RELIABILITY IN MEDAUSTRON POWER CONVERTERS

A look back at the power converter reliability since 2016

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Wiener Neustadt, May 31, 2023

CONTENTS

THE IMPORTANCE OF BEING RELIABLE

MedAustron is a cancer treatment and research center!

- We provide advanced patient care;
- Thus human lives are our first priority;

Power converters

- Have a significant role in the therapy accelerator;
- They should be consistently good in performance;
- And able to be trusted;

The importance of reliability in human life!

MEDAUSTRON POWER CONVERTERS

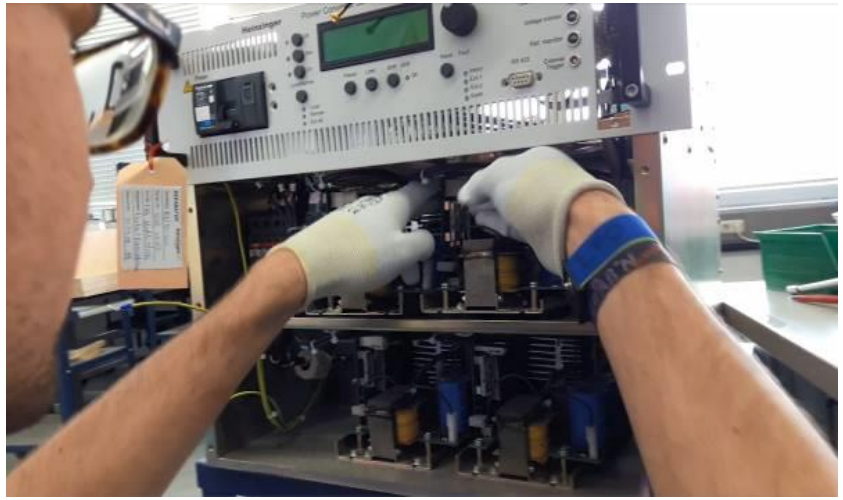
Family	Quadrants	Cooling	Voltage (V)	Current (A)	Magnet
A2	1	Air	50	200	LEBT-MEBT quadrupoles, solenoide
A3	1	Air	50	300	
B1	4	Air	30	50	LEBT, MEBT, HEBT correctors and quadrupoles, MR correctors, skew, betatron
B2	4	Air	30	150	
B3	4	Air	50	300	
B4	4	Air	90	300	
C1	4	Water	160	650	MR-HEBT quadrupoles and sextupoles
C2	4	Water	300	360	
C3	2	Air	250	1250	IH quadrupoles
C4	4	Water	200	2000	HEBT dipoles, septum
C5	4	Water	70	3300	
D1	4	Water	600	600	Scanning Dipoles
D2	4	Water	600	600	
E1	2	Water	1500	3000	Main Bending Dipoles
E2	2	Water	500	2300	90° Dipole
F1	4	Air	15	170	Quadrupole corrector

Family D1 power converter

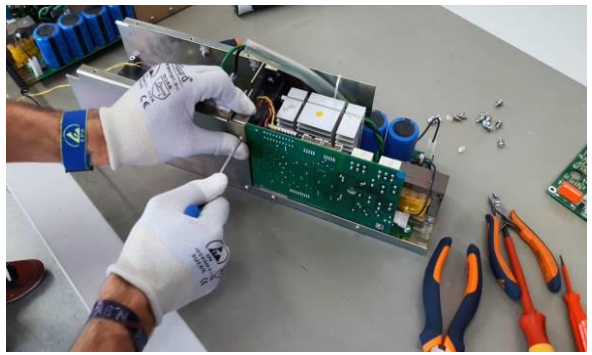
POWER CONVERTER INCIDENTS

Family A2 & **A3 power converters**

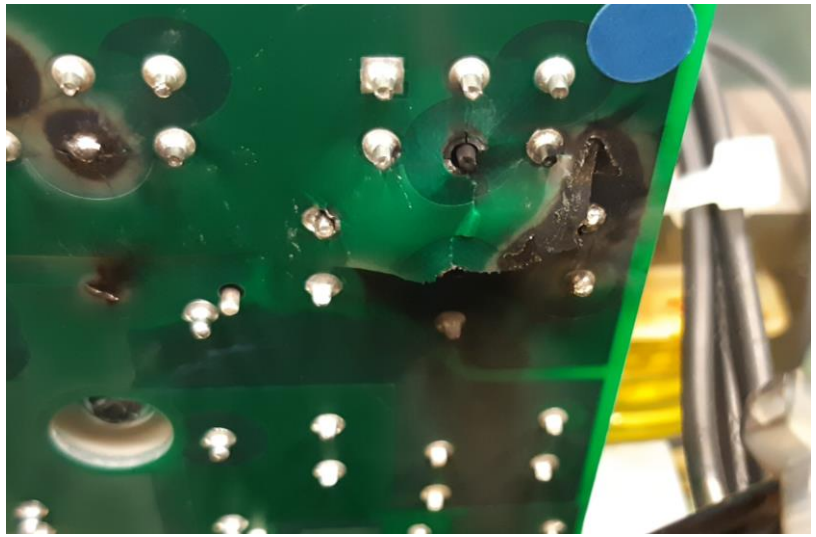
- No reply from serial link;
- Faulty output power stages;
- Burnt input power stage;



Family A3 PCO output power stages assembly



Family A PCO output power stages repair

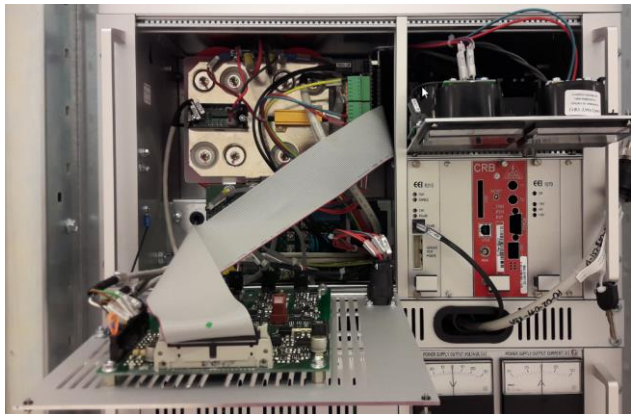


Family A2 PCO input power stage explosion

POWER CONVERTER INCIDENTS

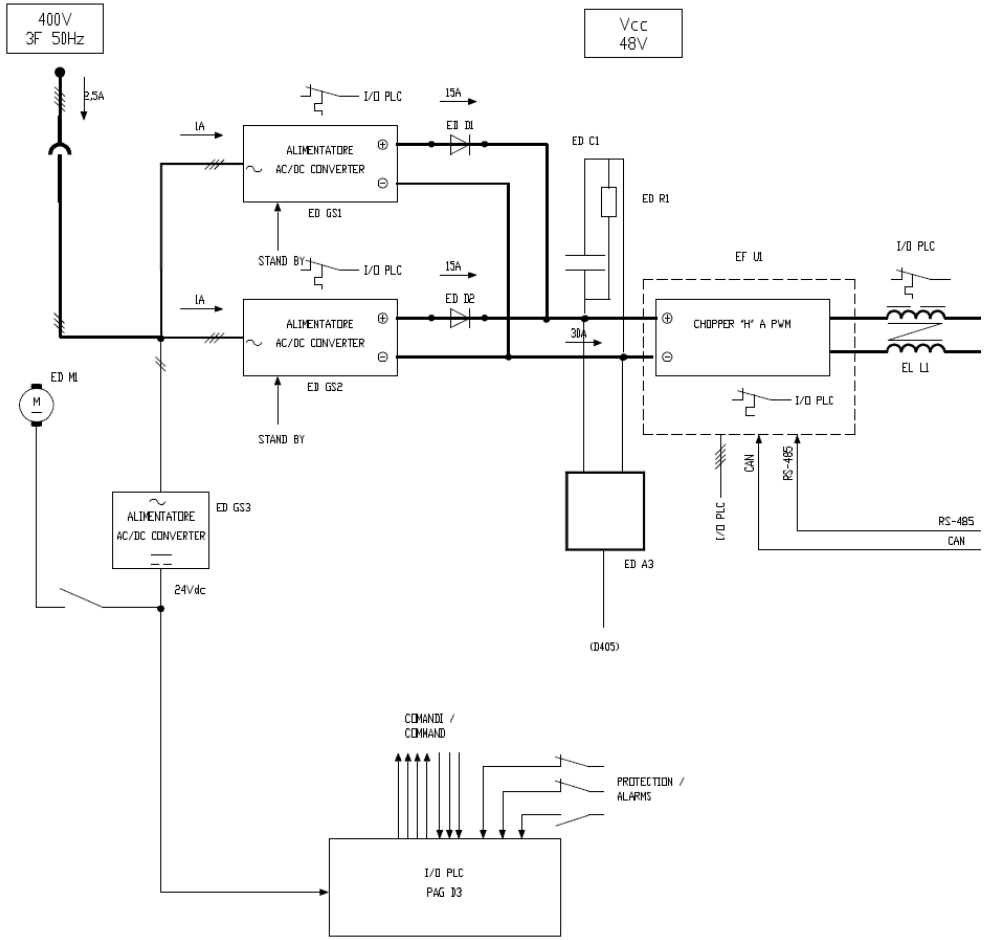
Family B1 power converters

- Dead time compensation ripple;
- Cabinet fans wrongly assembled;
- CAN BUS alarms;
- Faulty (R16R) current regulation board;
- Broken DC-link and system power supplies;



Family B1 PCO front panel

PULS AC/DC Switch Mode Power Supply

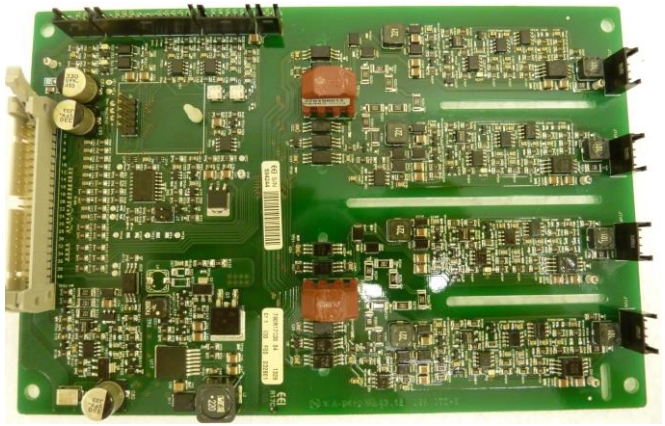


Family B1 wiring diagram

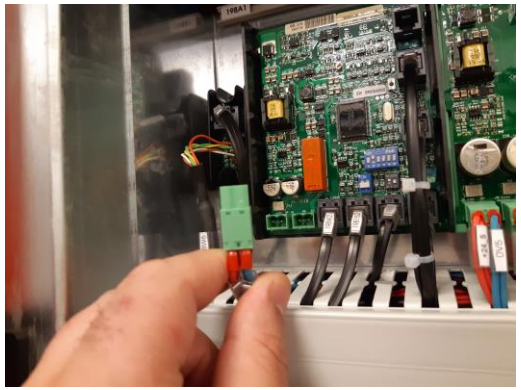
POWER CONVERTER INCIDENTS

Family B2, B3 & **B4 power converters**

- Broken PLC card;
- Loose connections Inside the power converter;
- Faulty (R17C3) IGBT boards;
- Main circuit breaker malfunction;



R17C3 IGBT driver board



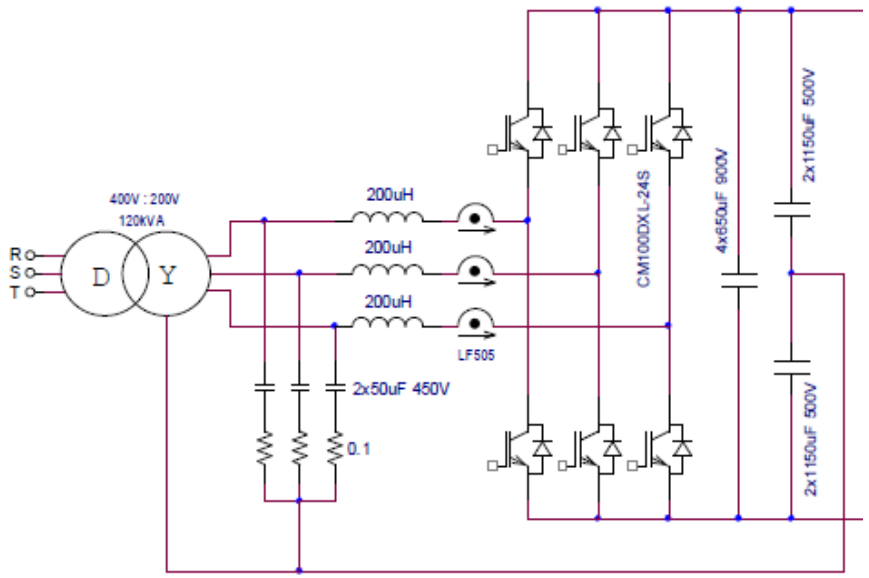
Family B2 PCO PLC card

Family B2 PCO PLC cards

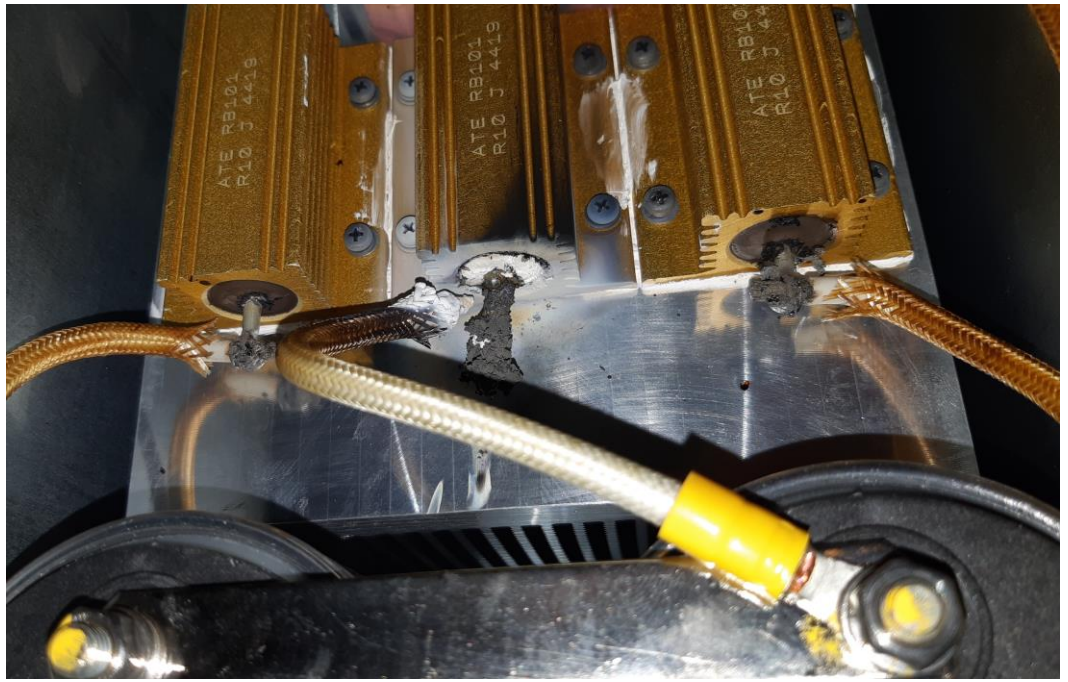
POWER CONVERTER INCIDENTS

Family C1 & **C2 power converters**

- High current on PWM filter;



Family C2 PCO wiring diagram

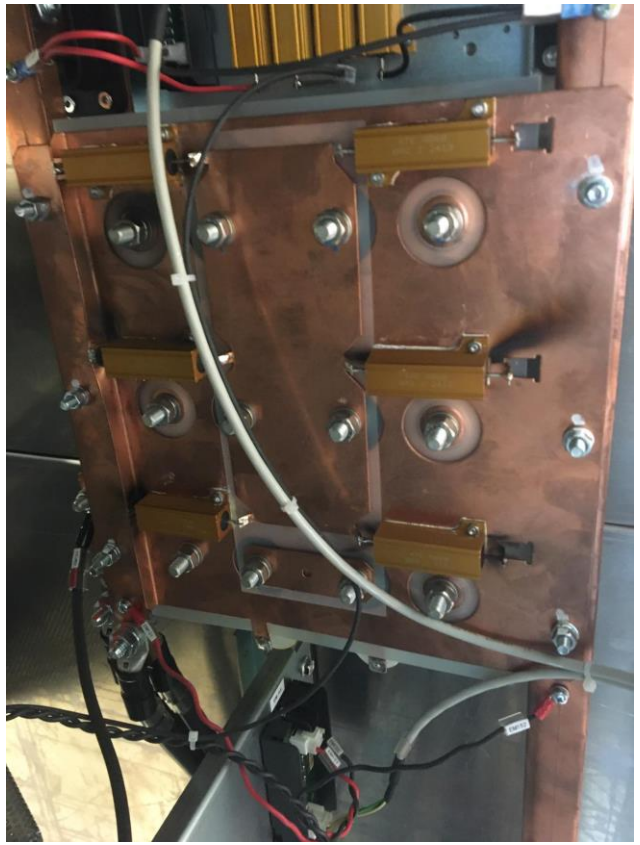


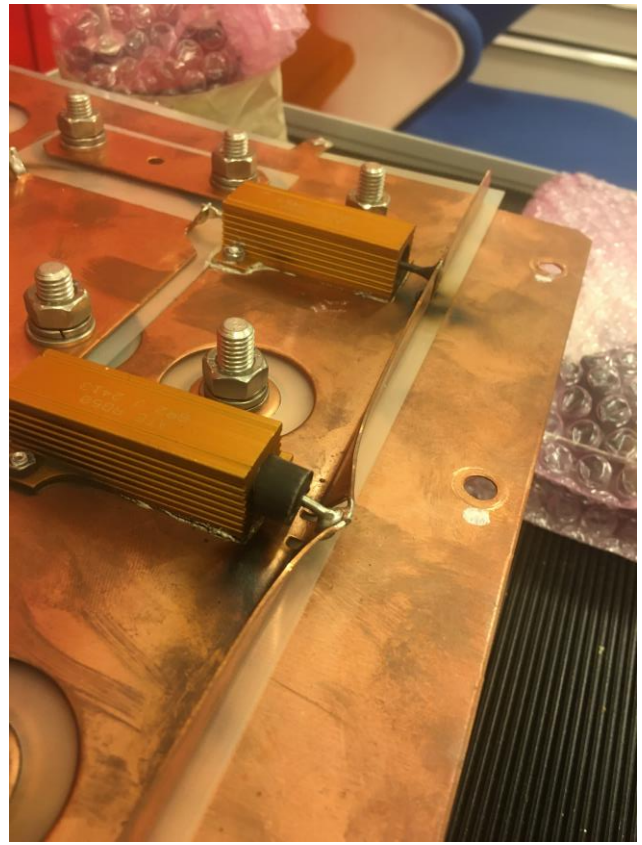
Broken resistors on PWM filter

POWER CONVERTER INCIDENTS

Family C1 & **C2 power converters**

- Weak output filter;
- CAN BUS alarm;
- AFE unbalanced current;
- IGBT driver;
- Dead zone compensation ripple;
- Current transducer board;





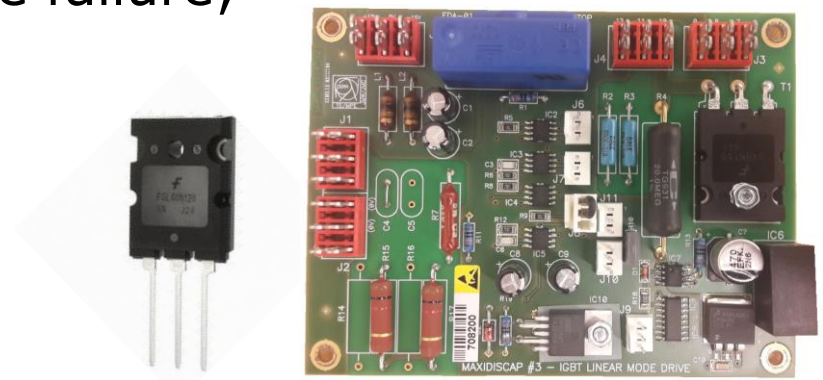
Family C1 PCO broken output filter

POWER CONVERTER INCIDENTS

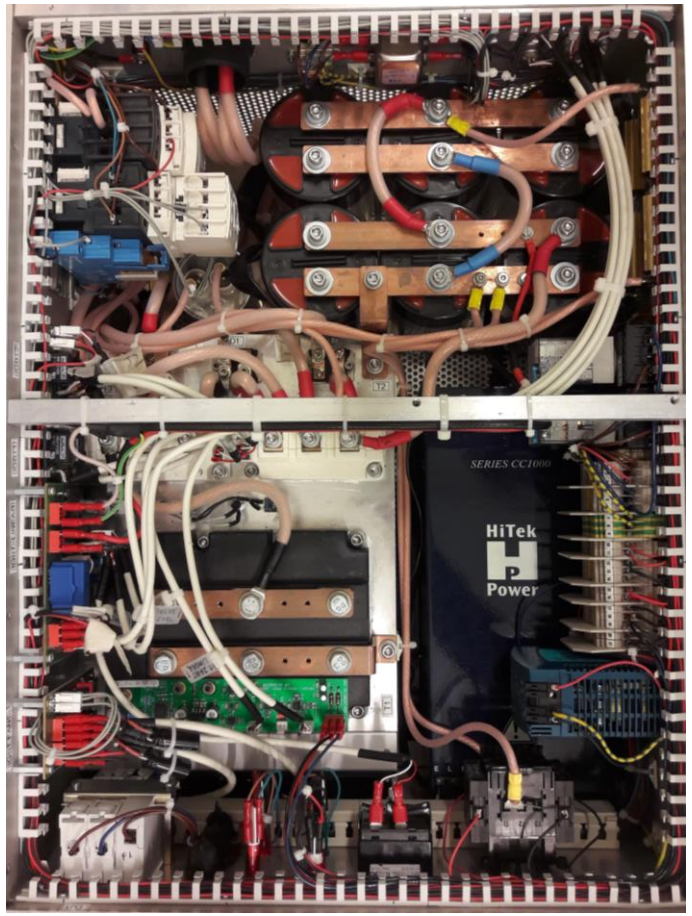
Family C3 power converters

- Defective Auxiliary contactor;
- Control card transients immunity;
- Main Circuit Breaker Wrong State;
- IGBT linear mode drive broken transistor;
- Hitek CC1000 Thermal fuse failure;
- Hitek CC1000 Faulty Fan;
- Relay bounce;

Hitek CC100 capacitor charger



IGBT linear mode drive card



MaxiDisCap power crate

POWER CONVERTER INCIDENTS

Family C4 & **C5 power converters**

- Clogged water system;
- Defective Mean Well PS;
- Jammed water pressure sensors;
- PLC software bug (stuck in transition);
- Several CAN BUS alarm;
- Defective IGB module (unbalanced output currents);
- Cabinet temperature overheats;

Family C4 clogged water pipe

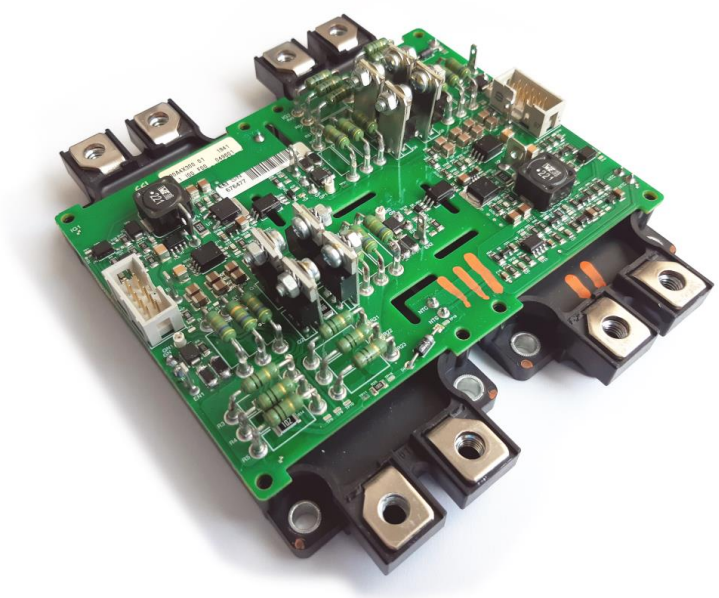
Mean Well TDR-960-48

Broken Mean Well TDR-960-48

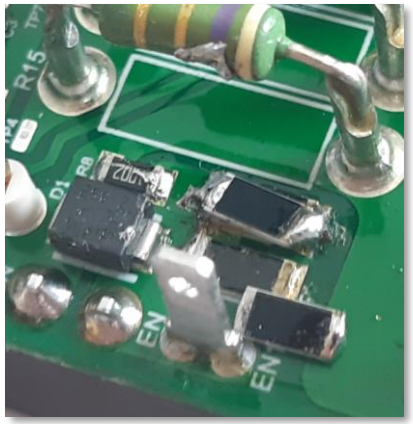
POWER CONVERTER INCIDENTS

Family D1 & **D2 power converters**

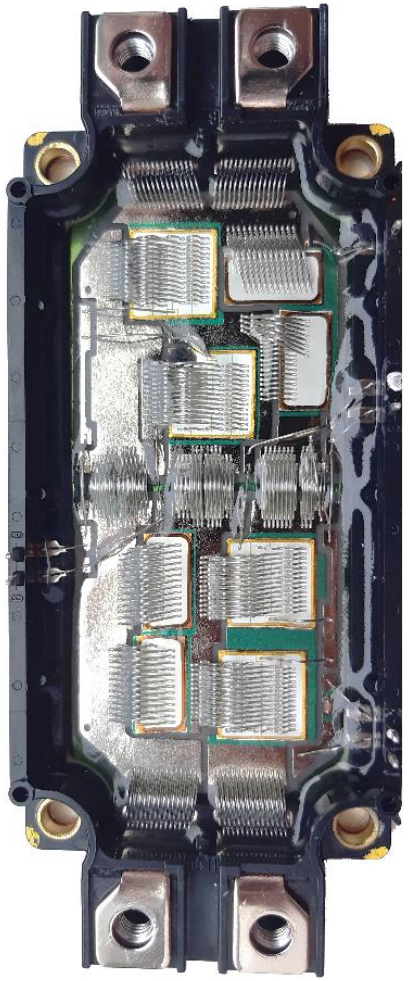
- IGBT gate driver card badly assembled;



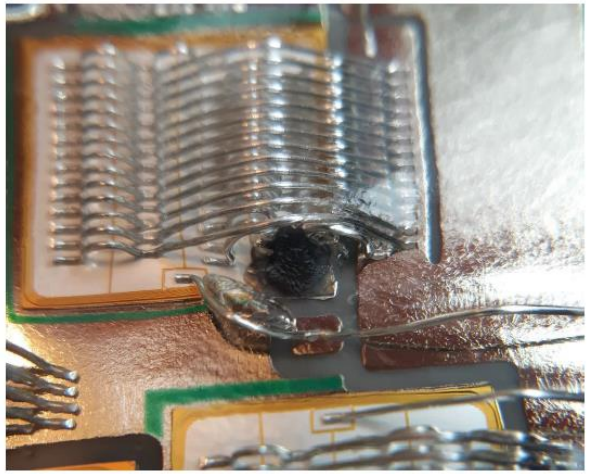
Family D IGBT module

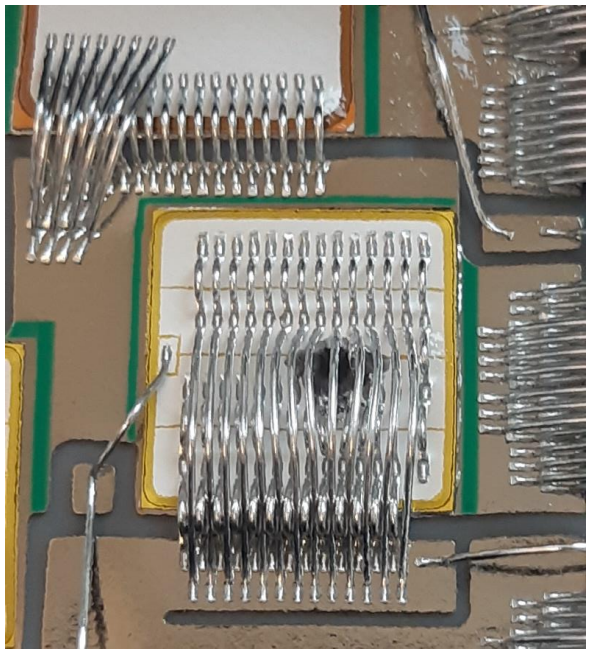


A4X30 board loose resistors



Mitsubishi CM600DX-24S1 (Half-bridge)





Broken IGBT detail

POWER CONVERTER INCIDENTS

Family D1 & **D2 power converters**

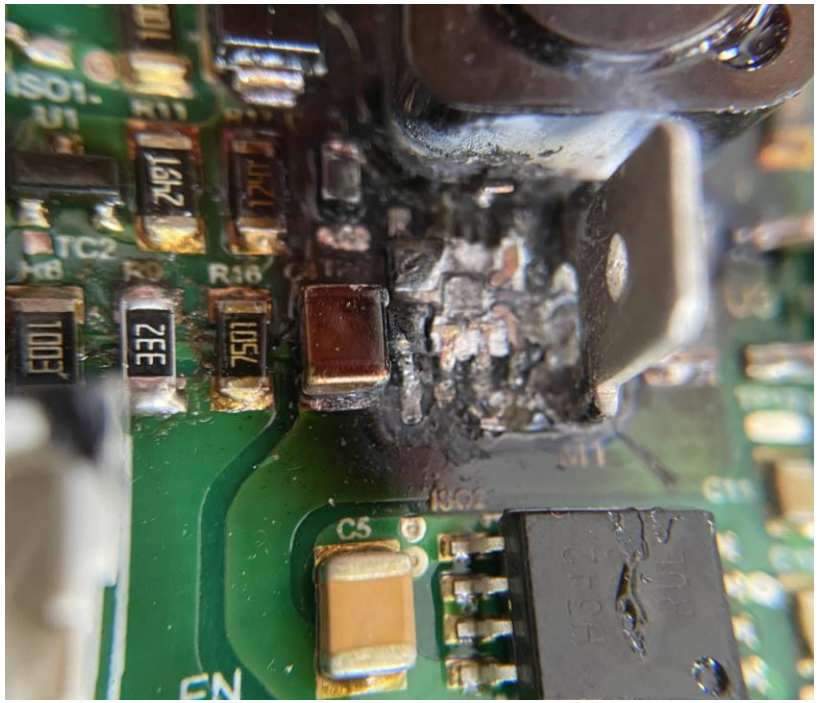
- PLC software bug (drivers protection);
- Noise sensibility;

Power converter fail as soon its cabinet door is closed!

POWER CONVERTER INCIDENTS

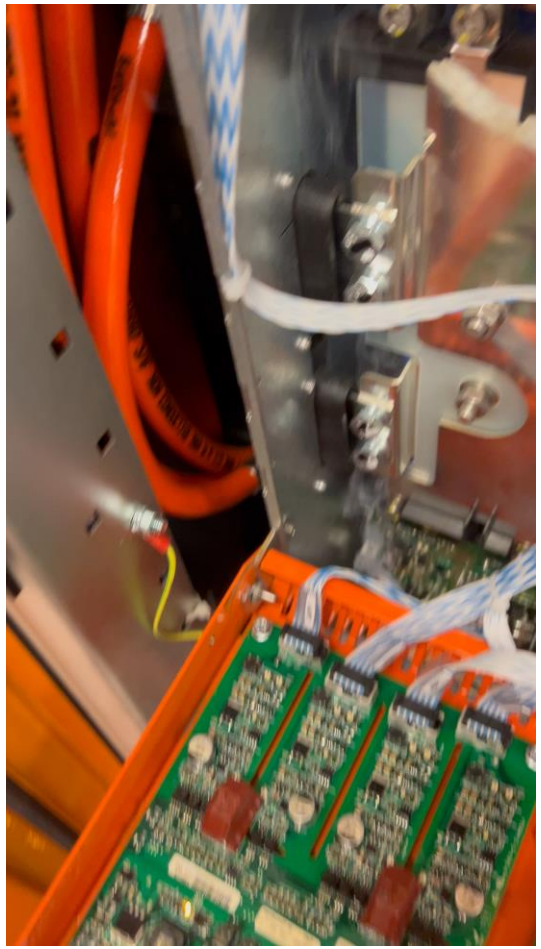
Family D1 & **D2 power converters**

- IGBT gate driver card SMPS burn;



Onsemi MC33063ADG SMPS

IGBT gate driver power supply burning!

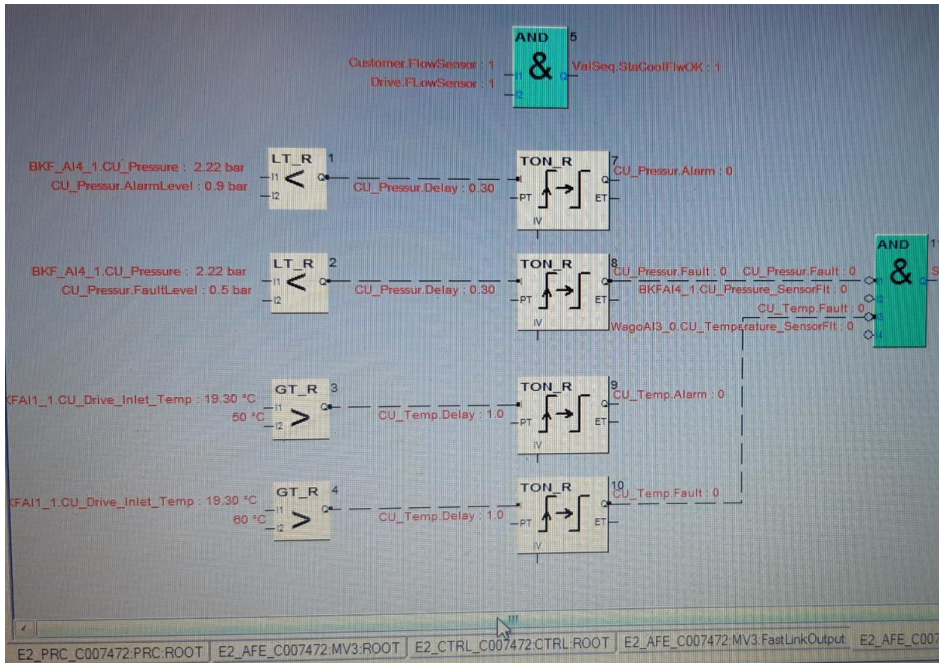


POWER CONVERTER INCIDENTS

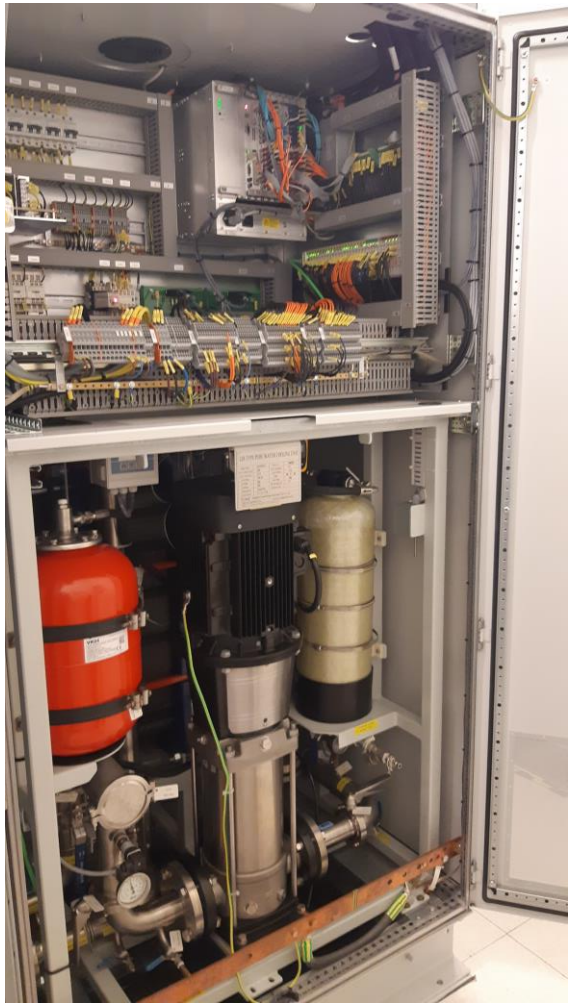
Family E1 power converter

- Water pump;
- Flow sensor;
- Water leaks;
- Software bug;
- Capacitor bank fan;
- Auxiliary contactor;

Water flow sensor



Family E1 cooling unit control software



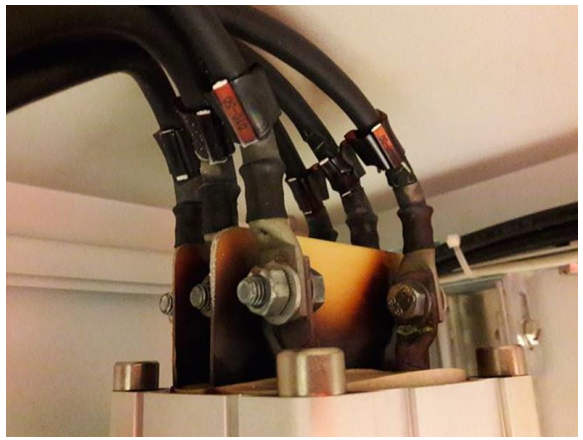
Family E1 PCO output cooling cabinet

POWER CONVERTER INCIDENTS

Family E2 power converter

- Sinus filter burn;
- Control cable routing;
- Water leaks;
- Faulty insulation monitoring device;
- Software bug (stuck in transition);

Socomec ISOM AM475

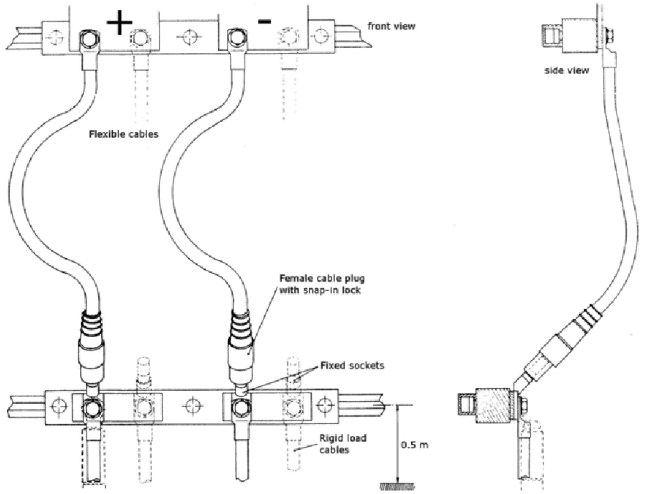


Sinus filter burnt resistor connections

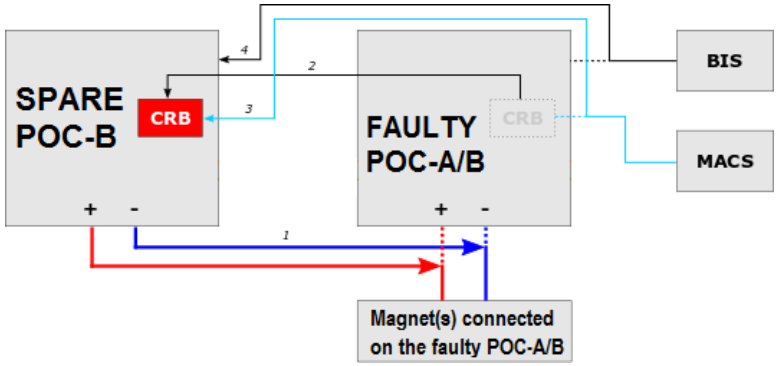
Family D2 PCO sinus filter resistor installation

IMPROVING POWER CONVERTER RELIABILITY

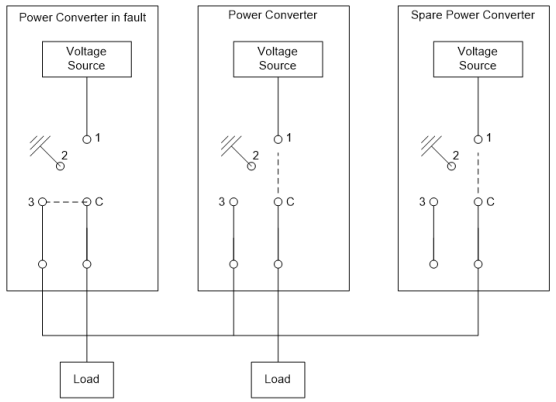
- Preventive maintenance;
- Continuous upgrade;
- New power converter design;
- Faulty power converter quick replacement:
  - Extension cables;
  - Output switch to a spare PCO;



Flexible output connections



Replacement of a faulty POC-A/B by a spare power converter diagram



Single-line diagram of the spare-converter

THANK YOU

"The unavoidable price of reliability is simplicity."

- Tony Hoare -