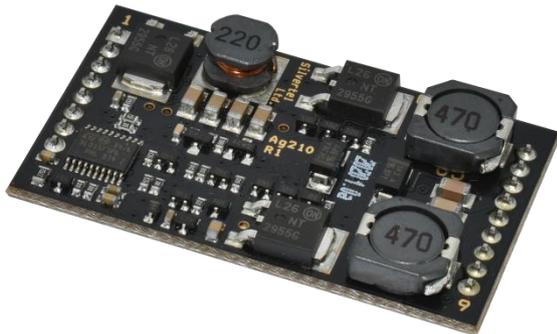




# Ag210

PoE LED Driver

## Features



- Adjustable Constant Current LED Driver
- Auxiliary DC Output (5V-12V)
- IEEE802.3bt compliant with up to 60W Power
- High efficiency (90%)
- Up to 1000mA LED Drive current
- Wide LED String Voltage (4V-40V)
- 0.5V-10V Dimmable capability
- I<sup>2</sup>C interface
- Open Circuit/Short-circuit/Over-Voltage protection
- Under-voltage protection
- Very Long Life - No external electrolytic capacitors required
- Low cost
- Silvertel “design-in” assistance
- Small DIL package

## Description

Silvertel’s Ag210 PoE constant-current LED driver module is designed to combine high power LED lighting applications with PoE connectivity. Conforming to the latest IEEE802.3bt Power-over-Ethernet (PoE) standard the module provides an easily implemented solution for designers/integrators of LED lighting systems.

The Ag210 is pre-configured as a Type 3 Class 6 PD device and capable of extracting a maximum of 60W (measured at the module input) from the PSE. Its wealth of features are all delivered in a tiny package, with an LED drive output capable of driving LEDs with a forward voltage of up to 40V. The Ag210 also provides for an auxiliary DC output to power any external circuitry such as a microprocessor.

The Ag210 incorporates a simple-to-use I<sup>2</sup>C interface allowing users access to lighting features such as “Brightness on Start-up”, “Scene” programming and a “Broadcast” mode to control other LEDs. PWM Dimming can also be performed via the I<sup>2</sup>C interface.

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# 1 Product Overview

## 1.1 Ag210 Product Selector

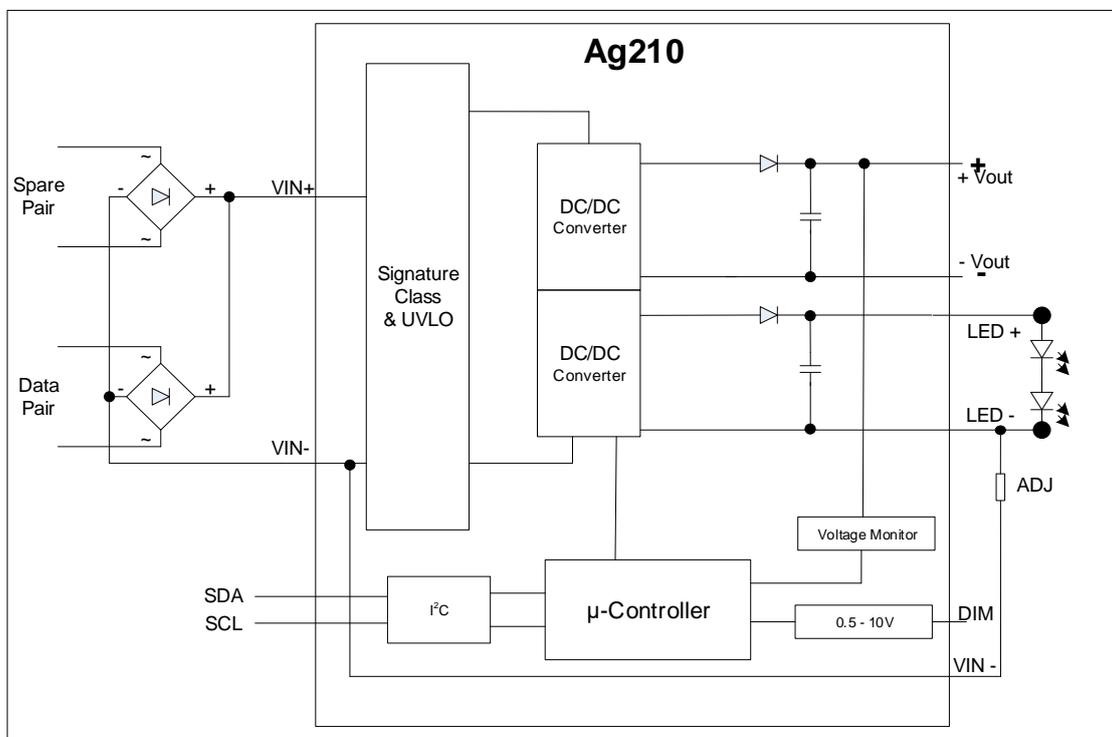
Part Number <sup>1</sup>	Function	Output	Maximum Continuous Output Power <sup>2</sup>	Date code <sup>3</sup> Marking
Ag210	LED Drive	300-1000mA	40 Watts	WWYY
	Auxiliary	5V to 12V	12 Watts	

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: At 25°C with  $V_{IN} = 48V$

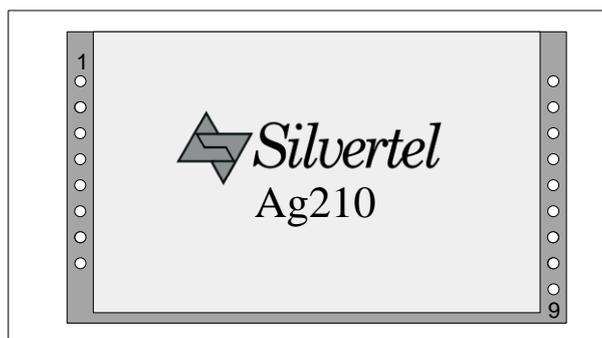
Note 3: Date code format: "WW" = Week Number, "YY" = Year.

**Table 1: Ordering Information**



**Figure 1: Block Diagram**

## 1.2 Package Format



**Figure 2: Ag210 Package Format**

## 1.3 Pin Description

### Input Connector Pins

Pin #	Name	Description
1	VIN+	<b>Direct Input +</b> This pin connects to the positive (+) output of the input bridge rectifier.
2	BT-DET	<b>Type 4 IEEE802.3bt Detect Output</b> This pin indicates if an IEEE802.3bt PSE is supplying Class 6 power to both inputs;
3	IC	<b>Internal Connection</b> Do not connect to this pin.
4	I2C - SDA	<b>Serial Data Analogue Input</b> This high impedance input pin is used in conjunction with the SCL pin to for the I <sup>2</sup> C bus.
5	I2C - SCL	<b>Serial Clock Input</b> This high impedance input pin connects to the I <sup>2</sup> C bus clock.
6	IC	<b>Internal Connection</b> Do not connect to this pin.
7	IC	<b>Internal Connection</b> Do not connect to this pin.
8	VIN-	<b>Direct Input -</b> This pin connects to the negative (-) output of the input bridge rectifier.

### Output Connector Pins

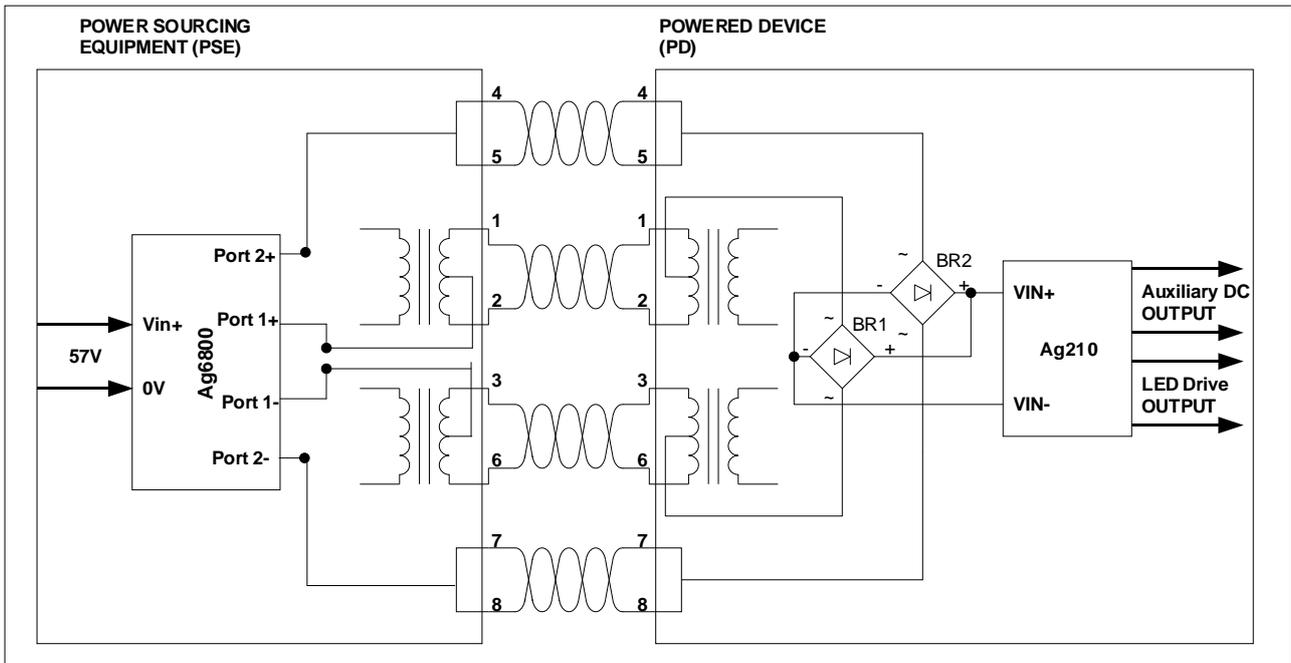
Pin #	Name	Description
9	LED+	<b>DC Output</b> This pin provides the regulated output from the DC/DC converter to the customers LED.
10	LED-	<b>DC Return</b> This pin is the return path for the LED+ output.
11	CA	<b>Current Adjust</b> This pin connects internally to Pin 8 (the negative (-) output of the input bridge rectifier). By connecting a resistor between this pin and the LED- Pin, the LED constant current can be altered.
12	DIM	<b>0.5-10V Dimming control</b> This pin can be connected directly to a positive power supply (0-10V), connected to a potentiometer (25K) or a standard shunt dimmer to set the required brightness.
13	OPT	<b>Option Control</b> This pin can be either left open circuit for I <sup>2</sup> C control or connected directly to -VAUX for 1-10V dimming.
14	+VAUX	<b>DC Output Positive</b> This pin provides the main auxiliary regulated output from the DC/DC converter.
15	VA	<b>DC Voltage Adjust</b> The output voltage can be adjusted from its nominal value, by connecting an external resistor from this pin to the +VOUT pin.
16 & 17	-VAUX	<b>DC Output Negative</b> The ground return for the auxiliary VOUT output as well as the GND reference for the I <sup>2</sup> C bus

**Table 2: Pin Description**

## 2 Functional Description

### 2.1 Input

The Ag210 has a single input that can be connected to two external bridge rectifiers (see Figure 3: Typical System Diagram). The Ag210 is designed to be powered by any IEEE802.3bt compliant PSE such as Silvertel's Ag6800 or Ag6120 PSE modules.



**Figure 3: Typical System Diagram**

### 2.1.1 PD Signature

The Ag210 input complies with the IEEE802.3bt specification and provides signature and control circuitry to give full backwards compatibility with IEEE standards. When the inputs are connected to a Power Sourcing Equipment (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.

### 2.1.2 Power Classification

The Ag210 is Type 3 - Class 6 PD requesting 60W of power from an IEEE802.3bt PSE by displaying the correct class pulses shown in Table 3 below. If the Ag210 is connected to a IEEE802.3at PSE, the PSE will recognise the initial Class 4 pulse from the Ag210 as a Type 2 PD and provide ~25W.

PD Type	Requested Class	Class Pulse A	Class Pulse B	Minimum Requested Power (W)
3	1	1	1	3.84
	2	2	2	6.49
	3	3	3	13
	4	4	4	25.5
	5	4	0	40
	6	4	1	51
4	7	4	2	62
	8	4	3	71.3

**Table 3: Classification Table**

### 2.1.3 PSE Type Detection

The Ag210 has an output pin to visually indicate, via use of an LED, that it has been connected to a PSE that can supply enough power to operate at its full power output. This information can additionally be obtained by interrogating the PSE type detect field over the I<sup>2</sup>C communication protocol. See Section 3.1 I<sup>2</sup>C Interface for more details.

## 2.2 Output

The maximum output power of the Ag210 is limited by the available power at the input pins of the module. An IEEE802.3bt PSE supplying Class 6 power levels shall provide a minimum of 60W at a lowest voltage of 50V from its output, however with connector, cable and diode bridge losses the available power and voltage at the input pins of the Ag210 can vary considerably.

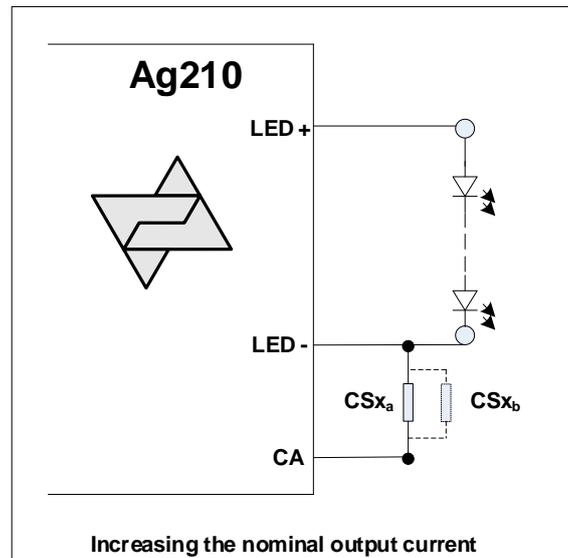
The Ag210 implements buck converter topology; as a result the maximum LED string voltage should always be lower than the input voltage, which will be determined by the cable length and PSE choice. The maximum LED drive current may be reduced if the input voltage is not sufficient.

### 2.2.1 LED Output Connection

The Ag210 has been designed to operate with no electrolytic capacitor connected to its LED output. In order to avoid undesirable operation no capacitor should be fitted across the LED+ and LED- pins.

### 2.2.2 LED Output Current Setting

The Ag210 has a nominal output current of 300mA but this can be adjusted by connecting additional resistors between the LED- and CA Pins as shown in Figure 4: Constant Output Current Adjustment. Table 4 shows common output currents and its associated resistor values. The resistors must be fitted as close as possible to the LED- and CA pins.



**Figure 4: Constant Output Current Adjustment**

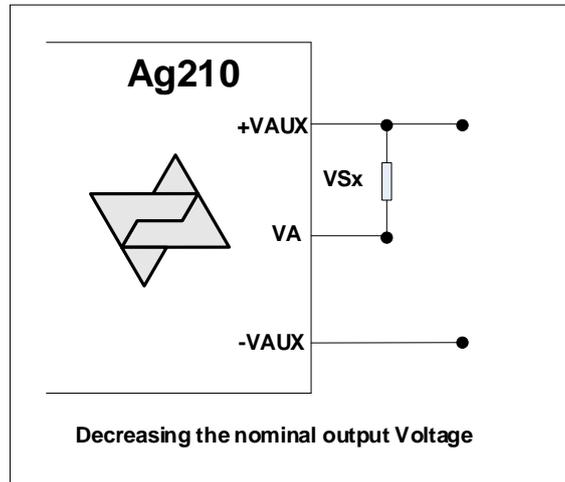
Increase the constant output current, connect CSx between LED- and CA		
I <sub>out</sub>	CS <sub>x</sub> <sub>a</sub> Value (Ohms)*	CS <sub>x</sub> <sub>b</sub> Value (Ohms)*
300mA	Not Fitted	Not Fitted
400mA	5R1	Not Fitted
500mA	2R49	Not Fitted
600mA	3R9	3R
700mA	2R49	2R49
750mA	3R	1R8
800mA	2R	2R
900mA	1R8	1R6
1000mA	1R0	2R49

\*We would recommend a resistor package size of 1206 for the appropriate power dissipation.  
 To set an output current other than listed above please contact Silvertel for information

**Table 4: Output Current Adjustment Resistor Values**

### 2.2.3 Auxiliary Output Voltage Setting

The Ag210 has an auxiliary DC supply (VAUX) that can be used to power the customers' external circuitry such as a microcontroller. The nominal output voltage +VAUX is 12V, however this can be reduced to any voltage down to a minimum of 5V. Table 5 below shows the output voltage and its associated resistor value.



**Figure 5: Output Voltage Adjustment**

Decrease Output Voltage (connect VSx between +VAUX and VA)	
VAUX	VSx Value (Ohms)*
12V	No Fit
5V	6K34

\*To set an output voltage other than listed above please contact Silvertel for information

**Table 5: Output Voltage Adjustment Resistor Values**

### 3 Control

The Ag210 can control the brightness of an LED from 100% down to 5% via its internal digital PWM controller which runs at ~1.25KHz. LED brightness can be set in a number of ways, via the I<sup>2</sup>C interface, connecting a positive supply voltage, a 25K potentiometer or a standard shunt dimmer directly at the DIM (12) pin.

#### 3.1 I<sup>2</sup>C Interface

The Ag210 is a slave device using two pins to connect to the I<sup>2</sup>C interface SCL (serial clock) and SDA (serial data). The interface connections should be referenced to the negative auxiliary supply of the Ag210. It is advisable to include 10kΩ pullup resistors on the SCL and SDA lines.

The I<sup>2</sup>C interface is implemented with use of a controller, to decode any chosen protocol carried over the network, being installed alongside the Ag210, as such; the interface signals are unbuffered prior to the microcontroller on the Ag210. If a long cable is to be used to carry the I<sup>2</sup>C signals, buffering should be added in order to protect the Ag210 from damage.

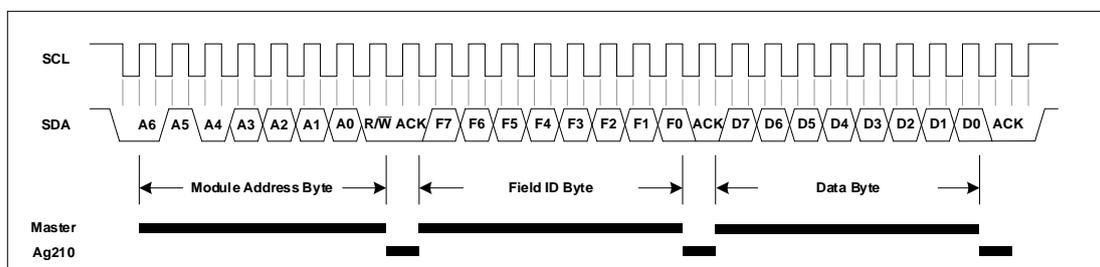
##### 3.1.1 I<sup>2</sup>C Parameters

Field name	Field ID	Default Value	Data Range	Read/Write	Stored in EPROM	Notes
LED Brightness	0x00	0x00	0 - 255	Read/Write	No	0 = LED off, 1 = 5%, 255 = 100%
Power up LED Brightness	0x01	0xFF	0 - 255	Read/Write	Yes	
Diming Time	0x02	0x10	0 - 255	Read/Write	Yes	Time taken to transition to the target diming value. Approximate time = DimTimeValue x 32ms Default value approx. 0.5 seconds
I2C Address	0x03	0x50	1-127	Read/Write	Yes	MSB to reset to default
I2C General Address	0x04	0x77	1-127	Read/Write	Yes	MSB to disable general address
PSE Type Detect	0x05	-		Read	-	Connected PSE type detected
Pre settable scenes	Run	0x1x	0 - 255	Read/Write	Yes	1 field value for setting and one for recalling
	Setup	0x2x				
Major Firmware Version	0xFD	1	-	Read	No	Fixed info on modules firmware version.
Minor Firmware Version	0xFE	0x0A	-	Read	No	Fixed info on modules firmware version.
Memory Reset	0xFF	-		Write	-	Reset all fields to defaults for testing and debug purposes

**Table 6: I<sup>2</sup>C Parameters**

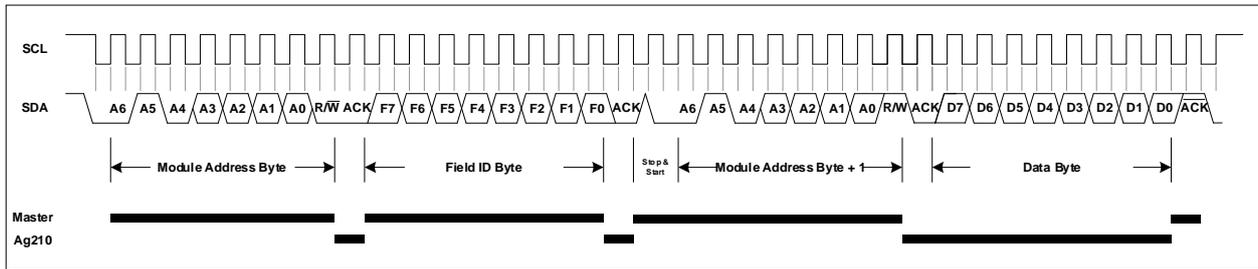
##### 3.1.2 I<sup>2</sup>C Protocol

To write to a field on the slave the data should be sent as per Figure 6.



**Figure 6: Writing to a Register**

To read a field from the slave the following should be sent.



**Figure 7: Reading a Register**

### 3.1.3 I<sup>2</sup>C Module Address

The Ag210 can be addressed using one of two addresses, the module address and the general address.

The module address is for communicating with a particular slave, and is by default set to 0x50 and can be changed to any value between 0x01 and 0xEF. Setting the MSB high will reset the module address to 0x50.

The general address is used to broadcast to all slaves listening to that address, as a result should only be used to perform write calls. The general address can be set just as the module address; however setting the MSB high will disable the use of the general address.

### 3.1.4 I<sup>2</sup>C Dimming

To dim the LED via I<sup>2</sup>C, first send the module address of the desired dimmer, then send the field ID, 0x00, followed by the desired dimming value sent as 1 Byte, where 0 is off and 1 to 255 is 5% to 100%.

To calculate the Dim Value to use for percentages between 5% and 100% use the formula:

$$\text{Dim Value} = \frac{\text{Dim}\% - 5}{95} \times 254 + 1$$

In addition to dimming the I<sup>2</sup>C provides a number of other functions as detailed in Table 6.

### 3.1.5 I<sup>2</sup>C Scenes

The Ag210 has the ability to store and recall up to 16 scenes. Each scene contains a single brightness value.

To save a new scene, a brightness value should be written to field ID 0x2x, where the final four bits denote the scene number that is to be written to.

To recall a scene, a read command should be sent to field ID 0x1x, where the final four bits denote the scene number that is to be recalled

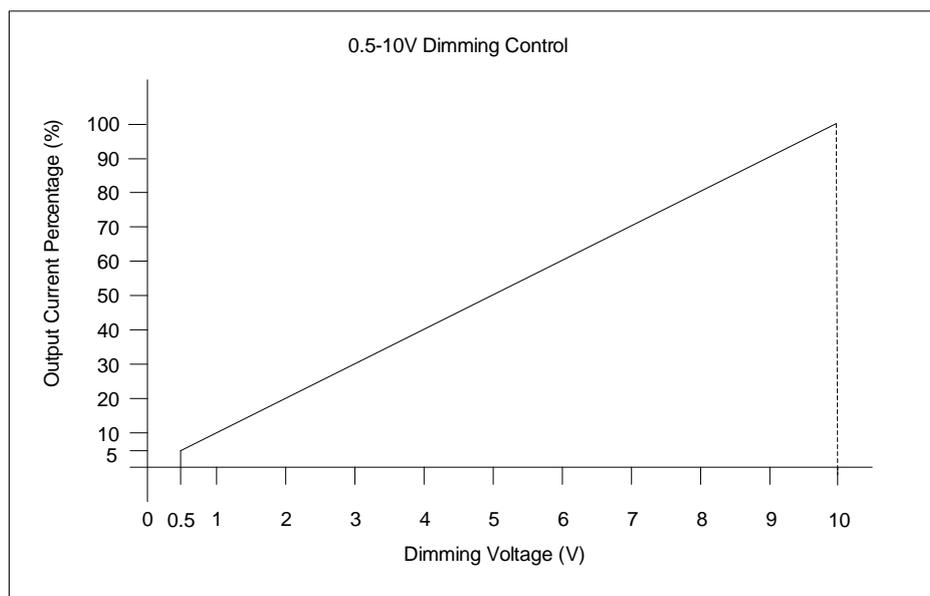
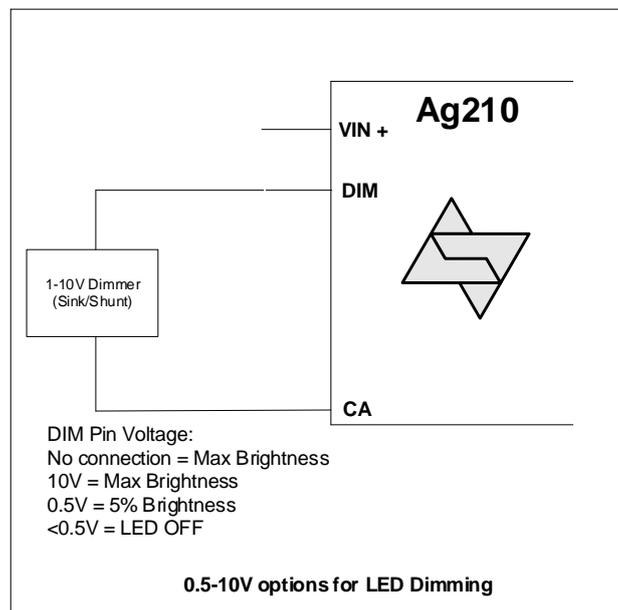
### 3.2 0.5-10V Dimming Control

The Ag210 DIM pin has an open circuit voltage of 11V providing a 0.7mA maximum current source enabling the customer to use a conventional dimmer to shunt the current, allowing the LED brightness to be dimmed from 100% - 5% using its internal digital PWM controller, as shown in Figure 8.

The DIM pin may also be over-riden by using an external voltage source.

Please note: Care must be taken to ensure no more than 10.5V is fed into the DIM pin as this can cause damage to the Ag210.

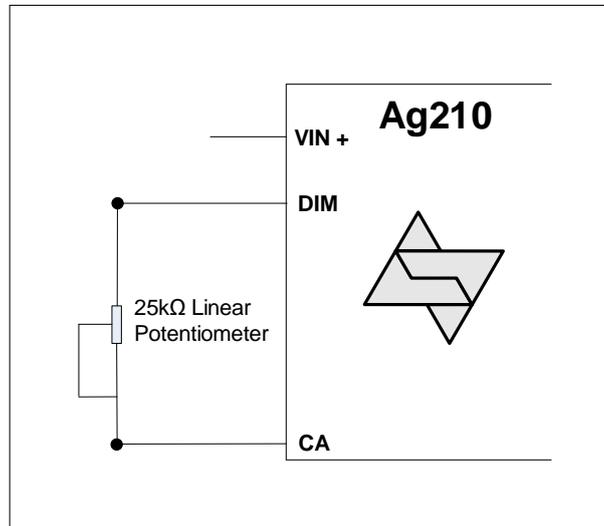
When the voltage on the DIM pin drops below 0.5V the LED will be turned off, as shown in Figure 8.



**Figure 8: 0.5-10V Dimming Control**

### 3.3 Resistive Dimming Control

The Ag210 DIM pin can be set using a 25kΩ linear potentiometer to CA as shown in Figure 9. This allows the LED to be dimmed from 100% to 0% using the modules internal digital PWM controller.



**Figure 9: Resistive Dimming Control**

## 4 Protection

### 4.1 Input Protection

The Ag210 must be protected from over-voltages exceeding the 80V maximum rated surge input voltage. An inexpensive but effective solution can be achieved by connecting a Transorb diode across the input; see Apps Note “ANX-POE-Protection”.

### 4.2 LED Output Protection

#### 4.2.1 Short Circuit Protection

The Ag210 is a constant current power device and thus when a short is applied to the output the Ag210 limits the current into the short to the output current which has been set via the CSx resistor.

#### 4.2.2 Open Circuit Protection

The Ag210 features open circuit clamping protection. The LED output voltage will be clamped to 48.5V if the output is left unloaded.

### 4.3 Auxiliary Output Short Circuit Protection

When a short is applied across the Auxiliary output, power will be withdrawn without any affect to the LED drive. The Ag210 will check whether the short has been removed approximately every 2 seconds until the short is removed, at which time the power is restored to the output.

### 4.4 Thermal Protection

The Ag210 does not contain any thermal protection so it is important that the maximum operating temperature is not exceeded.

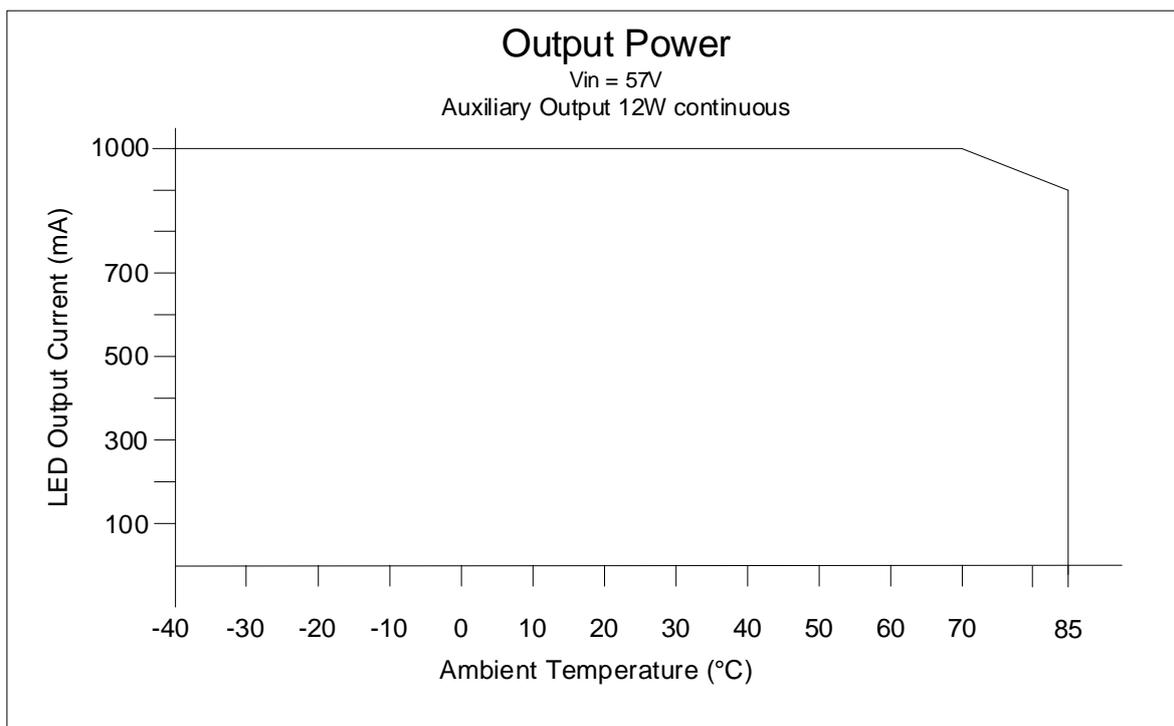
## 5 Operating Temperature Range

The Ag210 is a power component and will generate heat so it is important that this is taken into consideration at the design stage.

The core of the Ag210 is a DC/DC converter, which like any other power supply will generate heat. The amount of heat generated by the module will depend largely on the output current the device is supplying.

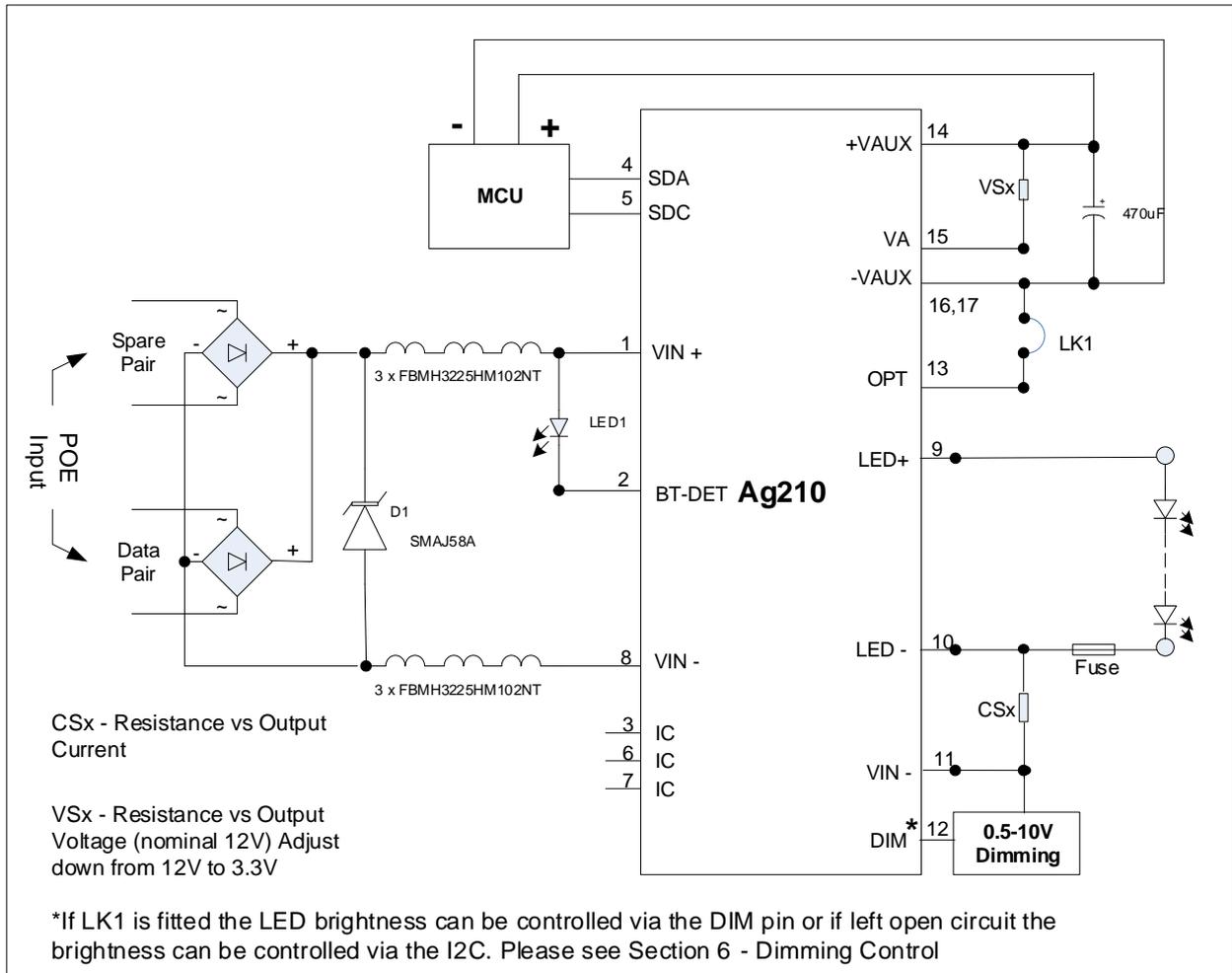
The Ag210 can operate up to a maximum of 85°C ambient, however the maximum LED current at temperatures over 70°C may need to be reduced to 900mA in order to prevent damage to the module. This derating is independent of the load applied to the auxiliary output. These results were performed in an environment chamber - Associated Environmental System SD-302, without any heat-sinking. The thermal performance of the Ag210 can be improved by forcing the airflow directly over the part or by using thermal relief pads to draw heat away from the module.

The Ag210 does not have thermal protection so it is important that the maximum operating temperature is never exceeded.



**Figure 10: Operating temperature**

## 6 Typical Application



**Figure 11: Typical Connection Diagram**

## 7 Efficiency

The Ag210 achieves an efficiency of 90% when both supplies are fully loaded with the Auxiliary supply set to 12V

## 8 Isolation

The Ag210 is a non-isolated module and in order to fully conform to the IEEE 802.3bt 1500V isolation requirements, the module and its associated circuitry (including the LED) must be isolated from the user. This is normally achieved without additional components and by using a suitable enclosure. Contact Silvertel for further details

## 9 EMC

The Ag210 has been designed to pass EN55032 Class B, however the Ag210 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 extensive experience we would recommend an inexpensive but effective solution to reduce emissions as shown in Figure 11.

## 10 Electrical Characteristics

### 10.1 Absolute Maximum Ratings

	Parameter	Symbol	Min	Max	Units
1	DC Supply Voltage	V <sub>CC</sub>	-0.3	60	V
2	Storage Temperature	T <sub>S</sub>	-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.

### 10.2 Recommended Operating Conditions

	Parameter	Symbol	Min	Typ	Max	Units
1	Input Supply Voltage <sup>1</sup>	V <sub>IN</sub>	36	50	57	V
2	Input Under Voltage Lockout	V <sub>LOCK</sub>	32		36	V
3	Operating Temperature	T <sub>OP</sub>	-40	25	85	T <sub>a</sub> / °C

Note 1: 42.5V input required for maximum load on either Auxiliary or LED drive outputs

### 10.3 DC Electrical Characteristics

#### 10.3.1 Auxiliary Supply

	DC Characteristic	Sym	Min	Typ <sup>1</sup>	Max	Units	Comments
1	Nominal Aux DC Output Voltage	+V <sub>OUT</sub>	4.75	12	12.5	V	
2	Continuous Aux Current output	I <sub>AUX</sub>		1	1.5	A	@12V Max 1A @5V Max 1.5A
3	Aux Line Regulation	I <sub>LINE1</sub>		0.1		%	
4	Aux Load Regulation	I <sub>LOAD1</sub>		1.0		%	
5	Aux Ripple and Noise	I <sub>RN</sub>		81		mV <sub>p-p</sub>	@ Max load
6	Minimum Load	I <sub>MIN</sub>	0			mA	

Note 1: Typical figures are at 25°C with a nominal output voltage = 40V and are for design aid only. Not Guaranteed.

### 10.3.2 LED Driver

	DC Characteristic	Sym	Min	Typ <sup>1</sup>	Max	Units	Comments
1	LED Open Circuit Clamp Voltage	V <sub>CLAMP</sub>		48.5		V	
2	Nominal Output Voltage	+V <sub>DC</sub>	4		40	V	
3	Idle Current	I <sub>IDLE</sub>		29	41	mA	
4	LED Output Current <sup>2</sup>	I <sub>LED</sub>	300		1000	mA	
5	Dimming Range	V <sub>DIM</sub>	5		100	%	
6	DIM Voltage (Injected)	V <sub>DMax</sub>			10.5	V	voltage injected into the module for dimming
7	Dimming Frequency	F <sub>DIM</sub>		1.25		KHz	
8	LED Line Regulation (36V-57V)	I <sub>LINE2</sub>		0.2	0.5	%	
9	LED Load Regulation - Min to Max (2V-40V)	I <sub>LOAD2</sub>		1.5	2.0	%	
10	LED Output Current Drift	I <sub>REG</sub>	0		1.1	%	
11	Max Output Current Deviation (combined)	I <sub>DEV</sub>	0		3.6	%	
12	Output Ripple and Noise <sup>3</sup> Ratio	V <sub>RN</sub>		1:1.1 5	1:1.3 <sup>4</sup>	mVp- I <sub>Av</sub>	Ratio of peak to average current
13	Short-Circuit Protection	T <sub>SC</sub>			I <sub>out</sub>	A	Current held at set I <sub>out</sub> via CSx
14	Peak Efficiency (combined)	Eff		90.0		%	40W LED power, 12V 1A Auxiliary

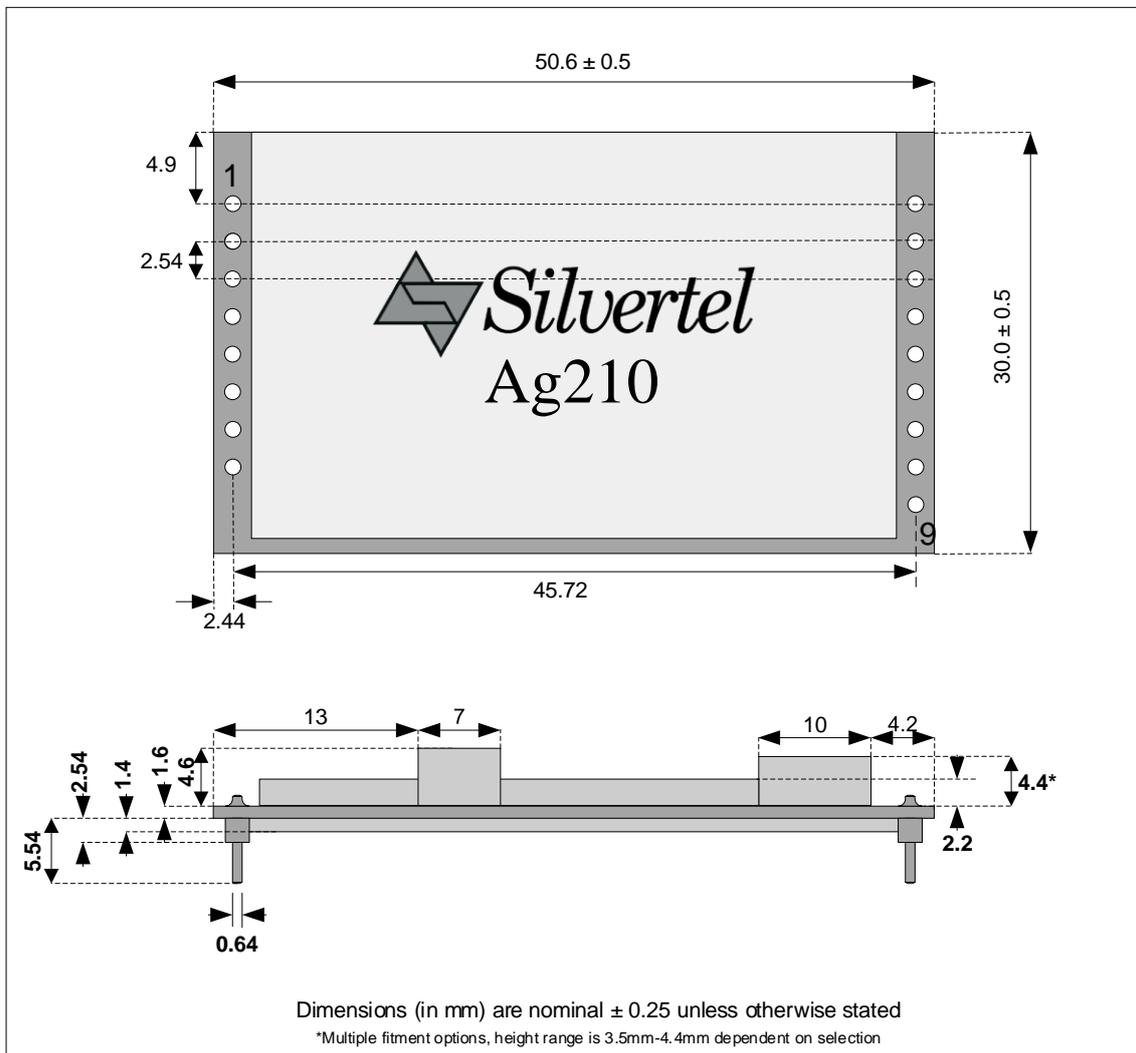
Note 1: Typical figures are at 25°C with a nominal output voltage = 40V and are for design aid only. Not Guaranteed.

Note 2: See Table 4

Note 3: Measurements made on a Picoscope with a 200MHz (x1) probe.

Note 4: Measured with a 30V LED running at 300mA

## 11 Package



**Figure 12: Package Dimensions**

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