Ag9400

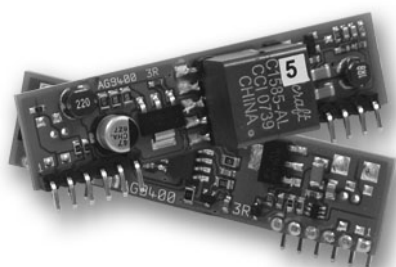**Power-Over-Ethernet Module**

1 Features

- ➢ IEEE802.3af compliant

- ➢ Small SIL package size - 56mm (L) x 14mm (H)

- ➢ Low cost

- ➢ Input voltage range 36V to 57V

- ➢ Minimal (low cost) external components required

- ➢ Short-circuit protection

- ➢ Adjustable Output

- ➢ 1500V isolation (input to output)

- ➢ Silvertel "design-in" assistance

2 Description

The Ag9400 series of modules are designed to extract power from a conventional twisted pair Category 5 Ethernet cable, conforming to the IEEE 802.3af Power-over-Ethernet (PoE) standard.

The Ag9400 signature and control circuit provides the PoE compatibility signature and power classification required by the Power Sourcing Equipment (PSE) before applying up to 15W power to the port. The Ag9400 provides a Class 0 signature.

The DC/DC converter operates over a wide input voltage range and provides a regulated output. The DC/DC converter also has built-in short-circuit output protection.

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3 Ag9400 Product Selector

Part Number†	Nominal Output Voltage	Maximum Output Power *	Marking
Ag9424-S	24.0V	12 Watts	24
Ag9412-S	12.0V	12 Watts	12
Ag9405-S	5.0V	10 Watts	5
Ag9403-S	3.3V	6.6 Watts	3
Ag9424-2BR	24.0V	12 Watts	24 2BR
Ag9412-2BR	12.0V	12 Watts	12 2BR
Ag9405-2BR	5.0V	10 Watts	5 2BR
Ag9403-2BR	3.3V	6.6 Watts	3 2BR

*At 25°C with V_{IN} = 48V
† The Ag9400 fully meets the requirements of the RoHS directive 2002/95/EC on the restriction of hazardous substances in electronic equipment.

Table 1: Ordering Information

The Ag9400-2BR is physically the same size as the Ag9400-S but it has the two input bridge rectifiers on-board (see Figure 1).
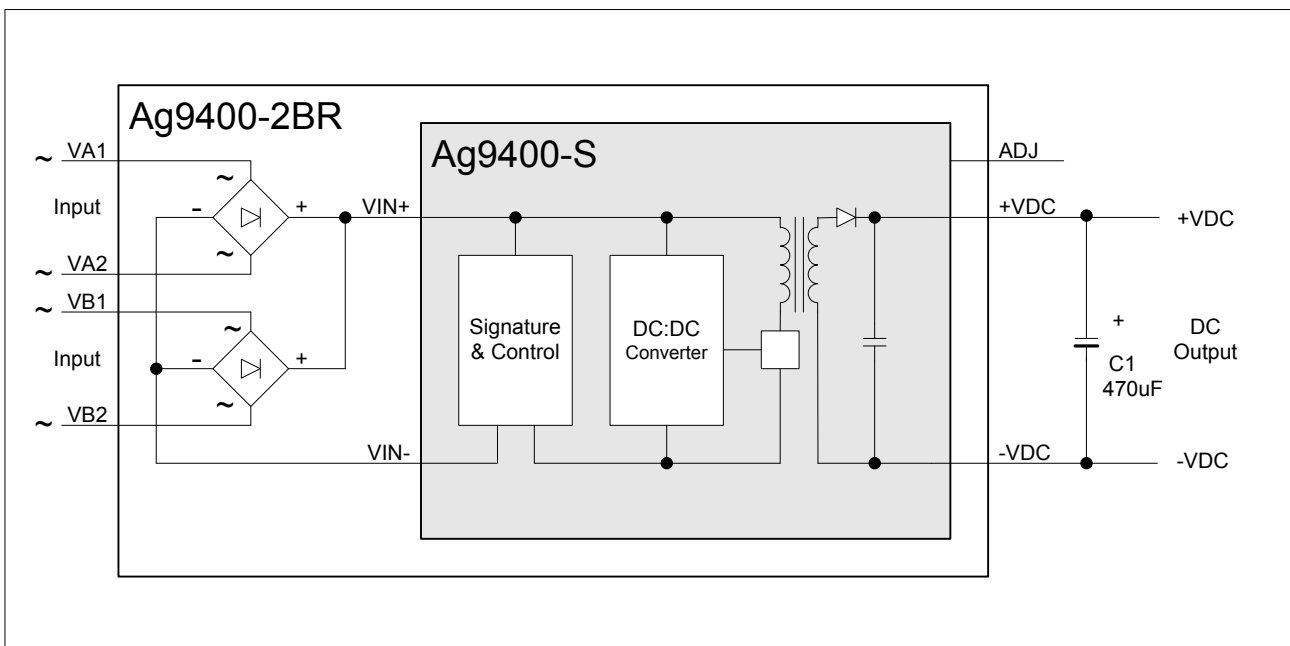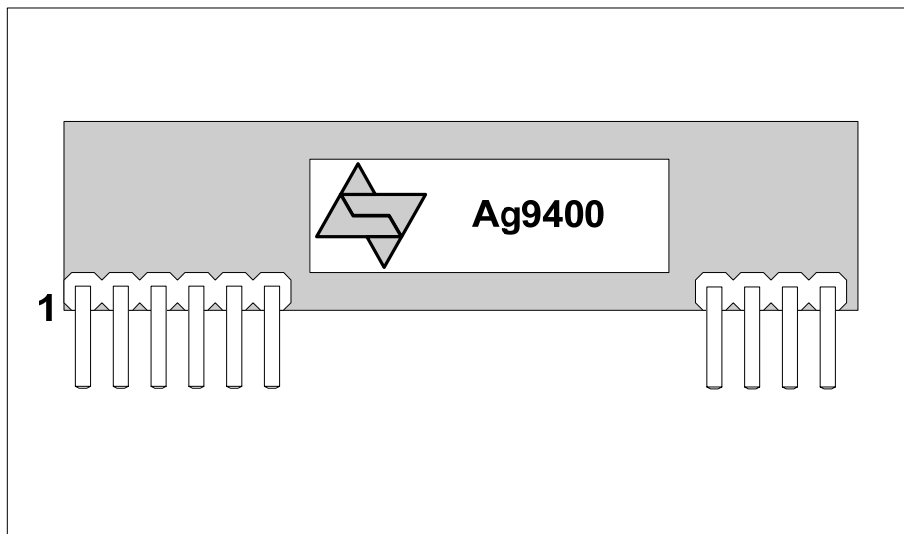

Figure 1: Block Diagram

Figure 2: Ag9400 Package Format

4 Pin Description

4.1 Ag9400-S

Pin #	Name	Description
1	VIN+	**Direct Input +**. This pin connects to the positive (+) output of the input bridge rectifiers (internally connected to pin 3).
2	VIN-	**Direct Input -**. This pin connects to the negative (-) output of the input bridge rectifiers (internally connected to pins 4 and 5).
3	VIN+	**Direct Input +**. Internally connected to pin 1.
4	VIN-	**Direct Input -**. Internally connected to pin 2.
5	IC	**Internal Connection.** Do not connect to this pin.
6	NC	**No Connection.**
7	-VDC	**DC Return.** This pin is the return path for the +VDC output.
8	+VDC	**DC Output.** This pin provides the regulated output from the DC/DC converter.
9	ADJ	**Output Adjust.** The output voltage can be adjusted from is nominal value, by connecting an external resistor from this pin to either the +VDC pin or the -VDC pin.
10	IC	**Internal Connection.** Do not connect to this pin.

Table 2: Pin Description

4.2 Ag9400-2BR

Pin #	Name	Description
1	VA1	**RX Input (1)**. This input pin is used in conjunction with VA2 and connects to the centre tap of the transformer connected to pins 1 & 2 of the RJ45 connector (RX) - it is not polarity sensitive.
2	VA2	**TX Input (2)**. This input pin is used in conjunction with VA1 and connects to the centre tap of the transformer connected to pins 3 & 6 of the RJ45 connector (TX) - it is not polarity sensitive.
3	VB1	**Direct Input (1)**. This input pin is used in conjunction with VB2 and connects to pin 4 & 5 of the RJ45 connector - it is not polarity sensitive.
4	VB2	**Direct Input (2)**. This input pin is used in conjunction with VB1 and connects to pin 7 & 8 of the RJ45 connector - it is not polarity sensitive.
5	IC	**Internal Connection.** Do not connect to this pin.
6	NC	**No Connection.**
7	-VDC	**DC Return.** This pin is the return path for the +VDC output.
8	+VDC	**DC Output.** This pin provides the regulated output from the DC/DC converter.
9	ADJ	**Output Adjust.** The output voltage can be adjusted from is nominal value, by connecting an external resistor from this pin to either the +VDC pin or the -VDC pin.
10	IC	**Internal Connection.** Do not connect to this pin.

Table 3: Pin Description

5 Functional Description

5.1 Inputs

The Ag9400 is compatible with equipment that uses the different power options, see Figure 3: Typical System Diagram. It is specified that the PSE does not apply power to both outputs at the same time (Refer to IEEE802.3af for more information).
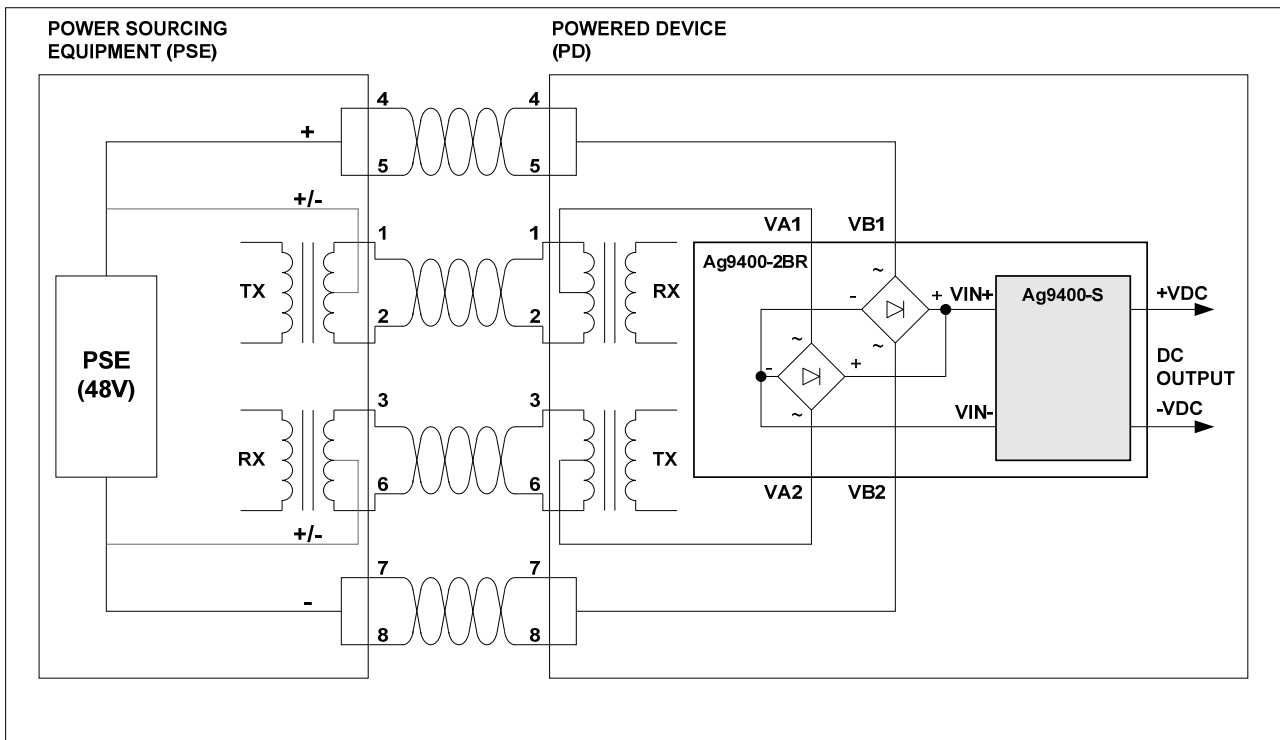

Figure 3: Typical System Diagram

5.2 PD Signature

When the Ag9400 is connected to the Cat 5e cable, it will automatically present a Powered Device (PD) signature to the Power Sourcing Equipment (PSE) or Midspan Equipment, when requested. The equipment will then recognise that a powered device is connected to that line and supply power.

5.3 Isolation

To meet the safety isolation requirements of IEEE802.3af section 33.4.1 a Powered Device (PD) must pass the electrical strength test of IEC 60950 sub clause 6.2. This calls for either a) 1500Vac test or b) 1500V impulse test. The Ag9400 is specified to meet the 1500Vdc impulse test. It is also important that the tracks on either side of the isolation barrier have at least a 3mm clearance, see Figures 7 & 8 and Section 11 for more information.

5.4 Power Classification

The Ag9400 is fixed for Class 0 (0.44 Watts to 12.95 Watts) operation. Should Class programming be required refer to other Silvertel POE products such as the Ag9200.

5.5 DC/DC Converter

The Ag9400's DC/DC converter provides a regulated low ripple and low noise output that has built-in short-circuit output protection – refer Table 1: Ordering information for voltage and power ratings

5.6 Output Adjustment

The Ag9400 has an ADJ pin, which allows the output voltage to be increased or decreased from its nominal value. Figure 4: Output Adjustment shows how the ADJ pin is connected.
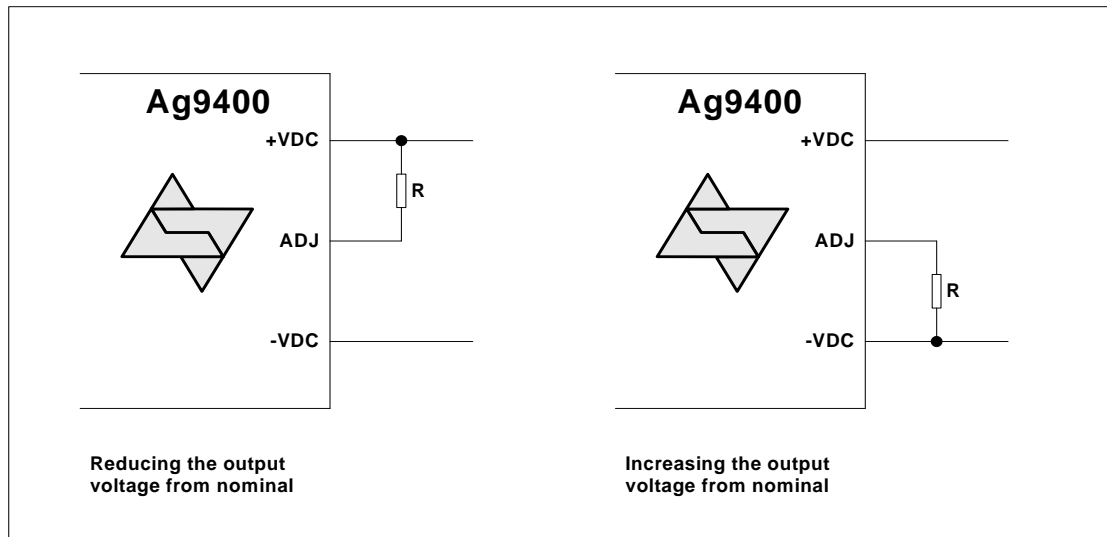

Figure 4: Output Adjustment

Reducing the output voltage, connect R between ADJ and +VDC							
Ag9403		Ag9405		Ag9412		Ag9424	
Value of R	Output	Value of R	Output	Value of R	Output	Value of R	Output
Open	3.30V	Open	5.00V	Open	12.00V	Open	24.00V
0 Ohms	2.80V	0 Ohms	4.40V	0 Ohms	9.90V	30K Ohms	18.20V
Increasing the output voltage, connect R between ADJ and -VDC							
Ag9403		Ag9405		Ag9412		Ag9424	
Value of R	Output	Value of R	Output	Value of R	Output	Value of R	Output
Open	3.30V	Open	5.00V	Open	12.00V	Open	24.00V
0 Ohms	3.70V	0 Ohms	5.70V	0 Ohms	12.80V	0 Ohms	25.50V

**Table 2: Output Adjustment Resistor (R) Value**

5.7 Typical Connections

The Ag9400 requires minimal external components as shown in Figure 5: Typical Connection Diagram.

C1 must be fitted for output stability, it should be a minimum of 470µF, and positioned as close to the output pins as possible. Its value also relates to the maximum load step change that the output needs to drive. For example, in an application were the output needs to cope with high load step changes, the value may need to be increased to a minimum of 1000µF. This can be a standard low cost electrolytic and does not need to be a low ESR type.

Figure 5 shows a 25V capacitor that would cover all product variants up to and including the Ag9424, see Table 1: Ordering Information

The Output Adjust inputs are optional and are provided to give great flexibility to the Ag9400 product range. Further information on using these inputs can be found in section Output Adjustment.
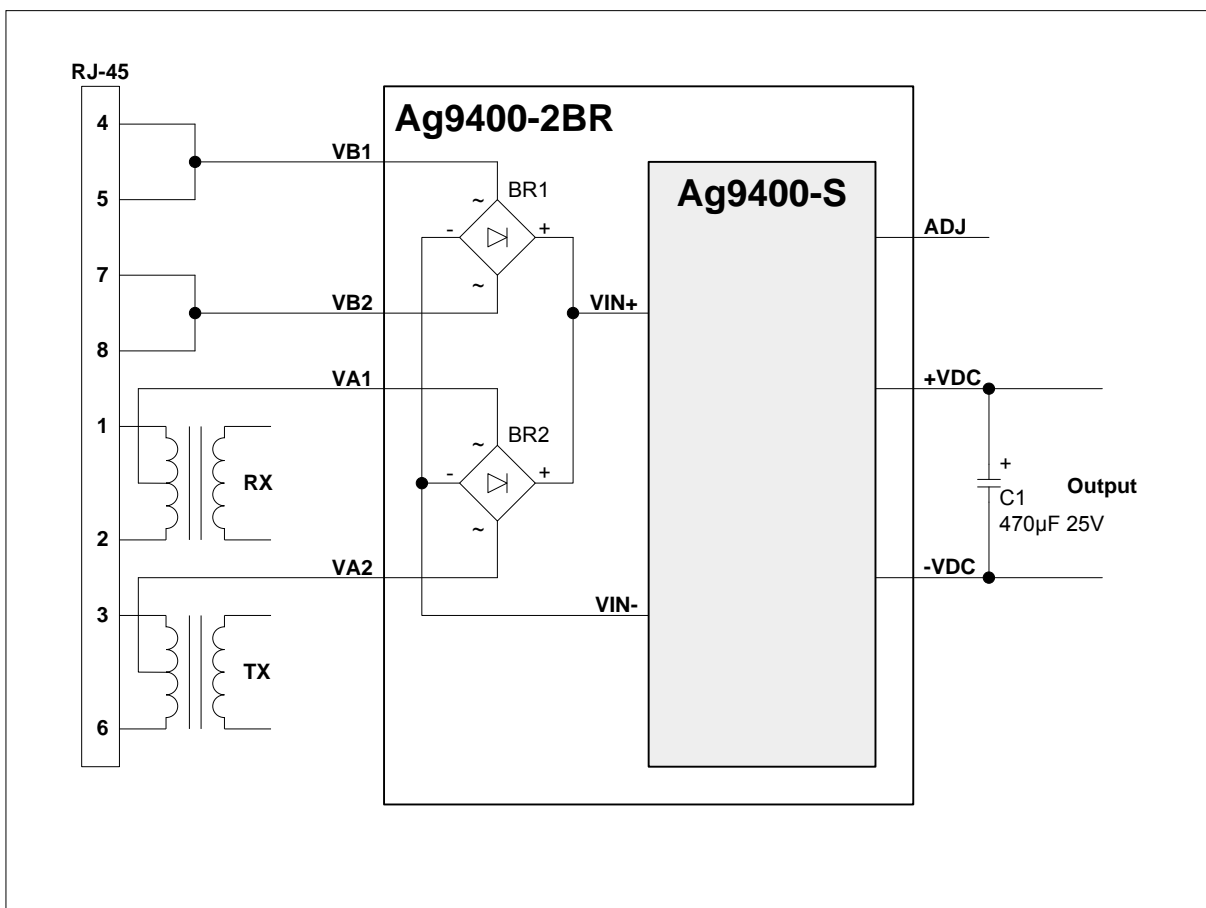
Figure 5: Typical Connection Diagram

Note: Please refer to Application note "ANX-POE EMI Considerations" on Silvertel website for any additional components that may be required to reduce EMI.
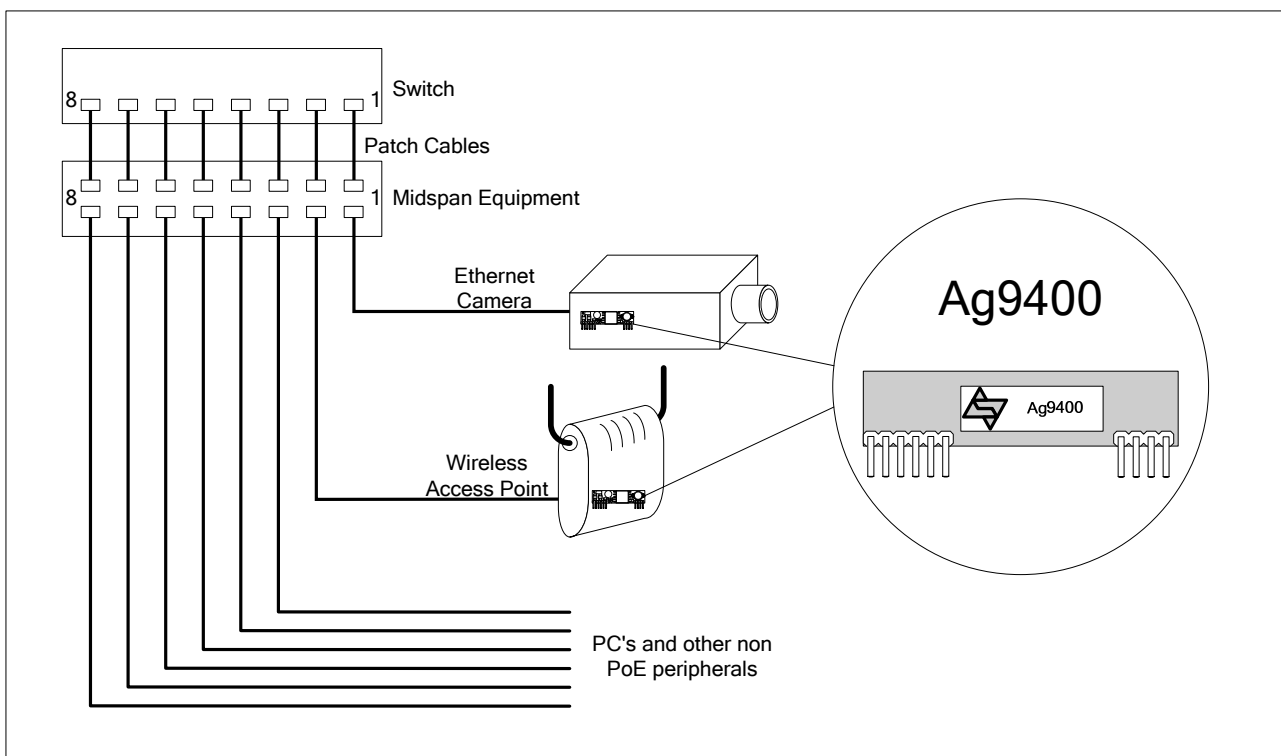
6 Typical Application

The Ag9400 can be used in numerous applications, in the example shown in Figure 6: Typical Application, the data outputs from the switch are connected to the inputs of a midspan. The midspan will then add power (to the data) on each output that supports Power over Ethernet (PoE).

In this example port 1 is connected to an ethernet camera and port 2 is connected to a wireless access point, both of these devices have a built-in Ag9400. When the midspan is switched on (or when the device is connected), the midspan will check each output for a PoE signature. On ports 1 and 2 the Ag9400 will identify themselves as PoE enabled devices and the midspan will supply both data and power to these peripherals.

The other ports (shown in this example) will not have a PoE signature and the midspan will only pass the data through to these peripherals. The midspan will continuously monitor each output to see if a PoE enabled device has been added or removed.

Figure 6: Typical Application

7 Typical Recommendations

Figure 7: Typical Layout gives an example of the tracking needed for the Ag9400. R1 and R2 are optional components, C1 must be fitted. The thermal performance of the Ag9400 can be improved by increasing the surface area of the output tracks (+VDC and -VDC). This is not applicable if the Ag9400 is in a socket.
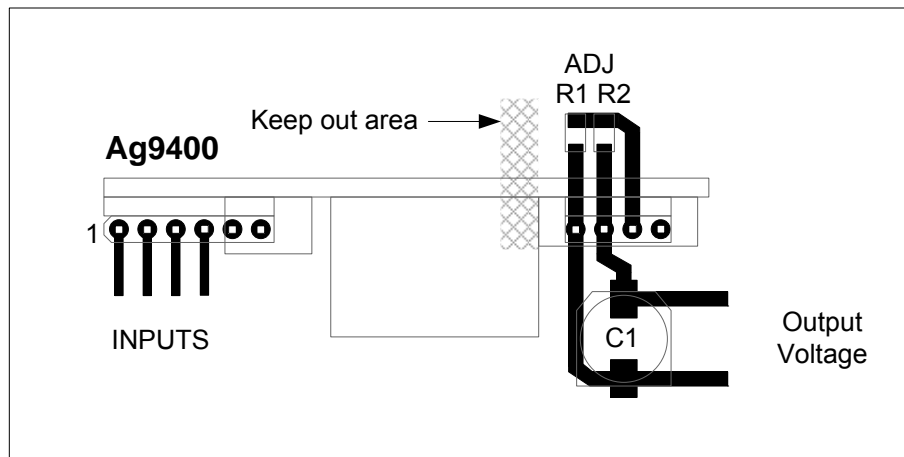

Figure 7: Typical Layout

8 Operating Temperature Range

Because the Ag9400 is a power component, it will generate heat, so it is important that this be taken into consideration at the design stage.

The heart of the Ag9400 is a DC/DC converter, which like any other power supply will generate heat. The amount of heat generated by the module will depend on the load it is required to drive and the input voltage supplied by the PSE. The information shown within this section of datasheet is referenced to a nominal 48Vdc input voltage supplied by the PSE.

The Ag9400 has a maximum ambient operating temperature of $70^{O}C$ see   Figure 9. These results are in still air without any heatsinking, the performance of the Ag9400 can be improved by forcing the airflow over the part or by using a heatsink (see the Ag9400 application note on heatsinking for more information).

The output stage of the Ag9400 has no built-in thermal protection, to prevent the module from being damaged it is recommended that the module be powered by an IEEE 802.3af compliant PSE or Midspan equipment. However the Ag9400 may be powered by a user designed power supply which should include thermal and over current protection.

Because each application is different it is impossible to give fixed and absolute thermal recommendations. However it is important that any enclosure used has sufficient ventilation for the Ag9400 and a direct airflow if possible.

One simple method for drawing some of the heat away from the Ag9400 is shown in Figure 8. Power planes connected to the +VDC and -VDC pins of the Ag9400 can be used to draw heat away from the DC/DC converter via the output pins.

These power planes must be on the outer layers of the PCB and the Ag9400 must not be fitted into a socket.
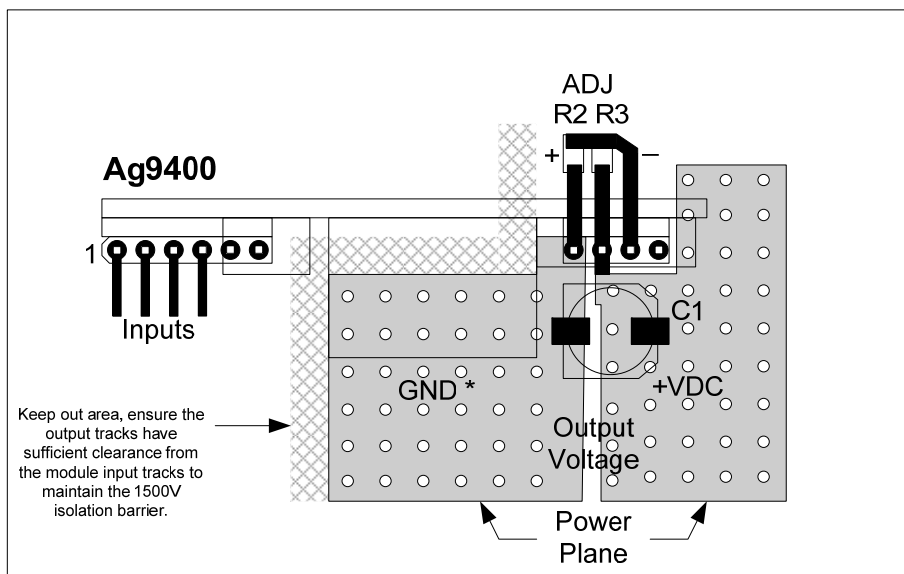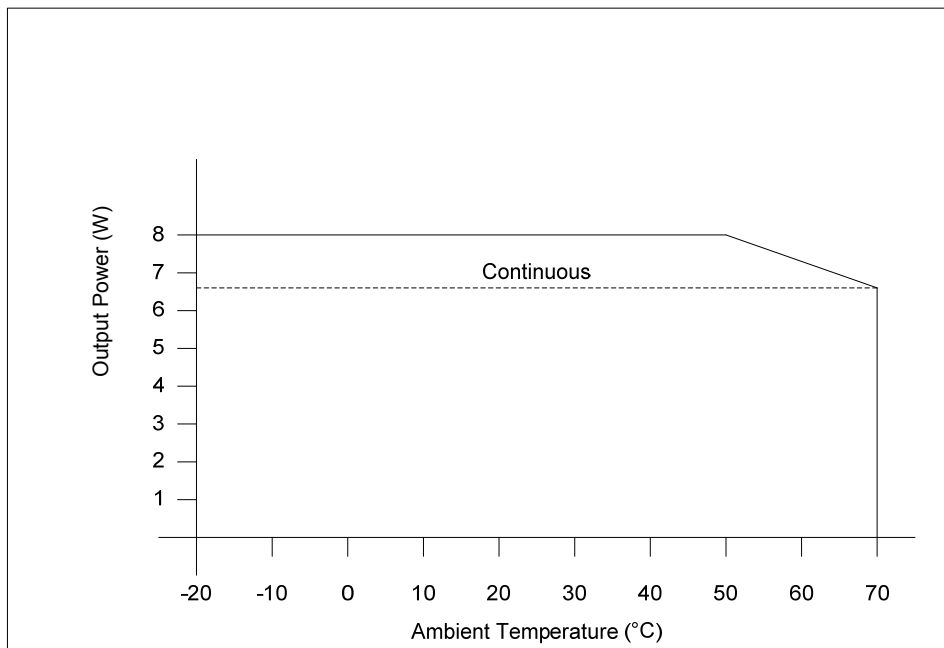

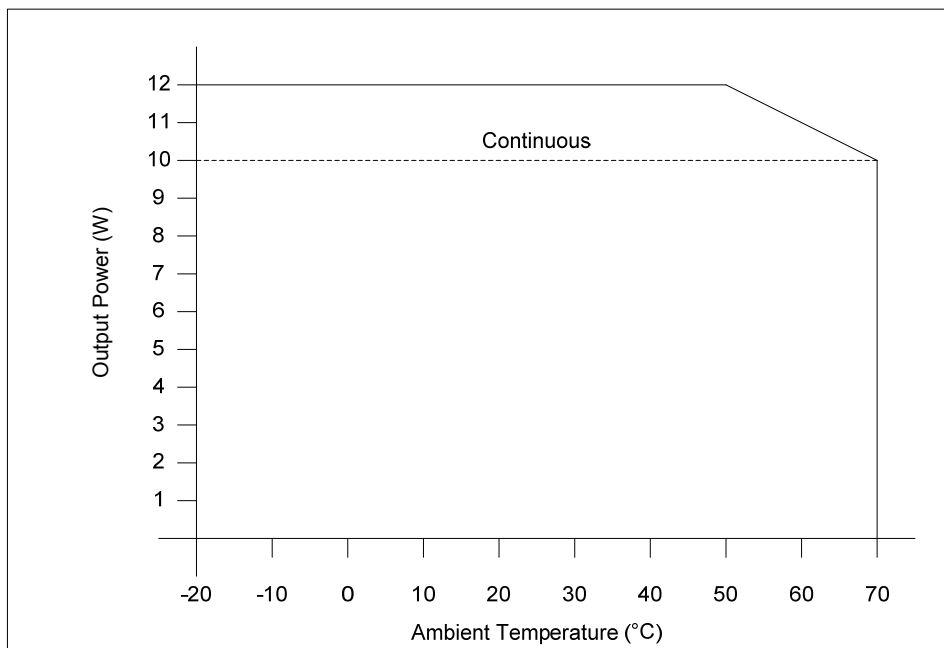Figure 8: Power Plane Heatsink for Ag9400

Figure 9: Ag9403 Operating Profile
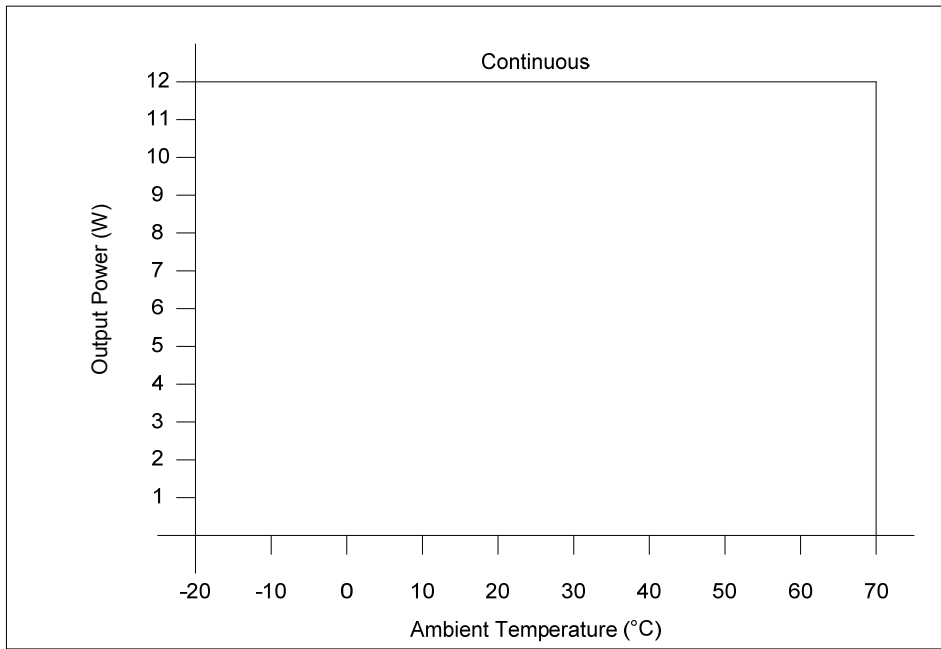

Figure 10: Ag9405 Operating Profile

Figure 11: Ag9412 Operating Profile

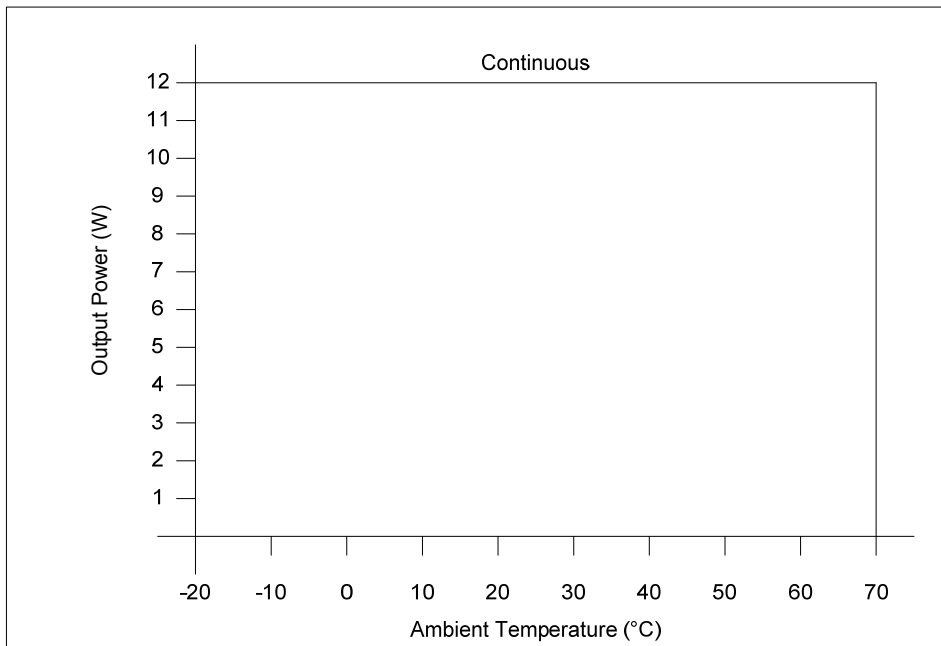

Figure 12: Ag9424 Operating Profile

9 Protection

The Ag9400 must be protected from over-voltages exceeding the 80V maximum rated surge input voltage. An inexpensive but effective solution can be achieved by connect Tranzorb diodes across each of the inputs; see Apps Note "ANX-POE-Protection".

10 Electrical Characteristics

10.1   Absolute Maximum Ratings[1]

	Parameter	Symbol	Min	Max	Units
1	DC Supply Voltage	V_{CC}	-0.3	60	V
2	DC Supply Voltage Surge for 1ms	V_{SURGE}	-0.6	80	V
3	Storage Temperature	T_S	-40	+100	^OC

Note 1: Exceeding the above ratings may cause permanent damage to the product. Functional operation under these conditions is not implied. Maximum ratings assume free airflow.

10.2   Recommended Operating Conditions

	Parameter	Symbol	Min	Typ	Max	Units
1	Input Supply Voltage[1]	V_{IN}	36	48	57	V
2	Under Voltage Lockout	V_{LOCK}	30		36	V
3	Operating Temperature[2]	T_{OP}	-20	25	70	Ta / ^OC

Note 1: With minimum load
2: See Section Operating Temperature Range
** Extended use close to, or at the maximum operating temperature can reduce the life time of the device.

10.3   DC Electrical Characteristics

	DC Characteristic	Sym	Min	Typ[1]	Max	Units	Test Comments
1	Nominal Output Voltage	+VDC	3.1 4.75 11.5 23.5	3.3 5.0 12.0 24.0	3.5 5.25 12.5 24.5	V V V V	Ag9403 Ag9405 Ag9412 Ag9424
2	Output Current (V_{IN} = 48V)	PWR			2 2 1.0 0.5	A A A A	Ag9403 Ag9405 Ag9412 Ag9424
3	Line Regulation	V_{LINE}		0.1		%	@ 50% Load
4	Load Regulation	V_{LOAD}		1		%	@ V_{IN}=48V
5	Output Ripple and Noise	V_{RN}		100		mVp-p	@ Max load[2]

	DC Characteristic	Sym	Min	Typ[1]	Max	Units	Test Comments
6	Minimum Load	R_{LOAD}	200 200 100 50			mA mA mA mA	Ag9403 Ag9405 Ag9412 Ag9424
7	Short-Circuit Duration3	T_{SC}			∞	sec	
8	Efficiency @ 80% Load	EFF		79 84 87 87		% % % %	Ag9403 Ag9405 Ag9412 Ag9424
9	Isolation Voltage (I/O)	V_{ISO}			1500	V_{PK}	Impulse Test
10	Temperature Coefficient	TC		0.02		%	Per ^OC

Note 1: Typical figures are at 25°C with a nominal 48V supply and are for design aid only. Not Guaranteed
  2: The output ripple and noise can be reduced with an external filter, see application note.
  3: Continuous short circuit duration is applicable at 25'C ambient temperature in free air. At higher temperatures or with restricted airflow (e.g. in a sealed enclosure) the duration will need to be limited to avoid overheating.

11 Package

18.0 (max)

56.0

3.0

13.5

14.0

Ag9400

0.6 ± 0.05

1

Isolation Barrier

3.0

7.0 (max)

1.8 ± 0.25   2.54 ± 0.05   30.48 ± 0.25   0.6 ± 0.05

(Recommended PCB hole diameter = 1.1 ± 0.05)

Dimensions (in mm) are nominal unless otherwise stated