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## Contents

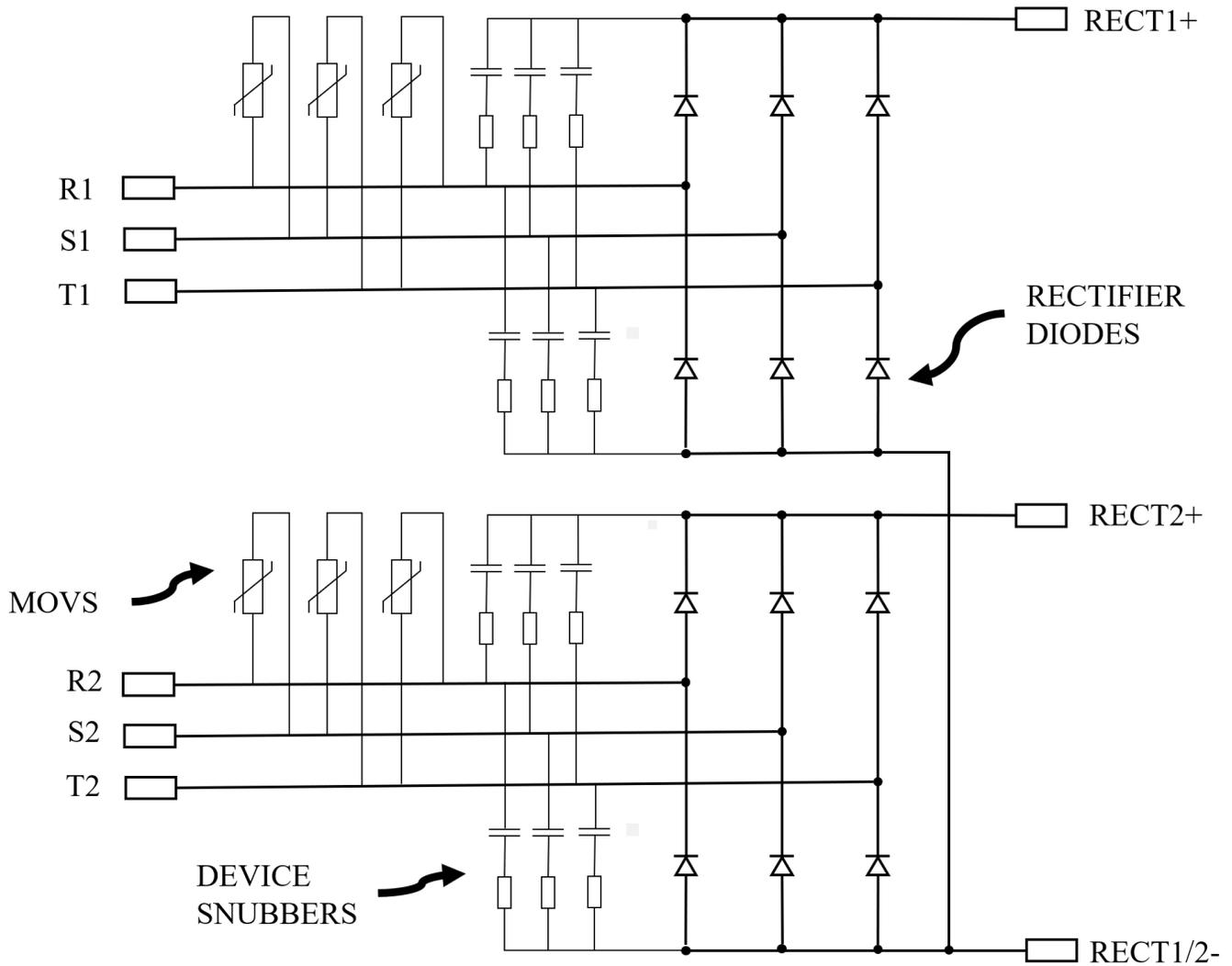
1. Introduction .....	4
1.1 Overview.....	4
1.2 Power Device Details .....	6
1.3 Typical Applications.....	6
1.4 Related Documents.....	6
2. WARNINGS .....	7
3. External Requirements .....	8
3.1 DC Link Pre-Charge .....	8
3.2 Over-Current Protection .....	8
3.3 Over-Temperature Protection .....	8
3.4 Input Inductance .....	9
3.5 Fuses .....	9
3.6 12-Pulse Systems .....	9
3.7 Coolant Flow .....	9
4. Specification.....	10
4.1 Electrical – Power Section.....	10
4.2 Power Connections .....	11
4.3 Electrical – Control Connections.....	12
4.4 Cooling .....	14
4.5 Environmental.....	15
4.5.1 Operating.....	15
4.5.2 Storage & Transport.....	16
4.6 Mechanical.....	17
5. Contact Details for Sales, Service and Support.....	18
6. Document Revision History .....	18

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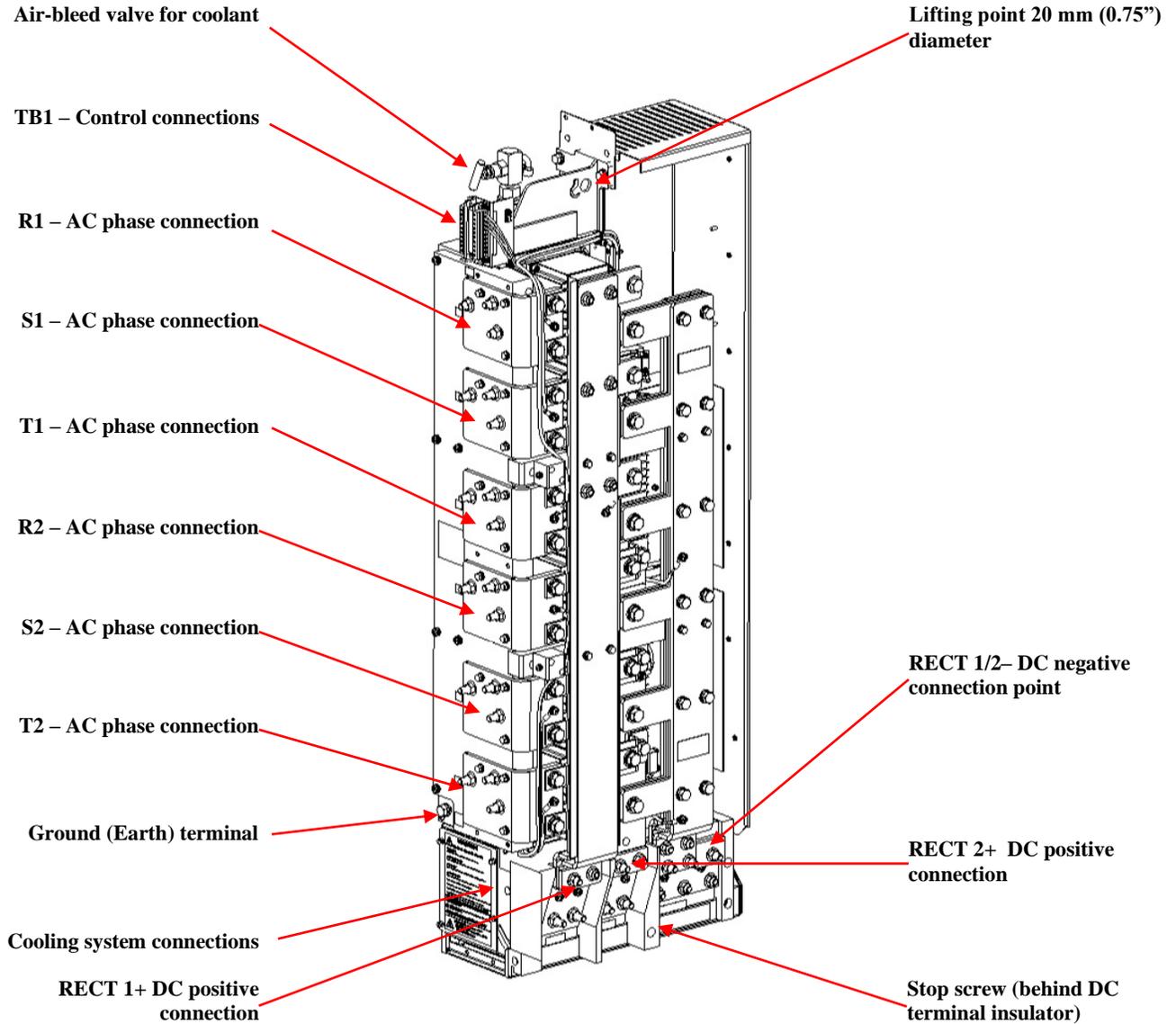
## 1. Introduction

### 1.1 Overview

- The AER3500L-4601-D is a liquid cooled module containing two identical standard 3-phase DIODE rectifier modules, along with MOV and SNUBBER protection for the DIODES.
- The combined current rating of the two rectifier bridges is 3500A DC (average).
- The following schematic shows the power circuits of the AER3500L-4601-D:



- The following illustration shows the mechanical arrangement of the module:



- The module fits into the standard cabinet mounting frames used for liquid cooled DELTA modules, Avid Extreme Inverter modules and MVRL2100 liquid cooled inverter modules.
- To help with system design, a 3D model of the AER3500L-4601-D may be downloaded from <https://avidcontrolsinc.com/step-files/>.

### 1.2 Power Device Details

- The following table details the main attributes of the power devices used in the unit. See the previous schematic for context:

Device	Main Parameters	Notes
RECTIFIER DIODES	Reverse Voltage = 2.2kV Nominal Current = 1100A	Type is Infineon DZ1070N22K
MOVs	Nominal Voltage = 750Vac Peak Current = 40kA Energy Rating = 1200J	For MOVs to operate correctly, the unit must be operated with input reactors on all AC connections. Type is TDK/EPCOS B72240B0751K001
DEVICE SNUBBERS	Capacitance = 0.3 $\mu$ F +/- 10% Resistance = 14.7 $\Omega$ +/- 5% 150W max.	For SNUBBERS to operate correctly, the unit must be operated with input reactors on all AC connections.

### 1.3 Typical Applications

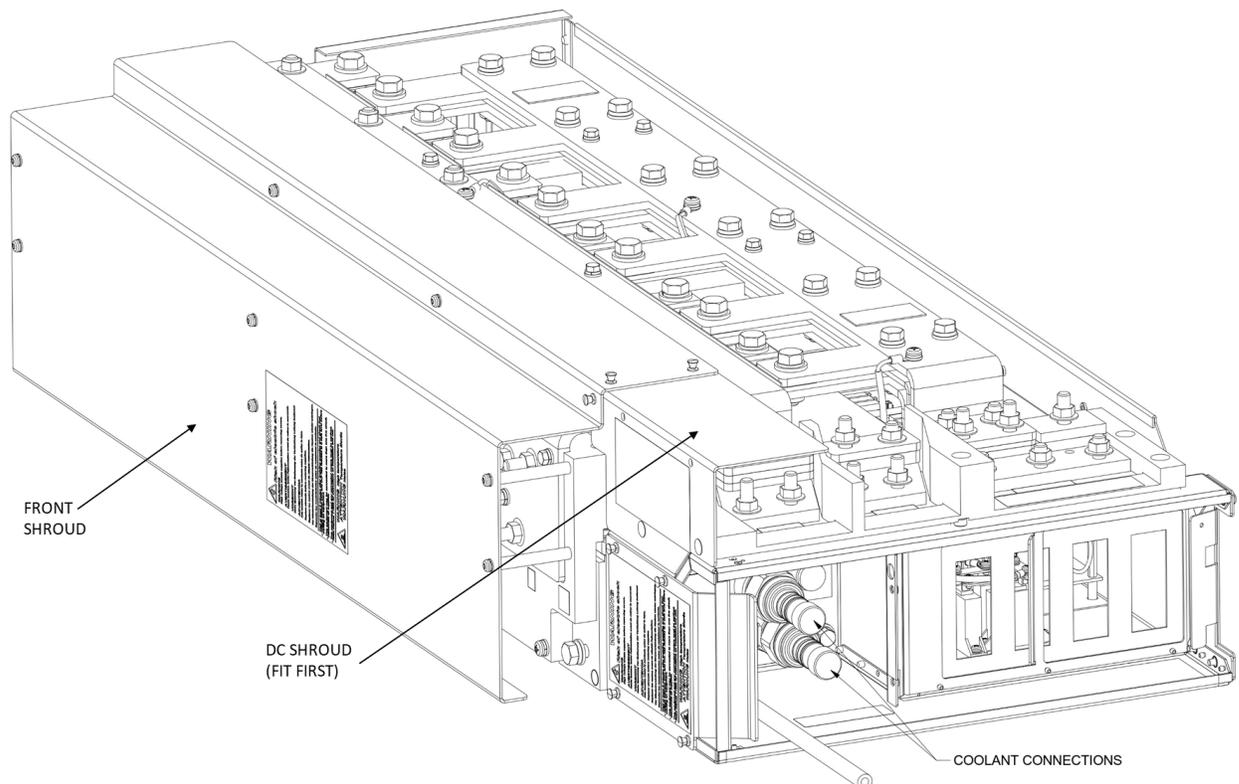
- The AER3500L-4601-D is typically used in MV3000 or AE3000 AC drive systems to provide a high-power DC link for multiple inverter modules.
- In these applications, the temperature of the AER3500L-4601-D is monitored by an MV3000 Common Drive Controller and if limits are exceeded, a TRIP signal is generated.
- The AER3500L-4601-D may be used as a DIODE rectifier in any application that provides the EXTERNAL REQUIREMENTS detailed below.

### 1.4 Related Documents

- Since the AER3500L-4601-D is primarily intended for use alongside Avid MVDL & AEI-L liquid cooled inverter modules, the following documents provide much necessary information:
  - T1693EN, MV DELTA Liquid Cooled Drive System
  - T1679EN, MV3000 Drive Range Software Technical Manual

## 2. WARNINGS

- This equipment may be connected to more than one live circuit.
- AER3500L-4601-D is a DIODE ONLY rectifier. Over-current and over-temperature protection must be implemented within the external application. Isolation to protect equipment and personnel must be implemented in the external application.
- Wait at least eight minutes after isolating all supplies and check all voltages have reduced to a safe level before working on the equipment.
- Surfaces on the coolant pipes can reach high temperatures and remain hot for some time after power is removed. Ensure that all coolant has cooled to a safe temperature and the equipment is suitably drained and isolated before the external pipework is disconnected from the equipment.
- AC & DC busbars can reach high temperatures and remain hot for some time after power is removed. Ensure they have cooled to a safe temperature before working on the unit.
- Unit is heavy: 125 kg ( 275 lb. ).
- The unit has an open-chassis (IP00) design. It must be enclosed in a suitable cabinet for use.
- The unit contains several clear polycarbonate shrouds to reduce the risk of accidental contact. After installation, these shrouds **MUST** be re-attached to the unit:



### **3. External Requirements**

- The AER3500L-4601-D is a DIODE ONLY rectifier – therefore it is unable to interrupt or limit current levels in the connected AC or DC circuits.

#### **3.1 DC Link Pre-Charge**

- When inverter units containing large DC link capacitor banks are connected to the RECT output terminals of the AER3500L-4601-D, those inverter units must be pre-charged to approximately 1.41 x the RMS value of the input mains supply.
- An external circuit must provide this pre-charge before the AEI3500L-4601-D is connected.
- Note that the AER3500L-4601-D can be disconnected during pre-charge on either the AC side (all phases must be disconnected) or the RECT side (in which case either positive or negative must be completely disconnected from the inverter modules until pre-charge is complete).
- It is the responsibility of the user to ensure that pre-charge design, rating and protection meet the application requirements.

#### **3.2 Over-Current Protection**

- The AER3500L-4601-D cannot limit or interrupt current.
- To protect the AER3500L-4601-D and all external components, suitably designed and rated current interruption devices (usually AC side fuses and breakers) must be included in the application.
- The use of correctly rated high-speed semiconductor fuses at all AC connections is recommended. This can provide protection from over-current damage for the AER3500L-4601-D in the event of a load-side short circuit. See section 3.5 for further details.

#### **3.3 Over-Temperature Protection**

- The AER3500L-4601-D monitors the internal heatsink temperature using both an NTC thermistor for analog temperature indication and open-on-overtemp thermostats for simple over-temperature indication.
- Again, the AER3500L-4601-D cannot disable current flow in the case of an over-temperature condition – an external function **MUST** disable current when an over- temperature condition is signaled.
- See the Specification section for details of the over-temperature signals.

### 3.4 Input Inductance

- For parallel operation of the two rectifier bridges, input reactors of at least 15μH per-phase are required to balance currents.
- In all applications, a minimum effective input inductance of 15μH is required between the AER3500L-4601-D and the source of any high voltage transients. This is required for the MOVES and PHASE SNUBBERS to effectively protect the RECTIFIER DIODES. This can be provided by discrete inductors or by the leakage inductance of transformers that are “downstream” of the transient voltage sources.
- This inductance is also required to provide for fuse-protection of the AER3500L-4601-D.

### 3.5 Fuses

- To protect the AER3500L-4601-D module from damage due to output short-circuits, it is necessary to use high-speed semiconductor-type fuses for all AC inputs.
- Due to the very high rating of the unit, it is expected that parallel fuses will be required – this should be implemented in accordance with the fuse manufacturer’s guidelines for parallel operation.
- The total I<sup>2</sup>T during the fuse clearing event must be less than 6x10<sup>6</sup> A<sup>2</sup>s. Note that for two fuses in parallel the total I<sup>2</sup>T is 4X the value for each fuse.
- To maintain this I<sup>2</sup>T, the 690V network transformer (or generator line-up) must have a sub-transient impedance of at least 22μH – this is equivalent to a per-unit value of 5% based upon the expected full load current of the rectifier at rated DC load.
- The following fuses are recommended by Avid for use with the AER3500L-4601-D at full rated current:

Manufacturer	Family	Rating	Number Paralleled	Total I <sup>2</sup> T
Mersen	Protistor® size 33 aR 690V	900A	2	3.1x10 <sup>6</sup> A <sup>2</sup> s
Cooper Bussmann	Square body DIN 43 653 690V/700V (IEC/UL). Size 2	900A	2	3.7x10 <sup>6</sup> A <sup>2</sup> s

### 3.6 12-Pulse Systems

- For 12-pulse operation, two balanced three-phase input supplies, 30° phase shifted from each other are required. An inter-bridge transformer is also required on the RECT side.

### 3.7 Coolant Flow

- A suitable cooling system must be provided that always maintains adequate flow of suitable coolant – see the Specification section of this Data Sheet for more details.

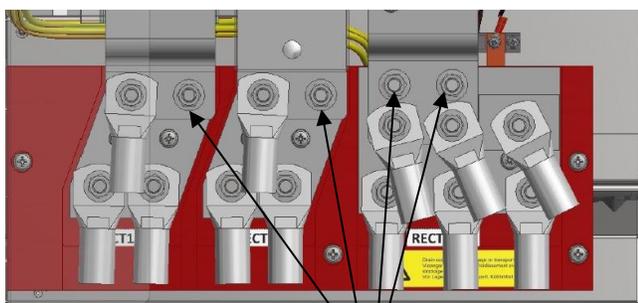
## 4. Specification

### 4.1 Electrical – Power Section

Specification	Value AER3500L-4601-D	Notes & Applicable Conditions
Continuous DC Current, total for both bridges	3500A	60s Overload = 110% once per 10 minutes, Average <= Continuous AC Voltage = Any within specification Coolant Temp. = 60°C
	2567A	60s Overload = 150% once per 10 minutes, Average <= Continuous AC Voltage = Any within specification Coolant Temp. = 60°C
Continuous current in any individual AC phase connection	1565A RMS	Total DC current (above) must also be respected  The system designer must ensure that AC phase voltage imbalance, or Star/Wye-Delta imbalance in a 12-pulse system, does not cause any phase to exceed this current
AC Supply Voltage & Frequency	690Vac RMS	690 V ac rms (nominal), +/- 10% long term, +/- 15% for 0.5 to 30 cycles 43 to 63 Hz
Maximum DC Operating Voltage	1250 Vdc	Typically during regeneration of inverter units
AC Network Type	TN or TT (earthed/grounded neutral). Can also be connected to IT network (delta/isolated neutral); if IT network separated from public mains supply by an isolating transformer.	
Insulation Standards	BS EN 61800-5-1: 2007	Also conforms to UL 840, CSA C22-2 No. 0.2, EN 50178 and UL508C (when used with external transient suppressors compliant to UL 1449)

**4.2 Power Connections**

Specification	Value, Notes & Applicable Conditions
General Requirements	External power cables must be mechanically supported – the AER3500L-4601-D terminals are NOT SUITABLE for support. Care must be taken to limit bend radii of cables as specified by the manufacturer.
Terminal Fastenings	M10 studs with provided non-marring nut/washer assemblies for Power. M10 threaded insert for ground/earth.
M10 Fastener Torques	Max: 40 Nm / 360 in-lb. / 30 ft-lb. Min: 27 Nm / 240 in-lb. / 20 ft-lb.
Fastener Count	AC Terminals : R1, S1, T1, R2, S2, T2: Three M10 studs per connection. RECT1+ & RECT2+: Three M10 studs per connection. RECT1/2-: Six M10 studs per connection. GROUND: One M10 threaded insert.
Maximum Cable/Crimp Cross Section	185 mm <sup>2</sup> This size, using high temperature cables, is recommended for 100% utilization of the AER3500L-4601-D current rating.
Cable Type	Due to high currents per cable, high temperature cables of sufficient size must be used to achieve the full rating of the AER3500L-4601-D. If more cables are needed than studs provided, then small adapter busbars should be used. The AER3500L-4601-D online 3D model may be used to help design these or contact Avid Controls for assistance.



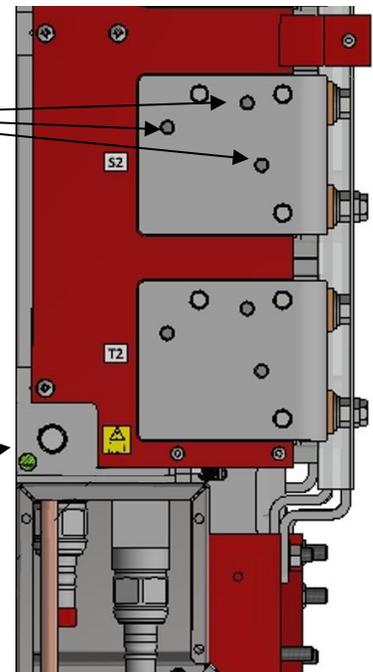
3 X M10 stud for RECT+ Connections (2 Places)

These studs are not for cable terminals – do not remove or loosen these nuts

6 X M10 stud for RECT- Connections

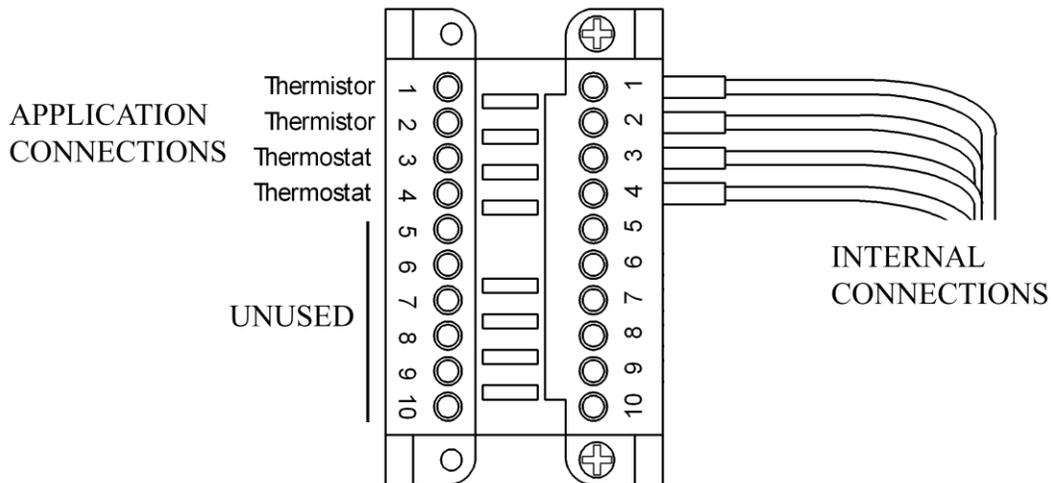
3 X M10 stud for AC Connection (six places)

M10 Bolt+Insert for GROUND connection

### 4.3 Electrical – Control Connections

- The AER3500L-4601-D provides only NTC thermistor and thermostat signals to the control system.
- These are connected to a pluggable terminal block, TB1 on the front of the module.
- TB1 is compatible with the older MV3000 rectifier modules, and its pinout is shown below:



- The thermistor and thermostats are mounted on the liquid-cooled heatsinks, directly adjacent to the hottest DIODE.
- The thermostats open at 90°C.
- ***IT IS IMPERATIVE THAT IF THE THERMOSTATS OPEN, THE APPLICATION DISABLES CURRENT THROUGH THE AER3500L-4601-D. FAILURE TO DO SO CAN RESULT IN DESTRUCTION OF THE AER3500L-4601-D.***

- The thermistor has the following characteristic

Temp. °C	Resistance kΩ						
0.0	13.168	30.0	4.159	60.0	1.647	90.0	0.626
5.0	10.850	35.0	3.487	65.0	1.434	95.0	0.531
10.0	8.925	40.0	2.951	70.0	1.242	100.0	0.482
15.0	7.340	45.0	2.523	75.0	1.065	105.0	0.497
20.0	6.047	50.0	2.176	80.0	0.901	110.0	0.598
25.0	5.000	55.0	1.890	85.0	0.752		

- The following polynomials allow Resistance (in kΩ) and Temperature (in °C) to be estimated from each other (with about 2°C maximum error):

$$Temperature = \sum_{n=0}^{n=6} Kt_n \cdot Resistance^n$$

$$Resistance = \sum_{n=0}^{n=4} Kr_n \cdot Temperature^n$$

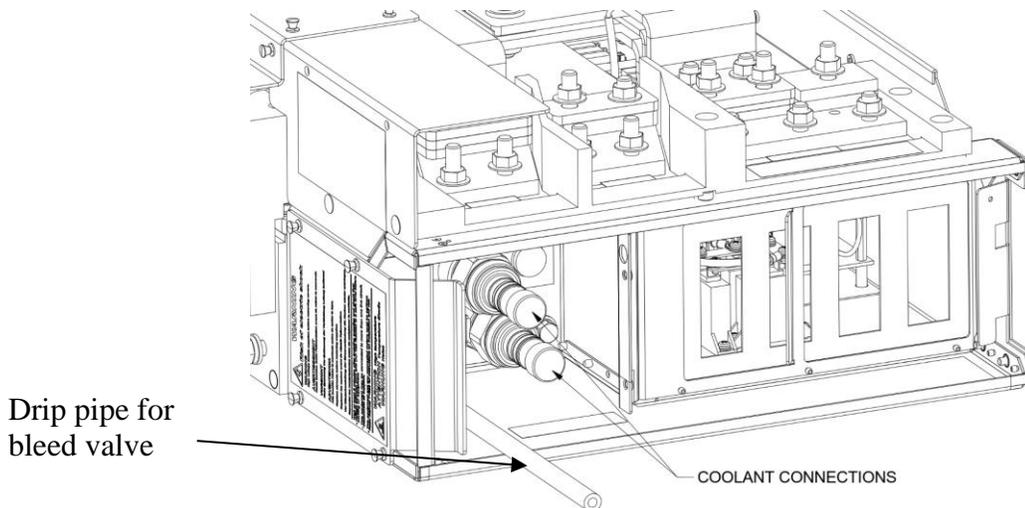
Coefficients:

	n = 0	n = 1	n = 2	n = 3	n = 4	n = 5	n = 6
$Kt_n$	1.343212E+02	-8.276622E+01	3.075495E+01	-6.380161E+00	7.125432E-01	-4.011640E-02	8.919915E-04
$Kr_n$	1.316766E+01	-5.064362E-01	8.972572E-03	-7.785761E-05	2.608998E-07		

- It is strongly recommended that the application reduces the current if the thermistor temperature exceeds 85°C (Resistance < 750 Ω), and it **must** disable current for temperatures above 90°C (Resistance < 530Ω), or when the thermostats open.

**4.4 Cooling**

Specification	Value, Notes & Applicable Conditions
Coolant Type	Water / Ethylene Glycol Maximum 50% Ethylene Glycol With suitable corrosion inhibitors for aluminum cooling elements of the AER3500L-4601-D
Minimum Coolant Flow	25 liters/min (6.6 US-GPM)
Maximum Coolant Inlet Pressure	300kPa (45psi)
Maximum Coolant Inlet Temperature	60°C
Minimum Coolant Inlet Temperature	0°C
Coolant Strainer	Coolant must be strained to remove particles Maximum recommended strainer mesh is 0.7mm (0.028") Inspect and clean strainer every six months
Coolant Lifetime	Check coolant constituent concentration every six months Remove coolant, flush system with de-ionized water and refill with new coolant every 24 months.
Coolant Connection	2x Quick-Disconnect at bottom of unit
Coolant Air-Bleed	Valve on unit. Coolant must be bled of all air during commissioning.
Typical Heat Load to Coolant	At 3500A DC Continuous: 7kW At 2600A DC Continuous: 5kW It is recommended to design the cooling system based upon 20% more than these values



**4.5 Environmental**

**4.5.1 Operating**

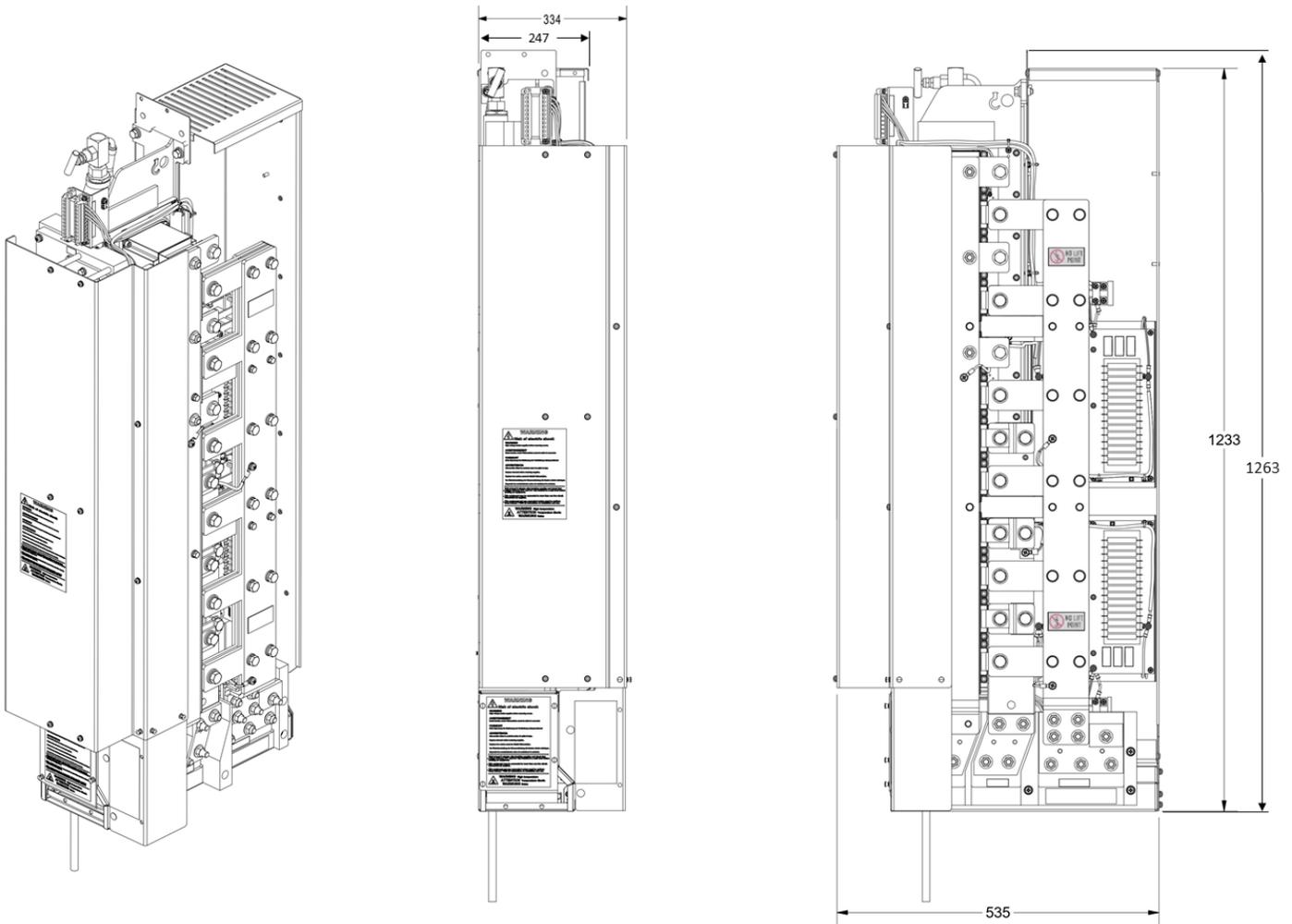
Specification	<i>Value</i>																
Ambient Temperature (Internal cabinet temperature)	0 to 50°C																
Humidity	5% to 95% RH Unit must not be operated in the presence of condensation.																
Pollution	Pollution Degree 2 as per IEC60664-1, UL 840 & CSA C22.2 No. 0.2-93 i.e. clean, free from dust, condensation and conductive or corrosive gases. Maximum chemicals 15ppm H <sub>2</sub> S, 25ppm NO <sub>2</sub> , 25ppm SO <sub>2</sub>																
Altitude	Normal operating altitude up to 1000 m (3280 ft) above sea level. From 1000 m (3280 ft) to a maximum of 2000 m (6551 ft) derate by 7.3% per 1000 m (3280 ft).																
Vibration	To IEC 61800-2 which specifies ‘Class 3M1’ of IEC 60721-3-3 and to the vibration requirements of EN50178. The product complies with the more severe requirements from both standards - this is given as the data represented in the following table:																
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 25%;">Frequency</th> <th style="width: 25%;">Limit</th> <th style="width: 25%;">Frequency</th> <th style="width: 25%;">Limit</th> </tr> </thead> <tbody> <tr> <td>2 to 9 Hz</td> <td>0.3mm amplitude</td> <td>57 to 150 Hz</td> <td>9.81 m/s<sup>2</sup> accel.</td> </tr> <tr> <td>9 to 18.4 Hz</td> <td>1 m/s<sup>2</sup> accel.</td> <td>150 to 200 Hz</td> <td>1 m/s<sup>2</sup> accel.</td> </tr> <tr> <td>18.4 to 57 Hz</td> <td>0.075mm amplitude</td> <td></td> <td></td> </tr> </tbody> </table>	Frequency	Limit	Frequency	Limit	2 to 9 Hz	0.3mm amplitude	57 to 150 Hz	9.81 m/s <sup>2</sup> accel.	9 to 18.4 Hz	1 m/s <sup>2</sup> accel.	150 to 200 Hz	1 m/s <sup>2</sup> accel.	18.4 to 57 Hz	0.075mm amplitude		
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18.4 to 57 Hz	0.075mm amplitude																

**4.5.2 Storage & Transport**

Specification	<i>Value</i>	
Temperature	-25 to +55°C Storage -25 to +70°C Transport Storage and Transport without coolant	
Relative Humidity	< 95% (non-condensing)	
Altitude	Will withstand air transport	
Vibration	To IEC 61800-2 which specifies Class 2M1 of IEC 60721-3-2 when equipment is packed for transport:	
	Frequency	Limit
	2 to 9 Hz	3.5 mm amplitude
	9 to 200 Hz	10 m/s <sup>2</sup> accel.
	200 to 500 Hz	15 m/s <sup>2</sup> accel.
Drop - Transport	To IEC 61800-2 which specifies Class 2M1 of IEC 60721-3-2 when equipment is packed for transport: 0.1m (mass >100 kg)	

**4.6 Mechanical**

Specification	Value
Dimensions	1263mm (Height) x 535mm (Depth) x 334mm (Width) [ 49.7-in (Height) x 21.1-in (Depth) x 13.1-in (Width) ]
Weight	125 kg [ 275 lb. ]
Enclosure – Ingress Protection	IP00 (to IEC 60529: 1989; BS EN 60529:1992), (NEMA 1) These modules must always be installed in an appropriate enclosure with restricted access.
3D model(s) of the AER3500L-4601-D may be downloaded from <a href="https://avidcontrolsinc.com/step-files/">https://avidcontrolsinc.com/step-files/</a>	



## 5. Contact Details for Sales, Service and Support

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## 6. Document Revision History

Rev.	Date	Author	Changes
00	12 <sup>th</sup> July 2019	Mark Woods	Original Issue
01	24 <sup>th</sup> April 2020	Mark Woods	Improved shroud diagrams and crimp size information
02	January 11 <sup>th</sup> 2021	Gary Pace	Heat load figures changed Additional information for external protection included Some format changes
03	October 20 <sup>th</sup> , 2021	Gary Pace	Fusing and external inductor information added Maximum AC current specified