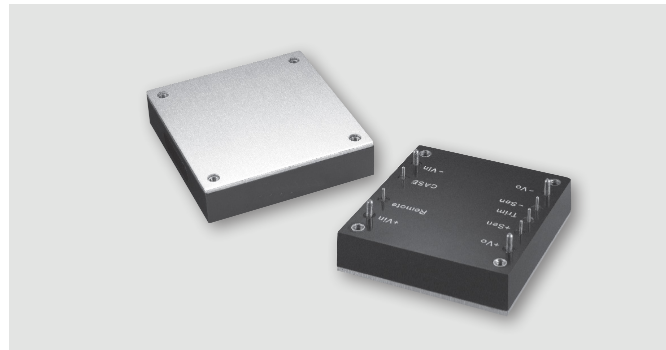
POWERBOX Industrial Line
PHB150U Series
150W 8:1 Single Output
DC/DC Converter
Manual V12



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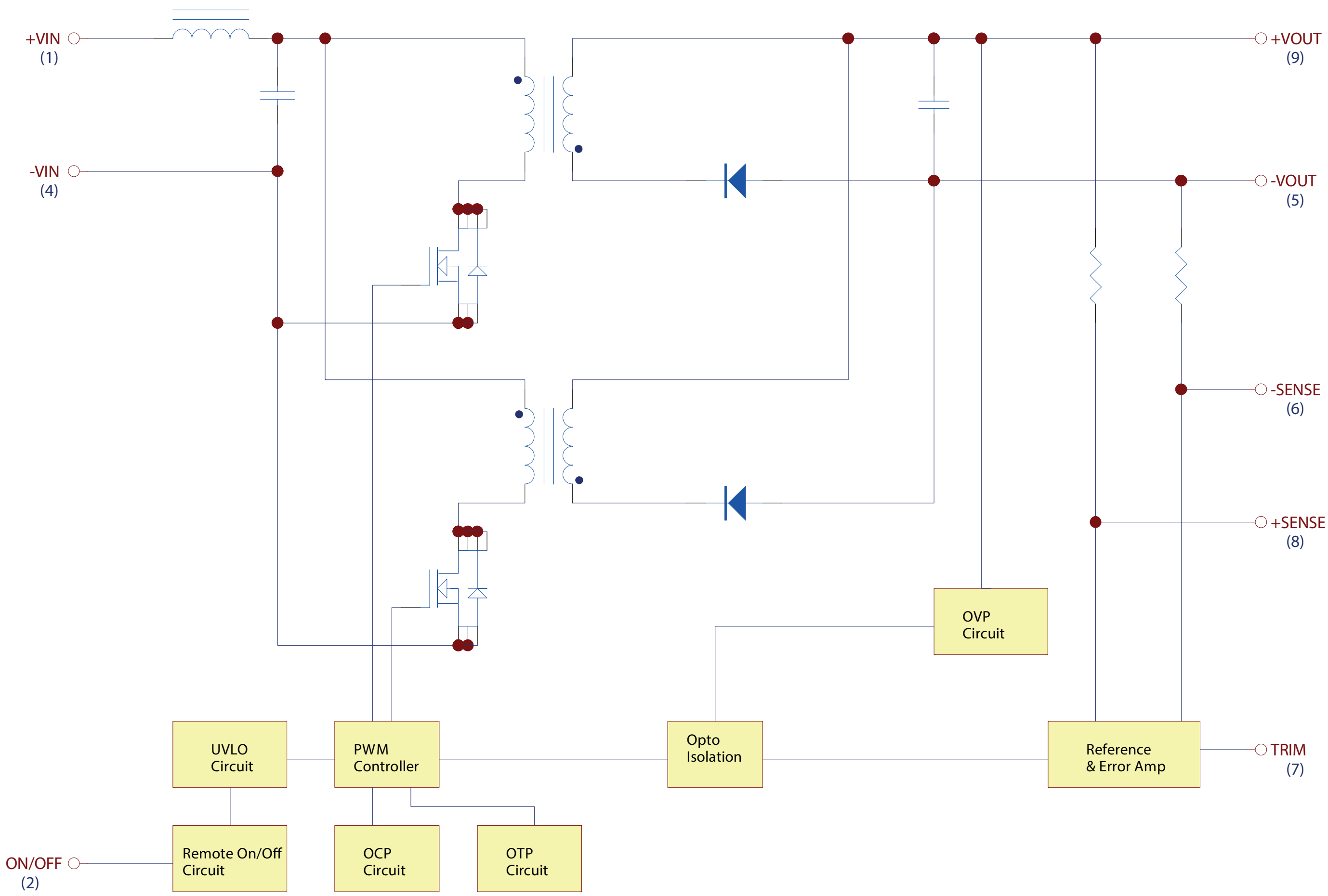
1. Introduction

This specification describes the features and functions of PHB150U series of isolated DC/DC converters. These are highly efficient, reliable and compact, high power density, single output DC/DC converters. The modules can be used in the field of telecommunications, data communications, wireless communications, servers etc. The PHB150U series can deliver up to 12.5A output current and provide a precisely regulated output voltage over a wide range of 9-75VDC. The modules can achieve high efficiency up to 90%. The module offers direct cooling of dissipative components for excellent thermal performance. Standard features include remote on/off (positive or negative), remote sense, output voltage adjustment, over voltage, over current and over temperature protection.

2. DC/DC Converter Features

- 150W Isolated output
- Efficiency up to 90%
- Regulated output
- Fixed switching frequency
- Input under voltage lockout protection
- Over current protection
- Remote On/Off
- Continuous short circuit protection
- Industry standard half-brick package
- Fully isolated to 1500VDC
- UL60950-1 approval
- High power density 54.7W/in^3

3. Electrical Block Diagram



4. Technical Specifications

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

Absolute Maximum Ratings

Parameters	**Notes and Conditions**	**Device**	**Min**	**Typical**	**Max**	**Units**
Input voltage						
Continuous		All	-0.3		75	VDC
Transient	100ms	All			100	VDC
Operating case temperature		All	-40		100	°C
Storage temperature		All	-55		105	°C
Isolation voltage, 1 minute	Input/output	All	1500			VDC

Input Characteristics

Parameters	**Notes and Conditions**	**Device**	**Min**	**Typical**	**Max**	**Units**
Operating input voltage		All	9	36	75	VDC
Input Under Voltage Lockout						
Turn-on voltage threshold		All	8.5	9.0	9.5	VDC
Turn-off voltage threshold		All	7.5	8.0	8.5	VDC
Lockout hysteresis voltage		All		1		VDC
Maximum input current	100% Load, Vin=9V	All		20		A
No-load input current	Vin=36V	36S12		60		mA
		36S15		60		mA
		36S24		60		mA
		36S28		60		mA
		36S48		60		mA
Inrush current (I^2t)		All			1	A^2s
Input reflected-ripple current	P-P thru 10uH inductor, 5Hz to 20MHz	All			50	mA
Recommended input fuse	Fast acting type	All		30		A
Input capacitance (external)	<0.7Ω ESR	All		330		uF

Output Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Output voltage set point	Vin=Nominal Vin, Io = Io_max, Tc=25°C	36S12	11.82	12	12.18	VDC
		36S15	14.775	15	15.225	VDC
		36S24	23.64	24	24.36	VDC
		36S28	27.58	28	28.42	VDC
		36S48	47.28	48	48.72	VDC
Output voltage regulation						
Load regulation	Io=Io_min to Io_max	All			±0.2	%
Line regulation	Vin=low line to high line	All			±0.2	%
Temperature coefficient	TC=-40°C to 100°C	All			±0.03	%/°C
Output voltage ripple and noise						
Peak-to-Peak	Full load, 1 0uF tantalum	36S12			120	mV
	(for 48Vout with 10uF aluminum)	36S15			120	mV
	and 1.0uF ceramic capacitors	36S24			280	mV
		36S28			280	mV
		36S48			480	mV
RMS	Full load, 1 0uF tantalum	36S12			60	mV
	(for 48Vout with 10uF aluminum)	36S15			60	mV
	and 1.0uF ceramic capacitors	36S24			100	mV
		36S28			100	mV
		36S48			200	mV
Operating output current range		36S12	0		12.5	A
		36S15	0		10	A
		36S24	0		6.25	A
		36S28	0		5.35	A
		36S48	0		3.13	A
Output DC current limit inception		All	105	160	200	%
Maximum output capacitance	Full load (resistive)	36S12	0		5000	uF
		36S15	0		5000	uF
		36S24	100		2000	uF
		36S28	100		1500	uF
		36S48	100		1000	uF

Dynamic Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Output voltage current transient						
Step change in output current	di/dt=0.1A/us, load change from	36S12			±5	%Vo
	75% to 100% to 75% of Io,max	36S15			±5	%Vo
	Vin=24,36,48V; output capacitance	36S24			±5	%Vo
	100uF, 10uF solid tantalum and	36S28			±5	%Vo
	1.0uF ceramic capacitors	36S48			±5	%Vo
Setting time (within 1% Vout nominal)	di/dt=0.1A/us, Vin=24,36,48,	36S12			500	us
	output capacitance 100uF	36S15			500	us
		36S24			500	us
		36S28			500	us
		36S48			500	us
Turn-on delay and rise time						
Turn-on delay time, from On/Off control	Von/off to 90%Vo_set	All		80	100	ms
Turn-on delay time, from input	Vin_min to 90%Vo_set	All		100	150	ms
Output voltage rise time	10%Vo_set to 90%Vo_set	All		30	50	ms

Efficiency

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
100% load	Vin=24V	36S12		89.5		%
		36S15		90		%
		36S24		89.5		%
		36S28		90		%
		36S48		90.5		%
	Vin=36V	36S12		89.5		%
		36S15		90		%
		36S24		89.5		%
		36S28		90		%
		36S48		90		%
	Vin=48V	36S12		89.5		%
		36S15		90		%
		36S24		89		%
		36S28		89.5		%
		36S48		89.5		%

Isolation Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Input to output	1 minute	All			1500	VDC
Isolation resistance		All	10			MΩ
Isolation capacitance		36S12		3500		pF
		36S15		3500		pF
		36S24		2500		pF
		36S28		2500		pF
		36S48		2500		pF

Feature Characteristics

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
Switching frequency		All		200		KHz
ON/OFF control, positive remote On/Off logic						
Logic low (module off)		All	0		1.2	V
Logic high (module on)		All	3.5 or open circuit		75	V
ON/OFF control, negative remote On/Off logic						
Logic high (module off)		All	3.5 or Open Circuit		75	V
Logic high (module on)		All	0		1.2	V
On/off current (for both remote on/off logic)	Ion/off at Von/off=0.0V	All			1	mA
Leakage current (for both remote on/off logic	Logic high, Von/off=15V	All			1	mA
Off converter input current	Shutdown input idle current	All		12	18	mA
Output voltage trim range	Vin=high line-low line, Pout=max rated power, Iout=max rated current	Others	-10		+10	%
	Vin=9-13V, Iout=max rated current	36S28	-10		0	%
	Vin=13-75V, Pout=max rated power, Iout=max rated current	36S28	-10		+10	%
Output over voltage protection		All	115	125	140	%
Over-temperature shutdown		All		110		°C

General Specifications

Parameters	Notes and Conditions	Device	Min	Typical	Max	Units
MTBF	Io=100% of Io_max: Ta=25°C per MIL-HDBK-217F	All		800		Khours
Weight		All		109		grams

5. Main Features and Functions

5.1 Operating Temperature Range

The PHB150U series converters can be operated within a wide case temperature range of -40°C to 100°C. Consideration must be given to the de-rating curves when ascertaining maximum power that can be drawn from the converter. The maximum power drawn from half brick models is influenced by usual factors, such as::

- Input voltage range
- Output load current
- Forced air or natural convection

5.2 Output Voltage Adjustment

Section 6.8 describes in detail how to trim the output voltage with respect to its set point. The output voltage on 12V&15V&24V&48V models is adjustable within the range of +10% to –10%. For 28V model, see input& output trim curves.

5.3 Over Current Protection

The converter is protected against over current or short circuit conditions. At the instance of current-limit inception, the module enters a hiccup mode of operation, whereby it shuts down and automatically attempts to restart. While the fault condition exists, the module will remain in this hiccup mode, and can remain in this mode until the fault is cleared. The unit operates normally once the output current is reduced back into its specified range.

5.4 Output Over Voltage Protection

The converter is protected against output over voltage conditions. When the output voltage is higher than the specified range, the module enters a hiccup mode of operation. The operation is identical with over current protection.

5.5 Remote On/Off

The On/Off input pin permits the user to turn the power module on or off via a system signal. Two remote on/off options are available. Positive logic turns the module on during a logic high voltage on the on/off pin, and off during a logic low. Negative logic remote on/off turns the module off during a logic high and on during a logic low. The on/off pin is internally pulled up through a resistor. A properly de-bounced mechanical switch, open collector transistor, or FET can be used to drive the input of the On/Off pin. If not using the remote on/off feature: For positive logic, leave the On/Off pin open. For negative logic, short the on/off pin to Vin(-).

5.6 UVLO&OVLO (Under/Over Voltage Lock Out)

Input under voltage lockout is standard with this converter. At input voltages below the input under voltage lockout limit, the module operation is disabled.

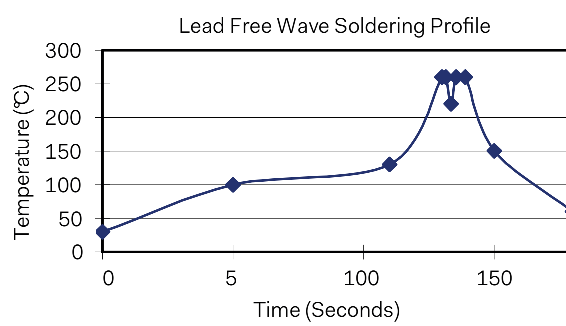
5.7 Over Temperature Protection

These modules have an over temperature protection circuit to safeguard against thermal damage. When the case temperature rises above over temperature shutdown threshold, the converter will shut down to protect it from overheating. The module will automatically restart after it cools down.

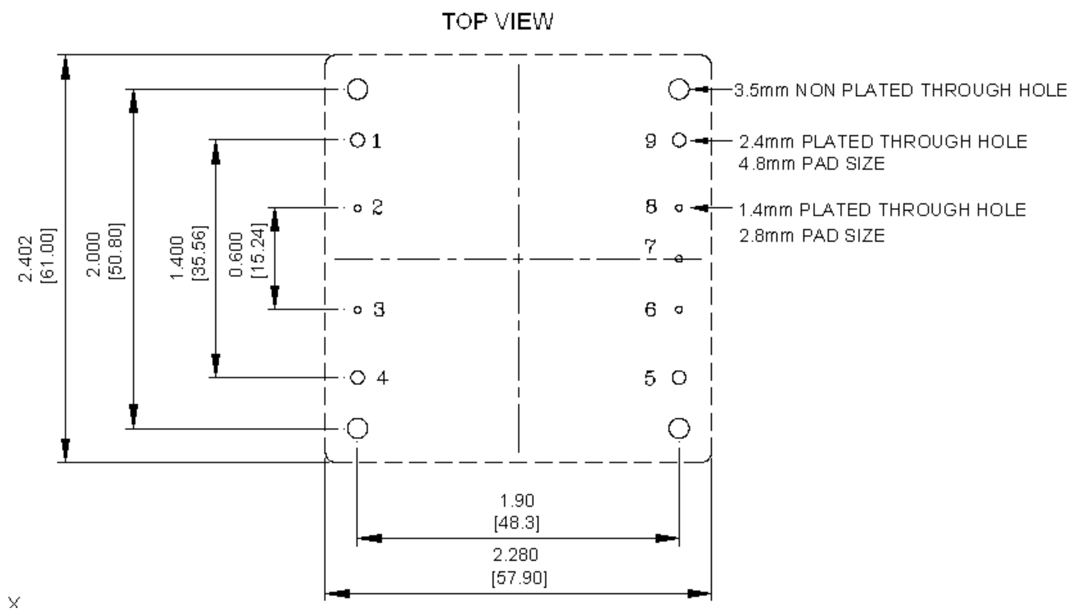
6. Applications

6.1 Recommended Layout, PCB Footprint and Soldering Information

The system designer or end user must ensure that metal and other components in the vicinity of the converter meet the spacing requirements for which the system is approved. Low resistance and 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 soldering profile and PCB layout are shown below.



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



6.2 Convection Requirements for Cooling

To predict the approximate cooling needed for the half brick module, refer to the power de-rating curves in section 6.4. These de-rating curves are approximations of the ambient temperatures and airflows required to keep the power module temperature below its maximum rating. Once the module is assembled in the actual system, the module's temperature should be monitored to ensure it does not exceed 100°C as being measured at the center of the top of the case (thus verifying proper cooling).

6.3 Thermal Considerations

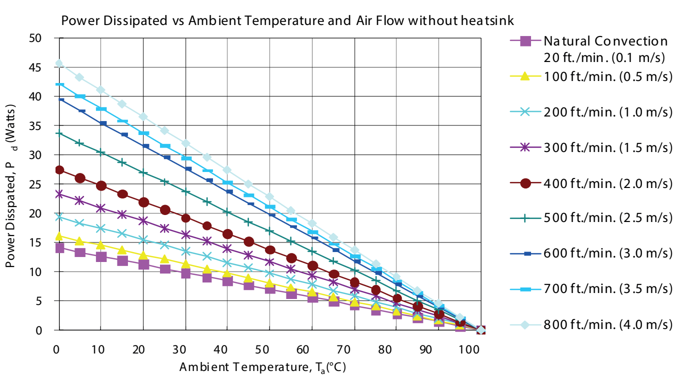
The power module operates in a variety of thermal environments; however, sufficient cooling should be provided to help ensure reliable operation of the unit. Heat is removed by conduction, convection, and radiation to the surrounding environment. The test data is presented in section 6.4. The power output of the module should not be allowed to exceed rated power (Vo_set x Io_max).

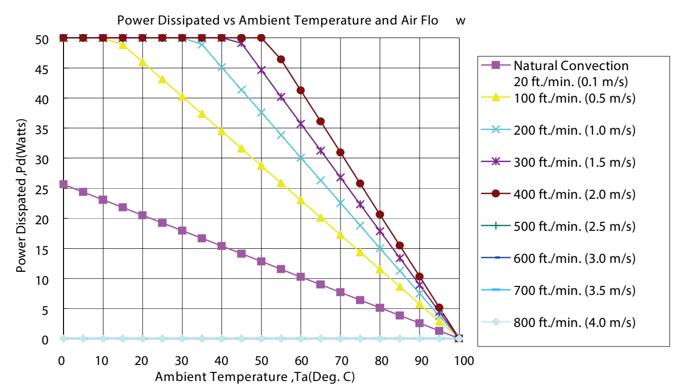
6.4 Power De-rating

The operating case temperature range of PHB150U series is -40°C to +100°C. When operating the PHB150U series, proper de-rating or cooling is needed. The maximum case temperature under any operating condition should not be exceeded 100°C. The following curve is the de-rating curve of PHB150U series without heat sink.

Example (without heatsink)
What is the minimum airflow necessary for a PHB150U-36S12 operating at nominal line voltage, an output current of 12.5A, and a maximum ambient temperature of 40°C?
Solution:
Given: V_{in}=36Vdc Vo=12Vdc Io=12.5A
Determine power dissipation (Pd):
Pd =Pi-Po=Po(1-η)/η
Pd =12V×12.5A×(1-0.895)/0.895=17.60Watts
Determine airflow:
Given: Pd =17.60W and Ta=40°C
Check above power de-rating curve:
Minimum airflow= 500 ft./min.
Verifying:
The maximum temperature rise:
ΔT = Pd × Rca=17.60W×2.96=52.1°C
The maximum case temperature:
Tc=Ta+ΔT=92.1°C <100°C
Where:
The R_{ca} is thermal resistance from case to ambient environment.
The T_a is ambient temperature and the Tc is case temperature.

Example (with heatsink M-C308):
Solution:
Given: Vin=36Vdc, Vo=12Vdc, Io=12.5A
Determine Power dissipation (Pd):
Pd=Pi-Po=Po(1-η)/ η
Pd=12Vx12.5Ax(1-0.895)/0.895=17.60Watts
Determine airflow:
Given: P_d=18.5W and Ta=40°C
Check above Power de-rating curve:
Minimum airflow= 100 ft./min.
Verifying:
The maximum temperature rise ΔT = Pd × Rca=17.60×1.74=30.6°C
The maximum case temperature Tc=Ta+ΔT=70.6°C <100°C
Where:
The R_{ca} is thermal resistance from case to ambient environment.
The T_a is ambient temperature and the T_c is case temperature.

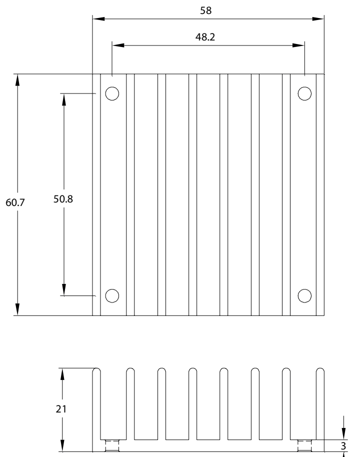




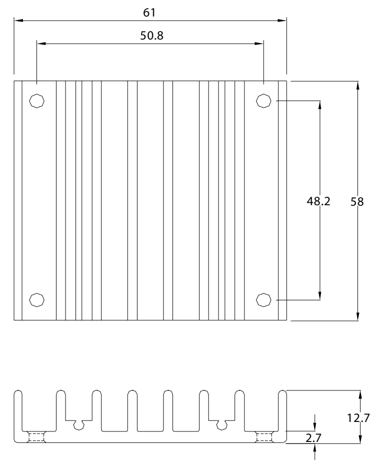
AIR FLOW RATE	TYPICAL Rca
Natural Convection 20ft./min. (0.1m/s)	7.12°C/W
100 ft./min. (0.5m/s)	6.21°C/W
200 ft./min. (1.0m/s)	5.17°C/W
300 ft./min. (1.5m/s)	4.29°C/W
400 ft./min. (2.0m/s)	3.64°C/W
500 ft./min. (2.5m/s)	2.96°C/W
600 ft./min. (3.0m/s)	2.53°C/W
700 ft./min. (3.5m/s)	2.37°C/W
800 ft./min. (4.0m/s)	2.19°C/W

AIR FLOW RATE	TYPICAL Rca
Natural Convection 20ft./min. (0.1m/s)	3.9°C/W
100 ft./min. (0.5m/s)	1.74°C/W
200 ft./min. (1.0m/s)	1.33°C/W
300 ft./min. (1.5m/s)	1.12°C/W
400 ft./min. (2.0m/s)	0.97°C/W

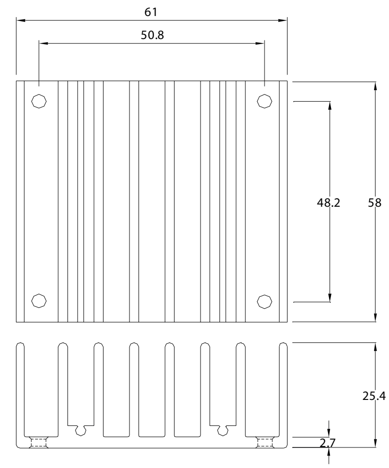
6.5 Half Brick Heat Sinks



M-C308



M-C091

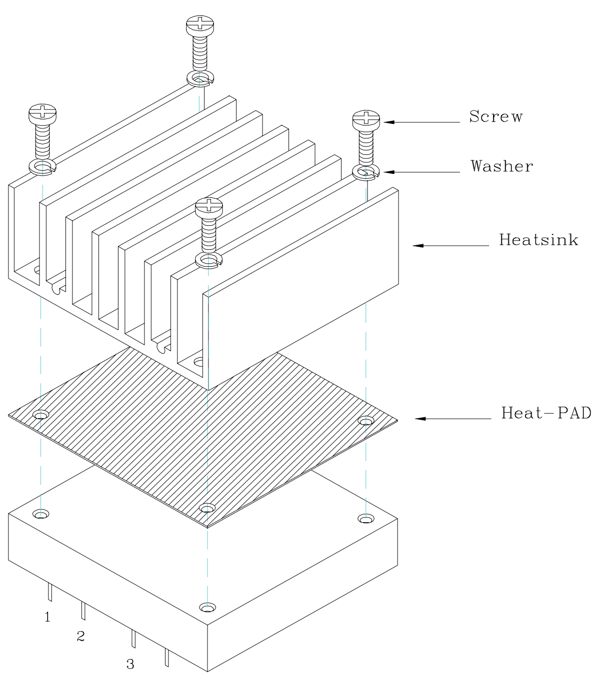


M-C092

M-C308 (G6620400201)
Longitudinal Heat Sink
Rca:
3.90°C/W (typ.), natural convection
1.74°C/W (typ.), at 100LFM
1.33°C/W (typ.), at 200LFM
1.12°C/W (typ.), at 300LFM
0.97°C/W (typ.), at 400LFM

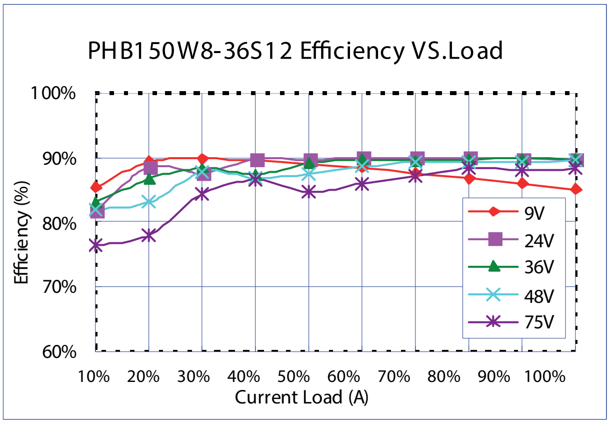
M-C091 (G6610120402)
Transverse Heat Sink
Rca:
4.70°C/W (typ.), natural convection
2.89°C/W (typ.), at 100LFM
2.30°C/W (typ.), at 200LFM
1.88°C/W (typ.), at 300LFM
1.59°C/W (typ.), at 400LFM

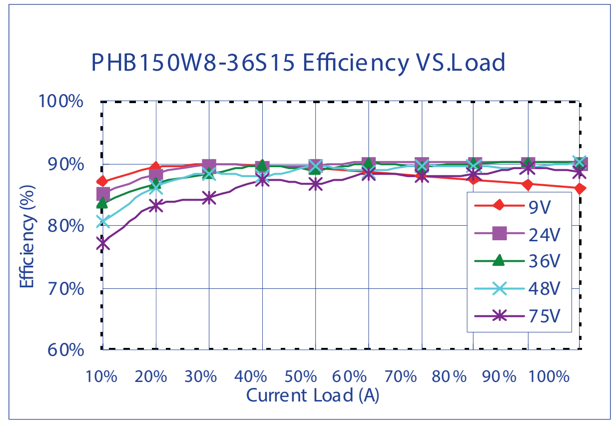
M-C092 (G6610130402)
Transverse Heat Sink
Rca:
3.00°C/W (typ.), natural convection
1.44°C/W (typ.), at 100LFM
1.17°C/W (typ.), at 200LFM
1.04°C/W (typ.), at 300LFM
0.95°C/W (typ.), at 400LFM

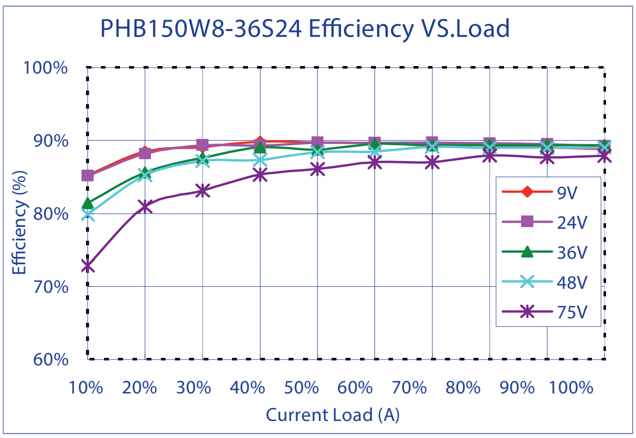


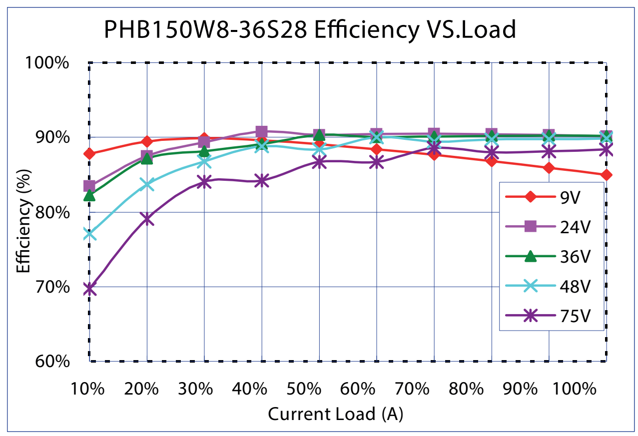
THERMAL PAD: SZ 56.9*60*0.25 mm (G6135041091)
SCREW: SMP+SW M3*8L
(G75A1300322)

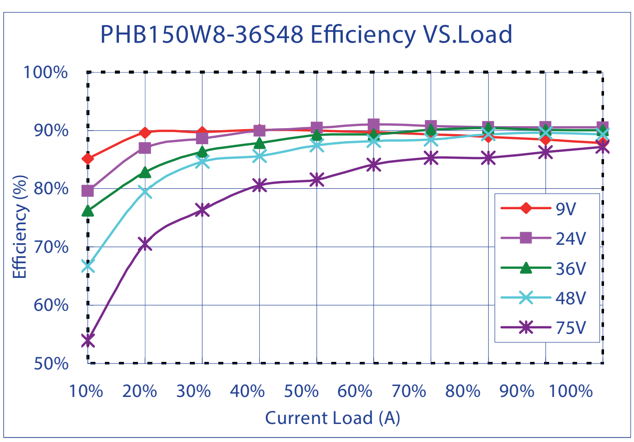
6.6 Efficiency VS. Load



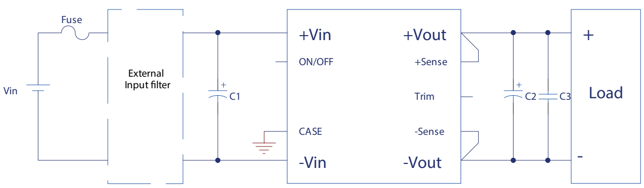




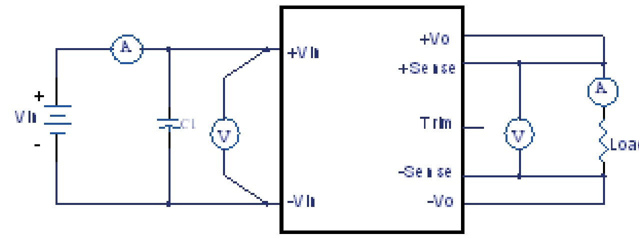




6.7 Test Set-Up



Typical electrical connection (Positive logic)



PHB150U Series Test Setup

For typical electrical connection, please refer to the connection above.

1. Put input capacitor, C1 more than 330uF for 36Vin models If the ambient temperature is less than -20°C,use twice of the recommended capacitor above. If the impedance of input line is high, input capacitor must be more than above.
2. Put output capacitor,C2 and C3, according to minimum and maximum capacitor recommendation on page 4. If the ambient temperature is less than -20°C, use at least 3 pieces of the recommended minimum capacitors.
3. Use external fuse for each unit. The basic test set-up to measure parameters such as efficiency and load regulation is shown below. 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:

- Efficiency
- Load regulation and line regulation.

The value of efficiency is defined as:

$$\eta = \frac{Vo \times Io}{Vin \times Iin} \times 100\%$$

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

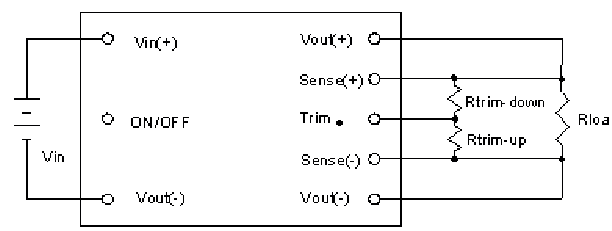
The value of line regulation is defined as:

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

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.

6.8 Output Voltage Adjustment

The Trim input permits the user to adjust the output voltage up or down 10%. This is accomplished by connecting an external resistor between the Trim pin and either the Vout (+) pin or the Vout(-) pin (COM pin), see Figure



Output voltage trim circuit configuration

The Trim pin should be left open if trimming is not being used. Connecting an external resistor (Rtrim-down) between the Trim pin and the Vout(+) (or Sense(+)) pin decreases the output voltage. The following equation determines the required external resistor value to obtain a down percentage output voltage change of Δ%

Vout=12V, 15V

$$Rtrim\_down = 20 * \frac{(Vo,set - \Delta\% * Vo,set - 1.24)}{\Delta\% * Vo,set} - 100K\Omega$$

Vout=24V

$$Rtrim\_down = 20 * \frac{(Vo,set - \Delta\% * Vo,set - 2.5)}{\Delta\% * Vo,set} - 100K\Omega$$

Vou=28V

$$Rtrim\_down = 23.7 * \frac{(Vo,set - \Delta\% * Vo,set - 2.5)}{\Delta\% * Vo,set} - 150K\Omega$$

Vout=48V

$$Rtrim\_down = 36 * \frac{(Vo,set - \Delta\% * Vo,set - 2.5)}{\Delta\% * Vo,set} - 200K\Omega$$

Where

$$V_{out} = V_{o,set}\ \Delta\% = \left(\frac{V_{o,set} - V_{desired}}{V_{o,set}}\right) x100$$

For example, to trim-down the output voltage of 12V module (PHB150U-36S12) by 5% to 11.4V, Rtrim-down is calculated as follow: Δ%=5%

$$R_{trim\text{-}down} = 20 * \frac{(12 - 5\%*12 - 1.24)}{5\%*12} - 100K\Omega$$

$$R_{trim\text{-}down} = 238.7\,K\Omega$$

Connecting an external resistor (Rtrim-up) between the Trim pin and the Vout (-) (or Sense (-)) pin increases the output voltage. The following equations determine the required external resistor value to obtain a up percentage output voltage change of Δ%.

Vout=12V, 15V

$$Rtrim\_up = 20 * \frac{(1.24 - \frac{0.46*100}{100+4.3})}{\Delta\%*Vo,set} - \frac{4.3*100}{100+4.3} K\ \Omega$$

Vout=24V

$$Rtrim\_up = 20 * \frac{(2.5 - \frac{0.46*100}{100+5.6})}{\Delta\%*Vo,set} - \frac{5.6*100}{100+5.6} K\ \Omega$$

Vout=28V

$$Rtrim\_up = 23.7 * \frac{(2.5 - \frac{0.46*150}{150+5.6})}{\Delta\%*Vo,set} - \frac{5.6*150}{150+5.6} K\ \Omega$$

Vout=48V

$$Rtrim\_up = 36 * \frac{(2.5 - \frac{0.46*200}{200+5.1})}{\Delta\%*Vo,set} - \frac{5.1*200}{200+5.1} K\ \Omega$$

Where

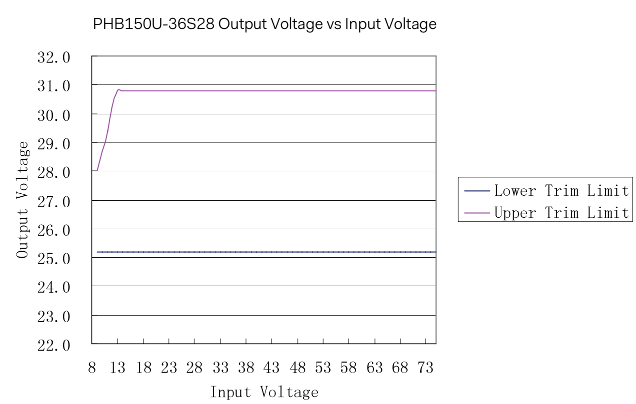
$$V_{out} = V_{o,set}\ \Delta\% = \left(\frac{V_{o,set} - V_{desired}}{V_{o,set}}\right) x100$$

For example, to trim-up the output voltage of 12V module (PHB150U-36S12) by 5% to 12.6V, Rtrim-up is calculated as follow: Δ%=5%

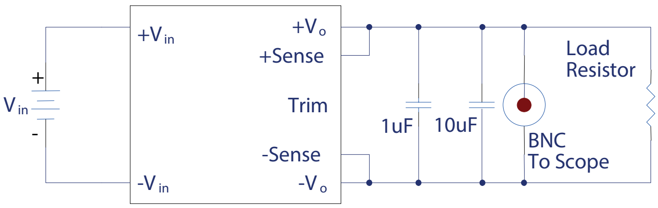
$$Rtrim\_up = 20 * \frac{(1.24 - \frac{0.46*100}{100+4.3})}{5\%*12} - \frac{4.3*100}{100+4.3} K\ \Omega$$

$$Rtrim\_up = 22.5K\,\Omega$$

Note: Although the output voltage can be increased by both the remote sense and by the trim, the maximum increase for the output voltage is not the sum of both. The maximum increase is the larger of either the remote sense or the trim. The amount of power delivered by the module is defined as the voltage at the output terminals multiplied by the output current. When using remote sense and trim, the output voltage of the module can be increased and consequently increase the power output of the module if output current remains unchanged. Care should be taken to ensure that the maximum output power of the module remains at or below the maximum rated power (Maximum rated power = Vo,set x Io,max) The output voltage on 12V&15V&24V&48V models is adjustable within the range of +10% to –10%.For 28V models, see input & output trim curves for trim up and trim down is -10%.



6.9 Output Ripple and Noise



Output ripple and noise is measured with 10uF solid tantalum capacitors (for 48Vout with 10uF Aluminum) and 1.0uF ceramic across the output.

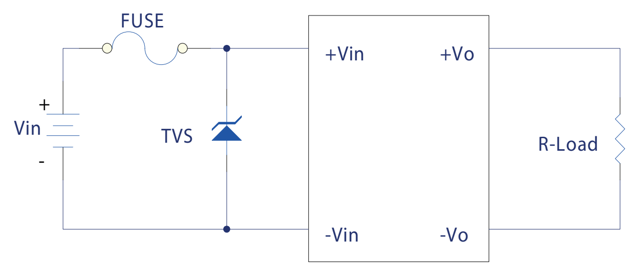
6.10 Output Capacitance

For good transient response, low ESR output capacitors should be located close to the point of load. PCB design emphasizes low resistance and inductance tracks in consideration of high current applications. Output capacitors with their associated ESR values have an impact on loop stability and bandwidth. The minimum output capacitance is 100uF which need three or four times capacitance when operating below -20°C and the absolute maximum value of PHB150U series' output capacitance, please refer to Page 4 Maximum Output Capacitance. For values larger than this, please contact your local Powerbox representative.

7. Safety & EMC

7.1 Input Fusing and Safety Considerations

The PHB150U series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommended a 30A fast acting fuse for 36Vin models, It is recommended that the circuit have a transient voltage suppressor diode (TVS) across the input terminal to protect the unit against surge or spike voltage and input reverse voltage (as shown).



7.2 EMC Considerations

EMI Test standard: EN55022 Class A and Class B Conducted Emission
Test Condition: Input Voltage: Nominal, Output Load: Full Load
(1) EMI and conducted noise meet EN55022 Class A:

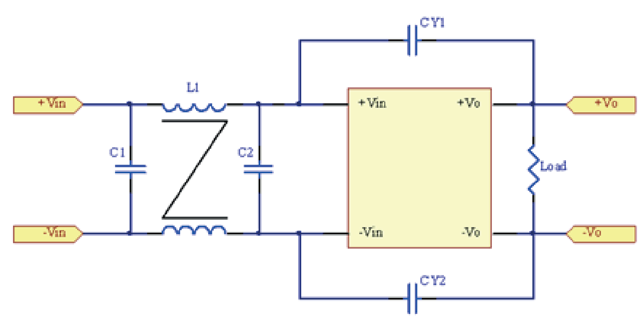
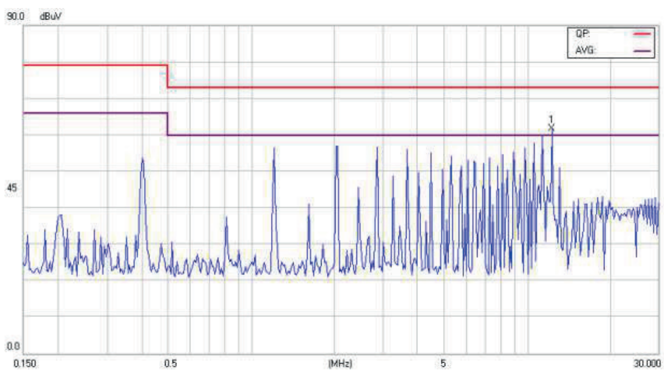


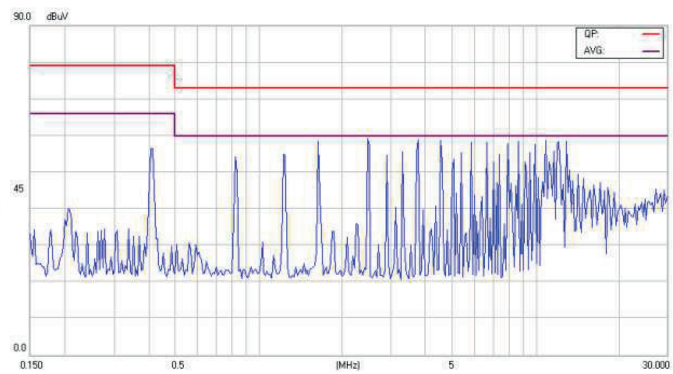
Figure1 Connection circuit for conducted EMI Class A testing

Model No.	C1	C2	CY1	CY2	L1
PHB150W8-36S12	220uF/100V	220uF/100V	1500pF	1500pF	0.2mH
PHB150W8-36S15	220uF/100V	220uF/100V	1500pF	1500pF	0.2mH
PHB150W8-36S24	220uF/100V	220uF/100V	1500pF	1500pF	0.2mH
PHB150W8-36S28	220uF/100V	220uF/100V	1500pF	1500pF	0.2mH
PHB150W8-36S48	220uF/100V	220uF/100V	1500pF	1500pF	0.2mH

Note: C1, C2 NICHICON PW series aluminum capacitors, CY1, CY2 is ceramic capacitors, L1 Core use SM CM20*12*10 Winding 5turns (double wire).

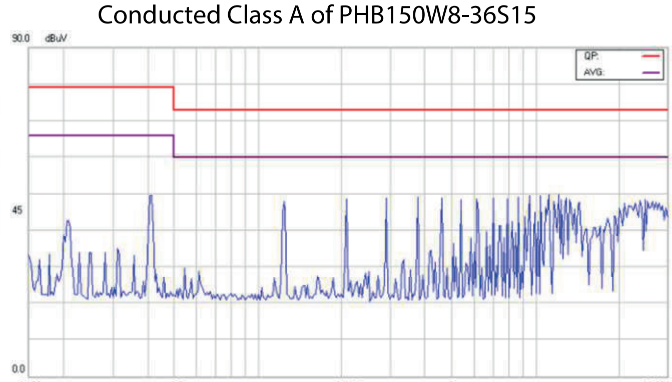


Conducted Class A PHB150W8-36S12

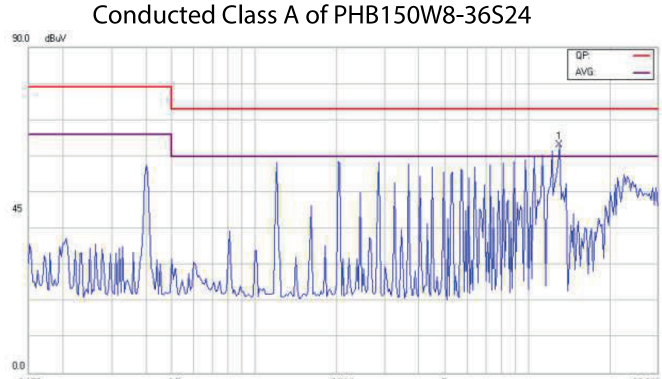


Conducted Class A of PHB150W8-36S15

Conducted Class A of PHB150W8-36S24



Conducted Class A of PHB150W8-36S28



Conducted Class A of PHB150W8-36S48

8. Part Number

Format: PHB150U – 36 X OO L

Parameter Symbol	Series PHB150U	Nominal Input Voltage 36	Number of Outputs X	Output Voltage OO	Remote ON/OFF Logic L
Value	PHB150U	36: 36 Volts	S: Single	12: 12 Volts 15: 15 Volts 24: 24 Volts 28: 28 Volts 48: 48 Volts	None: Positive N: Negative

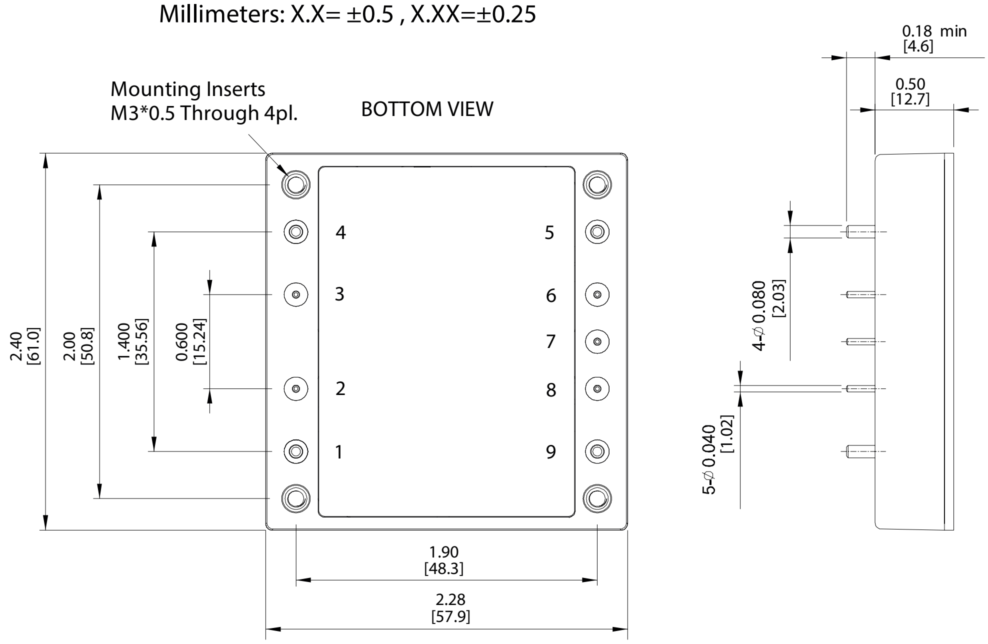
9. Mechanical Specifications

9.1 Mechanical Outline Diagrams

All Dimensions In Inches(mm)

Tolerances Inches: X.XX= ±0.02 , X.XXX= ±0.010

Millimeters: X.X= ±0.5 , X.XX=±0.25



Pin	Function
1	+V Input
2	ON/OFF
3	CASE
4	-V Input
5	-V Output
6	-Sense
7	Trim
8	+Sense
9	+V Output