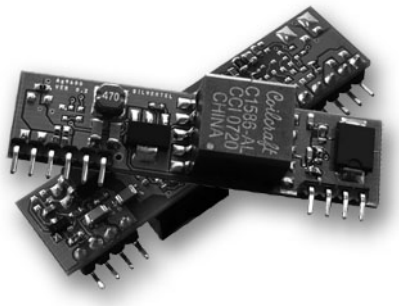
Silvertel

Ag9600

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 Ag9600 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 Ag9600 signature and control circuit provides the PoE compatibility signature required by the Power Sourcing Equipment (PSE) before applying up to 15W power to the port. The Ag9600 provides a Class 0 signature, classification programmable versions are available on request.

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. Ag9600 Product Selector

Part Number†	Nominal Output Voltage	Maximum Output Power *	Marking
Ag9612-S	12.0V	12 Watts	12S
Ag9605-S	5.0V	9 Watts	5S
Ag9603-S	3.3V	6 Watts	3S
Ag9612-2BR	12.0V	12 Watts	12B2
Ag9605-2BR[1]	5.0V	9 Watts	5B2
Ag9603-2BR	3.3V	6 Watts	3B2

*At 25°C with V_{IN} = 48V
† The Ag9600 fully meets the requirements of the RoHS directive 2002/95/EC on the restriction of hazardous substances in electronic equipment.
[1] Classification programmable version is available. Part number: Ag9605-2BRC. Marking is "5BC"

Table 1: Ordering Information

The Ag9600-2BR is physically the same size as the Ag9600-S but it has the two input bridge rectifiers on-board (see Figure 1).

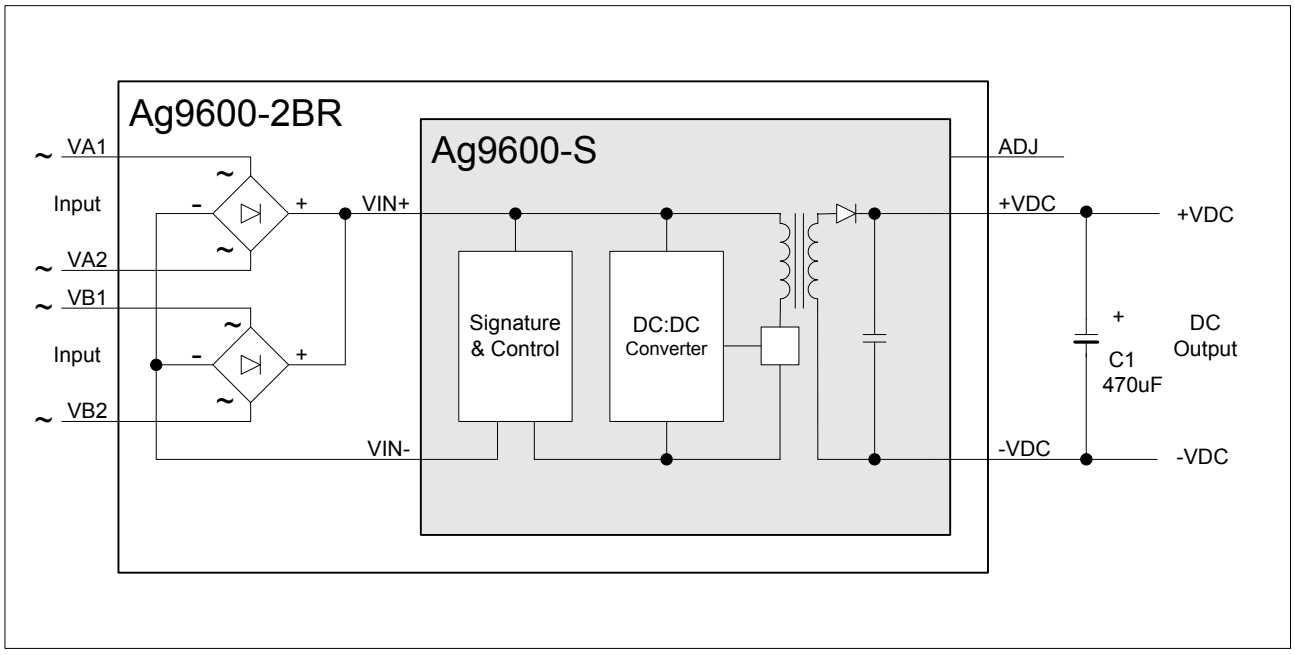


Figure 1: Block Diagram

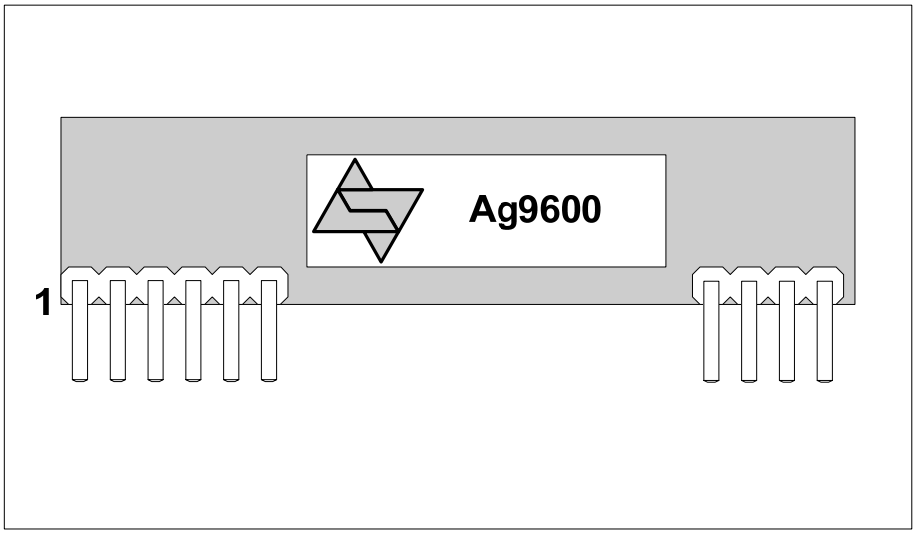


Figure 2: Ag9600 Package Format

4. Pin Description

4.1 Ag9600-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

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4.2 Ag9600-2BR

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

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5. Functional Description

5.1 Inputs

The Ag9600 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).

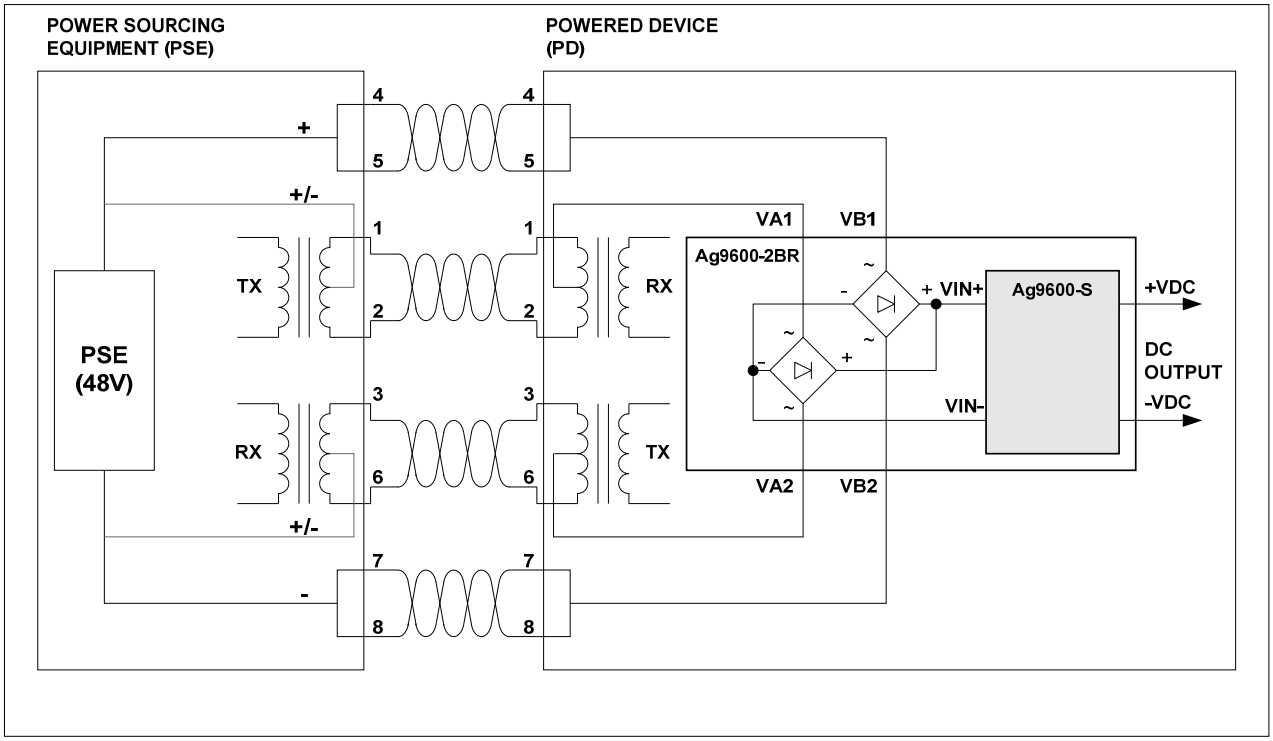


Figure 3: Typical System Diagram

5.2 PD Signature

When the Ag9600 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 Ag9600 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 12 for more information.

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5.4 Power Classification

To minimise cost, the Ag9600 is fixed for Class 0 (0.44 Watts to 12.95 Watts) operation, however class programmable versions are available on request. Please contact Silvertel, or your local agent for more information.

5.5 DC/DC Converter

The Ag9600'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 Ag9600 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.

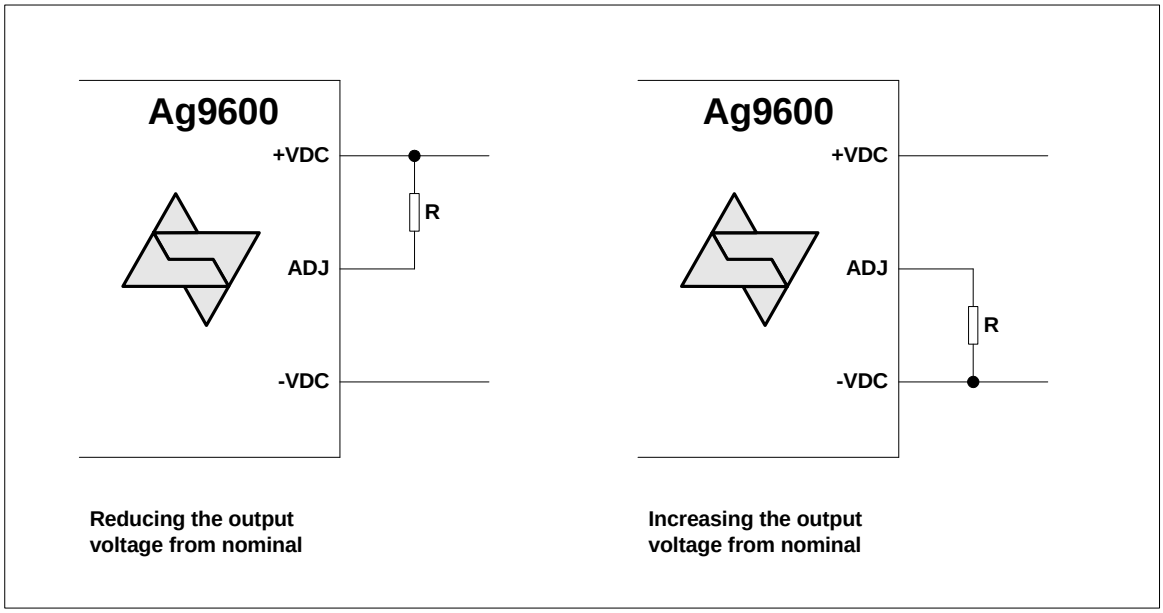


Figure 4: Output Adjustment

Reducing the output voltage, connect R between ADJ and +VDC					
Ag9603		Ag9605		Ag9612	
Value of R	Output	Value of R	Output	Value of R	Output
Open	3.30V	Open	5.00V	Open	12.00V
0 Ohms	-	0 Ohms	4.50V	0 Ohms	10.30V
Increasing the output voltage, connect R between ADJ and -VDC					
Ag9603		Ag9605		Ag9612	
Value of R	Output	Value of R	Output	Value of R	Output
Open	3.30V	Open	5.00V	Open	12.00V
0 Ohms	3.70V	0 Ohms	5.60V	0 Ohms	12.70V

Table 2: Output Adjustment Resistor (R) Value

5.7 Typical Connections

The Ag9600 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 16V capacitor that would cover all product variants, see Table 1: Ordering Information

The output adjust input (ADJ) is optional, it is provided to give great flexibility to the Ag9600 product range. Further information on using these inputs can be found in section Output Adjustment.

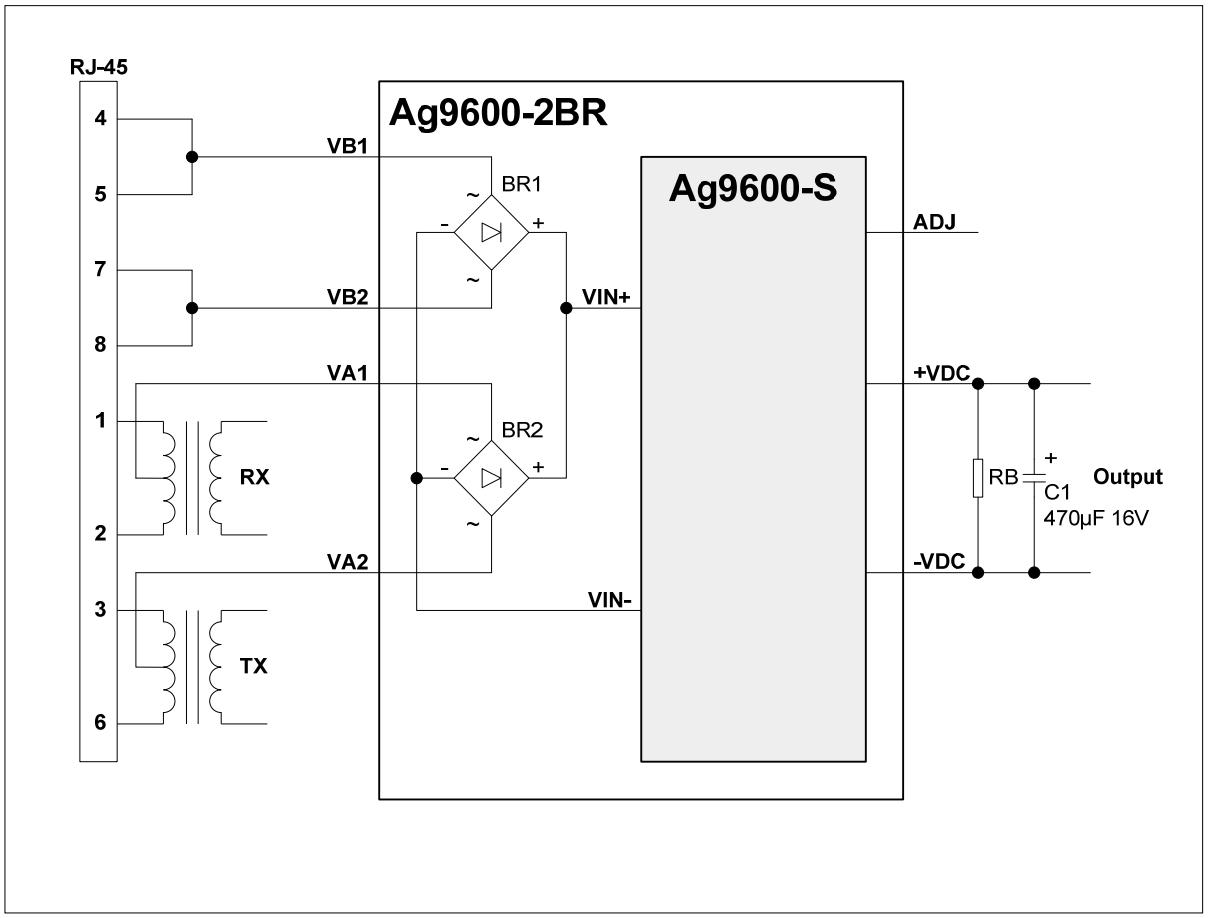


Figure 5: Typical Connection Diagram

The Ag9600 must always supply a minimum current to ensure that the on-board dc/dc converter functions normally. The resistor RB shown across the output must be fitted if the

current drawn by the load is less than the minimum shown in Section 11.3. Failure to meet this requirement may result in permanent damage to the Ag9600.

5.8 Additional Output Filtering

The Ag9600 offers basic output filtering for ripple and noise, which is shown in Figure 5, at maximum load this is typically 300mVp-p. Figure 6 shows two cost effective methods for reducing the ripple and noise, if required.

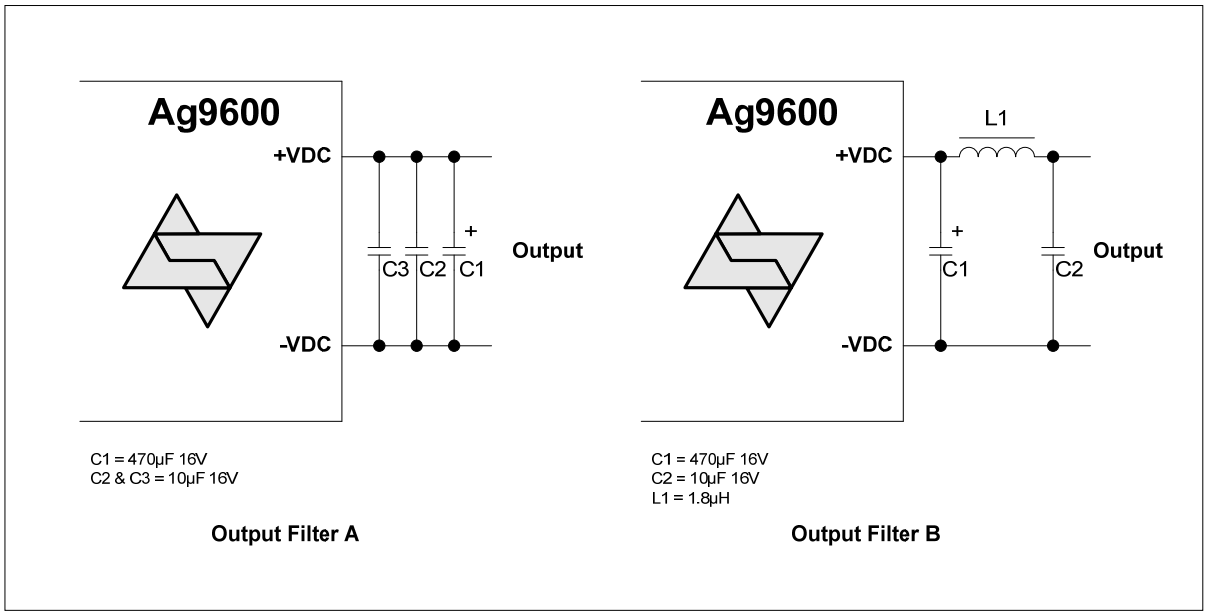


Figure 6: Output Filtering

The simplest and cheapest solution is shown in Figure 6 - Output Filter A. Adding two 10µF multi-layer ceramic capacitors directly across the output pins (as close as possible) will reduce the ripple and noise to typically 150mVp-p. Adding a PI filter, as shown in Figure 6 – Output Filter B, will take the ripple and noise level down to typically 12mVp-p.

6. Typical Application

The Ag9600 can be used in numerous applications, in the example shown in Figure 7: 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 Ag9600. 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 Ag9600 will identify themselves as PoE enabled devices and the midspan will supply both data and power to these peripherals.

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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.

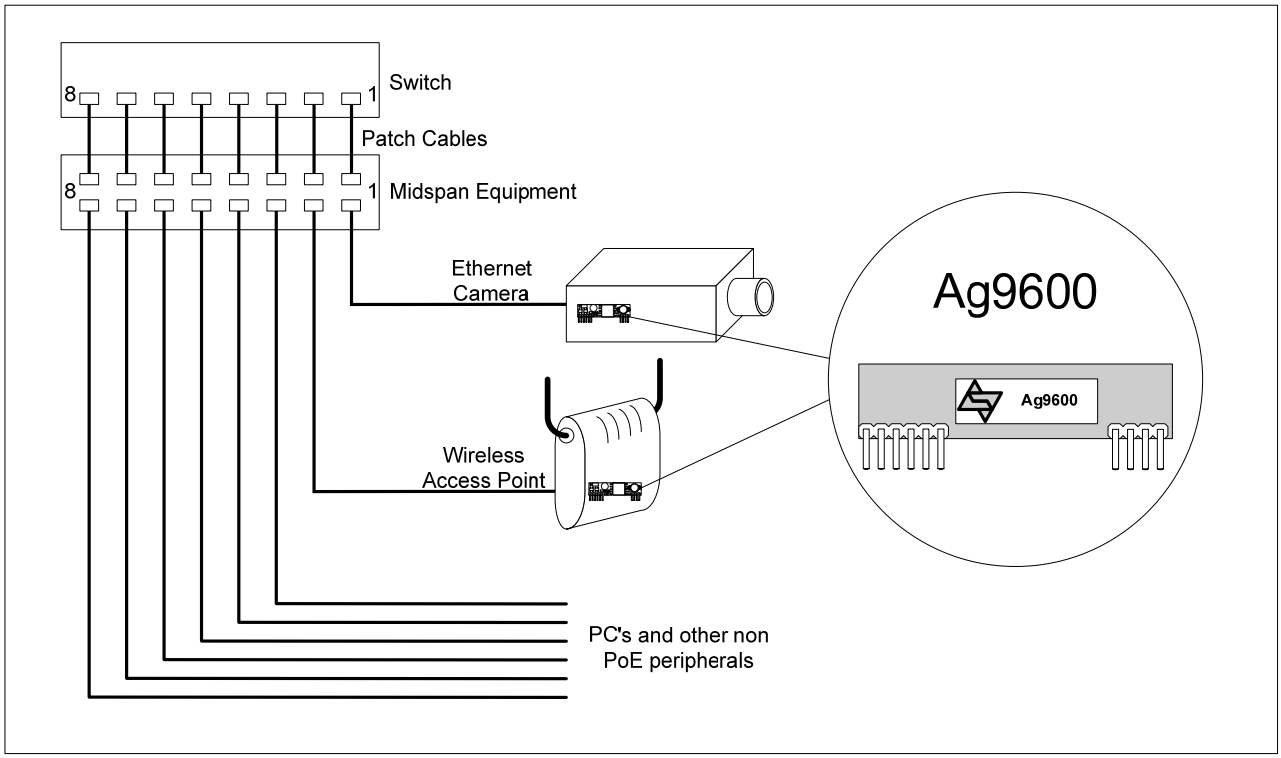


Figure 7: Typical Application

7. Layout Recommendations

Figure 8: Typical Layout gives an example of the tracking needed for the Ag9600. R1 and R2 are optional components, C1 must be fitted. The thermal performance of the Ag9600 can be improved by increasing the surface area of the output tracks (+VDC and -VDC). This is not applicable if the Ag9600 is in a socket.

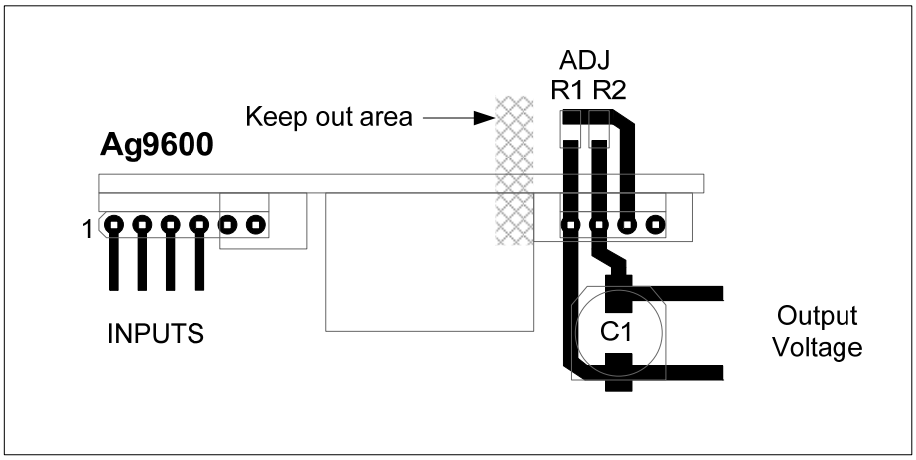


Figure 8: Typical Layout

8. Operating Temperature Range

Because the Ag9600 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 Ag9600 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 Ag9600 has a maximum ambient operating temperature of 70^{O}C see Figures 10 to 12. These results are in still air without any heatsinking. The performance of the Ag9600 can be improved by forcing the airflow over the part or by using a heatsink (see the Ag9600 application note on heatsinking for more information).

The output stage of the Ag9600 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 Ag9600 may be powered by a user designed power supply which should include thermal and over current protection.

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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 Ag9600 and a direct airflow if possible.
One simple method for drawing some of the heat away from the Ag9600 is shown in Figure 9. Power planes connected to the +VDC and -VDC pins of the Ag9600 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 Ag9600 must not be fitted into a socket.

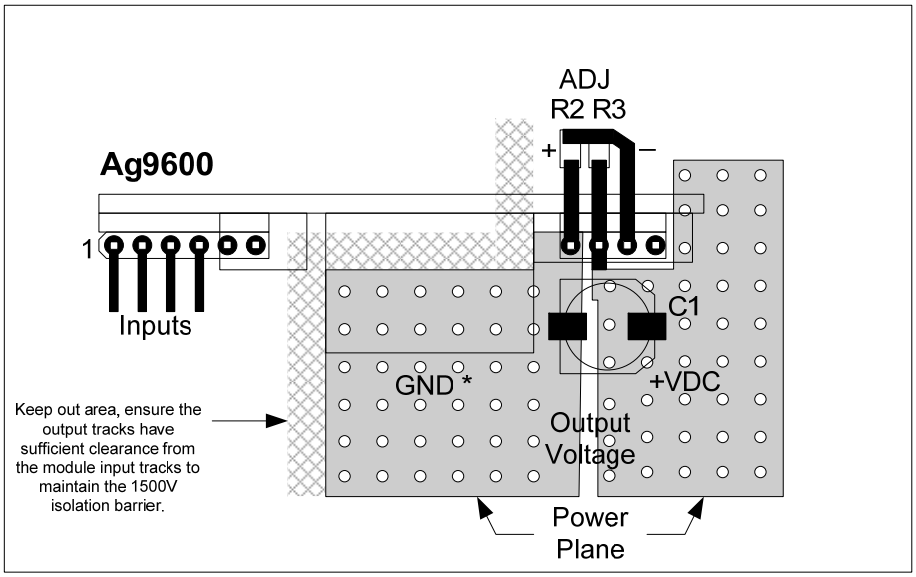


Figure 9: Power Plane Heatsink for Ag9600

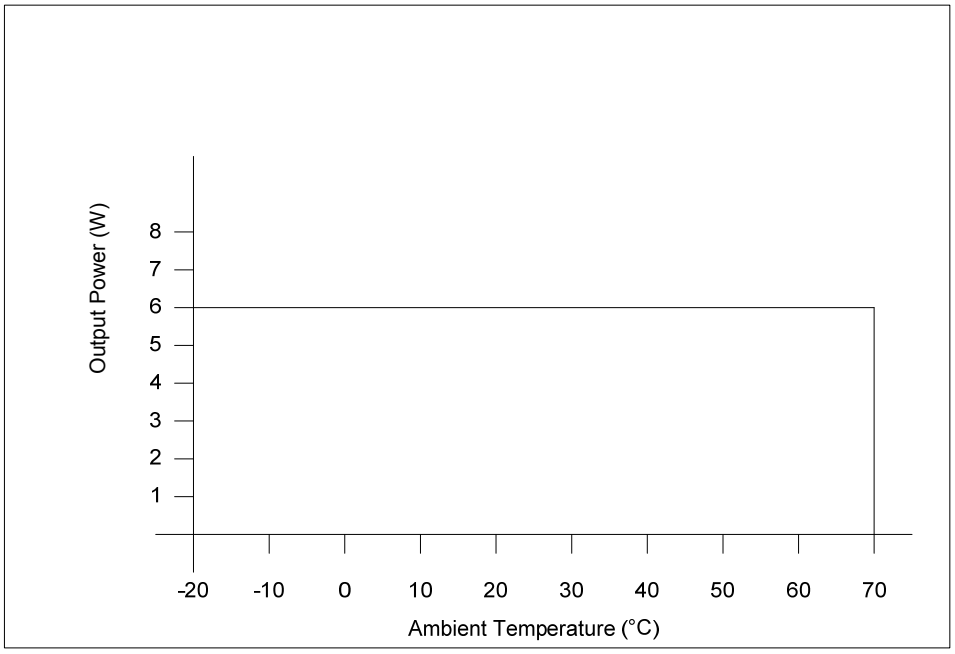


Figure 10: Ag9603 Operating Profile

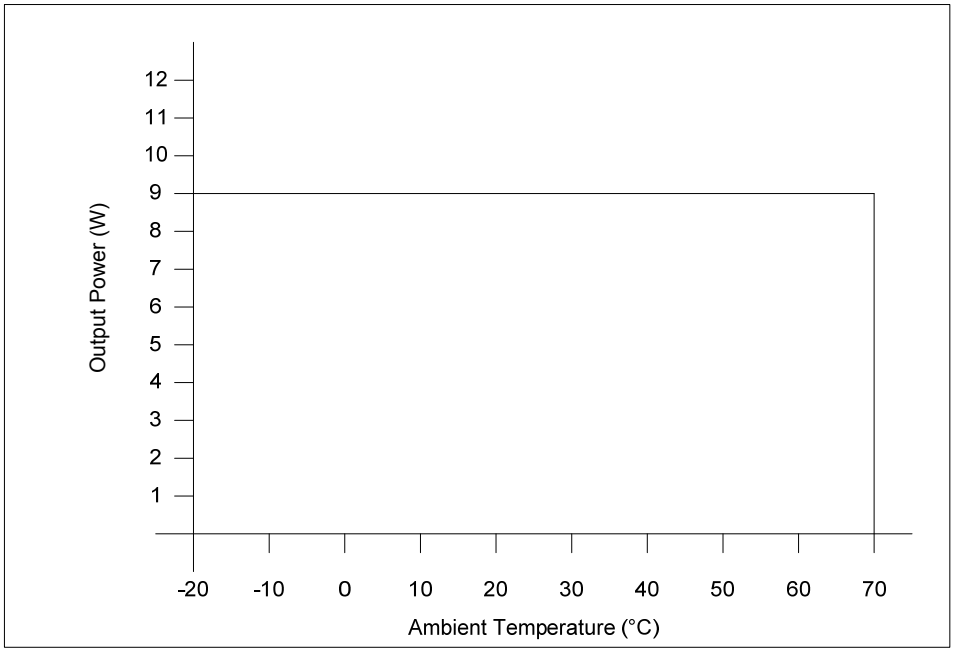


Figure 11: Ag9605 Operating Profile

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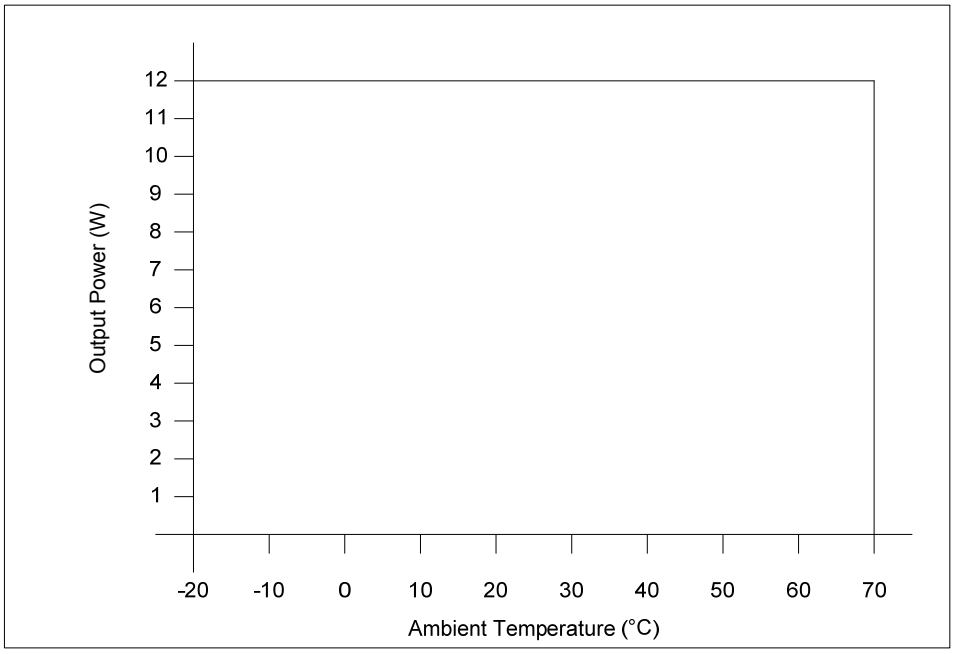


Figure 12: Ag9612 Operating Profile

9. Protection

The Ag9600 must be protected from over-voltages exceeding the 80V maximum rated surge input voltage. An inexpensive but effective solution can be achieved by connecting Tranzorb diodes across each of the inputs; see Figure 13.

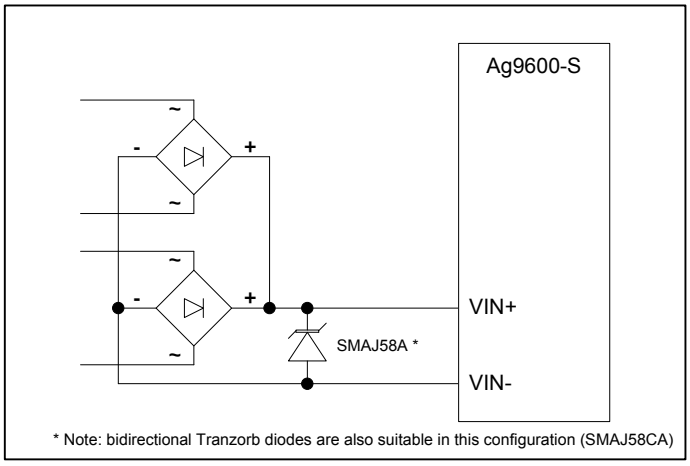


Figure 13: Input Protection

More information is available in Apps Note “ANX-POE-Protection”.

The Ag9600 does have limited output short circuit protection, but this fault condition must be removed within 10 Seconds. If additional protection is required, then this can be added externally in the form of a series fusible resistor or resettable fuse. It is important that any external protection be fitted after the output smoothing capacitor (and the output filter, if fitted), see Figure 14.

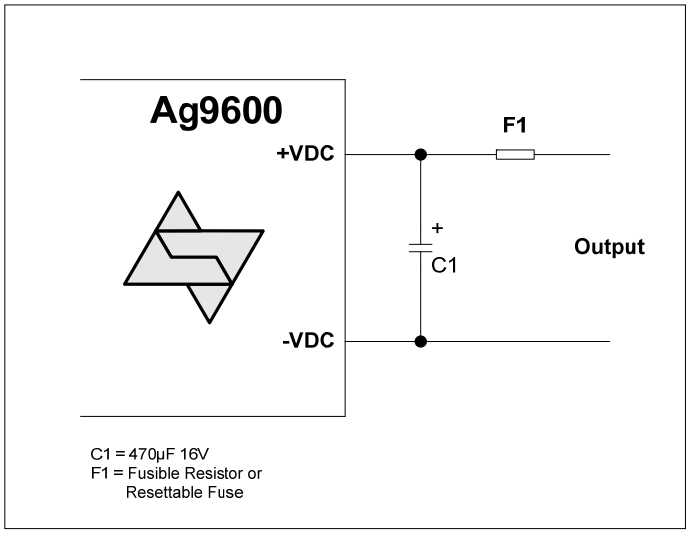


Figure 14: Output Protection

10. EMC

The Ag9600 has been designed and tested to meet EN55022 Class B. However, because the Ag9600 will only be one component within a system; it is impossible to say whether the final product will pass EMC testing, without the need for additional filtering. The Ag9600 uses a DC:DC converter with pulse frequency modulation, so care does need to be taken to minimise emissions.

Figure 15 shows our recommended EMC Filter configuration for the Ag9600-S. For more information on the other product variants, refer to the application note “ANX-POE-EMI” on our website.

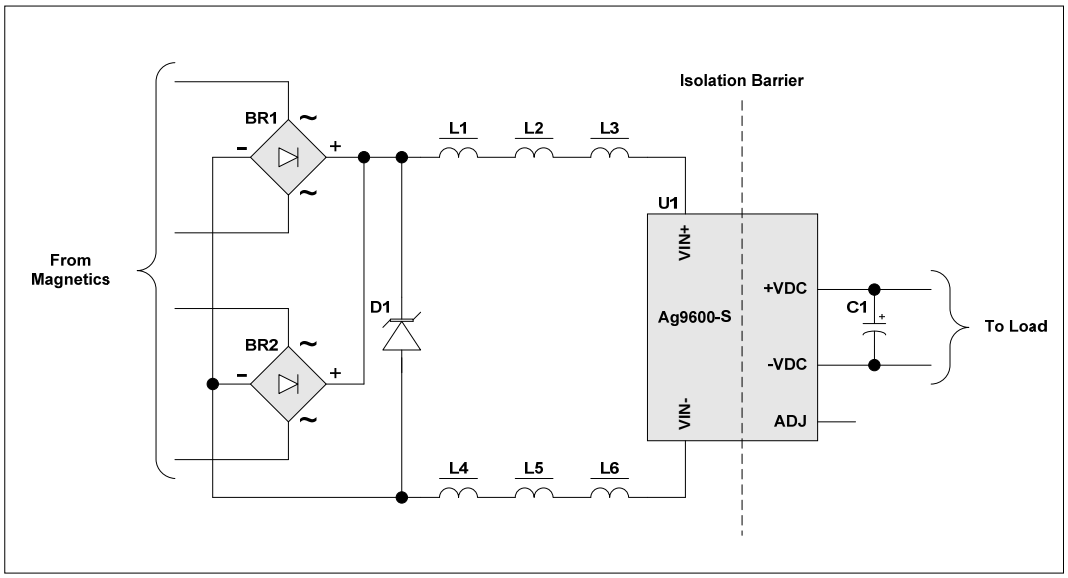


Figure 15: EMC Filtering

Components: -
BR1 & BR2 = MB4S, D1 = SMAJ58A, L1 – L6 = MMZ2012S102A, C1 = 470µF 16V.

11. Electrical Characteristics

11.1 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	^{O}C

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.

11.2 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 / ^{O}C

Note 1: With minimum load
2: See Section Operating Temperature Range

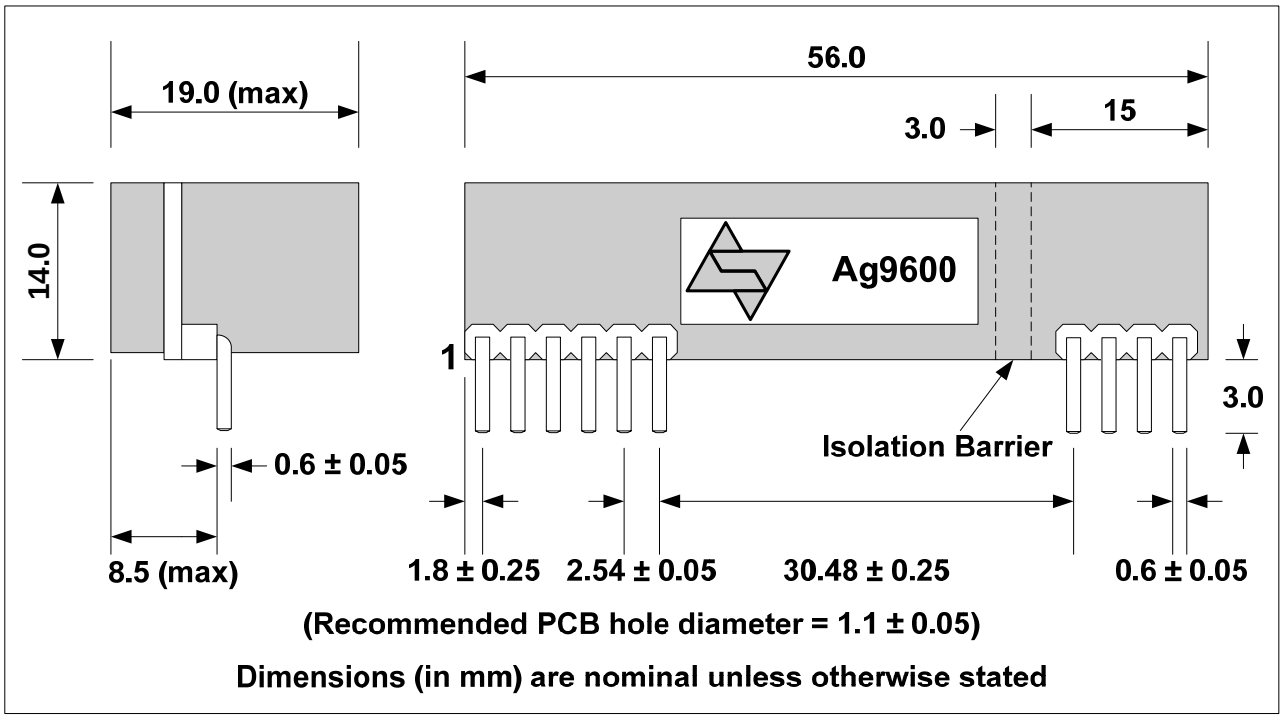
11.3 DC Electrical Characteristics

	DC Characteristic	Sym	Min	Typ[1]	Max	Units	Test Comments
1	Nominal Output Voltage	+VDC	3.1 4.75 11.5	3.3 5.0 12.0	3.5 5.25 12.5	V V V	Ag9603 Ag9605 Ag9612
2	Output Current (V_{IN} = 48V)	PWR			1.8 1.8 1.0	A A A	Ag9603 Ag9605 Ag9612
3	Line Regulation	V_{LINE}		0.1		%	@ Min Load
4	Load Regulation -Min to Max	V_{LOAD}		0.5		%	@ V_{IN}=48V
5	Output Ripple and Noise	V_{RN}		300		mVp-p	@ Max load[2]
6	Minimum Load[3]	I_{LOAD}	100 100 50			mA mA mA	Ag9603 Ag9605 Ag9612
7	Short-Circuit Duration	T_{SC}			10	sec	
8	Efficiency @ 80% Load	EFF		78 83 85		% % %	Ag9603-S Ag9605-S Ag9612-S
9	Isolation Voltage (I/O)	V_{ISO}			1500	V_{PK}	Impulse Test
10	Temperature Coefficient	TC		0.02		%	Per ^{O}C

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 Section 5.8.
3: Permanent damage may result if operated at less than the specified minimum I_{LOAD}.

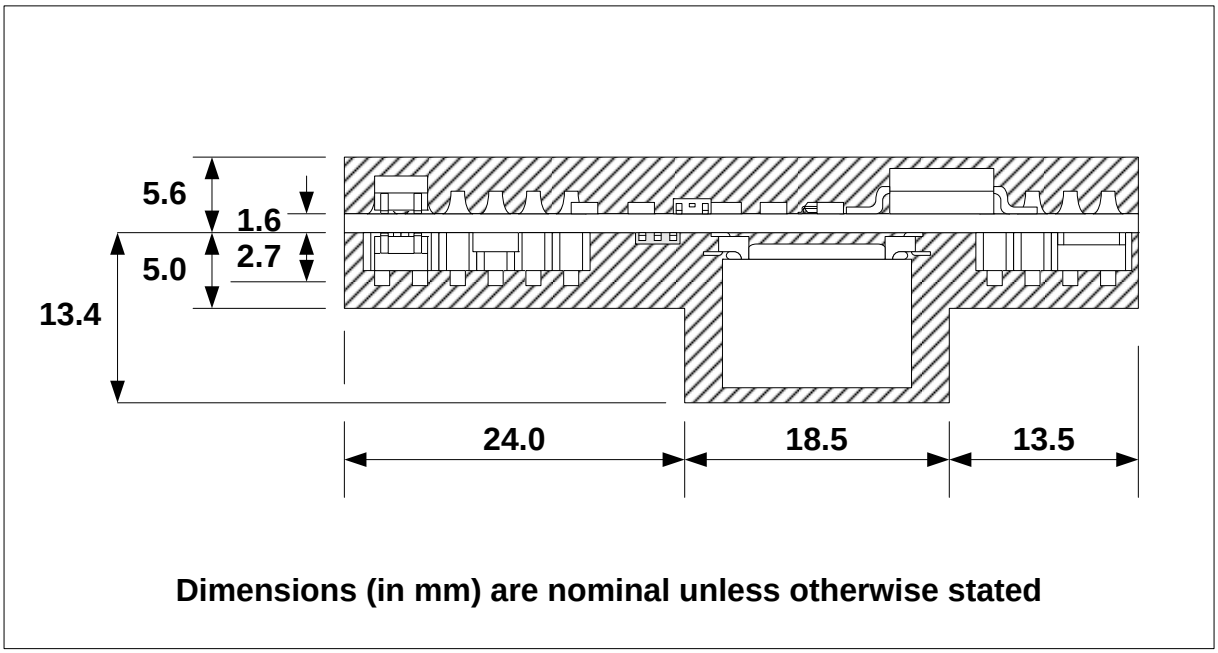
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12. Package



12.1 Plan View

The shaded section shows the external component keep-out area around the module.



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