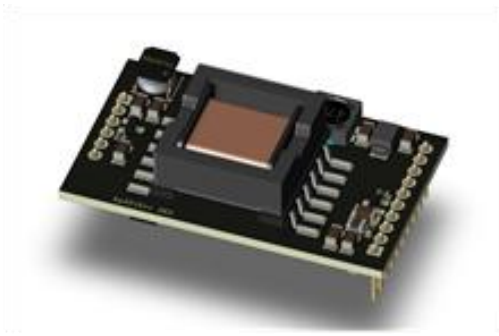
Silvertel

Ag401

POE++ to USB Power Delivery Controller 70W Power-over-Ethernet Module



Features

- Class 8, 70W (IEEE802.3bt) Output power – Single port USB PD Source 65W, Aux +5V, 5W Output
- IEEE802.3bt, IEEE802.3at & IEEE802.3af Compliant
- USB-C Output: 3.3V to 20V, PD Rev 3.1 V1.2 Compatible
- High Efficiency DC-DC Converter
- Overload, short-circuit, OVLO, TVS and thermal protection
- 1500Vdc isolation (input to output)
- Adjustable output voltage
- Industrial temperature range
- Minimal external components required
- Outline Dimensions: 51mm (L) x 30mm (W) x 16mm (H)
- Silvertel “design-in” assistance

RoHS

Description

The Ag401 Power-over-Ethernet (PoE++) module is designed to extract power from a conventional twisted pair Category 5 Ethernet cable, conforming to the IEEE802.3 PoE standard and output as a USB PD Source. The Ag401 is fully backwards compatible with previous versions of the IEEE802.3 PoE standard.

The Ag401 is pre-configured as a Type 4 Class 8 device, allowing the module to draw up to 70W of power from the PSE, with an output voltage range of 3.3V to 20V. The Output is compatible with Rev 3.1, Version 1.2 of the USB-C Power Delivery standard.

The high efficiency DC/DC converter 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 Ag401 Product Selector

Part Number[1]	Nominal Output Voltage	Output Power	Marking[2]	Package
Ag401	3.3V – 20V	65W Continuous	ab	DIL
	5V	5W Continuous		

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: 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.

Table 1: Ordering Information

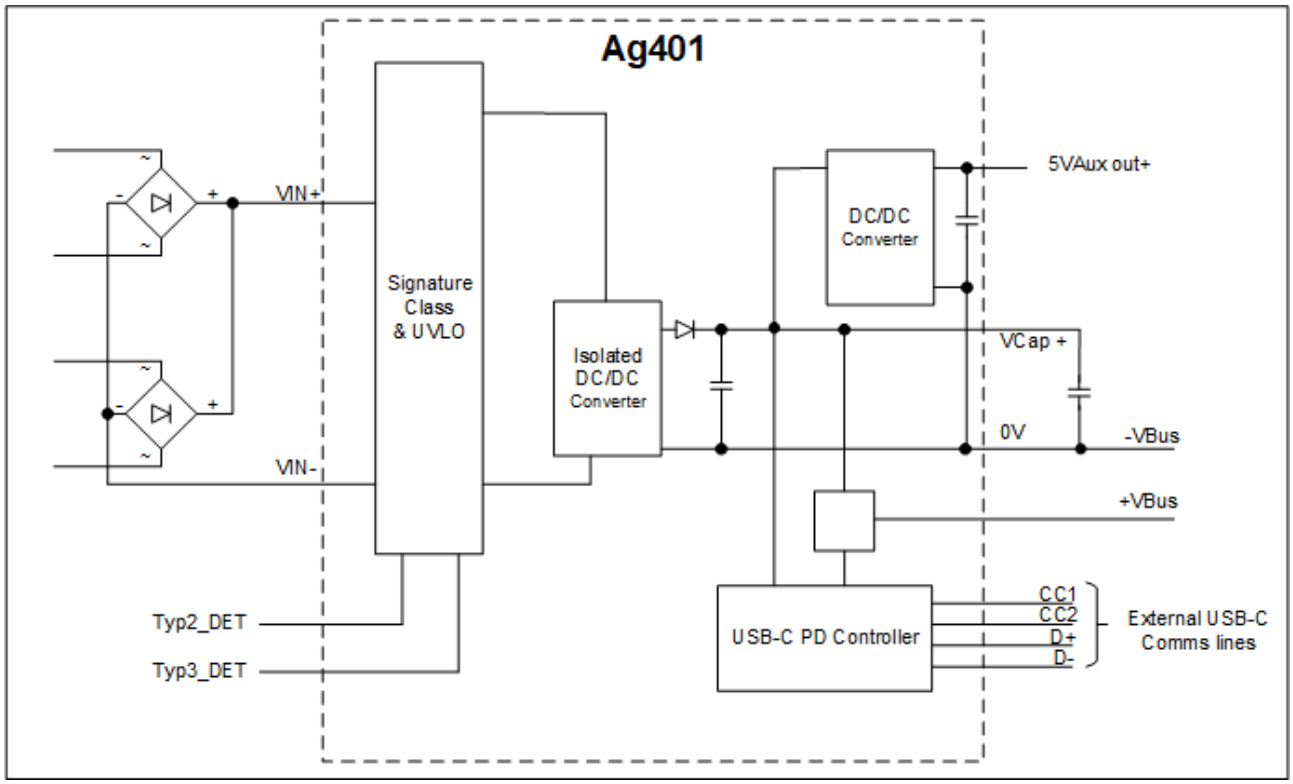

Figure 1: Block Diagram

1.2 Package Format

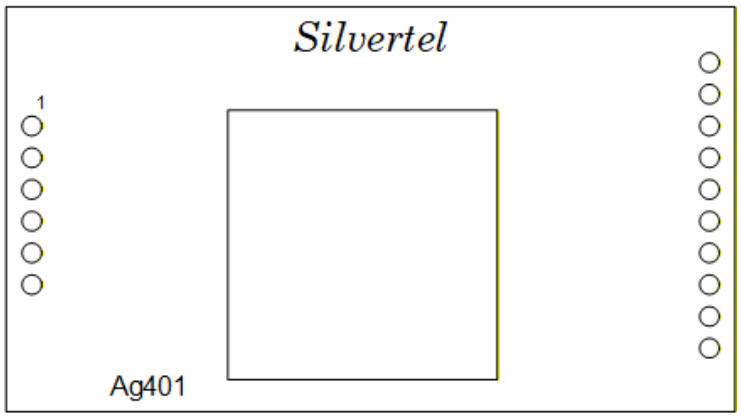

Figure 2: Ag401 Package Format

1.3 Pin Description

Pin #	Name	Description
1,2	VIN+	**POE Direct Input +**. This pin connects to the positive (+) output of the POE input bridge rectifiers.
3,4	VIN-	**POE Direct Input -**. This pin connects to the negative (-) output of the POE input bridge rectifiers.
5	Typ3_DET	**Type 3 Detect Output.** This pin indicates if an IEEE802.3bt Type 3 PSE is supplying power to the Ag401; see Section 2.2.3 for more details.
6	Typ2_DET	**Type 2 Detect Output.** This pin indicates if an IEEE802.3at Type 2 PSE is supplying power to the Ag401; see Section 2.2.3 for more details.
7,8	0V/-VBus	**0V/Ground.** USB System Ground – USB Return connection.
9	VCap+	**VCap.** Output Stabilisation node. Connect Capacitor between this node and 0V/-VBus.
10,11	+VBus	**USB-C Bus Voltage +**. Output Voltage for USB positive. Connects to USB-C connection A4 & A9.
12	D+	**Data Output +.** USB-C Data Output positive (optional for dedicated power ports). Connects to USB-C connection A6.
13	D-	**Data Output -.** USB-C Data Output negative (optional for dedicated power ports). Connects to USB-C connection A7.
14	CC1	**Configuration Channel 1.** Connects to USB-C connection A5.
15	CC2	**Configuration Channel 2.** Connects to USB-C connection B5.
16	5VAux+	**5V Auxiliary Output +.** 5V auxiliary supply positive, limited to 5W load.

Table 2: Pin Description

2 Functional Description

2.1 Typical Connections

The Ag401 only requires a few external components - the bridge rectifiers on the V_{IN} input are to conform to the input polarity protection requirement. The 470µF capacitor (C1) connected between VCap+, pin 9, and 0V/-VBus pins 7 & 8, is required for correct operation of the DC/DC converter. This capacitor must be positioned as close to the output pins as possible for optimal stability. A 470µF capacitor (C2) connected between 5Vaux+, pin 16 and 0V/VBus- pins 7 & 8, also needs to be fitted to stabilise the auxiliary supply. The positioning of C2 also needs to be close to the output pin. Both can be a low cost electrolytic capacitor (a minimum of 470µF, 25V is recommended for C1 and 470µF, 6.3V for C2) as shown in Figure 3; neither 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.

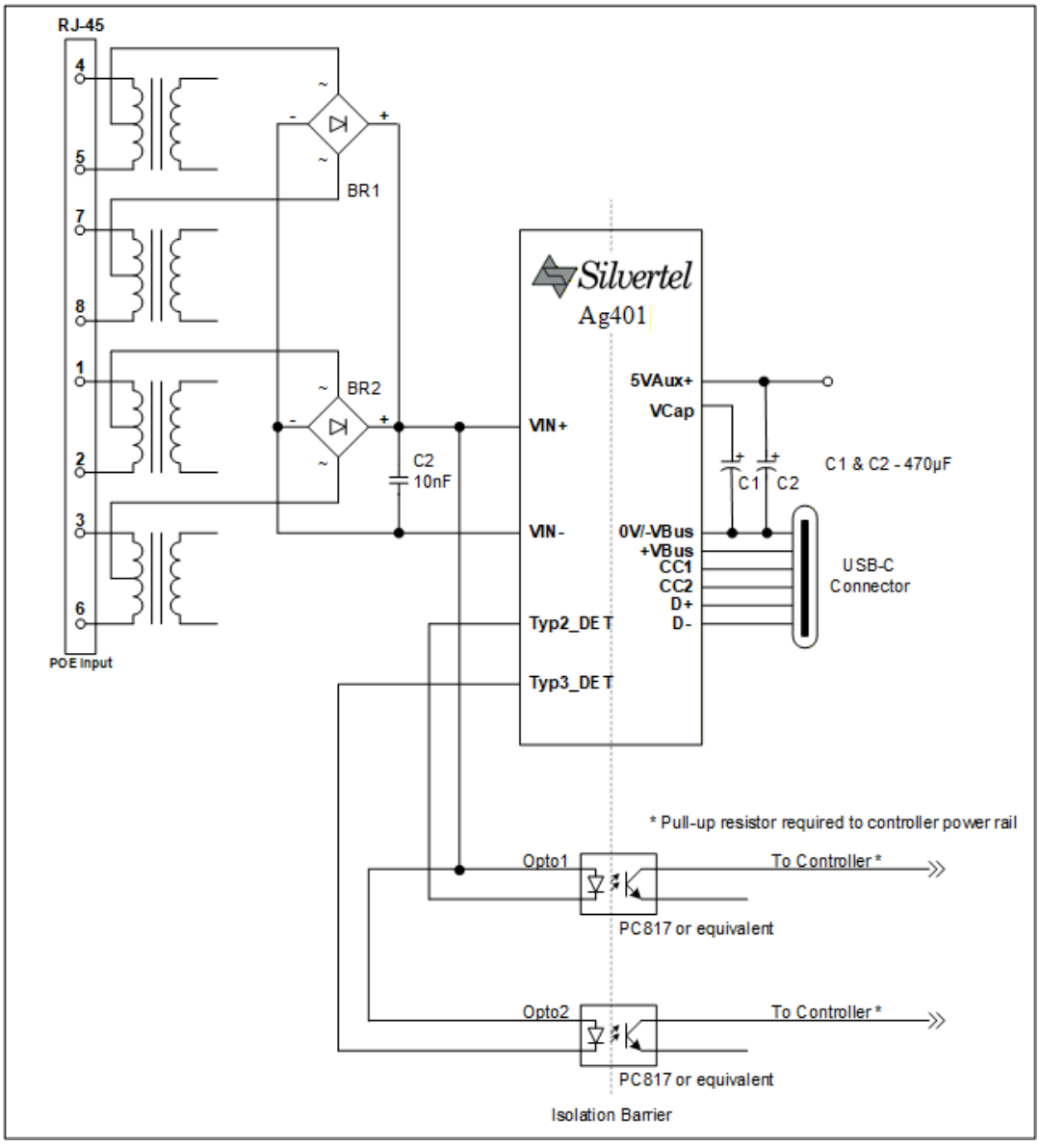

Figure 3: Typical System Diagram

2.2 Input

The Ag401 has four input pins, two for VIN+ and two for VIN-, these pins should be connected to the outputs of two external bridge rectifiers (see Figure 3: Typical System Diagram). This allows the Ag401 to comply with the IEEE802.3bt POE standard and be backwards compatible with older versions of the standard, ie, IEEE802.3 at and .af.

The Ag401 is designed to be powered by any compliant IEEE802.3 PSE such as Silvertel's Ag6120, but the maximum specified power will only be achievable when sourcing from a Type 4, IEEE802.3bt compliant PSE.

2.2.1 PD Signature

The Ag401 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.

2.2.2 Power Classification

The Ag401 is a fixed Type 4 - Class 8 PD requesting 70W of power from a compliant IEEE802.3 Type 4 PSE by displaying the correct class pulses shown in Table 3 below. If the Ag401 is connected to a Type 1 PSE, the PSE will not recognise the Class 8 request from the Ag401 and default to a Class 3 power level device and supply 15.4W.

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
5	4	40	<5	45	40	802.3bt
6	4	40	10	60	51	
7	5	40	20	75	62	
8	5	40	30	90	71.3	

Table 3: Classification Table

2.2.3 PSE Type Detection

The Ag401 has an two output pins, Typ2_DET and Typ3_DET, to indicate that it has been connected to a PSE that can supply enough power to operate at its full power output. These pins will pull low from V_{IN+} once the Ag401 has detected a multiple event physical layer classification, as described in the IEEE802.3at or IEEE802.3bt specification amendments, this can be used to drive an LED or Optocoupler as shown in Figure 4.

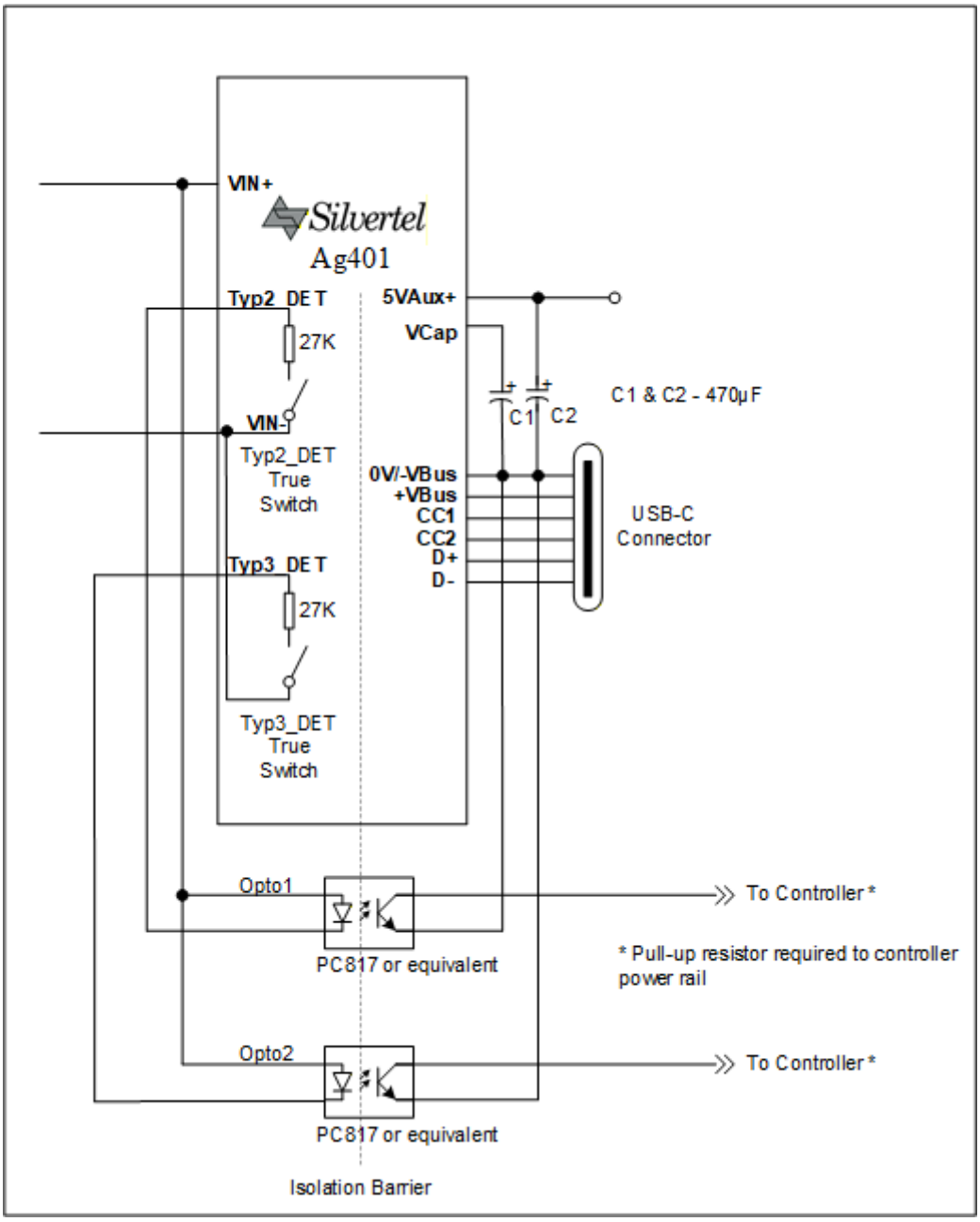

Figure 4: Multiple Event Physical Layer Detect Configuration.

If the Ag401 detects a Multiple Event Physical Layer classification, two type detect pins will indicate the PSE type detect indicated by the following table.

Detected PSE Type	TYP2-DET output	TYP3-DET output
1	Open	Open
2	Closed	Open
3	Open	Closed
4	Closed	Closed

For example for a 2 or 3 event classification (Type 2 PSE) the (Typ2_DET True) switch will close and Opto1 will turn ON. Opto1 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 Opto1 is ON the collector (output) will be Logic 0, the controller will then know that the PSE is capable of delivering 30W. Finally, to complete the protocol (and conform to the IEEE802.3 specification) the controller should then confirm that it is a Type 2, 3 or 4 PD over the Data Link Layer*.

If the Ag401 detects a Single Event Physical Layer classification, Opto1 and Opto2 will be OFF and the output collectors 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 PSE does not support the Physical Layer classification, Opto1 and Opto2 will both be OFF.

The Ag401 may operate with non-compliant IEEE802.3 POE+ PSE's.

*There are several PSEs (including Cisco) that will only deliver ≤15.4W until they receive Type 2 PD confirmation, over the Data Link Layer.

2.3 Output

2.3.1 Maximum Output Power

While the Ag401 is capable of delivering a maximum power output of 70W continuously, maximum output power delivery of the Ag401 will be limited by the available power at the input pins of the module.

A Type 4 (IEEE802.3bt) PSE supplying Class 8 power levels shall provide a minimum of 90W at its lowest voltage of 50V from its output, however with connector, cable and rectification losses, the available power and voltage at the input pins of the Ag401 can vary considerably. Refer to Application Note "ANX-POE-Power" for the minimum available power delivery in an IEEE802.3 compliant system.

2.3.2 Maximum Output Power (VBus)

The Ag401 is a POE++ to USB PD Controller to provide power to a USB port supplied by an IEEE-compliant POE PSE switch or injector. Power is negotiated with the connected device over the CC1/CC2 connections and power is made available following successful negotiation, via the +VBus/-VBus connections to the peripheral device connected at the USB-C port.

The power level is automatically negotiated as per the USB Power Delivery standard, and can deliver between 3V and 20V at a maximum continuous power level of 60W (@20V negotiated power delivery).

2.3.3 Maximum Output Power (5VAux+)

The Ag401 has a separate Auxiliary output of 5V which can be used to power a Microcontroller. The maximum power delivery from this output is 5W.

2.3.4 USB Output

2.3.4.1 CC1/CC2

The CC1 and CC2 are Channel Configuration pins. These connections are essential in the power negotiation between the Source and Sink devices required for USB-C power delivery.

2.3.4.2 D+/D-

The D+ and D- connections are the Data pins, forming the data transmission path. The Data output is configured as a differential pair; D+ carrying positively-biassed data whilst the D- carries negatively-biassed data to cancel out the effects of noise and EMC that might otherwise be induced in the final application.

3 Efficiency

The Ag401 has been designed as a high efficiency PoE++ solution.

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Figure 5: Ag401 Efficiency

4 Operating Temperature Range

The core of the Ag401 is a DC/DC converter, while this has been designed to be one of the highest efficiency modules on the market, it is still a power device and thus will generate heat, so it is important that this 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 Ag401 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 output capacitors (on both derived output supplies) that will retain the minimum output capacitance and ESR ratings for the Ag401 at the lowest temperature in the intended operating range are used. A Polymer Aluminium Electrolytic Capacitor is ideal for this application, however reputable brand rated to -55°C should suffice for most applications, please contact Silvertel if suggestions are required.

Full thermal performance of the Ag401 is yet to be verified and is therefore subject to revision.

*due to system losses 70W may not be available at the output.

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Figure 6: Ag401 Operating Temperature Profile

4.1 Thermal Considerations

Each application is different; therefore it is impossible to give fixed and absolute thermal recommendations. Due to the small size of this module, it is important that heat is drawn away from it. It is also important that any enclosure has sufficient ventilation for the Ag401.

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Figure 7: Thermal Relief

5 Protection

5.1 Input Protection

The Ag401 may be damaged by input voltage transients greater than 80V, while the module contains a TVS diode on board, removing the requirement for fitting external protection in the vast majority of applications. 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 VIN+ and VIN- input pins, see Figure and Application Note “ANX-POE-Protection” for more details.

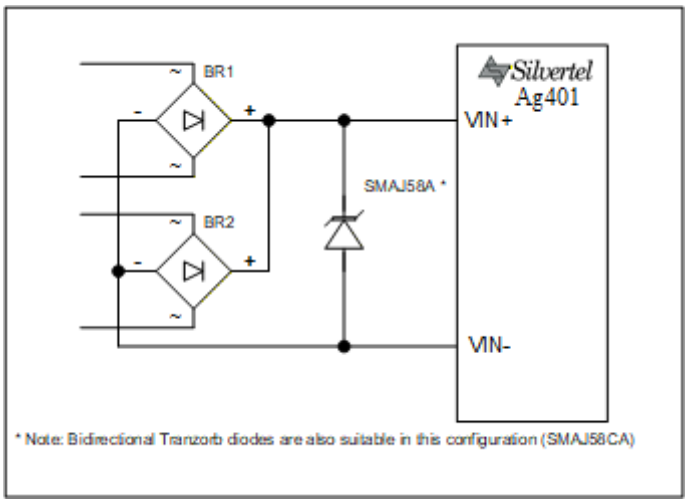

Figure 8: Input Protection

5.2 Output Short Circuit Protection

The Ag401 has various forms of over-current/short circuit protection. This includes short circuit protection for both Aux rail and primary VBus rails as well as over-current current trip on the main USB-PD output.

5.3 Thermal Protection

The Ag401 contains built in thermal protection to prevent the module becoming damaged in the event that it is operated beyond its temperature specification. When the Ag401 has detected it is over temperature, the output will be disabled until the module has cooled sufficiently.

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 Ag401 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 that the isolation barrier is not breached, see ANX-POE-Isolation-Barrier for more details.

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Figure 9: Isolation Barrier

7 EMC

The Ag401 has been designed to pass EN55032 Class B, however the Ag401 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 5, for more details please see ANX-POE-EMI-Considerations.

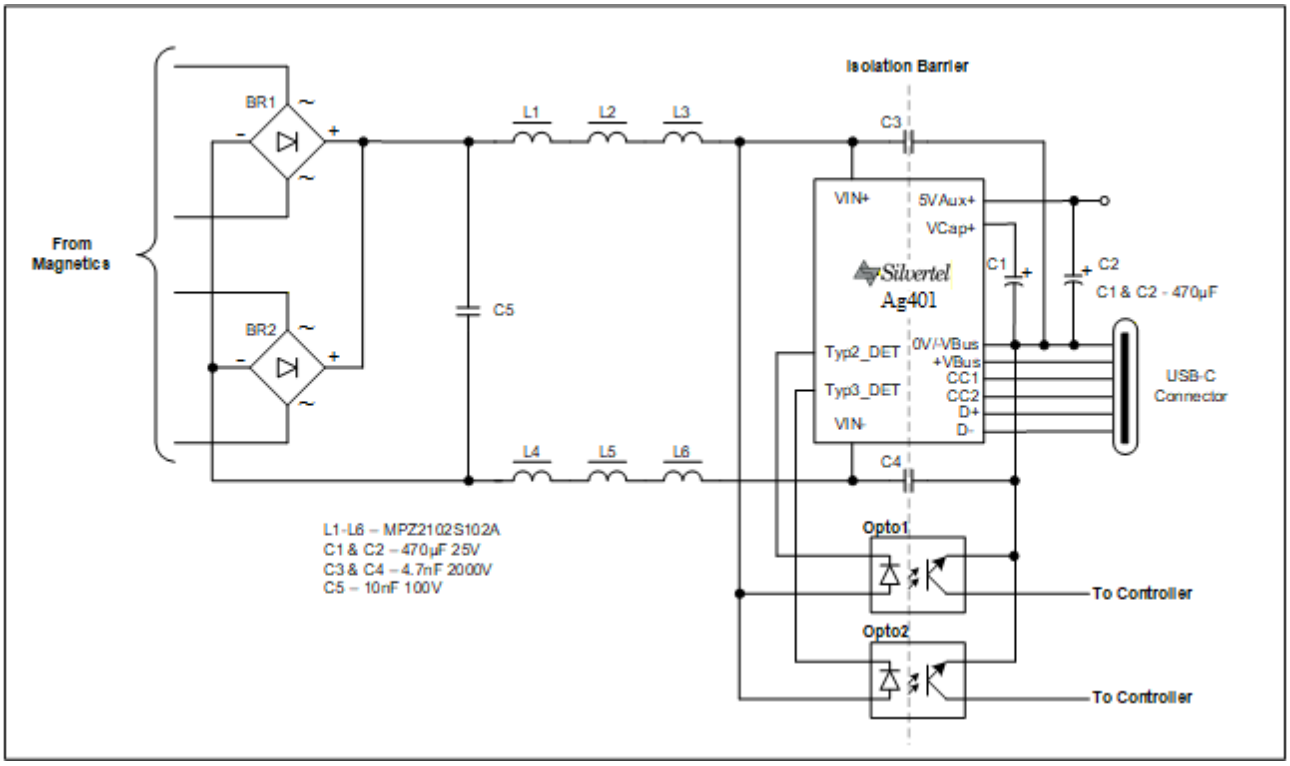

Figure 5: Typical Connection Diagram

8 Electrical Characteristics

8.1 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

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

8.2 Recommended Operating Conditions

	Parameter	Symbol	Min	Typ	Max	Units
1	Supply Voltage	V_{IN}	40	52	57	V
2	Transient Supply Voltage[1]	V_{TRAN}	36			V
3	Input Under Voltage Lockout	V_{ULOCK}	30.2		39.5	V
4	Operating Temperature	T_{OP}	-40	25	85	Ta / °C
5	Output Capacitance	C_{out}	470	470	1000	µF
6	Output Capacitor ESR[2]	C_{ESR}			300	mΩ

Note 1: For transient events lasting between 30µs to 250µs, as detailed in the IEEE802.3 specification

Note 2: At 100kHz

8.3 DC Electrical Characteristics

	DC Characteristic	Sym	Min	Typ[1]	Max	Units	Comments
1	Nominal Output Voltage	V_{Bus}	3		20	V	Negotiated USB power delivery
		V_{Aux}	4.75	5	5.25		
2	Continuous Current output[2]	I_{Bus}		3	3.25	A	Max. load
		I_{Aux}			1		Max. load
3	Line Regulation	V_{Line}		TBD		%	V_{Bus} & V_{Aux} V_{Bus} @ 50% load
4	Load Regulation	V_{Load}		TBD		%	V_{Bus} & V_{Aux} V_{Bus} @ 57V_{in}
5	Ripple and Noise	V_{RN}		TBD		mV_{p-p}	@ Max load
				TBD			
6	Minimum Load	I_{MIN}	0			mA	

	DC Characteristic	Sym	Min	Typ[1]	Max	Units	Comments
7	Short-Circuit Duration	T_{SC}			∞	sec	Continuous @ 25˚C
8	Peak Efficiency[2]	EFF		TBD		%	@ 42.5V_{in}
				TBD			@ 44V_{in}
9	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 57V supply with a 470µF output capacitor fitted and are for design aid only. Not Guaranteed.

Note 2: Minimum 42.5V_{in} for maximum output at 25˚C. Maximum output power may be limited by PSE

9 Package

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Figure 6: Package Dimensions

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