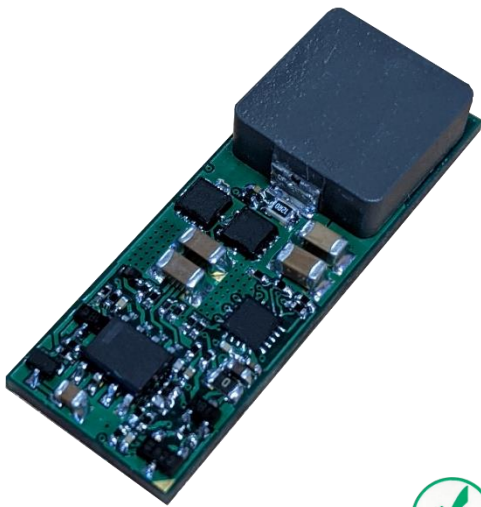# Silvertel

Ag7010

**High Efficiency Point of Load
Buck Converter Module**

Features

> ➢ >97% efficient DC/DC converter
> ➢ PMBus enabled
> ➢ 3V-12.7V output voltage
> ➢ 10A output current
> ➢ Wide input voltage range 8V-24V
> ➢ Very low heat output
> ➢ Low output ripple & noise
> ➢ Configurable UVLO, OVLO and thermal protection
> ➢ Overload & short-circuit protection
> ➢ Industrial temperature range
> ➢ Minimal external components required
> ➢ Low profile SMT package size – 37.4mm (L) x 14.4mm (H)
> ➢ Silvertel "design-in" assistance

Description

The Ag7010 is a low noise DC/DC buck converter featuring integrated PMBus commands through I^2C for use in a wide variety of point of load (PoL) and DC-DC converter applications including USB Powered Device (PD), Apple Lightning and Intel Thunderbolt.

The high efficiency DC/DC converter can achieve greater than 97% efficiency and operates over a wide input voltage range with low noise performance and low output ripple. The DC/DC converter also has built-in output overload, output short-circuit and over-temperature protection.

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1 Product Overview

1.1 Ag7010 Product Selector

Part Number[1]	Nominal Output Voltage	Output Current	Marking[2]
Ag7010	3V	10A Continuous	ab05c

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 Sensitivity 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.
The two digits are the nominal output voltage,
The final letter, c, is a Silvertel reference.

Table 1: Ordering Information
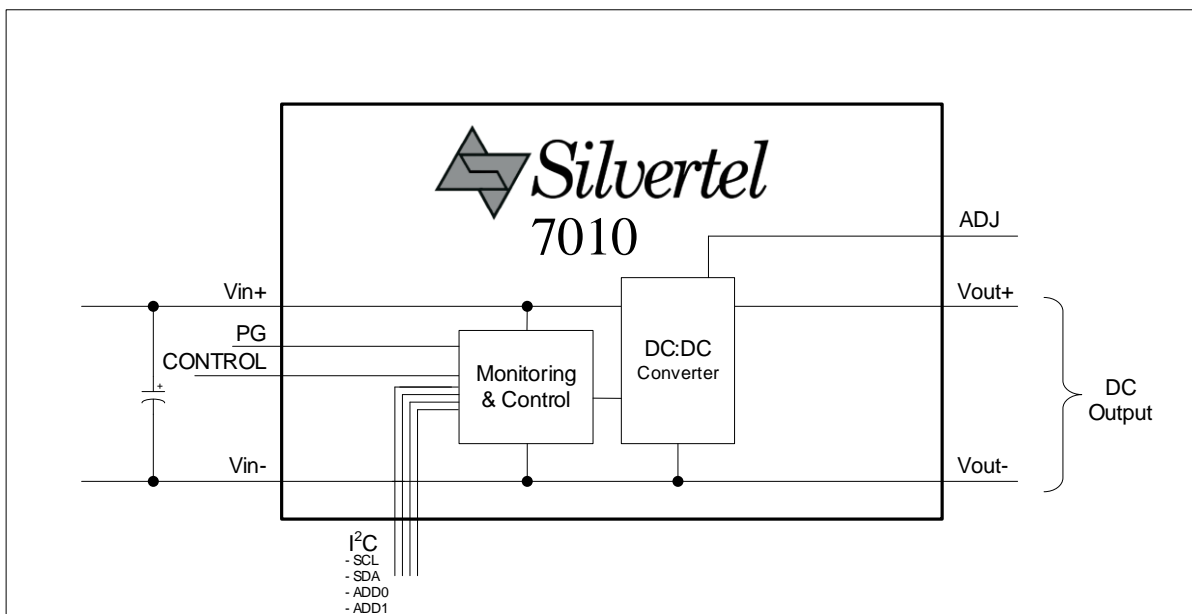
Figure 1: Block Diagram

1.2 Package Format
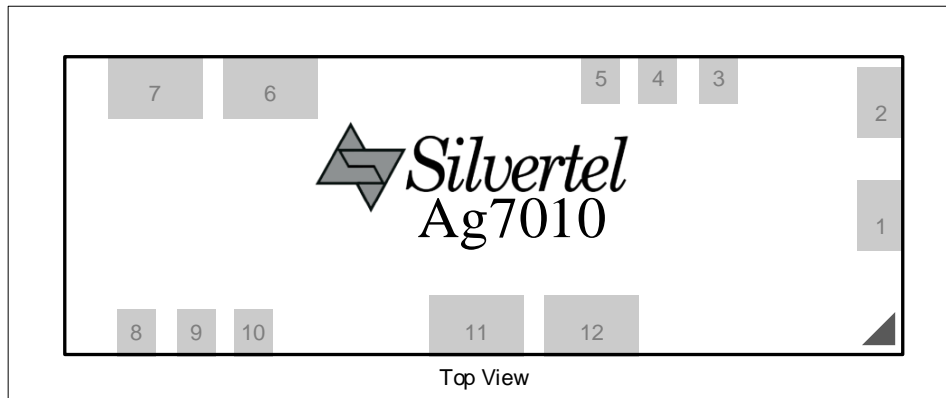
Figure 2: Ag7010 Package Format

1.3 Pin Description

Pin #	Name	Description
1	PG	**Power Good.** High signal indicates supply power.
2	CONTROL	**DC/DC Converter Enable Control.** Pull this pin low to disable the DC/DC converter, can be inverted or disabled as per PMBus specification
3	IC	**Internal Connection.** Do not connect to this pin.
4	ADD0	**I2C Address bit0.** Internally pulled HIGH
5	ADD1	**I2C Address bit1.** Internally pulled HIGH
6	Vin+	**High Supply.** This pin connects to the positive (+) supply
7	Vin-	**Low Supply.** This pin connects to the reference of the positive supply
8	SCL	**Serial Clock Input.** This high impedance input pin connects to the I^{2}C bus clock.
9	SDA	**Serial Data Analogue Input.** This high impedance input pin is used in conjunction with the SCL pin to for the I^{2}C bus.
10	ADJ	**Output Adjust.** The output voltage can be adjusted from its nominal value, by connecting an external resistor from this pin the Vout- pin.
11	Vout-	**Negative DC Output.** This pin provides the negative regulated output from the Ag7010 and is internally connected to pin 7.
12	Vout+	**Positive DC Output.** This pin provides the positive regulated output from the Ag7010.

Table 2: Pin Description

2 Functional Description

2.1 Typical Connections

The Ag7010 requires only a few external components for operation. The 470µF capacitor (C1) connected across the input is required for correct operation of the DC/DC converter. This capacitor must be positioned as close to the input pins as possible for optimal stability. This can be a low-cost electrolytic capacitor for operation in temperatures down to 0°C (a minimum of 470µF 16V is recommended for 12V supply) as shown in Figure 3. 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, R1, between the ADJ pin and the Vout– pin, see section 2.5.2 Output Voltage Adjust Setting for more details.
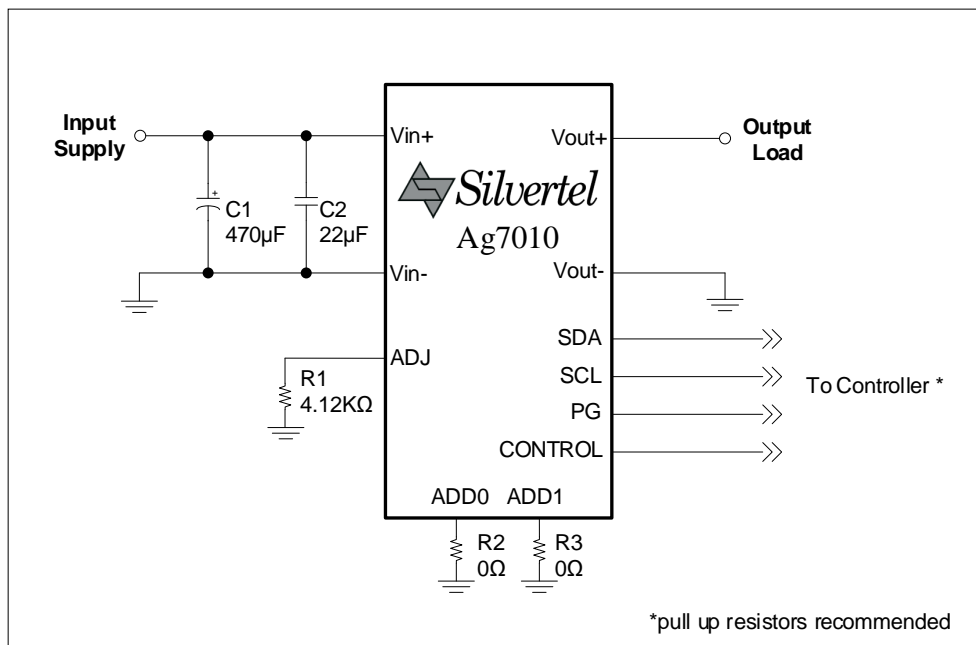
Figure 3: Typical System Diagram

2.2 Input

The Ag7010 has two input pins VIN+ and VIN-, these pins should be connected to an 8V-24V supply (see Figure 3: Typical System Diagram). For stability it is recommended that an 470µF electrolytic and a 22µF ceramic capacitor be fitted across these pins.

2.3 Enable/Disable

The Ag7010 has an Enable/Disable pin, CONTROL, the default operation is pulling this pin LOW will disable the output of the module, internally pulled HIGH.

This can be configured to invert or disable the pin operation as described in the PMBus specification, see section 4.3.1.2 for more details.

2.4 Power Good

The Ag7010 features a Power Good Output, PG, this will pull HIGH when the output has reached a regulated output voltage. This can be used for power sequencing.

2.5 **Output**

2.5.1 **Maximum output power**

Whist the Ag7010 can deliver a continuous output current of 10A, with up to 120W of continuous power, the peak output power may be reduced as a result of the operating conditions the module is operating in.

2.5.2 **Output Voltage Adjust Setting**

The Ag7010 has a nominal output of 3V, but with use of the output voltage adjustment pin, ADJ, this can be increased to a maximum of 12.7V at the output of the Ag7010.

+VDC

ADJ

R_{adj}

-VDC

Increasing the output voltage from nominal
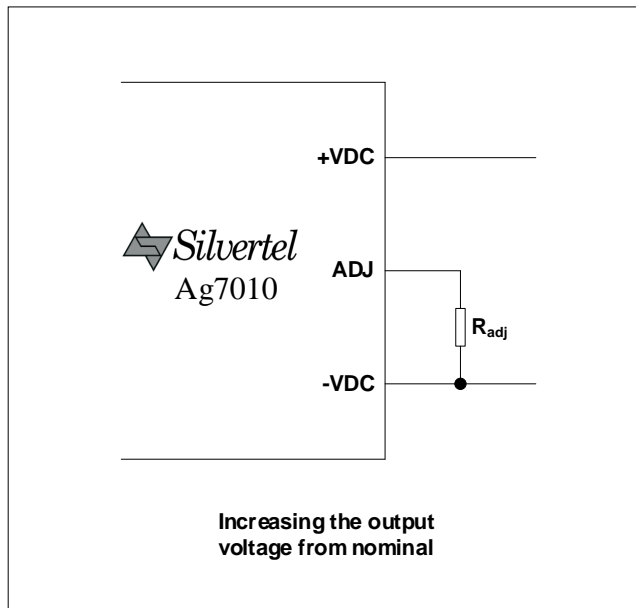
Figure 4: Output Voltage Adjustment

$$R_{adj} = \frac{37.2k}{V_{OUT} - 3.08}$$

R_{adj}				
Desired Output voltage	3V	3.3V	5V	12V
Recommended standard resistor Value of RA	OC	169K	19.1K	4.12K

Table 3: Common Output Voltage Adjustments with standard Resistor Values

Note 1: It is important that the output is not taken above 12.7V. Setting the output voltage above this level may result in the module being permanently damaged.

3 Efficiency

The Ag7010 has been designed as a high efficiency DC/DC solution,
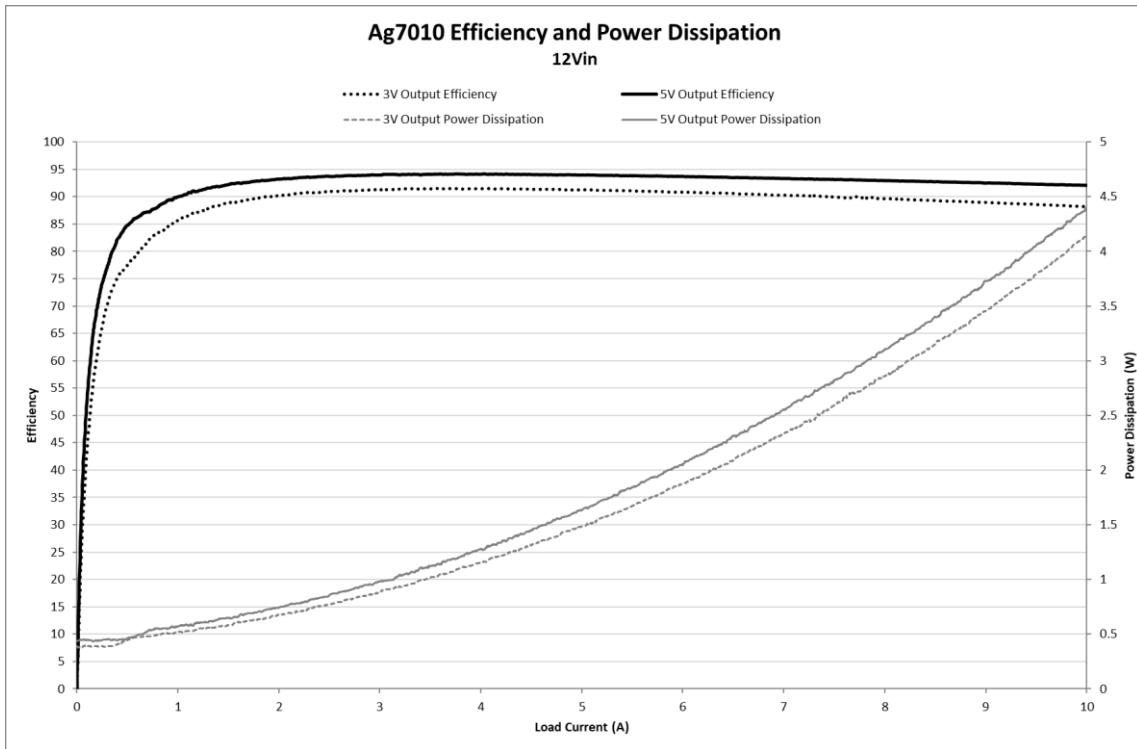
Figure 5: Ag7010 Efficiency with 12V Supply
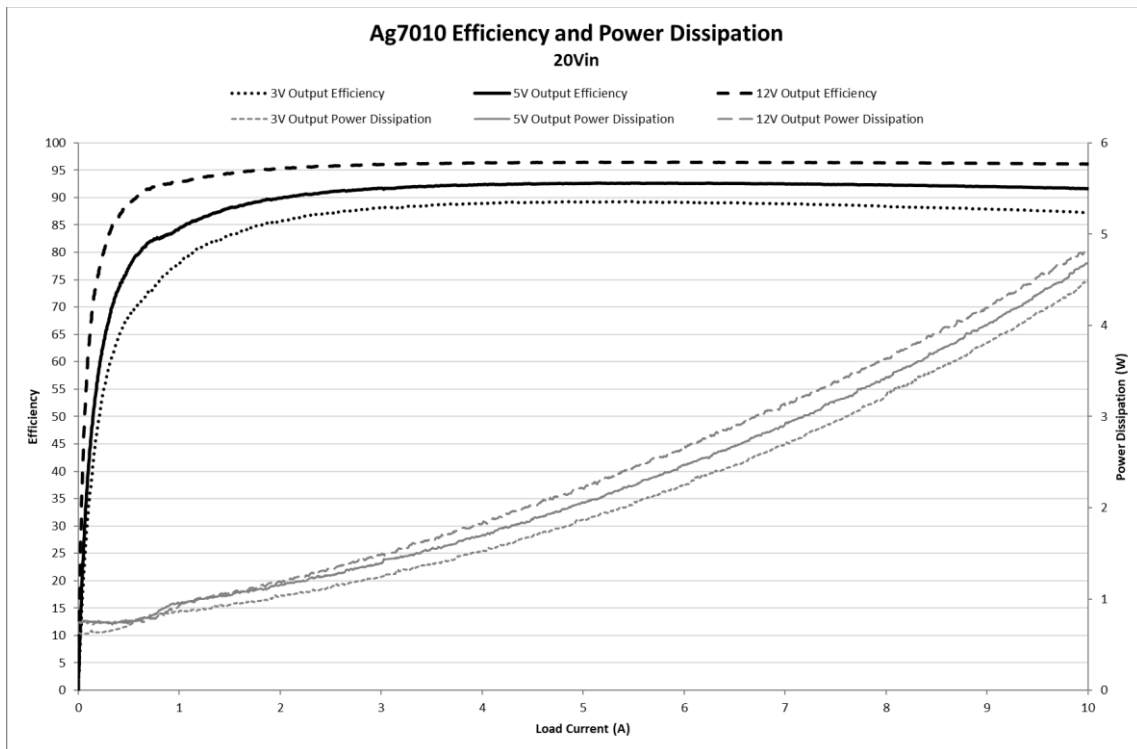
Figure 6: Ag7010 Efficiency with 20V Supply
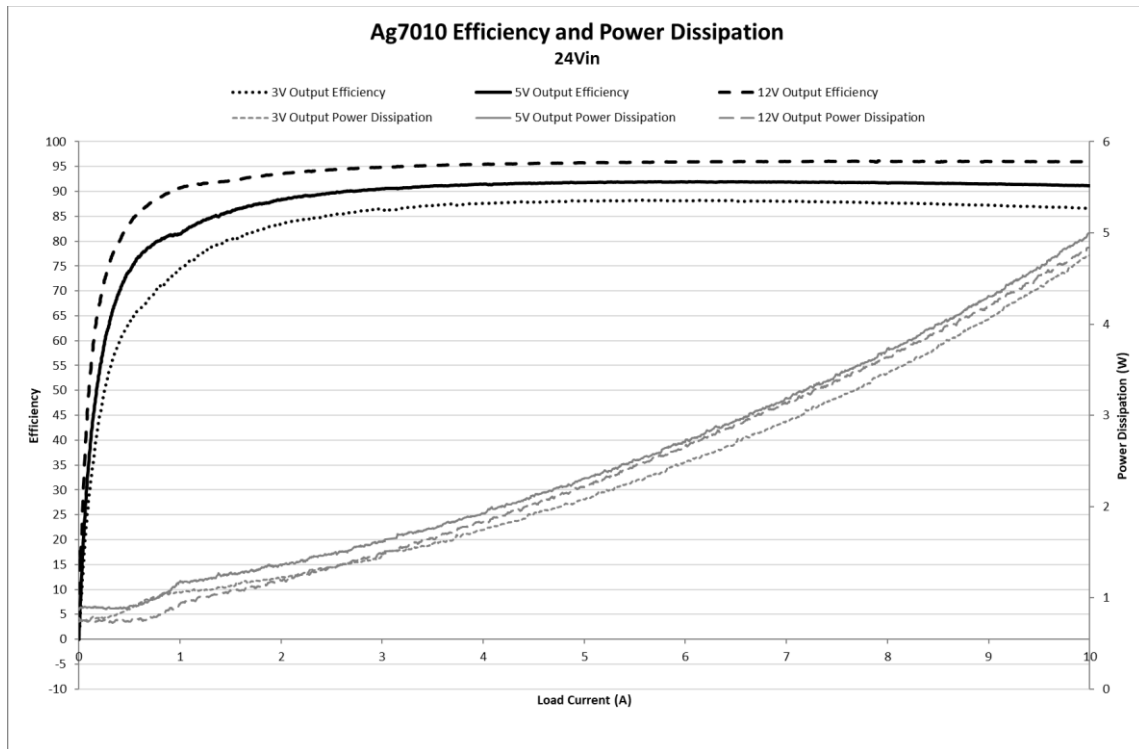
Figure 7: Ag7010 Efficiency with 24V Supply

4 I^{2}C Interface

The Ag7010's I^{2}C interface supports PMBus commands and is designed to the PMBus rev 1.3 specification. This allows for the configuration, control and monitoring of the DC/DC converter by a system controller.

The Ag7010 is a slave device using two pins to connect to the I^{2}C interface SCL (serial clock) and SDA (serial data). The interface connection should be referenced to the negative input supply V$_{in}$- and is compatible with a 3V and 5V bus.

The interface signals are unbuffered prior to the microcontroller on the Ag7010. If a long cable is to be used carrying the I^{2}C signals, buffering should be added to protect the Ag7010 from damage. It is advisable to include 10kΩ pullup resistors on the SCL and SDA lines.

4.1 I^{2}C Module Address

Up to four Ag7010 Modules can operate on the same I^{2}C communication bus by configuring the module address, this can be performed by pulling pins ADD0 and ADD1 low to change the I^{2}C address of the module, a power cycle may be required if the I^{2}C address is modified while the module is powered.

The modules Address byte will be 10101A$_1$A$_0$W, where A is the logic level of the ADD0 and ADD1 pins, and W is the read/write command.

4.2 I²C Protocol

4.2.1 Write Byte

Writing to a register in the slave device is performed with the protocol below.
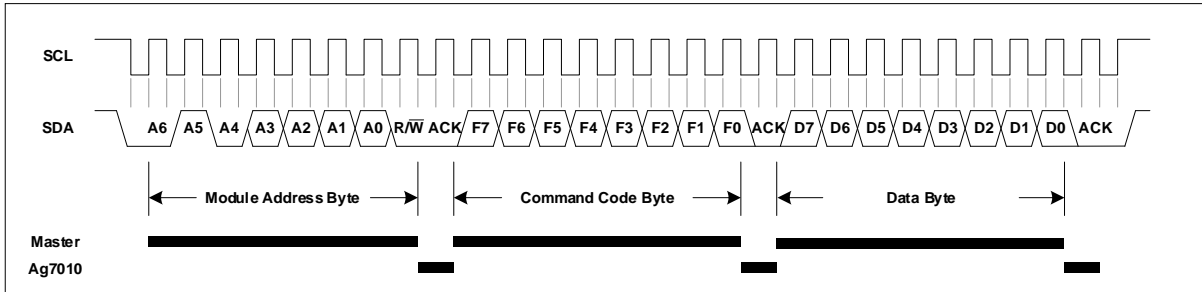
Figure 8: Writing to a Register

4.2.2 Read Byte

To read a register from the slave device the below protocol is used. If more than one byte is to be requested, then the master should respond to the data byte with an Acknowledge until it has received the expected number of bytes.

Figure 9: Reading a Register

4.2.3 Block Read, Block Write

Some of the supported PMBus commands implement a Block Read or Block Write & Block Read protocol. In the case of a block read or write command, the first transmitted data byte will be a count of the data bytes that are to follow.

Figure 10: Block Read, Block Write

4.3 PMBUS commands

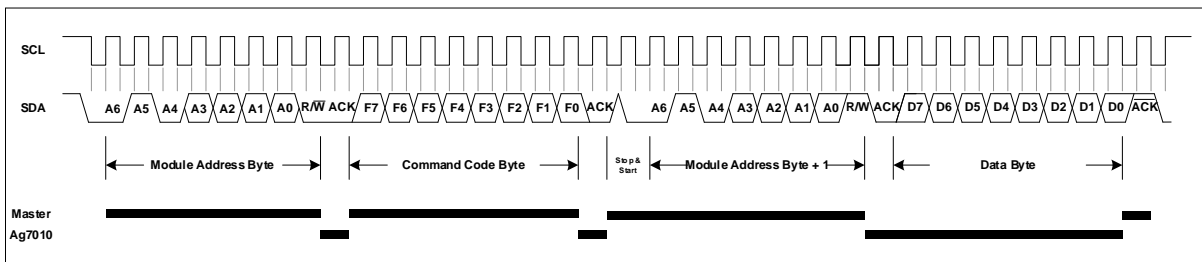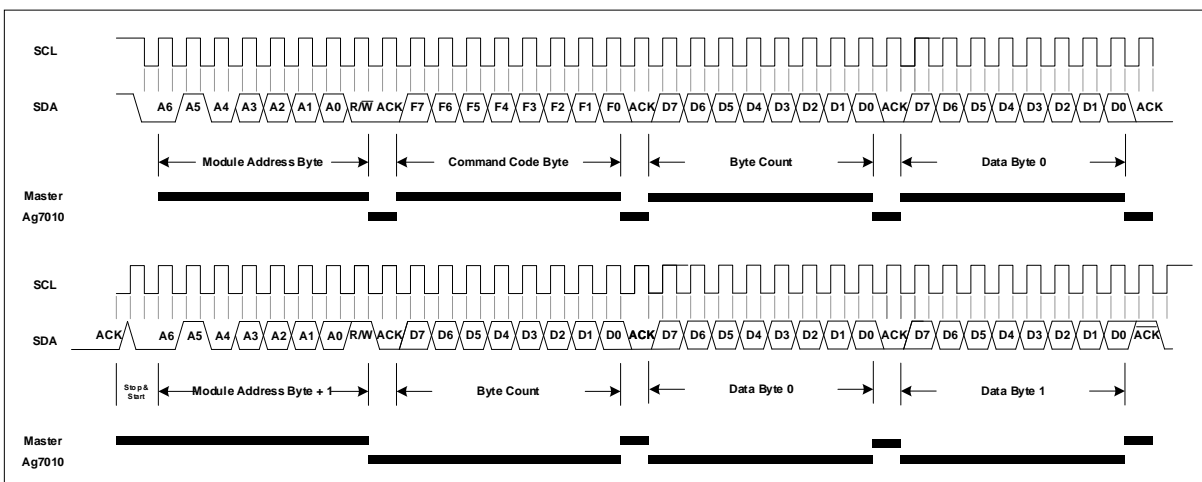| Category	Command Name	Command Code	Read	Write	# Data Bytes	Mem store	Default Value	Range	Conversion	QUERRY Command Response	Description
ON OFF Configuration	OPERATION	01h	✓	✓	1	✓	0x80	-	-	0xFC	Enable or disable the output of the module
	ON_OFF_CONFIG	02h	✓	✓	1	-	0x1F	-	-	0xFC	Configure the ON/Of control for the module
Input Configuration	VIN_ON	35h	✓	✓	2	-	625 (6.75V)	568 - 2480 (6-26.5V)	$\alpha = 92.5 \times V_{in}$	0xF8	Configure the voltage required before the module will enable the output
	VIN_OFF	36h	✓	✓	2	-	568 (6.1V)	568 - 2480 (6-26.5V)	$\alpha = 92.5 \times V_{in}$	0xF8	Configure the voltage before the module will disable the output
	VIN_OV_FAULT_LIMIT	55h	✓	✓	2	-	2480 (26.8V)	625 - 2480 (7-26.5V)	$\alpha = 92.5 \times V_{in}$	0xF8	Configure the voltage that will trigger the "Input Over Voltage Fault" flag
	VIN_OV_FAULT_RESPONSE	56h	✓	✓	1	-	0xF8	-	-	0xFC	Configure how the module recovers from an over voltage fault
	VIN_OV_WARN_LIMIT	57h	✓	✓	2	-	2420 (26.1V)	625 - 2481 (7-26.5V)	$\alpha = 92.5 \times V_{in}$	0xF8	Configure the voltage that will trigger the "Input Over Voltage Warning" flag
	VIN_UV_WARN_LIMIT	58h	✓	✓	2	-	590 (6.4V)	567 - 2480 (6-26.5V)	$\alpha = 92.5 \times V_{in}$	0xF8	Configure the voltage that will trigger the "Input Under Voltage Warning" flag
	VIN_UV_FAULT_LIMIT	59h	✓	✓	2	-	615 (6.25V)	566 - 2480 (6-26.5V)	$\alpha = 92.5 \times V_{in}$	0xF8	Configure the voltage that will trigger the "Input Under Voltage Fault" flag
	VIN_UV_FAULT_RESPONSE	5Ah	✓	✓	1	-	0xFB	-	-	0xFC	Configure how the module recovers from an under voltage fault
Vout Configuration	VOUT_OV_FAULT_LIMIT	40h	✓	✓	2	-	2177 (12.8V)	595 - 2213(3.5-13V)	$\alpha = 170.1 \times V_{out}$	0xF8	Configure the voltage that will trigger the "Output Over Voltage Fault" flag
	VOUT_OV_FAULT_RESPONSE	41h	✓	✓	1	-	0xF8	-	-	0xFC	Configure how the module recovers from an over voltage fault
	VOUT_OV_WARN_LIMIT	42h	✓	✓	2	-	2212 (13V)	596 - 2212 (3.5-13V)	$\alpha = 170.1 \times V_{out}$	0xF8	Configure the voltage that will trigger the "Output Over Voltage Warning" flag
Iout Configuration	IOUT_OC_FAULT_RESPONSE	47h	✓	✓	1	-	0xFB	-	-	0xFC	Configure how the module recovers from an over current fault
Temperature Configuration	OT_WARN_LIMIT	51h	✓	✓	2	✓	162 (115C)	2048 - 182 (25-110c)	See Datasheet for formula	0xF8	Configure the Temperature that will trigger the "Over Temperature Warning" flag
	OT_FAULT_LIMIT	4Fh	✓	✓	2	-	125 (125 C)	2048 - 125 (25-110c)	See Datasheet for formula	0xF8	Configure the Temperature that will trigger the "Over Temperature Fault" flag
	OT_FAULT_RESPONSE	50h	✓	✓	1	-	0xF8	-	-	0xFC	Configure the Temperature that will trigger the "Over Temperature Fault" flag
Memory	RESTORE_DEFAULT_CODE	14h	-	✓	1	-	-	-	-	0xD0	Restore the command specified in the data byte to the default setting
	STORE_DEFAULT_CODE	13h	-	✓	1	-	-	-	-	0xD0	Store the setting related to command specified in the data byte as the default setting
	RESTORE_DEFAULT_ALL	12h	-	✓	0	-	-	-	-	0xDC	restores the Default settings
	STORE_DEFAULT_ALL	11h	-	✓	0	-	-	-	-	0xDC	Store all current settings that support memory Store as the default settings
	RESET_REGISTERS	C4h	-	✓	0	-	-	-	-	0xDC	restores all settings to the value in the Default value column
	CLEAR_FAULTS	03h	-	✓	0	-	-	-	-	0xDC	Clears all status flags
Monitoring	STATUS_BYTE	78h	✓	✓	1	-	-	-	-	0xFC	Returns the Status Byte, this is the same as the lower Byte of the Status Word
	STATUS_WORD	79h	✓	✓	2	-	-	-	-	0xFC	Returns the Status Word
	STATUS_VOUT	7Ah	✓	✓	1	-	-	-	-	0xFC	Read or Clear the Output Voltage Status Byte
	STATUS_IOUT	7Bh	✓	✓	1	-	-	-	-	0xFC	Read or Clear the Output Current Status Byte
	STATUS_INPUT	7Ch	✓	✓	1	-	-	-	-	0xFC	Read or Clear the Input Status Byte
	STATUS_TEMPERATURE	7Dh	✓	✓	1	-	-	-	-	0xFC	Read or Clear the Temperature Status Byte
	STATUS_CML	7Eh	✓	✓	1	-	-	-	-	0xFC	Read or Clear the Communication Status Byte
	READ_VIN	88h	✓	-	2	-	-	-	$V_{in} = \frac{\alpha}{92.5}$	0xB8	states the Input Voltage Measurement
	READ_VOUT	8Bh	✓	-	2	-	-	-	$V_{out} = \frac{\alpha}{170.1}$	0xB8	states the Output Voltage Measurement
	READ_TEMPERATURE_1	8Dh	✓	-	2	-	-	-	See Datasheet for Formula	0xB8	states the module Temperature Measurement
Information	CAPABILITY	19h	✓	-	1	-	0x20	-	-	0xBC	States the supported PMBus capability options. See datasheet for more details
	QUERY	1Ah	-	✓**	1	-	-	-	-	0xBC	Query Commands to the operations that can be performed it
	VOUT_MODE	20h	✓	-	1	-	0x40	-	-	0xBC	The states format the output voltage is relayed. The module Directly provides a Byte value that is converted using the formula in the conversion column
	PMBUS_REVISION	98h	✓	-	1	-	0x33	-	-	0xBC	States the Module is compliant to PMBus part I and II revision 1.3
	MFR_ID	99h	✓*	-	9	-	"Silvertel"	-	ASCII Code	0xBC	States the Module Manufacturer
	MFR_MODEL	9Ah	✓*	-	6	-	"Ag7010"	-	ASCII Code	0xBC	States the Module Model
	MFR_REVISION	9Bh	✓*	-	2	-	-	-	ASCII Code	0xBC	States the Modules Hardware (MSB) and Firmware (LSB) Revision

* Block Read
** Block Write & Block Write

Table 4: Command List

4.3.1 Device Configuration Commands

4.3.1.1 OPERATION Command

The module's output can be enabled or disabled using the I^{2}C bus using bit 7 of the ON/OFF command. This is dependent on the configuration of the ON_OFF_CONFIG.

Bit	Function	Setting
7	ON/OFF Control	0 - DC/DC converter OFF 1 - DC/DC converter ON
6:0	Not Used	-

Table 5: Operation Byte

4.3.1.2 ON_OFF_CONFIG Command

The ON_OFF_CONFIG command configures whether the Ag7010 output is controlled by the OPERATION command, CONTROL pin or both, this command also allows for reversing the polarity of the CONTROL pin.

Bit	Function	Setting
7:5	Not Used	-
4	Control Override	0 - Converter is always ON when powered 1 - ON/OFF behaviour controlled by bits 2&3
3	PMBus Control	0 Disables PMBus ON/OFF control 1 - Enables PMBus ON/OFF control
2	EN-DIS pin Control	0 Disables CONTROL pin ON/OFF control 1 - Enables CONTROL pin ON/OFF control
1	EN-DIS Polarity	0 - Pull CONTROL pin Low to turn ON converter 1 - Pull CONTROL pin Low to turn OFF converter
0	Off Response	0 - Not Used 1 - Immediate Off

Table 6: ON_OFF_CONFIG Byte

4.3.1.3 Fault Response

The fault response commands dictate how the module will behave in the presence of the corresponding fault.

Bit	Function	Setting
7:6	Fault Response	11 - The Modules output is disabled and will resume normal operation once the fault is removed 10 - Device is disabled and will attempt to restart according the retry setting 01 - 00 - Not Used
5:3	Retry Setting	111 - The Module indefinitely attempts to restart 110 - 001 - The module attempts to restart 1-6 times before remaining off 000 - The Module does not attempt to restart
2:0	Delay Time	111 - 000* - The amount of seconds delay between each retry attempt

* 000 only valid when configured to not use the retry setting

Table 7: General FAULT_RESPONSE Byte

Bit	Function	Setting
7:6	Fault Response	11 - Device is disabled and will attempt to restart according the retry setting 10 - 00 - Not Used
5:3	Retry Setting	111 - The Module indefinitely attempts to restart 110 - 001 - The module attempts to restart 1-6 times before remaining off 000 - The Module does not attempt to restart
2:0	Delay Time	111 - 001 - The amount of seconds delay between each retry attempt

Table 8: Output Current FAULT_RESPONSE Byte

4.3.2   Over Temperature fault and warning setting

The Ag7010 uses an NTC to detect its operating temperature, this allows the temperature at which the module will trigger either the over temperature warning or the over temperature fault flags can be set to the user requirements.

By default, the module will flag the over temperature warning flag when the module detects it has exceeded approximately 115°C and will flag the over temperature fault and turn off the output when the module reaches 125°C.

The value to set these fields to can be calculated with the formula below, where a is the register value and T_c is the desired temperature in Celsius.

$$a = 4096 \times \frac{e^{\frac{4100(25-T_c)}{298.15(T_c+273.15)}}}{1 + e^{\frac{4100(25-T_c)}{298.15(T_c+273.15)}}}$$

Equation 1: Setting Temperature Field

4.3.3   Monitoring commands

4.3.3.1   Read Temperature Command

Use Equation 2 to convert the register value, where a is the register value and T_c is the temperature is Celsius.

$$T_C = 4100 \times \frac{298.15}{298.15 \times \ln\frac{a}{4096-a} + 4100} - 273.15$$

Equation 2: Reading Temperature Field

4.3.3.1   Status Byte Command

The Status Byte command returns the low byte only of the Status Word in Table 9. The STATUS_BYTE command reports the most important faults and warning, bit 0 of the STATUS_BYTE is used to highlight that there is a flag in the Higher byte that may require attention.

4.3.3.2   Status Word Command

Byte	Bit	Function	Description
Low	7	Busy	The Module is not currently able to accept and process commands from the bus
	6	Off	DC/DC converter is OFF
	5	Output Over Voltage fault	An Over Voltage Fault has occurred
	4	Over Current Fault	An Over Current Fault has occurred
	3	Input undervoltage fault	An Input Under Voltage Fault has occurred
	2	Temperature Status flagged	At least one Bit in STATUS_TEMPERATURE has flagged
	1	Communication fault	At least one Bit in STATUS_CML has flagged
	0	Other fault detected	A flag in the High Byte that is not reflected in a Low Byte Flag is present
High	7	Output Voltage Status	At least one Bit in STATUS_VOUT has flagged
	6	Output Current Status	At least one Bit in STATUS_IOUT has flagged
	5	Input Status Flagged	At least one Bit in STATUS_INPUT has flagged
	4	Not Used	-
	3	Power Good Status	Indicates the Power is good when low
	2	Not Used	-
	1	Not Used	-
	0	Other fault or warning	Miscellaneous error has occurred

Table 9: I²C Status Word

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4.3.3.3 Voltage Output Status Command

Bit	Function	Description
7	Output Over Voltage Fault	The Output Voltage has exceeded the VOUT_OV_FAULT_LIMIT setting
6	Output Over Voltage Warning	The Output Voltage has exceeded the VOUT_OV_WARN_LIMIT setting
5:0	Not Used	-

Table 10: STATUS_VOUT Byte

4.3.3.4 Current Output Status Command

Bit	Function	Description
7	Over Current/On Time fault	The output was removed due to an Overcurrent event
6:0	Not Used	-

Table 11: STATUS_IOUT Byte

4.3.3.5 Input Status Command.

Bit	Function	Description
7	Input Over Voltage Fault	The Input Voltage has exceeded the VIN_OV_FAULT_LIMIT setting
6	Input Over Voltage Warning	The Input Voltage has exceeded the VIN_OV_WARN_LIMIT setting
5	Input Under Voltage Warning	The Input Voltage has dropped below the VIN_UV_WARN_LIMIT setting
4	Input Under Voltage Fault	The Input Voltage has dropped below the VIN_UV_FAULT_LIMIT setting
3	DCDC converter Disabled due to under voltage	Converter shut down due to being below Voff or not having risen above Von
2:0	Not Used	-

Table 12: STATUS_INPUT Byte

4.3.3.6 Temperature Status Command

Bit	Function	Description
7	Over Temperature Fault	The Temperature Voltage has exceeded the OT_FAULT_LIMIT setting
6	Over Temperature Warning	The Temperature has exceeded the OT_WARN_LIMIT setting
5:0	Not Used	-

Table 13: STATUS_TEMPERATURE Byte

4.3.3.7 Communication status Command

Bit	Function	Description
7	Invalid Command Received	A command that the Module does not support has been received
6	Invalid Data Received	A unsupported data value has been received
5:2	Not Used	-
1	Other Communication fault	A communication fault not covered above has occurred
0	Memory or Logic fault	A logic or memory fault has occurred

Table 14: STATUS_CML Byte

4.3.3.1 Clearing status flags

When one of the status bits has flagged it will remain flagged until it is either cleared, or power is removed from the module.

The clearing of a status flag can be performed in one of two ways, either by sending a write request to the CLEAR_FAULTS command, or by writing a logic HIGH to the bit of the corresponding flag in the relevant status byte.

The only bits that can be cleared by writing to the STATUS_BYTE or STATUS_WORD registers are bit 7 of the low byte (Busy) and bit 0 of the high byte (Other fault or warning). All other bits are either reporting that a flag in the corresponding status register has been set or will clear when the condition is no longer true, i.e. 'Off' and 'Power Good Status'

4.3.4   Storing Configuration

All Configuration changes are volatile until saved using either the STORE_DEFAULT_ALL or STORE_DEFAULT_CODE commands. These will then be retained on powerup or reapplied with the RESTORE_DEFAULT_ALL or RESTORE_DEFAULT_CODE commands

The RESET_REGISTERS command will clear all stored values and revert back to the manufacturer defaults detailed in Table 4: Command List.

4.3.5   Device Information Commands

4.3.5.1   Capability Command

The capability field is a read only command that states the supported functionality of the module. The result of reading this field states that the module supports a maximum bus speed of 400kHz, does not use the IEEE half precision floating point format, does not utilise AVSBus support, SM Bus Alert response protocol or packet error checking.

4.3.5.2   Query Command

The Query command is used to probe the other commands to determine whether they are supported and their supported functionality for example, whether they support read/write commands and the data format that is used. Please refer to the PMBus specification for more details regarding this command.

The Query command utilises the block Write, and the Block read protocol, shown in Figure 10. In the case below the first byte count, transmitted by the master, will be 1 as the written data contains the one byte of command code being queried. The second byte count, transmitted by the Ag7010, in this transaction will also be 1.

5 Operating Temperature Range

The Ag7010 is a DC/DC converter. Whilst 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.

The Ag7010 can operate up to a maximum of 85˚C ambient, and a minimum of -40˚C ambient. When intended for use in ambient temperatures below 0°C it is recommended that an input capacitor that will retain capacitance and ESR ratings at the lowest temperature in the intended operating range is used. A reputable brand capacitor rated to -55°C should suffice for most applications, please contact Silvertel if suggestions are required.

The graph below shows the continuous load capabilities of the module across environmental temperatures, for a range of common input output configurations. These results have been recorded in a Temperature Applied Sciences ECO MT135 Environmental chamber (with circulating air) with forced airflow across the module at a rate of 1.5m/s. Under these conditions the Ag7010 is capable of sourcing its full output power for any given input and output voltage across an operating temperature range of -40°C to +65°C.

Operation in a sealed enclosure or with limited airflow will result in further de-rating of the operating temperature profile.

Figure 11: Ag7010 operating temperature profile
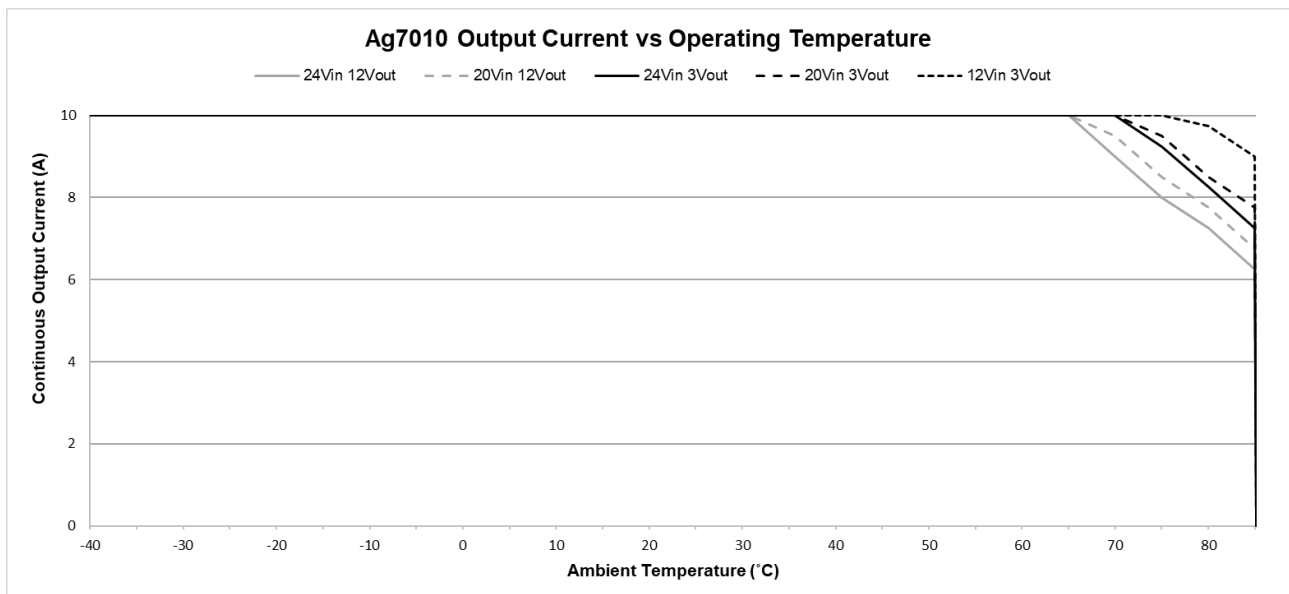
5.1 **Thermal Considerations**

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 out and away. It is also important that any enclosure has sufficient ventilation for the Ag7010.

One simple method for drawing some of the heat away from the Ag7010 is by means of power planes connected to the power pads of the module Vin+, Vin-, Vout+, and Vout-. These power planes must be on the outer layers of the PCB and the best results are achieved by having power planes on both sides of the main board with regular via connections to thermally bond the planes. An example of the topside layout is shown in Figure 12.

It should be noted that there are exposed pads on the underside of the module that should be left unconnected, no exposed copper should be present in this region. See Section 10: Package and Footprint.
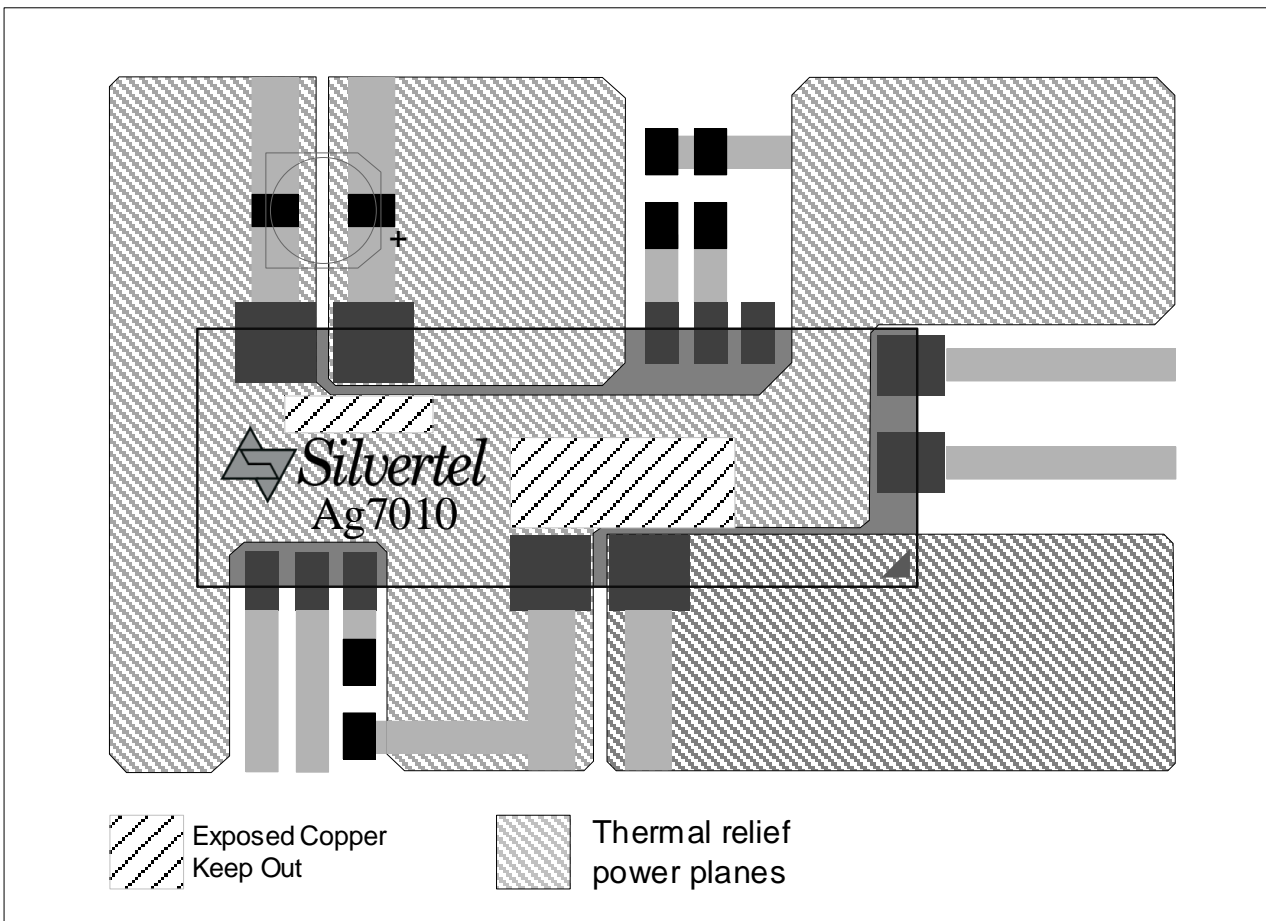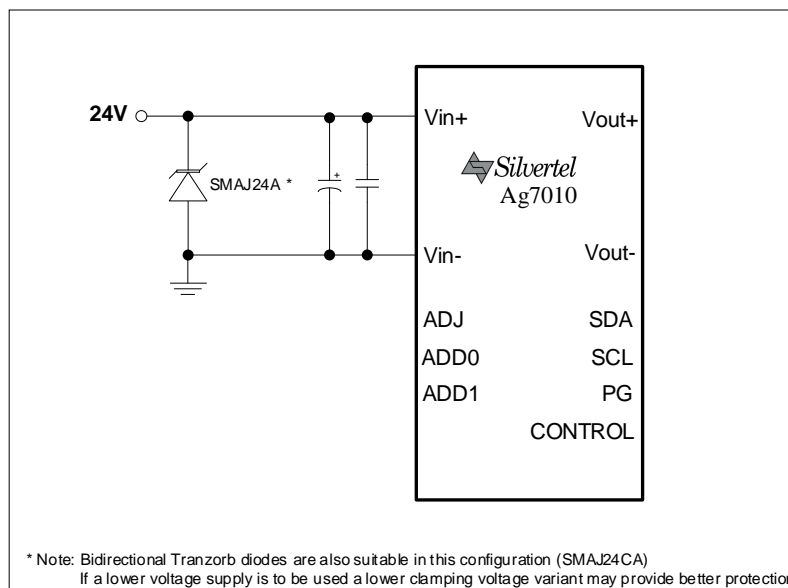

Figure 12: Thermal Relief

6 **EMC**

The Ag7010 has been designed to pass EN55032 Class B, however the Ag7010 will only be a single component within the system, depending on the application, filtering of the emissions passing through the Ag7010 may be required.

7 Protection

7.1 Input Protection

To reduce the risk of damage, the Ag7010 will shut down the DC/DC converter if an input voltage exceeding either the VIN_OV_FAULT_LIMIT or the maximum supply rating is detected.

The Ag7010 may still be damaged if input voltages exceed 28V. Over voltage protection such as a TVS diode can be fitted across the VIN+ and VIN- input pins, providing protection from electrostatic discharge (ESD) or other high voltage transients. One example of this is the SMAJ24A.

* Note: Bidirectional Tranzorb diodes are also suitable in this configuration (SMAJ24CA)
If a lower voltage supply is to be used a lower clamping voltage variant may provide better protection

Figure 13: 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 Ag7010 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 Ag7010 will disable the output, the Ag7010 will then indefinitely attempt restart according to the IOUT_OC_FAULT_RESPONSE setting. By default, the module will continuously test current draw approximately every 3 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 Ag7010 contains built-in thermal protection to prevent the module becoming damaged in the event that the module is operated beyond its temperature specification. When the Ag7010 has detected it is over temperature, the output will be disabled until the module has cooled sufficiently.

For applications where there is limited airflow, it is recommended that the over temperature fault limit is reduced to prevent damage to the module.

8 Solderability

While the Ag7010 can be mounted by hand or hot air reflow, it has been designed with an open frame design to keep weight to a minimum allowing it to be mounted via a fully automated assembly process.

The Ag7010 is lead-free (Pb-free) and RoHS compliant and fully compatible in a Pb-free soldering process. There are no specific requirements regarding stencil thickness or solder paste classification type.

Non-solder mask defined (NSMD) pads are preferred over solder mask defined (SMD) pads, for the improved solderability, the land pattern dimensions are given in Figure 16: Land Pattern.

The Ag7010 requires no components of greater than Moisture Sensitivity level 1, as a result no special processes are required in the reflowing process of the Ag7010.

Note : Do not pass the Ag7010 through the reflow process mounted to the underside of the assembly due to the risk of components falling off the module.

8.1 Nozzle Recommendation

The minimum recommended nozzle diameter for reliable handling is 4mm, with a maximum diameter of 10mm. The nozzle should be applied to the inductor with the centre point located within the region specified in Figure 14. For reliable operation the nozzle should be centred in this region as close to the centre of the module as the nozzle diameter will allow.

11
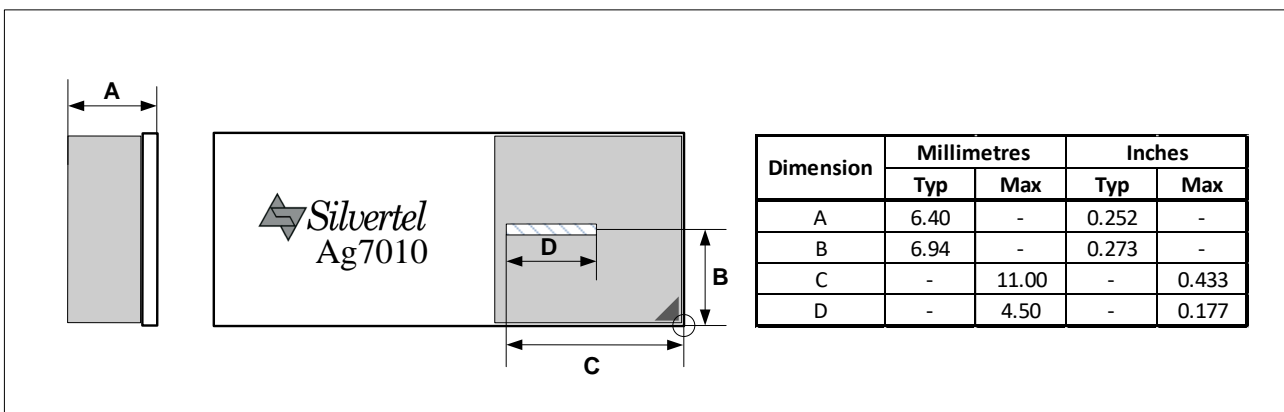

Dimension	Millimetres		Inches	
	Typ	Max	Typ	Max
A	6.40	-	0.252	-
B	6.94	-	0.273	-
C	-	11.00	-	0.433
D	-	4.50	-	0.177

Figure 14: Nozzle Centre Point

8.2 **Solder Profile**

Below is a typical profile that the Ag7010 should be mounted, based on the J-STD-020 standard for PB-Free applications. Exceeding these specifications may cause damage to the module. All production environments are different therefore please review these guidelines with the process engineer prior to use.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Units
Zone Duration	42	42	42	42	42	Seconds
Top Heater	150	180	210	240	270	˚C
Bottom Heater	150	180	210	240	270	˚C
Typical Slope	2.1	1.2	1.1	0.9	0.8	˚C/Second
Airflow rate	40					M^3/Minute

Table 15: Solder Profile

	Min	Max	Units
Soak Time (s) 150-180˚C	30	90	Seconds
Time above (s) ≥220˚C	30	90	Seconds
Peak Temperature (˚C)	230	255	˚C
ΔTemperature (˚C/s)	-3	3	˚C/Second

Table 16: Solder Parameters

9 Electrical Characteristics

9.1 Absolute Maximum Ratings

	Parameter	Symbol	Min	Max	Units
1	DC Supply Voltage	V_{CC}	-0.3	26	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 implied. Maximum ratings assume free airflow.

9.2 Recommended Operating Conditions

	Parameter	Symbol	Min	Typ	Max	Units
1	Input Supply Voltage	V_{IN}	8	-	24	V
2	Input Under Voltage Lockout	V_{ULOCK}	-	6.6	-	V
3	Input Over Voltage Lockout	V_{OLOCK}	--	26.5		V
4	Operating Temperature	T_{OP}	-40	25	85	Ta / °C
5	Input capacitance	C_{in}	220	470	1000	µF

9.3 DC Electrical Characteristics

	DC Characteristic		Sym	Min	Typ[1]	Max	Units	Comments
1	Nominal Output Voltage		V_{OUT}	3	3.08[2]	12.8	V	
2	Continuous Current output[3]		I_{LOAD}	-	-	10	A	
3	Line Regulation		V_{LINE}	-	-	0.15	%	
4	Load Regulation		V_{LOAD}	-	-	0.5	%	
5	Ripple and Noise		V_{RN}	-	170	-	mV$_{p-p}$	@ Max load
6	Minimum Load		I_{MIN}	0	-	-	mA	
7	Short-Circuit Duration		TSC	-	-	∞	sec	
8	Peak Efficiency		EFF	-	97.3	-	%	@ 15Vin
9	Power Good Threshold		PG_{TH}	-	90	-	%	%Vout
10	PG current		PG_C	-	-	60	mA	
11	Control	LOW	C_{OL}	-	-	0.9	V	
		HIGH	C_{OH}	2.4	-	3.3		

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

Note 2: With ADJ pin Open circuit.

Note 3: Maximum output Current may be limited as a result of input supply
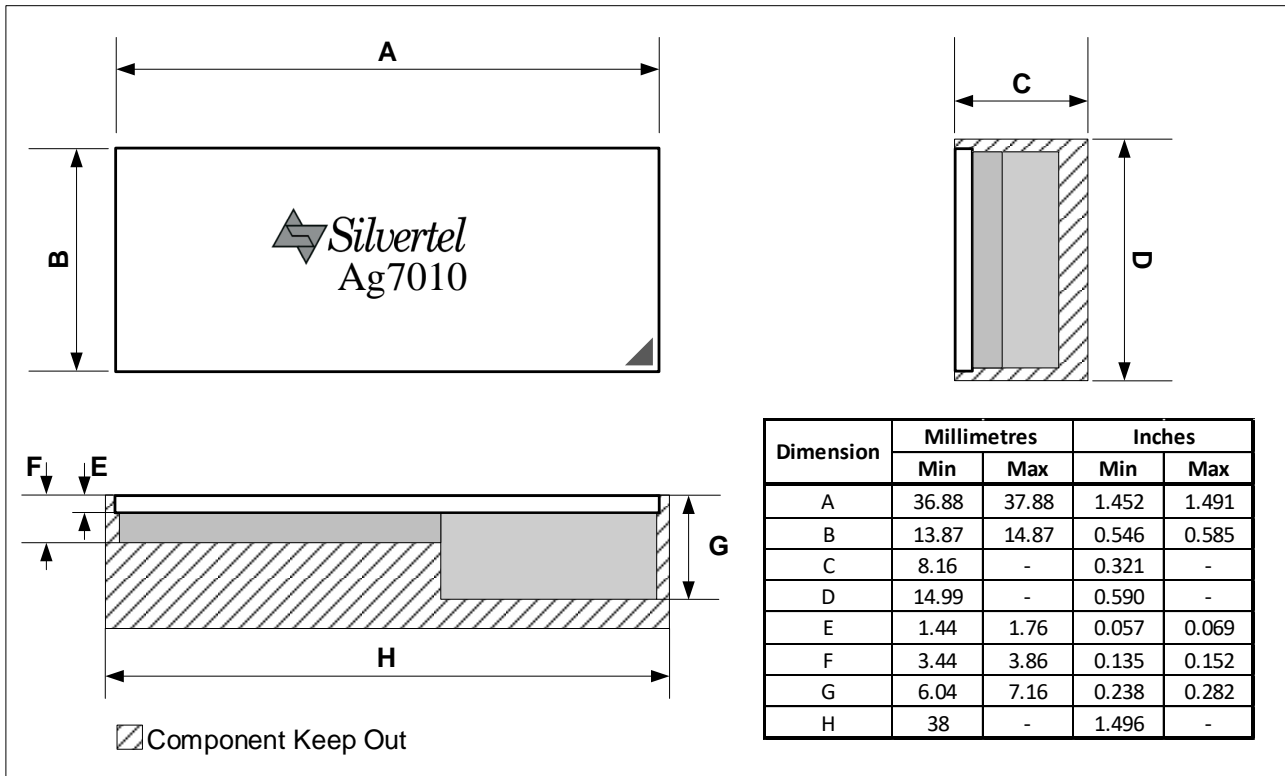
10 Package and Footprint

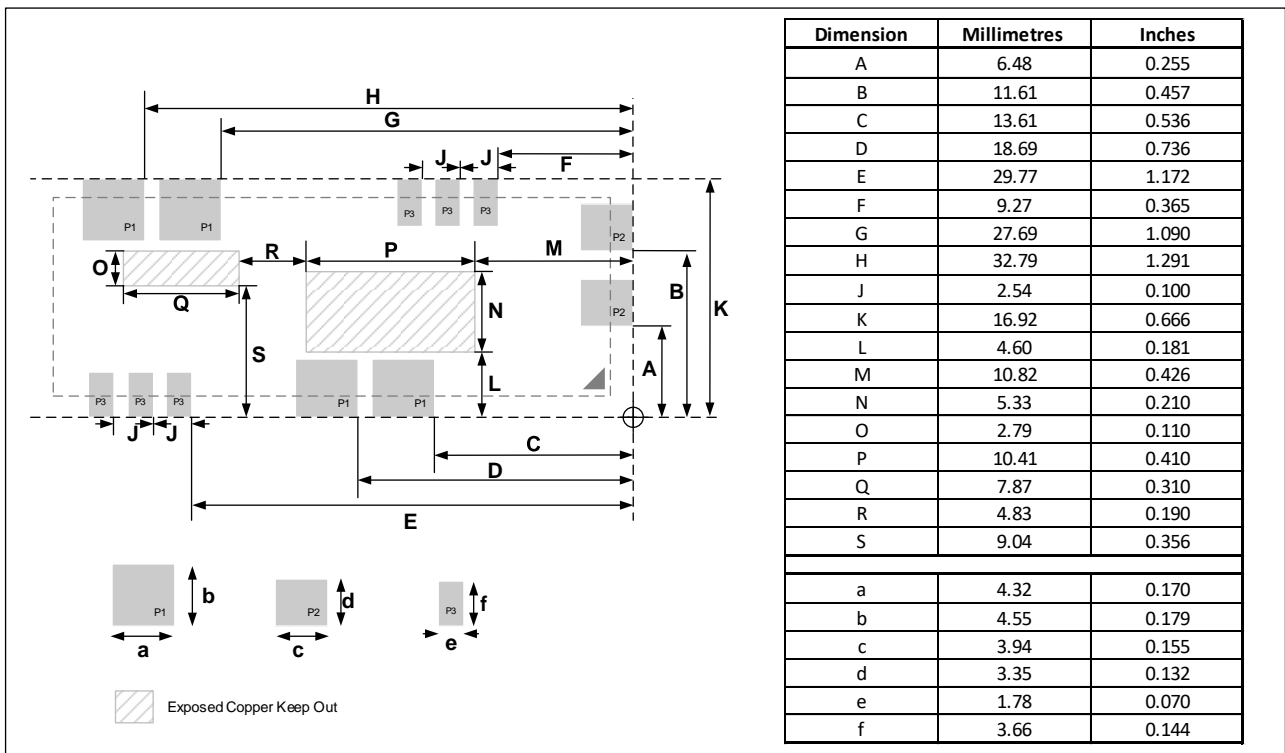| Dimension	Millimetres		Inches	
	Min	Max	Min	Max
A	36.88	37.88	1.452	1.491
B	13.87	14.87	0.546	0.585
C	8.16	-	0.321	-
D	14.99	-	0.590	-
E	1.44	1.76	0.057	0.069
F	3.44	3.86	0.135	0.152
G	6.04	7.16	0.238	0.282
H	38	-	1.496	-

Figure 15: Package Dimensions

Dimension	Millimetres	Inches
A	6.48	0.255
B	11.61	0.457
C	13.61	0.536
D	18.69	0.736
E	29.77	1.172
F	9.27	0.365
G	27.69	1.090
H	32.79	1.291
J	2.54	0.100
K	16.92	0.666
L	4.60	0.181
M	10.82	0.426
N	5.33	0.210
O	2.79	0.110
P	10.41	0.410
Q	7.87	0.310
R	4.83	0.190
S	9.04	0.356
a	4.32	0.170
b	4.55	0.179
c	3.94	0.155
d	3.35	0.132
e	1.78	0.070
f	3.66	0.144

Figure 16: Land Pattern

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