DESIGNERS MANUAL

EXCELSYS
Xsolo Series

High Efficiency, Extremely Compact Package Power Supply

Advanced Energy's Excelsys Xsolo Power Supply Designers Manual has been prepared by Advanced Energy experts to assist qualified engineers and technicians in understanding the correct system design practices necessary to deliver an incredible convection cooled 504W in an open-frame U-channel form factor and up to 1008W in an enclosed, fan cooled chassis with an extremely compact package.

AT A GLANCE

	XS500	XS/XB1000
Total Power	504W	1008W

Output Voltage 24V, 36V, 48V

Cooling

Convection cooled (504W)
Variable fan speed control (1008W)

Dimensions

237 x 128 x 39 mm (504W)
238 x 128 x 40 mm (1008W)

Certifications

- IEC60601-1 2nd and 3rd edition
- IEC60601-1-2 4th edition (EMC)
- IEC60950 2nd edition
- IEC62368-1
- 2 MOPP
- SEMI F47 (V_{IN} > 160Vac)
- MIL-STD-810G
- BF Ready (XB1000)

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SECTION 1 PRODUCT DESCRIPTIONS

1.1 Overview of Xsolo

The Xsolo series is a single-output power supply. The power supplies are available in two packages. The Xsolo 500 W is an incredible convection cooled, open-frame, U-channel form factor and the Xsolo 1000 W is an enclosed, fan-cooled chassis.

The Xsolo platform comes with a host of features including: variable speed fan, 12V/300mA isolated bias supply, remote ON/OFF, parallel operation for higher power applications and PMBus™ for digital communications. Nominal output voltages are 24V, 36V and 48V with wide adjustment ranges and user defined set-points.

Xsolo carries dual safety certification, EN62368-1 and EN60950 2nd Edition for Industrial Applications and EN60601-1 2nd and 3rd Edition for Medical Applications, meeting the stringent creepage and clearance requirements, 4KVac isolation and <300uA leakage current. The XB1000's Output to Earth isolation has been designed to meet the creepage, clearance and dielectric withstand requirements of 1 MOPP for a working voltage equal to the Input Line Voltage, which means it can be used in BF Type applications without the need for an additional isolation barrier from the Patient Connection to Earth. Xsolo is designed to meet MIL810G and is also compliant with SEMI F47 when V_{IN} > 160Vac for voltage dips and interruptions as well as being compliant with all relevant EMC emission and immunity standards.

The product can also be conformal coated and ruggedized for use in harsh environments. With convection cooled power capability of over 500W, the Xsolo is ideal for use in a wide range of applications: industrial, Hi-Rel MIL-COTS applications, as well as acoustically sensitive laboratory and medical environments.

Xsolo Power Supply

XS 500

XS 1000 / XB 1000

SECTION 1 PRODUCT DESCRIPTIONS CON'T

1.2 Operation Considerations

The Xsolo products are designed for use within other equipment or enclosures, which restricts access to authorized competent personnel only. The unit covers are designed only to protect skilled personnel from hazards. They must not be used as part of the external covers of any equipment where they may be accessible to operators, since, under full load conditions, part or parts of the unit may reach temperatures in excess of those considered safe for operator access.

The Xsolo can not be used to deliver continuous output power greater than the rated power. The plug shall be rated to a current not less than 125% of the rated current of the equipment.

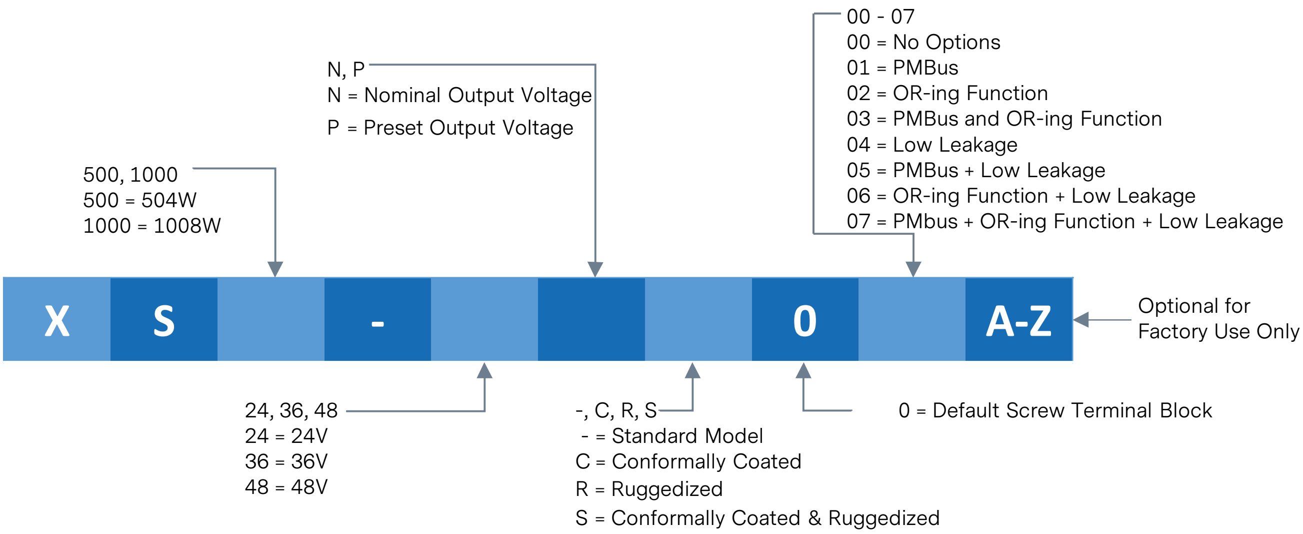
To protect against risk of fire, replace only with same rating and type. Fuses must be replaced by qualified service personnel only.

Series Model	Reference	Fuse Rating	Type	Voltage	Size
XS500	FS1	8A	F	250V	6.25x32mm
XS1000	FS1	12A	F	250V	6.25x32mm
XB1000	FS1	12A	F	250V	6.25x32mm

SECTION 2 MODEL / ORDERING INFORMATION

2.1 Xsolo Nomenclature

The XS500/1000 series power supply part-numbering system is described below.



Model Name

XS = XS Series

Output Voltage

24 = 24V, Single Output
36 = 36V, Single Output
48 = 48V, Single Output

Voltage Settings

N = Standard. Nominal Output Voltage
P = Configured. Preset Output Voltage

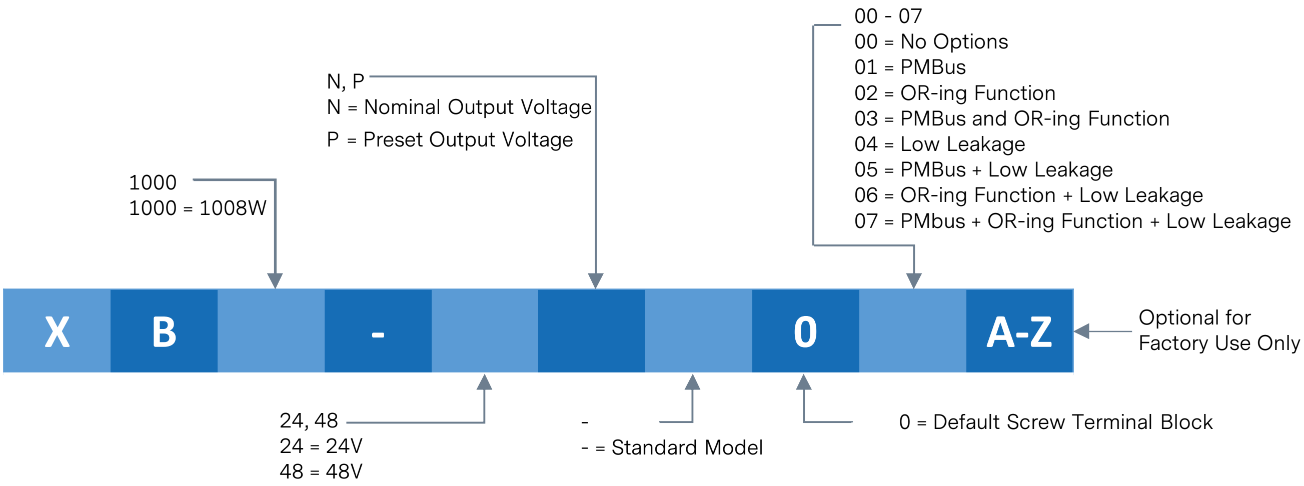
Ordering Example

Example 1: XS1000-24N-000 = Xsolo 1000W, 24V, output with no options

Example 2: XS1000-24N-003 = Xsolo 1000W, 24V, output with PMBus and OR-ing function

SECTION 2 MODEL / ORDERING INFORMATION CON'T

The XB1000 series power supply part-numbering system is described below.



Model Name

XB = XB Series, for type BF-rated applications

Output Voltage

24 = 24V, Single Output
48 = 48V, Single Output

Voltage Settings

N = Standard. Nominal Output Voltage
P = Configured. Preset Output Voltage

Ordering Example

Example 1: XB1000-24N-000 = Suitable for BF-rated applications 1000W, 24V, output with no options

Example 2: XB1000-24N-003 = Suitable for BF-rated applications 1000W, 24V, output with PMBus and OR-ing function

SECTION 2 MODEL / ORDERING INFORMATION CON'T

2.2 Output Models

Table 1 Output Voltage Table					
Model[1]	Output Voltage	Set Point Adjust Range[2]	Dynamic Vtrim Range[3]	Maximum Current	Maximum Power
XS500-24	24V	19-28V	14-28V	21.0A	504W
XS1000-24	24V	19-28V	14-28V	42.0A	1008W
XB1000-24	24V	19-28V	14-28V	42.0A	1008W
XS500-36	36V	26-40V	20-40V	14.0A	504W
XS1000-36	36V	26-40V	20-40V	28.0A	1008W
XS500-48	48V	36-58V	29-58V	10.5A	504W
XS1000-48	48V	36-58V	29-58V	21.0A	1008W
XB1000-48	48V	36-58V	29-58V	21.0A	1008W

Note 1 - XS500 for convection-cooled U-channel model, XS1000 and XB1000 for enclosed fan-cooled.
Note 2 - Multi-turn potentiometer on board of the power supply.
Note 3 - Output Voltage range by Vtrim.

SECTION 3 ELECTRICAL SPECIFICATIONS

3.1 Input Specifications

Table 2 Input Specifications

Parameter	Condition/Model	Symbol	Min	Typ	Max	Unit
Nominal Input Voltage, AC	47 to 440Hz[1]	$V_{IN,AC}$	85	-	264	Vac
Nominal Input Voltage, DC	All	$V_{IN,DC}$	120	-	380	Vdc
Maximum Input AC current	XS500 XS1000 XB1000	$I_{IN,max}$	- - -	- - -	5 10 10	A
Undervoltage Lockout	Shutdown		65	-	74	Vac
Inrush Current	$V_{IN,AC}$ = 230Vac	$I_{IN,inrush}$	-	-	25	A
Leakage Current to Earth Ground	$V_{IN,AC}$ = 264Vac/60Hz 25^{O}C	$I_{leakage}$	- -	300 150[2]	- -	uA
Operating Efficiency @ 25 ^{O}C	$V_{IN,AC}$ = 230Vac P_O = 1008W @ 24V/36V/48V	η	92	-	-	%

Note 1 - Safety approvals for 47Hz - 63hz operation only.
Note 2 - Low leakage for option 04, 05, 06, 07 power model.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

3.2 General Output Specifications

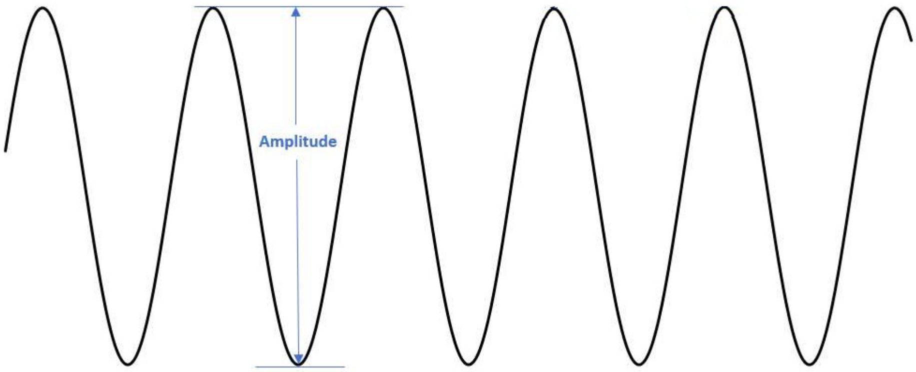
Table 3 Output Specifications

Parameter	Condition/Model	Symbol	Min	Typ	Max	Unit
Over Voltage Protection	XS500/1000-24 XB1000-24 XS500/1000-36 XS500/1000-48 XB1000-48	V_O	32 32 44 58 58	34 34 47 63 63	36 36 52 68 68	Vdc
Over Current Protection[1]	XS500 XS/XB1000	$I_{O,max}$	210 105	230 115	260 130	%
Standby Output Voltage	All	V_{sb}	-	12	-	Vdc
Standby Output Current	All	I_{sb}	-	300	-	mA
Remote Sense	All	V_O	-	-	0.5	Vdc
Rise Time	Monotonic	-	-	3	5	mS
Overshoot	All	V_O	-	-	2	%

Note 1 - Straight line with hiccup activation at <30% of normal output voltage.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Ripple and Noise



Parameter	Model	Symbol	Min	Typ	Max	Unit
Output Ripple[1]	XS500/1000-24 XB1000-24 XS500/1000-36 XS500/1000-48 XB1000-48	$V_{O,ripple}$	- - - - -	240 240 360 480 480	- - - - -	mV_{PK-PK}

Note 1 - Amplitude of ripple measured at nominal voltage and at 20 MHz Bandwidth.

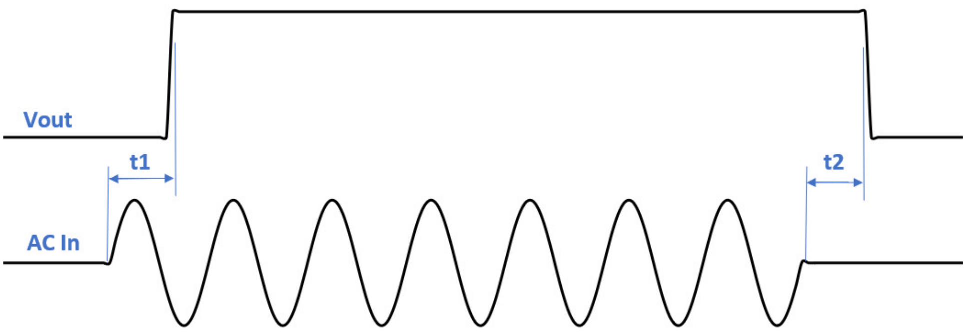
Regulation

Parameter	Model	Symbol	Min	Typ	Max	Unit
Load Regulation[1]	All Models	V_O	-	-	±0.2	%
Load Regulation[2]	All Models	V_O	-	-	±0.4	%
Line Regulation[3]	All Models	V_O	-	±0.5	-	%

Note 1 - 25-75% load condition.
Note 2 - Oring option (02, 03, 06, 07) model.
Note 3 - For ±10% change from nominal line.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

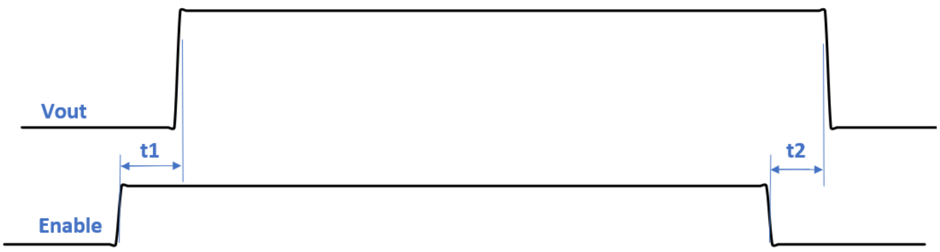
Start-Up / Shut-Down



Parameter	Model	Symbol	Min	Typ	Max	Unit
Turn-On Delay[1]	All Models	t1	-	500	800	mS
Turn-Off Delay[2]	All Models	t2	17	-	-	mS

Note 1 - From AC input in.
Note 2 - For nominal output voltage at full load.

Enable / Disable

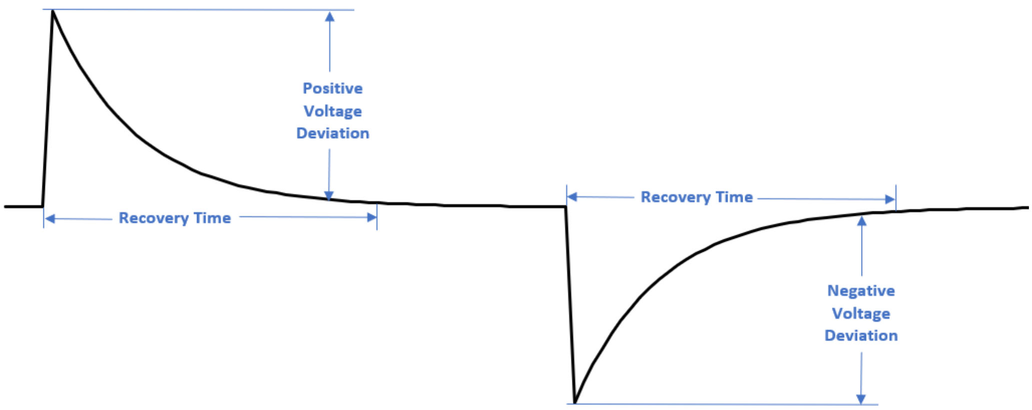


Parameter	Model	Symbol	Min	Typ	Max	Unit
Enable Delay[1]	All Models	t1	-	10	-	mS
Disable Delay	All Models	t2	-	2	-	mS

Note 1 - From remote On/Off.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Transient Response



Parameter	Models	Symbol	Min	Typ	Max	Unit
Transient Response, Voltage Deviation[1]	All Models	V_O	-	-	2.5	%
Transient Response, Recovery Time	All Models	T_s	-	-	500	uS

Note 1- From 25% to 75% load change voltage deviation.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

PMBus™ Communications

Standard models can be monitored with the following PMBus commands (for further details see the PMBus™ Manual available for download from the Advanced Energy website.

<table>
<tr><th colspan="5">Monitoring Command - Read only</th></tr>
<tr><th>Command</th><th colspan="4">Description</th></tr>
<tr><td rowspan="4">VOUT_MODE (0x20)[1]</td><td rowspan="4">The VOUT_MODE command is used to obtain information about the format of the voltage measurement.</td><td>Mode</td><td>Bits[7:5]</td><td>Bits[4:0]</td></tr>
<tr><td>Linear</td><td>000</td><td>5 bit mantissa which is returned as part of the output voltage data.</td></tr>
<tr><td>VID</td><td>001</td><td>VID Code Identifier</td></tr>
<tr><td>Direct</td><td>010</td><td>Always set to 00000</td></tr>
<tr><td rowspan="4">READ_VOUT (0x8B)</td><td rowspan="4">The READ_VOUT command is used to return the output voltage measurement in Volts formatted in linear format.</td><td>Model</td><td>Resolution</td><td>Accuracy[2]</td></tr>
<tr><td>XS/XB500-24N
XS/XB1000-24N</td><td>37mV</td><td>±1%</td></tr>
<tr><td>XS500-36N
XS1000-36N</td><td>54mV</td><td>±1%</td></tr>
<tr><td>XS/XB500-48N
XS/XB1000-48N</td><td>71mV</td><td>±1%</td></tr>
<tr><td rowspan="4">READ_IOUT (0x8C)</td><td rowspan="4">The READ_IOUT command is used to return the output current measurement in Amps formatted in linear format.</td><td>Model</td><td>Resolution</td><td>Accuracy[3]</td></tr>
<tr><td>XS/XB500-24N
XS/XB1000-24N</td><td>62mA</td><td>±2.5%</td></tr>
<tr><td>XS500-36N
XS1000-36N</td><td>44mA</td><td>±2.5%</td></tr>
<tr><td>XS/XB500-48N
XS/XB1000-48N</td><td>32mA</td><td>±2.5%</td></tr>
<tr><td rowspan="2">READ_TEMPERATURE _1 (0x8D)</td><td rowspan="2" colspan="2">The READ_TEMPERATURE_1 command is used to return the temperature measurement in Degrees Celsius from the on-board temperature sensor of the interface model.</td><td>Resolution</td><td>Accuracy[4]</td></tr>
<tr><td>1°C</td><td>±2°C</td></tr>
<tr><td rowspan="4">MFR_SPECIFIC_LINEARMODE (0xD0)</td><td rowspan="4">This command accepts a single byte which sets the mode for the READ_VOUT command.</td><td>Returned data</td><td colspan="2">Mode for READ_VOUT</td></tr>
<tr><td>11</td><td colspan="2">LINEAR11 mode is selected</td></tr>
<tr><td>16</td><td colspan="2">LINEAR16 mode is selected</td></tr>
<tr><td>Anything else</td><td colspan="2">mode remains unchanged</td></tr>
</table>

Note 1 - For Xsolo series, the data format is fixed as linear mode with an exponent of -5, so the data returned by this command shall always be 00011011=0x1B.

Note 2 - The specified accuracy is achieved following the calibration procedure.

Note 3 - The current measurement accuracy is not specified below 1.0A where the resolution is comparable with the quantity being measured.

Note 4 - The specified accuracy is achieved following application of the conversion equation:
Sensor_Temperature = (Returned_Temperature * 1.0361) + 8.948

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

<table>
<tr><th colspan="4">Calibration Commands[1] - Read and Write</th></tr>
<tr><th>Command</th><th colspan="3">Description</th></tr>
<tr><td rowspan="4">VOUT_SCALE_MONITOR (0x2A)</td><td rowspan="4">A voltage scale factor.
If issued as a read command, the option card shall return the two byte linear formatted voltage scaling factor.
If issued as a write command, with one or two bytes data representing the required scaling factor.</td><td>Model</td><td>Recommended Start Point</td></tr>
<tr><td>XS/XB500-24N
XS/XB1000-24N</td><td>0xD968</td></tr>
<tr><td>XS500-36N
XS1000-36N</td><td>0xDA0A</td></tr>
<tr><td>XS/XB500-48N
XS/XB1000-48N</td><td>0xDA00</td></tr>
<tr><td rowspan="4">IOUT_CAL_GAIN (0x38)</td><td rowspan="4">The relationship between the output current and the corresponding digitized value takes the forms of the a gain factor plus a small offset factor. The gain factor part can be edited/viewed using this command.
If issued as a read command, the option card shall return the two byte linear formatted current scaling factor.
If issued as a write command, with one or two bytes data representing the required scaling factor.</td><td>Model</td><td>Recommended Start Point</td></tr>
<tr><td>XS/XB500-24N
XS/XB1000-24N</td><td>0xB0C2</td></tr>
<tr><td>XS500-36N
XS1000-36N</td><td>0xB086</td></tr>
<tr><td>XS/XB500-48N
XS/XB1000-48N</td><td>0xB10E</td></tr>
<tr><td rowspan="4">IOUT_CAL_OFFSET (0x39)</td><td rowspan="4">The relationship between the output current and the corresponding digitized value takes the forms of the a gain factor plus a small offset factor. The offset factor part can be edited/viewed using this command.
If issued as a read command, the option card shall return the two byte linear formatted current offset factor.
If issued as a write command, with one or two bytes data representing the required offset factor.</td><td>Model</td><td>Recommended Start Point</td></tr>
<tr><td>XS/XB500-24N
XS/XB1000-24N</td><td>0xB10E</td></tr>
<tr><td>XS500-36N
XS1000-36N</td><td>0xB069</td></tr>
<tr><td>XS/XB500-48N
XS/XB1000-48N</td><td>0xB078</td></tr>
<tr><td>STORE_USER_ALL (0x15)</td><td colspan="3">The STORE_USER command instructs the option card to copy the entire operating memory to non-volatile storage (flash). Used to save calibration settings.</td></tr>
<tr><td>STATUS_MFR_SPECIFIC (0x80)</td><td colspan="3">The STATUS_MFR_SPECIFIC command returns a single byte value which represents the digital measurement of the output current before any scaling or offsets are applied.</td></tr>
</table>

Note 1 - See PMBus manual for calibration procedure.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Identification Commands	
Command	**Description**
MFR_SPECIFIC_REVISION (0xD2)	The MFR_SPECIFIC_REVISION command returns the revision of firmware which is running on the PMBus Option Card as an integer.
MFR_ID (0x99)	The MFR_ID command simply returns a string of ASCII encoded characters which identify the manufacturer of the PMBus device.
MFR_MODEL (0x9A)	The MFR_MODEL command simply returns a string of ASCII encoded characters which identify the model of the PMBus device.

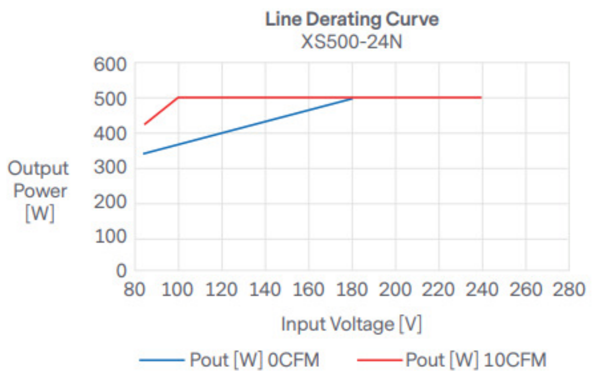
SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

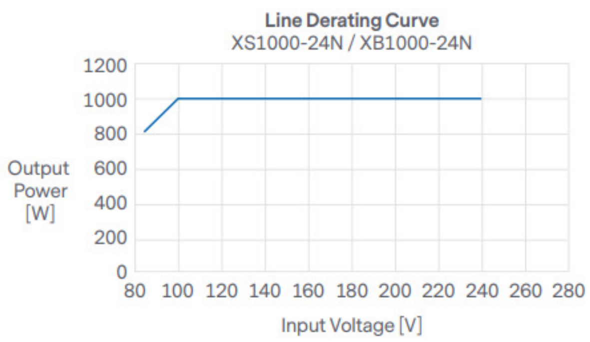
3.3 Power Ratings

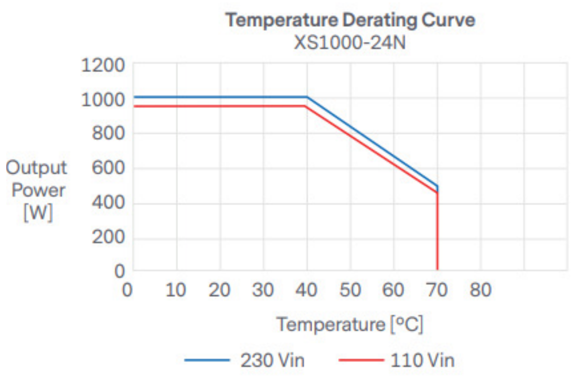
When selecting a power supply for an application, it is necessary to ensure it operates within its power capabilities by taking into account both Temperature Derating and Input Voltage Derating.

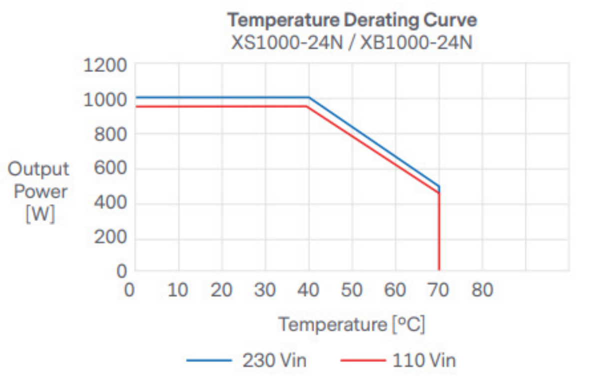
The line voltage and temperatures derating curves for the XS500 and XS1000/XB1000 are shown below. The XS500 is a 500 W convection-cooled part. The graphs below show the output power ratings with no system air flow and with 10 CFM of system air flow applied to the product.

Contact Advanced Energy for further information on the XS500 performance with system air flow applied to the product.







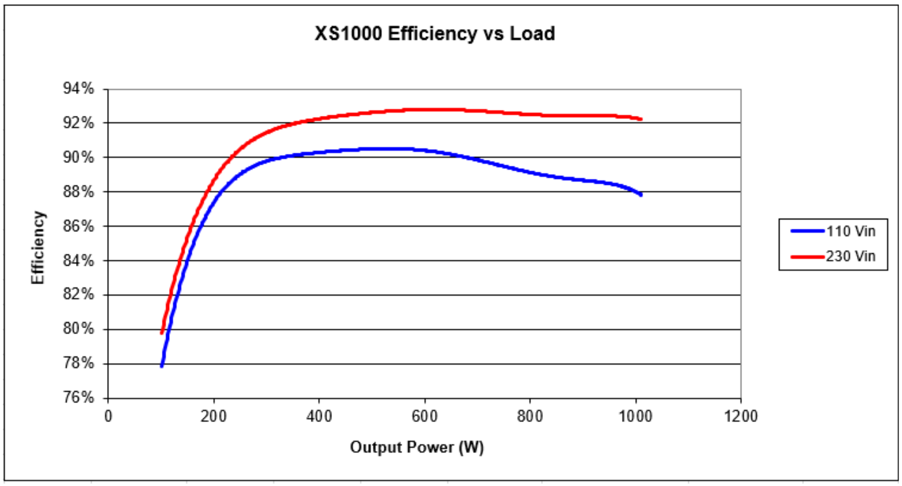


SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

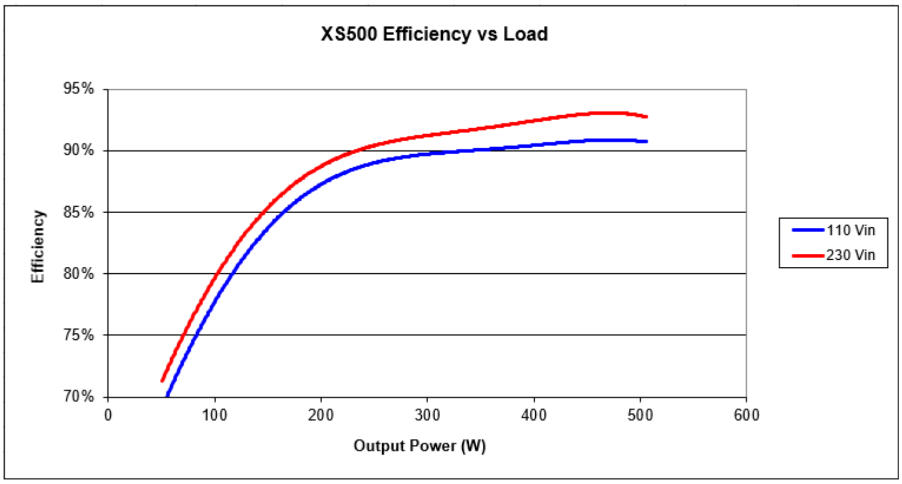
3.4 Efficiency Curve at 110Vac & 230Vac input

The Xsolo series offer unrivalled efficiency with a maximum efficiency of over 92%. It is often the case that power supplies are operating at lower levels than their maximum ratings. Most power supplies have optimised efficiency at a higher load ratings (close to full rating) but perform significantly worse at light or lower loads.

The Xsolo design and component selection ensures that conversion losses are kept to a minimum over a wide range of output loads. For example, in the graph below, The XS1000 is still over 90% efficient at 30% of rated output (300W).



The XS500 is over 90% efficient at loads of 250W or higher. The XS500 provides up to 504W with no fan cooling and is therefore a silent power supply.



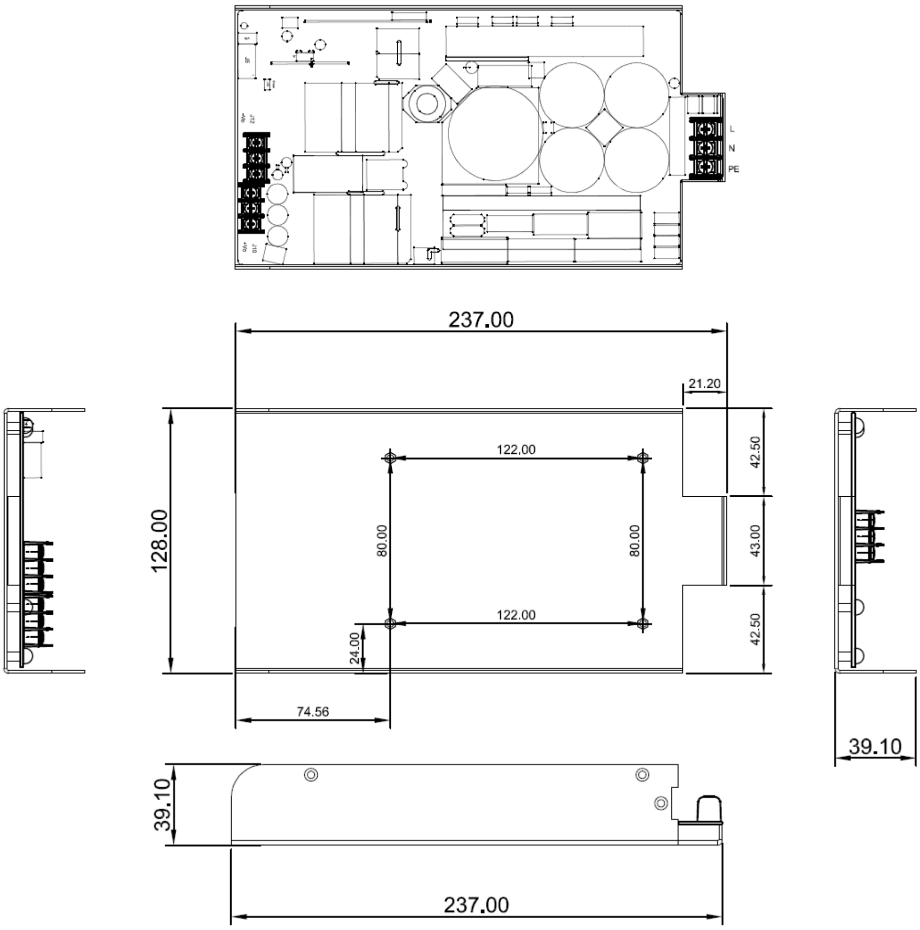
The XS500 can also be cooled using system air flow. Please refer to XS500 derating curves get detailed line and temperature derating of the XS500.

SECTION 4 MECHANICAL SPECIFICATIONS

4.1 Mechanical Information

The Xsolo mechanical outline is shown below. Full 3D and STEP files can be downloaded from www.advancedenergy.com or alternatively contact productsupport.ep@aei.com for details.

XS500 (unit: mm)

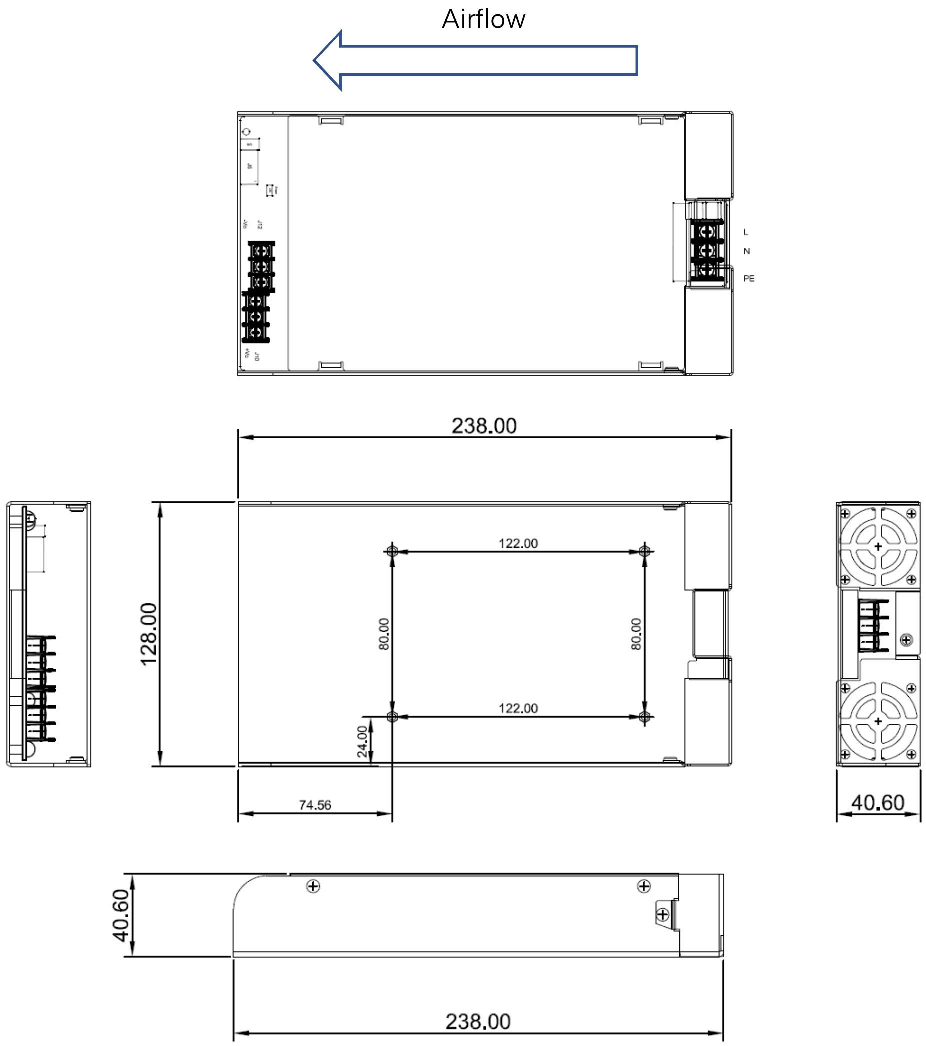


FRONT VIEW

BACK VIEW

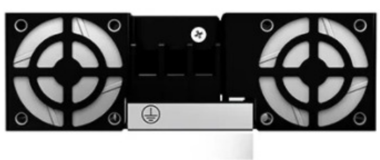
SECTION 4 MECHANICAL SPECIFICATIONS CON'T

XS1000/XB1000 (unit: mm)



Side VIEW

BACK VIEW



FRONT VIEW

SECTION 4 MECHANICAL SPECIFICATIONS CON'T

4.2 Weight Information

The XS500 series weight is normal 1.1kg.

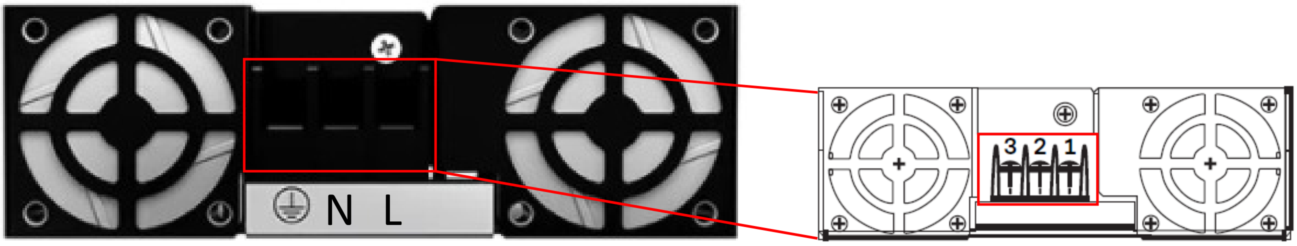
The XS1000 and XB1000 series weight is normal 1.3kg.

SECTION 4 MECHANICAL SPECIFICATIONS CON'T

4.3 Connectors Definition and Mating Connector

Input Connectors - J7

AC mains is applied to the Xsolo via the 3 Screw Terminal.

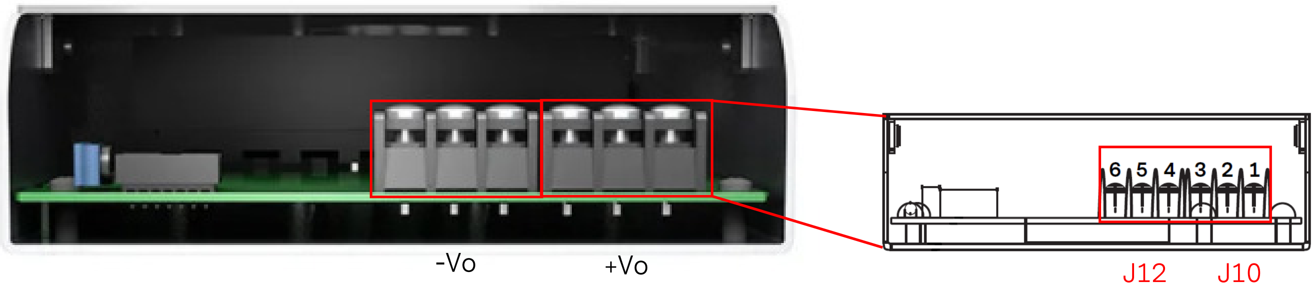


Reference	On Power Supply	Mating Connector or Equivalent
J7 AC Mains Input Connector	Molex 38720-7503	Stripped Wire

SECTION 4 MECHANICAL SPECIFICATIONS CON'T

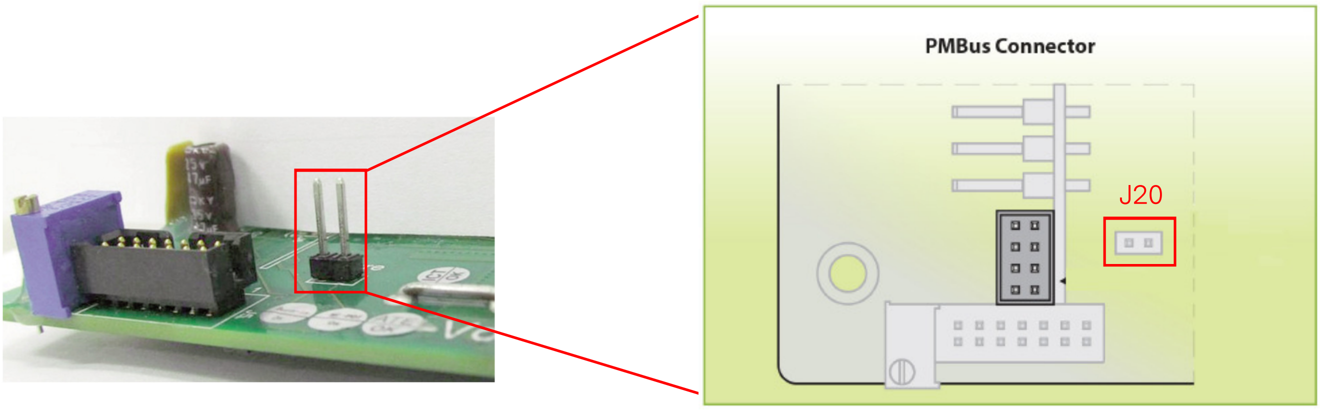
Output Connector - J10 & J12

The maximum current per screw terminal is 20Amps.



Reference	On Power Supply	Mating Connector or Equivalent
J10 & J12 Output Connector	Tyco 2-1437667-5	Stripped Wire

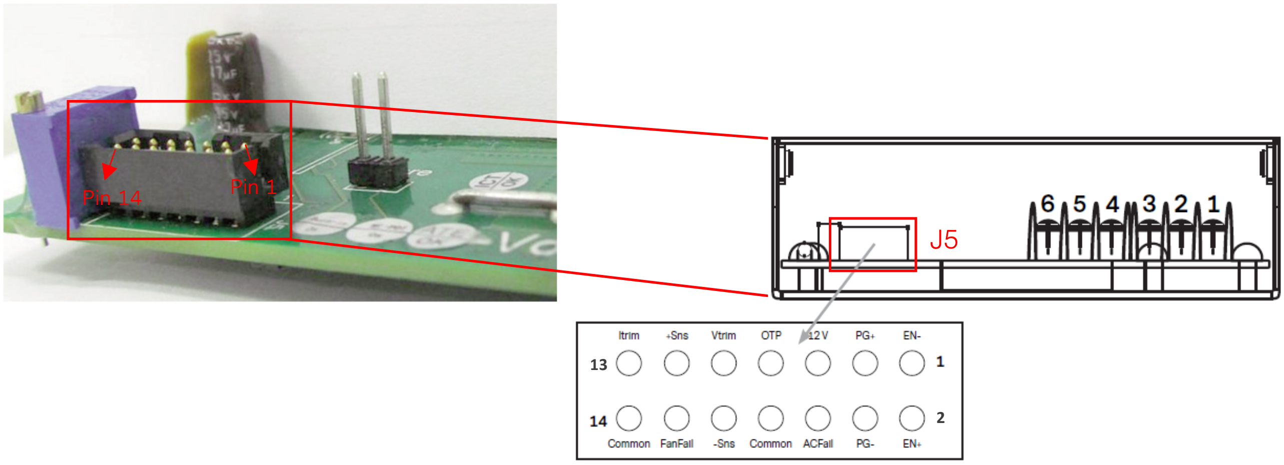
Current Share Connector - J20



Reference	On Power Supply	Mating Connector or Equivalent
J20 Current Share Connector	Jumper Socket, 2.54mm, 2-way	Harwin M7567-05

SECTION 4 MECHANICAL SPECIFICATIONS CON'T

Output Signal Connector - J5

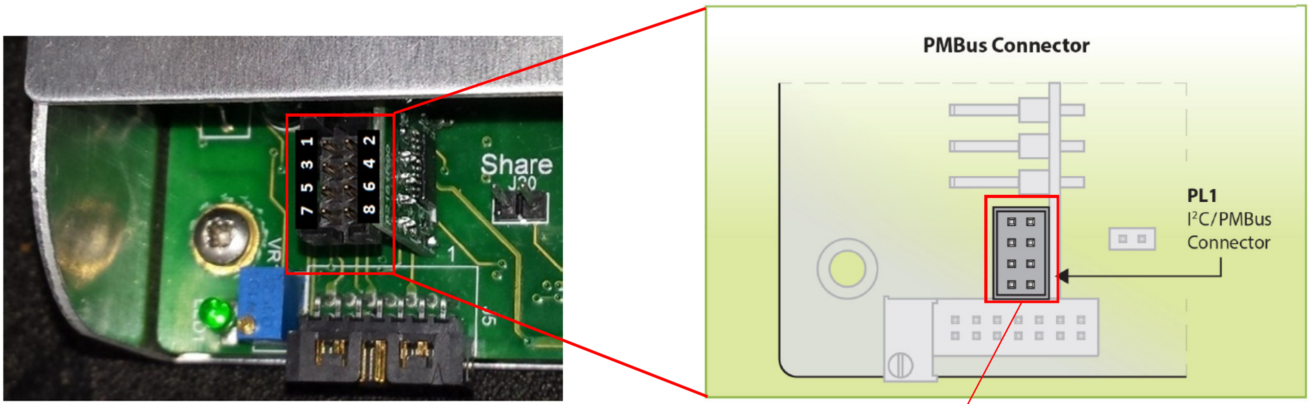


Reference	On Power Supply	Mating Connector or Equivalent
J5 Output Signal Connector	Molex 87831-1420	Locking Molex 51110-1451 Non Locking 51110-1450 Crimp Terminal Molex 50394

SECTION 4 MECHANICAL SPECIFICATIONS CON'T

PMBus™ Connector (Optional) - PL1

The PMBus™ compatible interface can be used for monitoring the output voltage and current. It can also be used to manage real time data for the PSU. For full details on PMBus™ please contact productsupport.ep@aei.com for details.



PL1 Pin 1: NC
Pin 2: GND
Pin 3: NC
Pin 4: NC
Pin 5: SCL
Pin 6: NC
Pin 7: NC
Pin 8: SDA

Reference	On Power Supply	Mating Connector or Equivalent
PL1 PMBus Connector	Molex 87833-0831	Locking Molex 51110-0860 Non Locking 51110-0850 Crimp Terminal Molex 50394

SECTION 4 MECHANICAL SPECIFICATIONS CON'T

Mounting Options

Base Plate Mounting

The Xsolo can be mounted in the system via the 4 mounting holes on the base of the power supply. See mechanical drawings for mounting hole positions. Use M3 mounting screws and ensure that maximum screw penetration depth is 6mm. Maximum allowable torque is 0.63Nm.

Side Mounting

The Xsolo can be mounted in the system via the 2 mounting holes on each side of the case. See mechanical drawings for mounting hole positions. Use M3 mounting screws and ensure that maximum screw penetration depth is 6mm. Maximum allowable torque is 0.63Nm.

SECTION 5 ENVIRONMENTAL SPECIFICATIONS

5.1 Environmental Parameters

The Xsolo series are designed for the following parameters

- Material Group IIIb, Pollution Degree 2
- Installation Category 2
- Class I
- Indoor use (installed, accessible to Service Engineers only).
- Altitude: -155 meters to +3000 meters from sea level.
- Humidity: 5 to 95% non-condensing.
- Operating temperature -40 ^{O}C to 70 ^{O}C.
- Storage temperature -40 ^{O}C to 85 ^{O}C.
- Derate at 1.67% per ^{O}C above 40 ^{O}C and up to 70 ^{O}C.

Environmental Conformal Coating (Option C)

Xsolo is available with conformal coating for harsh environments and MIL-COTs applications. It is IP50 rated against dust and protected against vertical falling drops of water and non condensing moisture. Conformal coating material is polyurethane based and military qualified.

Ruggedized Option (Option R)

Xsolo is available with extra ruggedisation for applications that are subject to extremes in shock and vibration. These parts have been tested on 3 axes, for a total of 300hours at 1.67g's rms.

Conformally Coated and Ruggedized (Option S)

Additional Information

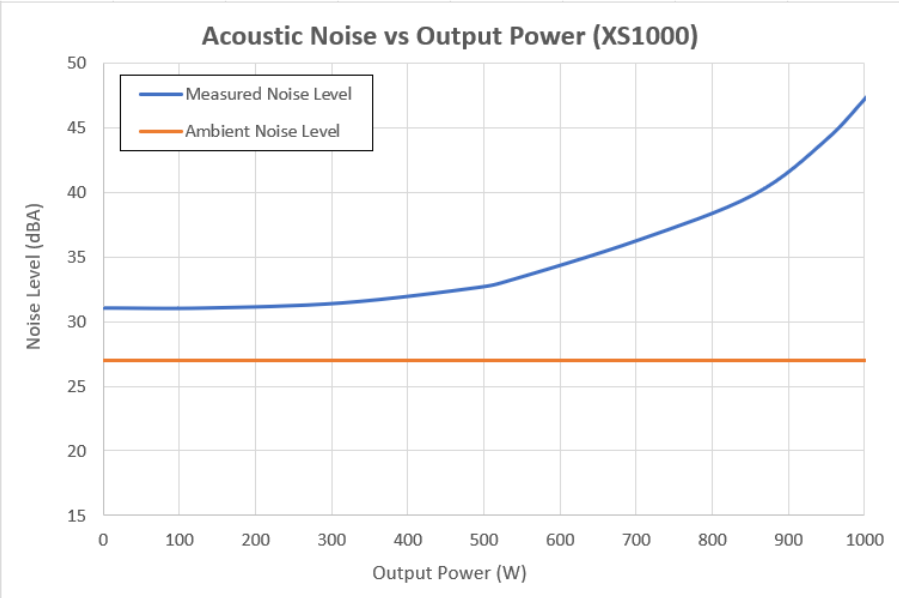
Additional information such as Application Note, White Papers, Safety Certificates etc. are available at www.advancedenergy.com . Alternatively, please do not hesitate to contact productsupport.ep@aei.com if you have any further questions or need additional information.

SECTION 5 ENVIRONMENTAL SPECIFICATIONS CON'T

5.2 Acoustic Noise

The XS500 provides up to 504W with no fan cooling and is therefore a silent power supply.

The XS1000 has an integral temperature controlled fan that only operates if and when the output load and internal component temperatures require. Please refer to the Acoustic Noise vs Output Power XS1000 graph below.



SECTION 5 ENVIRONMENTAL SPECIFICATIONS CON'T

5.3 EMC Characteristics

EMC Directive 2004/108/EC

Component Power Supplies such as the Xsolo series are not covered by the EMC directive. It is not possible for any power supply manufacturer to guarantee conformity of the final product to the EMC directive, since performance is critically dependent on the final system configuration. System compliance with the EMC directive is facilitated by AE products compliance with several of the requirements as outlined in the following paragraphs. Although the Xsolo meets these requirements, the CE mark does not cover this area.

The table below outlines the EMC characteristics of the Xsolo power supply under load conditions.

A full EN60601-1-2 4^{th} edition test report is available on request. Contact Advanced Energy for details.

Parameter	Conditions/Descriptions	Criteria
Radiated Emissions	EN55011, EN55022 and FCC, Class B	-
Conducted Emissions	EN55011, EN55022 and FCC, Class B	-
Power Line Harmonics	EN61000-3-2, Class A	-
Voltage Flicker	EN61000-3-3	-
ESD	EN61000-4-2, Level 2, 6kV contact, 8kV air	A
Radiated Immunity	EN61000-4-3, Level 3, 10V/m	A
Electrical Fast Transient	EN61000-4-4, Level 3, ±2kV	A
Surge Immunity	EN61000-4-5, Level 3, 2kV DM, 4kV CM	A
Conducted RF Immunity	EN61000-4-6, Level 3, 10Vrms	A
Power Frequency Magnetic Field	EN61000-4-11, SEMI F47 compliant[1]	-

Note 1 - SEMI F47 compliant at input voltage > 160Vac.

Radiated EMI should be tested in a system environment, Radiated EMI performance in a system will vary significantly from a stand-alone power supply due to the system enclosure which will provide additional shielding.

Criteria A: The apparatus shall continue to operate as intended. No degradation of performance or loss of function is observed during or after the test.

Criteria B: The apparatus shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer when the apparatus is used as intended. During the test, temporary degradation of performance is allowed if is self-recoverable.

Criteria C: Temporary loss of function is allowed during and after the test that require operator intervention to restore the product/apparatus to normal operation.

Criteria D: During the test, Loss of function which is not recoverable.

SECTION 5 ENVIRONMENTAL SPECIFICATIONS CON'T

Additional EMI Characterization

Xsolo is compliant with SEMI F47 for voltage dips and interruptions when input voltage > 160Vac. The Xsolo series of power supplies have been designed for used in harsh environments including military application.

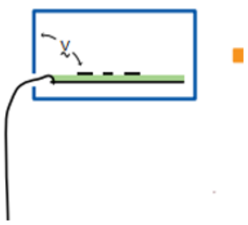
Guidelines for Optimal EMC Performance

Xsolo series products are designed to comply with European Normative limits (EN) for conducted and radiated emissions and immunity when correctly installed in a system. However, power supply compliance with these limits is not a guarantee of system compliance. System EMC performance can be impacted by a number and combination items. Design consideration such as PCB layout and tracking, cabling arrangements and orientation of the power supply amongst others all directly contribute to the EMC performance of a system.

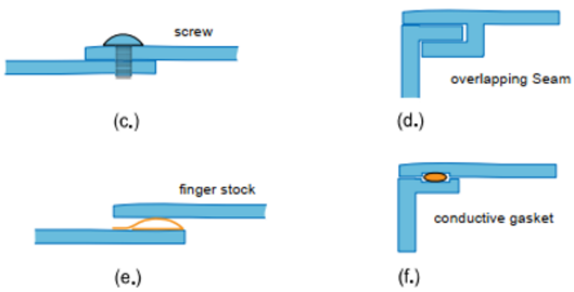
Cabling arrangements and PCB tracking layouts are the greatest contributing factors to system EMC performance. It is important that PCB tracks and power cables are arranged to minimise current carrying loops that can radiate, and to minimise loops that could have noise currents induced into them. All cables and PCB tracks should be treated as radiation sources and antenna and every effort should be made to minimise their interaction

- Route all cables as close as possible to a well earthed sheet of metal.
- Keep all cable lengths as short as possible
- Minimise the area of power carrying loops to minimise radiation, by using twisted pairs of power cables with the maximum twist possible.
- Run PCB power tracks back to back.
- Minimise noise current induced in signal carrying lines, by twisted pairs for sense cables with the maximum twist possible.
- Do not combine power and sense cables in the same harness.
- Ensure good system grounding. System Earth should be a "starpoint". Input earth of the equipment should be directed to the "starpoint" as soon as possible. The power supply earth should be connected directly to the "starpoint". All other earths should go to the 'starpoint".

If the power supply is enclosed in a larger system enclosure, it is preferable to use a conductive metal enclosure and that all seams have a good conductive bond using one of these methods.



System enclosure

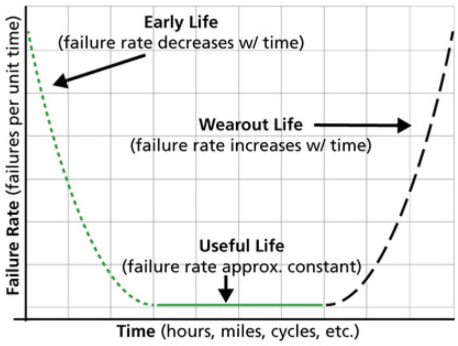


Treatment of Seams

SECTION 5 ENVIRONMENTAL SPECIFICATIONS CON'T

5.4 Reliability

The 'bath-tub' curve shows how the failure rate of a power supply develops over time. It is made up of three separate stages. Immediately after production, some units fail due to defective components or production errors. To ensure that these early failures do not happen while in the possession of the user, Advanced Energy carries out a full burn-in on each unit, designed to ensure that all these early failures are detected at Advanced Energy. After this period, the power supplies fail very rarely, and the failure rate during this period is fairly constant. The reciprocal of this failure rate is the MTBF (Mean Time Between Failures).



At some time, as the unit approaches its end of life, the first signs of wear appear and failures become more frequent. Generally 'lifetime' is defined as that time where the failure rate increases to five times the statistical rate from the flat portion of the curve.

In summary, the MTBF is a measurement of how many devices fail in a period of time (i.e. a measure of reliability), before signs of wear set in. On the other hand, the lifetime is the time after which the units fail due to wear appearing. The MTBF may be calculated mathematically as follows:

MTBF = Total x t / Failure, where

Total is the total number of power supplies operated simultaneously.
Failure is the number of failures.
t is the observation period.

MTBF may be established in two ways, by actual statistics on the hours of operation of a large population of units, or by calculation from a known standard such as latest Telecordia SR-332, MIL-HDBK-217 and its revisions.

Determining MTBF by Calculation

MTBF, when calculated in accordance with Telecordia, MIL-HDBK-217 and other reliability tables involves the summation of the failure rates of each individual component at its operating temperature. The failure rate of each component is determined by multiplying a base failure rate for that component by its operating stress level. The result is FPMH, the failure rate per million operating hours for that component. Then FPMH for an assembly is simply the sum of the individual component FPMH.

Total FPMH = FPMH1 + FPMH2 + ………... +FPMHn

MTBF (hours) = 1,000,000 ÷ FPMH

In this manner, MTBF can be calculated at any temperature.

Xsolo MTBF has an MTBF of 550,000 hours at 40 ^{O}C and full load based on the Telecordia SR-332 (fans excluded).

SECTION 5 ENVIRONMENTAL SPECIFICATIONS CON'T

MTBF and Temperature

Reliability and MTBF are highly dependent on operating temperature. The figures above are given at 40 ^{O}C. For each 10 ^{O}C decrease, the MTBF increases by a factor of approximately 2.

Conversely, however, for each 10 ^{O}C increase, the MTBF reduces by a similar factor. Therefore, when comparing manufacturer's quoted MTBF figures, look at the temperature information provided.

SECTION 6 SAFETY APPROVALS / CERTIFICATION

6.1 Safety Approvals

Xsolo is certified to EN62368-1 and EN60950 2nd Edition for industrial applications and certified to UL/EN660601-1 2nd and 3rd Edition for medical applications, meeting the stringent creepage and clearance requirements, 4KVAC isolation and <300uA leakage current. Xsolo is designed to meet MIL810G and is also compliant with SEMI F47 when V_{IN} > 160Vac for voltage dips and interruptions as well as being compliant with all relevant EMC emission and immunity standards.

XS1000 / XS500	Isolation Voltage		Creepage Distances
Input to Output	Reinforced (2 x MOPP)	4000Vac	8mm
Input to Case	Basic (1 x MOPP)	1500Vac	4mm

The XB1000's Output to Earth isolation has been designed to meet the creepage, clearance and dielectric withstand requirements of 1 MOPP for a working voltage equal to the Input Line Voltage, which means it can be used in BF Type applications without the need for an additional isolation barrier from the Patient Connection to Earth.

XB1000	Isolation Voltage		Creepage Distances
Input to Output	Reinforced (2 x MOPP)	4000Vac	8mm
Input to Case	Basic (1 x MOPP)	1500Vac	4mm
Output to Case	Basic (1 x MOPP)	1500Vac	4mm

Low Voltage Directive (LVD) 2006/95/EC.

The LVD applies to equipment with an AC input voltage of between 50V and 1000V or a DC input voltage between 75V and 1500V. The Xsolo series is CE marked to show compliance with the LVD. The relevant European standard for Xsolo is 62368 for ICT and AV equipment. The relevant European standard for Xsolo is EN60601-1 3rd Edition (Medical Devices Directive). With appropriate packaging, the Xsolo and can also meet the requirements of EN61010-1 for industrial scientific measuring equipment and process control.

The full table of Safety certifications are listed below.

Model	Standard	Certification / Description
XS500 XS1000 XB1000	EN60601-1	EN60601-1 2nd and 3rd Edition cTUVus 60601-1
	EN60950	EN60950 2nd Edition cTUVus 60950
	EN62368-1	EN62368-1 2nd Edition

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

7.1 Xsolo Operation

The Xsolo provides the front end input power to the model. The Xsolo can operates of 85-264Vac, 47-440Hz AC input or 120-380Vdc DC input.

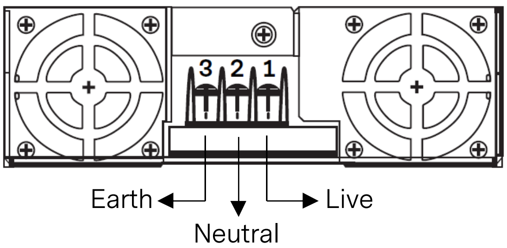
7.2 Input Power

AC Input Connector

L – Live

⏚ – Earth

N – Neutral



7.3 Output Power

Pin 1 – +Main Output (+Vo)

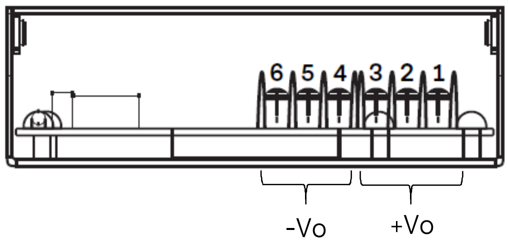
Pin 2 – +Main Output (+Vo)

Pin 3 – +Main Output (+Vo)

Pin 4 – Main Output Return (-Vo)

Pin 5 – Main Output Return (-Vo)

Pin 6 – Main Output Return (-Vo)



7.4 System Signal

J5 – Output Signal Connector

EN-, EN+ (Remote ON/OFF) – (Pins 1, 2 of J5)

The Xsolo will be inhibited by means of a high signal applied to an opto-isolated input (diode of an opto-isolater) on pins J5 connector Pin 2 (positive) and Pin 1 (negative). The delay from Inhibit to output turning OFF is typically <1ms.

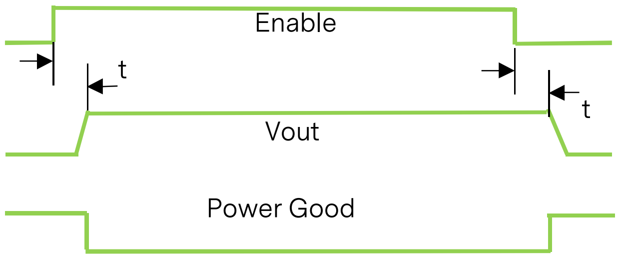
Maximum current source allowed is 6.5mA.

Maximum applied voltage allowed is 13V.

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

PG+, PG- (Power Good) – (Pins 3, 4 of J5)

The Xsolo contains an internal comparator which monitors the output voltage and determines whether this voltage is within normal operation limits. When the output voltage is within normal limits, the PowerGood signal is activated. The signal is implemented by an open collector of an opto-isolater which is available on J5 Pin 3 (collector) and J5 Pin 4 (emitter) (transistor ON = Power Good).



12V (Standby Output) – (Pin 5 of J5)

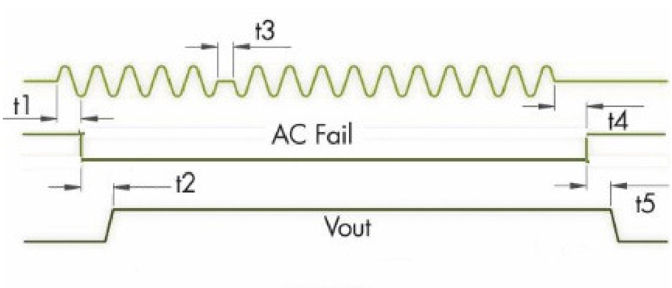
The standby voltage provide a 12V, 300mA bias output.

AC FAIL (AC Mains Fail) – (Pin 6 of J5)

AC Mains fail signal is accessed through J5 connector Pin 6. There is an on-board series current limit resistor of 2Kohm connecting Pin 6 to the collector of an NPN transistor optocoupler output. The emitter is connected to J5 Pin 8 or Pin 14 (Common). During normal operation the transistor is ON. When input voltage is lost or goes below 80Vac, the opto-transistor is turned OFF at least 2 ms before loss of output regulation.

Maximum current source allowed is 6.5mA.
Maximum applied voltage allowed is 13V.

The output voltage waveform below assumes a pull-up resistor to a maximum voltage of +13V.



80ms < t1 < 800ms

10ms <12 < 20ms

T3 = 10ms

T4 > 10ms

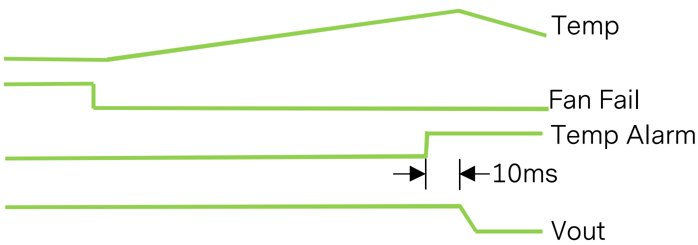
T5> 2ms

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

OTP (Over Temperature Protection) – (Pin 7 of J5)

This is an opto-isolated open collector transistor signal indicating that excessive temperature has been reached due to fan failure or operation beyond ratings. This signal is activated at least 10ms prior to system shutdown. The OTP signal is accessed via J5 connector Pin 7. There is an on-board series connect limit resistor of 2Kohm connecting Pin 7 to the collector of an NPN transistor opto-coupler output. The emitter is connected to J5 Pin 8 or Pin 14 (Common).

The Fan Fail and Temp Alarm signal waveforms in the diagram assume connection via a pull-up resistor to the 12 V bias source or an external voltage.



Vtrim (Voltage Adjustment) - (Pin 9 of J5)

The Xsolo has been designed with maximum user flexibility as a key objective. The output voltage can be adjusted over a wide range by by below method.

1. Voltage setting via the on board potentiometer.
2. Remote voltage programming by applying a control voltage between J5 Pin 9 (Vtrim) and J5 Pin 10 (-Sns).
3. Remote voltage programming by applying a resistor between J5 Pin 9 (Vtrim) and J5 Pin 10 (-Sns)

Remote Voltage Setting (Using External Voltage)

By applying an external voltage between J5 Pin 9 (Vtrim) and J5 Pin 10 (-Sense), the output voltage of Xsolo series may be adjusted over a wide range. The external voltage can be read from the graph below or calculated with the formula:

$$V_{trim} = \frac{V_{out}}{K}$$

Note: the V_{trim} must not exceed 2.5V.

Model	K	Vout Setting Range	Max Current
24V	12.59	14V – 28V	42A
36V	17.05	20V – 40V	28A
48V	24.75	29V – 58V	21A

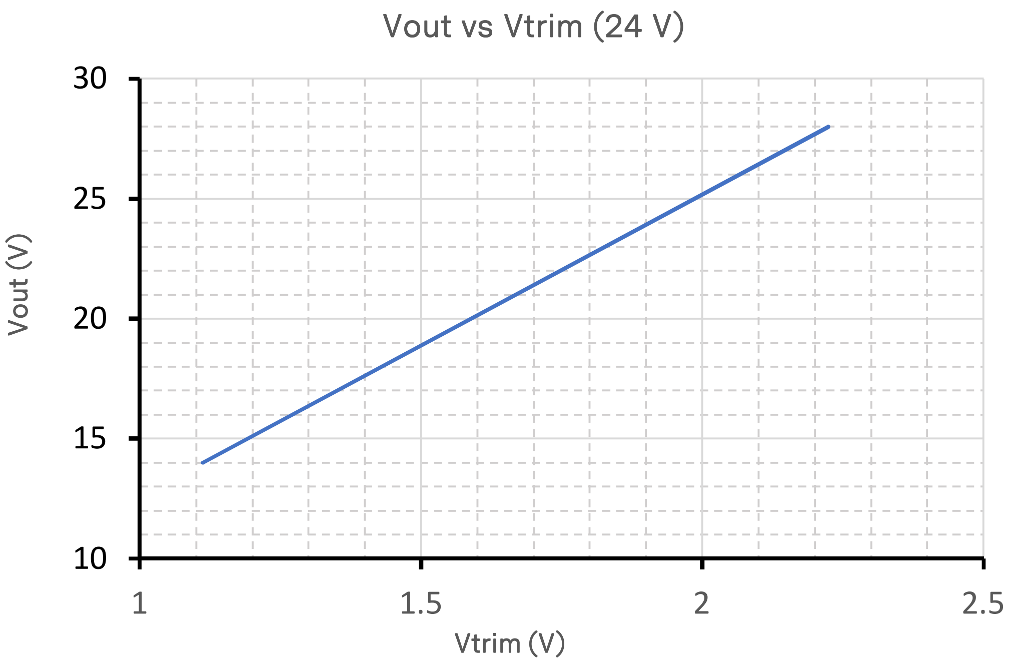
SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

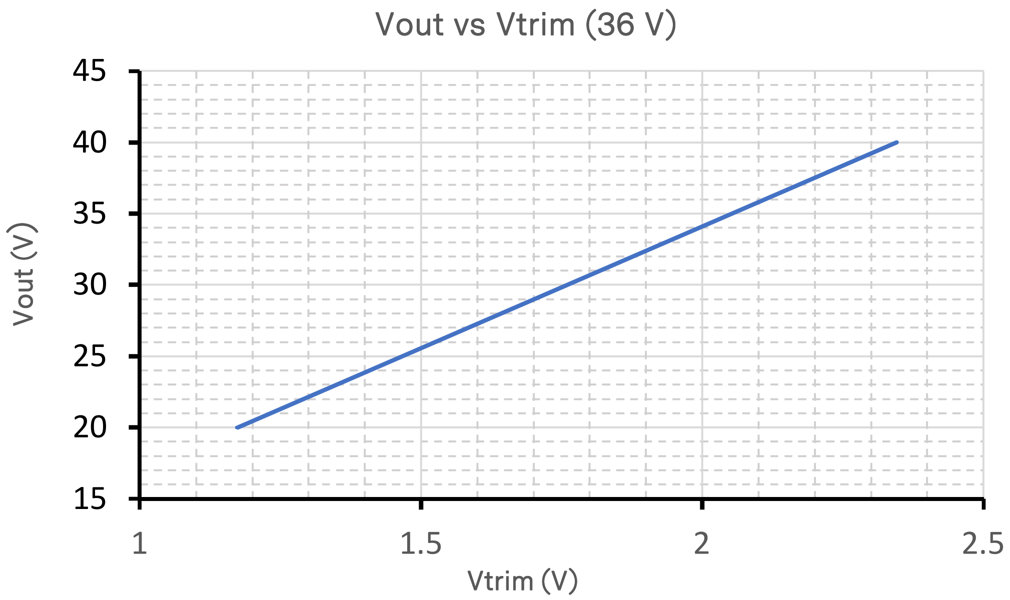
Example: Setting the V_{out} to 20V via the Vtrim Pin on XS500-24:

$$V_{trim} = V_{out}/12.59$$

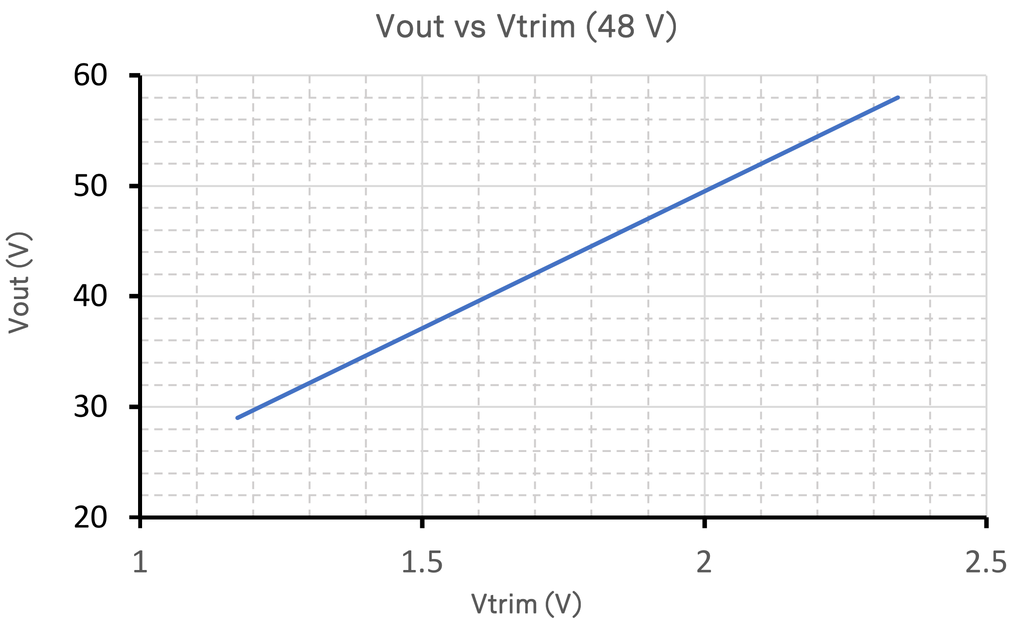
$$V_{trim} = 20/12.59$$

$$V_{trim} = 1.59V$$





SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T



Remote Voltage Setting (Using External Resistance)

By applying an external resistance between J5 Pin 9 (Vtrim) and J5 Pin 10 (-Sense), the output voltage of Xsolo series may be adjusted over a wide range. The R_{VTRIM} resistance required for the users desired output voltage can be calculated using the following formula.

$$R_{VTRIM} = \frac{3700Vout-250K}{2.5K-V_{out}}$$

Model	K	Vout Setting Range	Max Current
24V	12.59	14V – 28V	42A
36V	17.05	20V – 40V	28A
48V	24.75	29V – 58V	21A

Note 1 - Using this formula should set the output voltage to the maximum via the potentiometer on board.

Note 2 - If user need to set a desired output voltage with the potentiometer trimmed to any output voltage, please contact productsupport.ep@aei.com for details.

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

-Sns, +Sns (Remote Sense) – (Pins 10, 11 of J5)

Remote sensing can be used to compensate for voltage drops in the output loads.

Remote sensing may be implemented by connecting the Positive Sense pin (J5 pin 11) to the positive side of the remote load and the Negative Sense pin (J5 pin 10) to the negative side of the remote load. The maximum line drop, which can be compensated for by remote sensing is 0.5V, subject to not exceeding the maximum model voltage at the output terminals.

Fan Fail – (Pin 12 of J5)

The Fan Fail is an Open collector signal indicating that at least one of the Xsolo fans has failed. This does not cause power supply shutdown. The power supply will continue to operate for 10ms after the temperature alarm signal is generated.

The Fan Fail signal is accessed via J5 connector Pin 12. There is an on-board series current limit resistor of 2k connecting Pin 12 to the collector of an NPN transistor opto-coupler output. The emitter is connected to J5 Pin 8 or Pin 14 (Common). When a fan-fail condition is detected this transistor turns off.

Maximum current source allowed is 6.5mA.
Maximum applied voltage allowed is 13V.

Itrim (Current Limit) – (Pin 13 of J5)

The Xsolo has been designed to allow users to adjust the onset of Current Limit for reduced power or constant current applications.

The current limit can be set by below methods.

1. Remote current programming by applying a control voltage between J5 Pin 13 (Itrim) and -Vout.
2. Remote current programming by applying a resistor between J5 Pin 13 (Itrim) and -Vout.

Current Limit Adjustment(Using External Voltage)

By applying an external voltage between the Itrim pin (J5 Pin 13) and -Vout, current limit of the Xsolo can be adjusted from 0A to the max rated current of the supply.

The external voltage can be calculated with the formula:

$$V_{trim} = I_{limit} * F$$

Note: To set Iout to 0A, the Itrim signal must be able to sink 2.3mA.

Model	F	Max Current
24V	0.065	42A
36V	0.091	28A
48V	0.124	21A

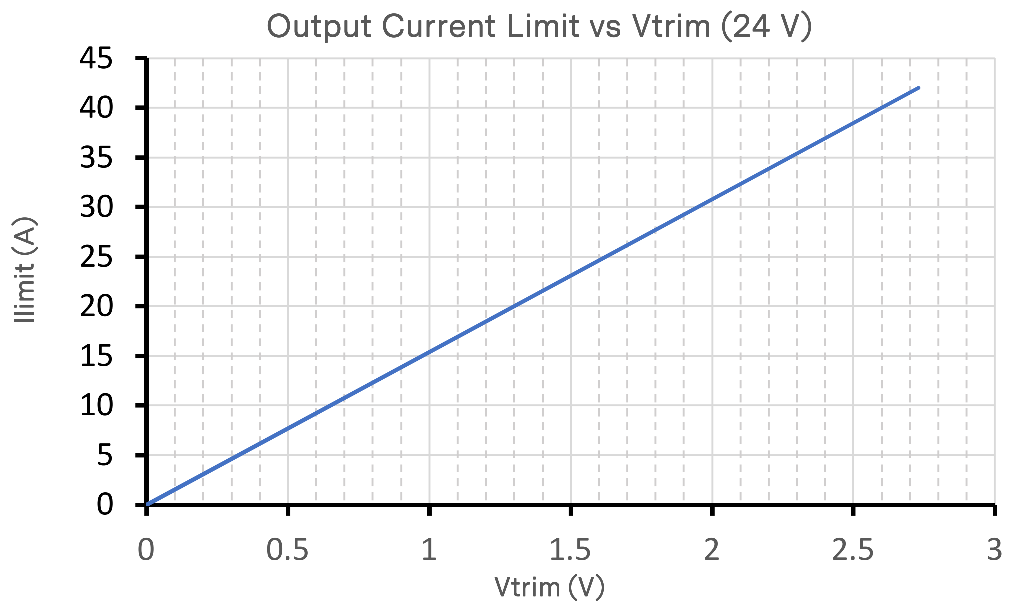
SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

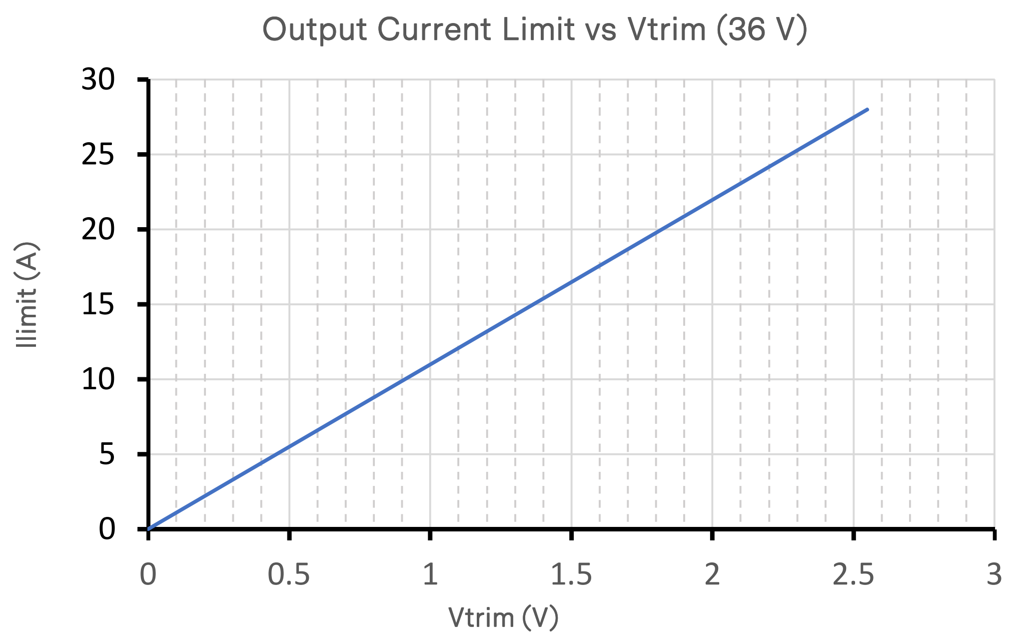
Example: Setting the I_{out} to 15A via the Itrim Pin on XS500-24:

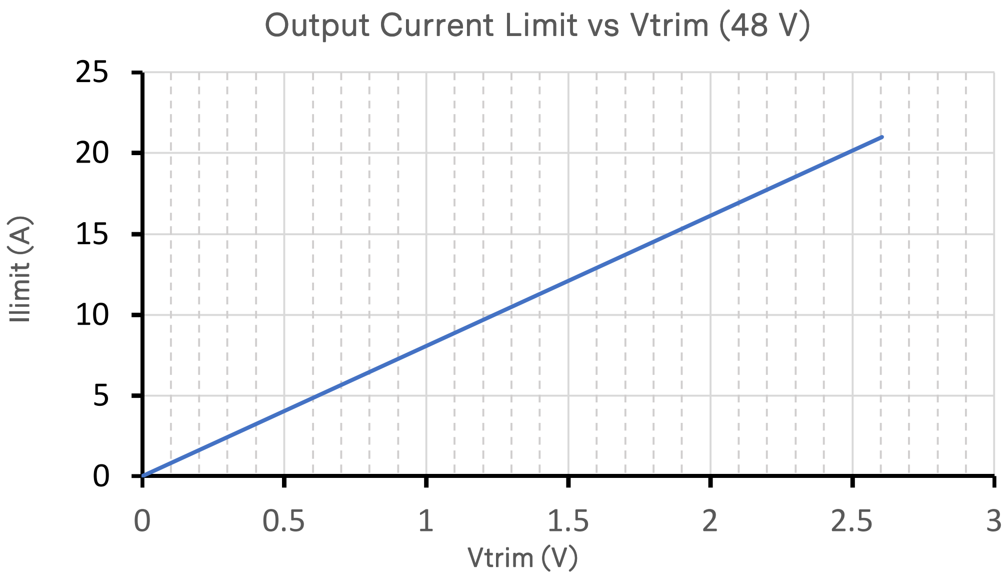
$$V_{trim} = 15 * 0.065$$

$$V_{trim} = 0.98V$$

By applying an external voltage between J5, Pin 13 (Itrim) and -Vout, current limit can be adjusted for a wide range as below.







Current Limit Adjustment (Using External Resistance or Potentiometer)

By apply an appropriate resistor value between J5 Pin 13 (Itrim) and $V_{O,}$ the output voltage can also be changed remotely. The R_{ITRIM} resistance required for the users desired output current limit can be calculated using the following formula along with the same table used to calculate ITRIM .

$$R_{ITRIM} = 1000\frac{FI_{limit}}{2.27 - 0.76(FI_{\text{limit}})}$$

Model	F	Max Current
24V	0.065	42A
36V	0.091	28A
48V	0.124	21A

Note 1 - User can contact productsupport.ep@aei.com for a quick/desired current limit value.

Current Limit Programming(Foldback)

The Current Limit characteristics of the Xsolo can be programmed to be either Straight Line or Foldback.

The previous sections refer to setting the Straight Line Current Limit of the Xsolo.

To implement Foldback Current Limit, please contact productsupport.ep@aei.com for details.

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

J20 – Current Share Connector

The Xsolo displays a very good current share performance but we still recommend a 5% derating when connecting within three models in parallel.

Contacting productsupport.ep@aei.com for more directions when paralleling more than three Xsolos.

SECTION 8 INSTALLATION

8.1 Installation Considerations

The Xsolo models can be mounted on any of three surfaces using standard M3 screws. The chassis comes with four mounting points on the base. Maximum allowable torque is 0.63Nm. The maximum penetration depth is 6mm. Maintain a 50mm minimum clearance at both ends of the Xsolo power supply and route all cables so airflow is not obstructed. The XS1000 and XB1000 unit draws air in on the input side and exhausts air out the load side. If airflow ducting is used, avoid sharp turns that could create back pressure.

Avoid excessive bending of output power cables after they are connected to the Xsolo power model. For high current outputs, use cable-ties to support heavy cables and minimize mechanical stress on output studs. Be careful not to short-out to neighboring output studs.

The maximum torque recommended on output connectors is 0.79Nm. Avoid applications in which the unit is exposed to excessive shock or vibration that exceed the specified levels. In such applications, a shock absorption mounting design is required.

When this product is used on 180 to 253 Volts AC mains with no neutral in north America area, connect one live wire to L (live) terminal and the other live wire to N (neutral) terminal on the input connector. For installation in accordance with EN60601-1, UL2601-1, IEC60950-1, UL60950-1, EN62368-1, the wires connected to the Neutral terminal must be provided with a suitable fuse protection device.

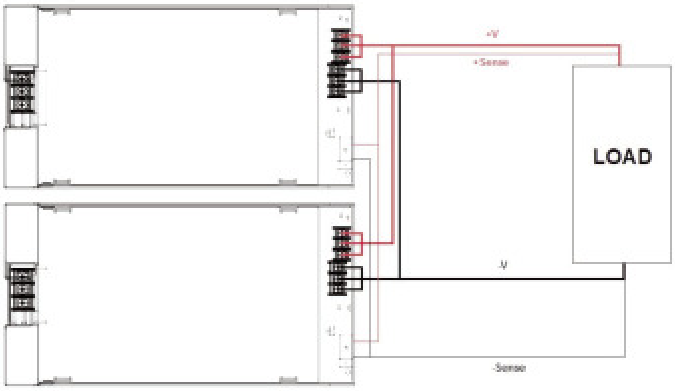
The plug shall be rated to a current not less than 125% of the rated current of the equipment.

SECTION 9 APPLICATION NOTES

9.1 Parallel Connection and N+1 Redundant Operation

How to Connect in Parallel

To achieve increased current capacity, 2 or more Xsolo power supplies may be connected in parallel. To connect in parallel the current share header J20 must be added to each Xsolo product, all -Vo pins must be connected together and then the outputs must be trimmed to within 5mV of each other using the on-board potentiometer. Only then can the positive parallel connectors be attached, and the parallel supplies connected to the load.



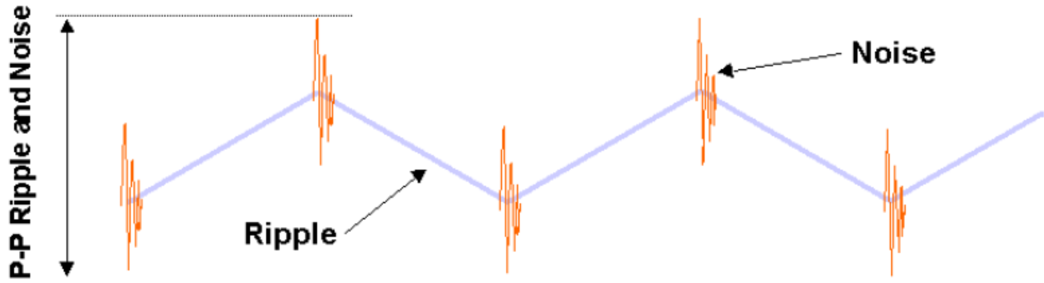
For optimal current sharing with the OR-ing option, a small load (around 5% of rated load) should be applied to the Xsolo during this paralleling procedure to forward bias the OR-ing FET. If paralleling 3 or more Xsolos consult Advanced Energy for applications support.

How To implement N+1 Redundancy

Xsolo can be utilised in systems that require N+1 redundant operation. For these applications, the OR-ing option should be selected. The OR-ing FET will isolated the Xsolo from the system in the unlikely event of an Xsolo failure, allowing the system to continue to function. Then simply connect the required number of Xsolo power supplies in parallel using the procedure for parallel connection of Xsolo.

SECTION 9 APPLICATION NOTES CON'T

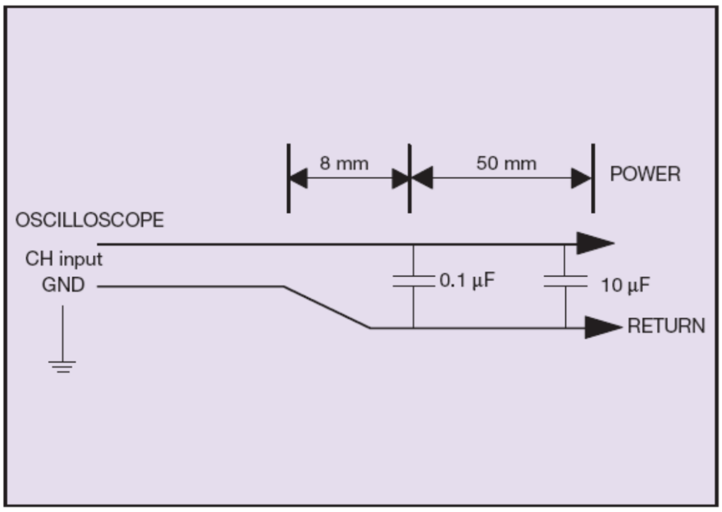
9.2 Ripple and Noise Measurement



As with all switched mode power supplies, it is important to ensure that the correct method is used to measure ripple & noise. Care should be taken to ensure that a loop antenna is not formed by the tip and ground lead of the oscilloscope probe as this would lead to erroneous readings consisting mainly of pickup from remnant radiation in the vicinity of the output connectors. Advanced Energy recommends the use of an x1 probe with the ground sheath of the probe tip used for ground connection. In some applications, further erroneous readings may result from Common Mode currents. These can be reduced by looping a few turns of the scope lead through a suitable high permeability ferrite ring. As most loads powered by a power supply will have at least small values of differential capacitance located near the load, We also recommends the use of small value of capacitance (approx.. 1uF) positioned at the point of measurement.

For further information refer to Application Note AN1105: Ripple and Noise for additional details on how to measure and reduce output ripple and noise.

The setup outlined in the diagram below has been used for output voltage ripple and noise measurements on the Xsolo series. When measuring output ripple and noise, a scope jack in parallel with a 0.1uF ceramic chip capacitor, and a 10uF tantalum capacitor will be used. Oscilloscope can be set to 20MHz bandwidth for this measurement.



SECTION 9 APPLICATION NOTES CON'T

Minimising System Noise

There are a number of causes of poor system noise performance. Some of the more common causes are listed below.

- Insufficient de-coupling on the PCB or load.
- Faulty wiring connection or poor cable terminations.
- Poor system earthing, system level grounding and shielding issues

There are some simple steps to eliminate, reduce or identify the causes of high frequency noise;

- Is the noise conducted or radiated? If changing the position of the power supply or screening improves performance, the noise is likely to be radiated. See EMC characteristics.
- Twist all pairs of power and sense cables separately.
- Ground connections (zero Volt) should be made with the shortest possible wiring via a capacitor to the nearest point on the chassis.

SECTION 10 RECORD OF REVISION AND CHANGES

Issue	Date	Description	Originators
1.0	09.29.2021	First Issue	K. Ma
1.1	03.24.2022	Update J5 pin assignment and current limit adjustment formula	K. Ma

ABOUT ADVANCED ENERGY

Advanced Energy (AE) has devoted more than three decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

Our products enable customer innovation in complex applications for a wide range of industries including semiconductor equipment, industrial, manufacturing, telecommunications, data center computing, and medical. With deep applications know-how and responsive service and support across the globe, we build collaborative partnerships to meet rapid technological developments, propel growth for our customers, and innovate the future of power.

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