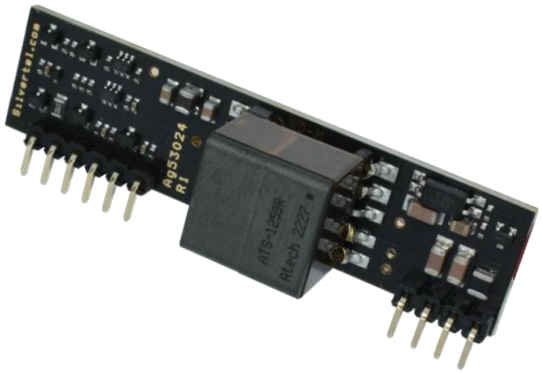
Silvertel

Ag53000

IEEE802.3at
Power-over-Ethernet Module



Features

- 24W, Class 4 PD, 30W peak output power
- IEEE802.3at, IEEE802.3af compliant
- 90% efficient DC/DC converter
- 12V and 24V output variants available
- Low output ripple & noise
- Overload, short-circuit and thermal protection
- Adjustable output voltage
- Industrial temperature range
- Minimal external components required
- Single In-Line (SIL) package 57.3mm(L) x 14mm(H)
- 1500Vdc isolation (input to output)
- Silvertel technical “design-in” assistance
- Designed and Manufactured in the UK
- Pin for Pin compatible with Ag5300, Ag5400, Ag97000 and Ag9700 series

Description

The Ag53000 series Power-over-Ethernet (PoE+) Powered Device (PD) modules are designed to extract power from a conventional twisted pair Category 5 Ethernet cable, conforming to the IEEE802.3 PoE standard, with full compatibility with the IEEE802.3at and IEEE802.3af amendments.

The Ag53000 is pre-configured as a Type 2 Class 4 PD device, requesting 30W of power from the PSE, with nominal output voltages of 12V or 24V.

The high efficiency DC/DC converter can achieve greater than 90% efficiency and operates over a wide input voltage range with a low ripple and low noise output. The DC/DC converter also has built-in output overload, output short-circuit and over-temperature protection and provides a 1500Vdc (input to output) isolation barrier.

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1 Product Overview

1.1 Ag53000 Product Selector

Part Number[1]	Nominal Output Voltage	Output Power	Marking[2]	Package
Ag53012	12V	24W Continuous, 30W Peak	ab12	SIL
Ag53024	24V		ab24	

Table 1: Ordering Information

Note 1: Complies with the European Directive 2011/65/EU for the Restriction of use of certain Hazardous Substances (RoHS) including Directive 2015/863 published in 2015, amending Annex II of Directive 2011/65/EU. Moisture Sensitive Level 1 and HBM 1.

Note 2: Located on the transformer.
The first letter, a, indicates the week as A-Z with uppercase being weeks 1-26, lower case weeks 27-52.
The second letter, b, indicates the year in uppercase A-Z starting from 2020.
The two digits are the nominal output voltage.

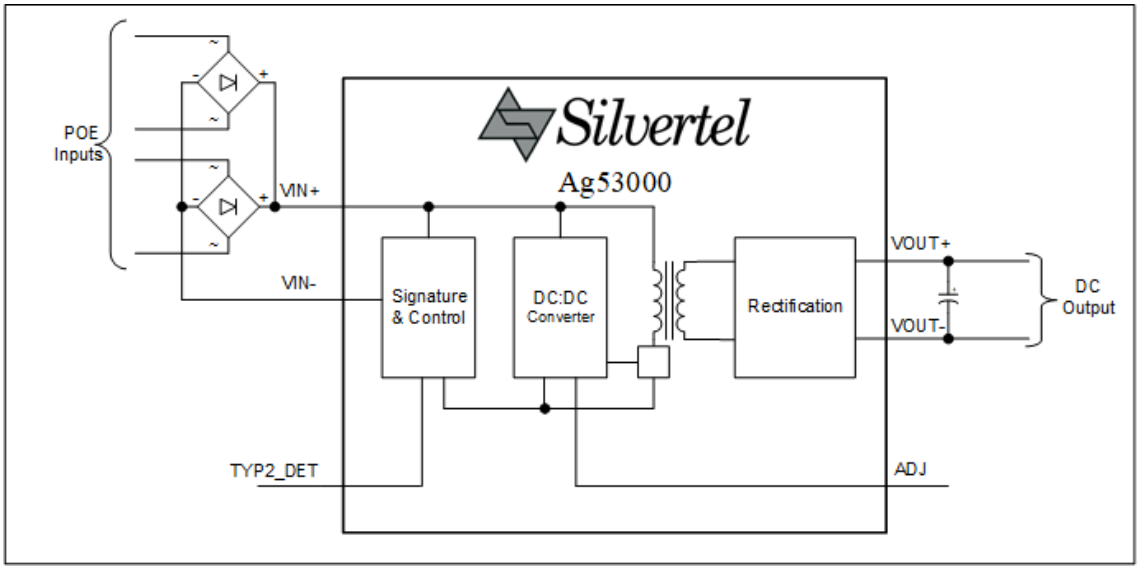


Figure 1: Block Diagram

1.2 Package Format

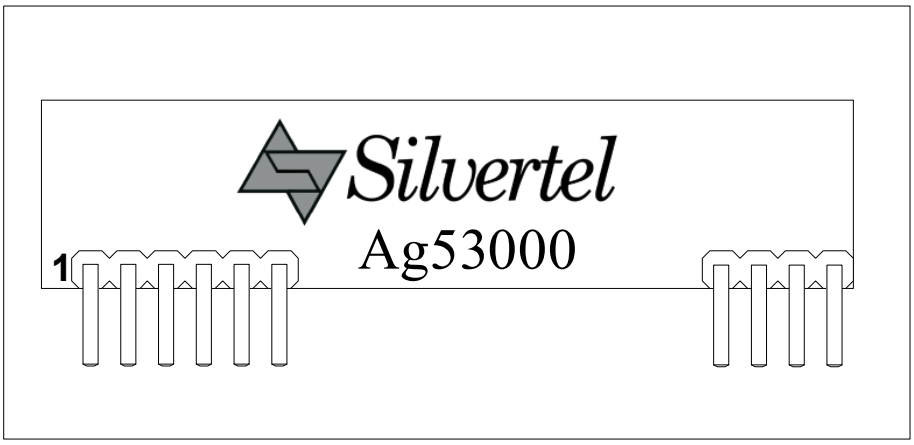


Figure 2: Ag53000 Package Format

1.3 Pin Description

Pin #	Name	Description
1	V_{IN+}	**POE Direct Input +.** This pin connects to the positive (+) output of the POE input bridge rectifiers.
2	V_{IN-}	**POE Direct Input -.** This pin connects to the negative (-) output of the POE input bridge rectifiers.
3	TYP2_DET	**Type 2 Detect Output.** This pin indicates if an IEEE802.3at PSE is supplying power to the Ag53000; see Section 2.3 for more details.
4	NC1	**No Connect.** Internal connection, do not connect
5	NC2	
6	NC3	
7	V_{OUT-}	**Negative DC Output.** This pin provides the negative regulated output from the Ag53000. Internally connected to pin 10.
8	V_{OUT+}	**Positive DC Output.** This pin provides the positive regulated output from the Ag53000.
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 V_{OUT+} pin or the V_{OUT-} pin.
10	V_{OUT-}	**Negative DC Output.** This pin provides the negative regulated output from the Ag53000. Internally connected to pin 7.

Table 2: Pin Description

1.4 Typical Connections

The Ag53000 only requires a few external components - the bridge rectifiers on the V_{IN} inputs are to conform to the input polarity protection requirement. The bulk capacitor (C1) connected across the output is required for correct operation of the DC/DC converter. This capacitor, typically 470µF, must be positioned as close to the output pins as possible for optimal stability. It can be an electrolytic capacitor as shown in Figure 3; it does not need to be a low ESR type for operation in temperatures down to 0°C. But if ambient temperatures below 0°C are expected, a capacitor that retains a moderately low ESR and the minimum capacitance is essential for operation. Polymer Aluminium Solid Electrolytic Capacitors are ideal for this application.

The output voltage can be adjusted by simply connecting a resistor between the ADJ pin and either the V_{OUT+} Pin or the V_{OUT-} pin, see section 3.2 Output Voltage Adjust Setting.

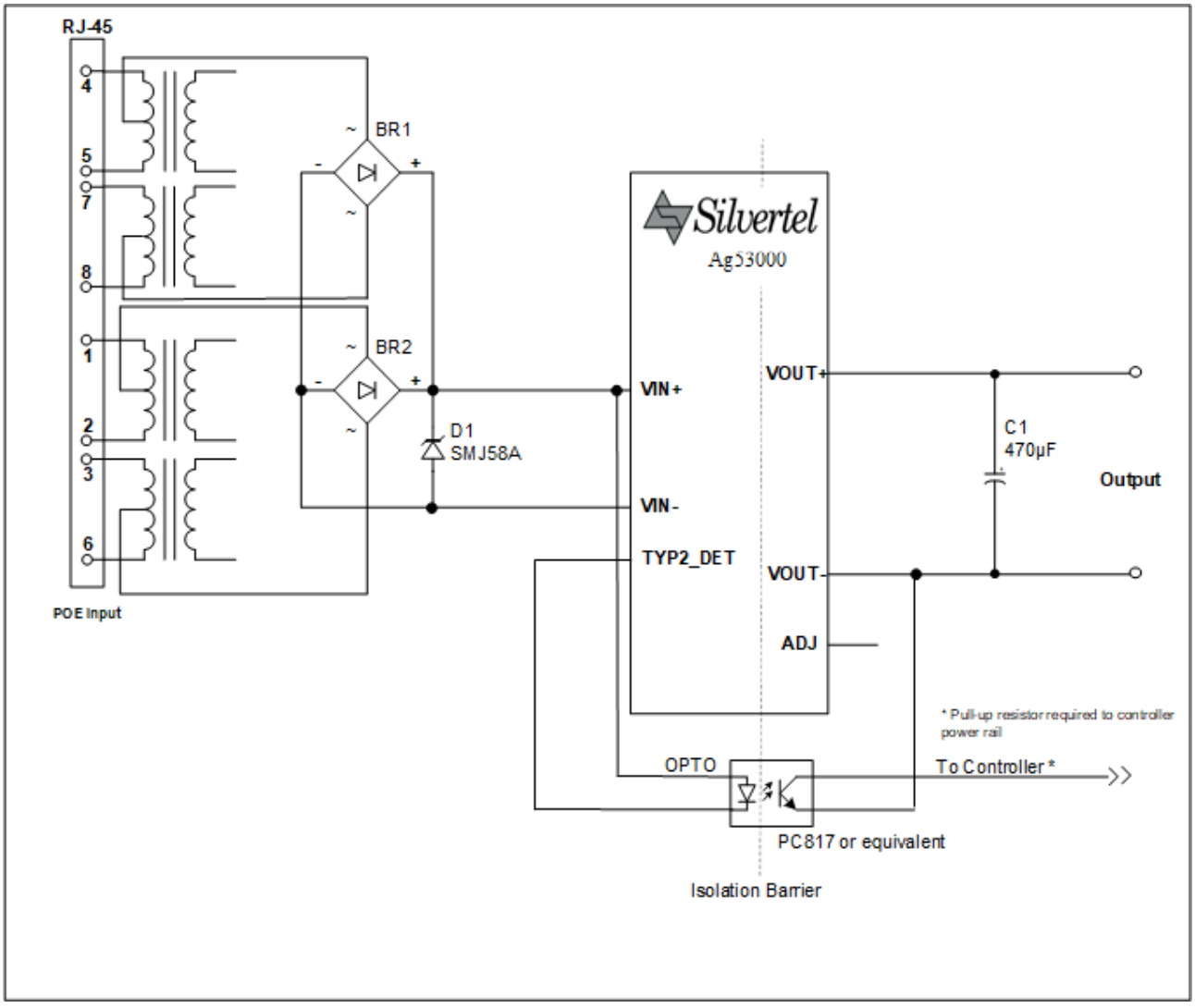


Figure 3: Typical System Diagram

2 Input

The Ag53000 has two input pins V_{IN+} and V_{IN-}, these pins should be connected to the outputs of two external bridge rectifiers, see Figure 3: Typical System Diagram. This allows the Ag53000 to be compatible with Power Sourcing Equipment (PSE) that utilise any of the different power polarities permissible.
The Ag53000 is designed to be powered by any compliant IEEE802.3 PSE such as Silvertel's Ag6120, Ag6130 or Ag6810.

2.1 PD Signature

The Ag53000 complies with the IEEE802.3 specifications and provides signature and control circuitry specified within. When the inputs are connected to a PSE, they will automatically present a Powered Device (PD) signature to the PSE (when requested). The equipment will then recognise that a PD is connected to that line and supply power.

2.2 Power Classification

The Ag53000 is a fixed Type 2 - Class 4 PD requesting 30W of power from a compliant IEEE802.3 Type 2 or greater PSE by displaying the correct class pulses shown in Table 3 below. If the Ag53000 is connected to a Type 1, the PSE will recognise the Class request as a valid request beyond maximum output and default to its highest output classification power level, and supply at least 15.4W to the Ag53000.

Requested Class	Class Pulse Count	Pulse 1&2 Classification Current (mA)	Pulse 3+ Classification Current (mA)	PSE Output Power (W)	Min. Available PD Power (W)	IEEE Spec. Amendment
0	1	<5	N/A	15.4	12.75	802.3af
1	1	10	N/A	4	3.84	
2	1	20	N/A	7	6.49	
3	1	30	N/A	15.4	12.75	
4	2 or 3	40	40	30	25.5	802.3at

Table 3: Classification Table

2.3 PSE Type Detection

The IEEE802.3 specification stipulates that if a device detects it is connected to a PSE that is not capable of providing the full requested power level, the device should either remain in a reduced power mode or indicate to the user that the device is under powered.

To achieve this, the Ag53000 monitors the detection and classification sequence to determine the type of PSE that performed the signature and classification. The module then uses the Type detection output pin, TYP2-DET, to flag the detected PSE Type to either the application circuitry or the user. This facilitates either the application adjusting the peak power draw of the application or to inform that the device is under-powered and may power cycle to the user.

When the PSE type has been detected, the relevant pin will pull low from V_{in+}, this can be used to drive an LED or an Optocoupler as shown in Figure 4.

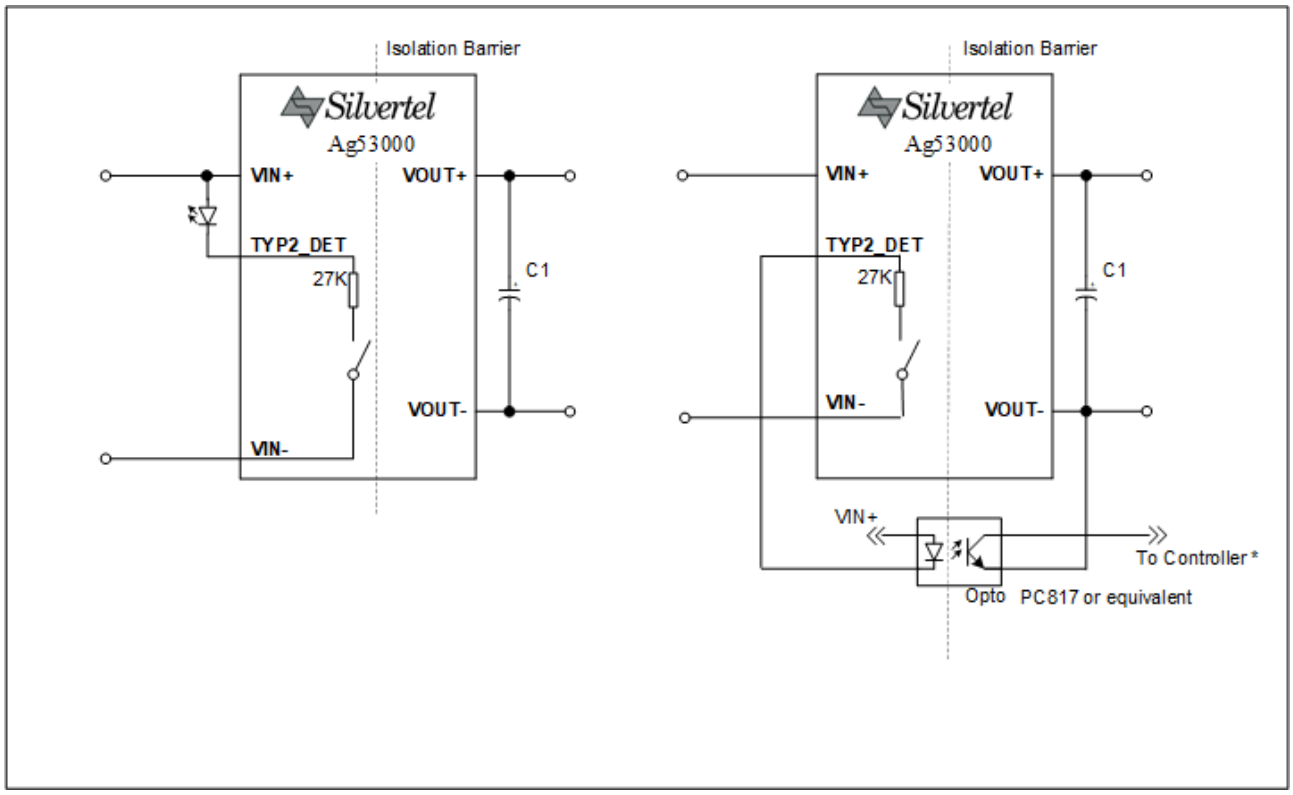


Figure 4: Physical Layer Detect Configuration

If the Ag53000 detects a greater than one Event Physical Layer classification, the switch will close and the Opto will turn ON. The Opto will pass this signal across the isolation barrier and the output collector can be connected to a controller (with a pull-up resistor connected to the controller's power rail). When the Opto is ON the collector (output) will be Logic 0, the controller will then know that the PSE is capable of delivering more than 15.4W. To complete the protocol (and conform to the IEEE802.3 specification) the controller should then confirm that it is a Type 2 PD over the Data Link Layer*.

If the Ag53000 detects a Single Event Physical Layer classification, the Opto will be OFF and the output collector will be Logic 1 (via pull-up resistor). The controller should then assume that the PSE is limited to only delivering up to 15.4W. If the Ag53000 detects a Two Event Physical Layer classification, the Opto will be ON. The controller should then assume that the PSE is limited to only delivering up to 30W.

If the PSE does not support the Physical Layer classification, the Opto will be OFF.

The Ag53000 may operate with some PSEs that are not compliant to the IEEE802.3 specification.

*There are several PSEs (including Cisco) that will only deliver ≤15.4W until they receive confirmation over the Data Link Layer.

3 Output

3.1 Maximum Output Power

While the Ag53000 is capable of delivering a peak power output of 30W, this will be limited by the available delivered power at the input pins of the module. Due to system losses only 25.5W is guaranteed to the application device. As a result, any application should be designed for a maximum continuous output power of 22.5W from the Ag53000.

In a fully compliant IEEE802.3 system, the power available, measured at the input to the bridge rectifiers, may be as low as 25.5W. See “ANX-POE-Power” for more details.

3.2 Output Voltage Adjust Setting

The Ag53000 has an output voltage adjustment pin, ADJ, which can be used to either increase or decrease the output voltage of the module.

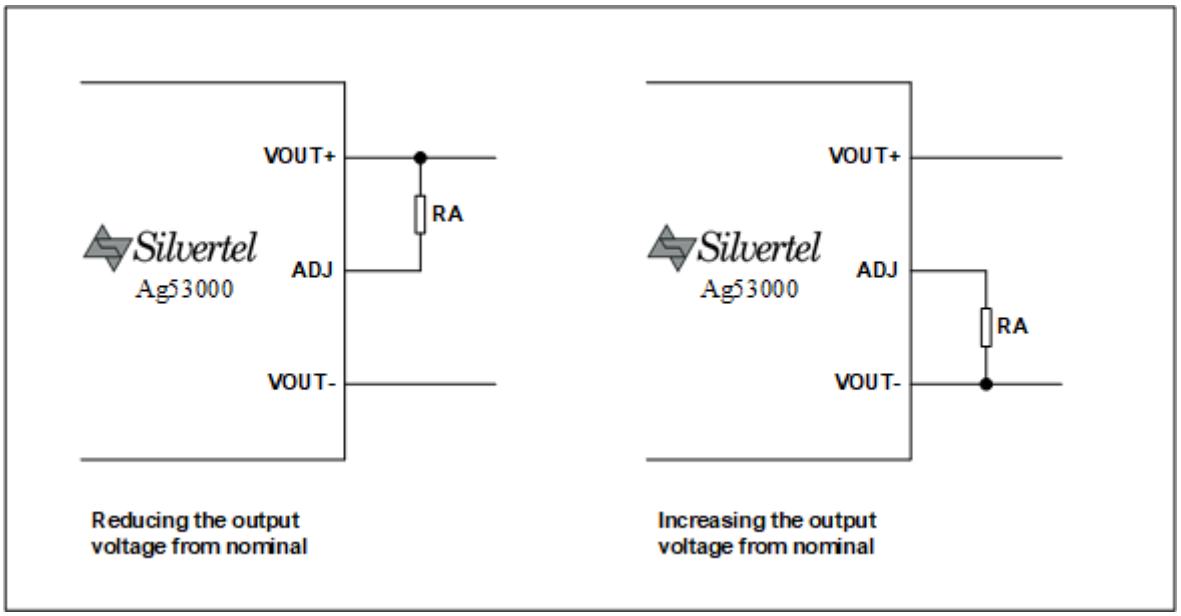


Figure 5: Output Voltage Adjustment

Reducing the output voltage, connect RA between ADJ and V_{OUT+}		
Value of RA	**Ag53012 output**	**Ag53024 output**
Open Circuit	12.0V	24.0V
68k Ohms	10.8V*	21.6V*
Increasing the output voltage, connect RA between ADJ and V_{OUT-}		
Value of RA	**Ag53012 output**	**Ag53024 output**
Open Circuit	12.0V	24.0V
0 Ohms	12.8V	24.8V

Table 4: Output Voltage Adjustment Resistor Values

*NOTE – It is important that the minimum output adjust is not taken below 10.8V on the Ag53012 and 21.6V on the Ag53024. Setting the output voltage below this level may result in the module being permanently damaged.

3.3 Output Filtering

The Ag53000 requires a bulk capacitance to be fitted on its output for stable operation, this is typically provided with just an electrolytic capacitor, this provides a high level of output regulation and low output ripple. The recommended output filtering is shown in Figure 6.

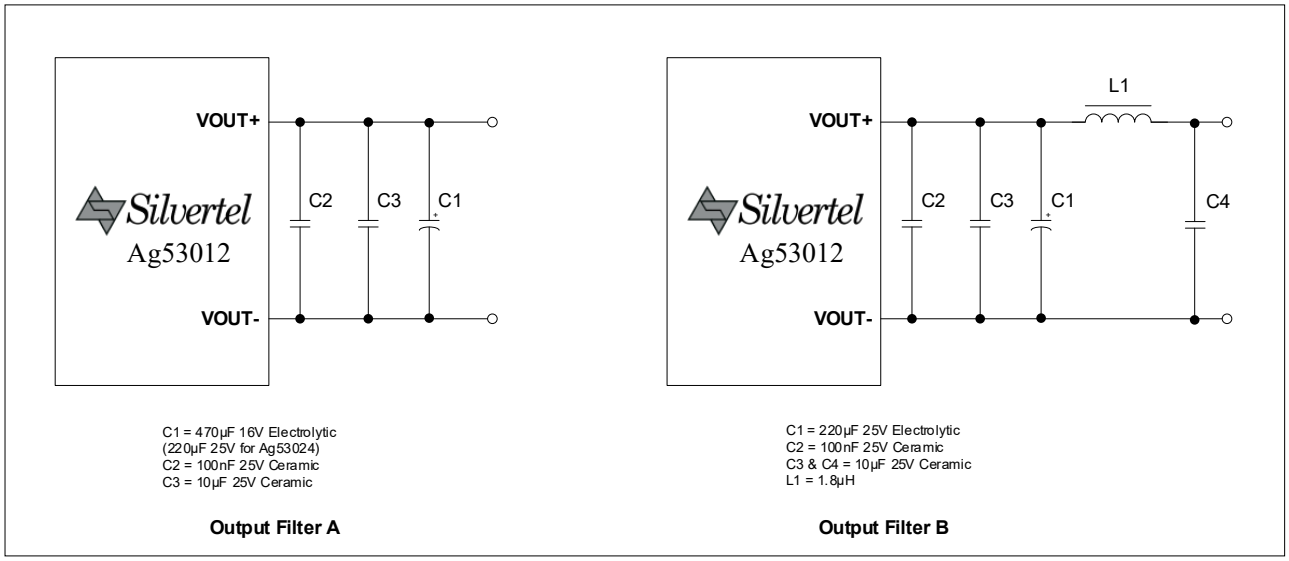


Figure 6: Output Filter

3.4 Maintain Power Signature

The Ag53000 does not require a minimum load for correct operation. However, when unloaded, the current draw from the PSE may not be high enough to satisfy the Maintain Power Signature (MPS) of the PSE, removing power from the link. The MPS requirement is stipulated in the IEEE802.3 specification to provide safety to the PoE system by ensuring power is not being sourced to an unconnected cable by monitoring the link to see if the PD has been disconnected.

If the applications load on the module drops below I_{OUT_MPS} in section 10.3 for a duration of time greater than 250ms (ignoring pulses less than 75ms in duration), then the PSE may determine that the device has been disconnected. Increasing the load for a sustained period of at least 75ms will reset the timer in the PSE, preventing a power removal event.

To reduce excess power dissipation, the load should be sized to increase the total loading of the module to meet the I_{OUT_MPS} current draw during these periods of low power draw. This load can be implemented in one of two methods; a static resistor connected across the modules output, this is the simplest method, but will increase the power draw of the application, even during the periods of highest power draw. Another method is to switch in a load only when required, this is more complex than a static resistor, but allows for power savings in low power applications, and does not reduce the maximum available power in applications that have high peak power draws.

4 Efficiency

The Ag53000 has been designed to deliver a maximum continuous power of 24W with short transient peaks of up to 30W with optimum efficiency. The following graphs show the typical efficiency and power dissipation that can be obtained relative to the Line Voltage supplied at the input of the module.

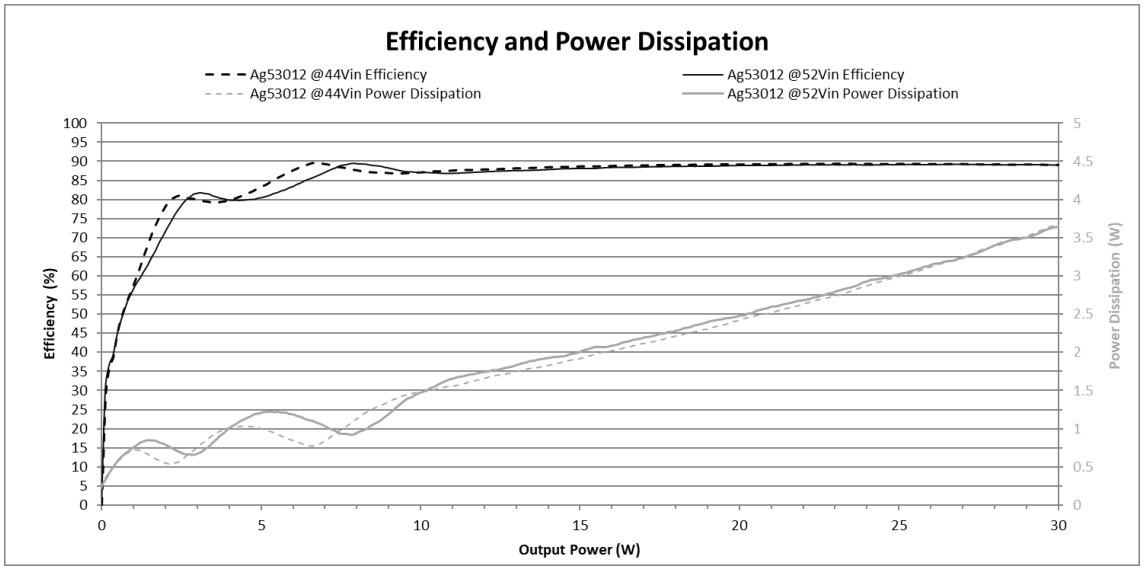


Figure 7: Ag53012 Efficiency and Power Dissipation

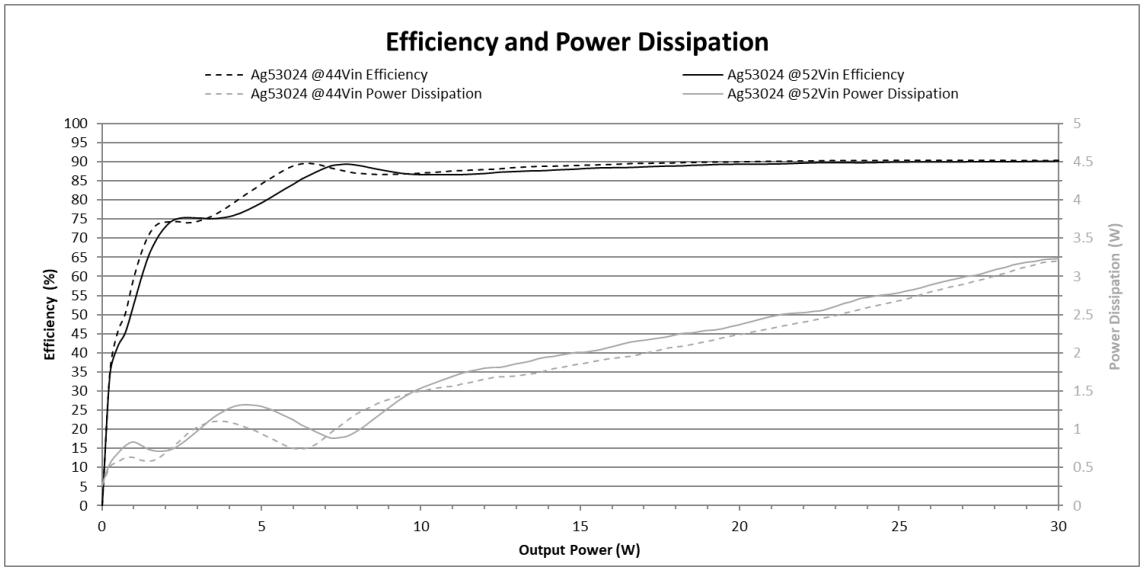


Figure 8: Ag53024 Efficiency and Power Dissipation

5 Operating Temperature Range

At the heart of the Ag53000 is a DC/DC converter, it will generate heat. While the product has been designed to be a high efficiency device, the small form factor requires that thermal management is taken into consideration at the design stage. 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 Ag53000 can operate up to a maximum of 85˚C ambient, and a minimum of -40˚C ambient. When intended for used in ambient temperatures below 0°C it is recommended that an output capacitor that will retain the minimum output capacitance and ESR ratings for the Ag53000 at the lowest temperature in the intended operating range is used. A Polymer Aluminium Electrolytic Capacitor is ideal for this application, a reputable brand rated to -55°C should suffice for most applications, please contact Silvertel if suggestions are required.

5.1 Thermal Considerations

Each application is different; therefore it is impossible to give fixed and absolute thermal recommendations. It is always recommended that the Ag53000 is positioned in moving air, whether forced or natural convection, to assist the removal of the thermal energy accumulated in the module and prevent the build-up of heated pockets of air, which elevate the effective ambient temperature.

It is often desirable for the application to be housed in a sealed enclosure to prevent water and dust ingress. Where this may be the case, it is recommended that the module is placed close to the enclosure housing, where use of a thermal gap pad along the rear of the Ag53000 can be implemented to facilitate heatsinking to the outer casing (preferably of metallic construction).

Where there is no possibility that the module can be located near to the enclosure housing it is recommended that heat is drawn away from the Ag53000 by means of copper planes connected to the power pins of the Ag53000. This technique can be used to draw heat away from the DC/DC converter to dissipate over a larger surface area.

The copper planes should be on the outer layers of the host PCB and best results are achieved with additional copper planes on internal layers of the PCB with multiple thermal via connections. An example of this is shown in Figure 9. It is also important that any enclosure has sufficient ventilation, where possible, for the Ag53000. Heat dissipation can be improved further by thermally connecting the PCBA to the enclosure of the application. The simplest method of performing this is to use a thermal gap pad located between the host PCB and the enclosure, situated over the area containing the thermal via arrays. See “ANX-POE-Thermal-Considerations” for more details.

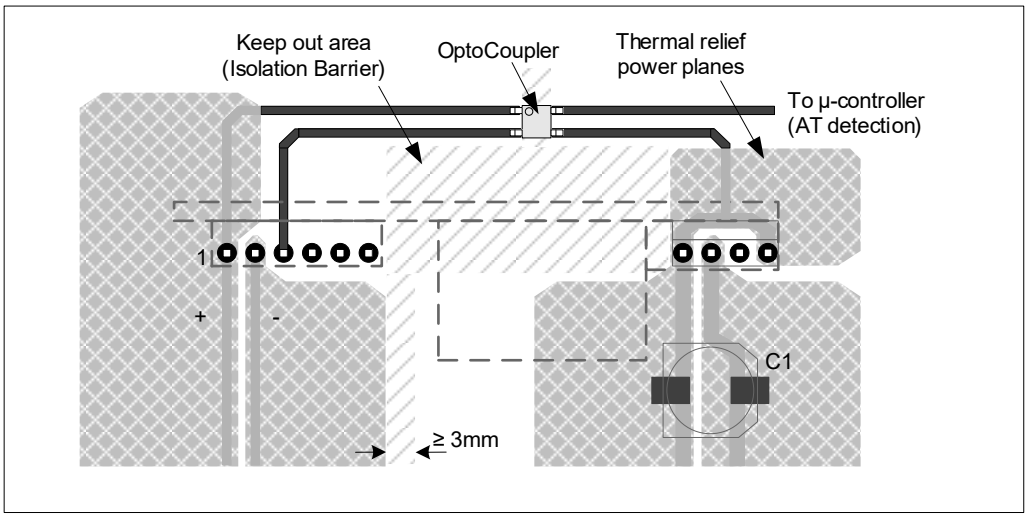


Figure 9: Thermal Relief

6 Isolation

To meet the safety isolation requirements of IEEE802.3 specification, a powered device must provide electrical isolation between all its accessible external connectors, including frame ground. In order to meet this requirement, the powered device should be subjected to and pass at least one of the following electrical strength tests of IEC 60950-1:2001 sub clause 6.2.1.

a) 1500V_{rms} at 50-60Hz for 60 seconds

b) 2250V_{dc} for 60 seconds or

c) 1500V_{dc} impulse test 10 times in either polarity.

To assist in this the Ag53000 has been designed to meet and pass the1500V_{dc} impulse test with no breakdown of insulation.

In order to maintain this isolation requirement, it is essential that the isolation barrier is not breached, see “ANX-POE-Isolation-Barrier” for more details.

7 Protection

7.1 Input Protection

The Ag53000 may be damaged by input voltage transients greater than 80V.The module contains a TVS diode on board which removes the requirement for fitting external protection in the vast majority of applications, however if additional protection from electrostatic discharge (ESD) or other high voltage transients is required, an additional over-voltage clamping device can be fitted across the V_{IN+} and V_{IN-} input pins, see Figure 10 and Apps Note “ANX-POE-Protection” for more details.

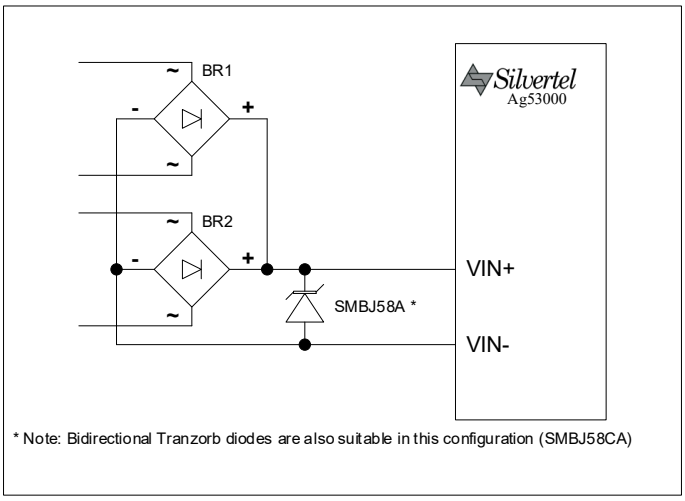


Figure 10: Input Protection

7.2 Output Back Feed Protection

If an external or auxiliary supply is to be used, it is essential that a blocking diode is present to prevent voltage injection on to the output circuitry of the module. This may cause damage to the module. The back feed protection is required even if the external voltage is present only while the module remains unpowered.

7.3 Output Short Circuit Protection

The Ag53000 has over-current protection to prevent the module from becoming damaged in the event of a short circuit event. If an over current event occurs the Ag53000 will disable the output, and the Ag53000 will then test the current draw approximately every 2 seconds until the cause of the over current is removed, after which, the power will be restored to the output.

7.4 Thermal Protection

The Ag53000 contains built in thermal protection to prevent the module becoming damaged in the event that it is operated beyond its temperature specification. When the Ag53000 has detected it is over temperature, the output will be disabled until the module has cooled sufficiently.

8 EMC

The Ag53000 has been designed to pass EN55032 Class B, however the Ag53000 will only be one component within the system so we would always advise that provisions are put in place in case further noise reductions are needed. From our experience we would recommend an inexpensive but effective solution to reduce emissions as shown in Figure 11, for more details please see “ANX-POE-EMI-Considerations”.

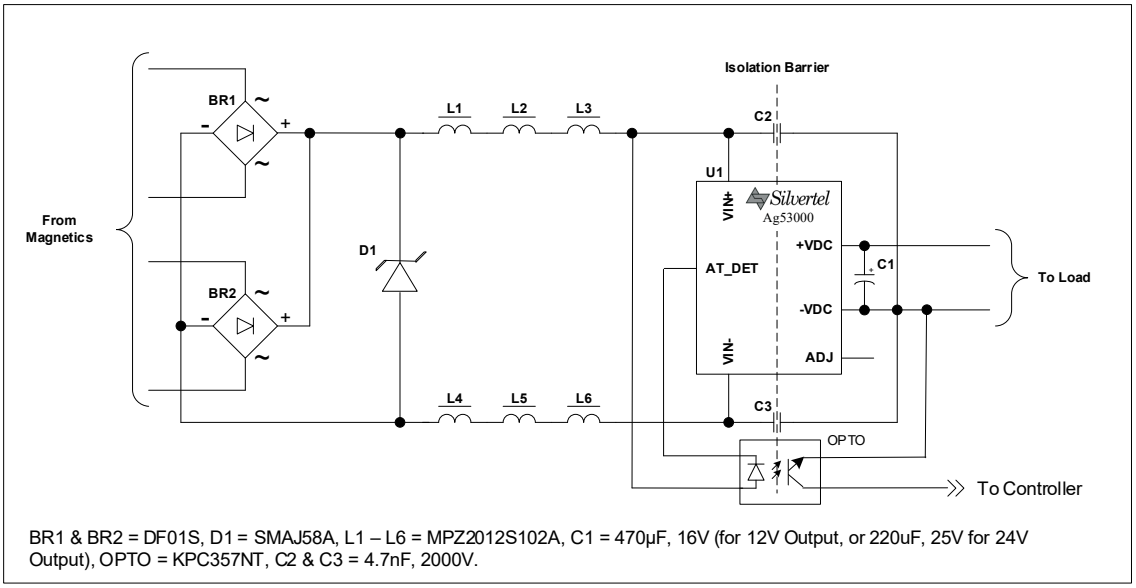


Figure 11: Typical Connection Diagram

9 Solderability

The Ag53000 is not suitable for a secondary reflow operation, and as such only wave soldering or hand soldering processes are recommended. Contact Silvertel for further information.

The Ag53000 is lead-free (Pb-free) device, RoHS compliant and fully compatible with a Pb-free automated assembly process. The Ag53000 can be mounted manually using soldering iron or hot air.

Thermal relief should be applied to the pads to allow for maximum thermal conductivity without hindering the reflow process, your Process Engineer should be able to provide suitable recommendations.

The Ag53000 requires no components of greater than Moisture Sensitivity level 1, as a result no special processes are required in the reflow process.

Note : Do not pass the Ag53000 through the reflow process mounted to the underside of the assembly due to the risk of components falling off the module.

10 Electrical Characteristics

10.1 Absolute Maximum Ratings

	Parameter	Symbol	Min	Max	Units
1	DC Supply Voltage	V_{CC}	-0.3	60	V
2	Storage Temperature	T_S	-40	+100	°C
3	Moisture Sensitivity Level	MSL	-	1	-

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

10.2 Recommended Operating Conditions

	Parameter		Symbol	Min	Typ	Max	Units
1	Input Supply Voltage		V_{IN}	41 [1]	50	57	V
2	Transient Supply Voltage[1]		V_{TRAN}	36			V
3	Input Under Voltage Lockout		V_{ULOCK}		34.5		V
4	Input Under Voltage Lockout Hysteresis		$V_{ULOCK-Hsy}$		3		V
5	Operating Temperature		T_{OP}	-40	25	85	Ta / °C
6	Output capacitance	Ag53012	C_{out}	330	470	560	μF
		Ag53024		180	220	330	

Note 1: At ≤ 50% load

10.3 DC Electrical Characteristics

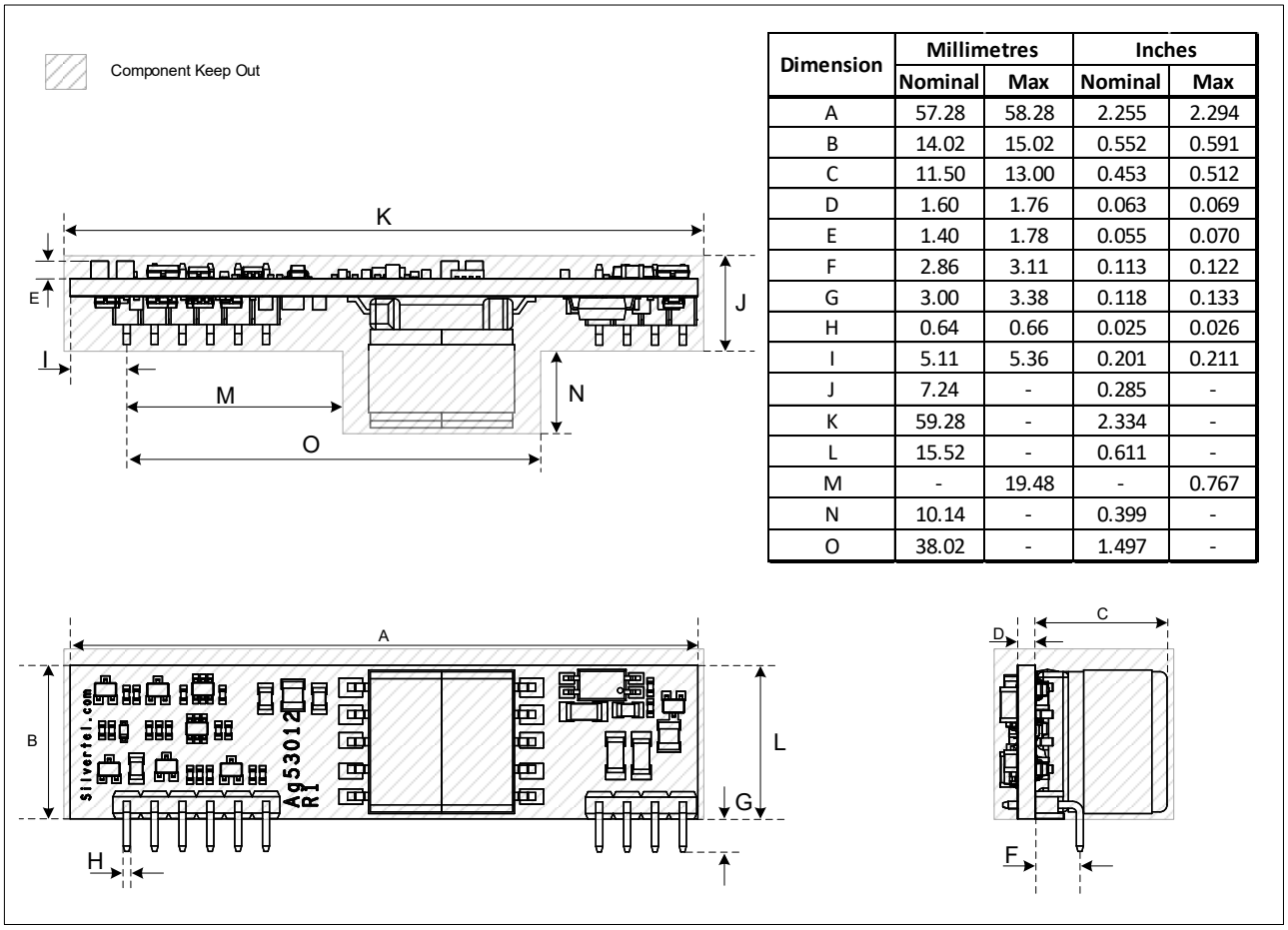
	DC Characteristic		Sym	Min	Typ[1]	Max	Units	Comments
1	Nominal Output Voltage	Ag53012	V_{OUT}	11.5	12	12.5	V	
		Ag53024		23.25	24	24.8		
2	Continuous Current output[2]	Ag53012	I_{LOAD}		2	2.5	A	
		Ag53024			1	1.2		
3	Line Regulation		V_{LINE1}		0.1		%	@ 50% load
4	Load Regulation		V_{LOAD1}		0.3		%	@ 52V_{in}
5	Ripple and Noise[3]	Ag53012	V_{RN}		82		mV_{p-p}	At Full Load
		Ag53024			37			
6	Minimum Load		I_{MIN}	0			mA	Observe PSE MPS requirements
7	MPS Output Load Requirement	Ag53012	I_{OUT_MPS}	25			mA	
		Ag53024		15				
8	Short-Circuit Duration		T_{SC}			∞	sec	
9	Peak Efficiency[2]	Ag53012	EFF		89		%	Vin = 52V typ.
		Ag53024			90			Vin = 52V typ.
10	Isolation Voltage (I/O)		V_{ISO}			1500	V_{PK}	Impulse Test

Note 1: Typical figures are at 25°C with a nominal output voltage with 53V supply with a 470µF output capacitor fitted and are for design aid only. Not Guaranteed.

Note 2: Minimum 44V_{in} for maximum output at 25˚C. Maximum output power may be limited by PSE.

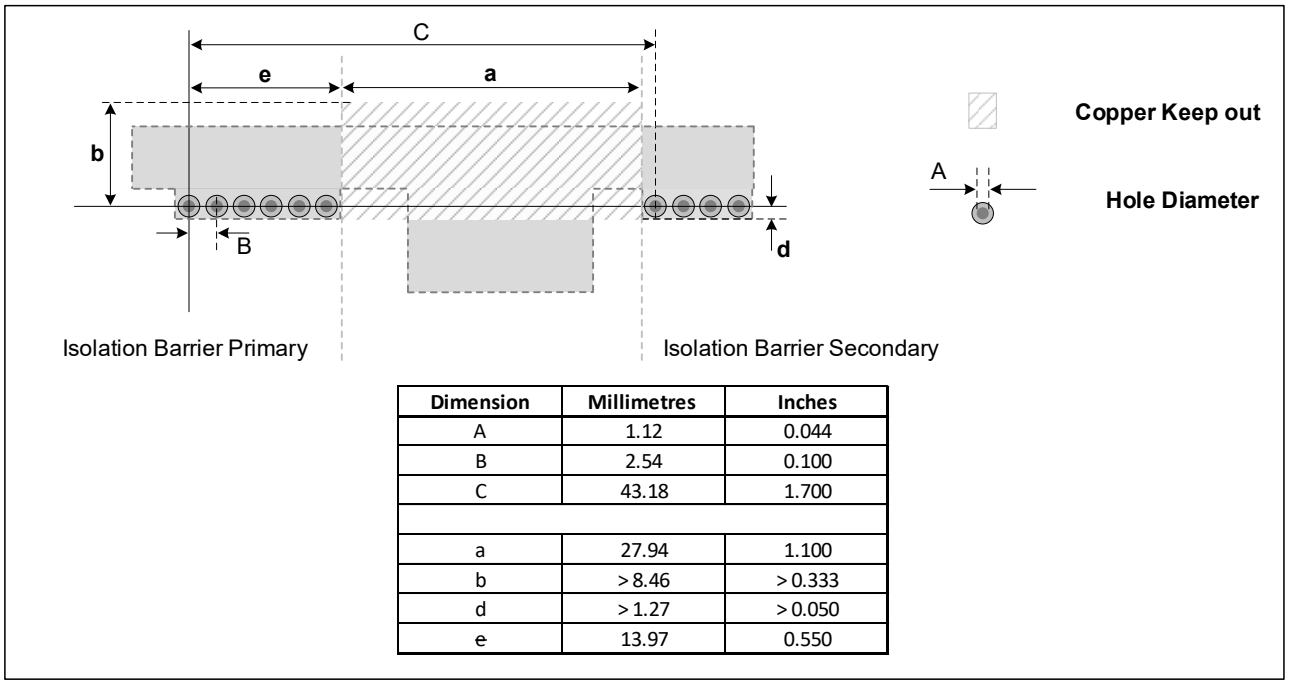
Note 3: Measured with external Output filter A, see Figure 6.The output ripple and noise can be reduced further with external filter B, see Section 3.3.

11 Package



Dimension	Millimetres		Inches	
	Nominal	Max	Nominal	Max
A	57.28	58.28	2.255	2.294
B	14.02	15.02	0.552	0.591
C	11.50	13.00	0.453	0.512
D	1.60	1.76	0.063	0.069
E	1.40	1.78	0.055	0.070
F	2.86	3.11	0.113	0.122
G	3.00	3.38	0.118	0.133
H	0.64	0.66	0.025	0.026
I	5.11	5.36	0.201	0.211
J	7.24	-	0.285	-
K	59.28	-	2.334	-
L	15.52	-	0.611	-
M	-	19.48	-	0.767
N	10.14	-	0.399	-
O	38.02	-	1.497	-

Figure 12: Package Dimensions



Dimension	Millimetres	Inches
A	1.12	0.044
B	2.54	0.100
C	43.18	1.700
a	27.94	1.100
b	> 8.46	> 0.333
d	> 1.27	> 0.050
e	13.97	0.550

Figure 13: Land Pattern

12 Packaging

The default standard packing for the Ag53000 series is supplied in trays of 40.

13 Ordering Code