Application notes

Power supplies

MAA family

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*exept MAA 3000-1T NEW

Abbreviations

UPS	uninterruptible power supply
PFC	power factor corrector
PSU	power supply unit
EMC	electromagnetic compatibility
AC	alternating current
DC	direct current

1. Product description

Low profile, integrated 1-, 2-, and 3-channel AC-DC power supply units of MAA family with output power from 30 to 3000 W designed for harsh operating conditions in the special-purpose equipment and industrial application. These application notes for PSUs of MAA family give detailed data on connection and operation, as well as describe peculiarities of MAA units operation as a part of equipment. For correct use of PSUs of MAA family it is recommended to read carefully through these application notes.

Features:

- wide operating temperature range -50…+85°C;
- low profile design;
- conductive cooling;
- a wide range of different types of mains and output voltages;
- service functions;
- output voltage adjustment;
- polymer potting;
- specialized MRM/MRR filters of conductive noise suppression compatible with MAA family;
- compliance to MIL-STD461E.

1.1. Part numbering

MAA 30 – 3 S XX XX XX S G N

MAA30 - **Rated output power, W** 30 W;
Quantity of channels: 3;
Input network index S: 220 VAC 50 Hz;
Voltage of channels:
Channel 1 – 5VDC;
Channel 2 – 12VDC;
Channel 3 – 12VDC;
SG - design version with potting, with screw terminals;
N – operating temperature range -40...+70 °C.
Example:
MAA30-3S051212SGN

1.2. External view and design

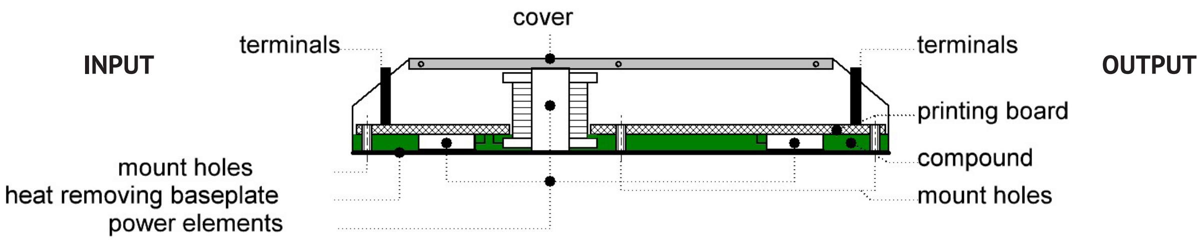
Units of MAA-family are fitted in a metal thermal conductive case, components are potted with compound, the top is closed by a steel cover.

Units can operate in any position. Units are non-repairable. Heat removing baseplate is either aluminum or copper unit's bottom that accommodates main heat emitting components. Due to the high power density of MAA-family units use of a heat sink is required for correct unit's operation (except MAA30 and MAA75). Mount the units on a heat removing surface or a heatsink using thermal paste.

⚠ **Operation without heat sink is permitted for units MAA30 and MAA75 according to temperature derating curve.**

Notes on installation of MAA units onto a heat sink and thermal specifications are described in section 6.

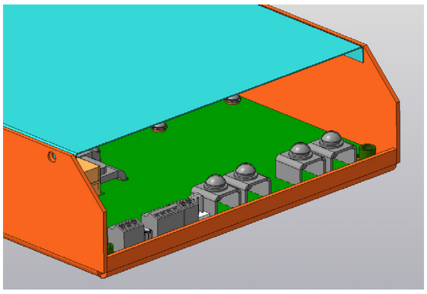
The units are mounted to the surface by screws through the mounting holes at the corners of the case.



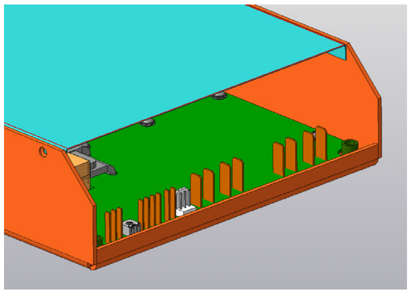
Output pins or terminals are grouped on opposite sides of the case: input ones are located on one side, while the output ones are on the opposite. Inputs and outputs are isolated from each other and from the housing, isolation voltage is specified in a datasheet for each PSU model. Multi-channel modules also have their output channels isolated from each other, allowing to connect them in series or to form bipolar voltage.

1.3. Types of outputs

Units of MAA family are available with two types of outputs: screw terminals and spring clamps, and blade contacts:



MAA-SG screw terminals



MAA-SD blade contacts

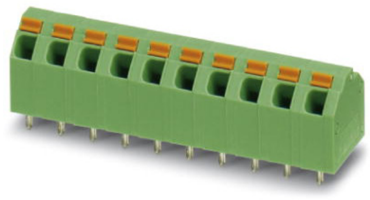
PSU of MAA family are connected by flexible wires.

⚠ **For normal operating conditions of MAA-SG units the wires are fixed by screw terminals and and spring-loaded clamps. For high vibration conditions it is recommended to use MAA-SD units with blade contacts; wires should be soldered to the blade contacts.**

Service functions of MAA-SG units are connected through Push-in terminal blocks with push-in clamps that designed for direct connection of wires without the use of additional tools. When inserting rigid and flexible wires with lug diameter from 0.34 mm² the contact spring will automatically expand and provide necessary contact pressure to the conductive bus. To unclamp the spring, for instance to remove wires or to connect wires with small cross section 0.14 mm² and above, simply push the built-in push mechanism (orange button above the wire hole) without danger to touch conducting parts.
Terminal blocks with Push-in spring clamp can withstand the pull-out force up to 5 N.

Wire specifications for connecting to spring clamps are shown in the table:

Wire insulation removal length	8 mm
Cross-section of a rigid wire, min.	0.2 mm²
Cross-section of a rigid wire, max.	1.5 mm²
Cross-section of a flexible wire, min.	0.2 mm²
Cross-section of a flexible wire, max.	1 mm²
Cross-section of flexible wire with cable lug without plastic sleeve, min.	0.25 mm²
Cross-section of flexible wire with cable lug without plastic sleeve, max.	0.75 mm²
Cross-section of flexible wire with cable lug with plastic sleeve, min.	0.25 mm²
Cross-section of flexible wire with cable lug with plastic sleeve, max.	0.75 mm²
AWG wire cross-section, min.	24
AWG wire cross-section, max	16



Use wires of the following square for screw connections:

1.5mm² for screws M2 M2,5;

2.5mm² for screws M3;

3.3mm² for screws M4;

4.9mm² for screws M5.

Torque for tightening screw connections:

0.4 N•m for thread diameter up to 2.8 mm;

0.5 N•m for thread diameter above 2.8 up to 3.0 mm;

1.2 N•m for thread diameter above 3.6 up to 4.1 mm;

3.5 N•m for thread diameter above 4.5 up to 5.1 mm..

Use the following rules when connecting units MAA-SD with blade-type pins:

- it is recommended to solder PSUs by electric soldering iron under 60 W at a temperature under 260°C, within not more than 5 sec for each single pin. It is allowed to solder pins not more than three times at distance at least 2 mm from the housing;
- to cut, bend and form wires use special template gages to ensure the immobility of pins between the bending point and the unit's body.

Allowed:

- solder of the pins of the units with solder flux at least 1mm from the case; pins must be preliminarily cleaned from of oxide films;
- cut out the unused pins;
- coat the pins of units after soldering by any type of varnish used for coating solder joints, for example Plastik-70;
- rinse the surface of the unit and pin by alcogas.

Not allowed:

- bend the pins when soldering;
- rotate pins around their axis.

The maximum number of flexible wires soldered to one pin of the unit is not more than 2.

It is prohibited to connect the units to circuits under supplied voltage. Blade contacts withstand stretching and pull-out force up to 40 N.

1.4. Potting

Vibration and environmental resistance of MAA units is achieved by means of compound potting. The space under the circuit board where SMD components are located is completely filled by compound potting. All discrete components are partially soaked into compound potting to ensure their secure mounting and uniform heat distribution inside the unit.

⚠ **Depending on output power and version of a unit, silicone or epoxy compound potting is used.**

2. Specifications and service functions

Power, W		MAA	30	50	60	75	150	200	250	400	500	500	800	1000	1200	1500	2000	3000
Efficiency			0.78-0.85		0.86	0.93	0.82-0.89			0.78-0.85			0.84-0.89		0.89-0.90		0.92	0.91-0.92
Input mains index	115 V 400 Hz									K								
	220 V 50 Hz	S	S		S		S			S			S		S	S	S	S
	220 V 50 Hz	C	C		C		C			C			C		C			
	3x380 V 50 Hz	T										T				T		T
	3x220 V 400 Hz	P														P		
PFC			passive					active										
Quantity of output channels			1, 2, 3							1, 2						1		
Output voltages, V			5, 9, 12, 15, 24, 28										24, 28, 48					28, 48, 60
Remote off		REMOTE OFF	-		-		+			+			+		+		+	+
Trimming of output voltage (at the single-channel module), +10%		By potentiometer	-		-		+			+			+		+		+	+
		By ADJ pin	-		-		-			-			-		+		+	+
Parallel operation		PARAL	-		-		-			+			+		+		+	+
Remote sense		+RS	-		-		-			+			+		+		+	+
Fan power out		±FAN	-		-		-			+			+		+		+	+
Diagnostic of output voltage		DC OK	-		-		-			-			-		-		+	+ (T)
Stand-by voltage source		+ST BY SRC	-		-		-			-			-		-		+	+
GND		GND	+		+		+			+			+		+		+	+
Recommended types of EMI filters			MAA200F MAA600F				MAA200F MAA600F			MAA600F		-	MAA2000F		-		-	-
			MRM4X1AM MRR2-X3AM				MRR2-X3AM MRR3-X7.5AM			MRR3-X7.5AM		- -	-		- -		- -	- -

2.1. Input

Units of the MAA family are designed to operate both from AC and DC mains of different voltage ranges. Input voltage rages of MAA family are marked by literal indexes K, S, C, T, and P which are specified in the part number after the quantity of output channels:

Example: MAA1000-1**S**24XXX

Input voltage		Input voltage range		Frequency	Transient		Duration of transient deviation
index	Uin VAC	Uin VAC	VDC	Hz	%	V	sec
K	115	81-138	160 (113-198)	400	+30	81-150	1
S	220	187-242	300 (263-340)	50	+20	176-264	
C	220	100-264	300 (141-372)		-55...+20	100-264	
T	3x380	323-437			+20	304-456	1
P	3x220	187-253		400	+20	176-264	

⚠ **Note. DC voltage within the specified range is supplied to the pins «L» and «N» for single-phase mains, and to any two-phase pin for three-phase mains without observance of polarity.**

2.2. Output channels and voltage

Nominal output voltages of MAA family (Un) under normal environmental conditions are selected from range 5, 9, 12, 15, 24, 27, 48 VDC. **Units with nominal output voltage other than above mentioned within the range from 3 to 68 VDC is available upon special request, as well as the units with extended output voltage adjustment range.**

⚠ **To achieve special output voltage, please, send request to KW Systems.**

Max output current (load current I_{LMAX}) of the first, second, and third channels I_{L1MAX}, I_{L2MAX}, I_{L3MAX} of MAA units should not exceed I_{L1}, I_{L2}, I_{L3} respectively, and should not exceed:

2.3. Max current

PSU		MAA30 MAA50	MAA60	MAA75	MAA150	MAA400 MAA500	MAA800 MAA1000	MAA1200 MAA1500	MAA2000	MAA3000	Примечание
Single-channel	I_{L1max}	6	12	15	30		66.6	80	83.3	125	$I_L = P_L / U_L$
Double-channel	$I_{L1,2max}$	3	6	7.5	15	60	33.3	40			$I_{L1} = P_L / 2U_L$ $I_{L2} = P_L / 2U_L$ $P_{1max} \geqslant R_{2max}$
Triple - channel	I_{L1max}	3	6	7.5	15	30					$I_{L1} = R_L / 2U_L$
	$I_{L2,3max}$	1.5	3	3.75	7.5						$I_{L2} = R_L / 4U_L$ $I_{L3} = R_L / 4U_L$ $P_{1max} \geqslant (P_{2max} + P_{2max})$

All PSUs meet the following conditions:

$P_{1MAX}=P_{2MAX}$; – for double-channel units;

$P_{1MAX}=(P_{2MAX}+P_{3MAX})$ – for triple-channel units,,

где:

$P_{1MAX} = I_{L1MAX} \cdot U_{L1}$
$P_{2MAX} = I_{L2MAX} \cdot U_{L2}$
$P_{3MAX} = I_{L3MAX} \cdot U_{L3}$
– maximal power of the first, second and third channels, respectively, W.

For adjustable units while increasing the output voltage U_{out}>UL the maximal output current should not exceed 90% of the max output current at nominal output voltage.

2.4. Environmental specs: contents and value

Name of the environmental factor	Environmental factor specification, Unit	Value
Sinusoidal Vibration	Frequency range, Hz	1-500
	Acceleration amplitude, m/sec² (g)	50 (5)
	Vibratory displacement amplitude, mm	0.5
Single mechanical shock	Peak shock acceleration, m/sec² (g) duration of the impact acceleration, ms	1000 (100) 1-2
Low ambient temperature	Min operation temperature, °C - for «N» temperature range - for «P» temperature range	-40 -50
High ambient temperature	Max operation temperature, °C:	70
High case temperature	Max operation temperature, °C:	85
Ambient temperature variation	Ambient temperature range, °C - for «N» temperature range - for «P» temperature range	-40 … +75 -50 …+ 75
Low atmospheric pressure (mechanical strength limits)	Operational value, Pa (mm Hg)	$0.67 \cdot 10^3$
Subatmospheric pressure (limited by convection cooling conditions)	Operational value, Pa (mm Hg)	$6.7 \cdot 10^3$
High atmospheric pressure	Operational value, Pa (mm Hg)	$2.92 \cdot 10^5$
Condensed atmospheric precipitation (frost, dew).	Min value for operation, °C	-20
Salt mist*		resistant

* In case of using units under external conditions (salt mist, frost, dew, etc.) it is recommended to protect the coating of unit's body by varnish in two layers as a part of equipment.

3. PSU structure and service functions

3.1. Typical structure

PSUs contain the built-in input EMC filter and protection circuits against excess of input current and voltage a fuse or varistor. The inrush current is limited by an NTC thermistor.

Units with output power over 150 W contain active PFC with a separate PWM controller.

Depending on the output power MAA units are based on different topology:

- flyback (MAA30-75);
- half-bridge (MAA150-1000);
- quasi-resonant phase-shifting bridge (MAA1500-3000).

Output circuits contain a built-in LC filter that ensure level max. 2% of output ripple across the complete operating temperature range, max. More detailed values of ripple are indicated in a dataset for each model. To further reduce output ripple it is recommended to use additional external LC filter.

Multi-channel PSUs contain a single inverter and several isolated secondary windings of the power transformer with rectifiers and output filters. Remote sense in multichannel modules connected to the first channel, magnetic coupling with other channels goes through windings of the power transformer.

The declared ripple and noise of output voltage of max. 2% is shown for the first channel only, for other channels the ripple and noise is max 4%.

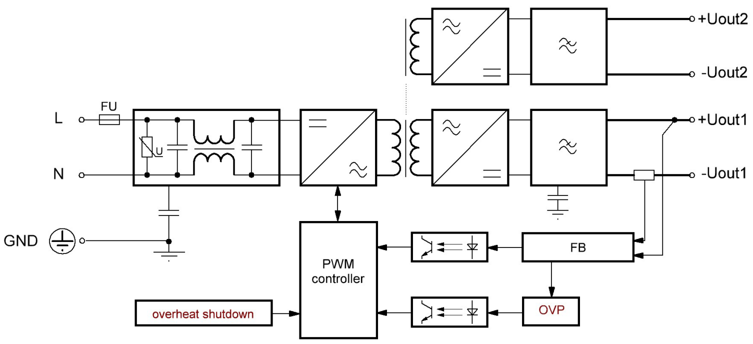


Fig.3.1. Block diagram of a dual-channel PSU MAA30-2XXX

Power supplies over 150 W are equipped with active PFC, service and diagnostics functions.

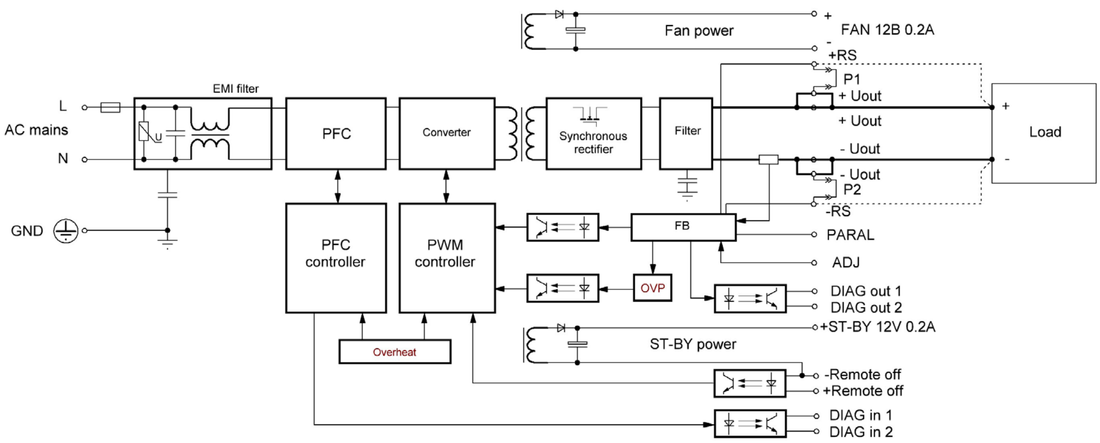


Fig.3.2 MAA2000 block diagram

In accordance with the specification table some service functions may be missing in power supply units of lower power.

3.2. PARAL lead is designed for current sharing between power supplies operating in parallel by output through active alignment of output voltages, similar to Active Current Sharing. For detailed description of parallel operation using PARAL output pin see section 6.3.

3.3. DIAG OUT – output voltage diagnostics pin. Voltage at this pin indicates the performance ability of the PSU, DIAG pin has 2 stages:

– low level (0-1 V), PSU is ON, output voltage is within nominal range.

– high level (5 V), PSU is not working.

In MAA family the DIAG output is an output of the comparator, with a deviation of ±10% of nominal output voltage.

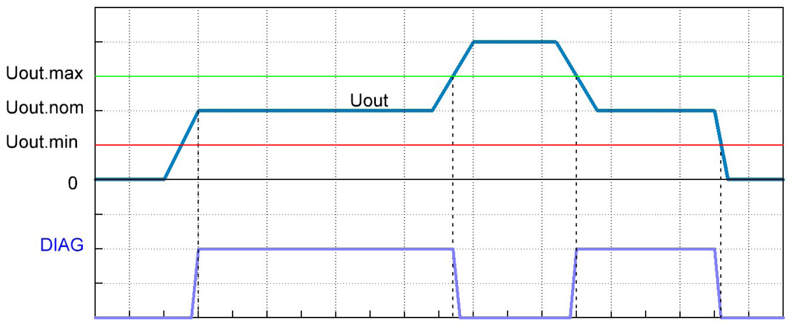


Fig. 3.3 Timing diagram of DIAG output operation.

3.4. DIAG in – output for mains check-up. This output a an isolated dry contact (30 V 100 mA max) optocoupler transistor output, which is open when the input voltage of the unit meets the values in the Specification. When unit is switched off using the remote control pin, as well as in an emergency mode of operation, the diagnosis output state is not defined, the transistor is closed. Available at MAA2000 only.

3.5. Remote sense

To compensate the voltage drop along the load wires, it is recommended to use remote sense function (RS). RS – remote sense, available in PSUs of MAA family with power over 400 W. This is an input of remote sense circuits used to stabilize the output voltage. This input is designed to compensate the voltage drop along the load feeding wires and stabilize the voltage directly at the remote load.

Units are made with installed jumpers P1 and P2 and can be used without any additional circuits. To activate RS remove jumpers P1 and P2 from the unit and connect RS pins directly to the load using additional wires. In this case the voltage feedback circuit in the unit will automatically maintain a stable voltage at the remote load, compensating for voltage drop in its wires. With activated RS engaged the output voltage of the unit will be changed dynamically. Voltage drop compensation can reach up to 5% - 10%.

RS function is useful for the following cases:

- the load is sufficiently remote from the PSU and there is no way to reduce this distance. The resulting voltage drop in conducting wires reduces the voltage at the load, increases ripple and impairs the EMC;
- the load is of pulsed character.

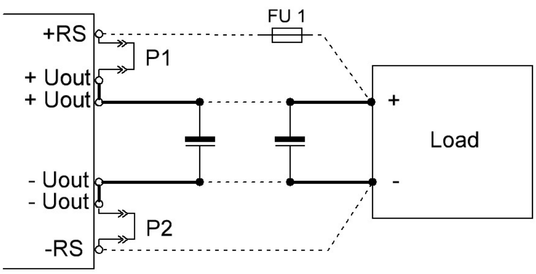


Fig.3.4. Remote load operation

To increase resistance to electromagnetic interference RS should be connected to the load using a twisted pair of conducting wires. Main load current does not flow over this line, so the cross section of Remote Sense conducting wires can have the min diameter, but not less than 0.15 mm².

When Remote Sense function is not used, the pin «+RS» and «-RS» must be connected directly to pin «+Uout1» and «-Uout1» respectively.

⚠ **If jumpers P1 and P2 are not installed, and the RS pins remain unconnected, the unit will switch into «hiccup» mode with voltage peaks above the nominal level. This is caused by a lack of remote sense signal and engagement of protection against overvoltage.**

⚠ **To prevent failure of a PSU it is prohibited to disconnect power circuits of the powered-on PSU from the load when remote sense wires remain connected to the load.**

- It is recommended to use fuses FU1 for current 0.05-0.1 A in RS circuit to avoid failure of the control circuits when the load circuit cuts off (with remote sense circuits being connected).
- If you have lines over 20 cm length between PSU pins and terminals or powered functional units, use ceramic capacitors 0.47-1.5 μF of appropriate voltage in the path of communication lines according to figure 3.5.

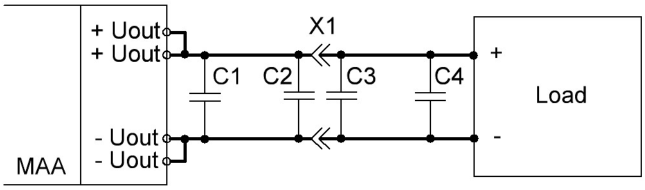


Fig. 3.5. Diagram of load connection to PSU with long conducting lines

3.6. Remote OFF/ON

Remote OFF/ON pin is available in PSUs of MAA family with output power over 150 W. To disable a PSU supply the voltage of 3.5-5 VDC to these pins. After switching the voltage off at the Remote OFF/ON pins, the PSU will restart.

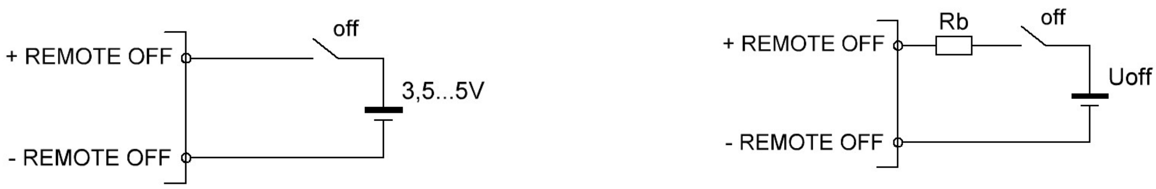


Fig. 3.6.

When using Remote OFF/ON pins from an independent source of voltage over 5 VDC, please use a current limiting resistor Rб, calculated according to the formula:

$R_b = (U_{off} - 5)/10$ (kOhm)

Current flowing through the Remote OFF/ON pins should be limited down to 10...15 mA. It is allowed to combine pin -Remote OFF/ON and -OUT and supply power off voltage in relation to the negative output . Output voltage max settling time of the first channel of a PSU after supplying input voltage, and for PSUs with Remote OFF/ON starts after supplying voltage to the Remote OFF/ON pin:

MAA800 – MAA3000 – 1 s.

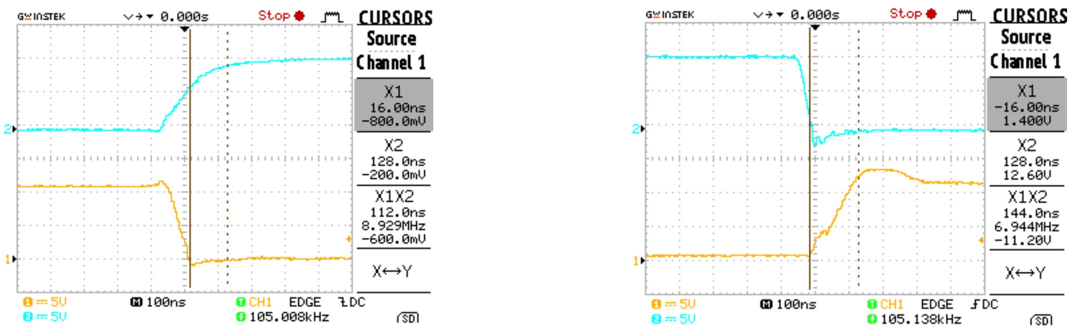


Fig. 3.7. Timing diagrams of MAA1500-1S24SGN power on and off by DC voltage at Remote OFF/ON pin are shown in the oscillogram.

3.7. STD-BY SRC

is the standby power source, 12 VDC 0.2 A isolated from PSU's outputs; it is used to power the internal control circuits. The voltage of STD-BY SRC pin may be used to supply low-voltage standby circuit in the equipment, and also PSU using Remote OFF/ON pin. Negative terminal STD-BY SRC is joined with -Remote OFF/ON inside the PSU.

The voltage at STD-BY SRC remain constant, while the unit is plugged to the mains and is not switched off using Remote OFF/ON input terminal.

STD-BY SRC pin is useful for remote power off without the use of additional power supply. Fig. 3.8 show how to use STD-BY SRC pin to power off a PSU using relay contacts or a transistor.

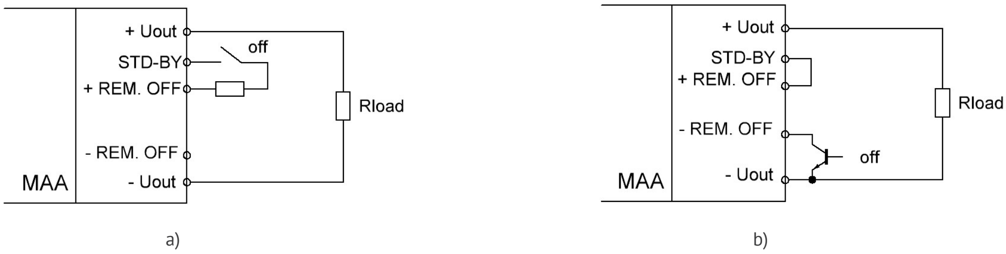


Fig. 3.8. PSU power off using STD-BY SRC

Ha Fig.3.8b shows the module that will shut down when closing power off to -Vout.

3.8. FAN is the output for a cooling fan 12 ± 3 VDC 0.2 A.

The voltage at terminals ± FAN is not stabilized, isolated from the rest of the uint's outputs. Available for PSUs with output power over 400 W. Voltage Ufan can be used as an additional channel of output voltage under condition not to exceed the output current and the lack of requirements for regulation and ripple.

The voltage at FAN output switches off by Remote OFF/ON along with the main output.

Fan may be connected by cable socket DS1070-3 F HU-3 or similar (for MAA-SG family).

3.9. Output voltage adjustment (ADJ)

PSU's output voltage adjustment within the range of at least ±10% by ADJ output can be done by the external potentiometer as shown in Fig. 3.9.

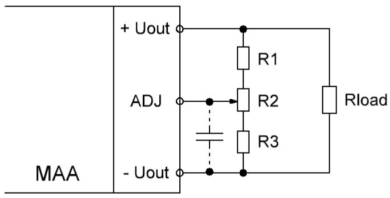


Fig.3.9. Output voltage adjustment using external potentiometer

Rating of the divider's resistors R1, R2, R3 should be selected in such a way, that when you move slider R2 from top to bottom position according to Fig 3.9, Ucontr voltage at ADJ output will change from max to min for the respective min and max levels of Uout output voltage. Apart from this the divider's resistors rating must not be too high to ensure input or output current Icontr, i.e. by connecting the ADJ pin through a resistor to the pin «-Uout1» to increase the output voltage or to the pin «+Uout1» to decrease output voltage. Resistor rating is indicated in the PSU's certificate of conformity.

It is also possible to change the output voltage by using only one of the divider's resistors as shown below.

In case you need to control PSU's output voltage by signal of an external voltage source, e.g. in an automated microprocessor control systems by DAC voltage, the external voltage must be supplied to the adjustment pin with regards to «-Uout1», in accordance to figure 3.10.

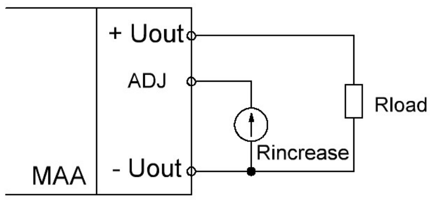


Fig. 3.10. Connecting an external voltage source to adjust the output voltage of the power supply unit.

⚠ **When using the function of output voltage adjustment the following requirements must be complied:**

- it is not allowed to use PSUs with output voltage outside the limits specified in the technical documentation. Excessive increase of output voltage can cause overload of PSU output circuits, and excessive decrease of output voltage can cause unstable start-up. This reduces the reliability of the power supply unit.
- as the output voltage of the power supply unit increases, the maximum output current is proportionally reduced. The increase of output current with decrease of output voltage can cause overcurrent of PSU output circuits and increase output voltage ripple. For example, for 150 W PSU with nominal output voltage 15 VDC and allowable range of output voltage adjustment ±10% (13.5 … 16.5 V), the output current for extreme levels of output voltage will be 150 W / 15 V = 10 A and 150 W / 16.5 V = 9.09 A respectively;

- adjustment pin is highly sensitive to interference. When PSU operates it is not allowed to touch the adjustment pin by hands, soldering iron, or apply any other effect that can cause interference to this pin, to avoid PSU's feedback circuit excitation;
- in case there is long external adjustment circuit, it is recommended to connect ADJ pin to -U_{out1} pin by small capacity (C1, fig. 3.9). Recommended C1 capacitor rating is about 0.47 ufd.

4. Protections:

All PSUs of MAA family are equipped with a set of built-in protections from emergency operating conditions in the input and output circuits as well as thermal protection.

Input protection:

4.1. Short-circuit protection at PSU input (overcurrent) – input fuse. It triggers when the mains voltage surges increase the stated ranges of transient deviations, as well as in emergency modes that cause mains overcurrent. After the fuse is blown the power supply unit no longer starts.

4.2. PSU protection against supply voltage surges (varistor).

It protect PSUs from failure during short-period input voltage surges (msec*10) above the max permissible level. During long (msec*100) exposure of high input voltage (over the stated ranges of transient deviations) the varistor non-linearly reduces internal resistance and causes the input fuse to blow; power supply unit will not restart.
Max allowable operating voltage is specified in the datasheet.

Output protection:

4.3. Load short-circuit protection of the PSU.

In the case of short circuit in the load the PSU is activated for a short period of time (0.05 to 0.15 sec) and after the emergency situation is detected it shuts down for a period of time (0.5-1.5 sec). This cycle repeats until either the power supply is off or the short-circuit at the output is removed. This condition is called a hiccup mode. For each PSU model duration of enabled state and pauses between enables is different. PSU will automatically restart after remove of the short-circuit.

⚠ **To prevent PSU from failure it is not recommended power it on for a long period in case of short circuit at the output. Short-circuit mode can be identified when you connect a voltage measuring device (oscilloscope) to the output by measuring the voltage in powered-on state: the output voltage in the enabled on-state intervals will to be minimal, not more than 1-2 VDC (Fig.5.1).**

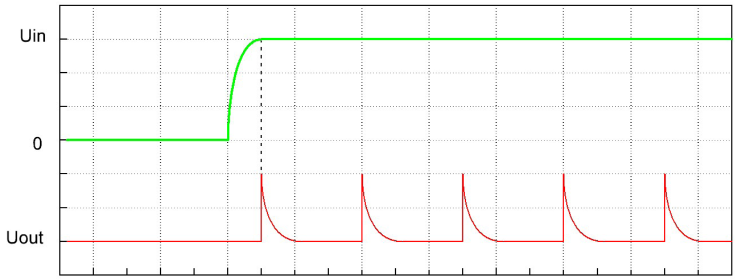


Fig.4.1. PSU's operation in short-circuit mode

On-state intervals and the pauses between starts depend on the output power and unit's voltage, as well as the input voltage.

⚠ **It is important to remember that for PSUs of high power (above 400 W) connection line of sufficient length (and with low output voltage, even a relatively short one) can act as load and make it difficult to determine the mode of short-circuit. Though in this case the PSU will decrease the output voltage (due to the current-limit circuit), but will give full power to the load. Therefore, in case it is necessary to protect and prevent emergency situations, the consumer of DC voltage should have its own protection circuit.**

4.4. Output overcurrent protection.

If the output current is exceed above the maximum value corresponding to the output power (1.2 - 1.8)*Pn, PSU will switch to output power limiting mode. In this mode with further increase of load (decrease of its resistance), the output voltage will decrease, limiting the output current.

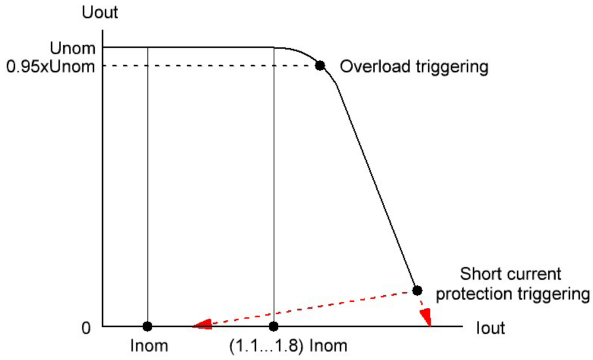


Fig.4.2. Output characteristic

4.5. Output overvoltage protection.

In case of any malfunction in the feedback circuits or breakage of the RS conducting wires, the output voltage may no longer be controlled by the unit and exceed the set value. To prevent failure of the equipment connected to the PSU, there is an overvoltage shutdown when the output voltage reaches critical level of not more than 1.25×Un. After triggering the overvoltage protection, the PSU switches to hiccup mode. This mode can be identified by an oscilloscope measurement of the voltage in the on state. In the switching intervals, the output voltage is above the maximum voltage specified in datasheet.

⚠ **Please note that standard voltmeters and multimeters will give incorrect valves in hiccup mode (too low).**

4.6. Thermal protection

protects the unit against overheating in case of failure of the cooling system. The temperature sensor is located inside the PSU on the baseplate near the most heating place. When the temperature of the unit case rises above the temperature of the thermal protection, the PSU is switched off. When thermal shutdown is triggered the unit is disabled, the output voltage will not be present until the case temperature gets 5-15 degrees below the temperature of the thermal shutdown, then the unit will restart.

The temperature of thermal protection triggering is specified in the datasheet of a specific model.

5. Connection and operation

5.1. Installation.

Before powering of the PSU, please install the heat sink on the PSU bottom of the heat removing baseplate to limit operating temperature of the unit's baseplate or the heatsink. When mounting the PSU on the heat sink it is recommended to apply thermal grease not more than 0.5 mm thick, spread it evenly over the entire surface of thermal contact.

⚠ **Note, that the worse is the quality of thermal contact the thicker is the layer of thermal paste (thermal resistance case-vs-heatsink increases). Thermal grease is needed to fill small scratches, irregularities and rough edges connecting the heat conductive surfaces.**

The unit is fastened to the heat sink by screws through the holes on the corners of the unit. Units over 800 W contain the 5th mounting hole (threaded, blind) at the center of the heat sink surface. Using of this mounting hole is recommended in case of insufficient thickness of the heat sink. Dimensions of mounting screws and recommended depth of mating threaded parts for fastening the modules is given in table 6.1.

5.2. Connection of PSUs.

Thickness of foil, width of paths for PCB or cross-section of conducting wires, used for connection, are selected considering the values of input and output current of the PSU. Their length should be as short as possible.
Power circuits and control circuits of power supply installed at the equipment should be spread as far as possible from each other on the board or in space. This is necessary to avoid interference of power circuits with control circuits, which can cause uncontrolled generation of excessive output voltage ripple.
To eliminate interference from the power supply onto control circuits of the equipment. It is not allowed to place under the power supply unit any wires.

⚠ **Precautions:**

1. It is strictly prohibited to mount and connect PSUs to electric circuits under supplied voltage.

2. Do not switch on the power supply units during inspection using contact devices which allow contact bounce.

3. The PSU must have the possibility of external disconnect from AC mains. Disconnect devices must have a contact gap at least 3 mm.

4. Long-term operation of the unit (more than 1 minute) with load current exceeding the maximum value is prohibited.

5. For case grounding of the PSUs through «CASE» pin use a wire with cross-section 1.5 to 2.5 mm², and length under 60 mm.

5.3. Parallel operation

Units MAA400-MAA3000 have the ability of parallel operation due to integrated current sharing circuit. This feature allows to increase the total output power, as well as create an N+1 redundancy system using external ORing diodes. Output current sharing is activated by connecting PARAL pins of the PSUs operating in parallel.
This Chapter provides guidelines and directions for proper parallel operation of the units and use of PARAL pin.

⚠ **Current sharing activates when the total load is more than 40% of the calculated full load. At lower load current flows through one of the units, the rest remain idle or operate with minimum output current. This situation is normal and does not lead to failure of the entire system.**

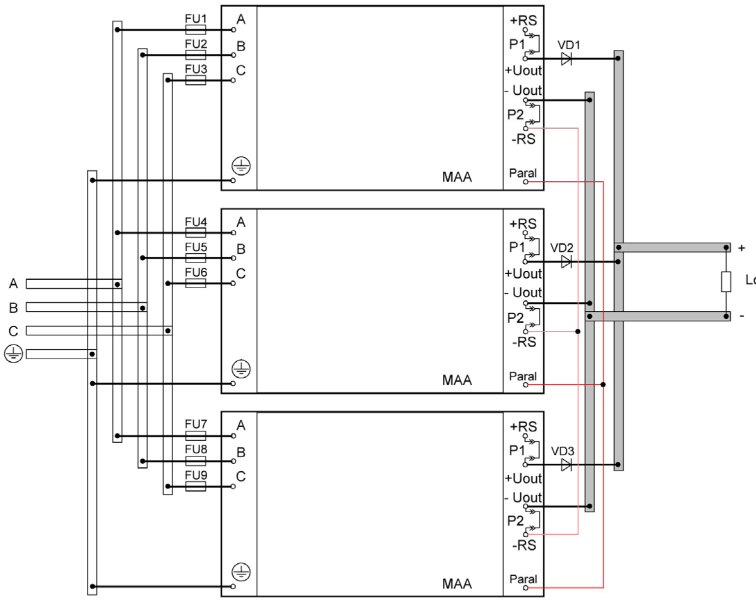


Fig.5.1. Parallel connection

Connect PARAL pins and RS of one of the PSUs to the load and between PSUs.

Use external ORing Schottky diodes with minimal forward voltage drop as ORing diodes. Their maximum reverse voltage should be 1.5-2 times greater than the rated output voltage of the units. The maximum allowable forward current of the diode must exceed rated output current of one PSU at least twice.

Fuses at the input and output ORing diodes isolate the faulty unit from the power supply system in case of failure.

⚠ **The voltage at PARAL pin relative to -U_{out1} at 50% load of PSU must be equal for all PSUs that connected in parallel with difference within 5%.**

⚠ **Despite the active current sharing system please keep the following conditions for correct operation of PSUs connected in parallel:**

- for parallel operation it is recommended to use power supply units with equal nominal output voltage with deviation within ±2%, preferably of same batch. Current sharing system will balance such units , but the voltage of the resulting system will be 10-15% different from nominal;
- PSUs must be placed as close as possible to each other;
- вPSU's outputs must be isolated between each other using ORingSchottky diodes and fuses connected in series. Isolating diodes and fuses should have the shortest way to connect with the corresponding pins or blade contacts of PSUs;
- wires connecting the pins of PSUs to wires must be equal, of min length and large section. In this case the special attention should be paid to the «minus» leads of PSUs. Connecting of ORing diodes and current-measuring resistors to «minus» output circuits is not allowed;
- the wires must be located in close proximity to the pins of the unit and have a cross section of N times larger than wires connecting the units to the wire, where N is the number of units connected in parallel;
- connection of the wires to the load must be located in the middle part of the wires;
- amperemeters for monitoring of power distribution between power supplies switched in parallel are recommended for use in the input circuits of PSUs.

Depending on the output voltage and other factors units connected in parallel may give different power. To avoid overloading of individual PSUs, taking into account possible technological difference of the parameters, temperature, instability of input voltage, there should be a margin of 30% for power. This means that total power of several PSUs switched in parallel must be increased according:

Ptotal = 0.7·N·Pmax

For example, 2 units of MAA1000 connected in parallel will not give total power of 2·1000=2000 W, but 2·1000·0,7=1400 W.

When power supply units are properly connected in parallel at nominal total output power, the imbalance of output currents of the units should not exceed 15 %. Min power of current sharing for actual MAA – 40 %, for new MAA – 10...15 %.

Table 6.1. Current consumed from the network.

Input mains index; Unom, V	Inrush current, A within full load											
	MAA30	MAA60	MAA75	MAA800	MAA1000	MAA1200	MAA1500	MAA2500	MAA3000	MAA500 3Ph	MAA1500 3Ph	MAA3000 3Ph
K (115)	2.64	5.2	6.5	52.8		79.2						
S (230)	0.7	1.5	1.9	15	18.7	22.5	28.1		56.2			
C (230)	2.2	4.3	6.5	44		66		75				
T (380) 3Ph										9.4	28.1	56.2
P (220) 3Ph										18.8	5.2	112.4

5.4. Redundancy

The aim of creating redundancy power supply systems is not to increase power but to switch PSUs connected in parallel between different mains without transients. There are passive and active redundancy schemes.

With active (cold) redundancy main PSU connected to the main network and remains constantly switched on. In case of mains or PSU failure, redundant PSU powered from a secondary network switches to the load. Active redundancy scheme provides low power consumption in standby mode, as a backup power supply unit is disabled, main PSU feeds from the mains. The main drawback of this scheme is the transient during switching to a backup network due to total enabling time of the redundancy PSU and the response time of the switch.

With passive redundancy, the main and backup PSUs are always enabled and connected by the output in parallel, similar to parallel connection, with the only difference that the inputs of the PSUs are connected to different networks – primary and backup. In case of failure of one network whole system switches to another one without transients.

To turn redundant PSU into idle mode, its output voltage must be set 0.7-1 VDC less than the voltage of the primary PSU. In this case primary PSU will be switched to backup one without transient processes with changing output voltage by 0.7-1 VDC. The disadvantage of this scheme is the constant idle power.

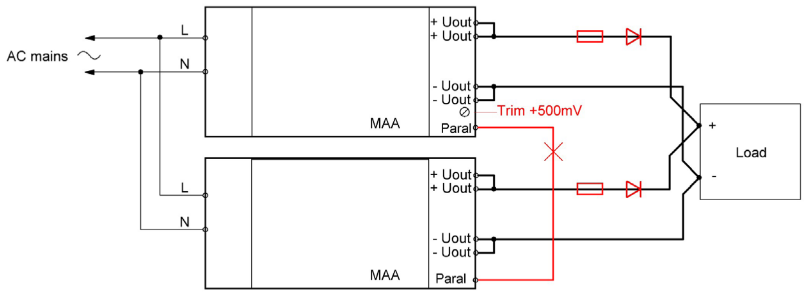


Fig.5.2. Redundancy connection

⚠ **In redundancy mode PARAL pin is not used!**

Unlike parallel operation, for passive redundancy schemes load power must be lower than one of the PSUs connected in parallel. If the load power is more than the power of a single PSU, then in case of failure of one of the networks, all the power will be applied to one PSU that will cause its failure, switch to output current limiting mode (decrease of output voltage) or overcurrent protection.

⚠ **Modules MAA 150-400 W may also operate in redundancy connection.**

5.5. Serial connection

MAA units may be connected in series using their outputs to increase the output voltage, and also to obtain bipolar voltage. It is allowed it to connect in series output channels both of one and several units.

Series connection shown here can be used to obtain increased voltage by summing up the voltages of each channel as shown in figure 5.3.

You can connect in series the units of different power, but the output current will be limited by the lesser of units.

⚠ **It is not allowed to connect PARAL terminal pins when connecting units in series.**

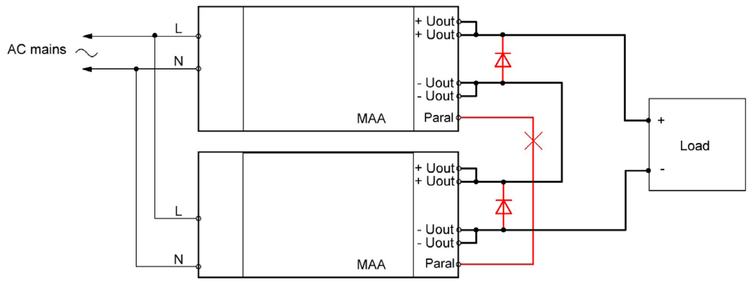


Fig. 5.3. Example of reaching high voltages by summing up the voltages of output channels.

Please note the following when connecting the units in series:

- use back-to-back diodes (VD1 and VD2 on Fig.6.3) to ensure protection against application of reverse polarity voltage to pins of PSUs under non-simultaneous start-up or failure. Reverse voltage of diodes must be 30% higher than the total output voltage, while the current should match the output current of units;
- the load current should not exceed the rated output current of each unit;
- with series connection you should consider possible increase of ripple and noise of output voltage.

5.6. Forming of bipolar voltage

To obtain bipolar voltage you can both connect in series output channels of one and the same unit, and the output channels of different units; the power of these units can be different. Figure 5.4 shows examples of bipolar output voltage obtained using a unit with two isolated output channels, and two single channel units.

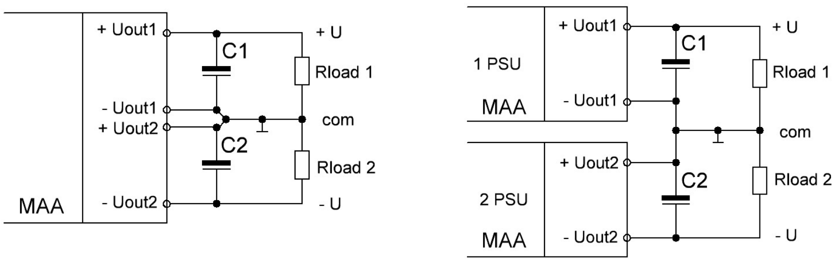


Figure 5.4. Examples of obtaining bipolar output voltage

⚠ **It is not allowed to connect PARAL terminal pins when connecting units in series.**

Output voltage adjustment can only be done by built-in potentiometer.

5.7. Particulars of supplying power to different types of loads: operation for pulse-type and capacitive load

Units are equipped with capacitors at the output to ensure the declared level of output voltage ripple at nominal load. However, there are some applications where the load has a pulsed character and changes steplike within wide limits, for example radar transmitters. This mode of operation is unusual for most PSUs, the output voltage deviates due to limited feedback reaction time. This is transient deviation which stays within max ±10% for MAA family at load change duration min 0.5 msec.

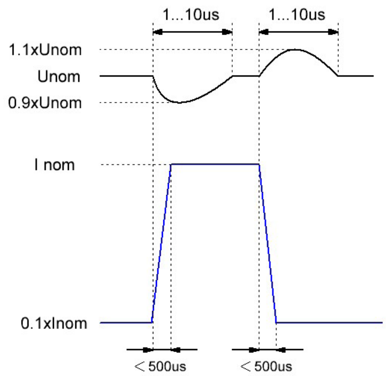


Fig. 5.5. Transient deviation of output voltage with pulse load (a - output voltage, b - load current).

When operating PSU for dynamic load to reduce dynamic instability the output pins need to be shunted by additional buffer capacitors. Dynamic instability of a PSU will be compensated by the energy released from the buffer capacitor to the load within the response time of feedback.

Buffer capacitor also helps to increase the hold-up time at no input voltage.

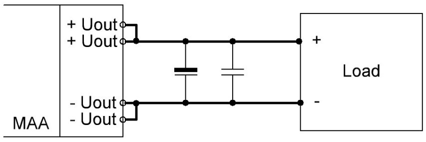


Fig 5.6. Connection of output capacitors

Please keep in mind that the PSUs are equipped with instant built-in short circuit protection at load, so even short-time exceed of the nominal output power is detected as short-circuit mode by the PSU. Capacitance at the PSU output Cout exceeding the permissible level, as well as supplying power to energy-intensive loads (relays, motors), resulting in short-term exceed of the nominal power output, can cause failure to start the PSU and to set it to the operation mode. Under such conditions, the unit will operate in «hiccup» mode: it will run for a short period of time before triggering of protection, then wait before restart, and next time will trigger the protection again.

Table 5.3 shows the values for the maximum total capacitance Cout that upholds the parameters of start time and maximum total value of capacitance Cmax, which is enough to start PSUs.

⚠ **The longer is the distance from the bank of capacitors to the PSU or the load, the greater is resistance and inductance of wires, which makes the capacitors less effective.**

Table 5.3. Min and max total capacity of shunt capacitors.

Rated output power, W	Rated output voltage, VDC							
	5...6 VDC		over 6...15 VDC		over 15...27 VDC		over 27...28 VDC	
	Cout, µF	Cmax, µF	Cout, µF	Cmax, µF	Cout, µF	Cmax, µF	Cout, µF	Cmax, µF
MAA30	7500	22500	2500	7500	833	2500	278	833
MAA50 - 60	15000	45000	5000	15000	1667	5000	556	1667
MAA75								
MAA150 - 180	45000	135000	15000	45000	5000	15000	1667	5000
MAA300 - 400	60000	180000	20000	60000	6667	20000	2222	6667
MAA600 - 800			26000	78000	8667	26000	2889	8667
MAA900 - 1200			33000	99000	11000	33000	3667	11000
MAA1500			33000	99000	11000	33000	3667	11000
MAA3000					12100	36500	4000	12100

MAA75 has no restrictions of the output buffer capacity value.

5.8. Decrease of in-rush current

When you connect the switching mode power supply to the mains it causes a burst of consumed current, caused by charge of internal capacitors and this current is significantly higher than the value of the input current in steady state. The high inrush current leads to failure of fuses, or false operation of protection circuit, circuit breakers.

The limitation of in-rush current up to the stated level is implemented in the input circuit by a built-in thermistor with a negative temperature coefficient, NTC-thermistor, however, in specific applications this may not be enough.

A further reduction of in-rush current is possible:

- by use of passive current limiting in the input circuit: an optional external NTC-thermistor or other current-limiting element;
- use of active current limiting in the input circuit: additional external current limiter (e.g. resistance), closed by relay contacts at the end of the current pulse;
- by using remote off to start the PSU, Remote on/off pins.

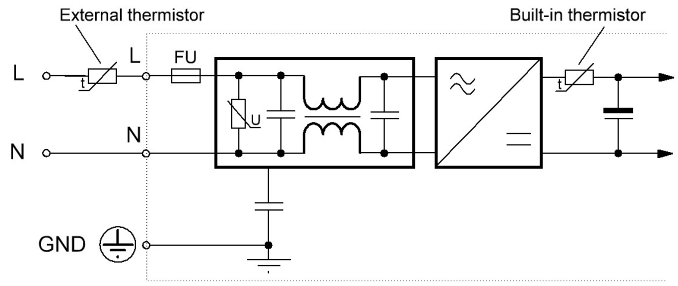
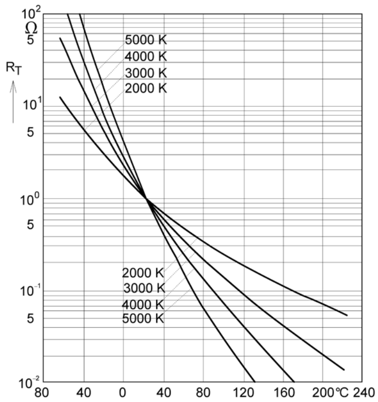
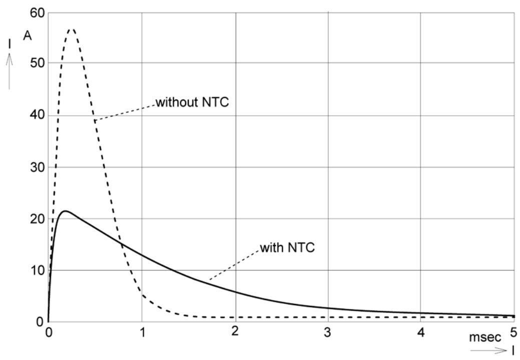


Fig. 5.7. Passive limiting of in-rush current using external thermistor..

In-rush current limiting with an NTC-thermistor is based on change of its resistance from self-heating by the flow of mains current through it. At low housing temperatures NTC-thermistor has nominal resistance (1-100 Ohm), and functions as a resistive current limiter. Initially the capacitor is discharged and the charging current is the highest. Flowing pulse of charging current is limited by the resistance of the thermistor, causing it to warm up. While the temperature is rising to the working level (80°C), the thermistor resistance goes down to fractions of Ohm, its allocated power turns to the lowest. With such resistance, the voltage drop at the thermistor is minimal and compares with the voltage drop at the fuse. By this time, the capacitor will have been charged and the power supply can operate at rated power.



NTC-thermistor resistance VS temperature



In-rush current limitation

Fig. 5.8.

Basic parameters to select an NTC-thermistor:

- resistance at 25°C;
- nominal current;
- operating temperature range.

The resistance and power of the thermistor should be selected with consideration of current flowing through it and ambient conditions. Note that the thermistor causes additional losses, reduces voltage at the input of the PSU, and its efficiency.

When the mains protection circuits (circuit breakers and fuses) are triggered at PSU start-up, it is recommended to use protection devices less sensible to impulse currents: circuit breakers class C and D, and slow blow fuses.

The max current of the input fuse should be selected based on the min input voltage and max output power, considering the efficiency. When connecting a unit to the mains there is the burst of consumed current which is much greater than the value of the input current in the steady state. That is why it is recommended to use slow-acting fuses, with sufficient response time and meeting safety requirements.

Fuses should be rated at current of at least 3·Ion. The value of Joule integral (A2·s) of the fuse shall not be less than specified in table 5.4.

Table 5.4. Joule integral VS PSU power and the value of the nominal input voltage

Network Index/ Nominal input voltage, VAC	Joule integral, A2·s at nominal output power, W/PSU type														
	20	30	50	60	150	180	300	400	600	800	900	1000	1200	1500	3000
K (115)	-	-	-	-	-	-	-	3.1	-	-	-	-	-	-	-
C (220)	3.5	3.5	4.4	4.4	13.7	13.7	9.6	9.6	19.3	19.3	397.7	19.3	397.7	397.7	397.7
T (380)	-	-	-	-	-	-	-	-	-	-	-	-	-	15.8	-
P (220)	-	-	-	-	-	-	-	-	-	-	-	-	-	19.3	-

5.9. Reduction of output voltage ripple

Switch mode power supplies comparing to power supplies operating at 50 Hz with linear stabilization have some advantages. SMPS contains high-frequency converter with rectangular waveform of voltage and current that is the source of high frequency noise with a wide range of emitted frequencies. Due to the principle of operation the output voltage of SMPS contain ripple and high frequency noise, which can cause some problems when operating with sensitive equipment, such as transceiver modules or weak signals amplifiers.

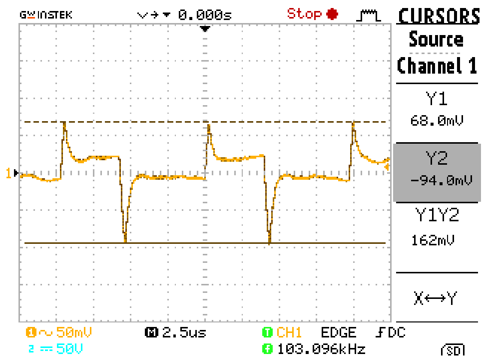


Fig.5.9. Output ripple

PSUs of MAA family contain the output RFI LC filters, providing the stated level of output voltage ripple, under 2%. For greater reduction of ripple use additional external components.

In most applications when output voltage ripple must be reduced below the stated level it is sufficient to use an additional external filtering capacitor C1. If the applied capacity is too big, the module may fail to start due to triggering of the short circuit protection. Limit C1 levels are shown in table 5.3 in section 5.7.

For equipment highly sensitive to noise use additional LC-filters at the output of the PSU (Fig. 5.10).

Dual-wound chokes are based on ferrite cores that have high level of magnetic permeability of 10000...20000, e.g.: Epcos cores, material T35, T38 or similar. The chokes are wound in one layer until the complete core is evenly covered, the quantity of winding coils is the same. The windings are located each in their sector of the core.

Single-wound chokes are made on cores with high saturation induction, e.g. made by Magnetics from MPP, High Flux, Kool Mμ or similar with magnetic permeability of 125...160. The choke is wound in a single layer unit the core is evenly covered.

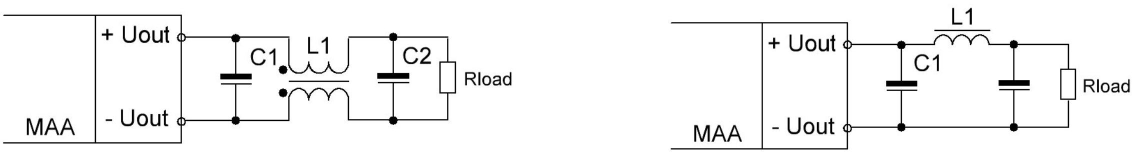


Fig.5.10. Examples of connecting output filters

5.10. Improving EMC, application of MAA filters

Due to high frequency switching of high voltage (300-400 V) with rectangular fronts, the spectrum of emitted frequencies of SMPS contains the higher harmonics of the basic frequency of conversion. The range of frequencies of higher harmonics can reach up to tens of megahertz. Decrease of RF interference and compliance to EMC requiements is achieved by circuit design, layout of the unit, as well as by built-in Y-capacitors. To reduce RF interference output pins of the PSU are recommended to shunt to the ground by ceramic Y-capacitors C2, C3 with capacitance from 2200 to 4700 pF, with a corresponding operating voltage (fig.5.11)

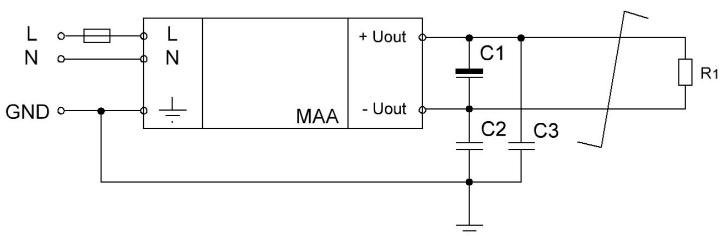


Fig.5.11. Connection to improve EMC

C1 - capacitor type K53-18-220...1000 uF, K50-68-220...1000 uF;
C2, C3 - capacitor type K10-47-4700 pF 2200;
R1 – load equivalent.

To improve EMC and reduce noise emitted into the network by switching mode power supplies of MAA family it is recommended to use filters MRM/MRR made by KW Systems.

Fig.5.12. MAA filters

PSU	Iout.max, A
MRM4-X1AM	1
MRR2-X3AM	3
MRR3-X7.5AM	7.5

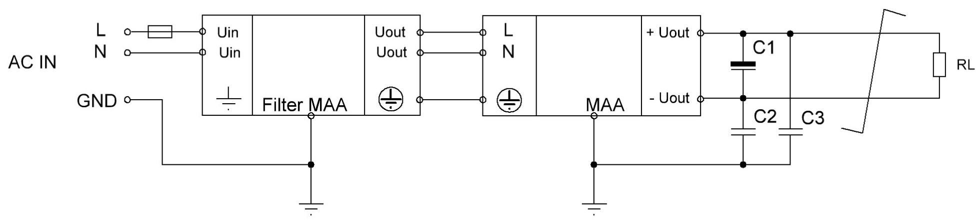


Fig.5.13. Recommended circuit for improved EMC and reduced output ripple.

C1 - capacitor type K53-18-220...1000 uF, K50-68-220...1000 uF;
C2, C3 - capacitor type K10-47-4700 pF 2200;
R1 – load equivalent.

If you cannot use filtering units MAA-F to improve electromagnetic compatibility (EMC) of the equipment, external EMI filters can be connected to the input as shown in fig. 5.14.

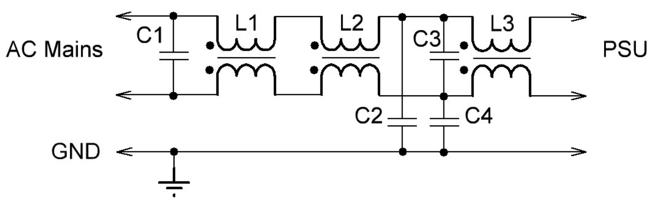


Fig. 5.14. Circuit for external EMI filters connected to the input of a PSU

Chokes L1, L2 are designed to suppress low-frequency harmonics of the PSU's conversion frequency and are based on ferrite cores that have a high level of magnetic permeability (7000...20000), for example, e.g. Epsos core rings from material T35, T38. The windings chokes L1, L2 are arranged on their part of the core, quantity of coils in each winding is the same. Inductance of each of the windings is 1-20 mH. Choke L3 is designed to suppress high frequency harmonics and consists several coils of double wire on a ferrite core ring with permeability of 2000...6000.
The cross section of choke wires in the circuits shown in figure 16, 17 is selected based on the maximum input current, i.e. the permissible value of voltage drop across the filter elements.

5.11. Starting PSU after long-term storage

Before switching units after storing them over 12 months make the procedure of polarizing the electrolytic capacitors of the DC link by feeding input voltage with time-delay. This is necessary to initiate electrochemical recovery processes of the electrolyte. The polarizing procedure is performed to prevent failure of the electrolytic capacitors of the network filter when you first enable a PSU.

The procedure:

1. Connect the unit to a stabilized DC power source;
2. Limit the current at the PSU to 10% of the max consumed current.
3. Set unit's output voltage to 0 V.
4. Turn on the output of the unit.
5. Gradually increase the voltage of the unit at 20 VDC/min up to the max operating voltage without changing the current (the voltage can be increased in steps of 10 VDC every 30 sec).
6. Keep the unit for 1 hour at the max. voltage.

5.12. Improper use of power supply units

Examples of improper operation of PSUs and filtering units.

Below are some typical user's operation mistakes of PSUs and filtering units, as well as actions that can cause failures:

- repeated bending of the output pins;
- mechanical processing of the output pins with the purpose to reduce diameter, length or geometry;
- measure the output voltage at the load, on the mating part of the connector, instead of the output pins of the PSU; this especially relates to high-power PSUs with high output current without consideration of the voltage drop in the output circuits;
- application of excessive mechanical impact to the PSU;
- overtorque of screws when fastening PSU to the heat sink; this can cause damage to its internal structure and components and further failure;
- overheating of output pins when soldering, excess soldering duration. This will cause spreading of the solder inside the PSU across the PSB, and short-circuit of electric circuits inside the module and failure;
- soldering of more than two flexible conductors to one output pin;
- use of flexible conductors with cross-section bigger than the cross section of the output pins;
- violation of storage conditions resulting in premature oxidation of PSU output pins;
- bad thermal contact of the housing between the unit and heat sink surface, which causes to overheating of the power supply unit.
- Lack of thermal paste or its excessive use (layer over 0.2-0.3 mm) will increase case - radiator thermal resistance in 2-3 times;
- long-term (over 1 min) use of short circuit mode at the output of the PSU;
- ignoring of input voltage surges, including short pulses over the max permissible PSU input voltage;
- use of power supply units over 100 W without heatsink; it may cause local overheating around power semiconductor components before setting thermal balance of the unit;
- use of power supply units over 100 W with heatsink with base thickness less than recommended; it will cause local overheating around power semiconductor components before setting thermal balance of the unit;
- disabling of the power circuits of enabled units from the load when Remote Sense lines are connected;
- use of filtering units with nominal input voltage other than the one of the power supply unit. This will reduce the efficiency of interference suppression; the filter might get overheated;
- parallel connection of multiple filtering units, which will reduce the efficiency of interference suppression.

5.13. Standard faults and troubleshooting

Fault	Cause	Troubleshooting
Output voltage is missing	1. The input voltage is outside operating range. 2. There is off-voltage on Remote on/off terminal pins.	1. Apply the input voltage within the specified range. 2. Remove off-voltage from Remote on/off pins.
Output voltage is below the nominal level	Output overloaded of the unit, overload has not reached the level of short circuit protection.	Reduce the load to the nominal level.
Output voltage is above the nominal level	1. There is low level voltage at ADJ terminal pin. 2. The voltage different from the nominal one is set by a trimming resistor.	1. Bring the wiring of ADJ pin into compliance with the documentation. 2. Set the required voltage by a trimmer.
PSU is in the "hiccup" mode	1. There is short-circuit and overcurrent protection at the output. 2. Unit output is connected with capacity over the max value. 3. RS jumpers have been removed, while RS pins are not connected; this causes the overvoltage protection to trigger (voltage surges at the output are above the max value). 4. Faulty RS of the unit. 5. Resistance of the input inrush-current limiter is too high. 6. N-index unit (low operating temperature -40°C) is started under lower temperature.	1. Repair the short circuit on the unit output. 2. Reduce output buffer capacity. 3. Connect RS to the load or restore RS jumpers in the unit. 4. Replace the unit. 5. Replace the inrush current limiter or connect a fixed resistor of low resistance. 6. Use a unit with P temperature range (-50°C).
The unit regularly turns off for less than 1 minute.	The unit is overheated, triggering of thermal protection. Improperly designed or faulty heat sink.	Make the temperature of the unit stable within the specified temperature range.
Output voltage ripple is above the stated value.	1. Incorrect measurement technique. 2. Interference caused by RS circuit: RS wires are too long, not twisted and/or pass near EMI sources. 3. N-index unit (low operating temperature -40°C) is started under lower temperature.	1. Apply the recommended measuring technique of ripple and noise. 2. Twist the RS wires, put them away from interference source (transformers, power lines), make them as short as possible. 3. Replace with the unit of P temperature range (down to -50°C).
Voltage of channels of multichannel unit is unstable	1st channel is underloaded.	Apply the min load of the 1st channel.
Inrush current is above the stated value	The unit was started not from Remote on/off pins.	Use Remote on/off pins to start the unit. Use external current-limiting circuits.

6. Temperature range, temperature derating

6.1. Temperature range

Thanks to the selection of components, circuit and design solutions units of MAA family can operate in a wide range of case temperatures from -50°C to +85°C. For easier application the operating temperature range has been divided into two sub-ranges, that differ by min low temperature: -40°C and -50°C.

Operating temperature ranges are specified in the part number by indices «N» and «P»:

"N": -40°C ... +85°C	
"P": -50°C ... +85°C	
-50°C ... +70°C	Storage temperature
"N": -40°C ... +100°C	Only for MAA30 and MAA75
"P": -55°C ... +100°C	
-55°C ... +100°C	Storage temperature of MAA30 and MAA75

Example: MAA1500-1S48SGN — operating temperature range from -40°C to +85°C.

Like the power supplies of other manufacturers the output power of MAA units depends on their case temperature. Derating VS operating temperature (temperature derating) diagrams are approximately the same for the entire MAA family, and appear as a straight line with the two slant parts in the beginning and in the end of the temperature range (Fig.6.1). Below is an example of the diagram of output power derating VS temperature MAA1500.

You will find output power derating VS temperature diagrams in the datasheets pf each MAA unit.

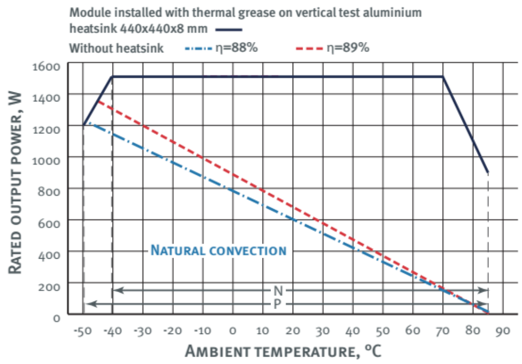


Fig.6.1. Temperature derating MAA1500

Dashed lines indicate the boundaries of unit operation without heat sink for different efficiency. They show that unit will not operate without heatsink at 85°C and will give only 1/3 of the rated power at +20°C ambient. Black line limits the safe operating area with cooling and has 2 slopes: in the boundary areas of low and high temperature. The limit of high temperatures is determined by thermal resistance «power component-insulator-case-heat sink», causing the maximum power at +85°C to be equal to approx. 0.6×Pmax. That is why special attention must be paid to mounting on cooling surface to prevent the increase of thermal resistance due to improper or faulty installation.
(Low temperature operation is limited by restrictions of parameters of PSU components).

6.2. Heat sink

MAA family, like other power converters, does not convert power without losses, part of consumed power is dissipated as heat. Heat dissipation depends on the load and efficiency of the converter.

Reasons to properly implement the heat sink:

- maintain unit case temperature below the limit
- increase reliability
- use the max output power of the unit.

Properly designed cooling will increase the life of the unit and will allow you to take the max output power within the min occupied volume.

MAA30 and MAA75 can operate without cooling

⚠ **Do not use PSUs over 100 W without heat sink. Derating curves of max output power VS temperature for these units are given in the datasets as reference for correct selection of heat sinks.**

Cooling of power supply units is possible to heat sinks of any design that ensures the specified case temperature of the unit, including forced air flow.
There are 3 basic methods of cooling MAA units:
1. The cooling to heat dissipating surface, which may be a wall of equipment. The wall material should be of high thermal conductivity, i.e. aluminum or copper, with sufficient thickness for uniform heat distribution on the cooling surface.
2. Use of a heat sink for convection cooling.
3. The use of forced air cooling of the heat sink. It allows to reduce the area of the heat sink twice comparing to convection with air flow 1 m/s.

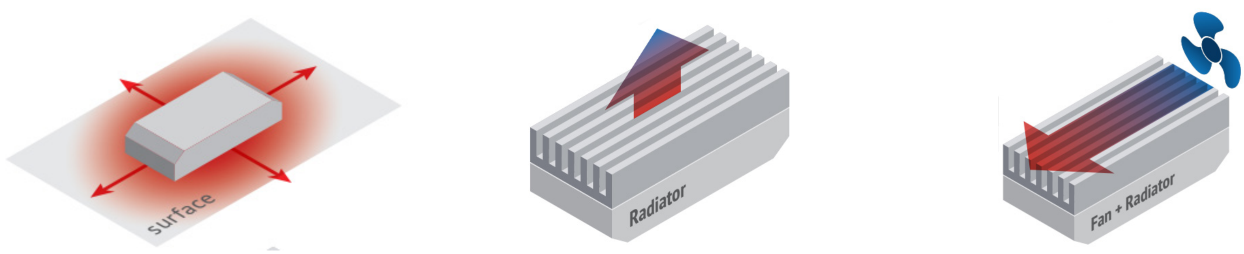


Fig.6.2. Types of conductive cooling.

KW Systems supplies aluminum heat sinks of RO family with transverse and longitudinal ribs for convection cooling for each size of MAA units. Heat sink material is AlMgSi, coating - anodic oxidation, black colored surface for better heat dissipation.

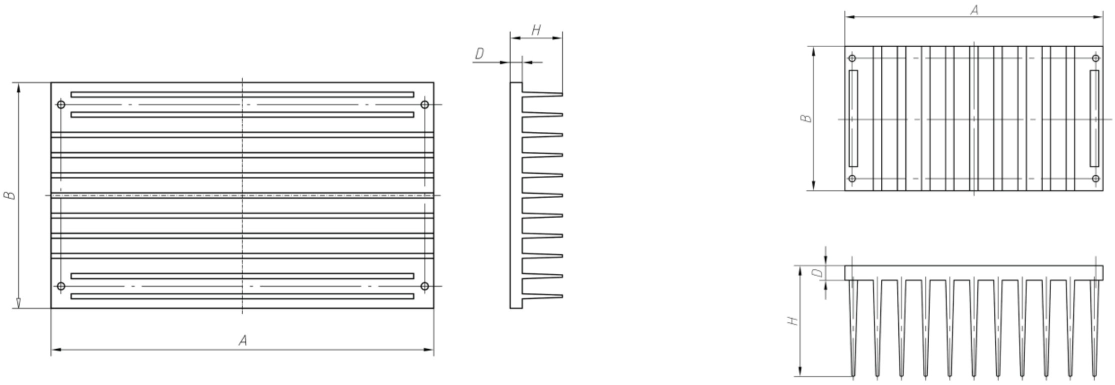


Fig.6.5. RO family heat sinks

However, there are situations when it is impossible to use standard RO heat sinks. In such cases use heat sinks of special shape, or cool down the unit using a wall of equipment. To reduce cooling area of the heat sink you can apply forced air or liquid cooling.
The following is a calculation of cooling surface area of a heat sink or plane.

6.3. Standard heat sinks made by KW SYSTEMS, RO family

To cool down each size of MAA units under convection KW Systems offers heat sinks of RO family with longitudinal and transverse fins. Heat sinks are made of aluminum with subsequent oxidation and surface blackening.

PSU	Heat sink #	Dimensions, mm		Fig.
		Heat sink #	S	
MAA30	BKYQ.752695.040	97×50×46×5.1	-	1
MAA60	BKYQ.752695.058	40×75.5×46×5.1	-	1
	BKYQ.752695.058-01	107×5.10×46×5.1	-	
MAA75			-	
MAA800	BKYQ.752695.006	204×116×46×5.1	-	2
MAA1000			-	
MAA1200	BKYQ.752695.0z6	284×174×46×5.1	-	2
MAA1500, MAA1500 3Ph	BKYQ.752695.056	249×139×46×11	-	4
MAA3000, MAA3000 3Ph			6	
MAA500 3Ph			-	

6.4. Calculation of cooling

To calculate or select a heat sink you need the following data:

- max loss power in unit. The value is either measured (preferably)

Ploss = Pin - Pout

or is calculated using the formula:

Ploss = Pout · (1-η) / η

where η is the PSU efficiency,
Pin is the power consumed by the input circuit
Pout is the power consumed by the load in the output circuit.
PSU efficiency depends on the output power and is shown in figure 6.3.

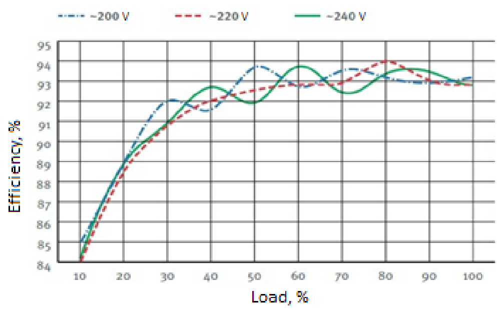


Fig. 6.3. MAA75C24XX efficiency VS output power

As you can see from the diagram, efficiency is the highest at 70% of the output power and decreases when approaching the max power. This is explained by additional increase of losses in PSU components when approaching their maximum power capacity. Efficiency is typically decreased by 3…5%, however, in some cases, this reduction may not occur. For best efficiency it is recommended to operate PSUs with load factor of power under 0.7. As a result, the PSU will operate with maximum efficiency, dissipate allowable power, and its reliability will be close to ultimate. In some cases, when PSU operates with a low load (0,1-0,3)·P_{nom} to calculate a heat sink it is necessary to consider that efficiency is 1.5-2 times less than the maximum value.

- max ambient operation temperature.

This value is used to calculate the max case temperature of the PSU according to the formula:

$T_{case} = T_{ambient} + P_{loss} \cdot R_{case\text{-}ambient}$

The obtained values determine the usefulness of a heat sink.

- permissible case overheating of the PSU VS ambient temperature (according to customer specifications):

$\Delta T = T_{case} - T_{ambient}$

Increase of PSU case temperature every 10-15°C reduces average MTTF roughly two times.

6.5. Heat sink dimensions.

To use a wall of cabinet or housing of equipment of sufficient thickness for conductive heat distribution apply the following ratio: to maintain ΔT= 35°C under natural convection cooling, 1W of thermal power will require heat sink area of 12-25 cm^2. For plate shaped heat sink or when using the wall of equipment, both sides of the plate can be considered except the attach area of the PSU.
The best material for heat sink is copper, then aluminum, and the last choice is steel. Using a heat sink with smaller foot thickness will decrease efficiency of heat emission into ambient.

if a standard product is used as a heat sink, the selection should be based on its thermal resistance.
When you use a heat sink that meets the specified condition, the allowable overheating ΔT will not exceed a predetermined value.
Forced fan convection can significantly reduce the size of heat removing system and sometimes eliminate it completely. 1 m/s air flow coming through PSU heat removing surface or through its heat sink will reduce the heat resistance about two times, i.e. it doubles the effective area of the heat sink compared to natural convection. When using fans as sources of air blowing, please pay attention to their reliability and lifetime, and timely maintain them, especially when operating in dusty environment, since jamming of fans may cause overheating and failure of the power supply unit. Another feature of air cooling is reduction of their effectiveness with increasing height above sea level or at lower atmospheric pressure. For example, at 3500 m, the efficiency of both natural convective and forced air cooling is reduced by 25%.

To improve the reliability of fans it is recommended to connect them to a source of low voltage to 50% of the nominal value.

The heat sink is recommended to be painted matt dark, or be subjected to etching with dark filler to ensure emissivity factor > 0.85.

The unit is recommended to be placed at the geometric center of the heat sink or the common heat sink. The heat sink should be oriented so that its side edges can be cooled by the flow of freely circulating air.

With active air cooling, the orientation of the PSU does not matter, but the air flow must pass along the fins of the heat sink. In any of the following types of cooling it is required to have a air gap 20-30 mm wide between heat sink fins and the nearest elements of the equipment.

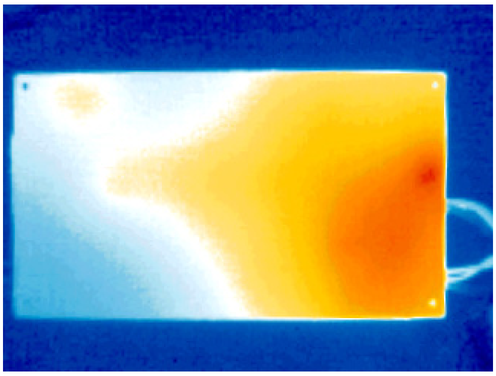


Fig. 6.4. Heat map of MAA1500-1S48SGN without heat sink, the hottest point is +50°C.