EC7BW-110 20W Isolated DC-DC Converters

Application Note V13 August 2017

ISOLATED DC-DC CONVERTER
EC7BW-110 SERIES
APPLICATION NOTE

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Content

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1. Introduction

The EC7BW-110 series offer 20 watts of output power in a 2.00x1.00x0.4 inches copper packages. The EC7BW-110 series has a 4:1 wide input voltage range of 43-160 VDC, and provides a precisely regulated output. This series has features such as high efficiency, 3000VDC of isolation and allows an ambient operating temperature range of -40°C to 85°C (de-rating above 73°C). The modules are fully protected against input UVLO (under voltage lock out), output over-current, over-voltage and short circuit conditions. Furthermore, the standard control functions include remote on/off and adjustable output voltage. All models are very suitable for distributed power architectures, telecommunications, battery operated equipment, industrial and railway system applications.

2. DC-DC Converter Features

* 20W Isolated Output
* Efficiency to 90%
* 2”X1”X0.4” Size Meet Industrial Standard
* 4:1 Input Range
* Regulated Outputs
* 250KHz Switching Frequency
* Remote On/Off
* Continuous Short Circuit Protection
* UL60950-1 (Basic Insulation) Approval
* Meet EN50155
* Low No Load Input Power
* Fire & Smoke meet EN45545-2

3. Electrical Block Diagram

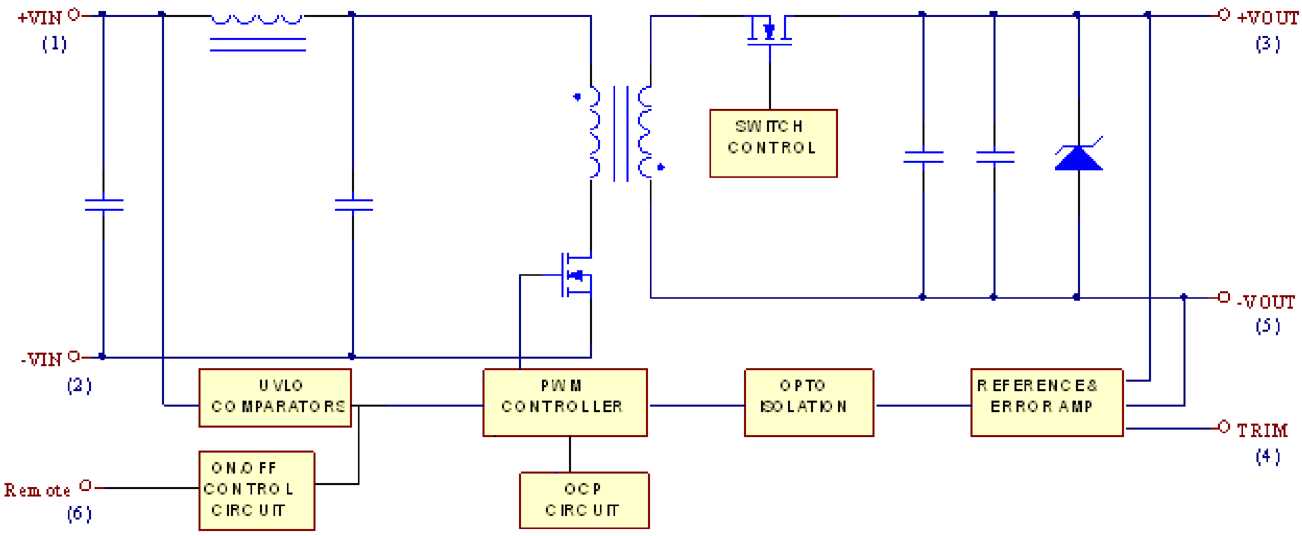


Figure 1 Electrical Block Diagram for Single Output Modules

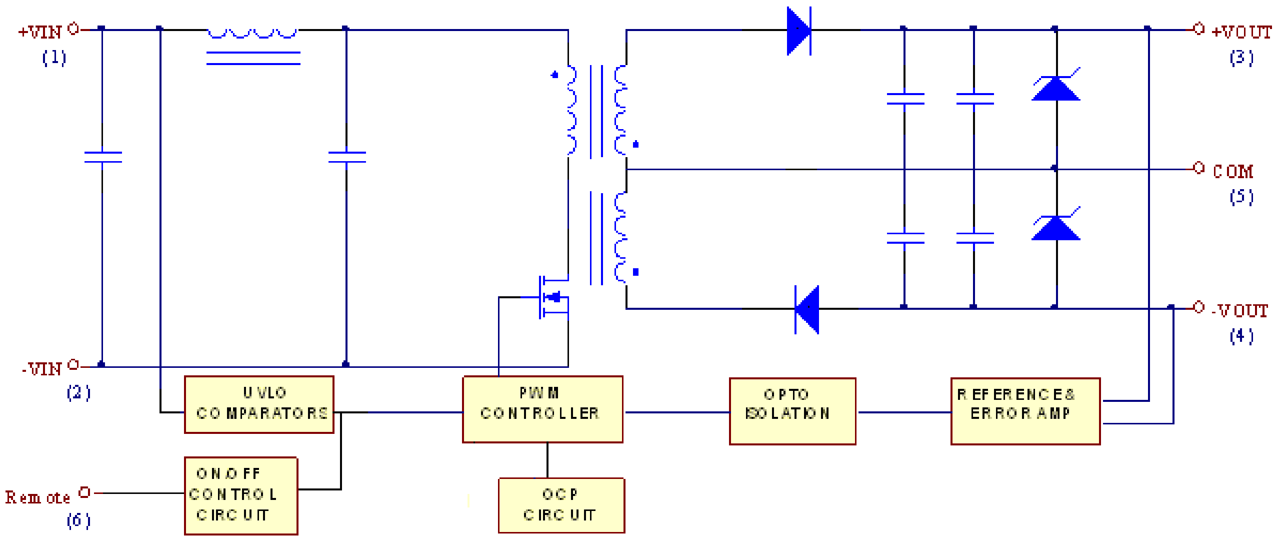


Figure 2 Electrical Block Diagram for Dual Output Modules

4. Technical Specifications

(All specifications are typical at nominal input, full load at 25℃ unless otherwise noted.)

ABSOLUTE MAXIMUM RATINGS						
PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
Input Voltage						
Continuous		All	-0.3		160	Vdc
Transient	100ms	All			200	Vdc
Operating Ambient Temperature	Derating, above 73℃	All	-40		+85	℃
Case Temperature		All			105	℃
Storage Temperature		All	-55		+125	℃
Input/Output Isolation Voltage	1 minute	All	3000			Vdc
INPUT CHARACTERISTIC						
PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
Operating Input Voltage		All	43	110	160	Vdc
Input Under Voltage Lockout						
Turn-On Voltage Threshold		All	38.5	40.0	41.5	V_{dc}
Turn-Off Voltage Threshold		All	36.5	38.0	39.5	V_{dc}
Lockout Hysteresis Voltage		All		2		V_{dc}
Maximum Input Current	100% Load, Vin=43V	All		540		mA
No-Load Input Current	Vin=110V	All		3		mA
Inrush Current (I^2t)	As per ETS300 132-2	All			0.1	A^2s
Input Reflected-Ripple Current	P-P thru 12uH inductor, 5Hz to 20MHz	All		30		mA
OUTPUT CHARACTERISTIC						
PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
Output Voltage Set Point	Vin=nominal input, Io= $Io_{max.}$	Vo=5.0V Vo=12V Vo=15V Vo=±12V Vo=±15V	4.925 11.82 14.775 ±11.82 ±14.775	5 12 15 ±12 ±15	5.075 12.18 15.225 ±12.18 ±15.225	Vdc
Output Voltage Balance	Vin=nominal input, Io=$Io_{max.}$	Dual			±1.0	%
Output Voltage Regulation						
Load Regulation	Io=full load to min. Load	Single			±0.5	%
		Dual			±1.0	
Line Regulation	Vin=high line to low line, full Load	All			±0.2	%
Cross Regulation	Load cross variation 10%/100%	Dual			±5	%
Temperature Coefficient	Tc=-40℃ to 85℃	All			±0.03	%/℃
Output Voltage Ripple and Noise (5Hz to 20MHz bandwidth)						
Peak-to-Peak	Vin=nominal input, Full Load with 1uF ceramic capacitor.	Vo=5.0V Vo=12V Vo=15V Vo=±12V Vo=±15V			75 100 100 100 100	mV

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Operating Output Current Range		Vo=5.0V	0		4000	mA
		Vo=12V	0		1670	
		Vo=15V	0		1330	
		Vo=±12V	0		±833	
		Vo=±15V	0		±667	
Output DC Current-Limit Inception	Vo=90% $V_{O,\ nominal}$	All	110	125	160	%
Maximum Output Capacitance	Full load (resistive)	Vo=5.0V	0		5600	uF
		Vo=12V	0		1000	
		Vo=15V	0		1000	
		Vo=±12V	0		±680	
		Vo=±15V	0		±350	

DYNAMIC CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Output Voltage Current Transient						
Step Change in Output Current	75% to 100% of Io.max.	All			±5	%
Setting Time (within 1% Vonominal)	di/dt=0.1A/us	All			250	us
Turn-On Delay and Rise Time						
Turn-On Delay Time, From On/Off Control	Von/off to 10%Vo, set	All		7		ms
Turn-On Delay Time, From Input	Vin, min. to 10%Vo, set	All		7		ms
Output Voltage Rise Time	10%Vo, set to 90%Vo, set	Single		8		ms
		Dual		18		

EFFICIENCY

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
100% Load	Vin=Nominal Vin, Tc=25°C	Vo=5.0V		88.5		%
		Vo=12V		90		
		Vo=15V		89.5		
		Vo=±12V		89		
		Vo=±15V		88.5		

ISOLATION CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Input to Output	1 minutes	All			3000	Vdc
Isolation Resistance		All	1000			MΩ
Isolation Capacitance		All		1000		pF

FEATURE CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Switching Frequency		All		250		KHz
On/Off Control, Positive Remote On/Off logic						
Logic Low (Module Off)	Von/off at Ion/off=1.0mA	All	0		1.2	V
Logic High (Module On)	Von/off at Ion/off=0.1uA	All	3.5 or Open Circuit		75	V

PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
On/Off Control, Negative Remote On/Off logic						
Logic Low (Module Off)	Von/off at Ion/off=1.0mA	All	3.5 or Open Circuit		75	V
Logic High (Module On)	Von/off at Ion/off=0.1uA	All	0		1.2	V
On/Off Current (for both remote on/off logic)	Ion/off at Von/off=0.0V	All		0.3	1	mA
Leakage Current (for both remote on/off logic)	Logic high, Von/off=15V	All			30	uA
PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
Off Converter Input Current	Shutdown input idle current	All		2	5	mA
Output Voltage Trim Range	Pout=maximum rated power	All	-10		+10	%
Output Over Voltage Protection	Zener or TVS clamp	Vo=5.0V Vo=12V Vo=15V Vo=±12V Vo=±15V		6.2 15 18 ±15 ±18		Vdc

GENERAL SPECIFICATIONS

PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
MTBF	Io=100%of Io.max.; Ta=25℃ per MIL-HDBK-217F	All		880		K hours
Weight		All		35		grams

Case Material	Copper	
Base plate Material	Plastic DAP	
Potting Material	UL 94V-0	
Pin Material	Base: Copper Plating: Nickel with Matte Tin	
Shock/Vibration	MIL-STD-810F/EN61373	
Humidity	95% RH max. Non Condensing	
Altitude	3000m Operating Altitude, 12000m Transport Altitude	
Thermal Shock	MIL-STD-810F	
EMI	Meets EN55011, EN55022 & EN50155 with external input filter, see 7.2 EN55032	Class A
ESD	EN61000-4-2 Level 3: Air ±8kV, Contact ±6kV	Perf. Criteria A
Radiated immunity	EN61000-4-3 Level 3: 80~1000MHz, 20V/m	Perf. Criteria A
Fast Transient	EN61000-4-4 Level 3: On power input port, ±2kV, external input TVS required, see 7.1	Perf. Criteria A
Surge	EN61000-4-5 Level 3: Line to line, ±1Kv external input TVS required, see 7.1	Perf. Criteria A
Conducted immunity	EN61000-4-6 Level 3: 0.15~80MHz, 10V	Perf. Criteria A

5. Main Features and Functions

5.1 Operating Temperature Range

The EC7BW-110 series converters can be operated by a wide ambient temperature range from -40℃ to 85℃ (de-rating above 73℃). The standard model has a copper case and case temperature can not over 105℃ at normal operating.

5.2 Remote On/Off

The EC7BW-110 series allows the user to switch the module on and off electronically with the remote on/off feature. All models are available in "positive logic" and "negative logic" (optional) versions. The converter turns on if the remote on/off pin is high (>3.5Vdc to 75Vdc or open circuit). Setting the pin low (0 to <1.2Vdc) will turn the converter off. The signal level of the remote on/off input is defined with respect to ground. If not using the remote on/off pin, leave the pin open (converter will be on). Models with part number suffix "N" are the "negative logic" remote on/off version. The unit turns off if the remote on/off pin is high (>3.5Vdc to 75Vdc or open circuit). The converter turns on if the on/off pin input is low (0 to <1.2Vdc). Note that the converter is off by default.

5.3 UVLO (Under Voltage Lock Out)

Input under voltage lockout is standard on the EC7BW-110 unit. The unit will shut down when the input voltage drops below a threshold, and the unit will operate when the input voltage goes above the upper threshold.

5.4 Over Current Protection

All models have internal over current and continuous short circuit protection. The unit operates normally once the fault condition is removed. At the point of current limit inception, the converter will go into hiccup mode protection.

5.5 Over Voltage Protection

The over-voltage protection consists of a zener diode to limiting the out voltage.

5.6 Output Voltage Adjustment

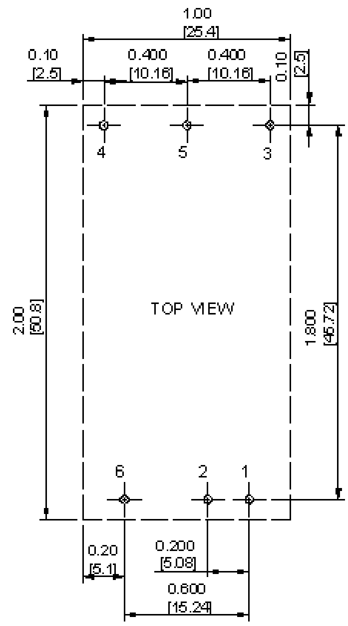
Section 6.6 describes in detail how to trim the output voltage with respect to its set point. The output voltage on all models is adjustable within the range of +10% to –10%. (Single output models only)

6. Applications

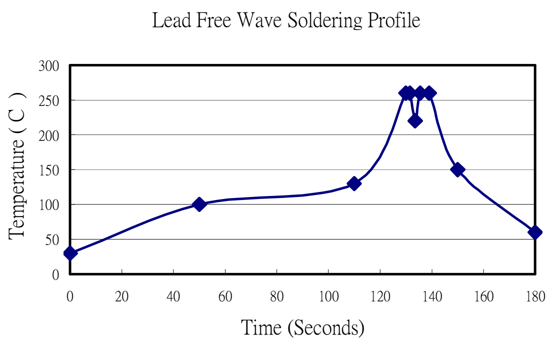
6.1 Recommended Layout PCB Footprints and Soldering Information

The system designer or the end user must ensure that other components and metal in the vicinity of the converter meet the spacing requirements to which the system is approved. Low resistance and low inductance PCB layout traces are the norm and should be used where possible. Due consideration must also be given to proper low impedance tracks between power module, input and output grounds. The recommended footprints and soldering profiles are shown below.

1.3mm PLATED THROUGH HOLE
2.5mm PAD SIZE



Note: Dimensions are in inches (millimeters)



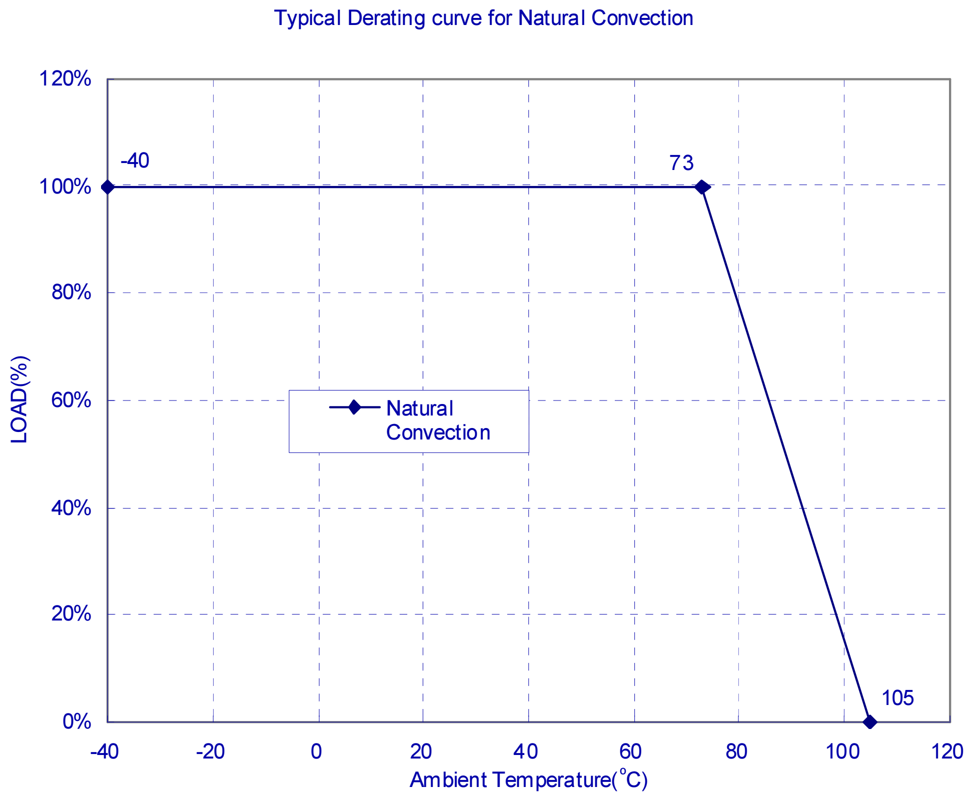
Note：

1. Soldering Materials: Sn/Cu/Ni
2. Ramp up rate during preheat: 1.4 ℃/Sec (From 50℃ to 100℃)
3. Soaking temperature: 0.5 ℃/Sec (From 100℃ to 130℃), 60±20 seconds
4. Peak temperature: 260℃, above 250℃ 3~6 Seconds
5. Ramp up rate during cooling: -10.0 ℃/Sec (From 260℃ to 150℃)

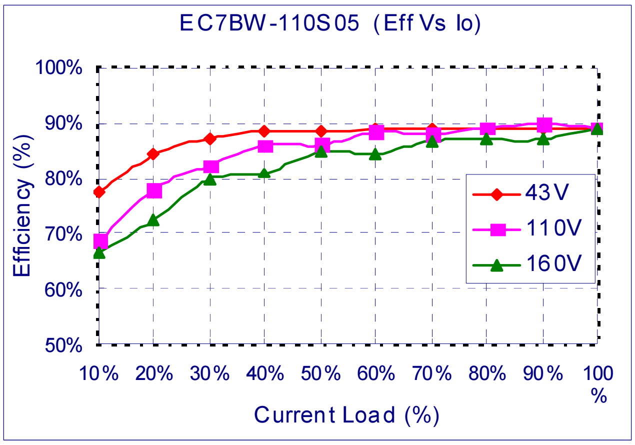
6.2 Power De-Rating Curves for EC7BW-110 Series

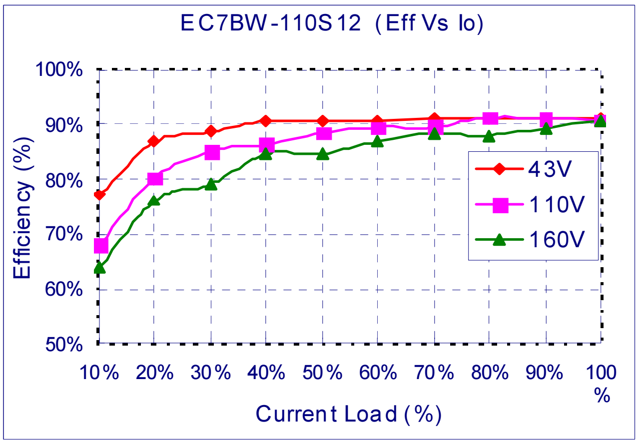
Operating Ambient temperature Range: -40℃ ~ 85℃ (derating above 73℃).

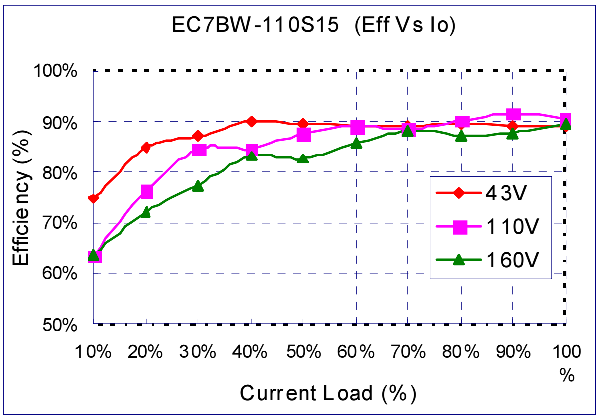
Maximum case temperature under any operating condition should not exceed 105℃.

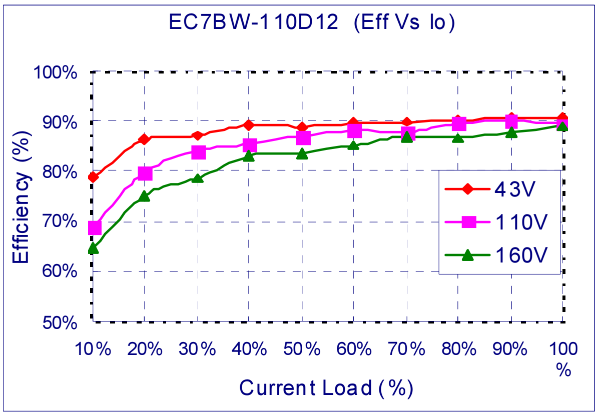


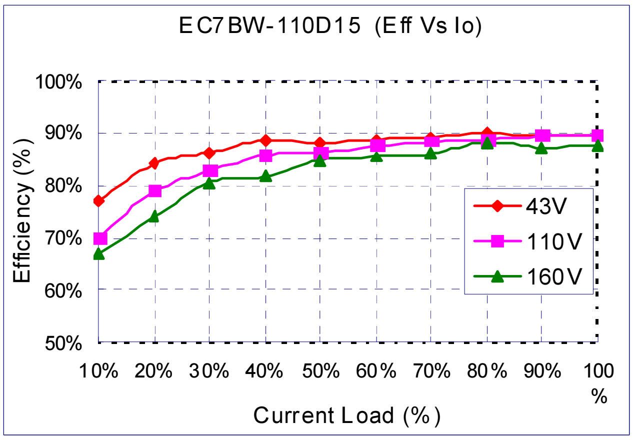
6.3 Efficiency vs. Load Curves







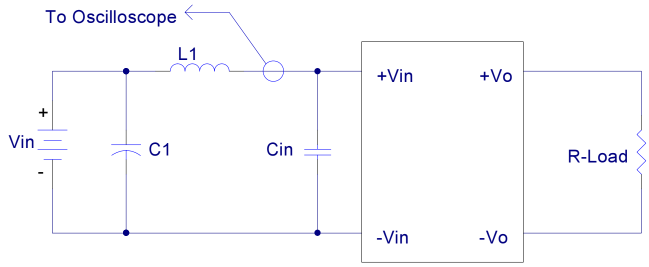




6.4 Input Capacitance at the Power Module

The converters must be connected to low AC source impedance. To avoid problems with loop stability source inductance should be low. Also, the input capacitors (Cin) should be placed close to the converter input pins to de-couple distribution inductance. However, the external input capacitors are chosen for suitable ripple handling capability. Low ESR capacitors are good choice. Circuit as shown in Figure 5 represents typical measurement methods for reflected ripple current. C1 and L1 simulate a typical DC source impedance. The input reflected-ripple current is measured by current probe to oscilloscope with a simulated.

source Inductance (L1).



L1: 12uH
C1: None
Cin: 22uF ESR<0.2ohm @100KHz

Figure 5 Input Reflected-Ripple Test Setup

6.5 Test Set-Up

The basic test set-up to measure parameters such as efficiency and load regulation is shown in Figure 6. When testing the modules under any transient conditions please ensure that the transient response of the source is sufficient to power the equipment under test. We can calculate the

- Efficiency
- Load regulation and line regulation.

The value of efficiency is defined as:

$$\eta = \frac{V_O \times I_O}{V_{IN} \times I_{IN}} \times 100\%$$

Where

V_O is output voltage,
I_O is output current,
V_{IN} is input voltage,
I_{IN} is input current.

The value of load regulation is defined as:

$$Load.reg = \frac{V_{FL} - V_{NL}}{V_{NL}} \times 100\%$$

Where

V_{FL} is the output voltage at full load
V_{NL} is the output voltage at no load

The value of line regulation is defined as:

$$Line.reg = \frac{V_{HL} - V_{LL}}{V_{LL}} \times 100\%$$

Where

V_{HL} is the output voltage of maximum input voltage at full load.
V_{LL} is the output voltage of minimum input voltage at full load.

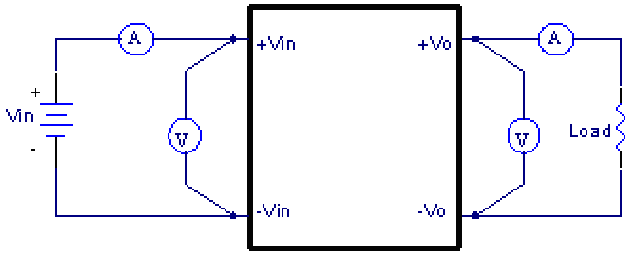


Figure 6 EC7BW-110 Series Test Setup

6.6 Output Voltage Adjustment

In order to trim the voltage up or down one needs to connect the trim resistor either between the trim pin and -Vo for trim-up and between trim pin and +Vo for trim-down. The output voltage trim range is ±10%. (Single output models only) This is shown in Figure 7 and 8:

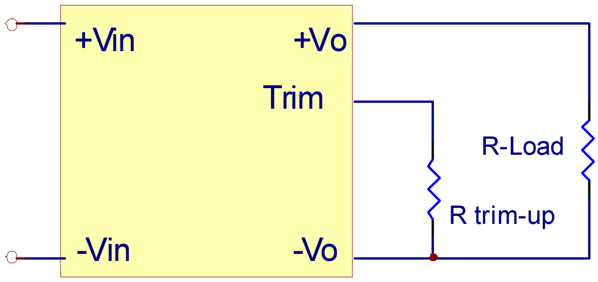


Figure 7 Trim-up Voltage Setup

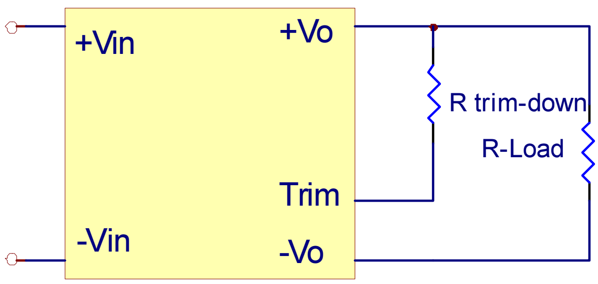


Figure 8 Trim-down Voltage Setup

1. The value of $R_{trim-up}$ defined as:

$$R_{trim-up} = \left(\frac{Vr \times R1 \times (R2 + R3)}{(Vo - V_{o,nom}) \times R2}\right) - Rt \ \ (K\Omega)$$

Where

$R_{trim-up}$ is the external resistor in Kohm.
$V_{O,\,nom}$ is the nominal output voltage.
V_O is the desired output voltage.
R1, Rt, R2, R3 and Vr are internal to the unit and are defined in Table 1.

Table 1 – Trim up and Trim down Resistor Values

Model Number	Output Voltage(V)	R1 (KΩ)	R2 (KΩ)	R3 (KΩ)	Rt (KΩ)	Vr (V)
EC7BW-110S05	5.0	2.32	2.32	0	8.2	2.5
EC7BW-110S12	12.0	6.8	2.4	2.32	22	2.5
EC7BW-110S15	15.0	8.06	2.4	3.9	27	2.5

For example, to trim-up the output voltage of 5.0V module (EC7BW-110S05) by 10% to 5.5V, R trim-up is calculated as follows:

$V_o - V_{o,\,nom}$ = 5.5 – 5.0 = 0.5V
R1 = 2.32 KΩ
R2 = 2.32 KΩ
R3 = 0 KΩ
Rt = 8.2 KΩ,
Vr= 2.5 V

$$R_{trim-up} = \left(\frac{2.5 \times 2.32 \times (2.32 + 0)}{0.5 \times 2.32}\right) - 8.2 = 3.4(K\Omega)$$

2. The value of $R_{trim-down}$ defined as:

$$R_{trim-down} = R1 \times \left(\frac{Vr \times R1}{(V_{o,nom} - Vo) \times R2} - 1\right) - Rt \ \ (K\Omega)$$

Where

$R_{trim-down}$ is the external resistor in Kohm.
$V_{O,\,nom}$ is the nominal output voltage.
V_O is the desired output voltage.
R1, Rt, R2, R3 and Vr are internal to the unit and are defined in Table 1

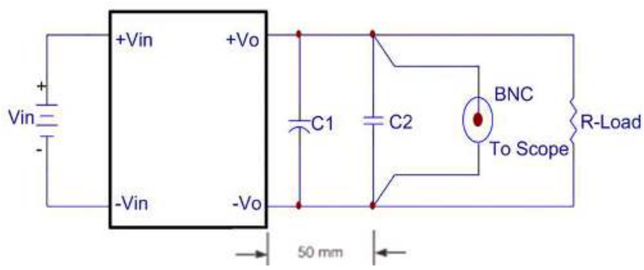
For example, to trim-down the output voltage of 5.0V module (EC7BW-110S05) by 10% to 4.5V, R trim-down is calculated as follows:

$V_{O,nom}$ – Vo = 5.0 – 4.5 = 0.5V
R1 = 2.32 KΩ
R2 = 2.32 KΩ
R3 = 0 KΩ
Rt = 8.2 KΩ
Vr= 2.5 V

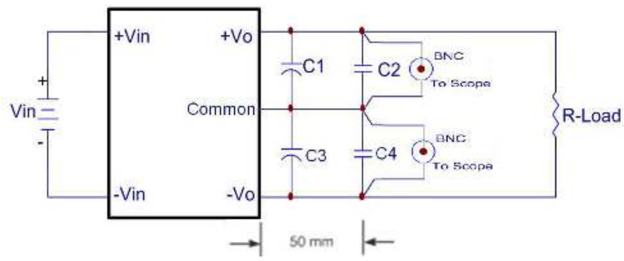
$$R_{trim-down} = 2.32 \times \left(\frac{(2.5 \times 2.32)}{0.5 \times 2.32} - 1\right) - 8.2 = 1.08 \ \ (K\Omega)$$

6.7 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in Figure 9. A coaxial cable was used to prevent impedance mismatch reflections disturbing the noise readings at higher frequencies. Measurements are taken with output appropriately loaded and all ripple/noise specifications are from 5Hz to 20MHz bandwidth.



Note: C1: none
C2: 1uF ceramic capacitor
EC7BW single output module



Note: C1 & C3: None
C2 & C4: 1uF Ceramic capacitor
EC7BW dual output module

Figure 9 Output Voltage Ripple and Noise Measurement Set-Up

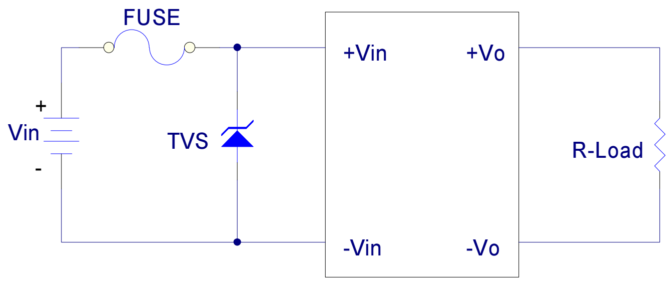
6.8 Output Capacitance

The EC7BW-110 series converters provide unconditional stability with or without external capacitors. For good transient response low ESR output capacitors should be located close to the point of load. These series converters are designed to work with load capacitance to see technical specifications.

7. Safety & EMC

7.1 Input Fusing and Safety Considerations.

The EC7BW-110 series converters have not an internal fuse. However, to achieve maximum safety and system protection, always use an input line fuse. We recommended a time delay fuse 0.8A. Figure 10 circuit is recommended by a Transient Voltage Suppressor diode across the input terminal to protect the unit against surge or spike voltage and input reverse voltage.



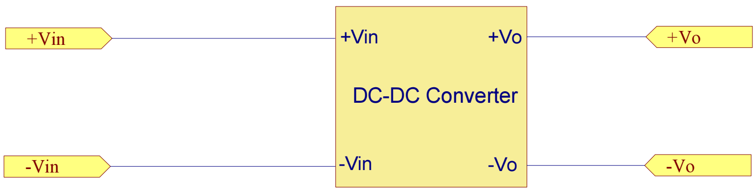
The external input TVS is required if EC7BW-110 series has to meet EN61000-4-4, EN61000-4-5.

The EC7BW-110 series recommended a TVS (P6KE180A Littelfuse) to connect parallel.

Figure 10 Input Protection

7.2 EMC Considerations

(1) EMI Test standard: EN55022 Class A Conducted Emission without External Input Filter
Test Condition: Input Voltage: Nominal, Output Load: Full Load



EMI and conducted noise meet EN55022 Class A

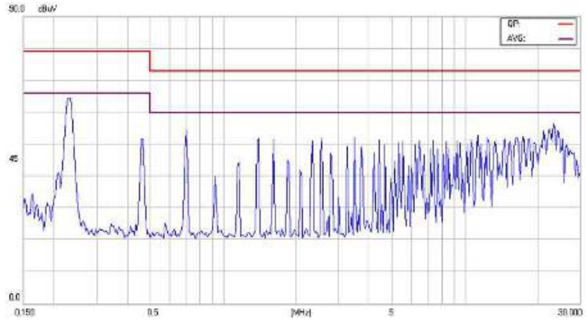


Figure 11 Conducted Class A of EC7BW-110S05

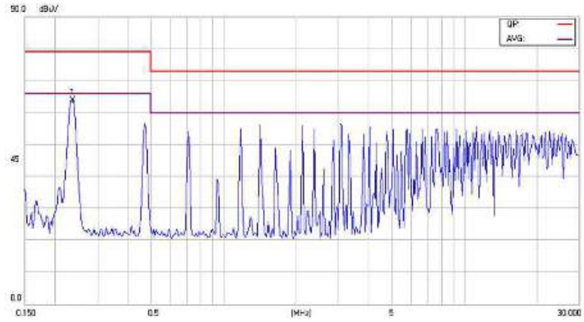


Figure 12 Conducted Class A of EC7BW-110S12

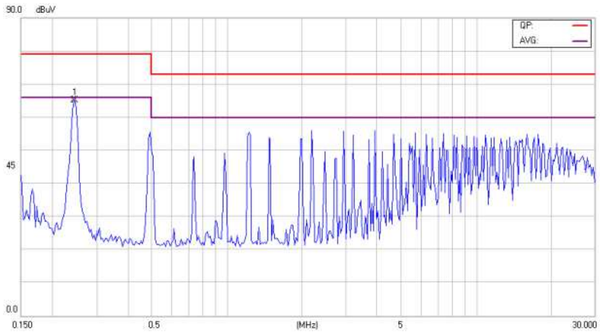


Figure 13 Conducted Class A of EC7BW-110S15

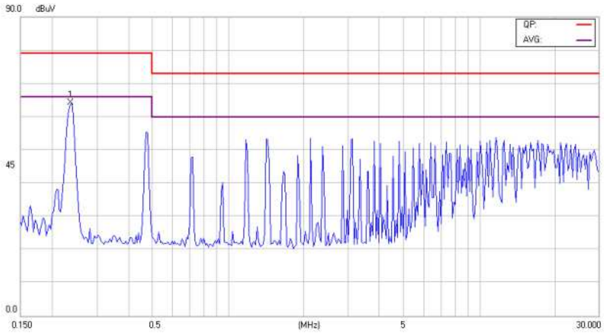


Figure 14 Conducted Class A EC7BW-110D12

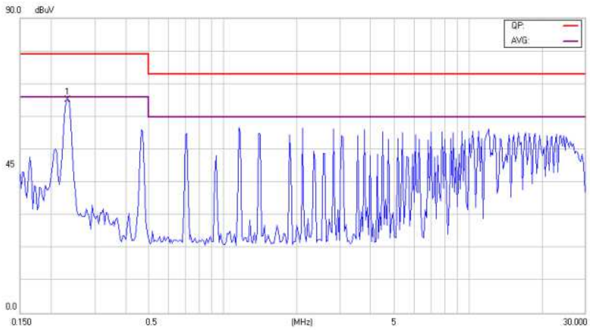
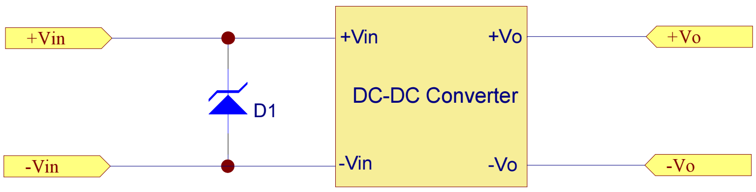


Figure 15 Conducted Class A of EC7BW-110D15

(2) EMC Test standard: EN50121-3-2 (EN55011 Class A Conducted & Radiated Emission)
Test Condition: Input Voltage: Nominal, Output Load: Full Load



Model No.	D1
EC7BW-110S05	P6KE180A Littelfuse
EC7BW-110S12	P6KE180A Littelfuse
EC7BW-110S15	P6KE180A Littelfuse
EC7BW-110D12	P6KE180A Littelfuse
EC7BW-110D15	P6KE180A Littelfuse

EMI and conducted noise meet EN55011 Class A

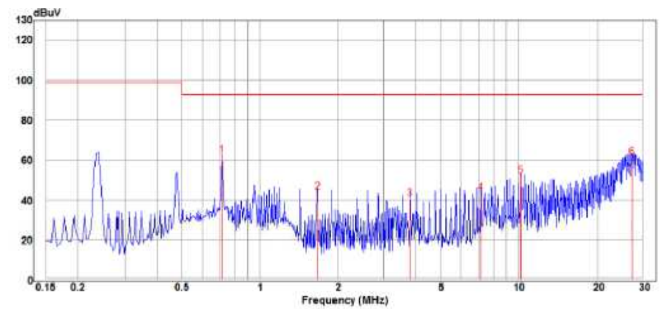


Figure 16 Conducted Class A of EC7BW-110S05

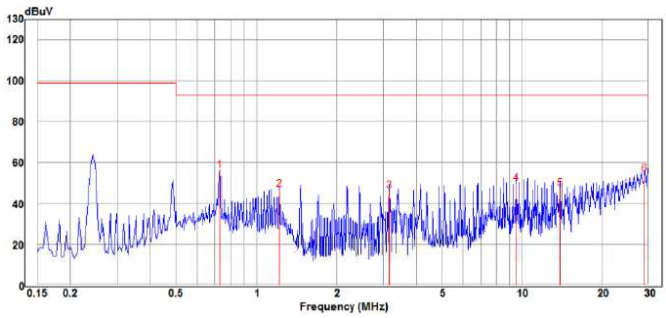


Figure 17 Conducted Class A of EC7BW-110S12

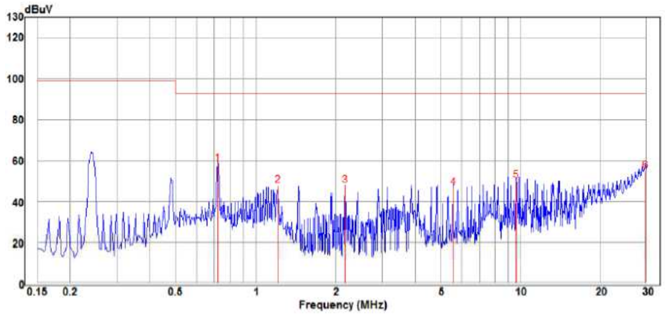


Figure 18 Conducted Class A of EC7BW-110S15

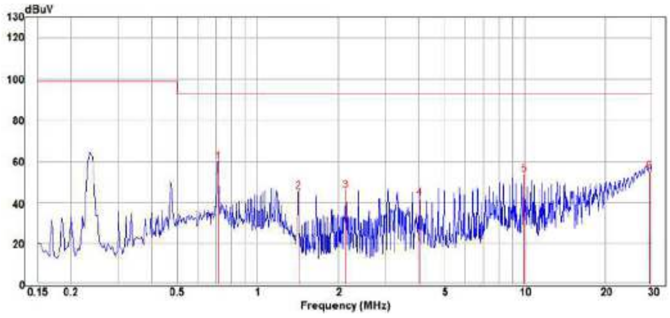


Figure 19 Conducted Class A EC7BW-110D12

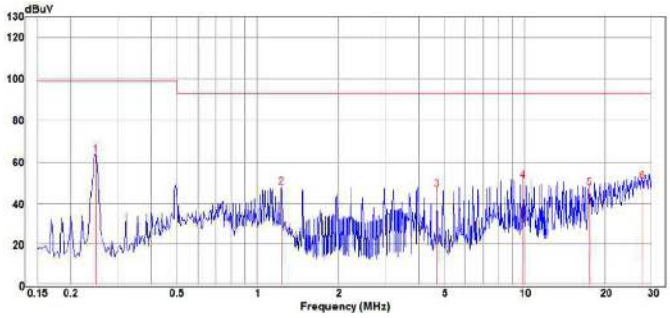
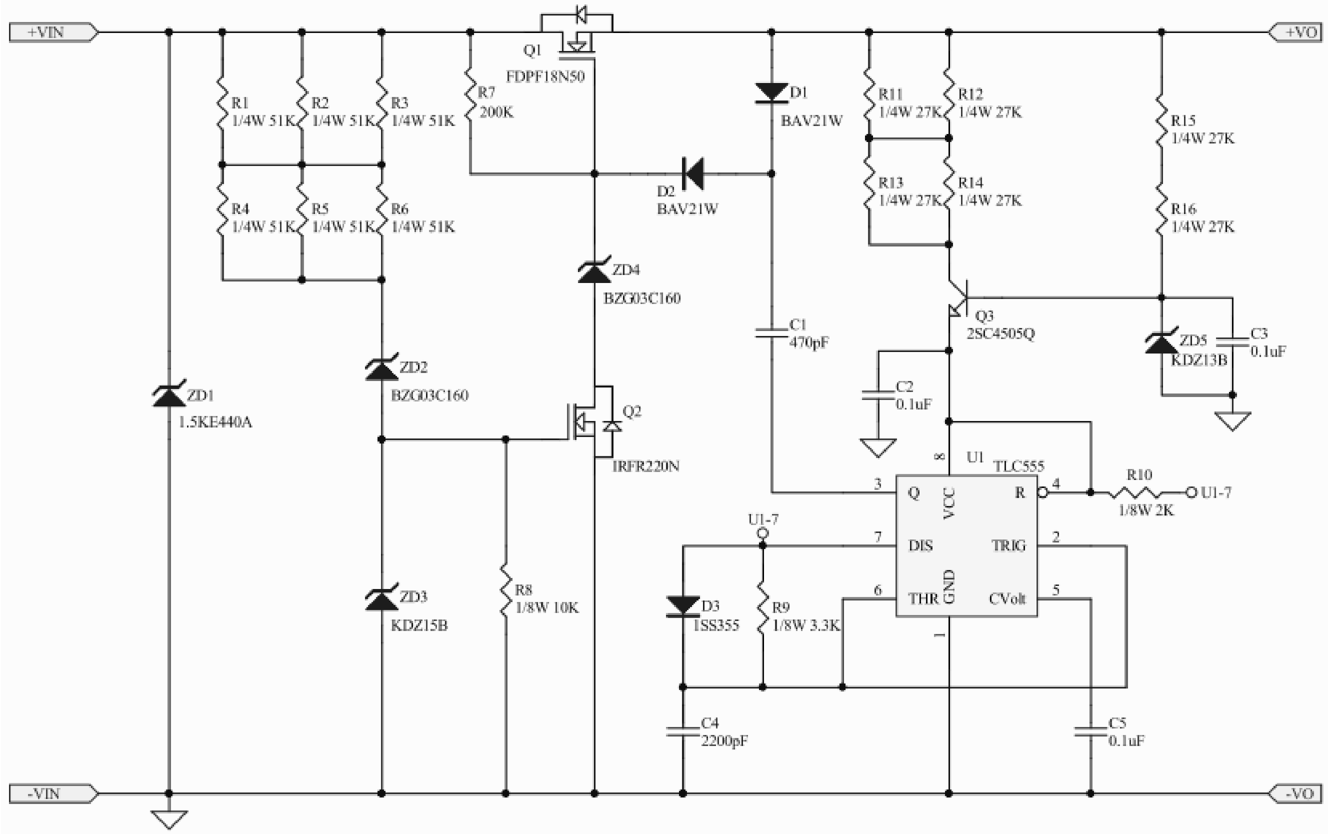


Figure 20 Conducted Class A of EC7BW-110D15

7.3 Suggested Configuration for RIA12 Surge Test



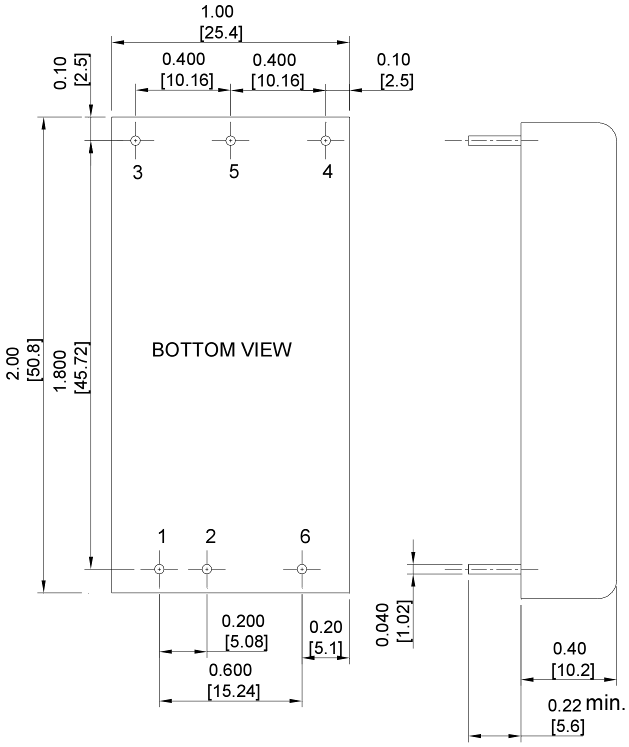
8. Part Number

EC7BW – XXX X XX N

- EC7BW → EC7BW Series
- XXX → 110：Nominal Input Voltage 110VDC
- X → S：Single Output; D：Dual Output
- XX → 05：Output Voltage 5 VDC (Single Vout Only); 12：Output Voltage 12 VDC; 15：Output Voltage 15 VDC
- N → None：Positive Logic; N：Negative Logic

9. Mechanical Specifications

All Dimensions In Inches (mm)
Tolerances Inches X.XX= ±0.02 , X.XXX= ±0.010
Millimeters X.XX= ±0.5 , X.XXX= ±0.25



PIN CONNECTION		
Pin	Single	Dual
1	+Vin	+Vin
2	-Vin	-Vin
3	+Vout	+Vout
4	Trim	-Vout
5	-Vout	Common
6	Remote ON/OFF	

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