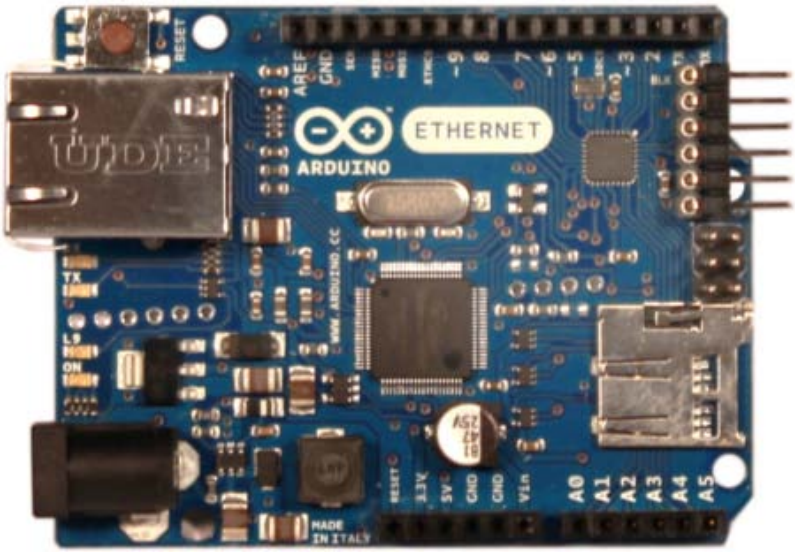
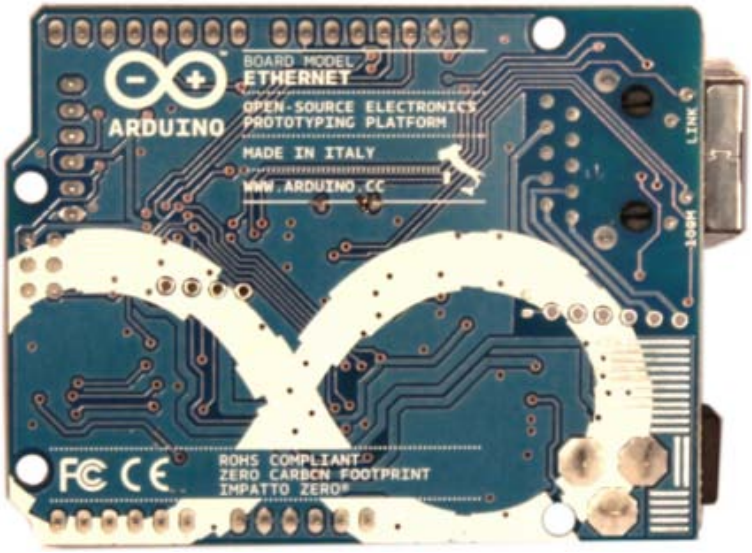
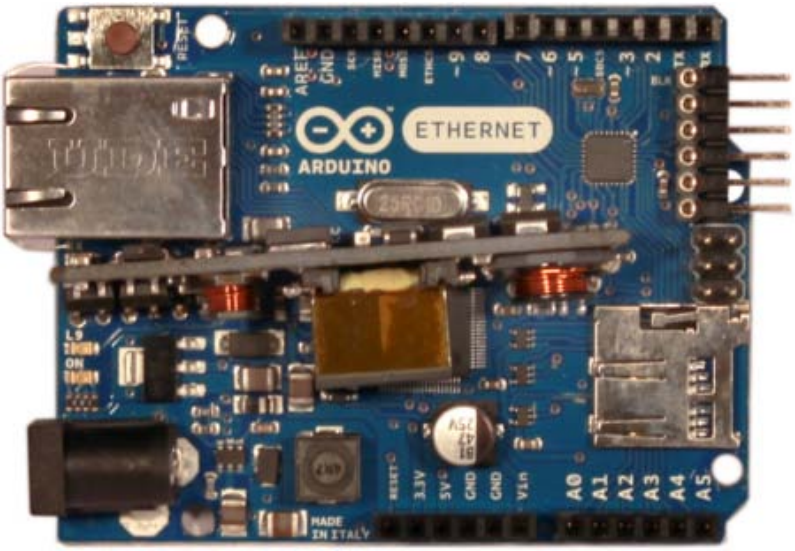
Arduino Ethernet



Arduino Ethernet board front view



Arduino Ethernet board rear view



Arduino Ethernet board front view with optional PoE module

w/o POE module with POE module

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Overview

The Arduino Ethernet is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins, 6 analog inputs, a 16 MHz crystal oscillator, a RJ45 connection, a power jack, an ICSP header, and a reset button.

NB: Pins 10, 11, 12 and 13 are reserved for interfacing with the Ethernet module and should not be used otherwise. This reduces the number of available pins to 9, with 4 available as PWM outputs.

An optional Power over Ethernet module can be added to the board as well.

The Ethernet differs from other boards in that it does not have an onboard USB-to-serial driver chip, but has a Wiznet Ethernet interface. This is the same interface found on the Ethernet shield.

An onboard microSD card reader, which can be used to store files for serving over the network, is accessible through the SD Library. Pin 10 is reserved for the Wiznet interface, SS for the SD card is on Pin 4.

The 6-pin serial programming header is compatible with the USB Serial adapter and also with the FTDI USB cables or with Sparkfun and Adafruit FTDI-style basic USB-to-serial breakout boards. It features support for automatic reset, allowing sketches to be uploaded without pressing the reset button on the board. When plugged into a USB to Serial adapter, the Arduino Ethernet is powered from the adapter.

Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage Plug (recommended)	7-12V
Input Voltage Plug (limits)	6-20V
Input Voltage PoE (limits)	36-57V
Digital I/O Pins	14 (of which 4 provide PWM output)
Arduino Pins reserved:	
	10 to 13 used for SPI
	4 used for SD card
	2 W5100 interrupt (when bridged)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

W5100 TCP/IP Embedded Ethernet Controller
Power Over Ethernet ready Magnetic Jack
Micro SD card, with active voltage translators

Schematic & Reference Design

EAGLE files: arduino-ethernet-reference-design.zip

Schematic: arduino-ethernet-schematic.pdf

Power

The board can also be powered via an external power supply, an optional Power over Ethernet (PoE) module, or by using a FTDI cable/USB Serial connector.

External power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.** This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

- **GND.** Ground pins.

The optional PoE module is designed to extract power from a conventional twisted pair Category 5 Ethernet cable:

- IEEE802.3af compliant
- Low output ripple and noise (100mVpp)
- Input voltage range 36V to 57V
- Overload and short-circuit protection
- 9V Output
- High efficiency DC/DC converter: typ 75% @ 50% load
- 1500V isolation (input to output)

NB: the Power over Ethernet module is proprietary hardware not made by Arduino, it is a third party accessory. For more information, see the datasheet

When using the power adapter, power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

Memory

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

Each of the 14 digital pins on the Ethernet board can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data.
- **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- **PWM: 3, 5, 6, 9, and 10.** Provide 8-bit PWM output with the analogWrite() function.
- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication using the SPI library.
- **LED: 9.** There is a built-in LED connected to digital pin 9. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off. On most other arduino boards, this LED is found on pin 13. It is on pin 9 on the Ethernet board because pin 13 is used as part of the SPI connection.

The Ethernet board has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

- **TWI: A4 (SDA) and A5 (SCL).** Support TWI communication using the Wire library.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analogReference().
- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

See also the mapping between Arduino pins and ATmega328 ports.

Communication

The Arduino Ethernet has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers.

A SoftwareSerial library allows for serial communication on any of the Uno's digital pins.

The ATmega328 also supports TWI and SPI communication. The Arduino software includes a Wire library to simplify use of the TWI bus; see the documentation for details. For SPI communication, use the SPI library.

The board also can connect to a wired network via ethernet. When connecting to a network, you will need to provide an IP address and a MAC address. The Ethernet Library is fully supported.

The onboard microSD card reader is accessible through the SD Library. When working with this library, SS is on Pin 4.

Programming

It is possible to program the Arduino Ethernet board in two ways: through the 6 pin serial programming header, or with an external ISP programmer.

The 6-pin serial programming header is compatible with FTDI USB cables and the Sparkfun and Adafruit FTDI-style basic USB-to-serial breakout boards including the Arduino USB-Serial connector. It features support for automatic reset, allowing sketches to be uploaded without pressing the reset button on the board. When plugged into a FTDI-style USB adapter, the Arduino Ethernet is powered off the adapter.

You can also program the Ethernet board with an external programmer like an AVRISP mkII or USBTinyISP. To set up your environment for burning a sketch with a programmer, follow these instructions. This will delete the serial bootloader, however.

All the Ethernet example sketches work as they do with the Ethernet shield. Make sure to change the network settings for your network.

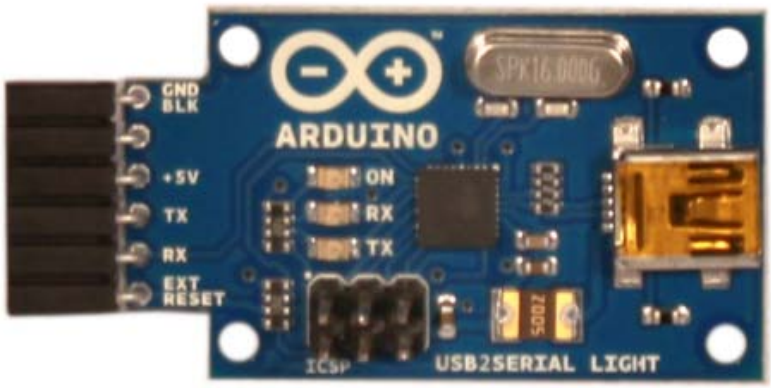
Physical Characteristics

The maximum length and width of the Ethernet PCB are 2.7 and 2.1 inches respectively, with the RJ45 connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

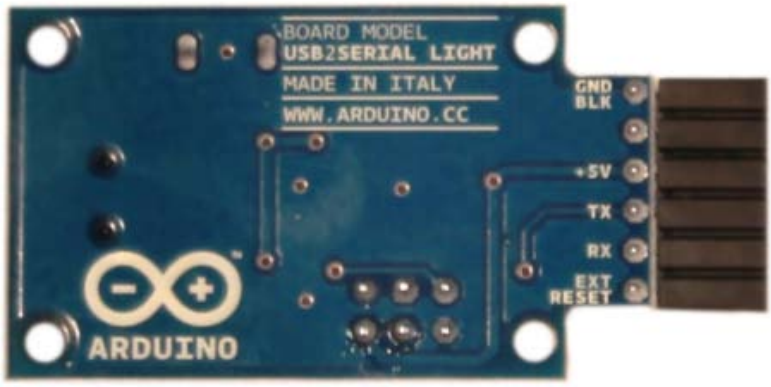
Setup

If you want to use a FTDI cable to download your sketches on the Arduino Ethernet, please refer to this guide: Upgrade the Arduino Ethernet bootloader to the latest version

USB Serial Light Adapter



USB Serial Light Adapter Front



USB Serial Light Adapter Rear

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Overview

This board converts a USB connection into a 5 volt Serial TX and RX that you can connect straight to the Arduino Mini, Arduino Ethernet or other microcontrollers, allowing them to talk to the computer. It features an Atmega8U2 programmed as a USB-to-serial converter, the same chip found on the Arduino Uno. The '8U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required.

The USB Serial Adapter has an onboard mini-USB connector and 5 pins including RX (for receiving data from the computer) and TX (for transmitting data). 5V, Ground and a Reset pin are also exposed.

Status lights include power, RX and TX activity.

The adapter can easily connect to the Arduino Ethernet, Mini, Mini Pro, LilyPad, LilyPad Simple, and Fio.

An onboard polyfuse limits the current to 500mA and protects the host computer from short circuits.

The ATmega8U2 firmware source code is available . The ATmega8U2 is loaded with a DFU bootloader, which can be activated by connecting the solder jumper on the back of the board and then resetting the 8U2. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader). See this user-contributed tutorial for more information.

Automatic (Software) Reset

The USB Serial connector is designed in a way that allows it to reset an attached board by software running on a connected computer.The external reset line mirrors the DTR line of the virtual serial device on the computer. It's typically connected to the reset line of the connected board (e.g. an Arduino Ethernet board) through a 100 nF capacitor, allowing the board to reset on upload.

This setup has other implications. When the board is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The pinouts on the connector are compatible with a standard FTDI header (as well as the Adafruit and Sparkfun USB-Serial adapters).

Schematic & Reference Design

EAGLE files: USBSerial04_Light.zip

Schematic: USBSerial04_Light-sch.pdf

Drivers & Setup

Windows users need a .inf file for this specific product: Arduino_USBSerial.zip
For installation follow the same procedure on how install an UNO board on your computer.

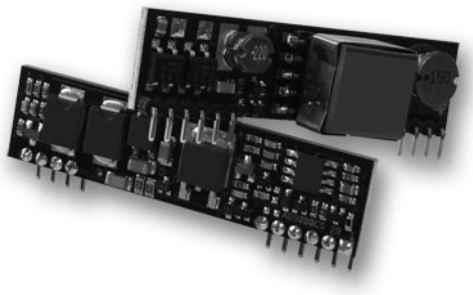
Connecting to the Arduino Mini

See the guide to the Arduino Mini for information on connecting the adapter to the Mini.

Silvertel

Ag9000-S

Power-Over-Ethernet Module



1. Features

- IEEE802.3af compliant
- Small SIL package size - 56mm (L) x 14mm (H)
- Low output ripple and noise
- Input voltage range 36V to 57V
- Only one low cost external decoupling capacitor required
- Overload and short-circuit protection
- Adjustable Output
- High efficiency DC/DC converter
- 1500V isolation (input to output)
- Silvertel “design-in” assistance

2. Description

The Ag9000-S 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.

IEEE 802.3af allows for two power options for Category 5 cables and the Ag9000-S series have two pairs of power inputs pins: - VA1&2 and VB1&2 to accommodate this, see Figure 1.

The Ag9000-S 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 Ag9000 is compatible with Class 0 to Class 3 equipment.

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

Table of Contents

Table of Figures

3. Ag9000-S Product Selector

Part Number†	Nominal Output Voltage	Maximum Output Power *	Marking
Ag9120-S	12.0V	12 Watts	12
Ag9050-S	5.0V	9 Watts	5
Ag9033-S	3.3V	6 Watts	3

*At 25°C with V_{IN} = 48V
† The versions of the Ag9000-S fully meet the requirements of the RoHS directive 2002/95/EC on the restriction of hazardous substances in electronic equipment.

Table 1: Ordering Information

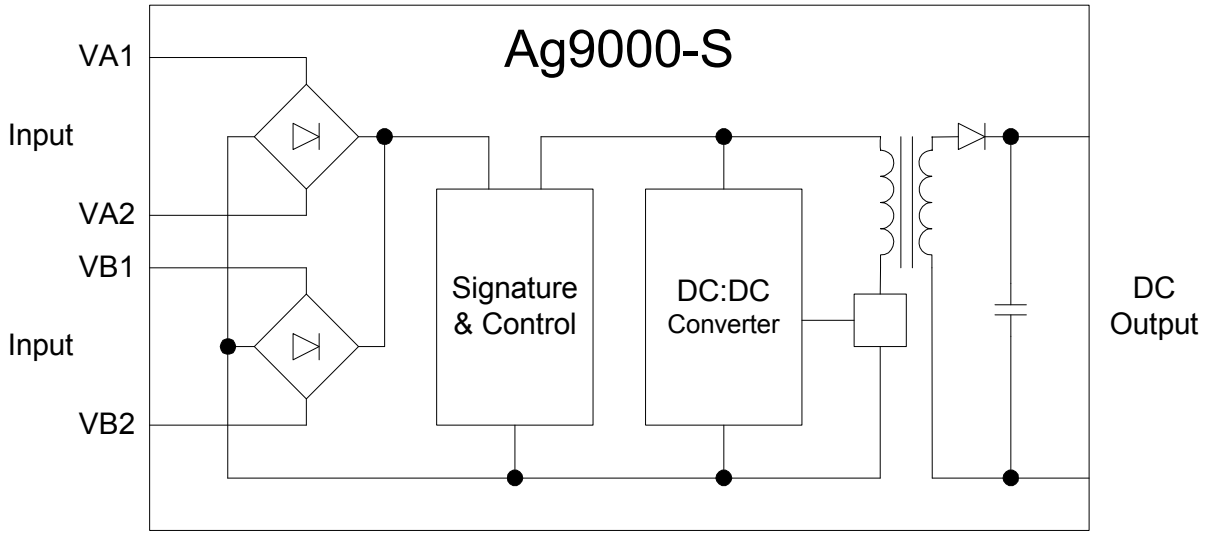


Figure 1: Block Diagram

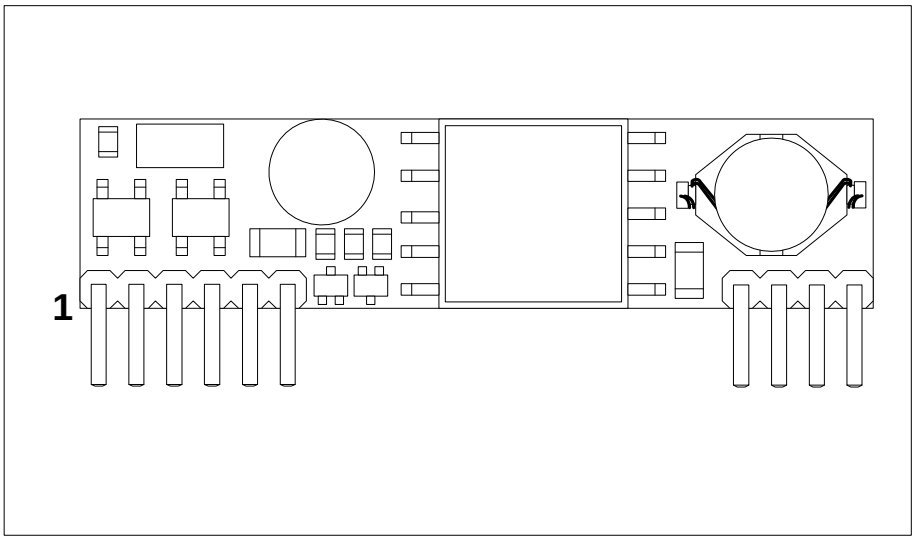


Figure 2: Ag9000-S Package Format

4. Pin Description

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	CP1	**Class Programming (1).** Connect an external resistor to CP2 will change the current class of the module. With no resistor fitted the Ag9000 will default to Class 0.
6	CP2	**Class Programming (2).** Connect an external resistor to CP1 will change the current class of the module. With no resistor fitted the Ag9000 will default to Class 0.
7	GND	**Ground.** The ground return 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 its nominal value, by connecting an external resistor from this pin to either the +VDC pin or the GND pin.
10	IC	**Internal Connection.** Do not connect to this pin.

5. Functional Description

5.1 Inputs

The Ag9000-S has two internal bridge rectifiers (see Figure 1: Block Diagram) connected to the VA1-VA2 and the VB1-VB2 inputs. This allows the Ag9000-S to be compatible with equipment that use the different power options, see Figure 3: Typical System Diagram. It is important that the PSE does not apply power to the VA and VB outputs at the same time (Refer to IEEE802.3af for more information).

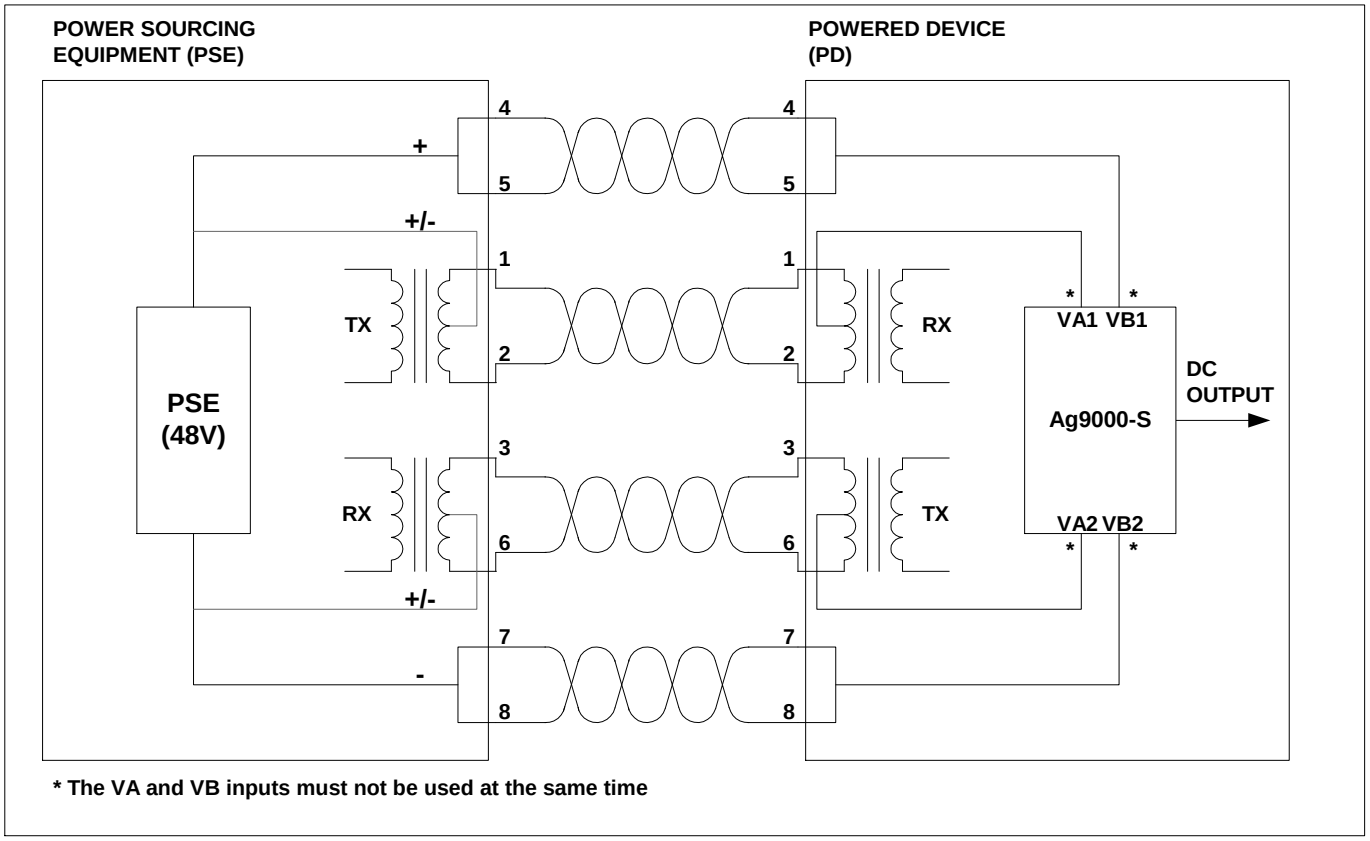


Figure 3: Typical System Diagram

5.2 PD Signature

When the Ag9000-S 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 Ag9000-S is specified to meet the 1500V impulse test. It is also important that the tracks on either side of the isolation barrier have at least a 3mm clearance, see Figures 8 & 9 and Section 11 for more information.

5.4 Power Classification

This is optional from the PSE and is used for power management. The Ag9000-S allows the current class to be externally programmed by connecting a resistor between the CP1 and CP2 pins, see Figure 4: Class Programming Option. If no resistor is fitted the Ag9000-S will default to Class 0, a full list of programming resistor values are shown in Table 2: Class Programming.

CLASS	Programming Resistance (Ohms)	Min Power (W)	Max Power (W)
0	Do not fit	0.44	12.95
1	698 ±1%	0.44	3.84
2	383 ±1%	3.84	6.49
3	249 ±1%	6.49	12.95
4	TBD	Reserved	Reserved

Table 2: Class Programming

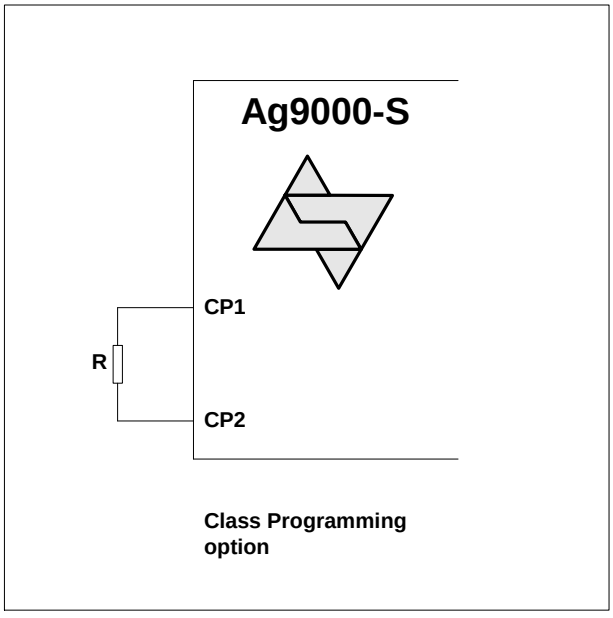


Figure 4: Class Programming Option

5.5 DC/DC Converter

The Ag9000-S's DC/DC converter provides a regulated low ripple and low noise output, that has built-in overload and short-circuit output protection - see Table 1: Ordering Information for voltage and power ratings.

5.6 Output Adjustment

The Ag9000-S has an ADJ pin, which allows the output voltage to be increased or decreased from its nominal value.

Figure 5: Output Adjustment shows how the ADJ pin is connected: -

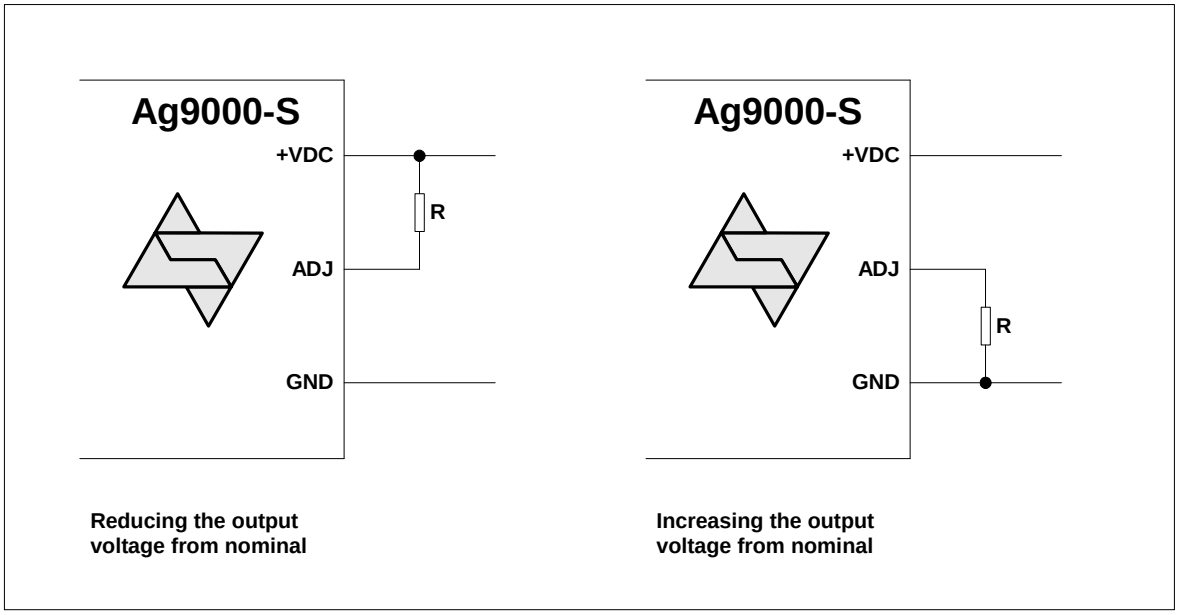


Figure 5: Output Adjustment

Reducing the output voltage, connect R between ADJ and +VDC			
Value of R	Ag9033-S output	Ag9050-S output	Ag9120-S output
Open Circuit	3.30V	5.00V	12.00V
100k Ohms	-	4.75V	10.00V
0 Ohms	-	4.50V	9.00V
Increasing the output voltage, connect R between ADJ and GND			
Value of R	Ag9033-S output	Ag9050-S output	Ag9120-S output
Open Circuit	3.30V	5.00V	12.00V
100k Ohms	3.40V	5.25V	12.75V
0 Ohms	4.70V	5.50V	13.15V

Table 3: Output Adjustment Resistor (R) Value

5.7 Typical Connections

The Ag9000-S only requires one external component as shown in Figure 6: Typical Connection Diagram, a minimum of 470µF is recommended.

The value of C1 will be related to the maximum load step change that the output needs to drive. For example, in an application were the output needs to cope with a 1.8 Amp load step change, a minimum of 1000µF should be used. This can be a standard low cost electrolytic and does not need to be a low ESR type.

Figure 6 shows a 16V capacitor that would cover all product variants up to and including the Ag9120-S, see Table 1: Ordering Information.

The Ag9000-S must always supply a minimum current (~20mA) to ensure that the on-board dc/dc converter functions normally. The resistor RB shown across the output must be fitted if the minimum current drawn is <20mA. Failure to meet this requirement may result in permanent damage to the Ag9000-S.

The Class programming and the Output Adjust inputs are optional and are provided to give great flexibility to the Ag9000-S product range. Further information on using these inputs can be found in sections Power Classification and Output Adjustment.

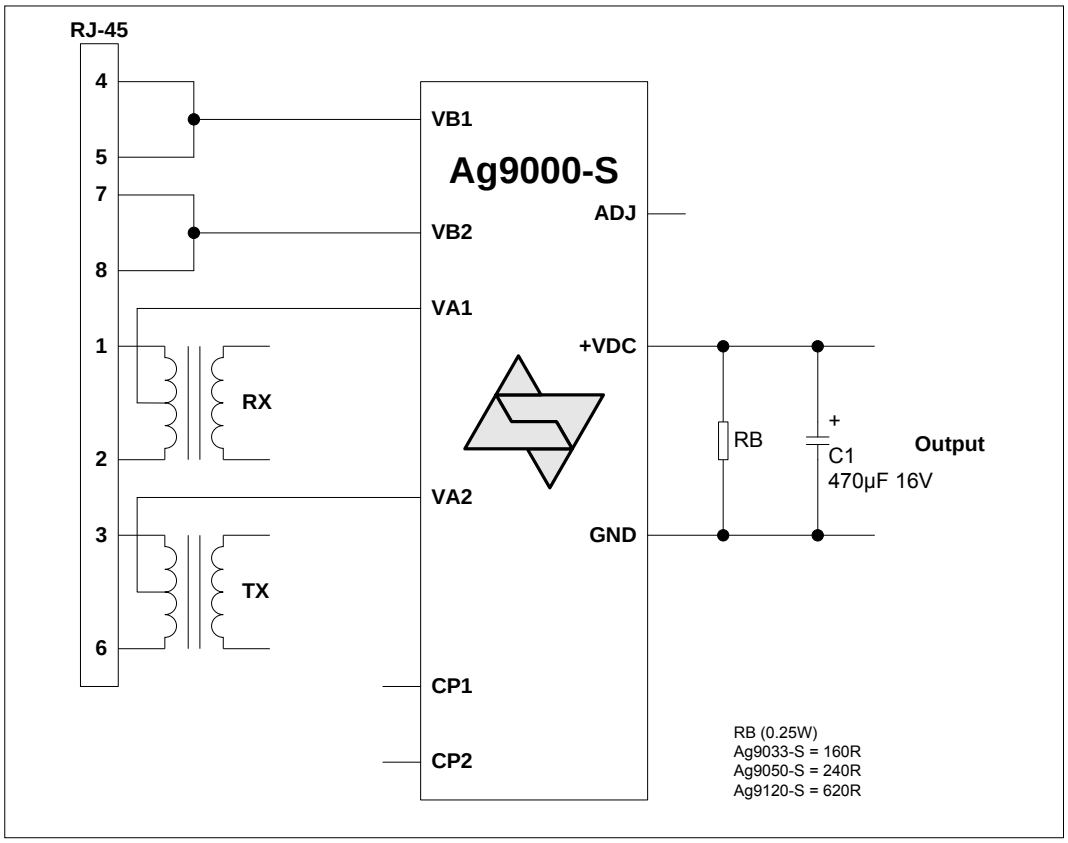


Figure 6: Typical Connection Diagram

6. Typical Application

The Ag9000-S 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 Ag9000-S. 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 Ag9000-S 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.

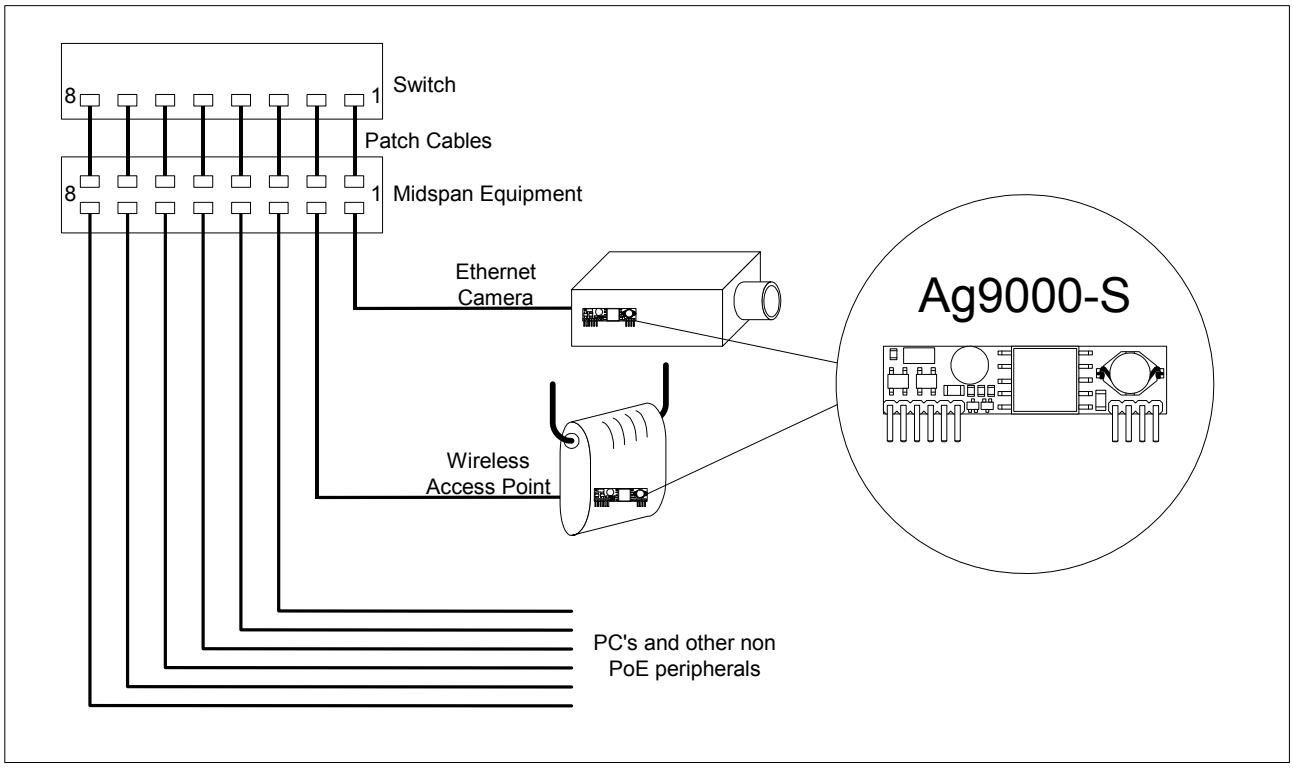


Figure 7: Typical Application

7. Typical Recommendations

Figure 8: Typical Layout gives an example of the tracking needed for the Ag9000-S. R1, R2 and R3 are optional components, RB is only needed if the minimum output current is <20mA. C1 needs to be positioned close to the output pins of the Ag9000-S as possible to minimise the current loop. The thermal performance of the Ag9000-S can be improved by increasing the surface area of the output tracks (+VDC and GND). This is not applicable if the Ag9000-S is in a socket.

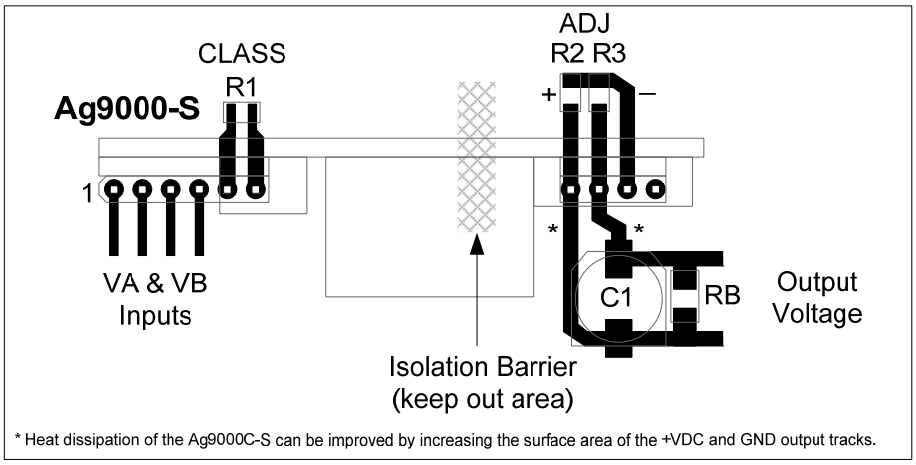


Figure 8: Typical Layout

8. Operating Temperature Range

Because the Ag9000-S 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 Ag9000-S 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 Ag9000-S has a maximum ambient operating temperature of 70^{O}C see Figure 10, Figure 11 & Figure 12. These results are in still air without any heatsinking, the performance of the Ag9000-S can be improved by forcing the airflow over the part or by using a heatsink (see the Ag9000-S application note on heatsinking for more information).

The output stage of the Ag9000-S has a built-in thermal protection circuit, to prevent the module from being damaged if operated beyond its power / temperature specification.

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 Ag9000-S and a direct airflow if possible.

One simple method for drawing some of the heat away from the Ag9000-S is shown in Figure 9. Power planes connected to the +VDC and GND pins of the Ag9000-S 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 Ag9000-S must not be fitted into a socket.

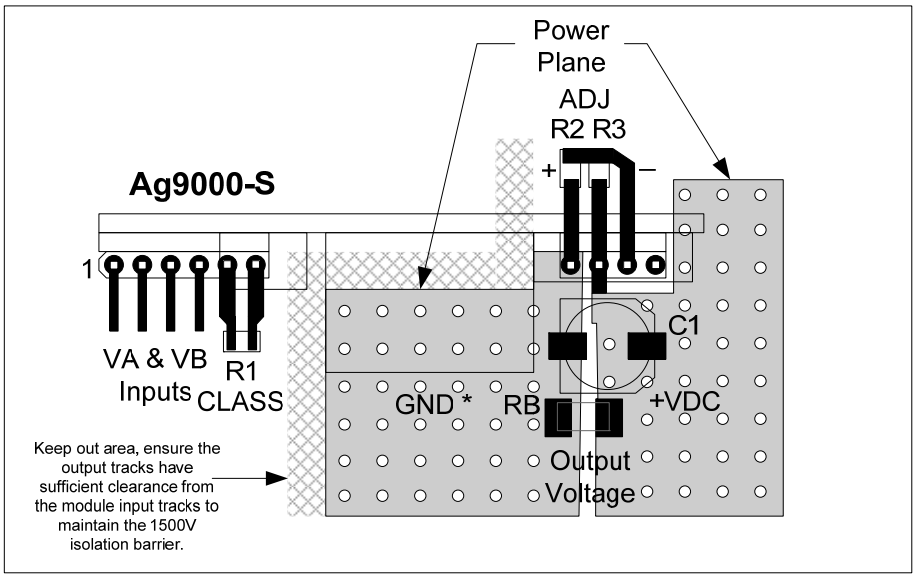


Figure 9: Power Plane Heatsink for Ag9000-S

Figure 10, Figure 11 & Figure 12 show the maximum ambient temperature under different load conditions. These figure have been recorded in a sealed enclosure (in still air) using a heater element to elevate the ambient temperature (within the enclosure).

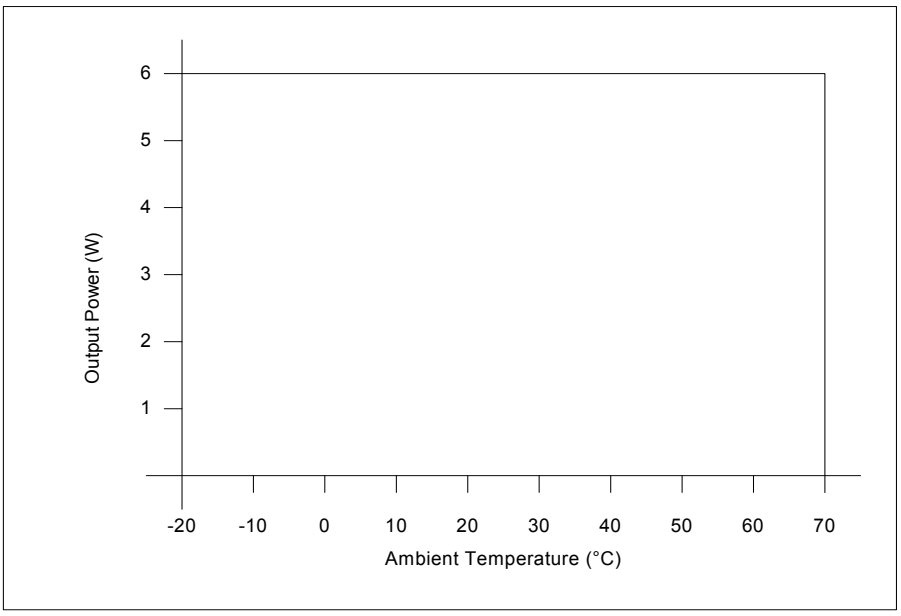


Figure 10: Ag9033-S Operating Profile

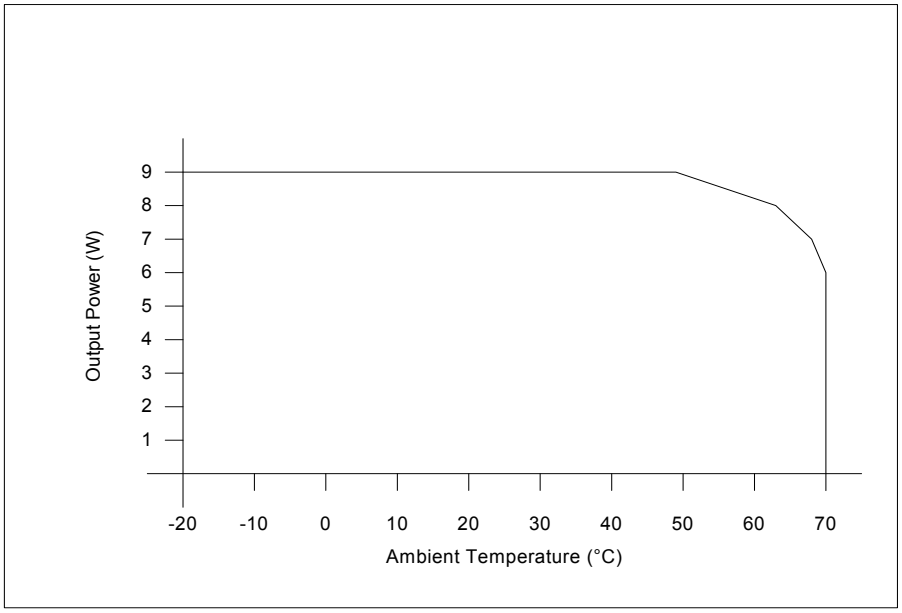


Figure 11: Ag9050-S Operating Profile

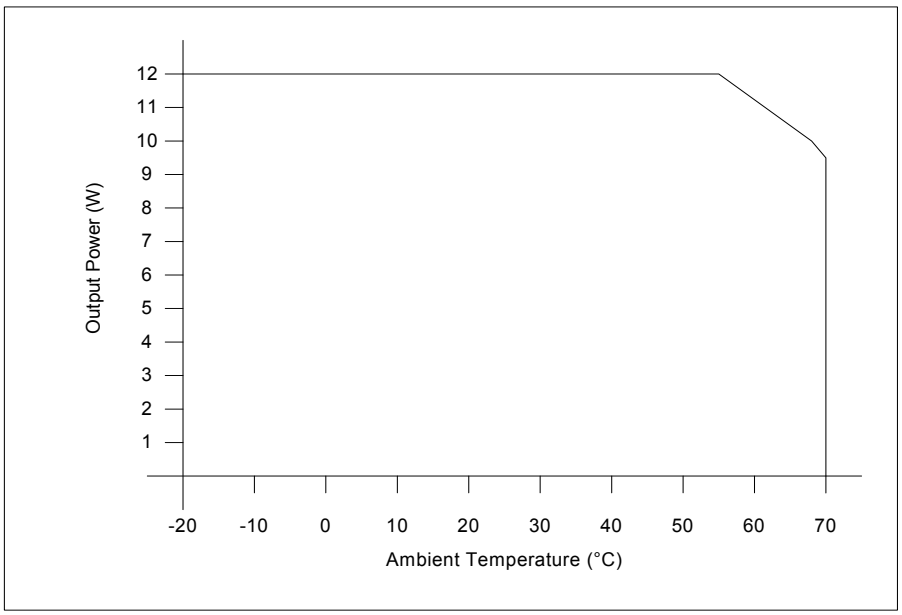


Figure 12: Ag9120-S Operating Profile

9. Protection

The Ag9000 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	^{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.

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 / ^{O}C

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

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	3.3 5 12	3.5 5.25 12.5	V V V	Ag9033-S Ag9050-S Ag9120-S
2	Output Current (V_{IN} = 48V)	PWR			1.8 1.8 1	A A A	Ag9033-S Ag9050-S Ag9120-S
3	Line Regulation	V_{LINE}		0.1		%	@ 50% Load
4	Load Regulation	V_{LOAD}		0.5		%	@ V_{IN}=48V
5	Output Ripple and Noise	V_{RN}		100		mVp-p	@ Max load[2]
6	Minimum Load	R_{LOAD}	100			mA	for specified regulation[3]
7	Short-Circuit Duration[4]	T_{SC}			∞	sec	
8	Efficiency	EFF		75		%	Ag9050-S @ 50% Load
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 application note.
3: Can be used with a minimum load of 20mA with reduced voltage regulation.
4: 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

11.1 Ag9000-S