



Power Supplies for XFEL



Structure



Types of power supplies

- Super / normal conducting
- Correctors=Steerers

Regulation

- Accuracy/Resolution

Numbers

Location

Reliability/Redundancy concept



Definition of types



There are three different categories of power supplies

- Small power supplies for superconducting magnets and steerers (correctors) :
 - 0 – 50 A, 0 – 10V, 0-10 A, 0 – 60V
- Medium size power supplies (mainly for Quads):
 - 0 – 200 A, 0 – 400 A, up to 150 V
- Large size power supplies (mainly for dipoles):
 - Above 400A, above 150 V



Regulation



- All power supplies will be equipped with full digital regulation
- based on Altera FPGA
- Resolution 20 bit for the reference value
- Accuracy $5 * 10^{-4}$ ($\Delta I/I_{nom}$ long term stability)



Special features



- Internet Access for remote diagnosis
- CAN bus interface to the control system
- Internal 24 bit resolution of ADC,
- 18 bit accuracy for regulation
- Self calibrating for high precision
- Self cable check for commissioning
- Check of magnet impedance for quench protection



Supercond.magnet power supplies and steerer



Switched mode power supply zero voltage/zero current

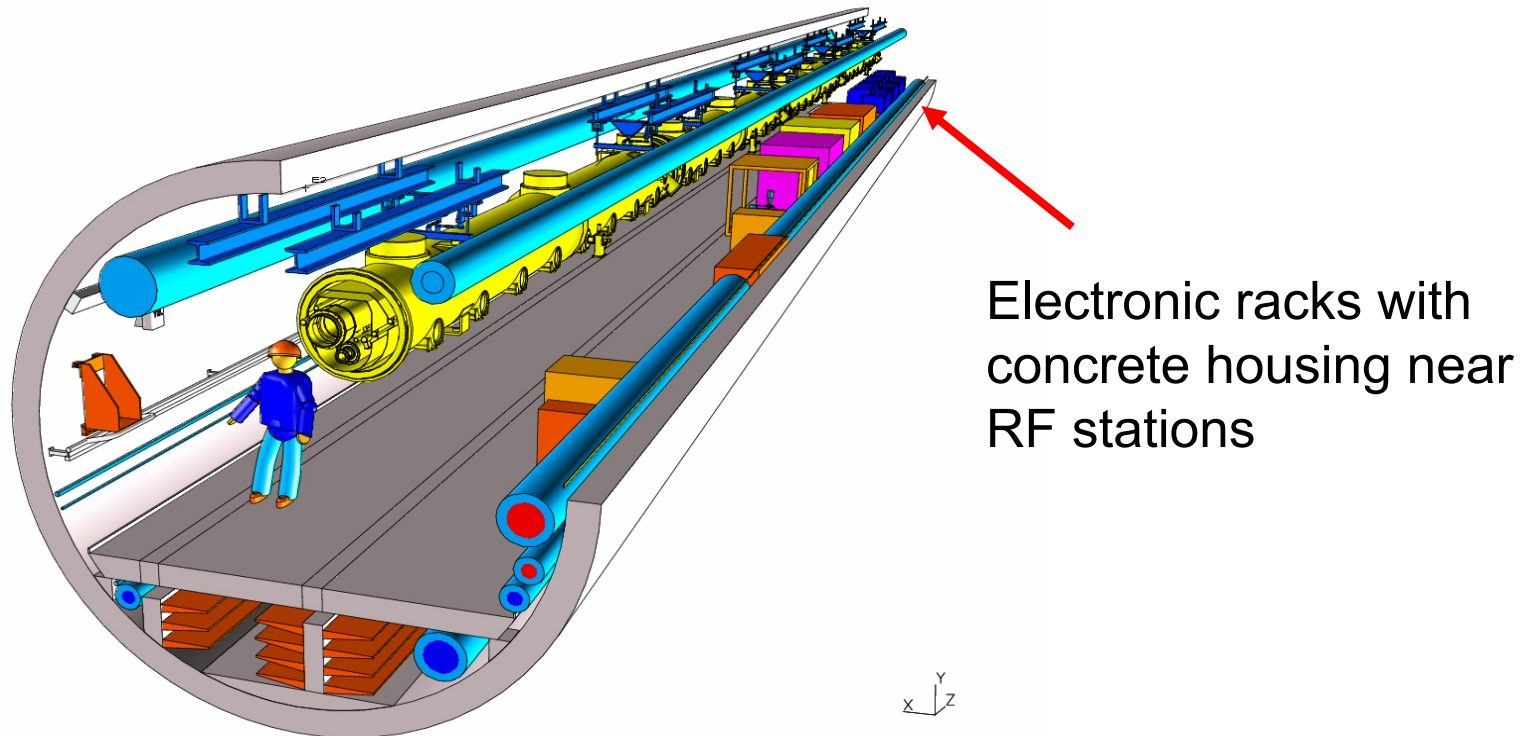
Superconducting quads	120
Superconducting steerer	120
Nominal current	50 A
Voltage	10 V
Steerer	580 in operation
Nominal current	10 A
Voltage	60 V



Location of the PS for sc. magnets



- Due to the large number of units and the distribution along the tunnel these power supplies will be placed inside the tunnel in electronic racks
- The racks will be protected against radiation by concrete housings
- Prototypes of the racks are ready
 - These have internal air/water heat exchangers to take the heat out of the racks and out of the tunnel



Electronic racks with
concrete housing near
RF stations

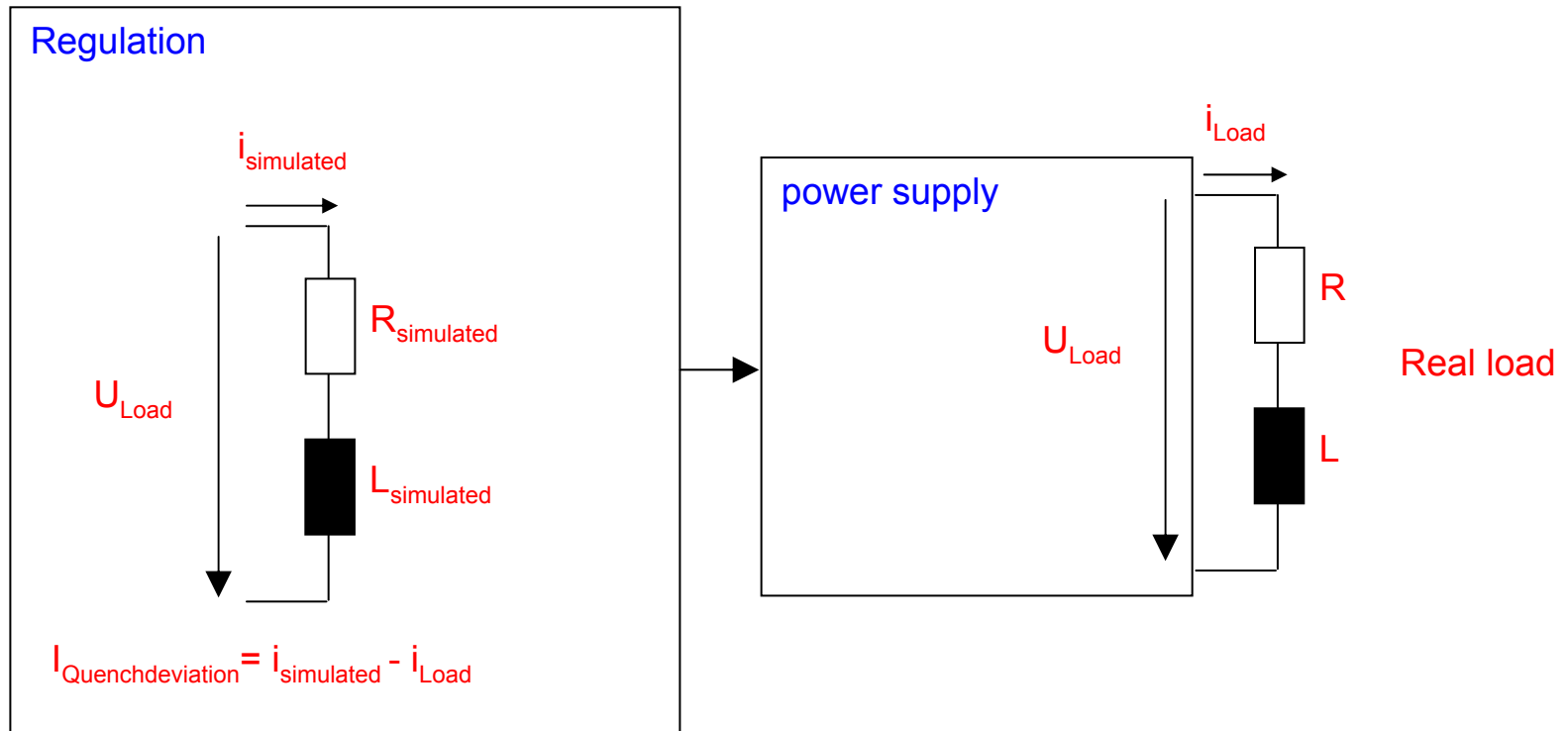


Quenchprotection



- Inductance of the magnet
 - QPs 1.15 H
 - Steerer 0.625 H
- Time constants
 - App. 20 – 40 sec
- The max. stored energy will be max.1500 J. This is less than 10 % of the stored energy in the magnets installed in FLASH
- It has to be checked whether additional hardware is required for the quench case. A solution with resistors that can be switched into the load circuit is ready.

Self calibrating load simulation and interlock



Web page:

62IQuenchDeviation:131032bit=-0.03662100A



Reliability concept



Since the PS is installed inside the tunnel with no access to the units

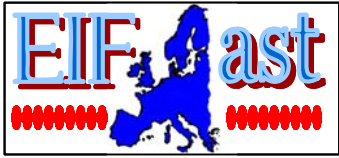
- A good diagnostic shall be installed
- The power part has to be redundant and in modules
- Access via control system, standard internet browser
- Fast reparability due to short maintenance time



Power supply in FLASH (former TTF)

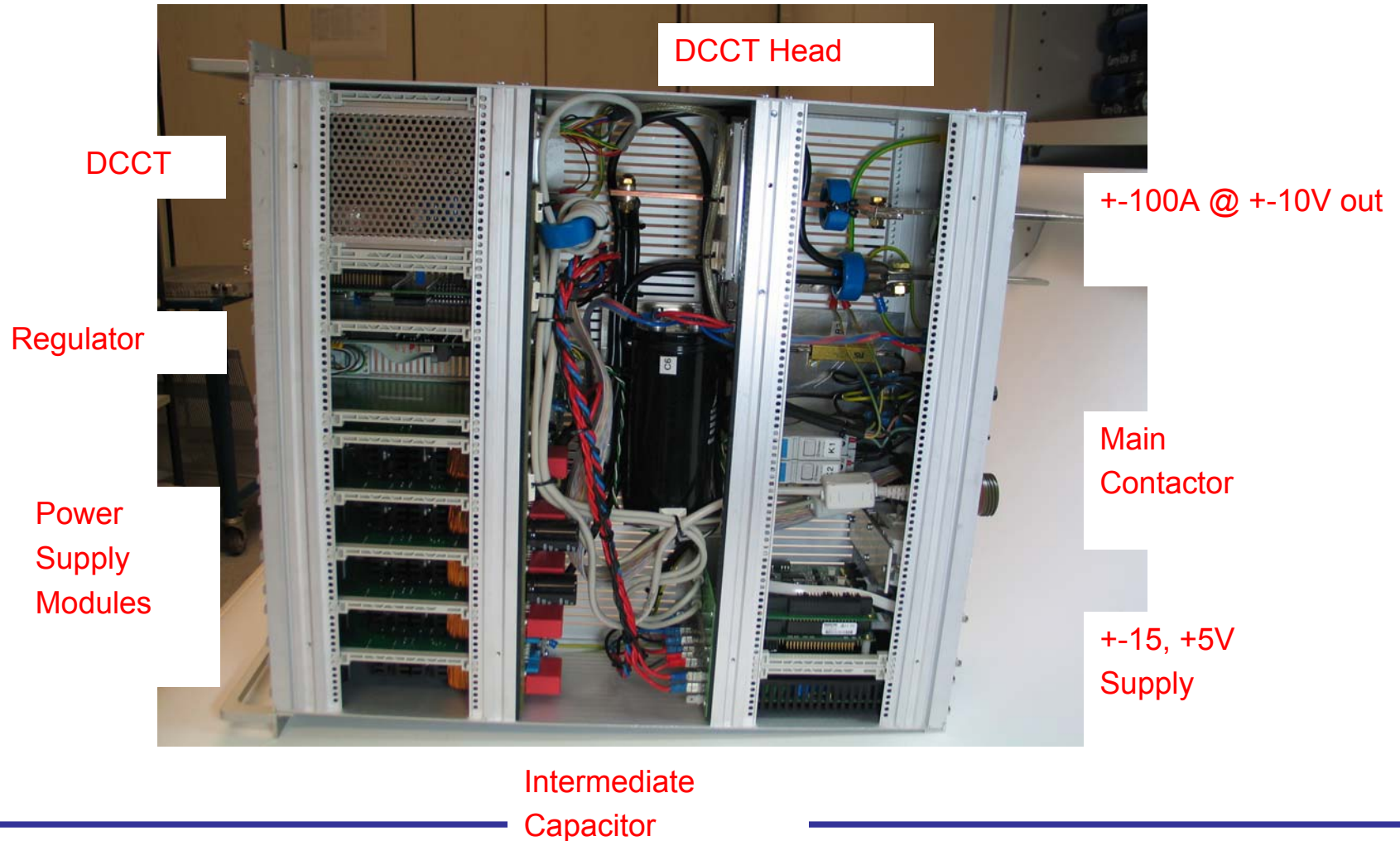


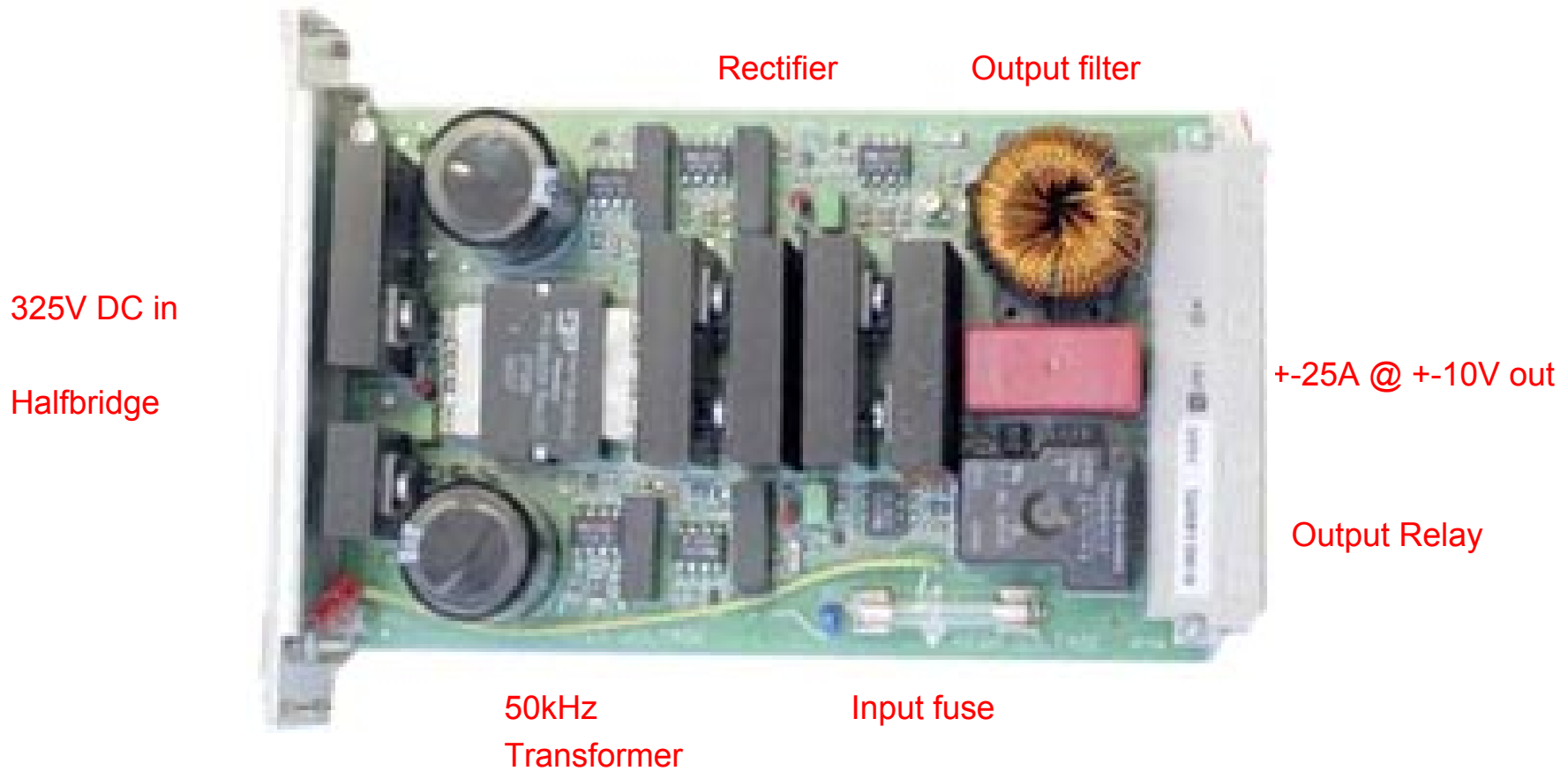
Already 50 units are working for
more than a year with very low



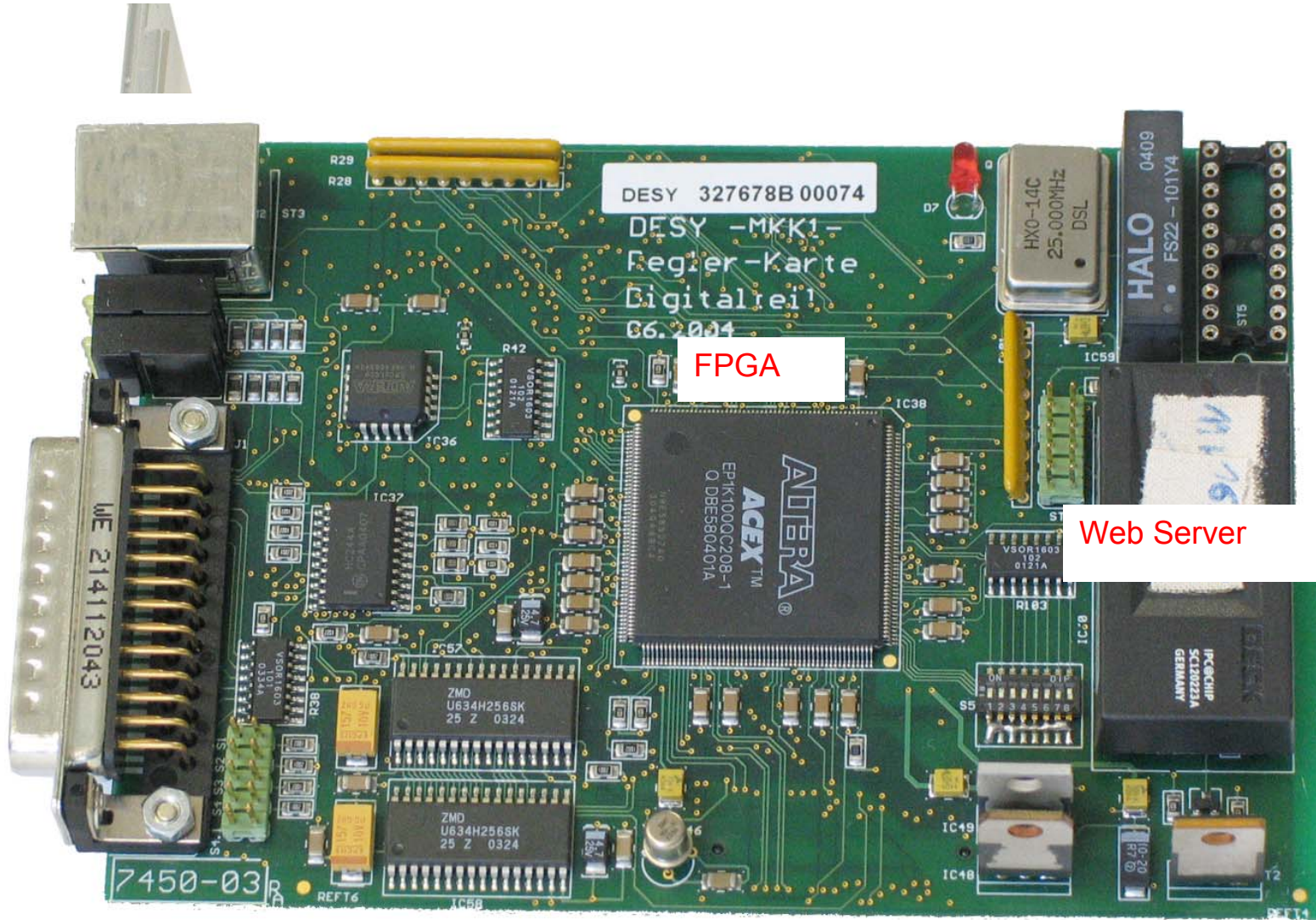
Power Supply for FLASH +/-100A, +/-10V







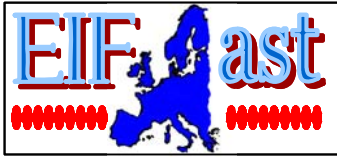
Ethernet



FPGA

Web Server

Temperature Sensor



Regulator board HTML access



Regulation
parameters

Derived
data

0 ReferenceCurrents [A] [help](#)

5 SwapSpeed [s]

20000 DrivingSpeed [s/11.25kA]

5000 200 PI CurrentRegulator

100 100 PI VoltageRegulator

31567 SupplyVoltageOffset

3634 14 PT1 QuenchSimulation

4098 0 ControlRegister

niels.heidbrook@desy.de Mailaddress

No Action

[q9acc1/ttf help](#)

Output Power= +0.00043242kW

Load Resistance= +0.04725910Ohm

DilSwitch1-5:CurrentLimit:+18.7500000A

ModuleDetected.....1Fail 2OK 3Fail 4OK 5Fail

TemperatureModule:1OK 2OK 3OK 4OK 5OK

StoredTemperature:1OK 2OK 3OK 4OK 5OK

PulsesInWindow.....1Fail 2OK 3Fail 4OK 5Fail

PulsesDoTurnOff.....1OK 2OK 3OK 4OK 5OK

IPCDisabled (Führung MST,PSC3)

FrontpanelSwitch1:LED-Anzeige:Fehler

FrontpanelSwitch2:List-Isoll

FrontpanelSwitch3:Reset

FrontpanelSwitch4:HauptschutzFreigabe

DilSwitch8:PulseInterlockEnabled

DilSwitch7:OptocouplerInterlockEnabled

DilSwitch6:QuenchEnabled

MagnetEnable(MagnetFreigabe) OK

Magnetstoerung OK

DCCT(OrOptocouplerInReserve2) OK

Key OK

0AdcTemperature:139bit=+18.8181810°C

1ReferenceCurrent:134376bit=+3.02490218A

2LoadCurrent:134376bit=+3.02490218A

3LoadCurrent2:262143bit=+119.999078A

4PowerSupplySteeringSignal:3530bit

5OffsetAdcA:1312bit=+1.20117181A

6GainAdcA:131913bit=-13.6248772A

7OffsetAdcB:1904bit=+1.74316397A

8GainAdcB:257032bit=+100.924982A

9Switches:7177bit

10ErrorAltera1:0bit

11LoadDeviation+:131073bit=+0.00091550A

12LoadDeviation-:131071bit=-0.00091550A

13Altera1SoftwareVersion:30bit

14AdcAToBOffset:0bit=-119.999993A

15ADCCalibrationDataInRam:506bit

16AutoRefCurrent:134376bit=+3.02490218A

17DrivingSpeed:20000bit

18PCurrentRegulator:5000bit

19ICurrentRegulator:200bit

20PVoltageRegulator:100bit

21IVoltageRegulator:100bit

22SupplyVoltageOffset:31567bit

23PQuenchSimulation:3634bit

24T1QuenchSimulation:14bit [help](#)

25ControlRegister1:4098bit

26ControlRegister2:0bit

27AdcCalibrationData:260670bit

28Reserve:260670bit

29PSCmirror-telegram:192bit

30PSCcommandRegister:3bit

31InternalMeasurement24:1bit

LengthOfThisPage:1394

32SupplyVoltage:57189bit=+320.470931V

33LoadVoltage:32988bit=+0.14422380V

34TemperaturePS1:0bit

35TemperaturePS2:149bit=+23.3636360°C

36TemperaturePS3:0bit

37TemperaturePS4:147bit=+22.4545450°C

38TemperaturePS5:0bit

39OverTemperature:0bit

40PulsesNotOkModule:693bit

41PulseDelayPS1:Start20ns_End0ns

42PulseDelayPS2:Start620ns_End600ns

43PulseDelayPS3:Start20ns_End0ns

44PulseDelayPS4:Start620ns_End600ns

45PulseDelayPS5:Start20ns_End0ns

46TripRangeStart:Start520ns_End720ns

47TripRangeEnd:Start480ns_End740ns

48DetailedPulsesNotOkModule:672bit

49HalfBridgePositionAtError:31744bit

50RectifierPositionAtError:32767bit

51Regulator15V:2888bit=+15.2000000V

52Regulator5V:2099bit=+5.07004830V

53Regulator3.3V:2702bit=+3.29110840V

54Regulator2.5V:2069bit=+2.52625152V

55OptocouplerSignals:16bit

56AutoResetTimes:1bit [help](#)

57SupplyRipple:129bit=+0.72287940V

58LoadRipple:31bit=+0.02023040V

59AbsoluteSteeringSignal:17bit

60QuenchLoadResistance:3634bit

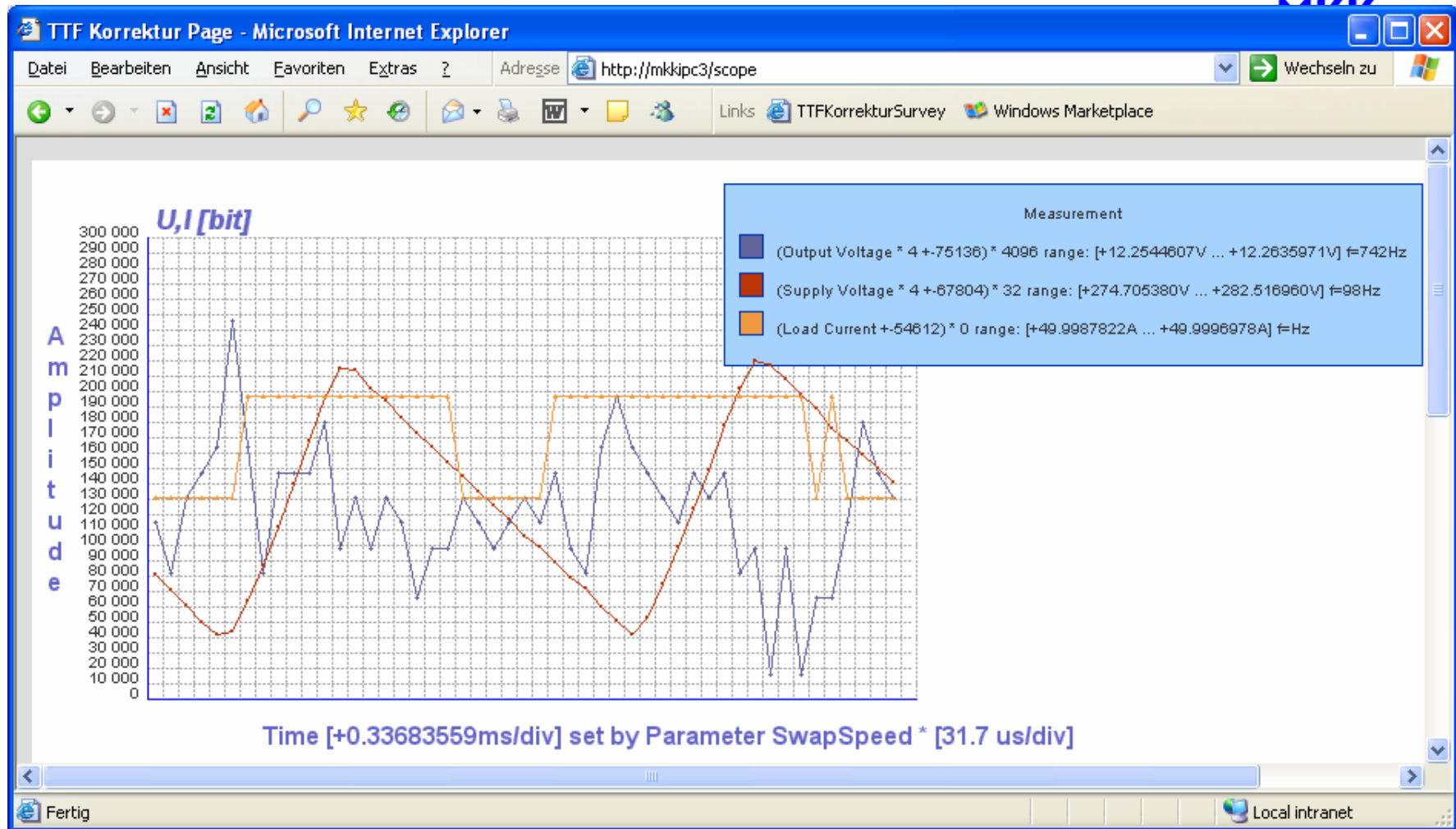
61QuenchTimeconstant:14bit

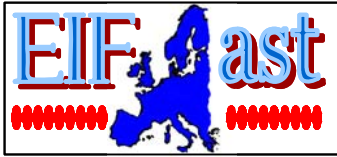
62IQuenchDeviation:130824bit=-0.22705070A

63InternalMeasurement54:1032bit

LengthOfThisPage:1457

FPGA
data





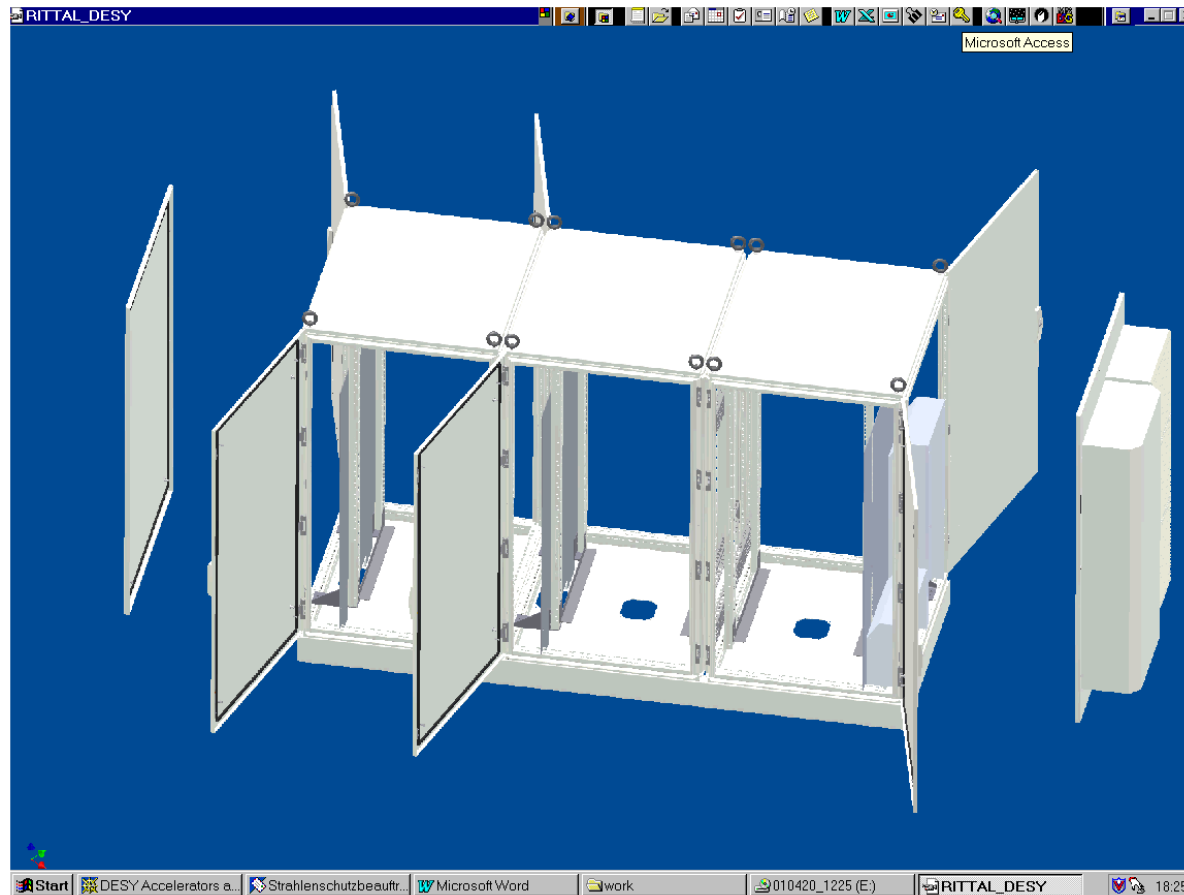
Error messages by email

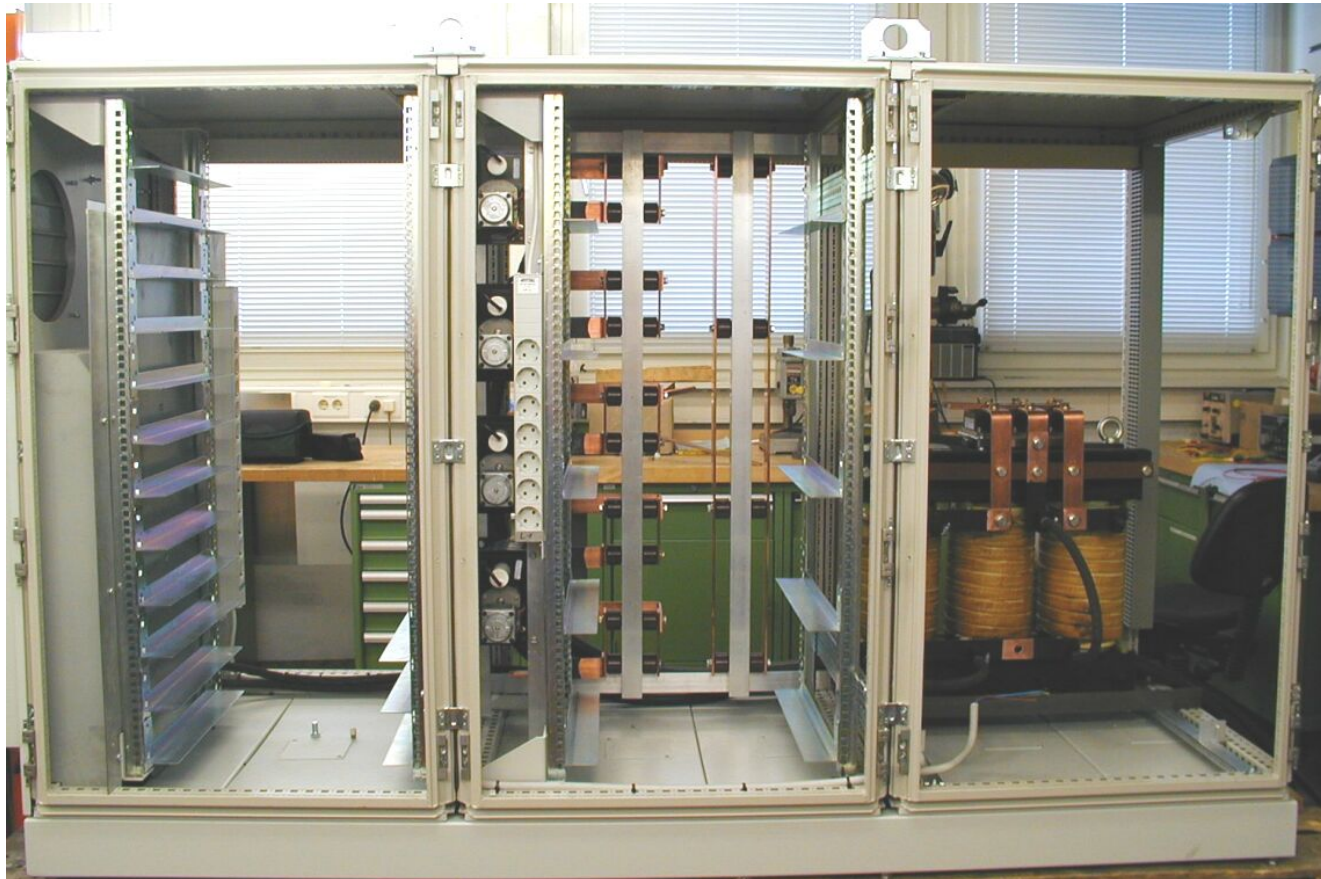


Von: mkkipc3@spamlock4.desy.de
Betreff: QuenchTooFewPSModulesForCurrent
An: Heidbrook, Niels
Cc:

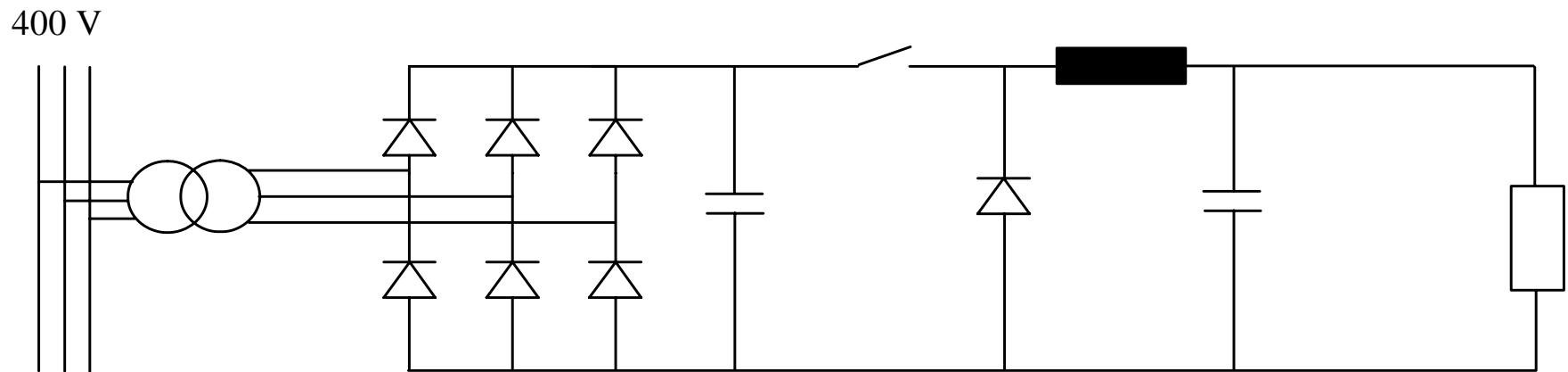
Parameter	Value
0AdcTemperature:190bit	+42.00000000°C
1ReferenceCurrent:131072bit	+0.00000000A
2LoadCurrent:131074bit	+0.00183100A
3LoadCurrent2:26952bit	-95.3247127A
4PowerSupplySteeringSignal:0bit	
5OffsetAdcA:2217bit	+2.02972424A
6GainAdcA:257010bit	+100.904852A
7OffsetAdcB:261944bit	-0.18310540A
8GainAdcB:261796bit	+105.286566A
9Switches:64575bit	
10ErrorAltera1:128bit	
11LoadDeviation+:131074bit	+0.00183100A
12LoadDeviation-:131073bit	+0.00091550A
13Altera1SoftwareVersion:33bit	
14AdcAToBOffset:0bit	-120.000007A
15ADCCalibrationDataInRam:501bit	
16AutoRefCurrent:132164bit	+0.99975590A
17DrivingSpeed:100bit	
18PCurrentRegulator:20bit	
19ICurrentRegulator:20bit	
20PVoltageRegulator:10bit	
21IVoltageRegulator:10bit	
32SupplyVoltage:52454bit	+293.937334V
33LoadVoltage:32748bit	-0.01239930V
34TemperaturePS1:203bit	+47.9090910°C
35TemperaturePS2:202bit	+47.4545440°C
36TemperaturePS3:202bit	+47.4545440°C
37TemperaturePS4:200bit	+46.5454550°C
38TemperaturePS5:199bit	+46.0909080°C
39OverTemperature:0bit	
40PulsesNotOkModule:31bit	
41PulseDelayPS1:Start640ns,End580ns	
42PulseDelayPS2:Start660ns,End620ns	
43PulseDelayPS3:Start640ns,End600ns	
44PulseDelayPS4:Start660ns,End620ns	
45PulseDelayPS5:Start640ns,End620ns	
46TripRangeStart:Start520ns,End720ns	
47TripRangeEnd:Start480ns,End740ns	
48DetailedPulsesNotOkModule:992bit	
49HalfBridgePositionAtError:31744bit	
50RectifierPositionAtError:32767bit	
51Regulator15V:2887bit	+15.1947368V
52Regulator5V:2089bit	+5.04589372V
53Regulator3.3V:2703bit	+3.29232643V

Links:
[mkkipc3 /tff help](#)
[BeamInhibit IsSentOut](#)
[EarthDetectVoltageOn 24VatOutputToGround](#)
[Quench Fail](#)
[TooFewPSModulesForCurrent Fail](#)
[IQenchDeviation=-3.76098655A](#)
[IPCEnabled \(Führung Internet\)](#)
Output Power=-0.00133531kW
Di1Switch1-5:CurrentLimit:+120.000000A
ModuleDetected.....:1OK 2OK 3OK 4OK 5OK
Temperature.Module:1OK 2OK 3OK 4OK 5OK
StoredTemperature:1OK 2OK 3OK 4OK 5OK
PulsesInWindow.....: **1Fail 2Fail 3Fail 4Fail 5Fail**
PulsesDoTurnOff.....:1OK 2OK 3OK 4OK 5OK
FrontpanelSwitch1:LED-Anzeige.Fehler
FrontpanelSwitch2:List-Isoll
FrontpanelSwitch3:Reset
FrontpanelSwitch4:HauptschützFreigabe
Di1Switch8:PulseInterlockEnabled
Di1Switch7:OptocouplerInterlockEnabled
Di1Switch6:QuenchEnabled
MagnetEnable(MagnetFreigabe) OK





HERA buck converter



Current 400 A
Voltage 150 V
By paralleling up to 800 A



Medium size power supplies



- Switched mode power supplies
 - Current 0 – 200 A, 0 – 600 A,
 - Voltage up to 150 V
- Topology is not fixed, so far buck converters are used
- The same type of regulation will be used
- The interface to the power part will be done via Light Link to enhance EMC
- These power supplies will be installed in Injector building, XS1 to XS5 and near the experimental hall. The power supplies will be accessible.

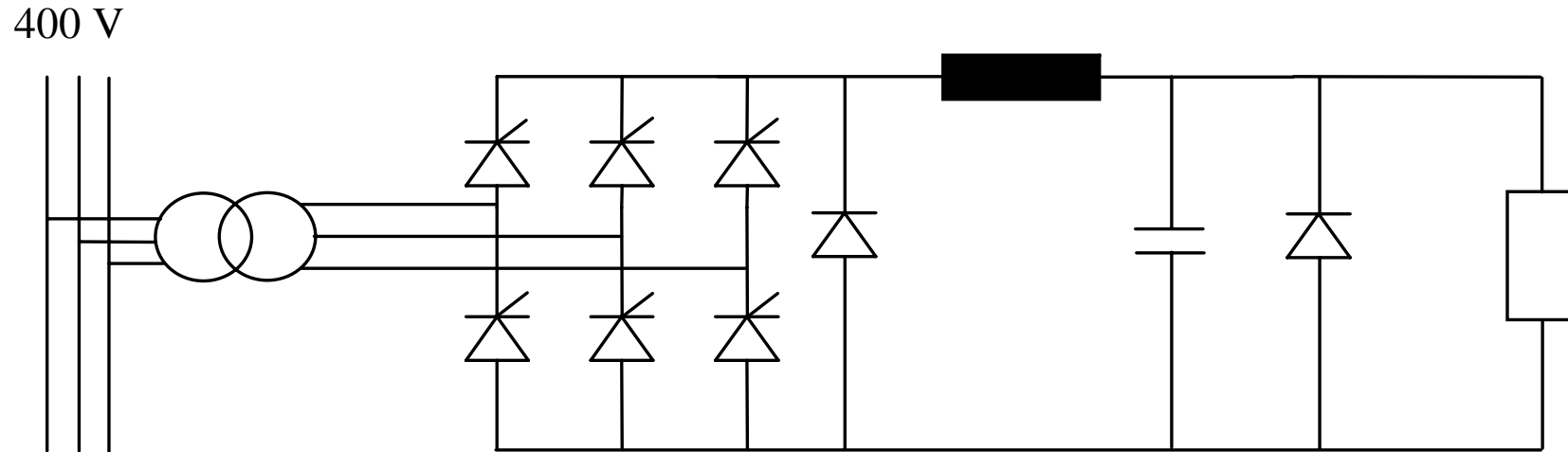


Chopper power supplies in FLASH



400A / 150 V

Large size power supplies SCR type



Current > 600A
Voltage > 150 V



Redundancy concept



- Aim to be back into operation after failure
⇒ **max. 15 min**
- Time to reach the hall + repair time exceeds this time
⇒ **a redundancy system is required**
- The PS will be equipped with motor-driven switches or contactors to disconnect the broken PS and reconnect the spare supply
- For a group of power supplies a spare power supply will be installed.



Redundancy system (2)



- In case of failure the shift crew detects the failure.
 - ⇒ control system generates an alarm.
- The shift crew tries to reset the power supply.
 - ⇒ If not successful, switch over to the spare PS.
- Within few minutes the machine can restart to operate.

Redundancy system





Cabling



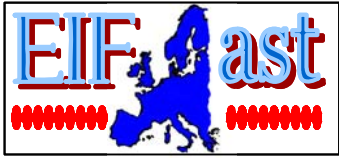
Diameter in mm ²	Length in km
2.5	100
4	30
16	15
25	28
120	8
185	56
240	8



Total number of power supplies



Type of PS	Number incl. spares
Superconducting magnets	300
Large size PS	35
Medium size	200
Steerer type	630
total	1175



Thank you for your attention

Please feel free to ask questions