Power **L**ine **C**ommunication and EMI

PLC is OFDM based communication in frequency band 10kHz to 490KHz. In recent years it is used in marine aplications for communication on same wiring as power supply to control for example fire doors.

Using power wires for communication purpose is questionabl in my opinion.

Non shielded wires are prone to EMI from adjecent power cables. Harmonics (DC-2kHz) , superharmonics (2kHz-150kHz) and conducted EMI (150kHz-30MHz) from propulsion drives (if not properly designed) , LED drivers, switching power PS's and various drives (HVAC, PP's, etc) are EM coupled into PLC long cable runs.

Cummulative errors due to reduced OFDM S/N can lead to communication stop and closing of all fire doors in section/branch, and as consequence heavy doors can hit people/children.

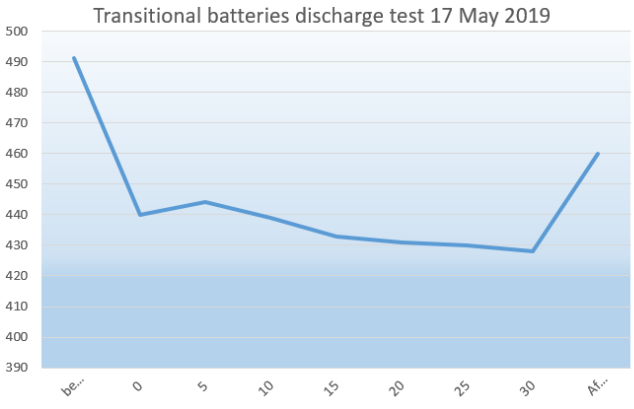
During commisioning phase and regulary during lifetime of vessel, all brenches should be monitored for EMI from adjecent cabling.

Battery related issues

Batteries in UPS's specialy transitional UPS (emergency lighting, critical consumers) should be regulary tested by full load discharge test. Apart from total Voltage drop curve check and each battery voltage check , it is recomended to do thermal survay of battery connections (lose connection check) and batteries housing for trace of cells overheating.

Time (min)	Voltage (Vdc)	Current(Idc)	UPS Load(kW)	Voltage(Vac)	Current(Sac)
before (trickle)	491	0	83,6	223	223
0	440	33	83,6	223	223
5	444	33	83,6	223	223
10	439	33	83,6	223	223
15	433	33	83,6	223	223
20	431	33	83,6	223	223
25	430	33	83,6	223	223
30	428	34	83,6	223	223
After(charge)	460	7	83,6	223	223

Room temperature	15 degC
Battery temperature	14 degC



UPS IGBT wear out danger

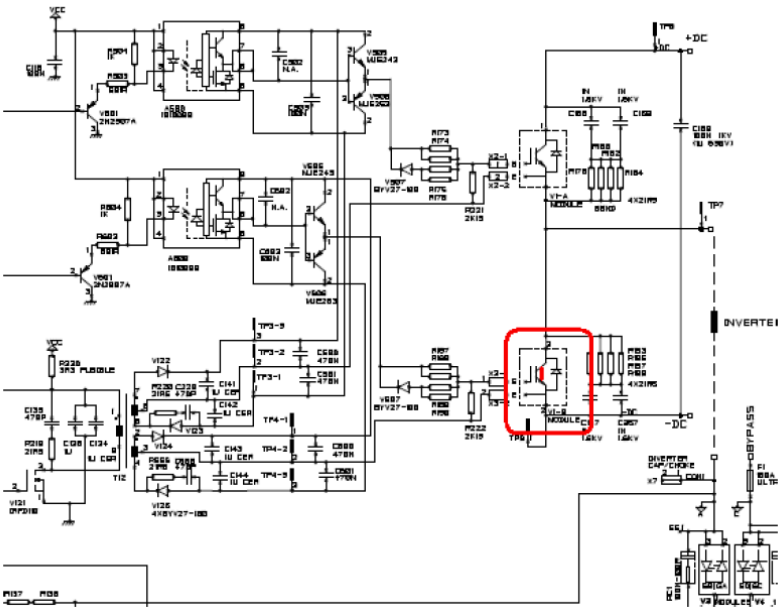
IGBT defects on UPS are nasty ones if IGBT shorts, due to DC voltage burning output consumers.

UPS supply is mandatory for switchboard control, drive control, automation, etc..

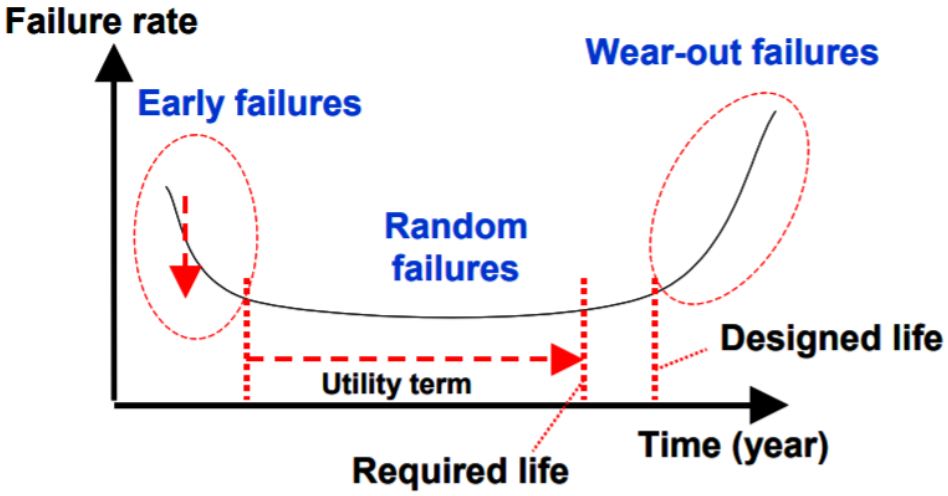
IGBT's have limited lifetime/operational cycles due to usage condition (over voltage, over temperature, Insulation failure), Power device defects (IGBT manufacturing defect, module internal wire bonds defects) and substrat defects (electromigration causing metalization, dielectric breakdown).

More info in latest study: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9316255

On one instance most of cycloconverter control cards(U/I propulsion motor stator and excitation phases feedback) have been burned, on another most of P/U/I/f transducers in switchboards.



IGBT can latch up and giving temporal DC on output, partly burning itself(fans) and consumers..



Only reliable UPS inverter output protection is isolation transformer and preventive maintatance according producer recomendadtions (Capacitors, batteries, fans replacement, control and power modules replacement). UPS lifetime for critical aplications should be 10 years. Cost of further maintanance and questionable reliability, overshoots new UPS purchase/installation.

PMS stabbility and aging process

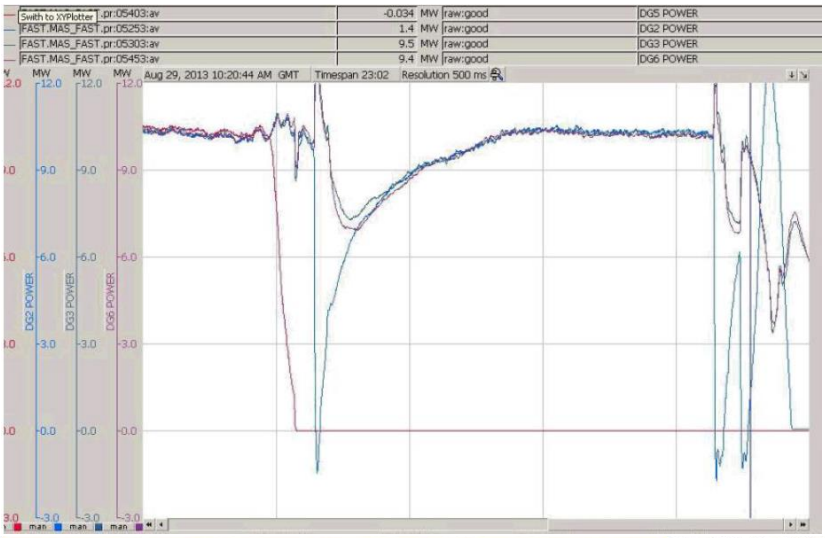
Stable PMS operation could be affected by aging process of its components. PMS should not be taken for granted by crew during manouverings and there shold always be enough 'reliable' gensets connected. Minimum 3 gensets should be connected in manouvering condition. Manouverings on margine with 2 gensets should be prohibited.

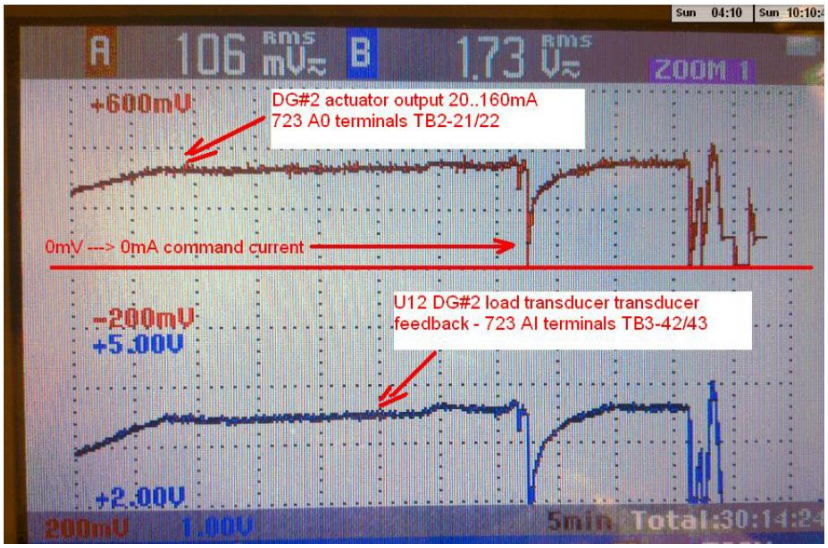
PMS issues:

Generators main breakers failures (mechanical issues, poles high resistance leading to breaker overheatting, loose connections in breaker feedback multiswitch, SF4 gase leackadge)

Synchronization issues due to mechanical/electrical prime moover speed control faults, fuel injection problems, frequency transducers aging/offsets

Gensets deloading: Aging of contactor coils in DG control pannel causing main breaker open feedback to Woodward723 and immediate command for generator deloading

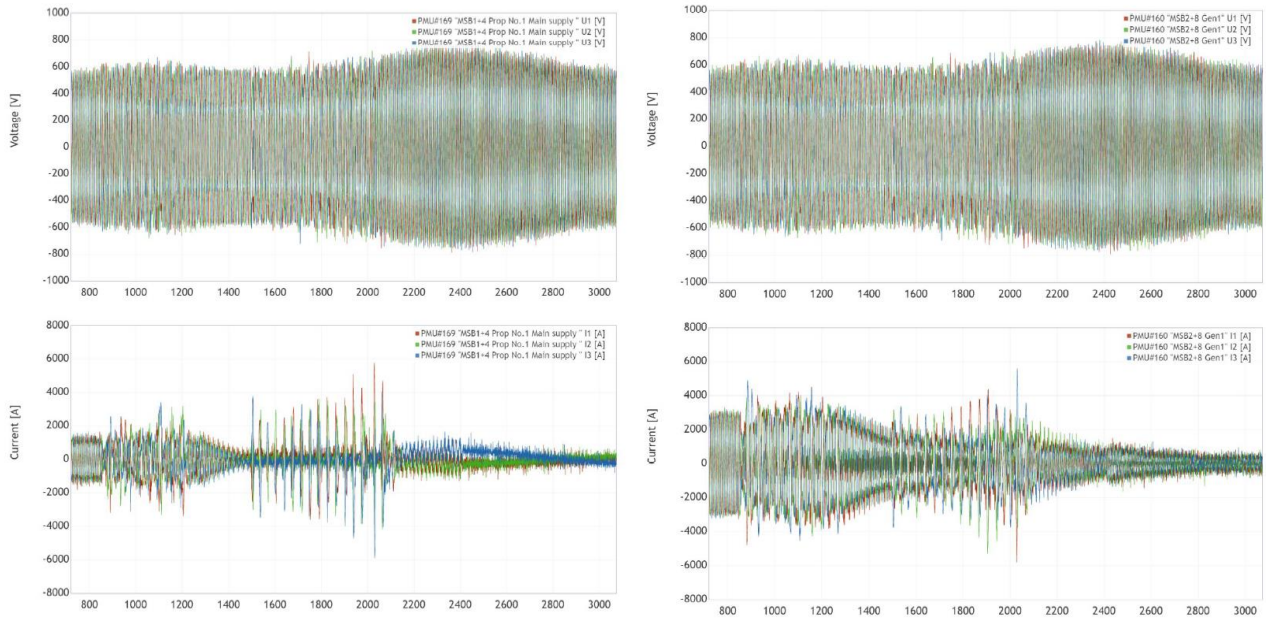




PMU/Synchrophasor analisys of PMS with STER PMU

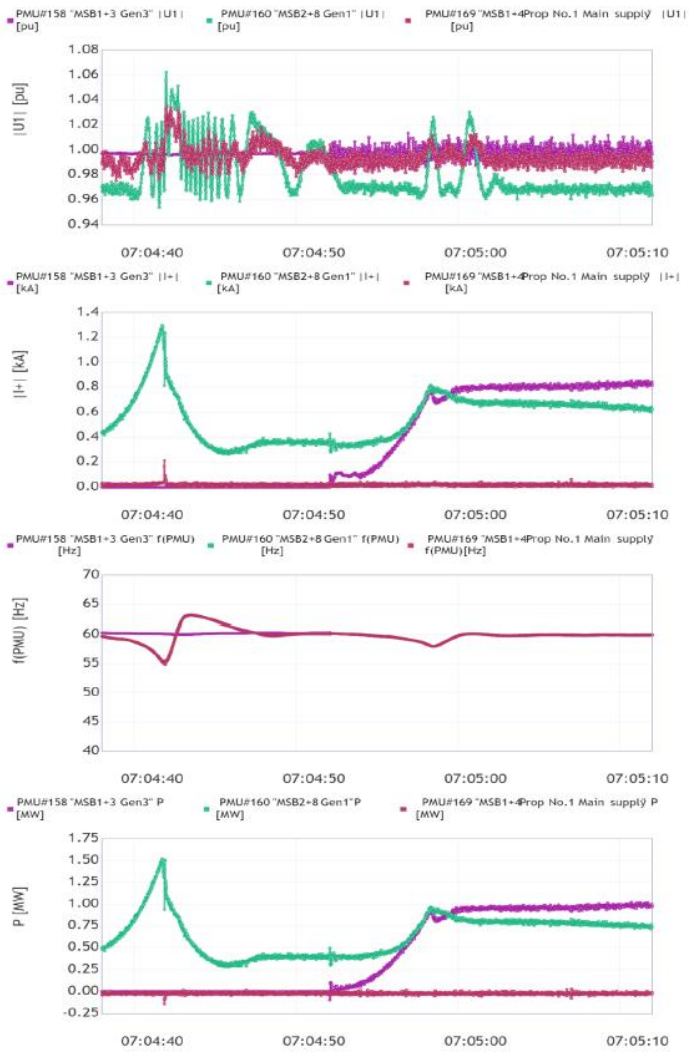
(http://www.wamster.net/w2/features/handheld-portable-pmu-device)

Regenerative power causing drive DC link overvoltage trips and gensets reverse power trips / absence of breaking resistor.



Triping drive

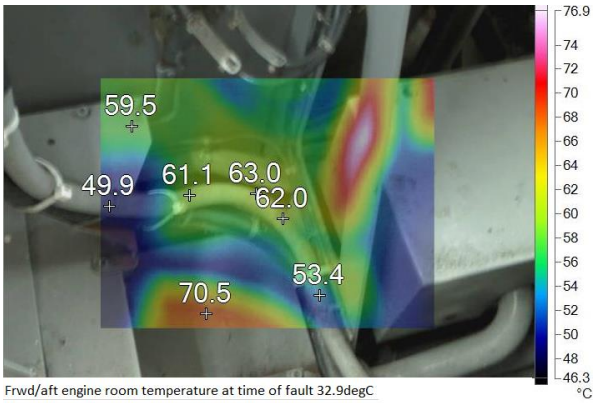
Triping genset



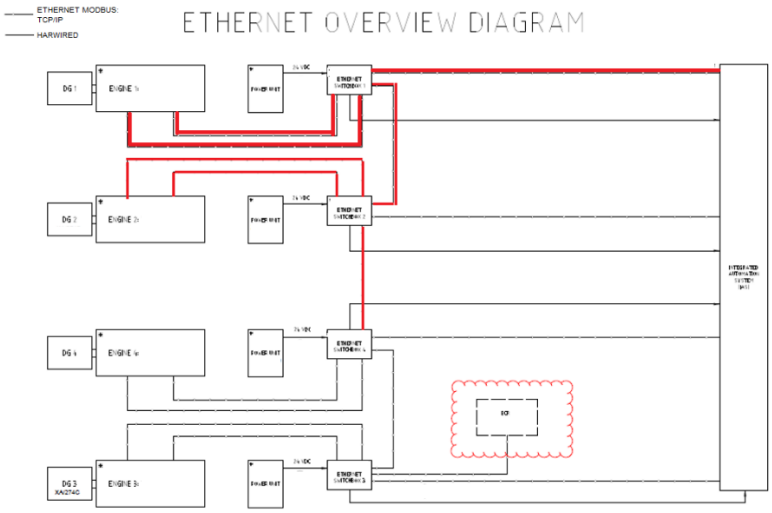
PMS stabilisation after starting another genset

Non Marine data cables issues

It is of very high importance to use Marine approved cables especialy for critical applications and areas. Below is case when Integrated Automation System lost communication with DG automation (TCP/IP Modbus). After rebooting engine controler, communication was restored. Earlier another engine communication alarm (engine automation to IAS) was received for short time as well. After investigation found that CAT5e cable used (Belden 1633ENH CAT 5E F/UTP LSNH) is not Marine type (not oil/chemmical resistant as well), with max allowed working temperature 60 degC . Afected communication cables ambient temperature near engine found to be more then 60 deg C (meassured with thermal camera Fluke Ti450).



Frwd/aft engine room temperature at time of fault 32.9degC

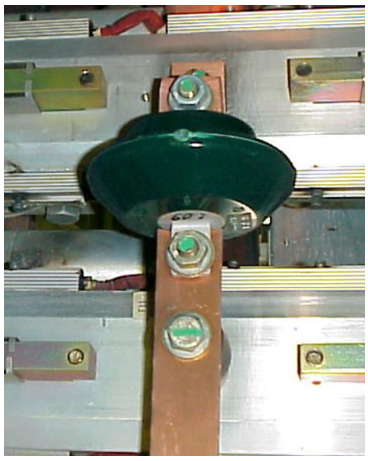


Due to unshielded pairs of cable and temperature limit of installed CAT 5e, high temp cause imbalance between the cable pairs, degrade electrical performance and increase susceptibility to ambient EMI/RFI. As consequence increased data transmition errors caused stop of communication between engine automation and ship automation system (IAS). The rated operating temperature of the insulating material shall be at least 10 °C higher than the maximum ambient temperature likely to exist, or to be produced, in the space where the cable is installed. (***Ref. IEC 61892-4, sec. 4.10***).

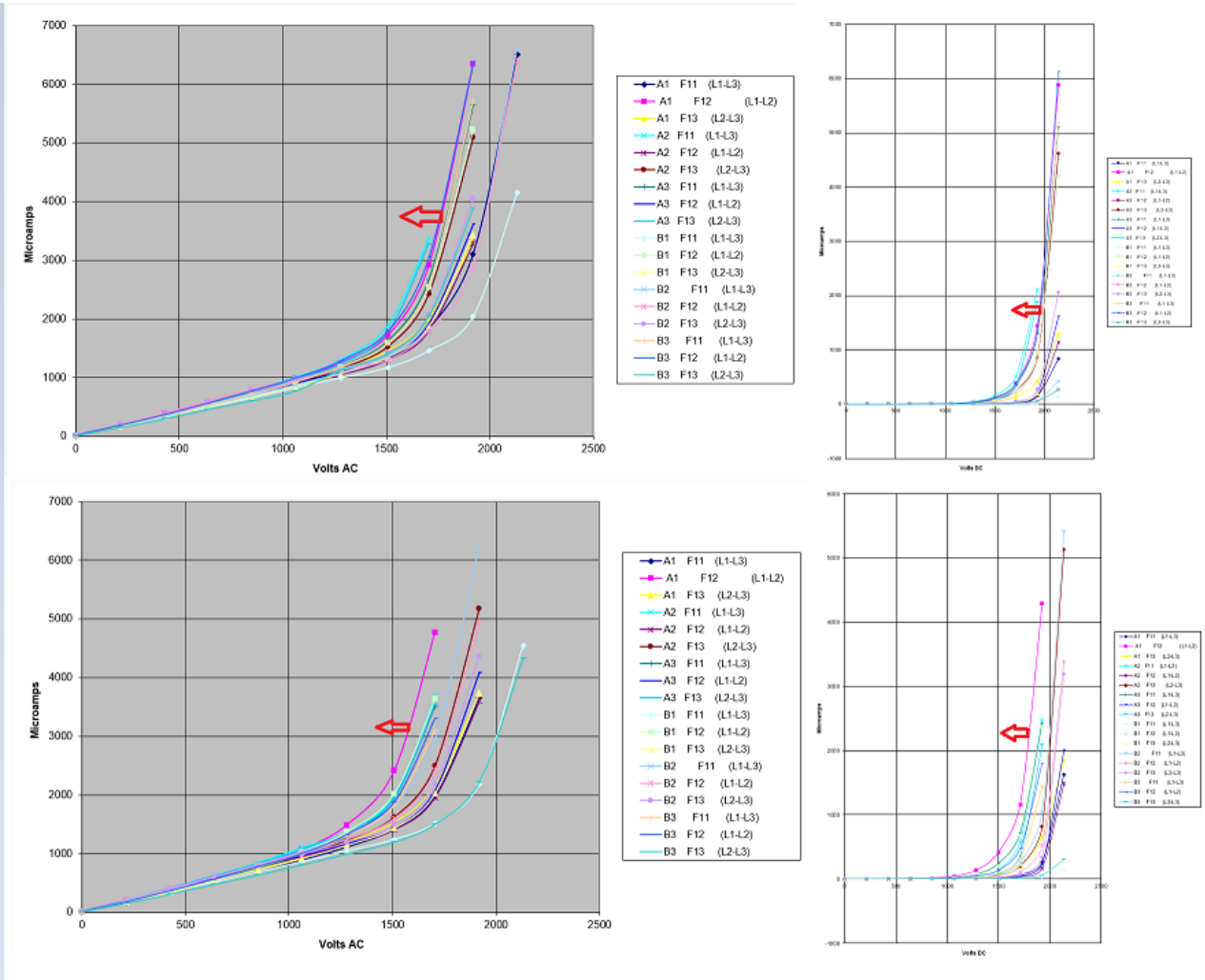
Danger of drive explosions due to Drifting of Varistor characteristic

Varistors are used for drive/net surge protection and are mounted between phases of drive supply.

Degradation/drifting of varistor AC/DC characteristic is aging process due to pulse current stresses on varistor material (positively charged ions in the depletion layer) and is too litle know in Marine sector.



Explosion of Varistor



Meassured AC/DC characteristic drift(leackage current increase) in one year period (cycloconverter A1 phase, F12 varistor between phases L1 & L2). If not replaced in time, AC/DC characteristic can drift up to point of Varistor explosion.

Surge Protection Device issues

Varistors are widely used as Surge Protection Devices in electronics power supplies (automation, IT, entertainment,etc.) and in power strips. PQ/EMI issues can accelerate agging of varistors. Increased rate of power supplies failures indicating network PQ/EMI problems. Power strips with SPD protecting one conductor only should not to be used onboard (Microsoft Word - 03-13b.docx (uscg.mil)). From experience, power strips should be without SPD due to varistor drifting phenomena. Increase in varistor (SPD) residual current (heatting) can be checked with thermographic surway. Power cords are usally hidden and their overheating can not be seen until they melt power strip or cause fire.

EPROM charge leackage issues

Not well known phenomena is charge leackage in EEPROMs and EPROMs chips. Due to floating gate space charge leackage, manufacturers specifies data retention time of their products from 10-20 years.

Due to charge leackage phenomena, not only running equipment will eventialy fail, but spare parts shell time is also limited. What does it means? Experience from the field (cycloconverter drive, SIMOS 31 automation failures) shows that if You have aged equipment and thinking You are safe having good stock, think again..

Back in 2001, repair of SIMOS 31 was done by cooling down EPROM's (reducing thermal efects on remaining gate space charge) downloading and reprograming new EPROM with 'cold code'.

ABB cycloconverter PSR CPU failure happened in one of most remote part of the world. By cooling affected CPU card EPROMS drive started, but went in fault when EPROM heated up. From 2 spare cards, only one was not working, spare card assembler code was checked on drive (service card SD A338) using original code received from ABB.