340 W Free Air, 460 W Forced Air Cooling, 3 x 5" Form Factor
Medical AC-DC Power Supply

MDP520 Series

Main Features

- Universal input voltage range (90 – 305 V_{AC})
- Input surge current limiting (< 20 A)
- 340 W at natural convection, 460 W forced air cooling, 520 W temporary (10 s)
- Open frame, 3 x 5" industrial standard footprint
- High efficiency up to 94.5%
- 24, 48 and 56 V_{DC} standard output voltages
- Low stand-by consumption (<0.35 W)
- Active PFC, EN61000-3-2 compliant (Class C, >20% load)
- Low earth / touch leakage current (<250 / 100 µA)
- Over temperature, OV, OC and SC protections.
- Stand by +5 V, 1 A output.
- Remote On / Off signal
- Power good and remote sense signals
- Medical IEC 60601-1 3rd edition certified, 2x MoPP rated and BF appliances compatible.
- IEC 60601-1-2 4th edition EMC compliant.
- RoHS 3 compliant (Directive EU 2015/863)
- Compatible with 5000 m altitude operation
- Protective cage option available

Description

The MDP520 series of medical grade AC-DC power supplies provide the compact form factor and high efficiency that the marketplace demands.

The series can provide 460 W of regulated DC power and 520 W peak operating over 90 to 305 V_{AC} input voltage range, in a 3.0 x 5.0 x 1.51" form factor. The MDP520 series comes in an open frame compact package to facilitate system integration and thermal management in space constraint and closed environments, thanks also to its 94% high efficiency which generate less heat.

The series comes in 24, 48 and 56 V_{DC} standard output voltages with additional 12, or 36 V_{DC} output voltages variants which will be available upon business case evaluation. It offers a +5 V_{DC} stand-by output capable of 1 A. Available control signals include Power Good (P_OK), Remote On / Off (PS_Inhibit) and Sense terminals (RS^+).

The series can be operated over the -40 to 70 °C ambient temperature range with output power derating factor applied above 50 °C and below -20 °C start up.

Protection features include slow blow fuses on both AC lines, input under voltage lockout (IUV), output over-current (OC), output short-circuit (SC), output over-voltage (OV) and over-temperature (OT).

The MDP520 Free Air series complies with the 3rd edition of the IEC60601-1 and ANSI/AAMI ES/EN 60601-1 safety standards for medical equipment requiring 2x MoPP protection grade. It is suitable for BF rated medical equipment under specific conditions.

The MDP520 Free Air series meets the EN 60601-1-2 EMC limits of Class B for conducted and radiated emissions as well as the IEC/EN61000-3 for flicker and harmonics content. It also meets the IEC 60601-1-2 4th edition for EMC immunity.

Market Segments and Applications

- Diagnostic Equipment
- Dialysis Equipment
- Surgical Device
- Monitoring Devices
- Hospital Beds
- Ultrasound / EM Therapy Devices
- Imaging Equipment
- Clinical Analyzer
- Ventilator
- Home health Care

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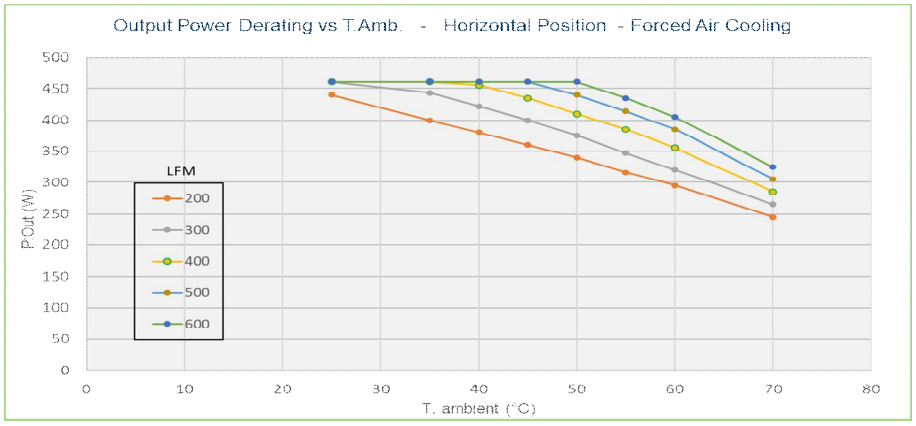
MODEL CODING AND OUTPUT RATINGS

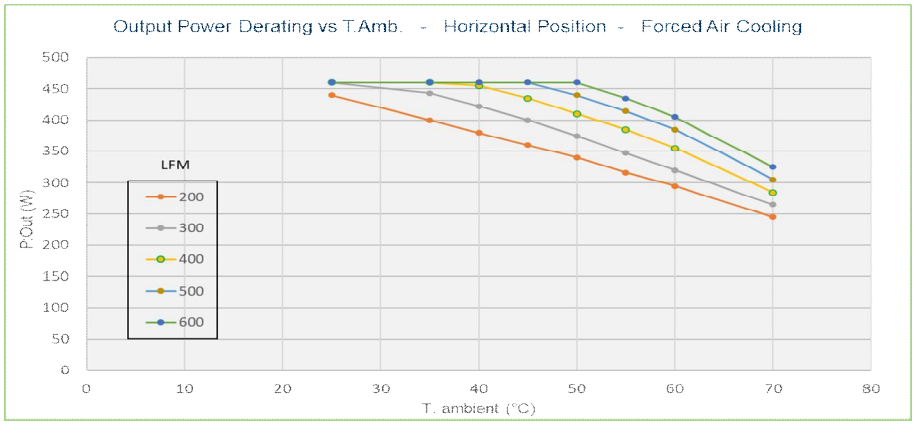
Model Code	V_{OUT} Nominal [V_{DC}]	V_{AC} Range [V]	I_{OUT} [A]	I_{SB} [A]	Cooling Mode	Max Combined Output Power [W]
MDP520-US12-OF	12	≥90	TBD	1.0	Natural Convection	TBD
		≥100	TBD	1.0		TBD
		≥180	TBD	1.0		TBD
		90-305	TBD	1.0	> 600 LFM forced air	TBD
MDP520-US12-PC	12	≥90	TBD	1.0	Natural Convection	TBD
		≥100	TBD	1.0		TBD
		≥180	TBD	1.0		TBD
		90-305	TBD	1.0	> 600 LFM forced air	TBD
MDP520-US24-OF	24	≥90	14.1	1.0	Natural Convection	340
		≥100	15	1.0		360
		≥180	17.3	1.0		415
		90-305	19.2	1.0	> 600 LFM forced air	460
MDP520-US24-PC	24	≥90	14.1	1.0	Natural Convection	310
		≥100	15	1.0		340
		≥180	17.3	1.0		390
		90-305	19.2	1.0	> 600 LFM forced air	460
MDP520-US36-OF	36	≥90	TBD	1.0	Natural Convection	TBD
		≥100	TBD	1.0		TBD
		≥180	TBD	1.0		TBD
		90-305	TBD	1.0	> 600 LFM forced air	TBD
MDP520-US36-PC	36	≥90	TBD	1.0	Natural Convection	TBD
		≥100	TBD	1.0		TBD
		≥180	TBD	1.0		TBD
		90-305	TBD	1.0	> 600 LFM forced air	TBD
MDP520-US48-OF	48	≥90	7.1	1.0	Natural convection	340
		≥100	7.5	1.0		360
		≥180	9.6	1.0		460
		90-305	9.6	1.0	>600 LFM forced air	460
MDP520-US48-PC	48	≥90	7.1	1.0	Natural convection	310
		≥100	7.5	1.0		340
		≥180	9.6	1.0		390
		90-305	9.6	1.0	>600 LFM forced air	460
MDP520-US56-OF	56	≥90	6.25	1.0	Natural convection	350
		≥100	6.6	1.0		370
		≥180	8.2	1.0		460
		90-305	8.2	1.0	>600 LFM forced air	460
MDP520-US56-PC	56	≥90	6.25	1.0	Natural convection	310
		≥100	6.6	1.0		340
		≥180	8.2	1.0		390
		90-305	8.2	1.0	>600 LFM forced air	460

Output Power Derating Curves



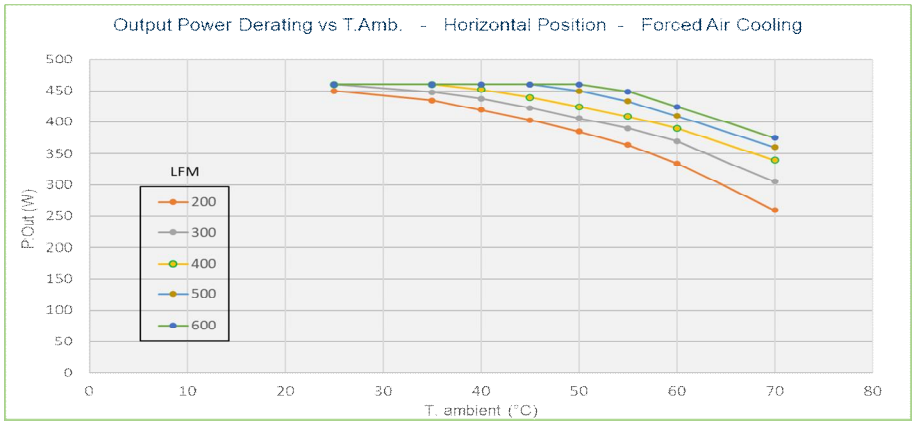
V_{OUT}: 24 V_{DC}

V_{IN}: ≥90V_{AC}



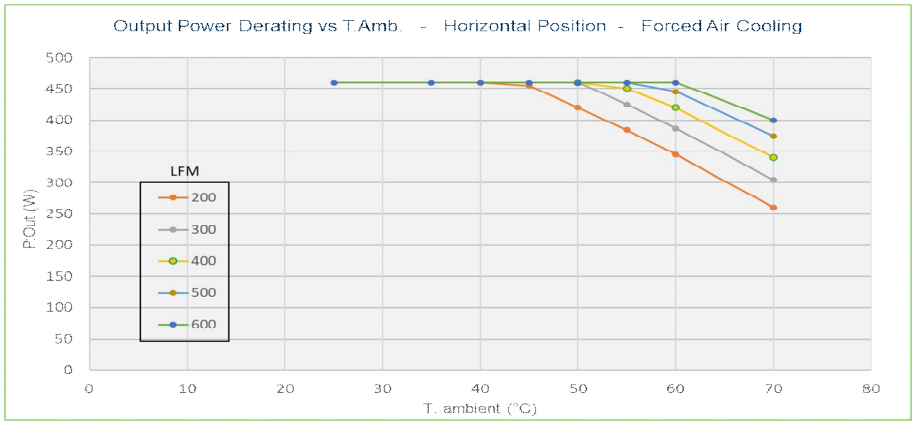
V_{OUT}: 48, 56 V_{DC}

V_{IN}: ≥90V_{AC}



V_{OUT}: 24 V_{DC}

V_{IN}: ≥115V_{AC}



V_{OUT}: 48, 56 V_{DC}

V_{IN}: ≥115V_{AC}

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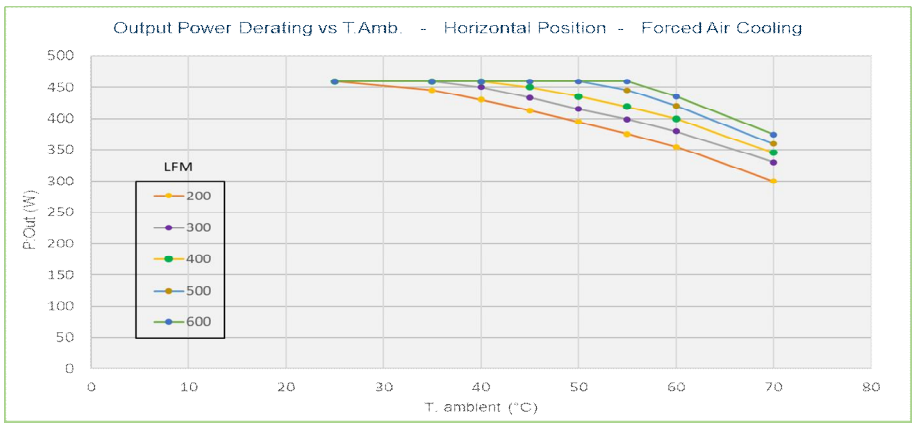
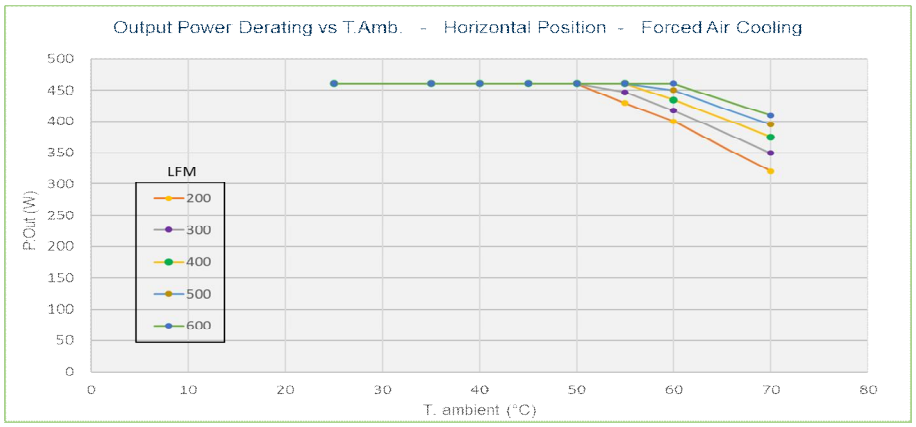
MDP520 Series



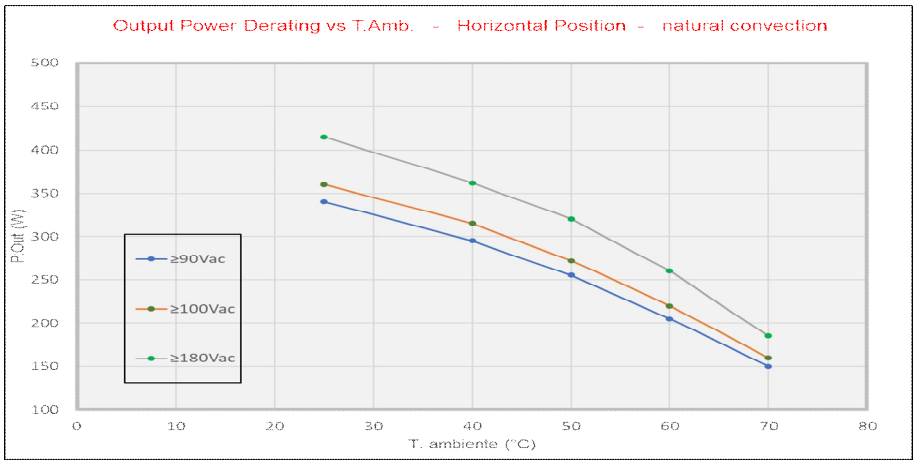
V_{OUT}: 24 V_{DC}

V_{IN}: ≥180V_{AC}

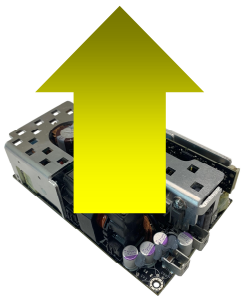


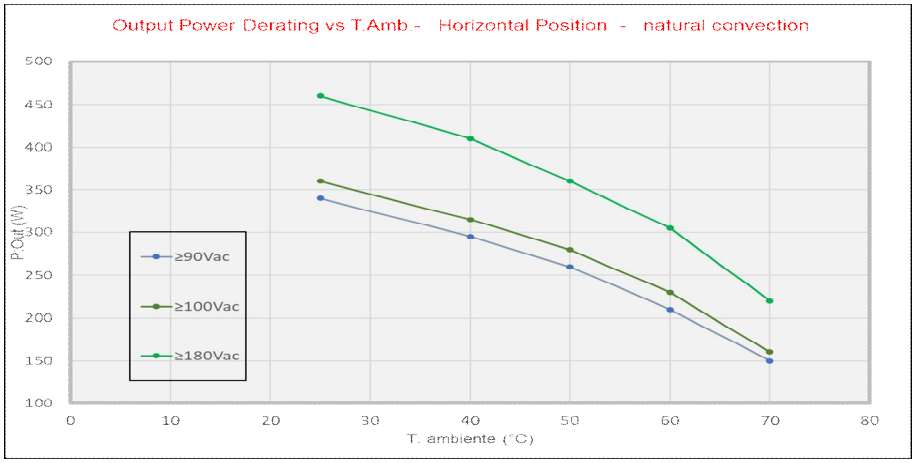
V_{OUT}: 48, 56 V_{DC}

V_{IN}: ≥180V_{AC}

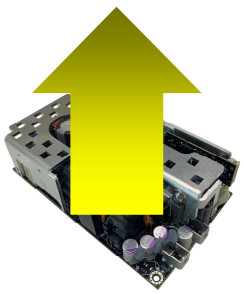


V_{OUT}: 24 V_{DC}





V_{OUT}: 48 V_{DC}



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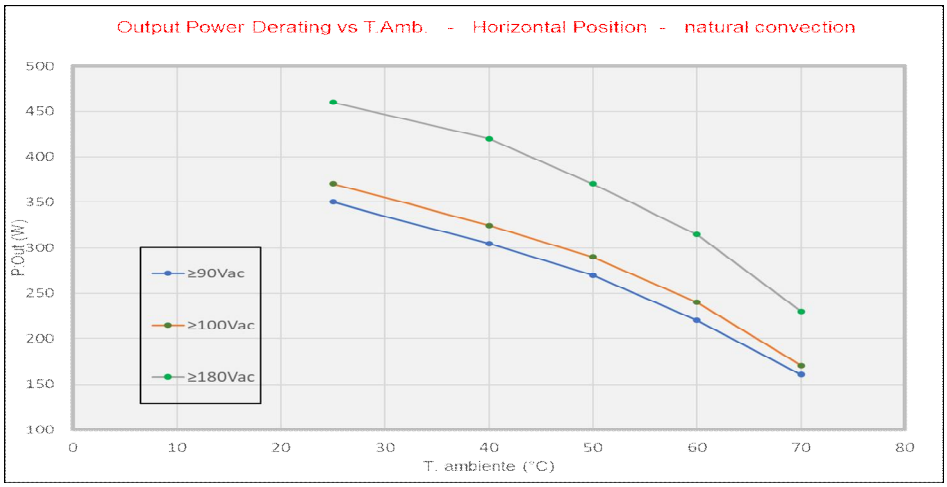
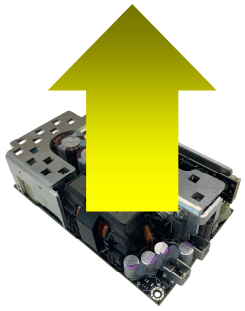
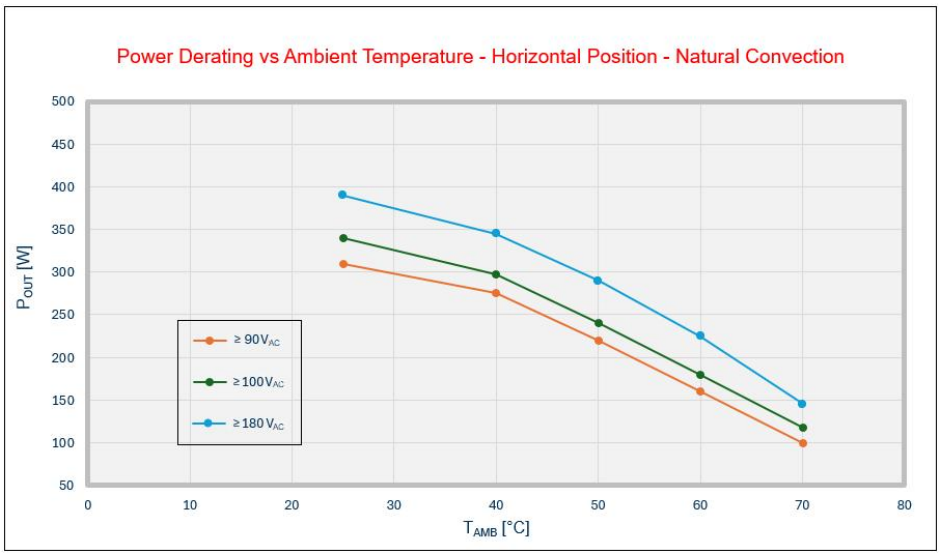
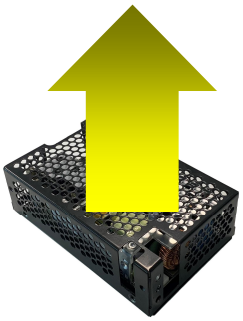


V_{OUT}: 56 V_{DC}





V_{OUT}: 24, 48, 56 V_{DC}



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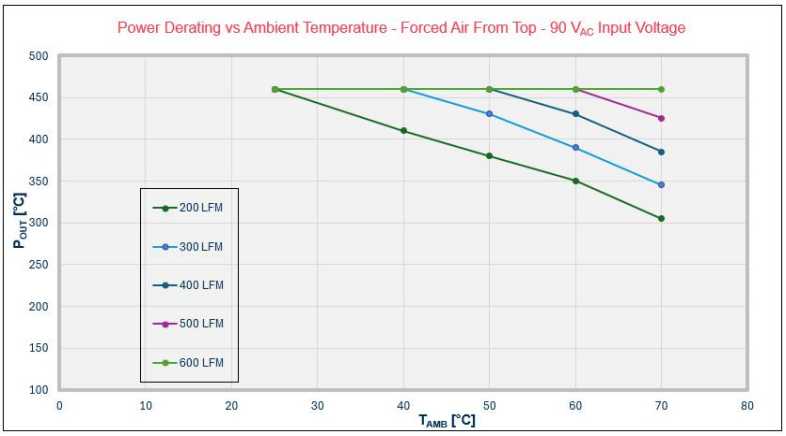

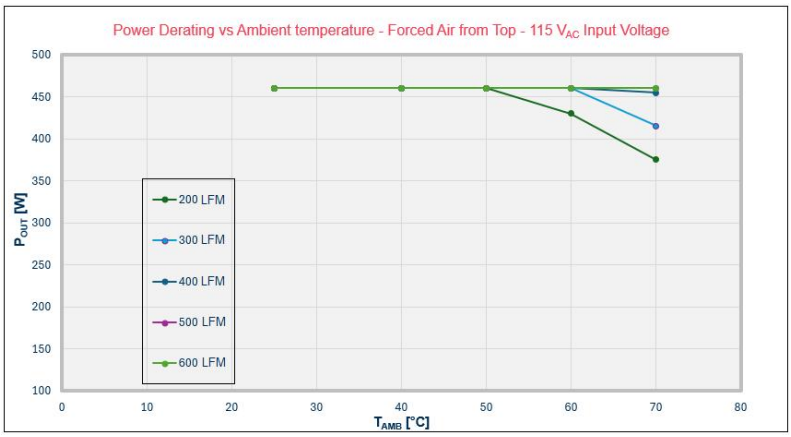

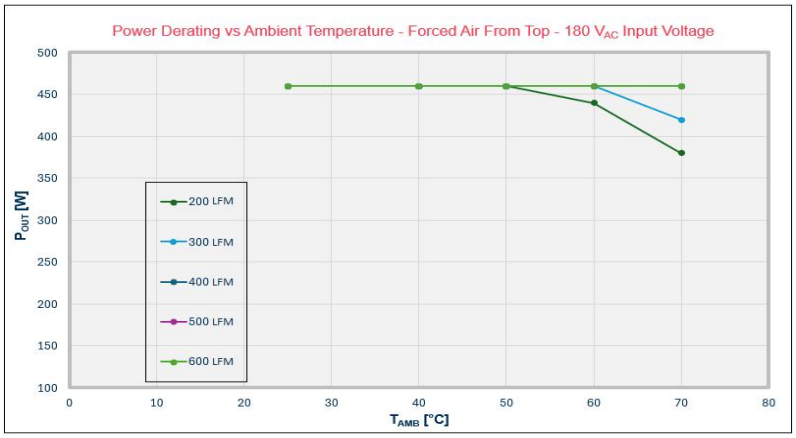

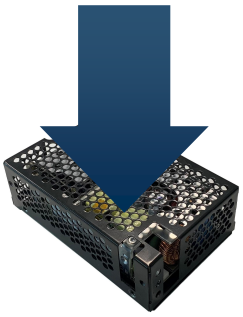

V_{OUT}: 24, 48, 56 V_{DC}

The above curves come from a climatic static chamber and a specific set up therefore they represent a thermal performance approximation of a MDP520 installed into a system where not all the variables can be controlled. Although they are a reasonable reference, it is always a recommended practice to monitor the power supply critical components temperature when operating into a system (see below hot-spots thermal map).

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INPUT SPECIFICATIONS

Specification	Test Conditions / Notes		Min.	Nominal	Max.	Units
AC Input Voltage	PS starts and operates at 85 V_{AC} at all load conditions		90	100 ÷ 277	305	V_{RMS}
DC Input Voltage			170	-	300	V_{DC}
Input Frequency	440 Hz with reduced PFC and output power rating - Consult factory for details.		47	50/60	440	Hz
Input Current	RMS at 180 V_{AC}, maximum load, 50 / 60 Hz RMS at 85 V_{AC}, maximum load, 50 / 60 Hz		-	-	3.5 7.0	A
Inrush Current (peak)	Cold start, 25 °C ambient, full load					
		115 V_{AC}	-	-	10	A
		230 V_{AC}	-	-	20	
		277 V_{AC}	-	-	24	
Fusing	Slow blow, 8A, 250V on each AC lines.		-	-	8	A
Efficiency	At 115 V_{AC}, 20% rated load		-	89	-	%
	50% rated load		-	93	-	
	100% rated load		-	92	-	
	At 230 / 277 V_{AC}, 20% rated load		-	90	-	
	50% rated load		-	94	-	
	100% rated load		-	94.5	-	
Input Power Consumption	Power on, 115 V_{AC}, no load		-	-	4	W
	Power on, 230 V_{AC}, no load		-	-	4	
	Stand by, 115, 230 V_{AC}, no load		-	-	0.35	
Power Factor	From 50 to 100% of rated load, 277, 230, 115 V_{AC}, 50 / 60 Hz input voltages.		0.90	-	-	-
THDi	From 50 to 100% rated load, 115, 230, 277 V_{AC} 50 / 60 Hz.		-	-	20	%
Harmonic Current Fluctuations and Flicker	Complies with EN 61000-3-2 at 230 V_{AC}, 50/60 Hz, Class A. Complies with EN 61000-3-2 Class C at 230 V_{AC}, 50/60 Hz, >150 W load. Complies with EN 61000-3-2 Class D at 230 V_{AC}, 50/60 Hz, >35 W load. Complies with EN 61000-3-3 at nominal voltages and full load.					
Earth Leakage Current	Normal conditions					
	115 V_{RMS}, 60 Hz		-	100	-	µA
	230 V_{RMS}, 50 Hz		-	180	-	
	264 V_{RMS}, 60 Hz (worst case)		-	200	-	
	277 V_{RMS}, 60 Hz		-	250	290	
Touch Leakage Current	264 V_{RMS}, 60 Hz					
	Normal Condition (NC)		-	-	100	µA
	Single Fault Condition (SFC)		-	-	500	
Patient Leakage Current	264 V_{RMS}, 60 Hz					
	Normal Condition (NC)		-	-	100	µA
	Single Fault Condition (SFC)		-	-	500	

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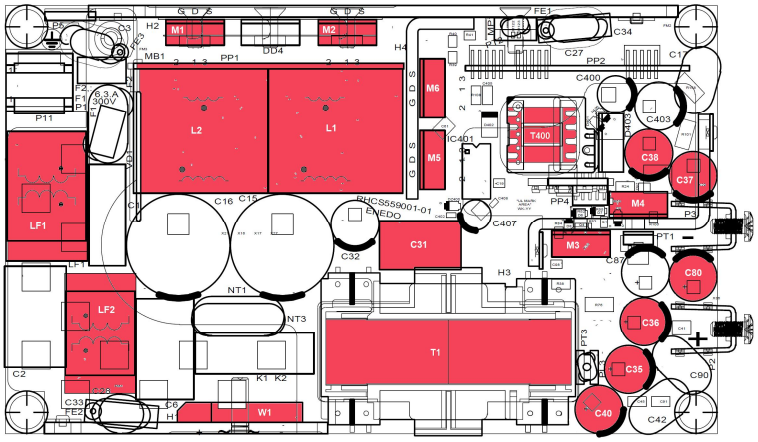
OUTPUT SPECIFICATIONS

Specification	Test Conditions / Notes	Min.	Nom.	Max.	Units
V1 Output Voltages	±0.5% set point accuracy, 20% load	-	12 24 36 48 56	-	V
V1 Output Power Rating	Natural Convection (see graph above) Forced air cooling (see graph above) Peak power	- - -	- - -	460 460 520	W
$5V_{SB}$ Output Voltage	±3% set point accuracy, 20% load	-	5	-	V
$5V_{SB}$ Output Current		-	-	1.0	A
V1 Voltage Adjustment Range	Manually by potentiometer	-	-	±5	%V1
V1 Load-Line-Cross Regulation	V_{AC}: 85 – 305 V_{RMS} ; I1: 0 – 100%	-	-	±2	%V1
$5V_{SB}$ Load-Line-Cross regulation	V_{AC}: 85 – 305 V_{RMS} ; I_{5SB}: 0 – 100%	-	-	±5	%$5V_{SB}$
V1 Line Regulation	V_{AC}: 85 – 305 V_{RMS}	-	-	±0.1	%V1
Transient Response: V1, $5V_{SB}$ Voltage Deviation	50% load changes at 1 A/µs 0.5 A load minimum load applied	-	-	±5	%V1 %$5V_{SB}$
V1 Ripple and Noise	Rated load, Peak-to-peak, 20 MHz BW. (100 nF ceramic, 10 µF tantalum at load)	-	-	1	%V1
V1 Start-up Rise Time	85<V_{IN}<305, any load conditions.	10	-	100	ms
Start-up Delay	V1 in regulation after de-asserting PS_ON V1 in regulation after AC is applied (worst case: 85 V_{AC}) $5V_{SB}$ in regulation after AC is applied (worst case: 85 V_{AC})	- - -	- - -	200 750 500	ms
Turn-on Overshoot		- -	- -	5 5	%V1 %V_{SB}
V1 Hold-up Time	At nominal V_{IN}, full load	16	-	-	ms
Minimum Load	V1and $5V_{SB}$	0	-	-	A
Maximum Load Capacitance	V1: 12 V_{DC} V1: 24 V_{DC} V1: 36 V_{DC} V1: 48 V_{DC} V1: 54 V_{DC}	- - - - -	- - - - -	28000 14000 12000 10000 8000	µF

To ensure the power supply proper operation when installed in a system or device, the hot-spots components operating temperature should not exceed the corresponding maximum limits shown in the table alongside.



Hot Components PCB Reference	Maximum Operating Temperature [°C]
T1	130
T400	110
W1	125
LF1, LF2	120
L1, L2	120
M1, M2	120
M3, M4	120
M5, M6	120
C31	105
C35, C36, C40, C80	105
C37, C38	105

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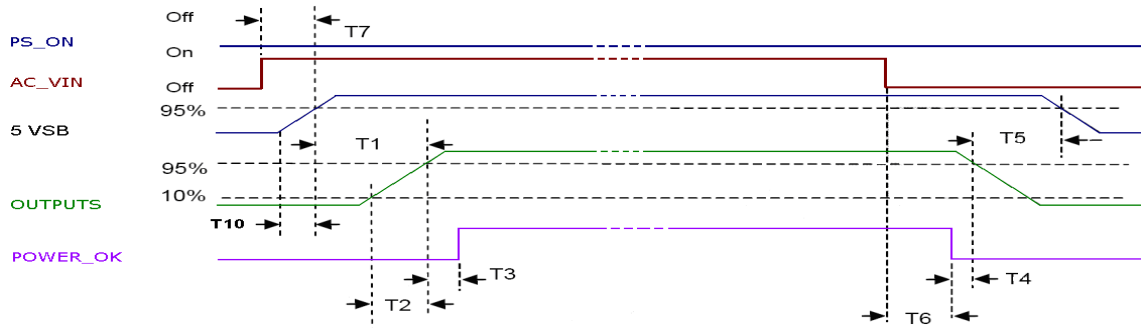
SIGNALS / CONTROLS

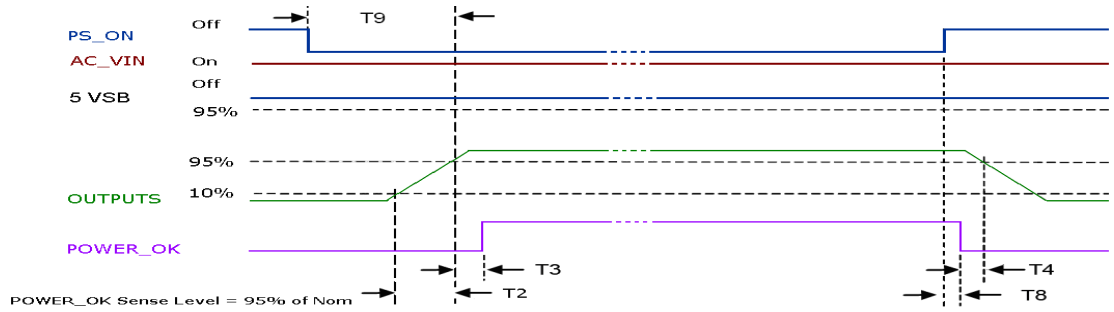
Signal	Notes	Min	Typ	Max	Unit
PS_ON	Active low, +5 V TTL signal compatible. Input low voltage	0	-	2.0	V
	Input high voltage (I_{IN}= 200 µA)	3.0	-	-	V
	V1 and V2 disabled when PS_ON is open				
	$5V_{SB}$ not affected by PS_ON				
	V1 and V2 enabled with PS_ON connected to RTN				
P_OK	+5 V TTL compatible				
	Logic level low (<10 mA sinking)	-	-	0.7	V
	Logic level high (100µA sourcing)	2.4	-	5	V
	Low to high time after V1 in regulation	0.05	-	0.1	s
	Power down warning time	1	-	-	ms
$5V_{SB}$ output	Active and in regulation after a 90<V_{AC}<264 is applied	-	-	200	ms
	$5V_{SB}$ not affected by PS_ON				

SIGNALS TIMING



Above waveforms are expected with AC Input ON/OFF:

5 V_{SB} On – V1 On	50 ms ≤ T1 ≤ 250 ms
V1 Rise Time	5 ms ≤ T2 ≤ 85 ms
5 V_{SB} Rise Time	1 ms ≤ T10 ≤ 10 ms
V1 On – P_OK delay	30 ms ≤ T3 ≤ 100 ms
Power down warning[1]	T4 ≥ 5 ms
V1 Off – $5V_{SB}$ Off[2]	T5 ≥ 1.2 s
AC Off – P_OK Low	T6 ≥ 10 ms (115/ 230 V_{AC})
AC_ON – $5V_{SB}$ turn On time	T7 ≤ 1000 ms



Above waveforms are expected with PS_ON Signal ON/OFF state change:

V1 Rise Time	5 ms ≤ T2 ≤ 85 ms
V1 On – P_OK delay	30 ms ≤ T3 ≤ 100 ms
Power down warning1	1 ms ≤ T4 ≤ 5 ms
-PS_ON – P_OK down	T8 ≤ 1 ms
-PS_ON – V1 On Timing	T9 ≤ 200 ms

[1] T4 parameter measurement setup will assume at least 10% of the maximum load on each output.
[2] T5 parameter measurement setup will assume at least 50% of the maximum load on main output.

PROTECTION FEATURES

Specification	Test Conditions / Notes	Min.	Nominal	Max.	Units
Input Under Voltage	Auto-recovering, hiccup mode.	58	65	75	V_{AC}
Input Fuse	8 A 300 V_{AC} Time Lag Radial Fuse T/H	-	-	8	A
Over Current	At nominal input voltages V1: Hiccup mode, auto-recovering $5V_{SB}$: Hiccup mode, auto-recovering:	 115 -	 - -	 160 -	$\%I1_{Rated}$
Short Circuit	At nominal input voltages V1: Hiccup mode, auto-recovering. $5V_{SB}$: Hiccup mode, auto-recovering.	 -	 -	 -	
Over Voltage	V1, Power shut down, latch off. $5V_{SB}$, Hiccup mode, auto-recovering.	110 -	- -	145 150	$\%V_{NOM}$
Over Temperature (on secondary and primary side)	Hiccup mode, auto-recovering.	-	-	-	°C
Isolation: Input-to-Output	Reinforced (2x MoPP)	6000 4250	- -	- -	V_{DC} V_{AC}
Isolation: Input-to-Earth	Basic (1x MoPP) Production tested at 2545 V_{DC}	2545 1800	- -	- -	V_{DC} V_{AC}
Isolation: Output-to-Earth	Basic (1x MoPP)	2121 1500	- -	- -	V_{DC} V_{AC}
Means Of Protection: Primary to secondary	2x MoPP (IEC 60601-1 3rd edition) at 100 – 250 V_{AC}, 50/60 Hz up to 4000 m 2x MoPP (IEC 60601-1 3rd edition) at 100 – 277 V_{AC}, 50/60 Hz up to 3000 m 2x MoOP (IEC 60601-1 3rd edition) at 100 – 277 V_{AC}, 440 Hz (50/60 Hz)				
Means Of Protection: Primary to Protection Earth	1x MoPP (IEC 60601-1 3rd edition) at 100 – 250 V_{AC}, 50/60 Hz up to 4000 m 1x MoPP (IEC 60601-1 3rd edition) at 100 – 277 V_{AC}, 50/60 Hz up to 3000 m 1x MoOP (IEC 60601-1 3rd edition) at 100 – 277 V_{AC}, 440 Hz (50/60 Hz)				
Means Of Protection: Secondary to Protection Earth	1x MoPP (IEC 60601-1 3rd edition) at 100 – 250 V_{AC}, 50/60 Hz up to 4000 m 1x MoPP (IEC 60601-1 3rd edition) at 100 – 277 V_{AC}, 50/60 Hz up to 3000 m (U-chassis variant only) 1x MoOP (IEC 60601-1 3rd edition) at 100 – 277 V_{AC}, 440 Hz (U-chassis variant only)				
Equipment Protection Class	Class I, compatible with BF (Body Floating) ME				

ENVIRONMENTAL SPECIFICATIONS

Specification	Test Conditions / Notes	Min	Nominal	Max	Units
Operating Temperature Range	Start up at -40 °C at <20% load. No de-rating up to 50°C at >600LFM	-40	-	50	°C
Operating Temperature Range with De-rating	See de-rating curves and conditions in the Output Specifications section	-	-	70	°C
Storage Temperature		-40	-	85	°C
Humidity	RH, Non-condensing Operating. Non-operating	-	-	90 95	% %
Operating Altitude	MoPP (100 – 250 V_{AC}, 50/60 Hz) MoPP (100 – 277 V_{AC}, 50/60 Hz) MoOP, ITE grade Power de-rating above 1800 m	- - -	- - -	4000 3000 5000	 m
Shock	EN 60068-2-27 Operating: Half sine, 30 g, 18 ms, 3 axes, 6x each (3 positive and 3 negative). Non-Operating: Half sine, 50 g, 11 ms, 3 axes, 6x each (3 positive and 3 negative).				
Vibration	EN 60068-2-64 Operating: Sine,10 – 500 Hz, 1 g, 3 axes, 1 oct/min., 60 min. Random, 5 – 500 Hz, 0.02 g^2/Hz, 1 g_{RMS}, 3 axes, 30 min. Non-Operating: 5 – 500 Hz, 2.46 g_{RMS} (0.0122 g^2/Hz), 3 axes, 30 min.				
MTBF	Full Load, 40 °C ambient 80% Duty cycle, Telcordia SR-332 Issue 2	400.000	-	-	Hours
Useful Life	Worst nominal V_{IN}, 80% load, 40 °C ambient.	-	5	-	Years

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ELECTROMAGNETIC COMPATIBILITY (EMC) – EMISSIONS

Phenomenon	Conditions / Notes	Standard	Equipment/Performance Class
Conducted	115, 230, 277 V_{RMS}. Maximum load.	EN 55011 (ISM) EN 60601-1-2 (Medical)	B
Radiated	At 10 m distance	EN 55011 (ISM) EN 60601-1-2 (Medical)	A[3]
Line Voltage Fluctuation and Flicker	At 20%, 50% and 100% maximum load. Nominal input voltages	EN 61000-3-3	
Harmonic Current Emission	230 V_{AC} input voltage, 50 / 60 Hz 230 V_{AC} 50 / 60 Hz, >150 W load 230 V_{AC} 50 / 60 Hz, >40 W load	EN 61000-3-2 EN 61000-3-2 EN 61000-3-2	A C D

[3] Radiated emissions should be assessed at system level.

ELECTROMAGNETIC COMPATIBILITY (EMC) – IMMUNITY

Phenomenon	Conditions / Notes	Standard	Test Level	Criteria
	Reference standard for the medical version Reference standard for Industrial/IMS equipment	EN 60601-1 EN 61000-6-2		
ESD	15 kV air discharge, 8 kV contact, at any point of the system.	EN 61000-4-2	4	A
Radiated Field	10 V/m, 80-1000 MHz, 1 KHz, 80% AM.	EN 61000-4-3	3	A
Electric Fast Transient	±2 kV on AC power port for 1 minute	EN 61000-4-4	3	A
Surge	±2 kV line to line; ± 4 kV line to earth on AC power port	EN 61000-4-5	4	A
Conducted RF Immunity	10 V_{RMS}, 0,15-80 MHz, 1 kHz/2 Hz 80% AM	EN 61000-4-6	3	A
Dips and Interruptions	200 – 277 V_{AC}:			
	Drop-out to 0% for 10 ms	EN61000-4-11		A
	Dip to 40% for 5 cycles (100 ms)	EN61000-4-11		A
	Dip to 70% for 25 cycles (500 ms)	EN61000-4-11		A
	Drop-out to 0% for 5 s	EN61000-4-11		B
	100 – 127 V_{AC}:			
	Drop-out to 0% for 10 ms	EN 61000-4-11		A
	Dip to 40% for 5 cycles (100 ms)	EN 61000-4-11		B (derating TBD)
	Dip to 70% for 25 cycles (500 ms)	EN 61000-4-11		A (derating TBD)
	Drop-out to 0% for 5 s	EN 61000-4-11		B

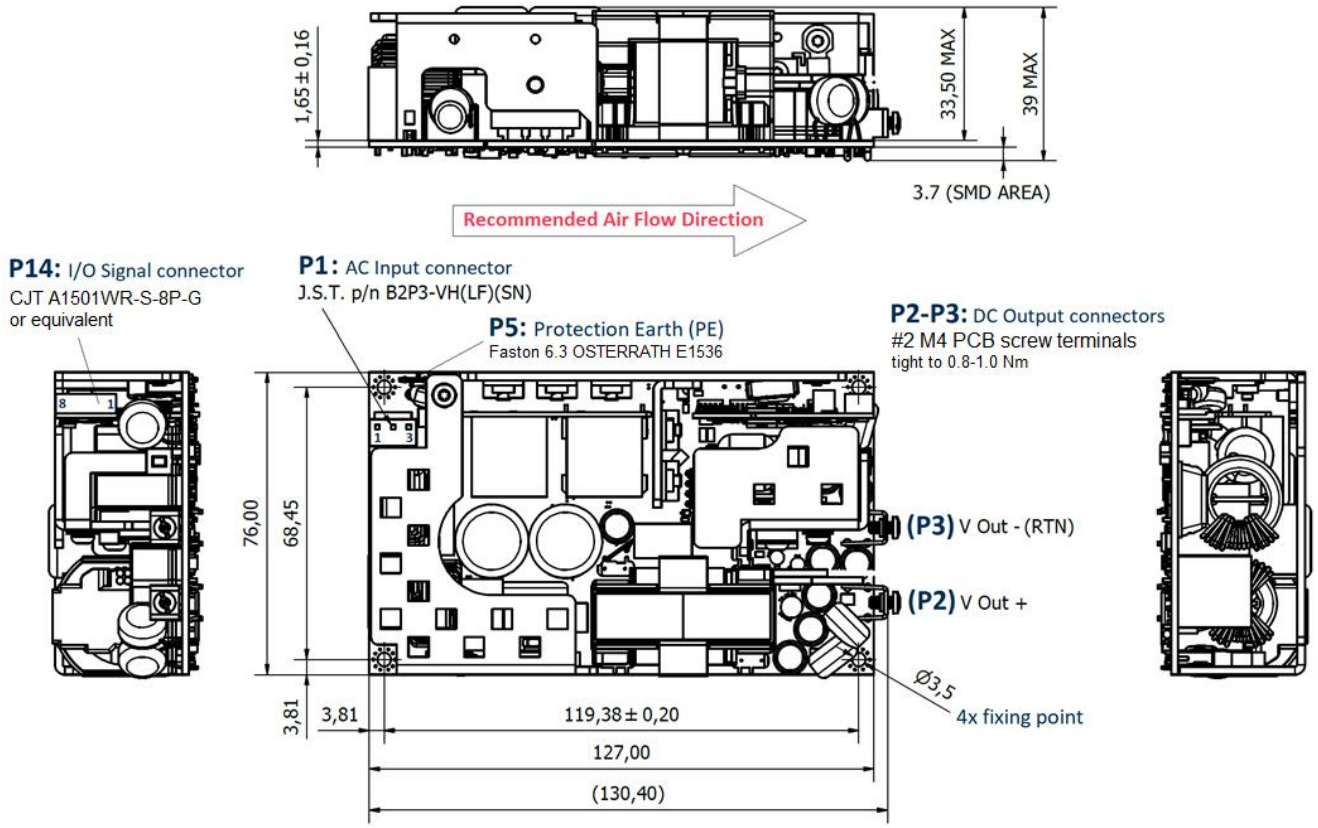
SAFETY AGENCIES APPROVALS

Certification Body	Safety Standards and file numbers	Category
	CSA C22.2 No.60601-1, ANSI/AAMI ES60601-1 3rd edition + A1	Medical
IEC IECEE CB Certification	IEC/EN 60601-1 3rd edition+A1	Medical
CE	Directive 2014/35/EU: Electrical Safety: Low Voltage electrical equipment (LVD)	Information Technology Equipment
	Directive 93/42/CEE: Safety Requirement of the Medical Device	Medical
	Directive 2014/30/EU: Electromagnetic Compatibility (EMC)	
	Directive EU 2015/863: RoHS 3	
Designed to meet IEC/EN/UL/CSA 61010-1 2nd edition and IEC/EN 60335-1 or IEC/EN 61558-1		

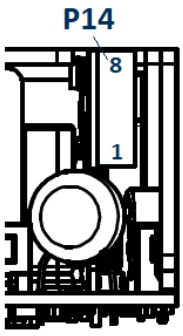
OUTLINE DRAWING AND CONNECTIONS – OPEN FRAME CHASSIS (-OF)

Overall dimensions: 76.2 x 127.0 x 38.5 mm (3.00 x 5.00 x 1.51 in)

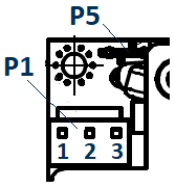
Weight: 400 g (0.88 lb)



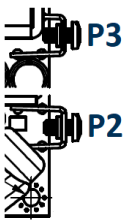
Signals Connector – P14		
CJT A1501WR-S-8P-G (or equivalent), mates with: CJT A1501H-8P *(housing)* CJT A1501-GP *(terminals)* or equivalent.	Pin Ref.	Function
	8	RS^-
	7	RS^+
	6	P_OK
	5	-PS_On
	4	RTN
	3	RTN
	2	$+5V_{SB}$
	1	$+5V_{SB}$



AC Input Connector – P1		
JST B2P3-VH(LF)(SN) Mates with JST NVAR-02VS *(housing)* JST SVT-41T-P1.1 *(terminal)* Use 16 AWG minimum wires	P1 Pin Ref.	Function
	1	L1
	2	NP
	3	L2
	P5: Protection Earth (PE)	



DC Output Connector – P2, P3		
2x M4 screw terminals KEYSTONE 7792 (tight to 0.8-1.0 Nm) Max deep screws 7 mm	Pin Ref.	Function
	P2	+V1
	P3	RTN



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OUTLINE DRAWING AND CONNECTIONS – PROTECTIVE CAGE (-PC)