POWERGOOD

ESC Series
50W / 2" x 1.2" DC/DC

Applications

Railway | Industry | Automation

Semiconductor | Network / Telecom | Military

Boat | Aviation | Medical

Automobile | Charger

3 Years Warranty

CE RoHS COMPLIANT UL ISO REACH

Features

2" x 1.2"	**2:1 / 4:1** Wide input range	**+70°C** without derating	**EMC FILTER** Built-in	**2250 VDC** Insulation	**MLCC** No life-span constrained	**ON / OFF** REMOTE	**90 %** High efficiency
MTBF ≥1.9M hours @50°C GB	**METAL CASE**	**UVLO**	**OCP**	**OVP**	**OTP**		

Model Number Structure

ESC 018 033 - S - P - F 50

Series Name	Input Voltage (VDC)	Output Voltage (VDC)	Output Quantity	Remote Control Option	Shape	Watt
Evolving Sirius-Chivalry series –	**012** : 9-18 **018** : 9-36 **024** : 18-36 **036** : 18-75 **048** : 36-75 **110** : 40-160	**033** : 3.3 **050** : 5 **120** : 12 **150** : 15 **240** : 24	**S** : Single	**P** : Positive logic **N** : Negative logic **1** : Positive logic + EMC Filter **0** : Negative logic + EMC Filter	**F** : Flat **P** : Groove Cover **B** : BasePlate	**20** **30** **40** **50**
		120 : ±12 **150** : ±15 **240** : ±24	**D** : Dual			

Model Selection Guide

Typical @ Ta=+25 ℃ under nominal line voltage conditions unless noted

Model	Input			Output			Efficiency
	Voltage (V)		Current (A)	Voltage	Current	Power	
	Range	Nominal	Full load	(V)	(A)	(W)	Typ.(%)
ESC012033-S-□-□30	9-18	12	2.81	3.3	9.1	30	89%
ESC012050-S-□-□30	9-18	12	2.78	5	6	30	90%
ESC012120-S-□-□30	9-18	12	2.81	12	2.5	30	89%
ESC012150-S-□-□30	9-18	12	2.81	15	2	30	89%
ESC012240-S-□-□30	9-18	12	2.81	24	1.3	30	89%
ESC012120-D-□-□30	9-18	12	2.81	±12	±1.3	30	89%
ESC012150-D-□-□30	9-18	12	2.81	±15	±1.0	30	89%
ESC012240-D-□-□30	9-18	12	2.84	±24	±0.6	30	88%
ESC012033-S-□-□40	9-18	12	3.75	3.3	12.1	40	89%
ESC012050-S-□-□40	9-18	12	3.70	5	8	40	90%
ESC012120-S-□-□40	9-18	12	3.75	12	3.3	40	89%
ESC012150-S-□-□40	9-18	12	3.75	15	2.7	40	89%
ESC012240-S-□-□40	9-18	12	3.75	24	1.7	40	89%
ESC012120-D-□-□40	9-18	12	3.75	±12	±1.7	40	89%
ESC012150-D-□-□40	9-18	12	3.75	±15	±1.3	40	89%
ESC012240-D-□-□40	9-18	12	3.79	±24	±0.8	40	88%
ESC012033-S-□-□50	9-18	12	4.68	3.3	15.1	50	89%
ESC012050-S-□-□50	9-18	12	4.63	5	10	50	90%
ESC012120-S-□-□50	9-18	12	4.68	12	4.2	50	89%
ESC012150-S-□-□50	9-18	12	4.68	15	3.3	50	89%
ESC012240-S-□-□50	9-18	12	4.68	24	2.1	50	89%
ESC012120-D-□-□50	9-18	12	4.68	±12	±2.1	50	89%
ESC012150-D-□-□50	9-18	12	4.68	±15	±1.7	50	89%
ESC012240-D-□-□50	9-18	12	4.73	±24	±1.0	50	88%
ESC018033-S-□-□30	9-36	18	1.89	3.3	9.1	30	88%
ESC018050-S-□-□30	9-36	18	1.87	5	6	30	89%
ESC018120-S-□-□30	9-36	18	1.89	12	2.5	30	88%
ESC018150-S-□-□30	9-36	18	1.89	15	2	30	88%
ESC018240-S-□-□30	9-36	18	1.89	24	1.3	30	88%
ESC018120-D-□-□30	9-36	18	1.89	±12	±1.3	30	88%
ESC018150-D-□-□30	9-36	18	1.89	±15	±1.0	30	88%
ESC018240-D-□-□30	9-36	18	1.92	±24	±0.6	30	87%

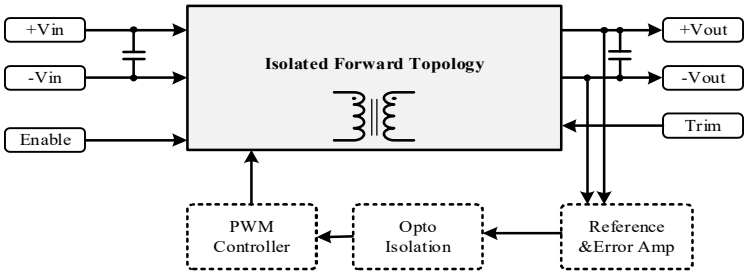
Model	Input			Output			Efficiency
	Voltage (V)		Current (A)	Voltage	Current	Power	
	Range	Nominal	Full load	(V)	(A)	(W)	Typ.(%)
ESC018033-S-□-□40	9-36	18	2.53	3.3	12.1	40	88%
ESC018050-S-□-□40	9-36	18	2.50	5	8	40	89%
ESC018120-S-□-□40	9-36	18	2.53	12	3.3	40	88%
ESC018150-S-□-□40	9-36	18	2.53	15	2.7	40	88%
ESC018240-S-□-□40	9-36	18	2.53	24	1.7	40	88%
ESC018120-D-□-□40	9-36	18	2.53	±12	±1.7	40	88%
ESC018150-D-□-□40	9-36	18	2.53	±15	±1.3	40	88%
ESC018240-D-□-□40	9-36	18	2.55	±24	±0.8	40	87%
ESC024033-S-□-□30	18-36	24	1.40	3.3	9.1	30	89%
ESC024050-S-□-□30	18-36	24	1.39	5	6	30	90%
ESC024120-S-□-□30	18-36	24	1.40	12	2.5	30	89%
ESC024150-S-□-□30	18-36	24	1.40	15	2	30	89%
ESC024240-S-□-□30	18-36	24	1.40	24	1.3	30	89%
ESC024120-D-□-□30	18-36	24	1.40	±12	±1.3	30	89%
ESC024150-D-□-□30	18-36	24	1.40	±15	±1.0	30	89%
ESC024240-D-□-□30	18-36	24	1.40	±24	±0.6	30	89%
ESC024033-S-□-□40	18-36	24	1.87	3.3	12.1	40	89%
ESC024050-S-□-□40	18-36	24	1.85	5	8	40	90%
ESC024120-S-□-□40	18-36	24	1.87	12	3.3	40	89%
ESC024150-S-□-□40	18-36	24	1.87	15	2.7	40	89%
ESC024240-S-□-□40	18-36	24	1.87	24	1.7	40	89%
ESC024120-D-□-□40	18-36	24	1.87	±12	±1.7	40	89%
ESC024150-D-□-□40	18-36	24	1.87	±15	±1.3	40	89%
ESC024240-D-□-□40	18-36	24	1.87	±24	±0.8	40	89%
ESC024033-S-□-□50	18-36	24	2.34	3.3	15.1	50	89%
ESC024050-S-□-□50	18-36	24	2.31	5	10	50	90%
ESC024120-S-□-□50	18-36	24	2.34	12	4.2	50	89%
ESC024150-S-□-□50	18-36	24	2.34	15	3.3	50	89%
ESC024240-S-□-□50	18-36	24	2.34	24	2.1	50	89%
ESC024120-D-□-□50	18-36	24	2.34	±12	±2.1	50	89%
ESC024150-D-□-□50	18-36	24	2.34	±15	±1.7	50	89%
ESC024240-D-□-□50	18-36	24	2.37	±24	±1.0	50	88%

Model	Input			Output			Efficiency
	Voltage (V)		Current (A)	Voltage	Current	Power	
	Range	Nominal	Full load	(V)	(A)	(W)	Typ.(%)
ESC036033-S-□-□30	18-75	36	0.95	3.3	9.1	30	88%
ESC036050-S-□-□30	18-75	36	0.94	5	6	30	89%
ESC036120-S-□-□30	18-75	36	0.95	12	2.5	30	88%
ESC036150-S-□-□30	18-75	36	0.95	15	2	30	88%
ESC036240-S-□-□30	18-75	36	0.95	24	1.3	30	88%
ESC036120-D-□-□30	18-75	36	0.95	±12	±1.3	30	88%
ESC036150-D-□-□30	18-75	36	0.95	±15	±1.0	30	88%
ESC036240-D-□-□30	18-75	36	0.96	±24	±0.6	30	87%
ESC036033-S-□-□40	18-75	36	1.26	3.3	12.1	40	88%
ESC036050-S-□-□40	18-75	36	1.25	5	8	40	89%
ESC036120-S-□-□40	18-75	36	1.26	12	3.3	40	88%
ESC036150-S-□-□40	18-75	36	1.26	15	2.7	40	88%
ESC036240-S-□-□40	18-75	36	1.26	24	1.7	40	88%
ESC036120-D-□-□40	18-75	36	1.26	±12	±1.7	40	88%
ESC036150-D-□-□40	18-75	36	1.26	±15	±1.3	40	88%
ESC036240-D-□-□40	18-75	36	1.28	±24	±0.8	40	87%
ESC048033-S-□-□30	36-75	48	0.70	3.3	9.1	30	89%
ESC048050-S-□-□30	36-75	48	0.69	5	6	30	90%
ESC048120-S-□-□30	36-75	48	0.70	12	2.5	30	89%
ESC048150-S-□-□30	36-75	48	0.70	15	2	30	89%
ESC048240-S-□-□30	36-75	48	0.70	24	1.3	30	89%
ESC048120-D-□-□30	36-75	48	0.70	±12	±1.3	30	89%
ESC048150-D-□-□30	36-75	48	0.70	±15	±1.0	30	89%
ESC048240-D-□-□30	36-75	48	0.70	±24	±0.6	30	89%
ESC048033-S-□-□50	36-75	48	1.17	3.3	15.1	50	89%
ESC048050-S-□-□50	36-75	48	1.16	5	10	50	90%
ESC048120-S-□-□50	36-75	48	1.17	12	4.2	50	89%
ESC048150-S-□-□50	36-75	48	1.17	15	3.3	50	89%
ESC048240-S-□-□50	36-75	48	1.17	24	2.1	50	89%
ESC048120-D-□-□50	36-75	48	1.17	±12	±2.1	50	89%
ESC048150-D-□-□50	36-75	48	1.17	±15	±1.7	50	89%
ESC048240-D-□-□50	36-75	48	1.17	±24	±1.0	50	89%

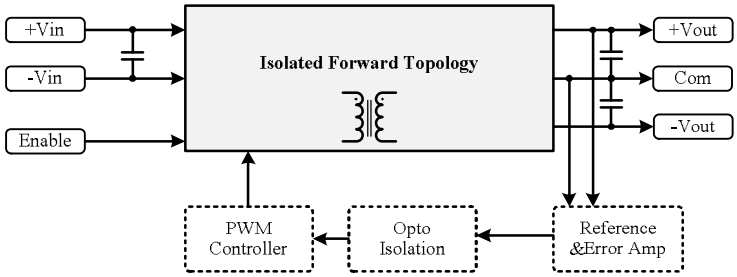
Model	Input			Output			Efficiency
	Voltage (V)		Current (A)	Voltage	Current	Power	
	Range	Nominal	Full load	(V)	(A)	(W)	Typ.(%)
ESC110033-S-□-□20	40-160	110	0.21	3.3	6.1	20	88%
ESC110050-S-□-□20	40-160	110	0.20	5	4	20	89%
ESC110120-S-□-□20	40-160	110	0.21	12	1.7	20	88%
ESC110150-S-□-□20	40-160	110	0.21	15	1.3	20	88%
ESC110240-S-□-□20	40-160	110	0.21	24	0.8	20	88%
ESC110120-D-□-□20	40-160	110	0.21	±12	±0.8	20	88%
ESC110150-D-□-□20	40-160	110	0.21	±15	±0.7	20	88%
ESC110240-D-□-□20	40-160	110	0.21	±24	±0.4	20	87%
ESC110033-S-□-□30	40-160	110	0.31	3.3	9.1	30	88%
ESC110050-S-□-□30	40-160	110	0.31	5	6	30	89%
ESC110120-S-□-□30	40-160	110	0.31	12	2.5	30	88%
ESC110150-S-□-□30	40-160	110	0.31	15	2	30	88%
ESC110240-S-□-□30	40-160	110	0.31	24	1.3	30	87%
ESC110120-D-□-□30	40-160	110	0.31	±12	±1.3	30	88%
ESC110150-D-□-□30	40-160	110	0.31	±15	±1.0	30	88%
ESC110240-D-□-□30	40-160	110	0.31	±24	±0.6	30	87%
ESC110033-S-□-□40	40-160	110	0.41	3.3	12.1	40	88%
ESC110050-S-□-□40	40-160	110	0.41	5	8	40	89%
ESC110120-S-□-□40	40-160	110	0.41	12	3.3	40	88%
ESC110150-S-□-□40	40-160	110	0.41	15	2.7	40	88%
ESC110240-S-□-□40	40-160	110	0.42	24	1.7	40	87%
ESC110120-D-□-□40	40-160	110	0.41	±12	±1.7	40	88%
ESC110150-D-□-□40	40-160	110	0.41	±15	±1.3	40	88%
ESC110240-D-□-□40	40-160	110	0.42	±24	±0.8	40	87%
ESC110033-S-□-□50	40-160	110	0.52	3.3	15.1	50	88%
ESC110050-S-□-□50	40-160	110	0.51	5	10	50	89%
ESC110120-S-□-□50	40-160	110	0.52	12	4.2	50	88%
ESC110150-S-□-□50	40-160	110	0.52	15	3.3	50	88%
ESC110240-S-□-□50	40-160	110	0.52	24	2.1	50	87%
ESC110120-D-□-□50	40-160	110	0.52	±12	±2.1	50	88%
ESC110150-D-□-□50	40-160	110	0.52	±15	±1.7	50	88%
ESC110240-D-□-□50	40-160	110	0.52	±24	±1.0	50	87%

Description

Evolving Sirius - Chivalry series converter is composed of Isolated, board-mountable, fixed switching frequency dc-dc converters that use synchronous rectification to achieve extremely high power conversion efficiency. These DC-DC converter modules use advanced power processing, control, and packaging technologies to enhance the performance, flexibility, reliability, and cost effectiveness of mature power components. Each module is six-sided metal case enclosed to provide protection from the harsh environments seen in many industrial and transportation applications.



ESC Single Series Block Diagram



ESC Dual Series Block Diagram

Electrical Specifications

(Typical @ Ta=+25°C under nominal line voltage conditions unless noted.)

Input Specifications

Parameter	Notes and Conditions	Min.	Typ.	Max.	Unit
Transient Input Voltage Ranges	ESC012 models (100ms max)			50	VDC
	ESC018 models (100ms max)			50	
	ESC024 models (100ms max)			50	
	ESC036 models (100ms max)			80	
	ESC048 models (100ms max)			80	
	ESC110 models (100ms max)			180	
Operating Input Voltage Ranges	ESC012 models	9	12	18	VDC
	ESC018 models	9	18	36	
	ESC024 models	18	24	36	
	ESC036 models	18	36	75	
	ESC048 models	36	48	75	
	ESC110 models	40	110	160	
Under-Voltage Lockout Start up Voltage	ESC012 models		8.5	9	VDC
	ESC018 models		8.5	9	
	ESC024 models		17.5	18	
	ESC036 models		17.5	18	
	ESC048 models		35	36	
	ESC110 models		38	40	
Under-Voltage Lockout Shutdown Voltage	ESC012 models	7	8		VDC
	ESC018 models	7	8		
	ESC024 models	16	17		
	ESC036 models	16	17		
	ESC048 models	32	34		
	ESC110 models	35	37		

Parameter	Notes and Conditions		Min.	Typ.	Max.	Unit
Enable Function Input	ESC110 models	Positive logic	ON OFF	Open or 8 ~20 Short or 0 ~ 1.2		VDC
		Negative logic	ON OFF	Short or 0 ~ 1.2 Open or 8 ~ 20		VDC
	Others	Positive logic	ON OFF	Open or 4.5 ~ 5.5 Short or 0 ~ 1.2		VDC
		Negative logic	ON OFF	Short or 0 ~ 1.2 Open or 4.5 ~ 5.5		VDC
Input Filter	All models		Built-in PI or EMC Filter			

Output Specifications

Parameter	Notes and Conditions		Min.	Typ.	Max.	Unit
Output Voltage Accuracy	V_{NOM} 50% Load				±1.5	%
Line Regulation	Low Line to High Line				±0.3	%
Load Regulation	10% to 100% Load				±0.5	%
Minimum Load	Single output		0			%
	Dual output		10			%
Output Ripple & Noise Voltage	Bandwidth 20MHz and with 1μF MLCC Output Capacitor each output	3.3V & 5V			75/100	m Vp-p
		All others		1	1.5	$\%V_{pk-pk}$
Temperature Drift					±0.04	% /˚C
Transient Recovery Time	25% load step change			800		μSec.
Transient Peak Deviation	ΔIo/Δt=2.5A/us				±2	%Vo
Start-Up Time	When use Enable Function			20		mSec.
Trimming Output Voltage	V_{NOM} 10% Load			±10		%
Over Voltage Protection	V_{NOM} 10% Load			120		%
Output Power Protection	V_{NOM} (Current limit / Hiccup Mode)			120		%

General Specifications & Environmental Specifications

Parameter	Notes and Conditions		Min.	Typ.	Max.	Unit
Switching Frequency	V_{NOM}	2:1 wide	270	300	330	kHz
		4:1 wide	220	260	300	
Storage Temperature Range	All models		-55		125	˚C
Operating Case Temperature	All models		-45		115	˚C
Over temperature Protection	All models, Auto. Recovery			120		
Thermal impedance	Natural convection (Flat)		5.4 (Vertical) / 7.2 (horizontal)			˚C/Watt
	Natural convection (Groove Cover)		4.6 (Vertical) / 6.5 (horizontal)			
	Natural convection (Base Plate)		4.8 (Vertical) / 7.0 (horizontal)			
Isolation Voltage (Input to Output)	All models, 1 Minute		2250			VDC
Isolation Resistance (Input to Output)	All models, 500VDC, At 70%RH		100			MΩ
Isolation Capacitance (Input to Output)	All models			1500		pF
Humidity (non condensing)	All models				95	%
Calculated MTBF	BellCore-TR-332@ 50˚C G.B			1.54		M HR

Parameter	Notes and Conditions	Min.	Typ.	Max.	Unit
Thermal shock	Environmental Engineering Experimental Tests	MIL-STD-810F			
Vibration		MIL-STD-810F			
Drop		MIL-STD-810F			
Weight	Shape-F (Flat)	33 (1.2)			g (oz.)
	Shape-P (Groove Cover/ Heat Sink)	39 (1.38)			
	Shape-B (Base Plate)	41 (1.45)			
Dimensions	Shape-F (Flat)	2.00” x 1.20” x 0.40” (50.8 x 30.5 x 10.2mm)			
	Shape-P (Groove Cover/ Heat Sink)	2.00” x 1.20” x 0.50” (50.8 x 30.5 x 12.7mm)			
	Shape-B (Base Plate)	2.03” x 1.68” x 0.46” (51.5 x 42.6 x 11.7mm)			
Case Material	Six-Sided Continuous Shield	Aluminum			
Potting Material		Silicone			

Standards Compliance

Parameter	Standard	Test Conditions	Performance Criteria
Environmental Compliance	Reach; RoHS		PASS
EMI	EN55022		Class B
ESD	EN61000-4-2	±4 kV Air Discharge ±4 kV Contact Discharge	Crit. A
Radiated Immunity	EN61000-4-3	Level 2, 3 V/m	Crit. A
Fast Transient	EN61000-4-4	±2 kV Applied	Crit. A
Surge	EN61000-4-5	±2 kV Applied	Crit. A
Conducted Immunity	EN61000-4-6	Level 2, 3 V rms	Crit. A

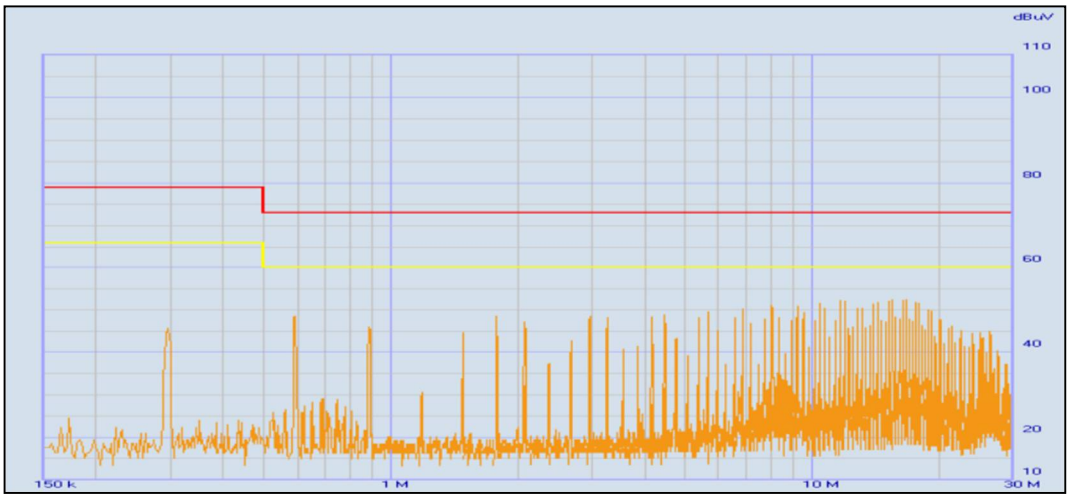
It is recommended to protect the input by fuses or other protection devices.

The standard modules meet EN55032 Class A and Class B standard with external components.

The information and specifications contained in this data sheet are believed to be correct at time of publication. All specifications are subject to change without notice. No rights under any patent accompany the sale of any such products or information contained herein.

Conducted EMI

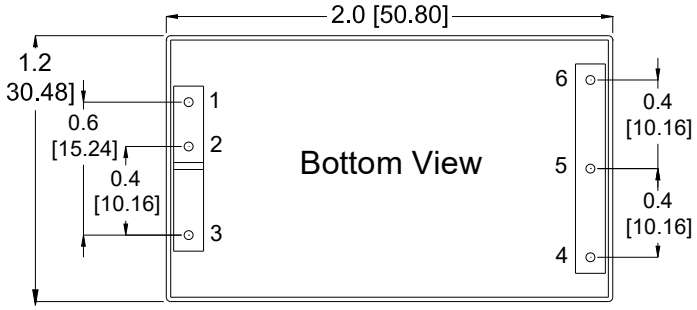
Input terminal value (typ.) ESC110050-S-1-P50 @Vin = 110VDC, Iout = 10A

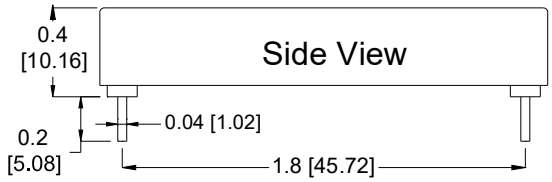


The fundamental switching frequency of the module is 260 kHz.

Mechanical Dimensions & Pin Assignments

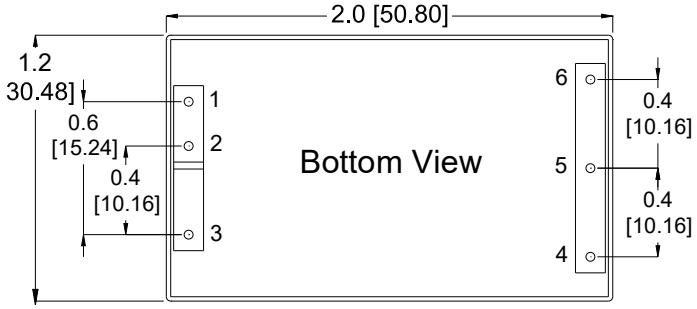
Shape – F

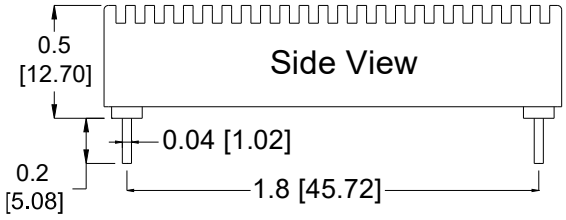




(Metal Case –Flat)

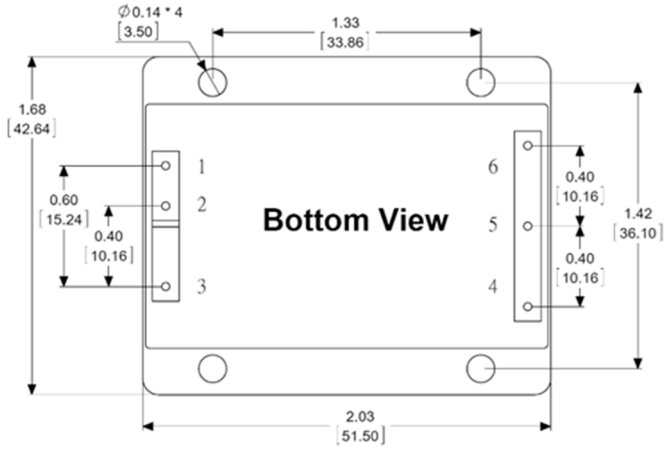
Shape – P (Groove Cover/Heat Sink)

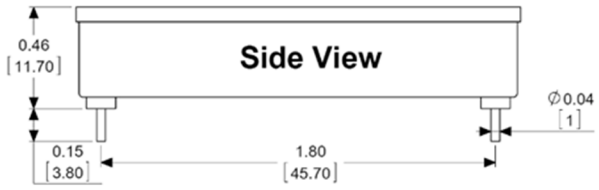




(Metal case shell with Heat-Sink)

Shape – B (BasePlate)





(Metal case shell with Heat-Sink)

Pin Assignments:

Pin#	Single	Dual
1	+Vin	+Vin
2	-Vin	-Vin
3	Enable	Enable
4	Trim	-Vout
5	-Vout	Comm
6	+Vout	+Vout

Note:

Pin Pitch tolerance: ±0.01 [0.25]
Pin Dimensions: .XX±0.02 [.X±0.5mm]
Pin Material: Copper Alloy
Pin Plating: Gold
Dimensions in inches [mm]
Tolerances: .XX±0.02 [.X±0.5mm]
.XXX±0.001 [.X±0.025mm]

Characteristic Curves

Testing conditions are at typical input, Ta=+25˚C, full load (horizontal mount) Unless otherwise indicated

The figures of ESC110050-S-P-R50

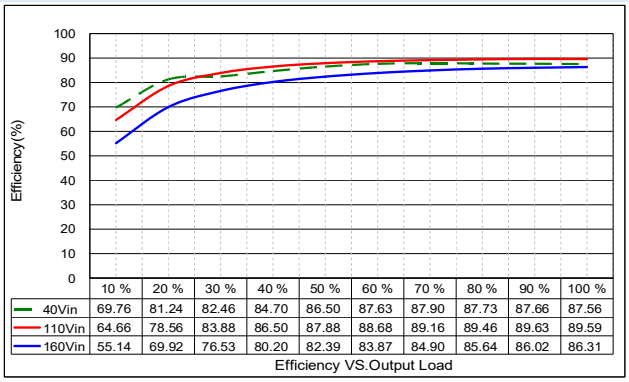


Figure 1 : Efficiency at Minimum, Nominal and Maximum Input voltages VS. Output load.

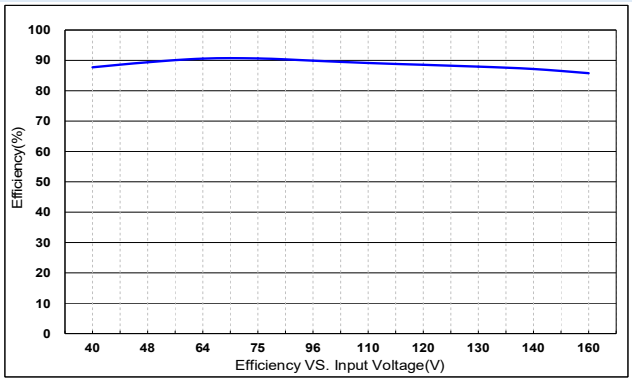


Figure 2 : Efficiency VS. Input Voltages at 100% rated power

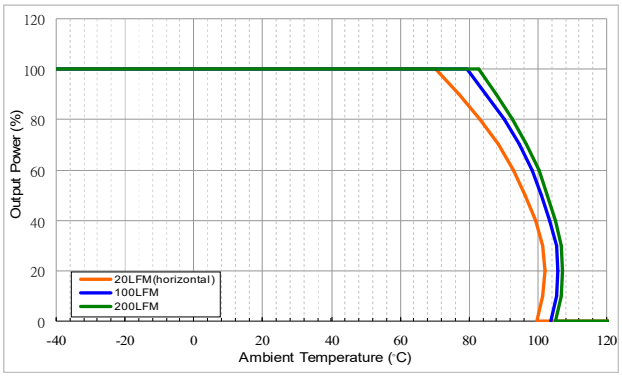


Figure 3 : Ambient Temperature VS. Output Power Derating Curves(Note: 20LFM = Free Air)

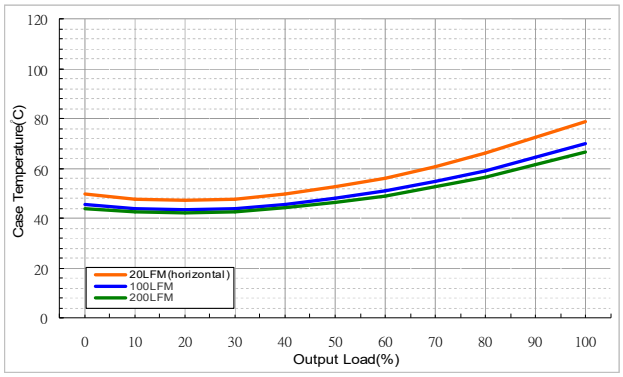


Figure 4 : Case Temperature VS. Output rated Power (Note: 20LFM = Free Air)

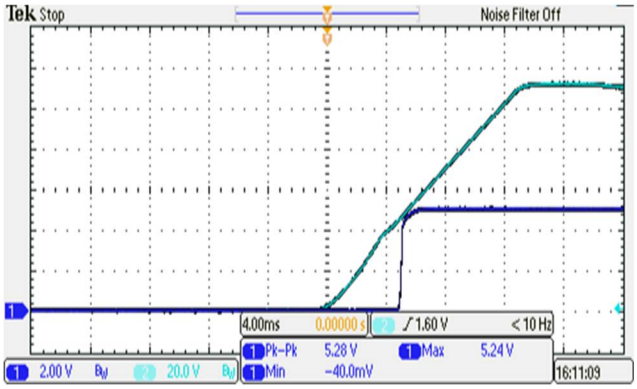


Figure 5 : CH1 = Vout, CH3 = Nominal Input Typical Start-up waveform at Full load.

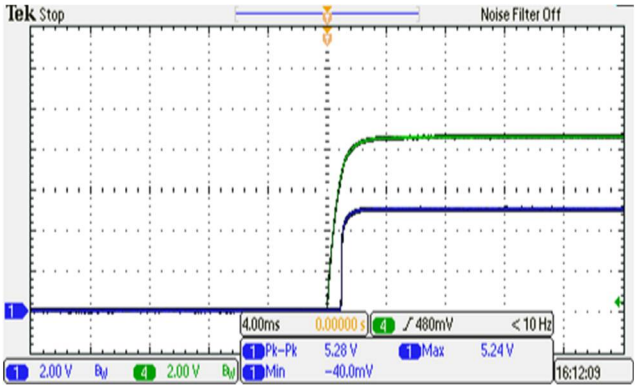


Figure 6 : CH1 = Vout, CH3 = Enable Pin Typical Start-up waveform. Input voltage pre-applied

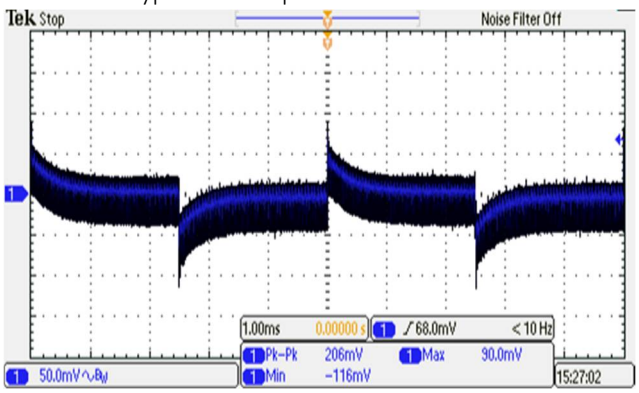


Figure 7 : Transient Response at Output step load (Vin: Typical ,50~75% of output current; ΔIo/Δt =1A/μS)

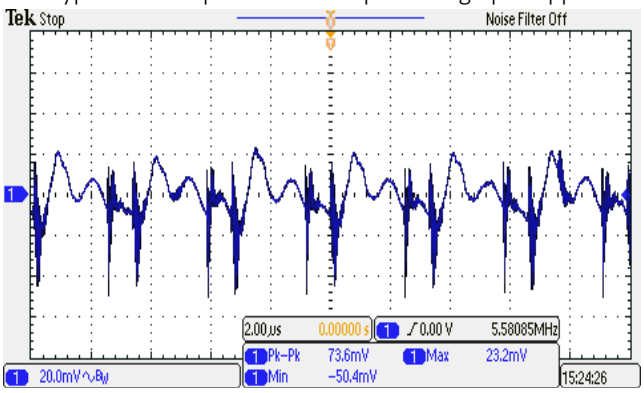


Figure 8 : Output Voltage Ripple & Noise at full load. (Vin: Typical, With Output Capacitor to add 1uF MLCC)

Trimming Output Voltage – for Single output models

Only the single output converters have a trim function. That allows users to adjust the output voltage from +10% to –10%, please refer to the trim table that follow for details. Adjustments to the output voltage can be used with a simple fixed resistor as shown in Figures 1 and 2. A single fixed resistor can increase or decrease the output voltage depending on its connection.

Note:

※ Trim adjustments higher than the specified range can have an adverse effect on the converter's performance and are not recommended.

※ If the trim function is not used, leave the trim pin open.

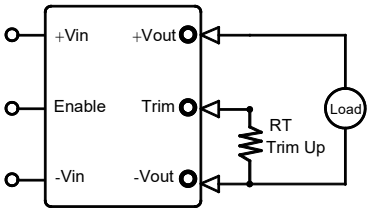


Figure 1. Trim Connections To increase Output Voltages Using Fixed Resistors

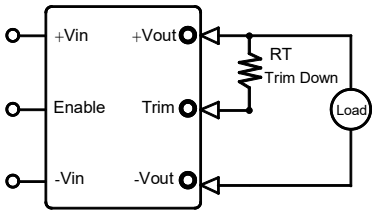


Figure 2. Trim Connections To Decrease Output Voltages Using Fixed Resistors

	Trim up resistor value(KΩ)									
Vout	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
3.3	75	34	20.6	13.7	9.6	6.9	4.9	3.5	2.3	1.4
5	112.2	51.1	30.7	20.5	14.4	10.4	7.5	5.3	3.6	2.2
12	267.8	121.9	73.3	49.0	.34.4	24.6	17.7	12.5	8.4	5.2
15	332.9	151.5	91	60.7	42.6	30.5	21.8	15.4	10.3	6.3
24	542	247	149	100	70.7	51.1	37.1	26.6	18.4	11.9

	Trim down resistor value(KΩ)									
Vout	-1%	-2%	-3%	-4%	-5%	-6%	-7%	-8%	-9%	-10%
3.3	83	37	21.9	14.3	9.7	6.7	4.5	2.9	1.6	0.6
5	139.8	63.5	38.1	25.4	17.8	12.7	9.0	6.3	4.2	2.5
12	342.5	155.9	93.7	62.6	44.0	31.5	22.7	16.0	10.8	6.7
15	454.5	205	125.8	84.7	60.1	43.6	31.9	23.1	16.2	10.7
24	592	266	158	104	70.9	49.2	33.7	22.1	13.0	5.8

Enable Control Function

The primary-side, Enable Control function can be specified to operate with either positive or negative polarity. Positive-polarity devices are enabled when the enable pin is left open or is pulled high. See "Enable Function Input.

Positive-polarity devices are disabled when the enable pin is pulled low (under +1.0V with respect to –input). Negative-polarity devices are off when the enable pin is high/open and on when the enable pin is pulled low. See Figure 3.

Output Ripple Noise

The two copper strips simulate real-world PCB impedances between the converter and its load. Scope measurements should be made using BNC connectors or the probe ground should be less than 1/2 inch and soldered directly to the fixture.

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 be taken 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. See Figure 4.

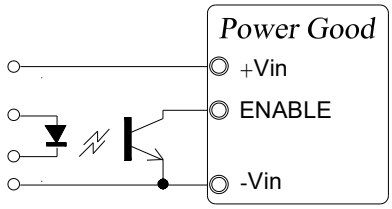


Figure 3. Driving the Enable Control pin

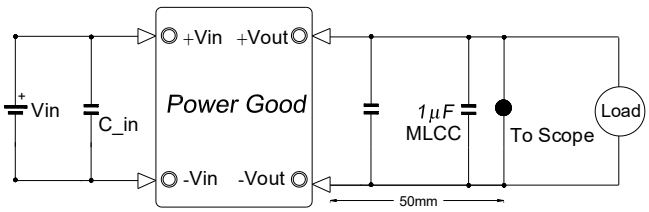


Figure 4. Measuring Output Ripple/Noise(20MHz bandwidth)

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