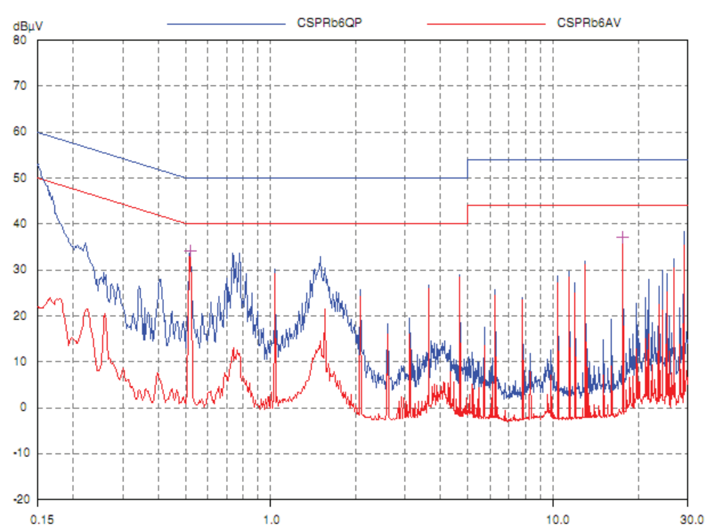


Figure 28. EMI Input Filter

Conducted EMI Test Results



48 Vin, Io min



48 Vin, Io max

Mechanical Specifications

Pin #	Designation	Pin #	Designation
J1	$+V_{IN}$	J5	-Sense
J2	Enable	J6	Trim
J3	$-V_{IN}$	J7	+Sense
J4	$-V_{OUT}$	J8	$+V_{OUT}$

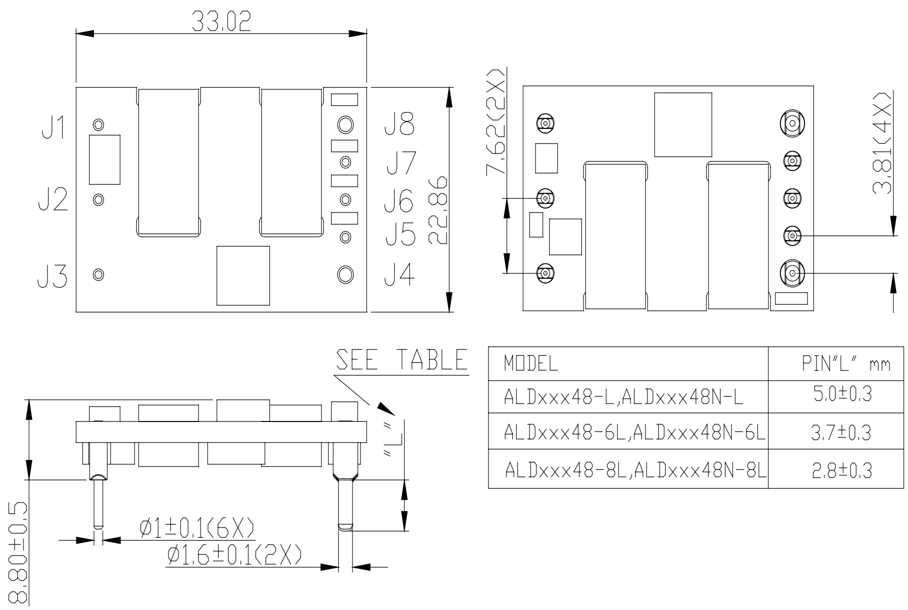


Figure 29. ALD Through Hole Termination Mechanical Outline

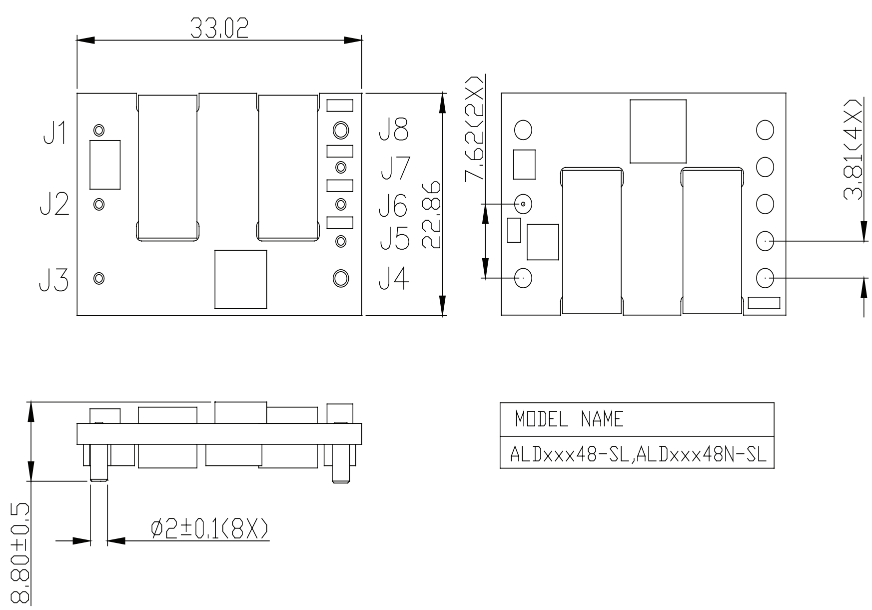


Figure 30. ALD Surface Mount Termination Mechanical Outline

Embedded Power for
Business-Critical Continuity

Soldering Considerations

The ALD15 through hole terminated converters are intended for wave soldering process. The RoHS-compliant terminal pin finish of the converter is compatible with both Lead (Pb) and Lead free (Pb-free) wave soldering techniques. The modules are recommended to be preheated for 20-30 sec at 110 °C and wave soldered at 260 °C for Pb solder and 270 °C max for Pb-free solder, for less than 10 sec.

The ALD15 surface-mount terminated converters are compatible with standard reflow soldering process with a maximum peak temperature of 230 ˚C.

Ordering Information

Model Number	Vin	Vo	Io	Construction	Enable Logic	Pin Length	Pin Termination
ALD03B48-L	36 - 75 V	12 V	2.75 A	Open frame	Positive	5.0 mm	Through-hole
ALD03B48N-L	36 - 75 V	12 V	2.75 A	Open frame	Negative	5.0 mm	Through-hole
ALD03B48-SL	36 - 75 V	12 V	2.75 A	Open frame	Positive	NA	Surface Mount
ALD03B48N-SL	36 - 75 V	12 V	2.75 A	Open frame	Negative	NA	Surface Mount
ALD07A48-L	36 - 75 V	5.0 V	7 A	Open frame	Positive	5.0 mm	Through-hole
ALD07A48N-L	36 - 75 V	5.0 V	7 A	Open frame	Negative	5.0 mm	Through-hole
ALD07A48-SL	36 - 75 V	5.0 V	7 A	Open frame	Positive	NA	Surface Mount
ALD07A48N-SL	36 - 75 V	5.0 V	7 A	Open frame	Negative	NA	Surface Mount
ALD10F48-L	36 - 75 V	3.3 V	10 A	Open frame	Positive	5.0 mm	Through-hole
ALD10F48N-L	36 - 75 V	3.3 V	10 A	Open frame	Negative	5.0 mm	Through-hole
ALD10F48-SL	36 - 75 V	3.3 V	10 A	Open frame	Positive	NA	Surface Mount
ALD10F48N-SL	36 - 75 V	3.3 V	10 A	Open frame	Negative	NA	Surface Mount
ALD11G48-L	36 - 75 V	2.5 V	11 A	Open frame	Positive	5.0 mm	Through-hole
ALD11G48N-L	36 - 75 V	2.5 V	11 A	Open frame	Negative	5.0 mm	Through-hole
ALD11G48-SL	36 - 75 V	2.5 V	11 A	Open frame	Positive	NA	Surface Mount
ALD11G48N-SL	36 - 75 V	2.5 V	11 A	Open frame	Negative	NA	Surface Mount

Note:

1) L suffix designated RoHS 6/6 compliance. Please consult factory for RoHS 5/6 availability.
2) Consult factory for shorter pin length options.
3) STRL designates Taped and Reeled option for SMT.

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