



VCCM600 Series

AC/DC conduction cooled configurable power supplies

User Manual

Cool it your way. Conduction | Convection | Forced Air

4"x7"x1.61"
SMALL

600W
POWERFUL

SILENT
FAN-LESS



The VCCM600 series user manual has been prepared by our design team to assist qualified engineers in correctly designing in the VCCM600 product into their application to achieve the best reliability and performance possible.

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VCCM600 Series Overview

The VCCM600 series of conduction cooled configurable power platform delivers a silent 600 Watts and up to 750 Watts of peak power for 5 seconds in a rugged 4" x 7" package and is the ultimate power solution for applications where reliability or audible noise are of concern. The product combines the advantages of a modular power supply with the high reliability of a fan-less architecture. Depending on your application, the VCCM600 can be configured as a conduction, convection or forced air cooled solution and this versatility allows the unit to be seamlessly integrated across a vast range of applications, which makes it perfect for standardising your power platform.

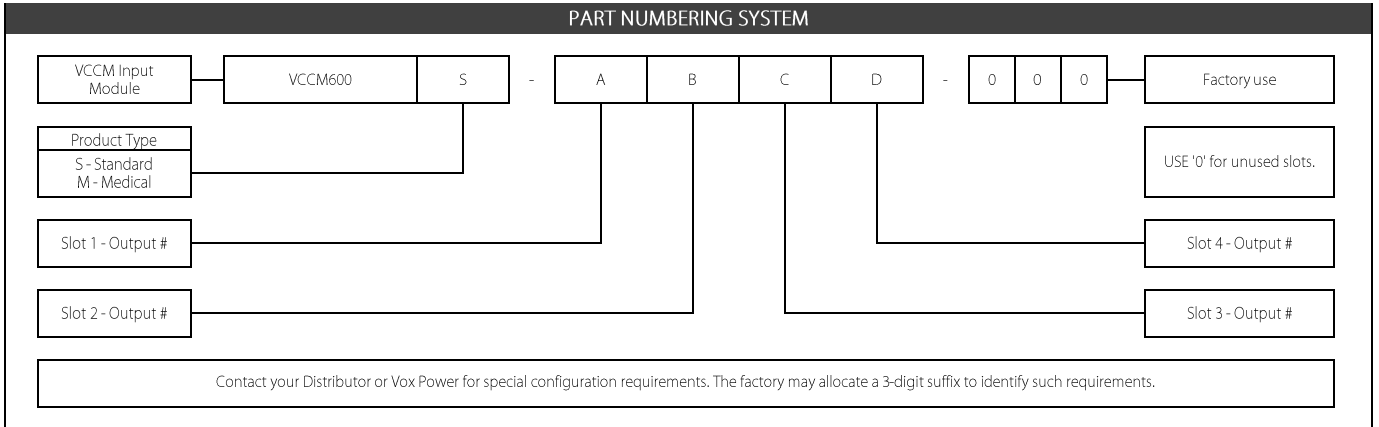
Designed with highest reliability and versatility in mind, the VCCM600 is suitable for applications ranging from the most controlled environments to the harshest conditions. Each configured modular solution can accommodate up to 4 isolated DC output modules which utilize 100% SMT components for increased reliability. Standard features include full output voltage adjust range, externally controllable voltage and current and series & paralleling of outputs. The unique design approach and heat dissipation techniques allows the unit to be mounted in virtually any orientation giving system designers even more flexibility. The series is approved to latest safety and EMC standards and features market leading specifications and design in application support.

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Part Numbers and Ordering Information

INPUT MODULES							
Input Module	Details						
VCCM600S	600 Watt Input Module with ITE Approvals (IEC60950 Edition 2)						
VCCM600M	600 Watt Input Module with Medical Approvals (IEC60601 Edition 3 + IEC60601-1-2 Edition 4 EMC)						
OUTPUT MODULES							
Module	Nominal voltage	Rated current	Rated Power	Adjustment range	Load regulation	Line regulation	OVP
OP 0	Unused slots						
OP A	5V	25A	125W	1.5V-7.5V	±50mV	±0.1%Vnom	9V
OP B	12V	15A	150W	4.5V-15V	±100mV	±0.1%Vnom	18V
OP C	24V	7.5A	150W	9V-30V	±150mV	±0.1%Vnom	36V
OP D	48V	3.5A	150W	18V-58V	±300mV	±0.1%Vnom	66V



Important installation information

The VCCM600 series of configurable power supplies are intended for use within end customer applications which restrict access to un-authorized personnel. The instructions in this manual and all warning labels on the product must be adhered to carefully.

SAFETY

The VCCM600S and VCCM600M series are designed in accordance with the relevant safety requirements of UL60950-1, IEC/EN60950-1, UL60601-1, IEC/EN60601-1, CSA22.2 no 601-1, Low voltage Directive LVD 2014/35/EU and EMC directive EMC 2014/30/EU.

All VCCM600 series power supplies must be installed correctly in a controlled environment which restricts access to any un-authorized personnel. Equipment and system manufacturers must protect service personnel against unintentional contact with the output terminals.

HAZZARDS

Dangerous voltages are present within the power supply. It should only be handled by qualified personnel when the power supply has been disconnected from the mains supply voltage for more than 3 minutes.

External surfaces of the power supply may become extremely hot during and after operation. Appropriate care should be taken.

If series and/or parallel combinations of outputs exceed safe voltage and/or energy levels, the final equipment manufacturer must provide the appropriate protection for both users and service personnel.

DE-RATINGS

Ambient Temperature	The input module power must be de-rated by 2.5%/°C above 50°C ambient up to a maximum ambient temperature of 70°C.
Baseplate Temperature	The output module power and current must be de-rated by 2.5%/°C above 85°C baseplate up to a maximum baseplate temperature of 105°C.
Input Voltage	The input module power must be de-rated by 5W/VRMS below 120 VRMS (600W @ 120 VRMS, 450W @ 90 VRMS)

Remember to take the appropriate de-rating into consideration before specifying any VCCM600 power supply for an application. If in any doubt, please contact Vox Power directly or your local Vox Power representative.

HEALTH AND SAFETY

To comply with section 6 of the health and safety at work act, a label that is clearly visible to service personnel must be placed on the final equipment. These labels warn that surfaces of the power supply may be hot and should not be touched when the product is operating.

FUSING

The power supply has internal dual pole fusing. One fuse in each line.

Fuses should only be replaced by authorised personnel and to ensure continued protection against risk of fire, fuses must be replaced with the same type and rating of fuse.

For DC operation, an appropriately rated DC fuse must be included in the end application.

SERVICING

The power supply contains no user serviceable parts. Repairs must be carried out by authorised personnel only. Contact Vox Power for further information.

APPROVAL LIMITATIONS – NORTH AMERICA

When this product is used with 180VAC–253VAC mains where no neutral is present, connect the two live wires to L (Live) and N (Neutral) on the input connector.

COOLING

For proper operation of the power supply, the user must ensure sufficient cooling to maintain all component temperatures within specifications. A thorough review of the user manual should be carried out for details of thermal performance.

EARTH TERMINAL MARKING

To comply with the requirements of UL60950-1, IEC/EN60950-1, CSA22.2 no. 60950-1, UL60601-1, IEC/EN60601-1, CSA22.2 no 601-1 where the incoming wiring earth is intended for connection as the main protective earth conductor and where the terminals for such a connection is not supplied on a component or subassembly, the user shall add an appropriate label displaying a protective earth symbol in accordance with 60417-2-IEC-5019 directly adjacent to the terminal. The label should be durable and legible and should withstand the 15 second rub test as per UL60950-1 section 1.7.15.

WARRANTY

Contact your sales agent or Vox Power for product repairs. See Vox Power standard terms and conditions for warranty conditions.

PRODUCT LABELS

The external product label contains information relevant to the power system. The label contains input voltage, maximum input current, input frequency, maximum output power, fuse rating and type, serial number, approvals and product part number in form VCCM600x-yyyy-zzz.

VCCM OUTPUT MODULES

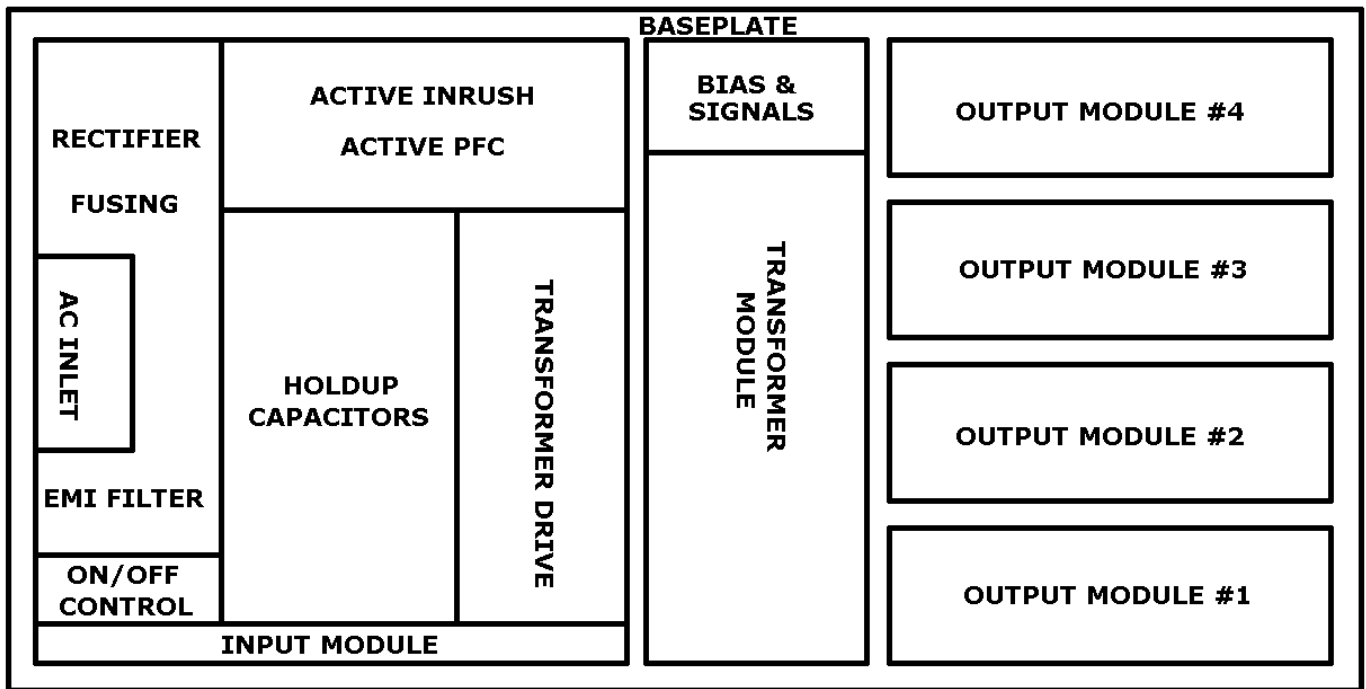
Each output module label contains information relevant to that output. The label contains voltage adjustment range, maximum output current, serial number, approvals and the part number in format OPx.

OTHER

- A label warning that external surfaces are hot during operation and that the unit should be allowed to cool down properly should be placed on the unit where such a label is clearly visible.
- The VCCM600 series is designed to comply with EMC standards but it does not imply that the end system will comply.
- To prolong the life of the unit, use in dust free environment.
- Units can sometimes be damaged during transit. In the event of transit damage, DO NOT connect power to the unit. Contact your sales agent or Vox Power.
- Always use adequately sized cables and ensure good crimp connections. Use cable supports to minimise stress on connectors.
- Avoid excessive shock or vibration.

Theory of Operation

The diagram below outlines the topology and major internal components of a fully assembled VCCM600 configurable power supply. Four output slots are provided and can be populated by any combination of *output modules*. The remaining components in the block diagram are housed in the *input* and *transformer modules*.



The *input module* is responsible for receiving the AC mains line voltage and converting it to an appropriate DC voltage whilst providing protection from AC line disturbances and preventing excessive EMI emissions and current harmonics. The integrated EMI filter attenuates high frequency current emissions to levels below EN55022 class B. It also provides dual pole fusing, one fuse in each conductor and protection from line disturbances as outlined in EN61000.

Inrush current is controlled by a resistive element upon initial connection to the AC line. Once the internal capacitances have been charged, the resistive element is bypassed to reduce losses.

Active Power Factor Correction (PFC) is used to ensure an accurate input current waveform with extremely low harmonic content, exceeding the requirements of EN61000. This stage also provides active input current limiting which prevents overloading of the input stage while maintaining high power factor.

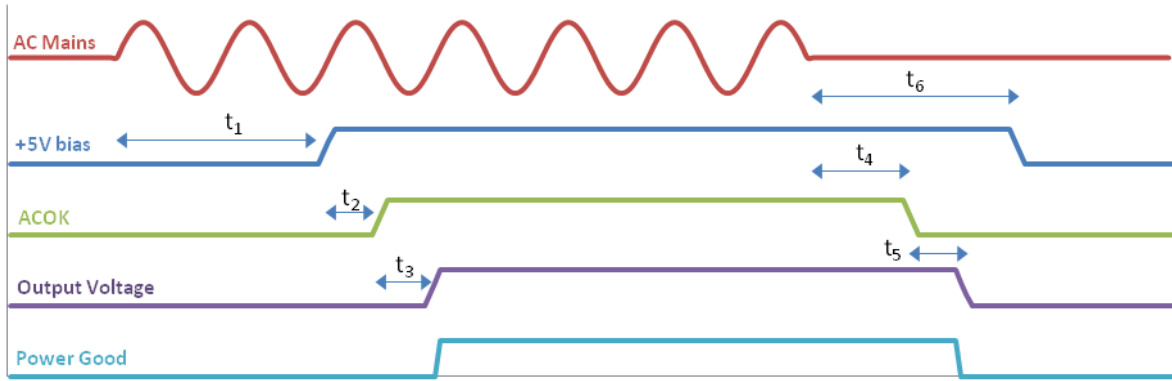
The output of the PFC stage charges the hold-up electrolytic capacitors which store enough energy to allow the VCCM600 configured product to continue operating during minor line disturbances. Long lifetime and high temperature capacitors are used which ensures extended lifetime and product reliability.

A highly efficient zero voltage switching circuit is used to drive the isolated transformer from the hold-up capacitors. The output modules connect to the transformer secondary and provide safe isolated power to a high performance synchronous rectifier power converter. This power converter is controlled using the latest analog control technology to produce superior output performance in a miniature size.

Input Module Operation

Startup & Shut Down

The VCCM input module operates from a universal input voltage range and starts automatically upon application of adequate AC mains voltage (>84Vrms). After a short delay, the global 5V bias supply starts and the ACOK signal goes high to indicate that the mains voltage is present and input stage is operating correctly. Once the ACOK signal is high, the output modules turn on and deliver power to the application loads. The power good signals will indicate that the output voltages are within specification. The diagram below shows the normal start up/shut down sequence and gives typical timings.



Typical timing values at 120Vac 600W 25°C: $t_1 \phi \approx 500$ ms, $t_2 \phi \approx 170$ ms, $t_3 \phi \approx 1500$ ms, $t_4 \phi \geq 15$ ms, $t_5 \phi \geq 5$ ms (minimum), $t_6 \phi \geq 100$ ms

When the AC mains voltage is removed, the internal hold-up capacitors will supply power to the load for typically 20 ms (t_4+t_5) at maximum power. The ACOK signal will go low at least 5ms before the output voltages fall below the power good threshold level. This allows the application to prepare for the impending loss of power. The 5V bias supply will remain on for typically 100ms, after the output modules have turned off.

*Output modules that are adjusted above nominal voltage, will have reduced ACOK warning time.

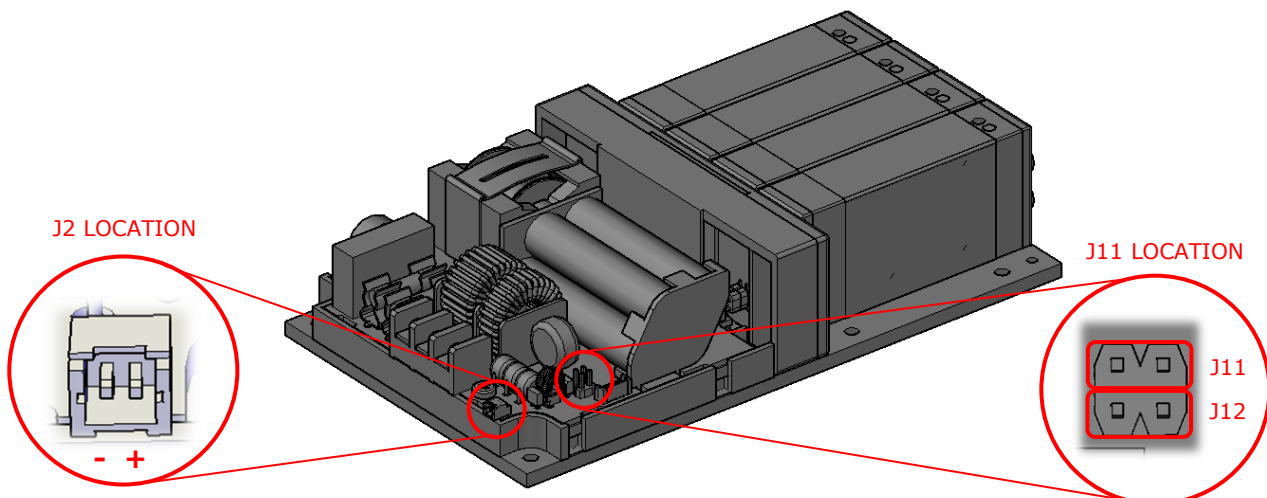
Standby control

The unit may be completely shut down by shorting (<10Ω) the terminals of J2. The unit will restart once the short is released. The control uses transformer coupled pluses to detect the short and is fully isolated to 2xMOPP. The voltage present on J2 ranges from +3.3V to -0.8V with a peak current of 15mA. In active mode, the control is pulsed every 1.3ms while in standby mode the control is pulsed every 400ms. A signal MOSFET or switch may be used to activate this control. This shutdown will not generate the ACOK warning signal.

Programmable start-up state

The start-up and standby control logic can be inverted by shorting J11 with a jumper. The functionality is shown in the table below.

J11	J2	Operational mode	Comments
Open	Open	NORMAL	Default. Unit will start into NORMAL mode
Open	Closed	STANDBY	<1W power consumption
Closed	Open	STANDBY	Unit will start into STANDBY mode. <1W power consumption
Closed	Closed	NORMAL	



Note - J12 is reserved for internal use. Do not short J12

Hold-up

For short line disturbances (<20ms), the output voltages will not be affected*. However, the ACOK signal may still go low to warn that there is an impending loss of output power. The ACOK signal will return to the high state once the unit has recovered from the disturbance.

*Output modules that are adjusted above the hold-up voltage (as detailed in their respective datasheets), may experience a dip in voltage.

No Load Power/Standby Power Consumption

The no-load power consumption of the VCCM600 series PSU is extremely low when compared to similar configurable power supplies. With the output modules enabled the unit typically only requires less than 15W with no output load. To reduce the no-load power further the outputs can be disabled using the inhibit pins. With the outputs disabled the unit typically requires less than 10W. When the unit is in the standby (latched off) state, the power consumption is less than 1W.

Peak Power capability

The input module can provide a peak output power of up to 750W for a period of up to 5 seconds, provided the input current remains below the over current protection threshold. Peaks of power lower than 750W can be supported for longer times provided the excess watt-seconds are equivalent. For example, 750W peak for 5 seconds is an excess power of $150W \cdot 5s = 750Ws$. 650W can be supported for $750Ws / 650W = 1.15s$. When using peak power capability, the user must ensure the average power remains within ratings. Note that input module de-ratings apply to both rated power and peak power.

Input Module Protections

Over current protection (OCP)

The input module is protected from excessive input current by means of an over current protection circuit which limits the input current to approximately 7Arms. If the OCP threshold is exceeded the unit may shut down and attempt to automatically restart. This shutdown will generate the usual ACOK warning.

Under voltage protection (UVP) & Brown-Out Protection (BOP)

The input module is protected from excessively low input voltages by under voltage and brown out protection circuits that sense the input line voltage. The under-voltage protection circuit maintains the unit in standby mode until the input voltage rises above the UVP threshold as detailed in the datasheet. Once the unit is active, the brown out protection monitors the input voltage and shuts down the unit when input voltage goes below approximately 60Vrms. This shutdown will generate the usual ACOK warning. The unit will restart once the input voltage increases above the UVP threshold.

Over Temperature Protection (OTP)

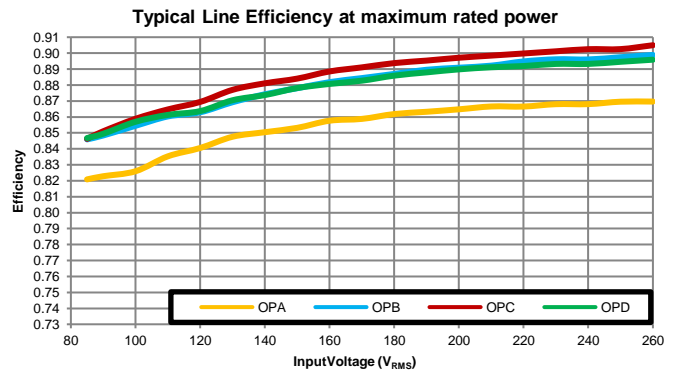
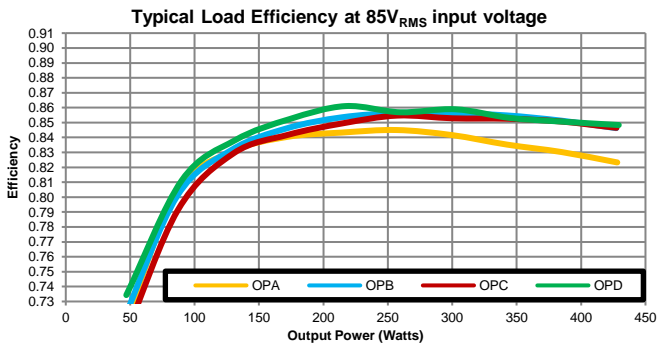
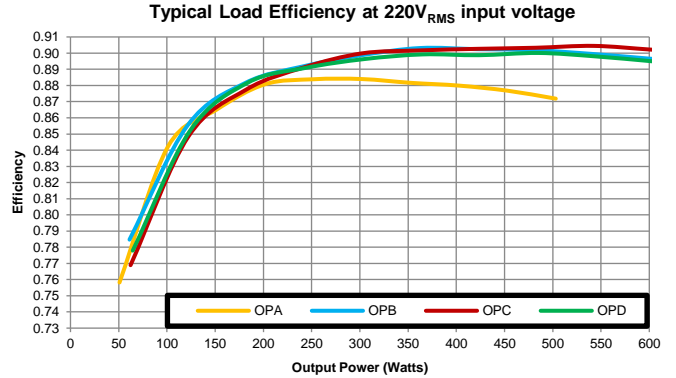
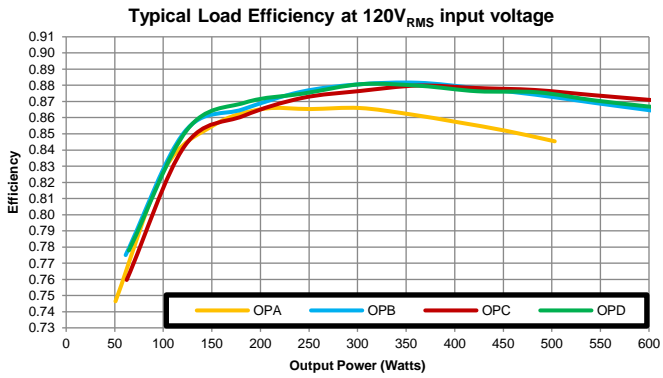
The input module is protected from excessive temperatures by means of various internal temperature sensors. If temperature thresholds are exceeded the entire unit may latch off, with no ACOK warning. To re-enable the unit, it must be allowed to cool, then either disconnect the AC mains for approximately 20 seconds, or toggle the standby control on J2.

Over Power Protection (OPP)

The input module is protected from excessive power by means of an over power protection circuit. Should the rated power be exceeded the unit will shut down and attempt to recover automatically. This shutdown will not generate the usual ACOK warning.

Efficiency Performance

The efficiency of the configured VCCM600 product is dependent on parameters such as input line voltage, load level and on the combination of output modules. The plots below show typical efficiencies of a VCCM600 product fitted with all modules A, B, C or D. The plots cover the full load and line voltage range. All modules are adjusted to nominal voltages and are equally loaded.



An estimate of the overall efficiency for any configured system may be obtained from these graphs.

Power Ratings

VCCM600 series products must always be operated within stated operating limits. Equipment manufacturers and other users must take the appropriate de-rating into account when specifying a unit for the intended application. If in doubt, contact your sales representative or Vox Power for assistance.

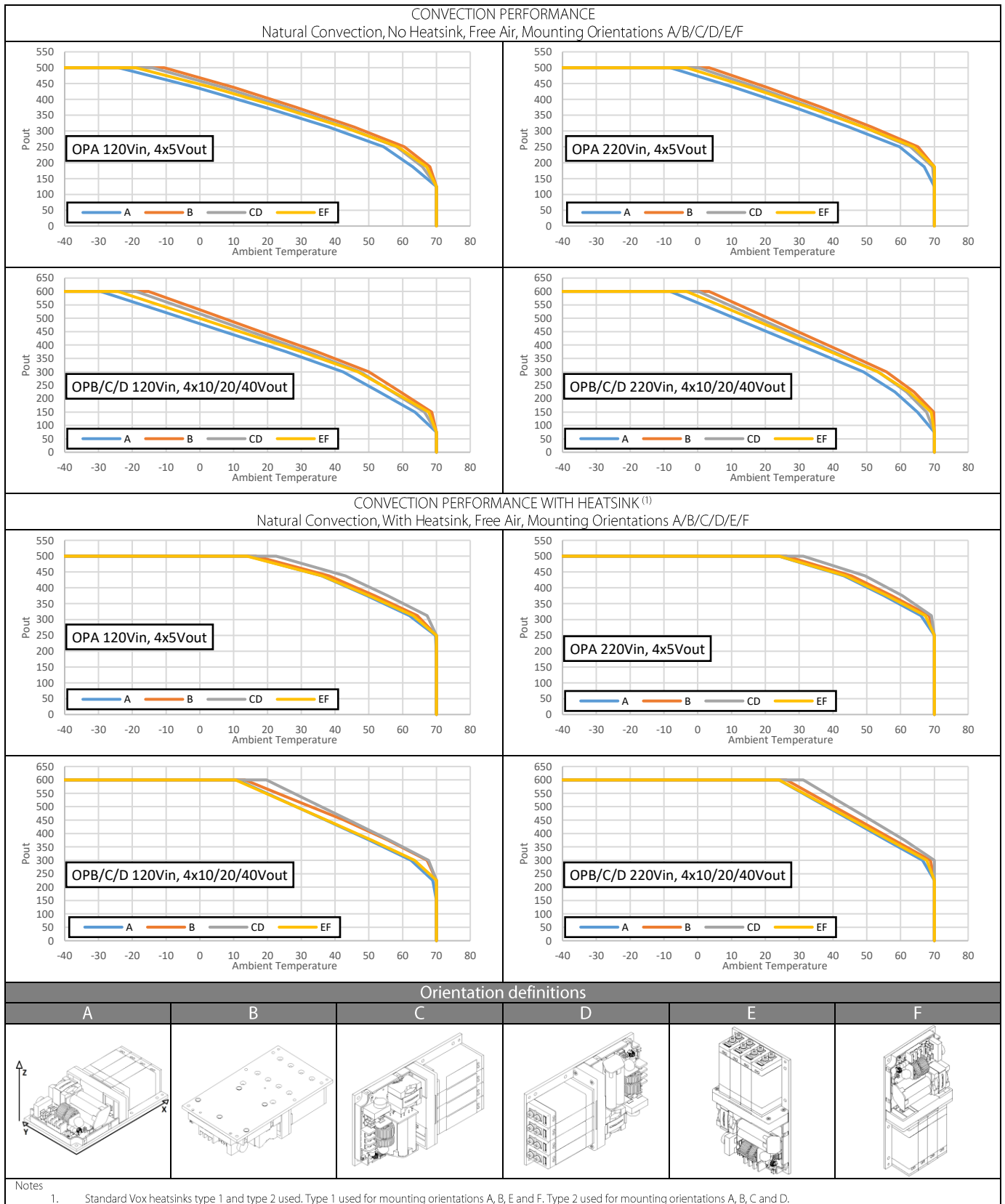
There are three main de-ratings for the VCCM600 series of configurable power supplies when used in a conduction cooled application,

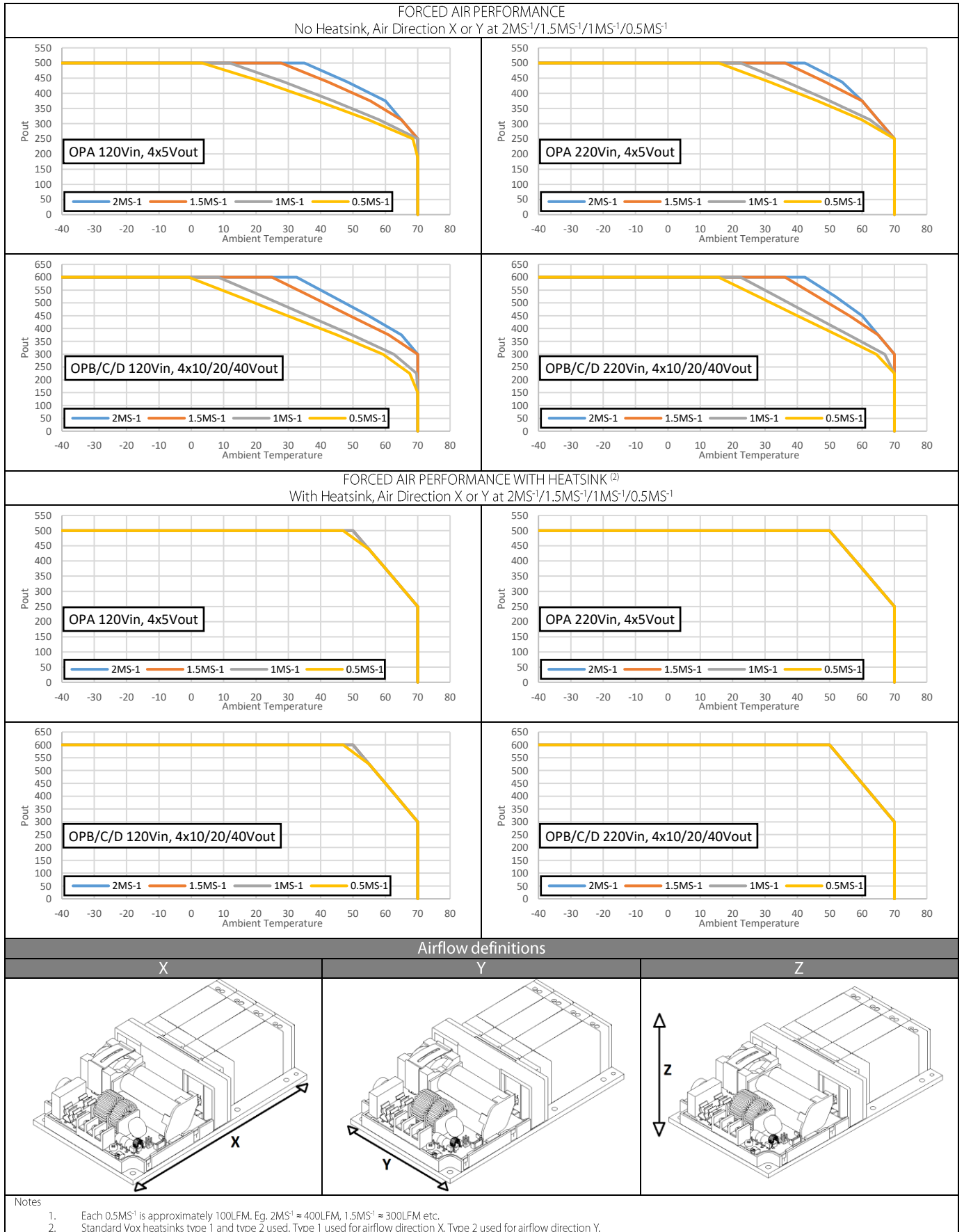
<p>1. Ambient air temperature ⁽¹⁾</p> <p>Ambient air temperature de-ratings apply to the input module rated and peak power only. ⁽³⁾</p> <p>The input module must be de-rated by 2.5% per degree Celsius above 50°C, up to a maximum of 70°C.</p>	
<p>2. Baseplate temperature ⁽²⁾</p> <p>Baseplate temperature de-ratings apply to output module rated power, peak power and rated current, and bias supply power.</p> <p>The output module parameters must be de-rated by 2.5% per degree Celsius above 85°C, up to a maximum of 105°C.</p>	
<p>3. Input line voltage</p> <p>Input line voltage de-ratings apply to the rated power and peak power for both the input module and output module. ⁽³⁾</p> <p>All parameters must be de-rated by 2.5% for every 3 volts below 120Vrms, down to a minimum of 85Vrms.</p>	
<p>Notes:</p> <ol style="list-style-type: none"> 1. Ambient air temperature is the air temperature immediately surrounding the PSU. 2. Baseplate temperature is measured at baseplate temperature sensing location TS1. 3. A normalized value of 1 is equivalent to 100%. 4. Input line voltage deratings are cumulative with temperature deratings. 	

Examples of power ratings calculation for various input voltages, ambient temperatures and baseplate temperatures							
	1	2	3	4	5	6	7
V _{IN} (V _{RMS})	120	85	85	120	120	100	120
Normalised V _{IN} Rating [A]	1	0.708	0.708	1	1	0.833	1
T _{AMBIENT} (°C)	70	50	70	50	60	60	50
Normalised T _{AMBIENT} Rating [B]	0.5	1	0.5	1	0.75	0.75	1
T _{BASE} (°C)	85	85	85	95	105	95	105
Normalised T _{BASE} Rating [C]	1	1	1	0.75	0.5	0.75	0.5
Normalised Total input rating [A*B = D]	0.5	0.708	0.354	1	0.75	0.624	1
Normalised Total output rating [A*C = E]	1	0.708	0.708	0.75	0.5	0.624	0.5
Input module P _{RATED/PEAK} [600W/750W*D]	300/375	424.8/531	212.4/265.5	600/750	450/562.5	374.4/468	600/750
Bias supply power [5W*C]	5	5	5	3.75	2.5	3.75	2.5
OPA P _{RATED/PEAK} [125W/187.5W*E]	125/187.5	88.5/132.75	88.5/132.75	93.75/140.625	62.5/93.75	78/117	62.5/93.75
OPA I _{RATED} [25A*C]	25	25	25	18.75	12.5	18.75	12.5
OPB P _{RATED/PEAK} [150W/225W*E]	150/225	106.2/159.3	106.2/159.3	112.5/168.75	75/112.5	93.6/140.4	75/112.5
OPB I _{RATED} [15A*C]	15	15	15	11.25	7.5	11.25	7.5
OPC P _{RATED/PEAK} [150W/225W*E]	150/225	106.2/159.3	106.2/159.3	112.5/168.75	75/112.5	93.6/140.4	75/112.5
OPC I _{RATED} [7.5A*C]	7.5	7.5	7.5	5.625	3.75	5.625	3.75
OPD P _{RATED/PEAK} [150W/217.5W*E]	150/217.5	106.2/154	106.2/154	112.5/163.125	75/108.75	93.6/135.72	75/108.75
OPD I _{RATED} [3.75A*C]	3.75	3.75	3.75	2.8125	1.875	2.8125	1.875

System Cooling

The power ratings shown in the previous section are for conduction cooling, however the unit may be operated with forced air cooling, convection cooling or combinations of all three. To assist in specifying the product for these applications, the typical thermal performance has been characterised under controlled conditions. The ratings achieved are based on maintaining the baseplate temperature within the conduction cooled ratings specified on page 9.





The ratings provided above are for guidance only and all VCCM600 configured solutions must be evaluated in the end application to ensure the conditions set out in the power ratings section are met.

Specifying the VCCM600 product for convection or forced air cooling

To specify a VCCM600 series product for an end application, the required output power, minimum input line voltage, maximum ambient, mounting orientation and air flow rate (if applicable) should be determined. Check the requirements against the closest characteristic plot from the tables above to ensure ratings can be achieved. Be conservative when specifying the product as convection and forced air cooling can be highly dependent on the end application enclosure and power supply mounting. The estimated performance must be verified in the end application and temperatures may exceed predicted levels. It is also important to note that ambient temperature refers to the ambient temperature immediately surrounding the PSU. If the PSU is mounted within an enclosure the enclosure ambient temperature is likely to be higher than the external air ambient temperature.

Evaluating the VCCM600 product in the end application

To ensure the product is operating within its ratings in the end application the following procedure should be performed during the design stage.

1. Install a thermocouple in position TS1 of the product. (See Mechanical dimensions and mounting for details.) The thermocouple wire should exit on the top side between slots 2 and 3. The bottom side should be flush for heatsink mounting if necessary. Glue should be used to hold the thermocouple in place.
2. Setup the application in worst case conditions, considering Input line voltage, Output power, ambient temperature, airflow and cooling restrictions.
3. Power the system and monitor the baseplate temperature until it reaches steady state.
4. Ensure that under worst case conditions, the baseplate temperature cannot exceed the rated temperature as outlined in the power ratings section of this manual.

If a cover is placed over the primary components, then the following component temperatures must also be measured to ensure they are below the maximum specified temperatures.

Description	Reference	Maximum allowed temperature	Drawing
Fuse	FS1, FS2	125°C	
Electrolytic capacitors	C12	105°C	
Inductors	L1, L2, L3, L5	130°C	
Other capacitors	C1, C4	110°C	

If excessive temperatures are measured during this evaluation, then one or more of the following remedies may improve thermal performance.

- Increase heatsink size
- Increase airflow rate
- Improve air intake & outlet
- Reduce power requirement

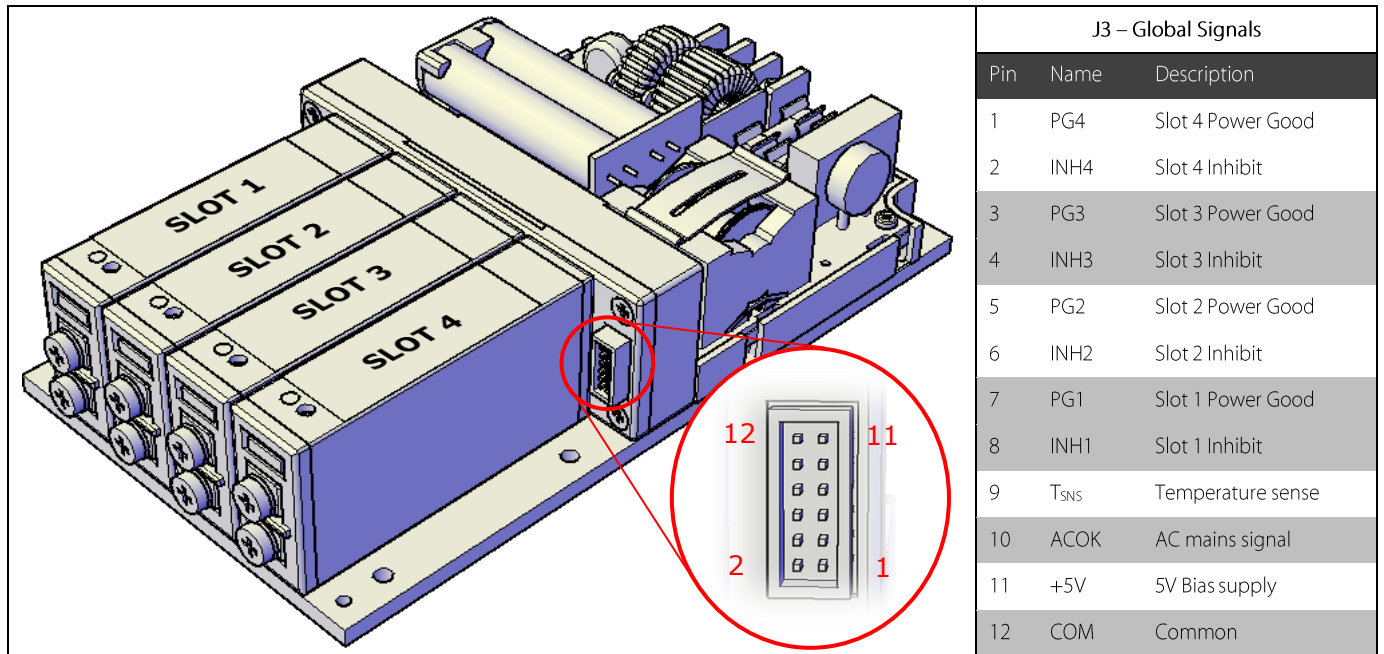
Using the internal temperature sensor to control external application cooling

An internal temperature sensor T_{SN5} is available on J3 pin 9 (See page 14 for details). The output voltage of this sensor gives a measurement of the internal transformer temperature and can be used to control external cooling systems or to provide a warning of impending over temperature protection. The internal temperature (T_{SN5}) should never exceed 120°C (2.74V), however, system reliability will be maximised if the PSU temperature is maintained as low as possible in any given application.

Signalling

Global Signals

To reduce cabling in the end system, all major input and output signals and the global 5V bias supply are wired to a single signals circuit that is accessed through connector J3 on the transformer module as shown in the diagram below.



All the signals are referenced to the bias supply common rail (COM) and external control and/or monitoring circuits can be easily powered and interfaced to the PSU through this connector. The entire signals circuit is fully medically isolated and can be considered a SELV output. The table below lists the isolation voltages.

Signals isolation voltages		
Signals to Input	4000	V _{AC}
Signals to Chassis	500	V _{DC}
Signals to Output	500	V _{DC}

Bias Supply (+5V [Power])

The VCCM600 series has one isolated bias supply located on the transformer module (J3) beside slot 4. The output side bias supply generates 5V and is rated up to 1A. The supply is available whenever the AC mains voltage is connected and the input module is operating correctly. A shutdown through the standby control on J2 or any of the following abnormal conditions will disable the 5V bias supply:

- Over temperature of any part of the unit
- Over voltage on any output module
- Internal over current (device failure)

AC Mains Signal (ACOK [Output])

An ACOK signal is provided to indicate to the user that the AC mains voltage is applied and the input module is operating correctly. The output signal is driven from an internal operational amplifier. Under normal operating conditions this signal gives a warning of 5ms before the output voltage falls below the power good threshold. A shutdown through the standby control on J2 or any of the following abnormal conditions may cause the unit to turn off without the minimum 5mS ACOK warning:

- Over temperature of any part of the unit
- Over voltage on any output module
- Internal over current (device failure)

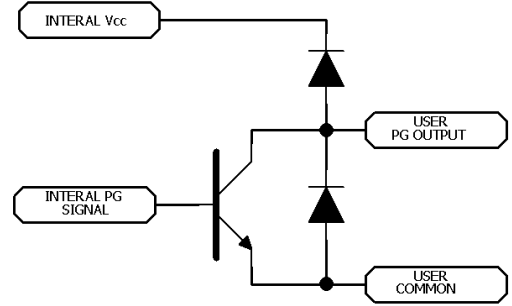
*Output modules that are adjusted above nominal voltage, will have reduced ACOK warning time.

Power Good Signals (PG1-PG4 [Output])

Each output module provides a power good (PG) signal to indicate when the output voltage is above approximately 90% of the pre-set voltage for that module. Each PG signal on an output module is internally connected through an opto-isolator to the signals circuit, which provides an open collector output, as shown.

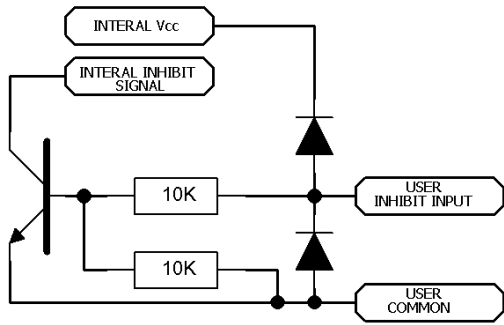
The LED on the front of each module gives a visual confirmation of the PG status.

Note that remote adjustments of the output voltage using the $V_{CONTROL}$ and $I_{CONTROL}$ pins do not change the PG signal threshold. The PG threshold is always approximately 90% of the voltage set with the manual potentiometer.

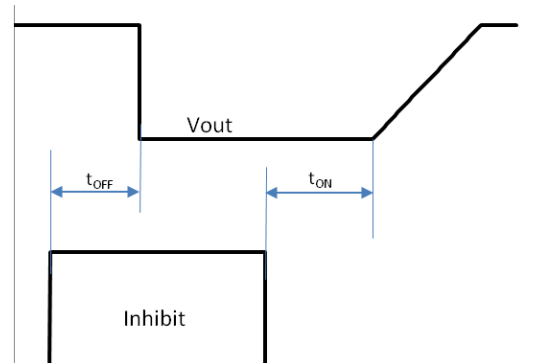


Output Inhibits (INH1-INH4 [Input])

The signals circuit provides an inhibit input to disable each output module individually. Each inhibit input is internally connected through an opto-isolator to the respective output modules. The basic internal electrical circuit and timing diagrams are shown below.



Internal circuit



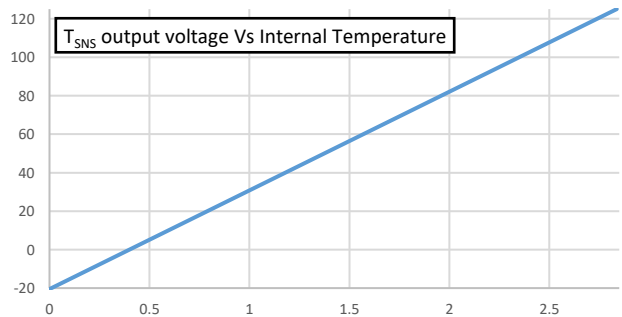
Timing: Typically, $t_{OFF} = 100 \mu s$ and $t_{ON} = 8 ms$.

Internal Temperature sensor (T_{SNS} [Output])

An internal temperature sensor is embedded in the transformer module. The output voltage of this sensor gives a measurement of the internal transformer temperature and can be used to control external cooling systems or to provide a warning of impending over temperature protection. The sensor output voltage is related to temperature as follows,

$$V = 0.4 + 0.0195 * T$$

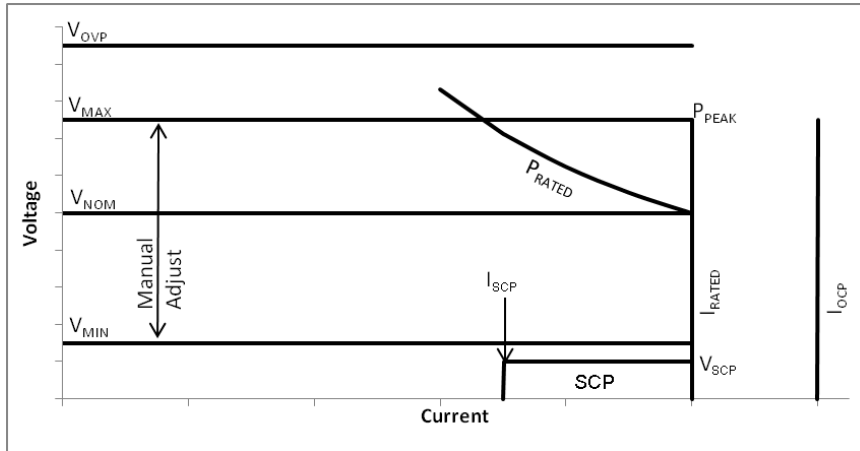
The sensor will accurately measure temperatures in the range $-10^{\circ}C$ to $+125^{\circ}C$. The internal temperature should never exceed $120^{\circ}C$ ($2.74V$)



Output Module Operation (A, B, C & D)

Power Profile

The power profile diagram below is a voltage/current plot that together with the associated table provides details of the main features of the currently available output modules.



Parameter	OPA	OPB	OPC	OPD
V_{NOM} (V)	5	12	24	48
V_{MIN} (V)	1.5	4.5	9	18
V_{MAX} (V)	7.5	15	30	58
V_{OVP} (V)	9.5	17	32	66
I_{RATED} (A)	25	15	7.5	3.75
I_{OCP} (A)	27.5	16.5	8.25	4.125
V_{SCP} (V)	1	2	4	4
I_{SCP} (A)	22	13.2	6.6	3.3
P_{RATED} (W)	125	150	150	150
P_{PEAK} (W)	187.5	225	225	217.5

Output Voltage Adjustment

Each output can be adjusted within the range as described in the table above or in the datasheet. Voltage adjustment can be achieved by two methods;

1. Manual potentiometer adjustment

Using the manual adjust potentiometer (located beside the "Power Good" indicator on the top of each output module), the preset output voltage (V_{SET}) of each output module is adjustable over the entire range of V_{MIN} to V_{MAX} as specified in the power profile table above. A clockwise rotation of the potentiometer results in an increase of the output voltage while an anti-clockwise rotation results in a decrease of the output voltage.

2. Remote Voltage Programming

Using remote voltage programming, the output voltage may be adjusted beyond the V_{MIN} and V_{MAX} range specified in the power profile table above. However, certain precautions must be taken to ensure correct operation. Please see the "Advanced output module features" section for more details.

Over Voltage Protection (OVP)

In the event of an output module fault, the modules are protected against excessive output voltages. This is implemented as a fixed voltage threshold V_{OVP} , in the table above. If the output voltage exceeds this threshold, all outputs will be disabled temporarily. If the fault persists after 20ms the entire unit will be latched off, otherwise the outputs will auto recover. To resume operation of a latched unit, disconnect the AC input voltage for 5 seconds or toggle the standby control on J2. Note that no warning is given on the AC_OK signal for faults of this type.

Over Current & Short Circuit Protection (OCP & SCP)

For increased safety and reliability all output modules in the VCCM series have over current and short circuit protection. The over current threshold is typically set at 115% of the rated current and has a constant current, straight line characteristic that reduces the output voltage as the load resistance decreases. If the output voltages falls below the short circuit voltage threshold (V_{SCP}) the module enters short circuit protection mode. In this mode the output module uses a hiccup scheme to reduce system losses and potential damage. When in this mode, the output will be enabled for approximately 3% of the time, disabled for 97% and will attempt to restart at approximately 125 ms intervals. The module remains in this state until the short circuit condition is removed, at which point normal operation resumes.

Reverse Current Protection (RCP)

The standard output modules use synchronous rectification in the output stages to achieve high efficiency and as a result the outputs can both source and sink current. The sink current is internally limited to approximately -6% of the maximum rated current. However, in applications where the output modules are connected to external power sources such as batteries or other power supplies certain precautions must be observed to prevent damage to the unit.

The outputs should never be directly connected to external power sources without some form of reverse current protection such as an external diode or controlled mosfet. If protection is not used, large reverse currents which will ultimately result in damage to the unit will occur, especially when the AC mains is disconnected.

Output Module Average and Peak Power

All modules have an average and peak power rating. The average power of each unit must at all times remain below it's specified limit. However, each output can deliver up to 150% of it's average power rating for a maximum of 5 seconds at 50% duty cycle, subject to the current limit not being exceeded and subject to the overall average power drawn being less than the specified average power rating (including any input derating due to temperature or line voltage). The available peak power is a function of the output voltage and maximum current for each module. Full peak power is only possible when the output voltage is adjusted to V_{MAX} and the maximum current is drawn from the module. Note that both average and peak power ratings are subject to the same temperature derating as the input module (derate by 2.5% per °C above 50°C), but are not subject to any line derating.

Start-up & Shut Down

All outputs are designed to have a regulated monotonic start-up with a rise time of approximately 3ms as shown in the diagram right. The power good signal will not assert until the voltage exceeds the power good threshold ($\approx 90\%$).

Where multiple output modules are used, the default start up scheme is ratio-metric with all outputs starting at the same time as shown in the diagram right. External control circuits may be used to implement tracking or sequenced start up if necessary.

The outputs are not designed to start into pre-biased loads and may discharge any externally capacitance before beginning to ramp the output voltage up in the normal way.

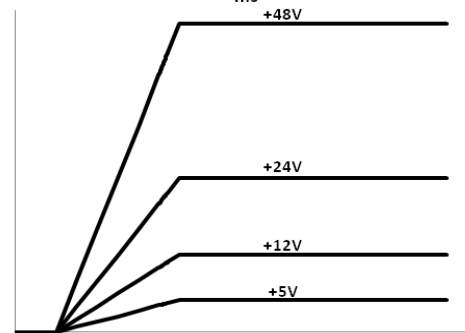
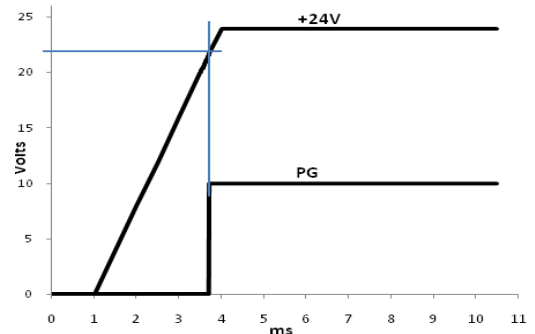
At shutdown, the outputs enter a high impedance state. Where no external load is present it may take some time for the voltage to decay. When driving inductive loads, care must be taken to limit the voltage at the output terminals to prevent damage to the unit.

Synchronisation

All output modules in the same product are synchronised. The typical operating frequency is 260kHz and paralleled or series connected units will not produce ripple beat frequencies.

External capacitance

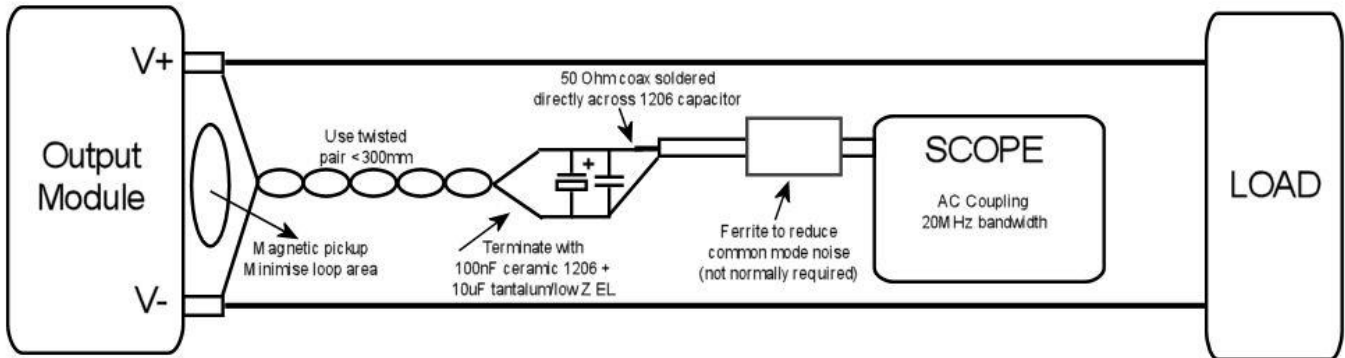
All outputs can support a large external capacitance as detailed in the table shown. The capacitances specified ensure monotonic start-up with rated load applied. Larger capacitances can be applied for lower load currents.



OP	C _{EXT_MAX}
A	12mF
B	4mF
C	1mF
D	500uF

Ripple and Noise

The ripple and noise figures stated in the datasheet are defined based on a standard measuring method. To obtain the same results the same test setup must be used and care must be taken to eliminate any parasitic noise pickup. The diagram below shows details of the setup and sources of noise pickup.



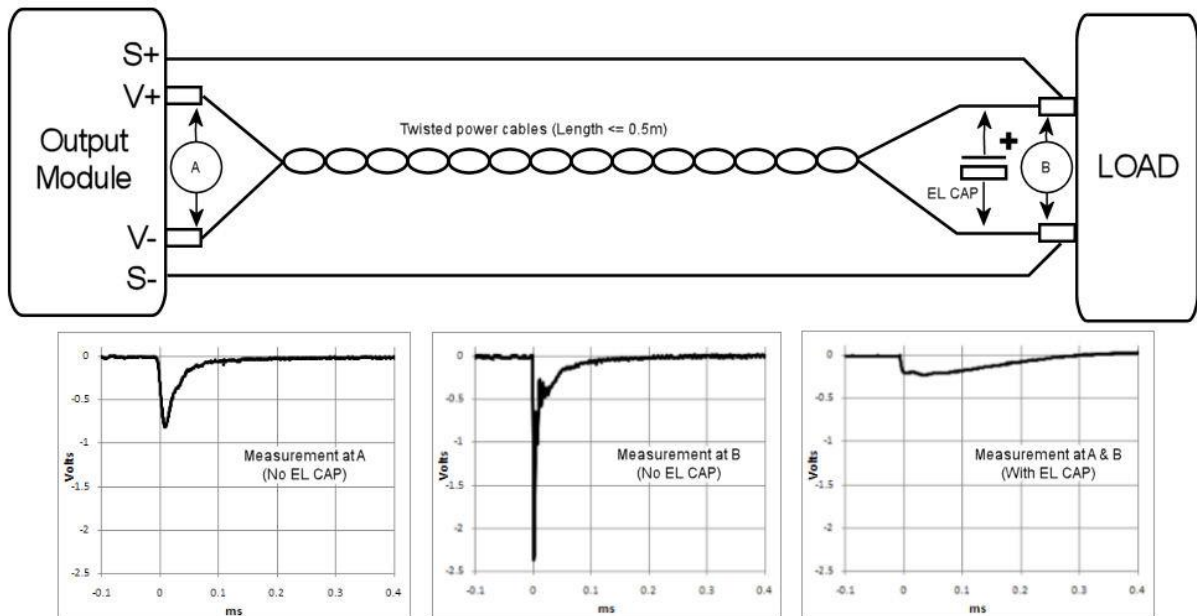
Over Temperature Protection (OTP)

Each output module is protected against excessive temperatures. In the event of an internal temperature exceeding safe levels the output module will shut off. If the temperature reduces the output module will automatically recover. Should the temperature continue to rise a second over temperature circuit will shut down the input module and all outputs. To resume operation of the unit, disconnect the AC input voltage for 20 seconds then reconnect. If all temperatures are within specifications the unit will restart. Note that no warning is given on the AC_OK signal for faults of this type.

Transient Response

The VCCM output modules have been especially designed to have high reliability. To achieve this all electrolytic capacitors have been eliminated from the design. As a result of this, high dynamic load transients can cause relatively high voltage deviations at the output and although the outputs have a very high loop bandwidth with typical recovery times of less than 100µs, the voltage deviations may still be excessive for some applications.

An example application is detailed in the diagram below and shows typical responses at the terminals of the output module and at the load. Notice that the voltage deviation due to cable inductance exceeds the module response and hence a capacitor located at the module terminals will have little effect at the load. The optimum solution is to locate a low impedance electrolytic capacitor at the load which will eliminate the inductive cable drop and reduce the typical voltage deviation at the module.



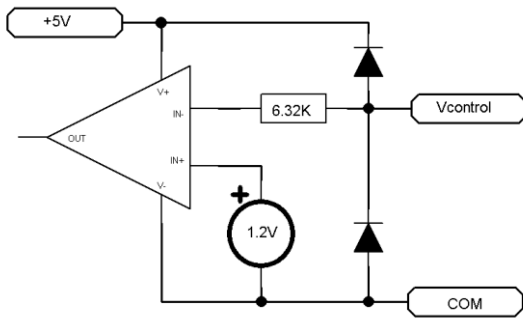
Advanced Output Module Features

Remote Voltage Programming (External Voltage Control)

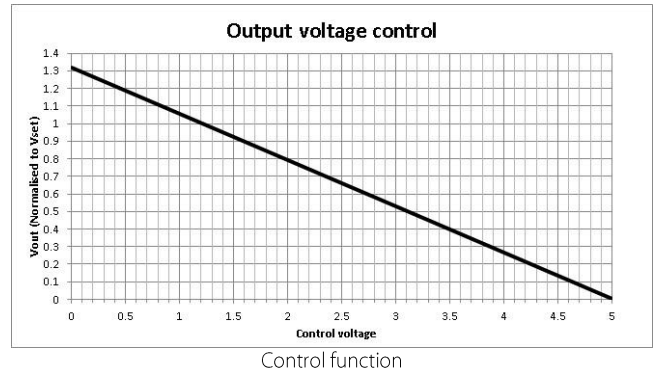
The output voltage of the module can be adjusted using an external voltage source connected between the COM and $V_{CONTROL}$ pins on the signals connector J4 as shown below.

In this configuration the output voltage will follow the typical equation below,

$V_O = V_{SET}((5 - V_{CONTROL}) / 3.8)$, where V_{SET} is the manual preset voltage of the module.



Equivalent internal circuit



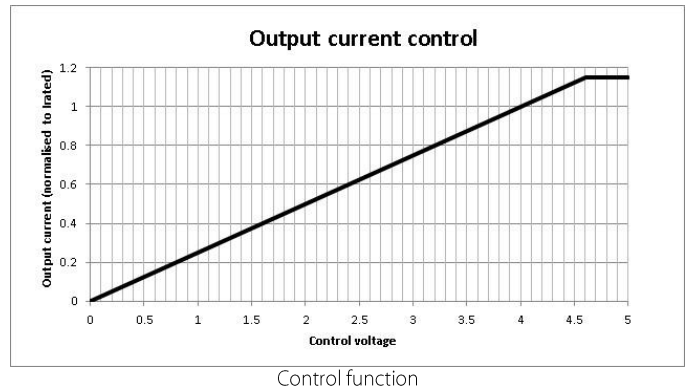
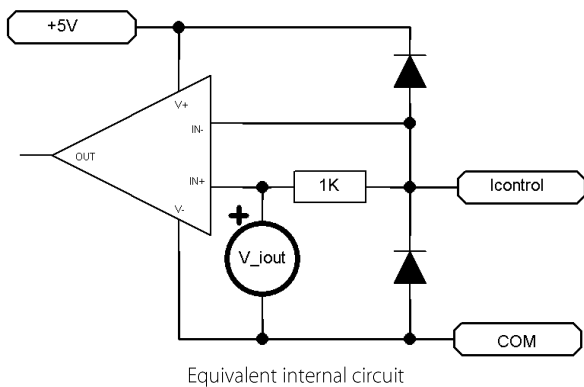
The output voltage can be controlled from 0% to 131.5% of the preset voltage using this control method. However, care must be taken to ensure the output voltage does not exceed the OVP level, as this will trigger OVP protection.

Remote adjustment of the output voltage using the $V_{CONTROL}$ pin does not affect the preset power good threshold. Hence, remotely adjusting the output voltage below $0.9 \cdot V_{set}$ will cause the power good signal to go low.

Where tight voltage adjustment tolerances are required, it is recommended to use external circuitry to provide closed loop control of the $V_{CONTROL}$ pin.

Remote Current Programming (External Voltage Control)

The output current limit of the module can be reduced using an external voltage source connected between the COM and I_{CONTROL} pins on the signals connector as shown below. In practice this also means that the output can be used as a modulated or constant current source.



In the diagram above, V_{i_out} is an internal voltage source that is proportional to the internal inductor current and approximates the equation,

$V_{i_out} = 4 \cdot I_{OUT} / I_{RATED}$, where I_{rated} is the maximum rated current for the module.

In this configuration the output current limit will approximate the following equation,

$I_{LIMIT} = I_{RATED} \cdot V_{CTRL} / 4$, where I_{RATED} is the maximum rated current for the module.

It is not possible to increase the maximum current limit of the module, and control voltages exceeding 4.6V will have no effect on the current limit.

When using an output module as a modulated current source, the output voltage should be manually adjusted to the maximum that will be required by the application and this will be the upper voltage limit. Once the load is connected, the output current can then be modulated by applying a control voltage as described above.

Note that the power-good threshold level is fixed and defined by the manually preset voltage. Hence, while the output module is limiting or modulating the output current the PG signal may go low.

Where tight current adjustment tolerances are required, it is recommended to use external circuitry to provide closed loop control of the I_{CONTROL} pin.

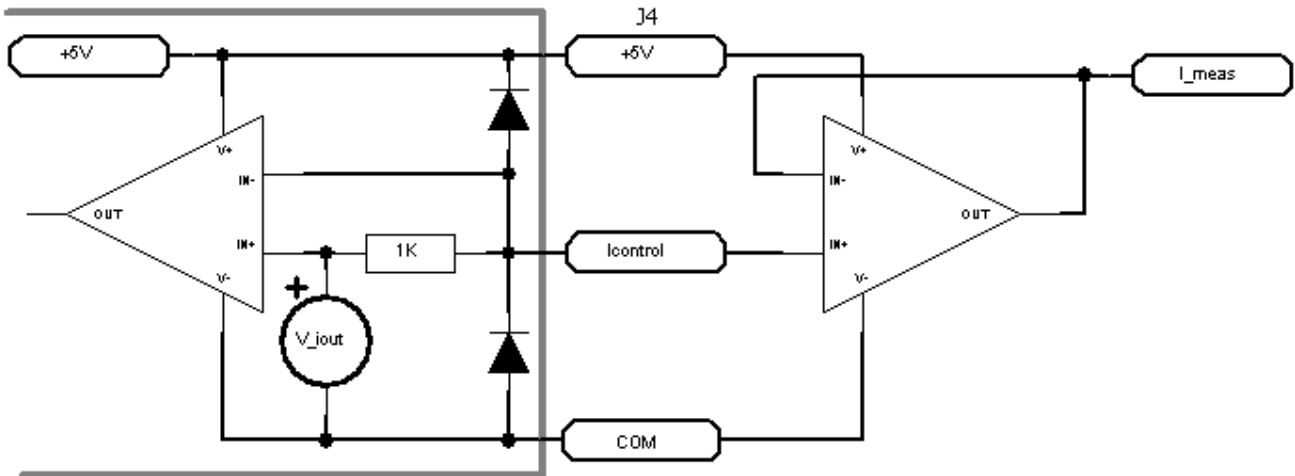
Output Current Measurement

The output current of the module can be measured using the I_{CONTROL} signal. If this pin is not loaded its output voltage will follow the typical equation,

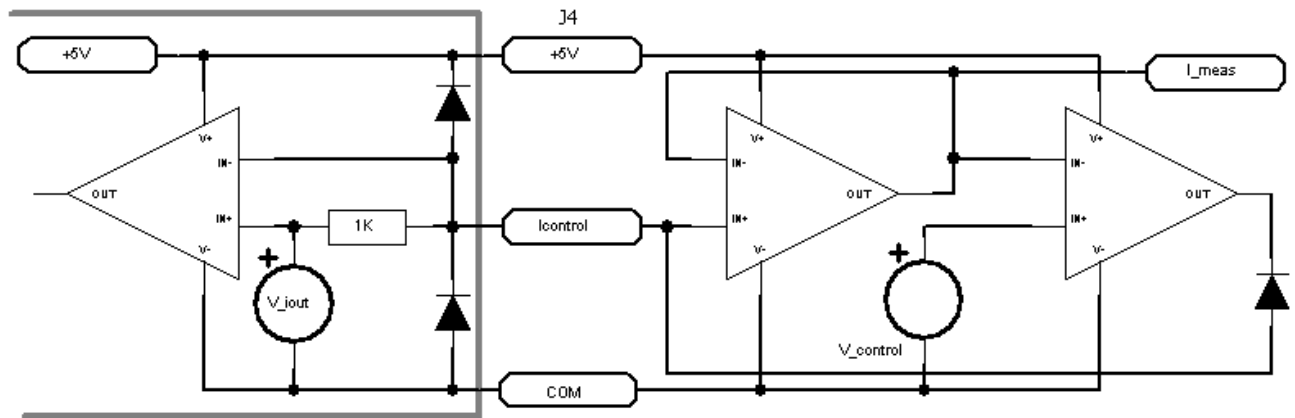
$$V_{I_OUT} = 4 * I_{OUT} / I_{RATED}$$

where I_{RATED} is the maximum rated current for the module.

Note that the I_{CONTROL} output voltage is representative of the internal inductor current not the actual load current. However, this will only have an influence during dynamic events. It is recommended to add an external buffer amplifier (as shown below) when using the I_{CONTROL} signal to measure the output current as loading the I_{CONTROL} signal, even with microamps can cause the current limit to be reduced. If it is required to measure the output current and adjust the output current limit simultaneously, this can be achieved by using a clamp circuit instead of a voltage source to adjust the current limit, while continuing to use an amplifier to measure the output current. An example circuit is shown below. In this case V_{CONTROL} will control the current limit while the buffered I_{CONTROL} signal will provide a measurement of the output current.



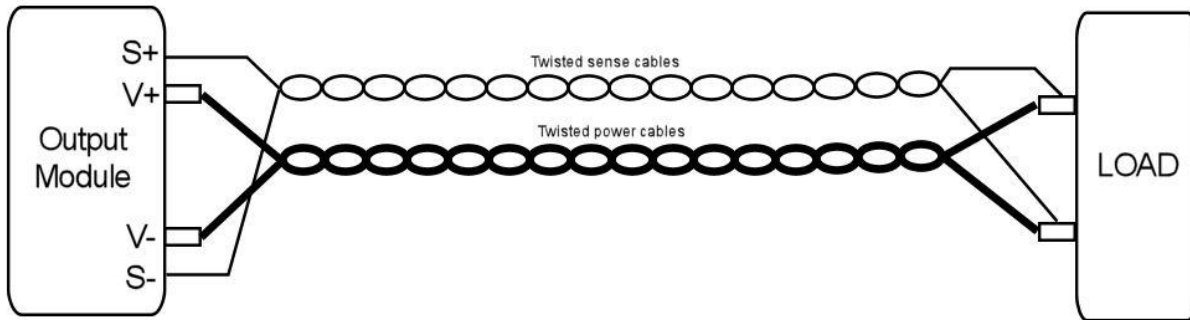
Measuring output current



Measuring & controlling output current

Remote Sensing

Remote sensing is available on all output modules and can be used to compensate for a voltage drop in the power leads connecting the power supply to the load. To implement remote sensing connect the positive sense pin (S+, connector J4.2) to the positive side of the remote load and the negative sense pin (S-, connector J4.1) to the negative side of the remote load. The voltage will be regulated at the points where the sense cables are connected.



Active protection against damaged power cables or accidental power cable removal is provided and prevents damage to the unit in each case. An internal circuit measures the voltage between S+ to V+ and S- to V-, when this voltage exceeds the thresholds specified in the datasheet, the output voltage is reduced to benign levels. During system design, care must be taken to ensure power cables have a sufficiently low voltage drop at maximum load current to ensure this protection does not activate unintentionally.

In systems where remote sensing is not used, the output voltage at the power terminals will be slightly higher than that at the sense terminals. This voltage difference is termed, "open sense offset" and occurs due to internal bias currents in the sensing circuit. Factory set units are set with the sense cables connected unless otherwise specified.

Local Bias Supply

A local non-isolated +5V bias supply is provided on each output module (+5 V on J4.6, referenced to COM on J4.3). This supply is intended to power interface circuits for monitoring and controlling the output modules. The output can supply up to 10mA maximum, and exceeding this can damage the unit.

Also, as COM is connected to an internal voltage that is **NOT** equivalent to S- or V-, particular attention must be given to grounding issues when interfacing COM to any control circuit in the application. Connecting COM to S- or V- may result in damage to the unit.

Series Connected Outputs

VCCM output modules of the same type can be series connected to achieve higher output voltages. Links for series connecting modules are available directly from Vox Power or our local representatives.

The following instructions must be followed for output modules configured in this manner.

WARNING!

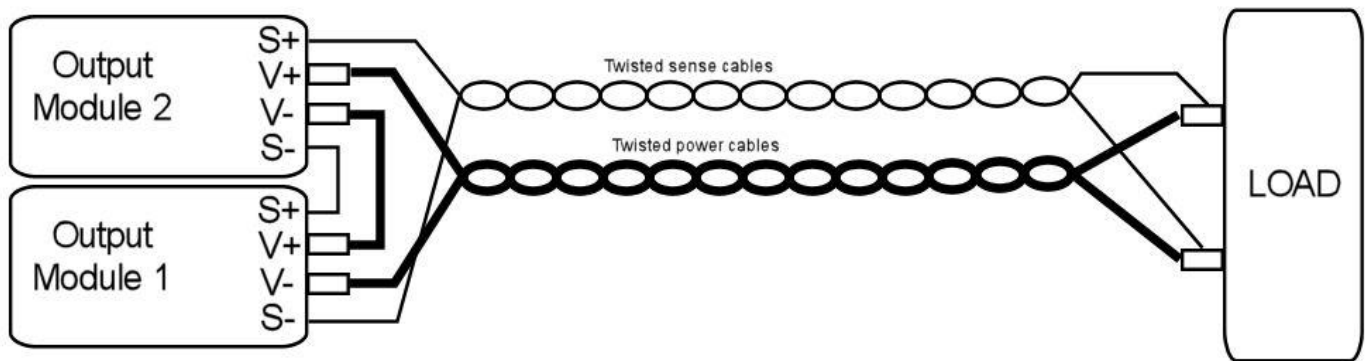
- Energy and Voltage hazards may arise when individual modules are series connected. See the Safety section for more details.
- When modules are connected in series, their inhibit lines (J3), if used, should be paralleled.
- Inhibiting series connected modules individually may cause damage

Isolation to Ground

Care must be taken not to exceed the output module isolation to chassis ground when series connecting modules. Each output module is rated for 500 Volts maximum between each output terminal and chassis ground. Exceeding this voltage may damage the module.

Remote Sensing

For series connected modules, remote sensing is achieved by connecting the upper most positive sense terminal (S+) and the lower most negative sense terminal (S-) from the series of modules to their respective load regulation points. All inner sense terminals in the series must be daisy chained i.e. S+ to S- from the first module in the series to the last module in the series. An example of two series connected modules is shown below.



Series Connected Remote Voltage/Current Control

Remote voltage and/or current control is possible with series connected modules using the advanced $V_{CONTROL}$ and $I_{CONTROL}$ functions described earlier. However, individual control of each module can be complex as the various control terminals are referenced to the positive output of the preceding module and require the use of multiple isolated control voltages to attain control over the full voltage range. Please contact Vox Power or your distributor for assistance if remote voltage or current control is required for series connected modules.

SELV Precautions

Where series combinations of output modules exceed 60V, the output can no longer be considered SELV (Safety Extra Low Voltage) and hence the final equipment manufacturer must provide suitable protection for both users and service personnel.

External capacitance

When large external capacitances are connected to series connected outputs, the maximum input power can be exceeded at start-up and the unit can latch off. Consider sequencing output start-up to prevent exceeding the input power limit when charging large external capacitances.

Parallel Connected Outputs

VCCM output modules of the same type can be paralleled within the same product to achieve higher output currents. Links for paralleling modules are available directly from Vox Power or our local representatives.

The following instructions must be followed for output modules configured in this manner.

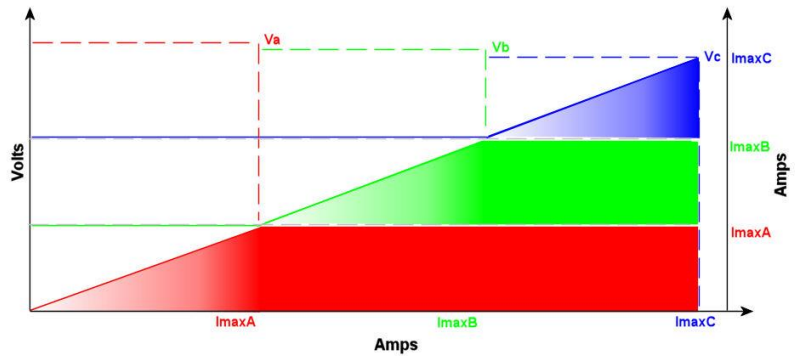
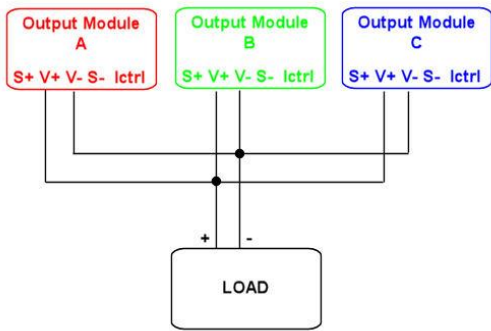
WARNING!

- Energy Hazards may arise when individual modules are paralleled. See the Safety section for more details.
- When modules are paralleled, their inhibit lines (J3), if used, should also be paralleled. Inhibiting paralleled modules individually may cause damage

When paralleled, the outputs can operate in two distinct modes, Normal parallel mode or Share parallel mode.

Normal Parallel Mode

For normal parallel mode, the positive power cables should be connected together and the negative power cables should be connected together. No other connections are required as shown in the diagram below.



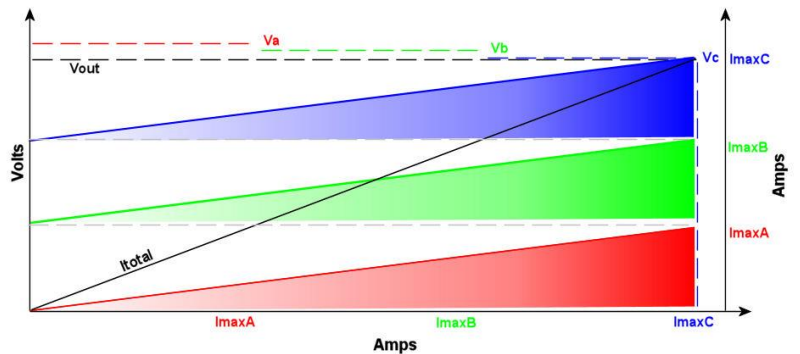
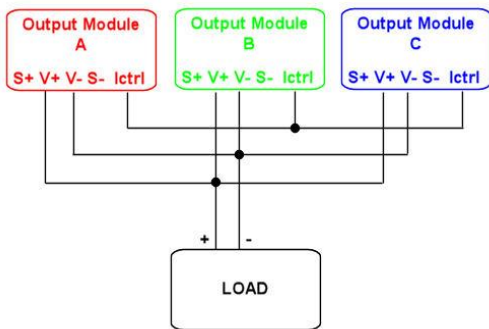
In this mode, the highest adjusted output module will supply all of the load current until its current limit is reached. If the load demand exceeds this level the output voltage will drop to the level of the next highest adjusted module and that module will begin to supply the load current while the first module continues delivering full current. This process repeats for the total number of paralleled modules. The diagram above shows the VI curve for such a system.

Output modules that are not delivering current will typically sink a small amount of current from the other outputs, but this will not exceed -6% of each module's maximum rated current.

Typically, system reliability is reduced in this mode as the higher adjusted modules will do most of the work with the lower adjusted modules only delivering current during peak load demand.

Share Parallel Mode

In share parallel mode, the outputs are paralleled as before and the I_{CONTROL} pin of each module connected together as shown in the diagram below.



Connecting the I_{CONTROL} pins together forces all the outputs to deliver the same current, ensuring that the system reliability is maximised and the work load is distributed evenly across all paralleled modules.

In this mode, the lowest adjusted output module will determine the actual output voltage and all higher adjusted outputs will reduce their voltage.

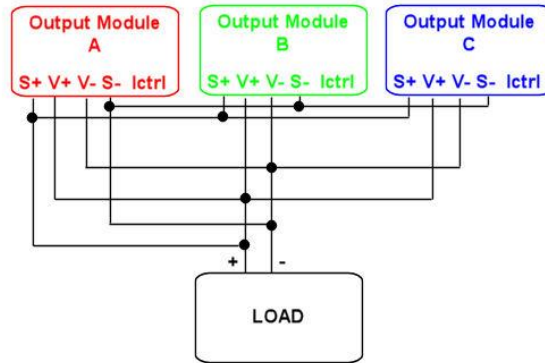
The current output signal (I_{CONTROL}) can still be used to measure the output current but it must be scaled by N, where N is the number of paralleled modules.

WARNING!

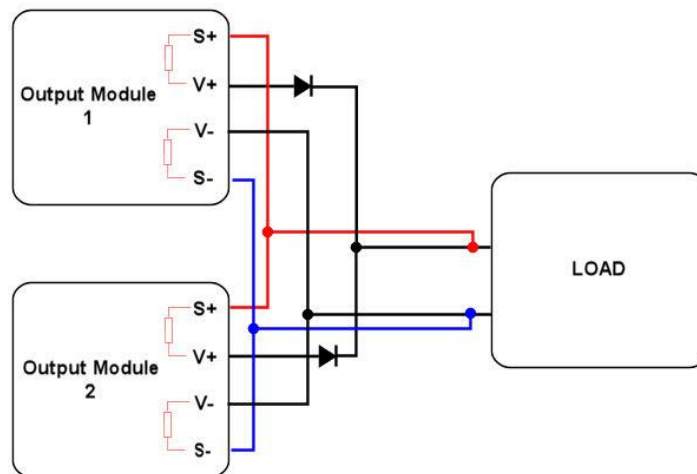
Care must be taken to avoid differential voltages between the negative power output terminals of share mode paralleled modules as this can cause errors at the control pins. To avoid this, it is recommended to use Vox Power parallel links to parallel modules in share mode.

Parallel Remote Sensing

Remote sensing can be used as normal with paralleled modules. The sense lines (S+ and S-) from each of the output modules should be connected together, S+ to S+, and S- to S- as shown below. This should be done close to the power supply output and a single pair of cables brought from these sense lines to the load. Keeping cable lengths to a minimum and using twisted pairs where necessary will help reduce noise pickup in the sense lines.

**N+1 Configurations**

When using N+1 redundant configurations, a suitably rated diode (or controlled MOSFET) must be used on each output to prevent a device failure from causing a system failure. However, the diode introduces voltage drops between the supply and the load that significantly degrade the load regulation. To counteract this, the remote sense lines can be used to regulate the voltage at the load as shown below.

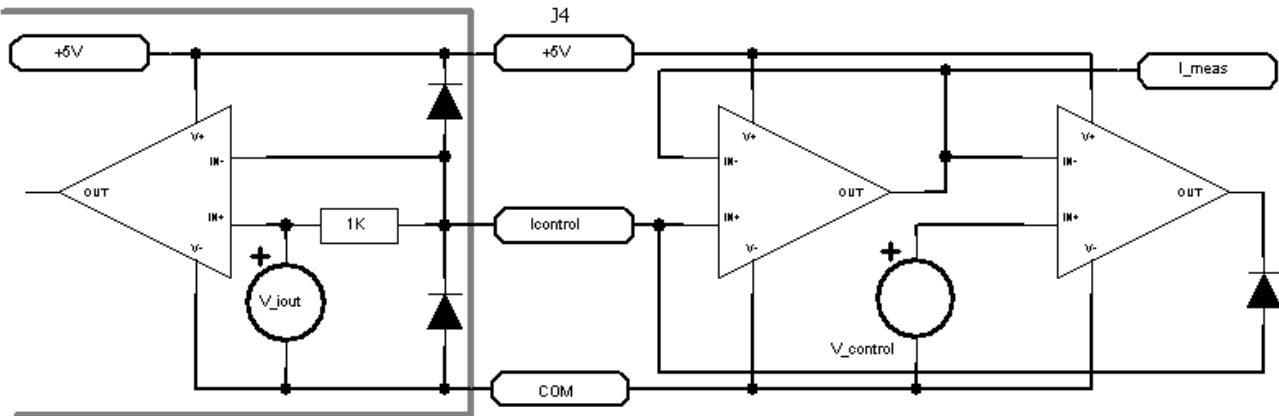


Typically, this configuration can damage the internal sense resistors used within a power supply. However, the VCCM outputs have integrated protection to prevent this type of damage and are completely N+1 compatible without any additional external protection circuitry. Note that only the positive sense terminal is protected and diodes should be used in the positive connection only.

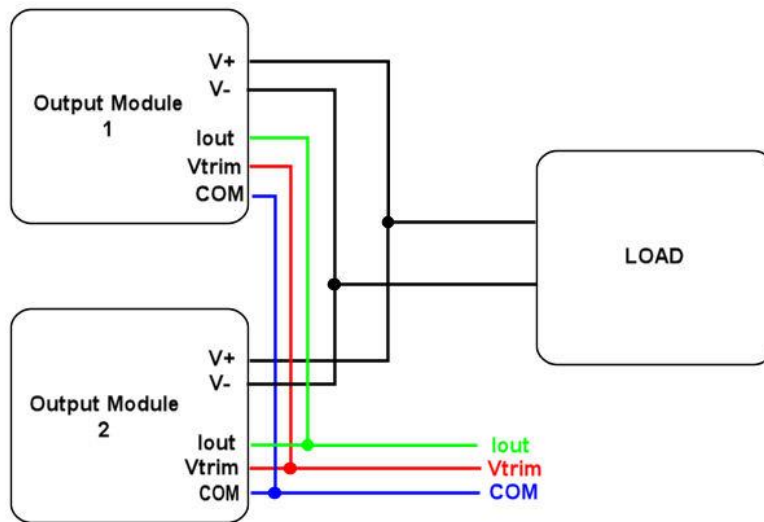
Paralleled Remote Voltage/Current Adjustments

Remote voltage programming with paralleled outputs can be achieved by simply joining all $V_{CONTROL}$ and COM pins together and applying the external control voltage between COM and $V_{CONTROL}$.

Remote current programming with paralleled outputs can be achieved by joining all $I_{CONTROL}$ and COM pins together but directly applying an external control voltage would override the current share signal and force the outputs to operate in normal parallel mode. Instead it is required to clamp the $I_{CONTROL}$ bus voltage using a circuit similar to that shown below.



It is not recommended to use remote voltage/current programming in normal parallel mode.



WARNING!

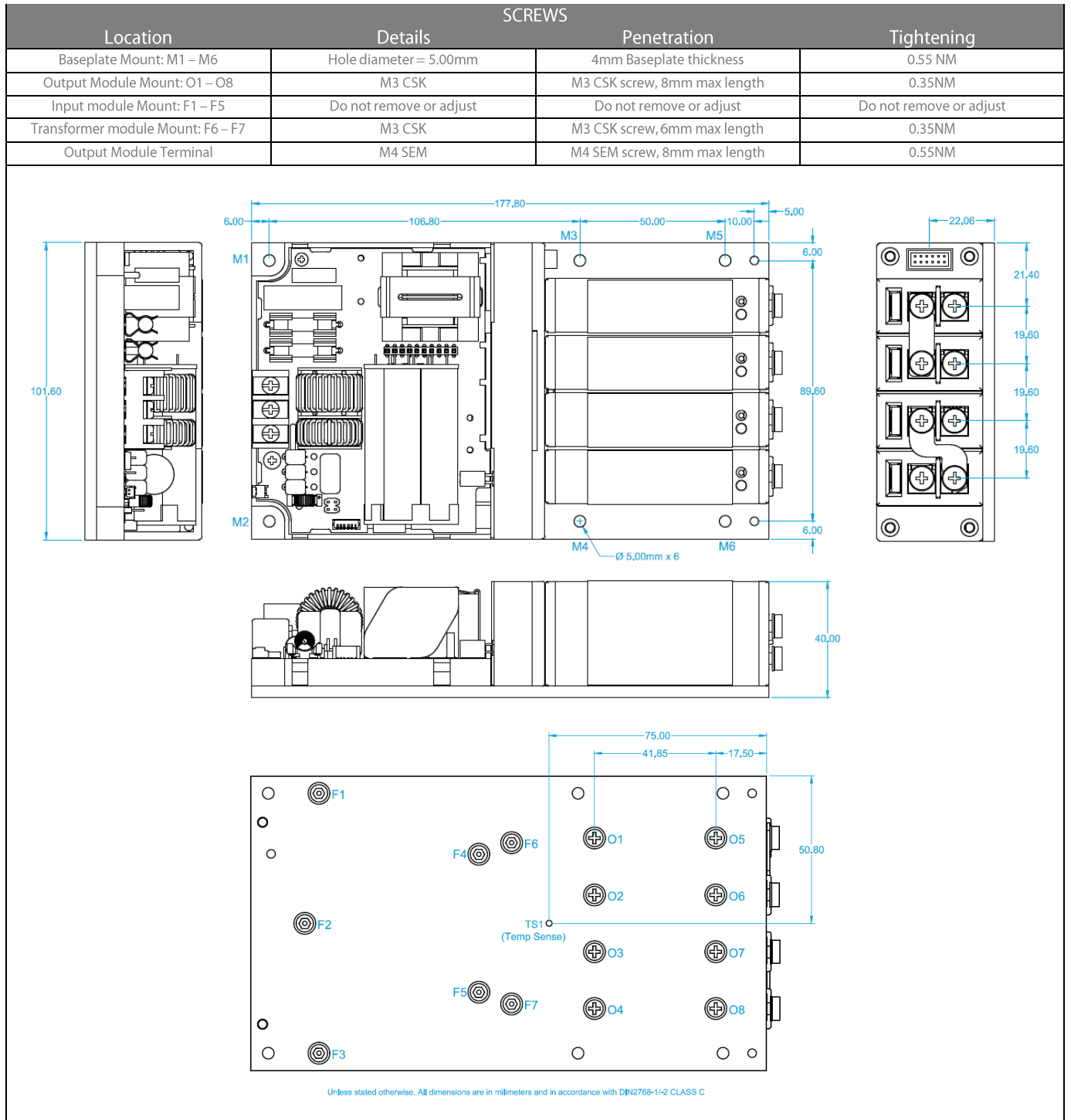
Care must be taken to avoid differential voltages between the negative power output terminals of share mode paralleled modules as this can cause errors at the control pins. To avoid this, it is recommended to use Vox Power parallel links to parallel modules in share mode.

Paralleling Across Multiple Products

Paralleling across multiple product is not possible without external protection (such as external diodes or controlled MOSFETs) to prevent circulating currents between each product. Failure to provide such protection may result in damage to the power supplies. Consult Vox Power for details on how best to implement such applications.

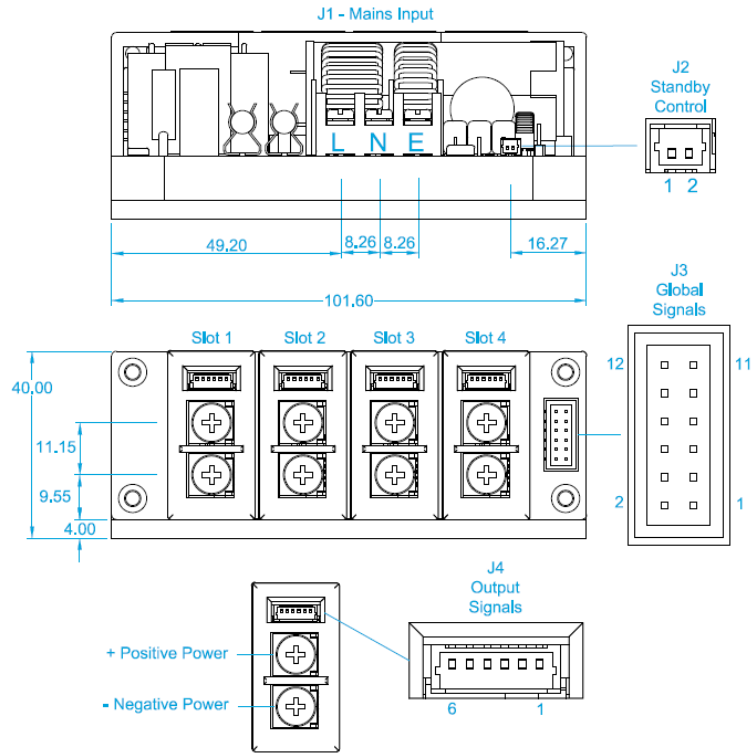
When modules are paralleled across multiple products, the outputs in each product will not be synchronised and the peak to peak output ripple may contain beat frequencies in the audio spectrum.

Mechanical Dimensions and Mounting



Connector details

PINOUTS	
Circuit	Details
J1 – Mains Input	
1	Live
2	Neutral
3	Earth
J2 – Standby control	
1	Standby control negative
2	Standby control positive
J3 – Global Signals	
1	Slot 4 - Power Good
2	Slot 4 - Inhibit
3	Slot 3 - Power Good
4	Slot 3 - Inhibit
5	Slot 2 - Power Good
6	Slot 2 - Inhibit
7	Slot 1 - Power Good
8	Slot 1 - Inhibit
9	Temperature sense (T _{SEN})
10	AC OK
11	+5V (Bias Supply 1A)
12	COM
J4 - Output Signals	
1	- Sense
2	+ Sense
3	COM
4	I Control
5	V Control
6	+5V (Bias Supply 10mA)



Unless stated otherwise, All dimensions are in millimeters and in accordance with DIN2768-1/2 CLASS C

MATING CONNECTORS				
Ref.	Details	Manufacturer	Housing	Terminal
J1 - Mains Input	3 Pin, Barrier, 6-32 Steel Screws, 0.8 Nm or 7 Lb-In Torque ⁽¹⁾			
J2 - Standby control	2 Pin, 1.25mm, with Friction Lock, 28-30AWG	MOLEX	0510210200	0500588000
J3 - Global Signals	12 Pin, 2mm, with Friction Lock, 24-30 AWG, WIRE TO BOARD	MOLEX	0511101260	0503948051
	12 Pin, 2mm, with Friction Lock, 24-30 AWG, IDT CABLE TO BOARD	MOLEX	0875681273	
J5 - Output Signals	6 PIN, 1.25mm, with Friction Lock, 28-30AWG	MOLEX	0510210600	0500588000
Output Power	Positive/Negative, M4 terminal, 0.55Nm, use appropriately rated crimp terminal			
Notes				
1. Cable 14-18AWG, 300V, 16A, 105°C, use appropriately rated crimp terminal.				
2. Direct equivalents may be used for any connector parts.				
3. All cables must be rated 105°C min, equivalent to UL1015				

Safety

The VCCM unit has been designed to comply with the Low Voltage Directive DIR 2014/35/EU (LVD), the EMC Directive DIR 2014/30/EU and DIR 2011/65/EU regarding the restriction of certain hazardous substances and is CE marked to show its compliance.

When correctly installed (per the installation manual) in a limited access environment the VCCM600S & M comply with the requirements of EN60950 2nd Edition and EN60601 3rd Edition respectively.

- The power supply should not be operated close to combustible materials or atmosphere.
- Care should be taken to ensure liquid or metal shavings do not enter the power supply as this can cause a fire hazard.
- The power supply does not contain any user serviceable parts and should be returned to Vox Power for repair.

Approval Limitations (North America)

When this product is used with 180V_{AC}–253V_{AC} mains where no neutral is present, connect the two live wires to L (Live) and N (Neutral) on the input connector.

WARNING!

- Series connected modules with combined voltages exceeding 60 volts are not considered SELV. Paralleled and/or series modules with combined energy ratings greater than 240 VA may cause energy hazards. The equipment manufacturer must provide additional and adequate protection to service and technical personnel.
- Always remove the power before handling the unit. During operation, the external surface of the unit can become hot. Leave to stand for 10 minutes to allow the unit to cool down before handling the unit.
- Dangerous voltages are present within the power supply. Covers may only be removed by qualified personnel when the power supply has been disconnected from the mains supply voltage for more than 2 minutes. Covers must be replaced and all screws secured properly before reconnecting to the mains voltage.

SAFETY SPECIFICATIONS

Parameter	Details	Max	Units	Notes
Isolation Voltages	Input to Output (2 MOPP)	4000	V _{AC}	
	Input to J2 standby control (2 MOPP)	4000	V _{AC}	
	Input to Chassis (1 MOPP)	1500	V _{AC}	
	Global signals (J3) to Output/Chassis	500	V _{DC}	
	Output to Output/Chassis (Standard modules)	500	V _{DC}	
Earth Leakage Current	INDUSTRIAL: Normal condition, 264V _{AC} , 63Hz, 25°C	1500	uA	
	MEDICAL: Normal condition, 264V _{AC} , 63Hz, 25°C	200	uA	
Touch Leakage Current	Standard modules NC/SFC	20/200	uA	
Patient Leakage Current	Standard modules 264V _{AC} , 63Hz, 25°C NC/SFC	-----	uA	Not applicable

INSTALLATION SPECIFICATIONS

Parameter	Details	Parameter	Details
Equipment class	I	Flammability Rating	94V-2
Overvoltage category	II	Ingress protection rating	IP10
Material Group	IIIb (indoor use only)	ROHS compliance	2011/65/EU
Pollution degree	2	Intended usage environment	Home Healthcare (M)/ Industrial (S)

EMC Compliance

To support compliance of the final system design with the EMC directive 2014/30/EU, the VCCM600 PSU has been designed and tested to the following

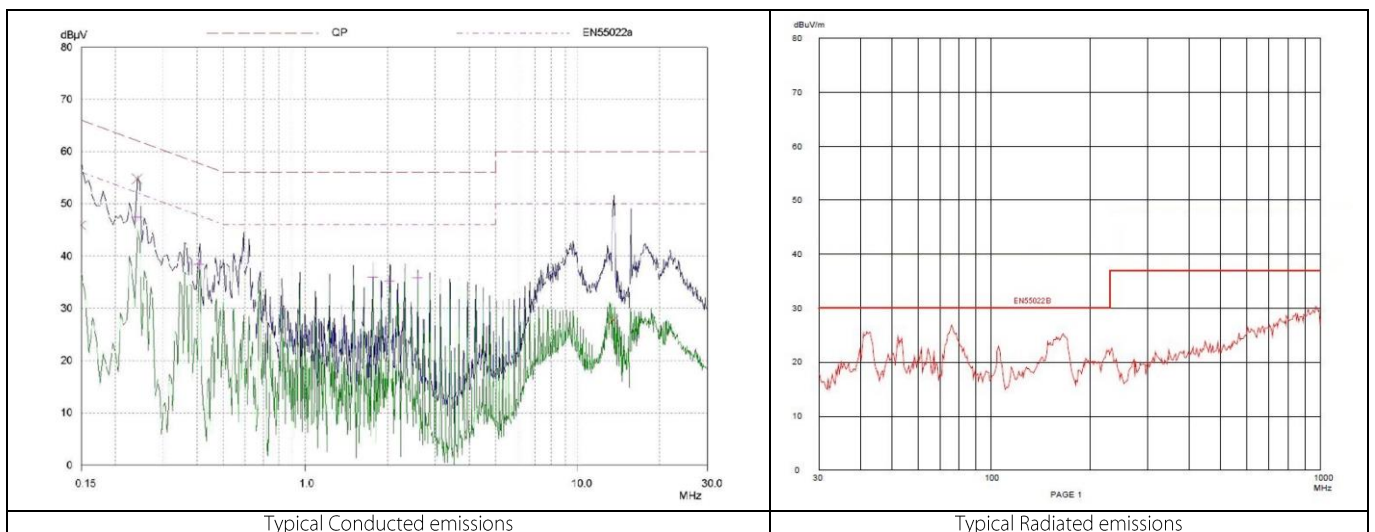
ELECTROMAGNETIC COMPLIANCE – EMISSIONS		
Phenomenon	Basic EMC Standard	Test Details
Radiated emissions, electric field	EN55011/22	Class B compliant
Radiated emissions, electric field, 30Hz-18GHz.	MIL-STD-461F: RE102 (Ground, Fixed)	Compliant (When mounted in enclosure)
Conducted emissions	EN55011/22, FCC part 15, CISPR 22/11	Class B compliant
Conducted emissions, power leads, 10kHz-10Mhz.	MIL-STD-461F: CE102	Compliant (External filter may be required)
Harmonic Distortion	IEC61000-3-2	Compliant
Flicker & Fluctuation	IEC61000-3-3	Compliant

ELECTROMAGNETIC COMPLIANCE – IMMUNITY		
Phenomenon	Basic EMC Standard	Test Details
Electrostatic discharge	IEC61000-4-2	Test level 4: 15kV air, 8kV contact
Radiated RF EM fields	IEC61000-4-3	Test Level 3: (10V/m, 80MHz-2.7GHz) sine wave AM 80% 1kHz
Proximity fields from RF wireless communications equipment	IEC61000-4-3	Test levels as per IEC60601-1-2:2014 Table 9
Radiated susceptibility, electric field, 2 MHz to 40 GHz.	MIL-STD-461F: RS103	20V
Electrical Fast Transients/bursts	IEC61000-4-4	Test Level 3: (2kV Power, 1kV I/O) 5kHz(ed3) & 100kHz(ed4)
Conducted susceptibility, Bulk cable injection, impulse excitation	MIL-STD-461F: CS115	
Surges	IEC61000-4-5	Test Level 3: 1kV L-N, 2kV L-E
Conducted susceptibility, damped sinusoidal transients, cables and power leads, 10kHz-100MHz	MIL-STD-461F: CS116	
Shipboard Electric Power. Voltage Spike Test	MIL-STD-1399, SECTION 300A	Type 1, 115V60Hz single phase
Conducted disturbances induced by RF fields	IEC61000-4-6	Test Level 3: 10V, 0.15 to 80Mhz sine wave AM 80% 1kHz
Conducted susceptibility, power leads, 30Hz-150kHz	MIL-STD-461F: CS101	
Conducted susceptibility, Bulk cable injection, 10kHz-200Mhz	MIL-STD-461F: CS114	
Power Frequency Magnetic Fields	IEC61000-4-8	Test level 4: 30A/m 50Hz
Radiated susceptibility, Magnetic field, 30Hz-100kHz	MIL-STD-461F: RS101	
Voltage Dips	IEC61000-4-11 ⁽²⁾	0% 10ms, 0% 20ms (Criterion A) 70% 0.5s, 40% 200mS (Criterion A at 240V and Criterion B at 100V) 0% 20mS, 80% 1s, 80% 10s, 90% continuous (Criterion A) 70% 0.5s, 50% 200mS (Criterion A at 240V and Criterion B at 100V) Criterion A is achieved for full power when $V_{in} \geq 160V$ Criterion A is achieved at all input voltages when $P_{out} \leq 350W$
Voltage Sag Immunity	SEMI-F47-0706 ⁽²⁾	0% 250/300 cycle as per IEC60601-1-2:2014 (Criterion B)
Voltage interruptions	IEC61000-4-11	SAC102,104,105,109,110 (MIL-HDBK-704-2) & SXF102,104,105,109,110 (MIL-HDBK-704-6)
Aircraft Electric Power Characteristic	MIL-STD-704F	

Notes:

1. Criterion A = No degradation of performance or loss of function.
Criterion B = Temporary degradation of performance or loss of function is allowed, provided the function is self-recoverable.
Criterion C = Temporary loss of function is allowed but requires operator intervention to recover..
Tested at nominal range (100V to 240V). Line deratings applied where appropriate.
- 2.

standards.



For radiated and conducted emissions, compliance of the final system relies on proper installation of the PSU component. The installation guidelines detailed below should be followed.

Installation Guidelines for optimum EMC performance

- VCCM units should be mounted within a metal enclosure using the mounting fixtures provided.
- If the application enclosure is not metal, then a metal ground plate should be used to mount both the power supply and the load.
- Both input and output cables should be fixed as close as possible to the ground plate or metal enclosure.
- Input and output cables should be separated as much as possible from each other or a shield/screen used to isolate RF currents
- Output power and sense cables should be twisted pairs and routed parallel to each other. Do not twist sense and power cables together.
- All cables lengths and loop areas should be minimised.
- Where cables must enter or exit the enclosure, good high frequency 100nF decoupling capacitors of sufficient voltage rating should be connected to the cables as close to the entry/exit point as possible.

For further details or assistance contact Vox Power.

Reliability

The VCCM600 series has undergone extensive testing, including HALT and Environmental testing. Reliability data is collected on an ongoing basis. Please contact Vox Power or your distributor for the most up to date reliability data.

The reliability data quoted in the datasheets are the calculated *failures per million hours* (FPMH) using the Telcordia SR-332, issue 2 standard. The procedure defined in SR-332 allows several different techniques to be used for calculating MTBF and when evaluating competing MTBF figures it is important that only the same techniques are compared.

The quoted VCCM reliability figures use Method I Case 3, Ground, Fixed, Controlled which specifies an ambient temperature of 30°C and an upper confidence level of 90%. It is also assumed that the product is operated at 100% duty cycle, has an input voltage of 220V_{RMS}, an output power of 600W and that the baseplate temperature is the same as the ambient temperature.

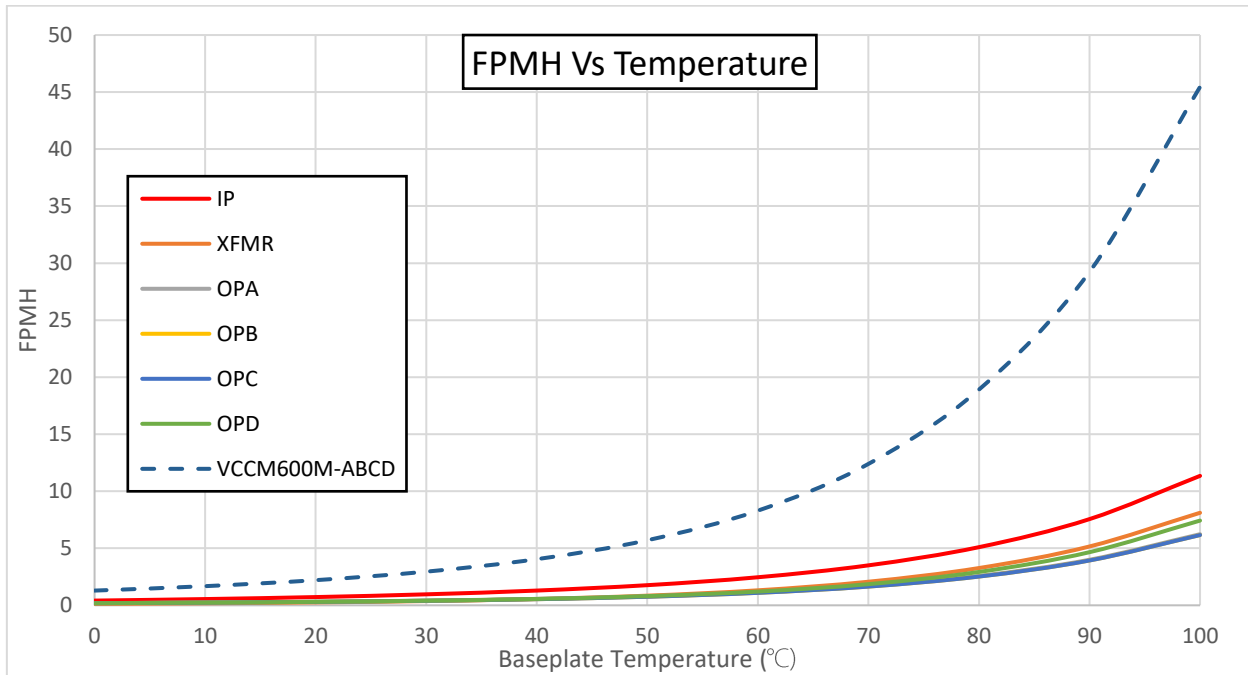
The table below shows a summary of the FPMH & MTBF for all system components and for a typical fully assembled system.

Assembly	Failure Rate (FPMH)	MTBF (Hrs)
IP	0.962972	1038452
XFMR	0.371919	2688754
OPA	0.415368	2407499
OPB	0.397808	2513774
OPC	0.398170	2511487
OPD	0.405630	2465300
VCCM600M-AAAA	2.996363	333737.934

To calculate the MTBF of any VCCM system,

- Add the FPMH figures for each system component to give the total FPMH.
- Get the MTBF by dividing 1,000,000 by the total FPMH.

The variation in FPMH is shown in the graph and table below.



Temp	IP	XFMR	OPA	OPB	OPC	OPD	VCCM600M-ABCD
0	0.41329578	0.127619	0.192619	0.185396	0.186105	0.186243	1.291276945
10	0.54688976	0.178886	0.245347	0.235357	0.235992	0.2362	1.678671789
20	0.72397837	0.255159	0.316147	0.302737	0.30326	0.305183	2.206465072
30	0.96297168	0.371919	0.415369	0.397808	0.39817	0.40563	2.951868534
40	1.29407059	0.555049	0.560829	0.538309	0.538452	0.559393	4.046103211
50	1.76616217	0.846405	0.782692	0.754326	0.754185	0.803972	5.707742381
60	2.46010898	1.315415	1.130884	1.095712	1.095216	1.202005	8.299340054
70	3.50420104	2.067304	1.686039	1.643019	1.642101	1.855247	12.39791075
80	5.09894211	3.266645	2.575169	2.523173	2.52177	2.925702	18.91140128
90	7.55815578	5.160517	3.995269	3.93316	3.931214	4.659641	29.23795696
100	11.3495991	8.112606	6.236851	6.163284	6.160733	7.430093	45.4531658

Configuring Your VCCM Product

The VCCM600 power supply is designed to be used as part of an end-system in a restricted environment and therefore should only be accessible to qualified and trained personnel. Persons attempting to configure a unit must have the necessary knowledge and training before doing so. Incorrect configuration may cause damage to the power supply and may affect the warranty of the power supply.

Output power modules may be added, replaced or moved by strictly following the sequence of operations described below.

Before configuring your VCCM product, remove the VCCM600 input module and any output modules which are going to be used in the configuration from their packaging and inspect for damage.

DO NOT use parts if any part of the product exhibits any kind of physical damage.

DO NOT connect any mains power before the configuration is complete.

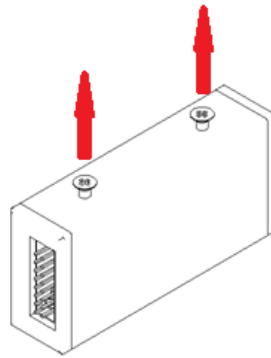
Once configuration changes have been completed, operation of the unit should be verified and voltages can be adjusted to application requirements.

Please contact Vox Power or your distributor for assistance in configuring your power supply. Never assume, always ask.

Adding Output Modules (A, B, C & D)

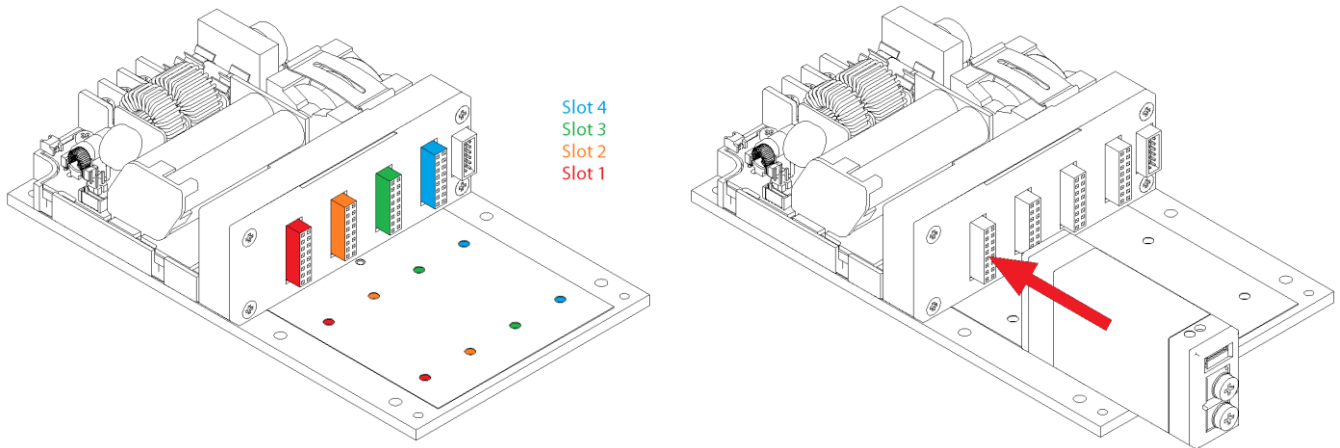
STEP 1:

Each module is provided with two M3x8 Stainless Steel Posi-drive Countersunk screws at the bottom. These are used to attach the module to the baseplate. Remove these screws using the correct No1 Posi-drive screw driver.



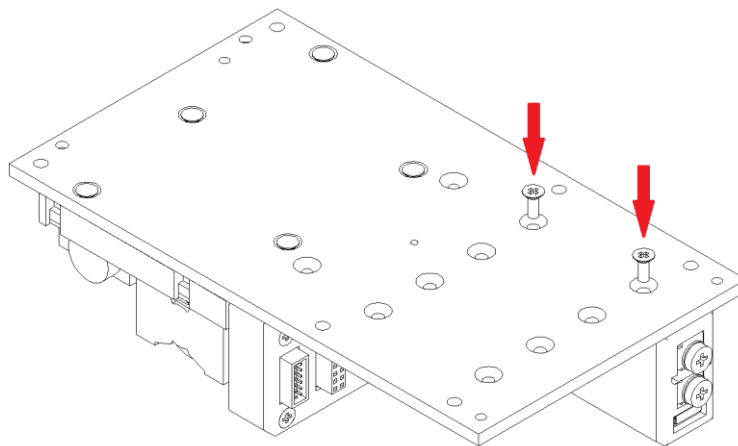
STEP 2:

Ensure that the output module base and baseplate thermal interface are both clean and free from any debris. Insert output modules as required into any one of the four available slots in the VCCM600 transformer module. Ensure the output module and transformer connectors are properly aligned and push together. There will be a solid 'click' once a proper connection is established. Each VCCM600 product can be configured to have up to four isolated outputs by inserting the desired output modules into the correct slots as required.



STEP 3:

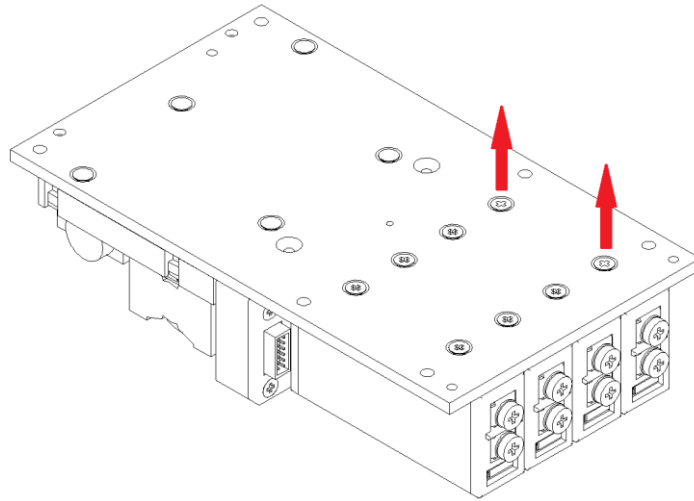
Once the output modules are in place, turn the entire assembly upside down and rest on a flat surface. Secure the screws which were removed in step 1 as shown below. Tighten the screws using an appropriate No1 Posi-drive screwdriver to 0.35NM.



Removing Output Modules (Type A, B, C & D)

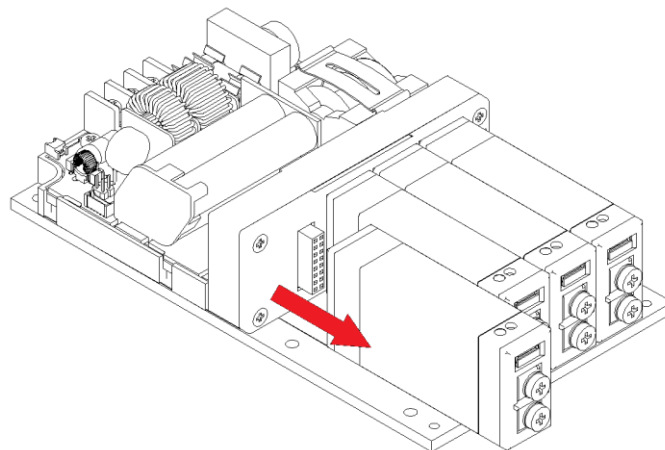
STEP 1:

Turn the configured unit upside down and identify the slot of the module you need to remove. Remove the two screws using an appropriate No1 Posi-drive screwdriver.



STEP 2:

Turn the configured unit right side up and unplug the module by pulling it away from the transformer module. To minimise stress on the connectors do not wriggle the module to remove. Take care not to damage the thermal interface material on the baseplate.



Verifying operation after assembly

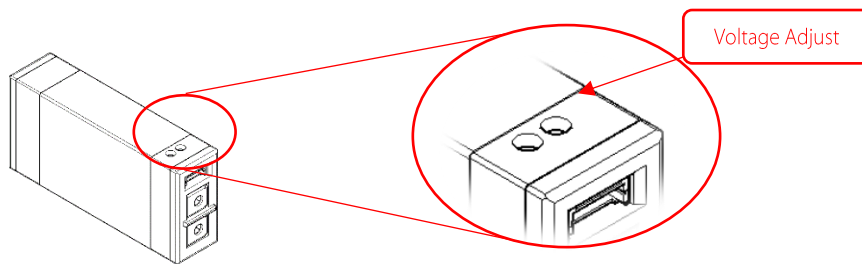
Connect the Live (L), Neutral (N) and Earth (E) terminals of the mains power cable to the corresponding terminals on the mains input connector (J1) on the VCCM600 input module. Only apply power from the mains power outlet once the connection to the VCCM600 input module has been completed. Once power has been applied, confirm that the "Power Good" indicators for all output modules are lit. If any "Power Good" indicators are not lit it may indicate a faulty output module or incorrect assembly. The mains power should be removed and the non-functioning output module re-seated or replaced.

WARNING!

- Dangerous voltages are exposed on certain parts of the power supply even after power has been removed. The unit should only be handled by qualified personnel when the power supply has been disconnected from the mains supply voltage for more than 3 minutes.
- During operation, external surfaces of the unit can become hot. Appropriate precautions should be taken when handling the unit.

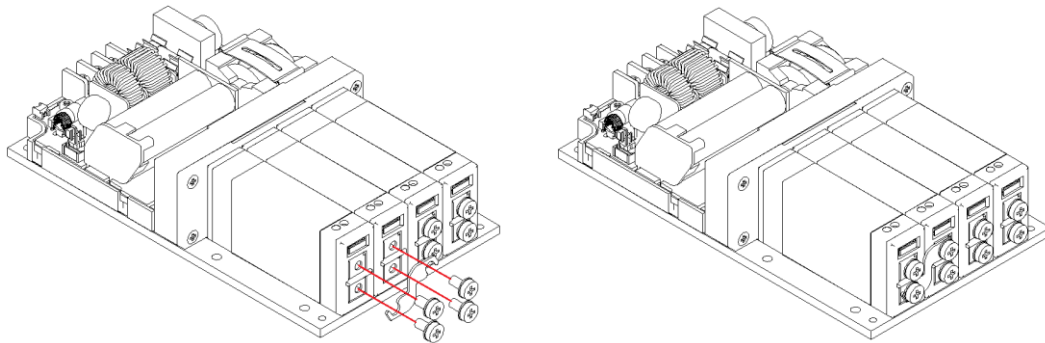
Adjusting output voltages

Each VCCM output module contains a built-in potentiometer to allow for accurate output voltage adjustments. To adjust the output voltage, connect a calibrated voltmeter (or DMM) to the output terminals and insert an appropriate trimming tool (e.g. Bourns Model H-90, maximum diameter 3mm) through the hole marked "Adjust" at the top of the output module as shown below. Do not use excessive force as this may damage the unit. Ensure the trimming tool mates correctly with the internal potentiometer and slowly turn the tool clockwise to increase the voltage or counter-clockwise to decrease the voltage. Once the desired voltage has been achieved, remove the trimming tool and disconnect the voltmeter. Repeat this step for each output module in need of adjustment.



Connecting Output Modules in series

VCCM output modules of the same type can be series connected to achieve higher output voltages. Below is an illustration of how to series connect two output modules in slot 1 and slot 2 using a Vox series link. The Vox series link can be inserted by loosening the output module power terminal screws and rotating the series link into position. The screws should then be tightened to 0.5Nm. The example below shows the series connection from slot 1 negative to slot 2 positive with the output voltage taken from slot 1 positive to slot 2 negative. Further output modules can be added to the series chain by adding more series links across the remaining slots.



WARNING!

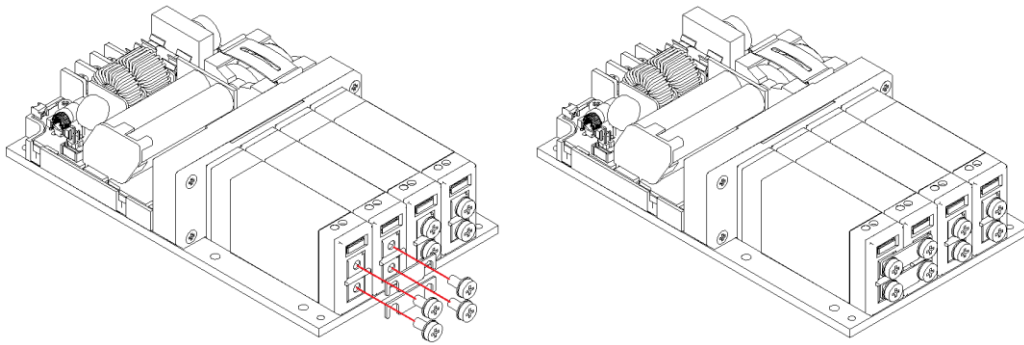
Energy and voltage hazards may arise when individual modules are series connected. When safe energy and voltage levels are exceeded ensure that an appropriate warning label is affixed to the power supply in a manner that service personnel will always notice it. See the Safety section for more details.

Connecting Output Modules in parallel

VCCM output modules of the same type can be paralleled in any number within the same product to achieve higher output currents. For best performance, the output voltages of each paralleled module should be pre-adjusted to within 1% of the required output voltage. It is recommended to fit Vox current share links on all paralleled output modules. Vox Power has a range of 2, 3 and 4-way current share links available. Please discuss your requirements with your distributor or with Vox Power before ordering your unit.

Below is an illustration of a mechanical connection to parallel connect two modules in slot 1 and slot 2 using Vox parallel links. Vox parallel links can be inserted by loosening the output module terminal screws on adjacent modules and sliding the parallel link into position. The screws should then be tightened to 0.5Nm. One link is required to connect the negative power terminals and another is required to connect the positive terminals. Vox Power has a range of parallel links to connect 2, 3 or 4 output modules in parallel.

The example below shows a parallel connection from slot 1 to slot 2.



WARNING!

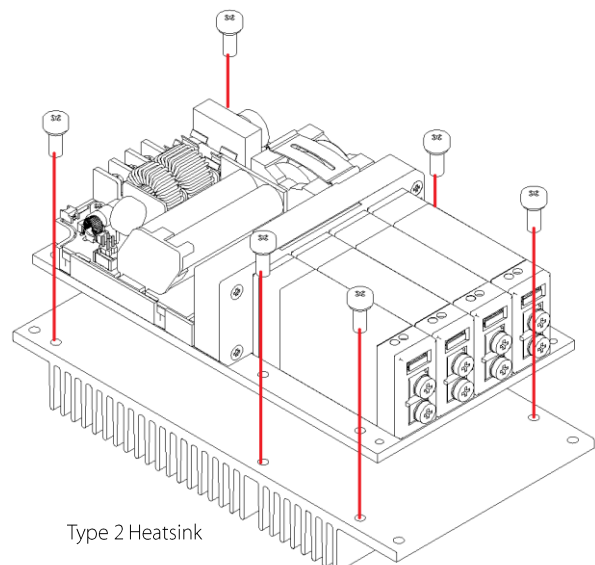
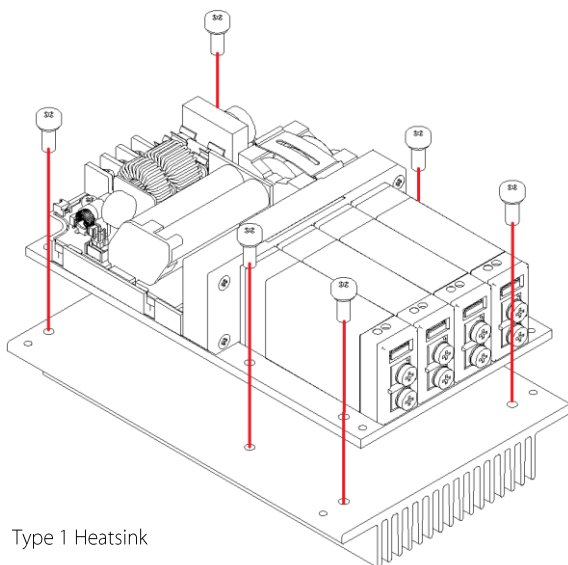
Energy and voltage hazards may arise when individual modules are paralleled. When safe energy and voltage levels are exceeded ensure that an appropriate warning label is affixed to the power supply in a manner that service personnel will always notice it. See the Safety section for more details.

Attaching a heatsink or cooling plate

For improved performance, the baseplate of the VCCM600 unit can be attached to a heatsink or cooling plate. Vox Power has a range of heatsinks available to allow the VCCM600 to be mounted horizontally or vertically.





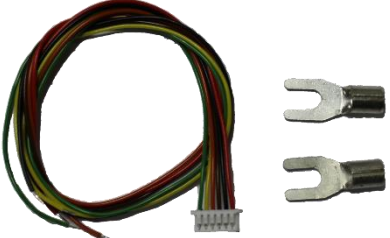

Each heatsink comes pre-assembled with a high performance thermal interface pad and 6 x M4 x 10mm Pozi Pan screws which can be used to attach the heatsink to the baseplate.

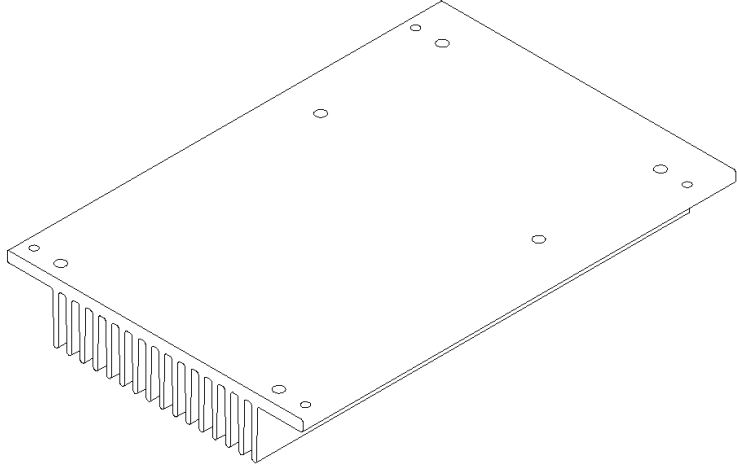
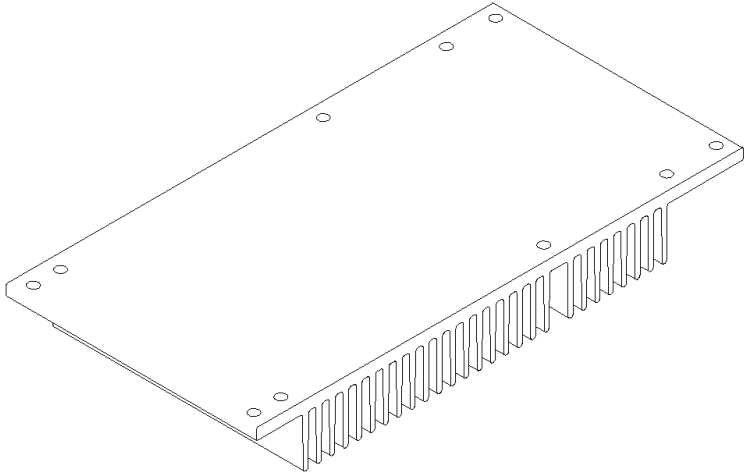
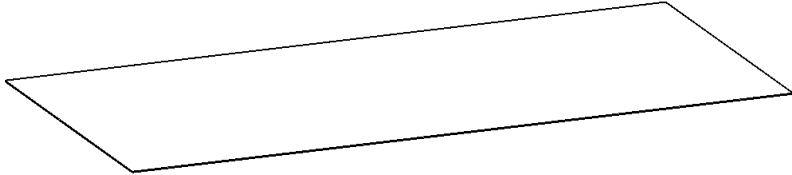
The diagrams below show a VCCM600 unit attachment to a Type 1 and Type 2 heatsink. Before assembly ensure both the baseplate and heatsink surfaces are clean and free from debris. The final assembly can then be mounted into the end system via the four holes (Type 1: 2 each side, Type 2: 2 each end) on the flange of the heatsink.



It is recommended to tighten the baseplate mounting screws to 0.55NM. In high vibration environments, an appropriate thread lock should be used. All recommended screw tightening torques are nominal values and should be verified in the application where appropriate.

Accessories

Description	Photo/Drawing	Order code
Output Parallel Links	2 WAY PARALLEL LINK 	2 way = LINK-VP2 3 way = LINK-VP3 4 way = LINK-VP4
Current share cables	4 WAY SHARE CABLE 	2 way = CAB-CS2 3 way = CAB-CS3 4 way = CAB-CS4
Output Series Link		LINK-VS
Output Quick-Connect terminal (6.3x0.8mm TAB x2)		ACC-QCT
Output Cable Set 1x Signals cable (~200mm) 2x Power terminals		CAB-VSOPL
Input Cable Set 1x Signals cable (~200mm) 1x Standby cable (~200mm) 3x Power terminals		CAB-VC6

<p>Heatsink1</p> <p>(Provided with 6x M4 x 10mm Posi-Drive screws for baseplate mounting and thermal interface ACC-TF)</p>		ACC-HS1
<p>Heatsink2</p> <p>(Provided with 6x M4 x 10mm Posi-Drive screws for baseplate mounting and thermal interface ACC-TF)</p>		ACC-HS2
<p>Thermal interface</p> <p>(170mmx80mm)</p>		ACC-TF