Upgrade of Converter Units of EAST Poloidal Field Power Supply

Ge Gao for EAST PFPS Team
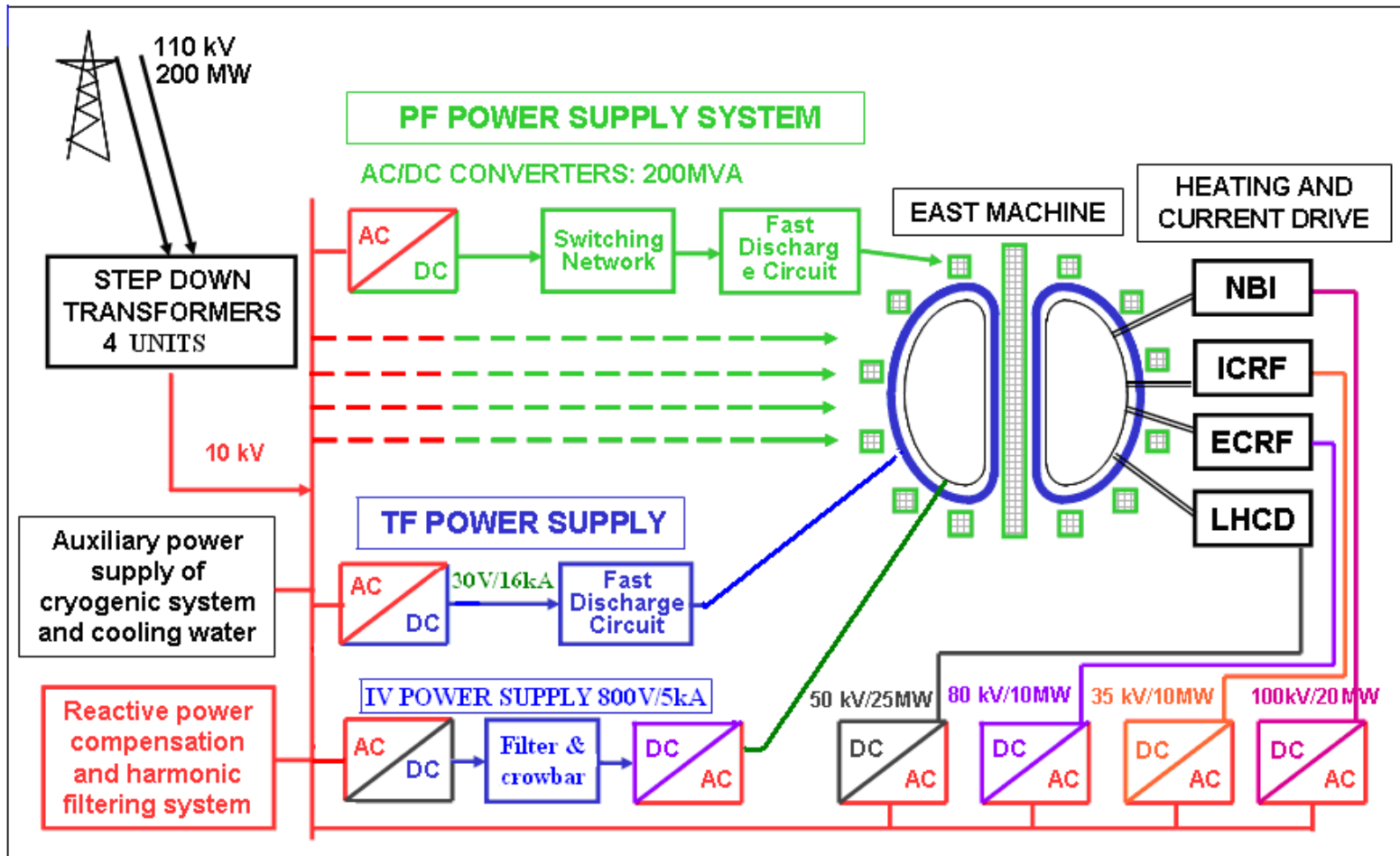
The Institute of Plasma Physics, Chinese Academy of Sciences
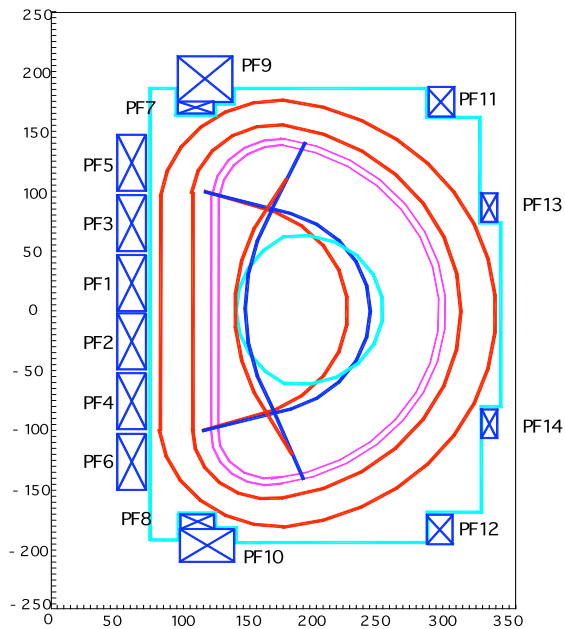
2011-06-30 SOFE

Content

- Introduction and background

- Analysis and simulation on the upgraded converter unit
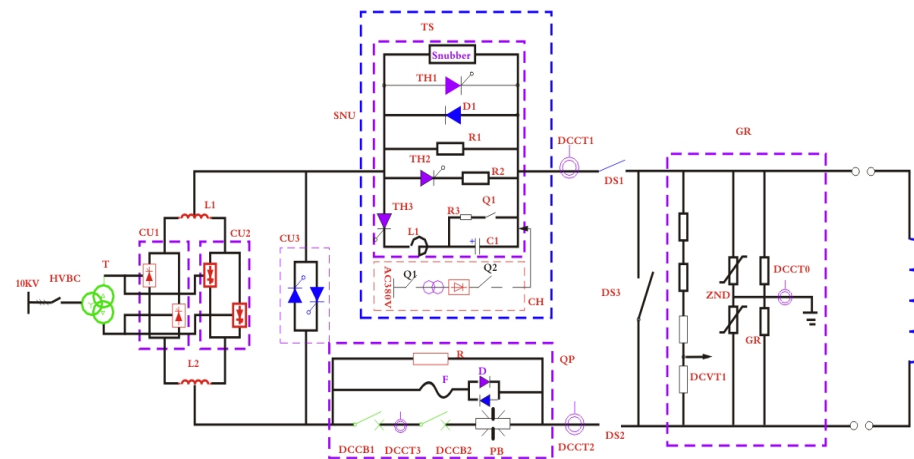
- New converter units in EAST campaign

EAST Power Supply

EAST PFPS

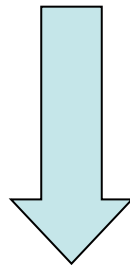- EAST Poloidal Field Power Supply (2006~now)

EAST PF Coil Distribution

Circuit of each set of PFPS

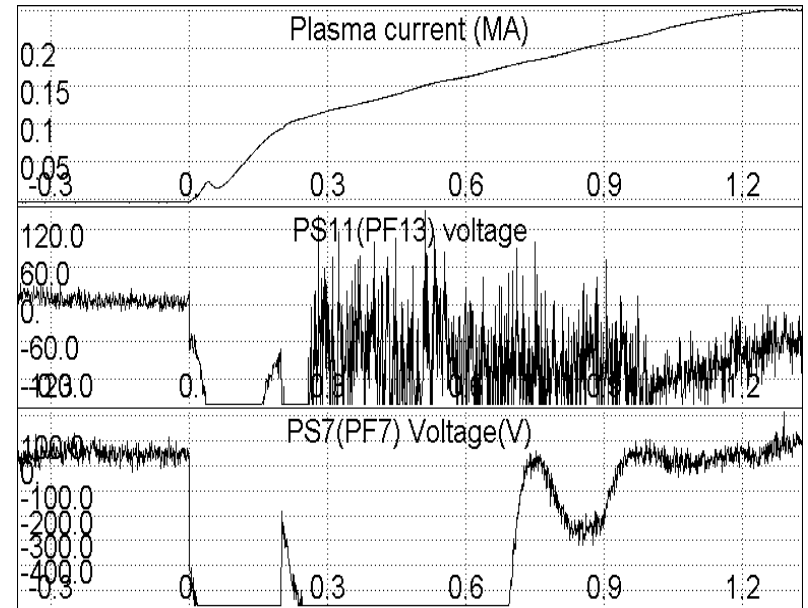| No.	Voltage	Current
PS11,PS12	200 V	15 kA
PS7,PS8	700 V	15 kA
PF1~PF6,PF9,PF10	350 V	15 kA

EAST PFPS Converter Units

More PS power Requirement

- – Bz can't catch up with the fast Ip growth rate

- – Startup, elongation or X control requires higher voltage.

Solution

Plasma current and voltage requirement

✓ PS7,PS8 converter units to PS11,PS12
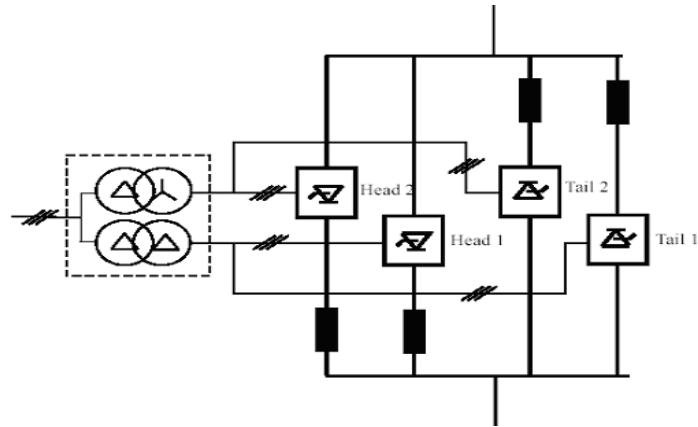✓ New converter units for PS7 and PS8

Converter Unit Improvements

(PS7,PS8)

	Voltage	Time Delay	Converter Control
Former	700V	4.3 ms	analog controller
New	1100V	2.6 ms	digital compact-PCI based fast controller
		due to change on topology ▶	Also can be used on ITER PF main converter ▶

New PS7,PS8 Converter Unit
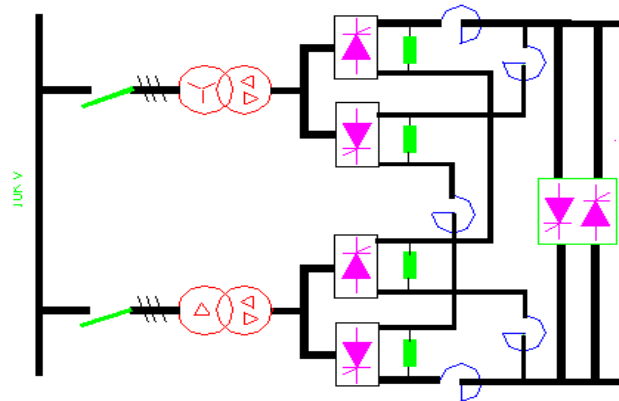
Former Converter Unit

New Converter Unit

Dry-type converter transformer
(2*10/0.815 kV, 6 kVA)

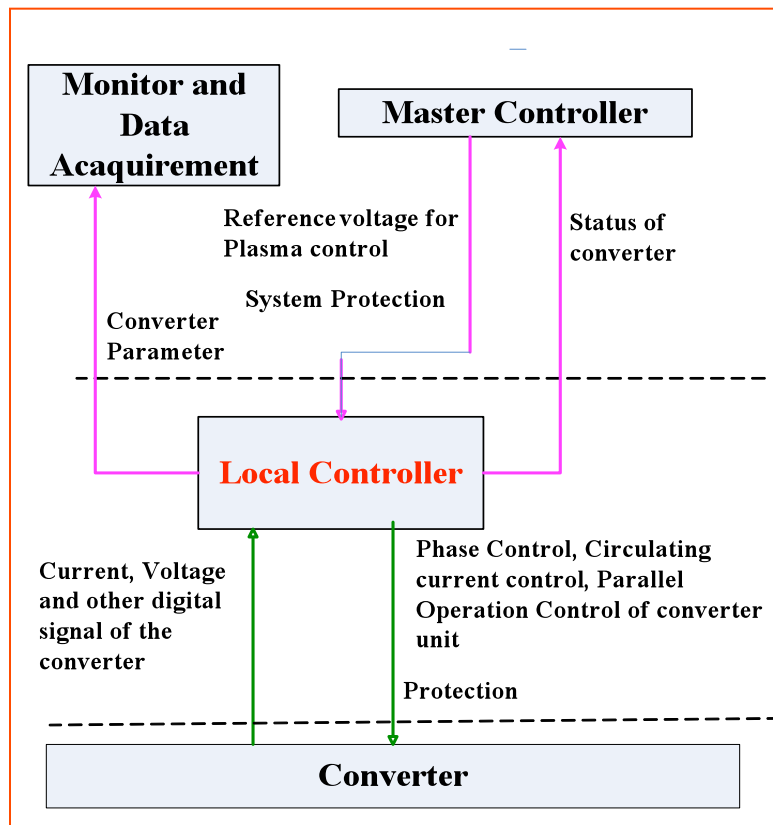Water-cooling DC inductor
(4*0.5 mh)
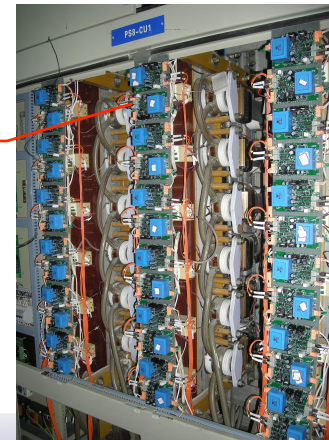
Converter unit
(2*1100 V, ±7500A)

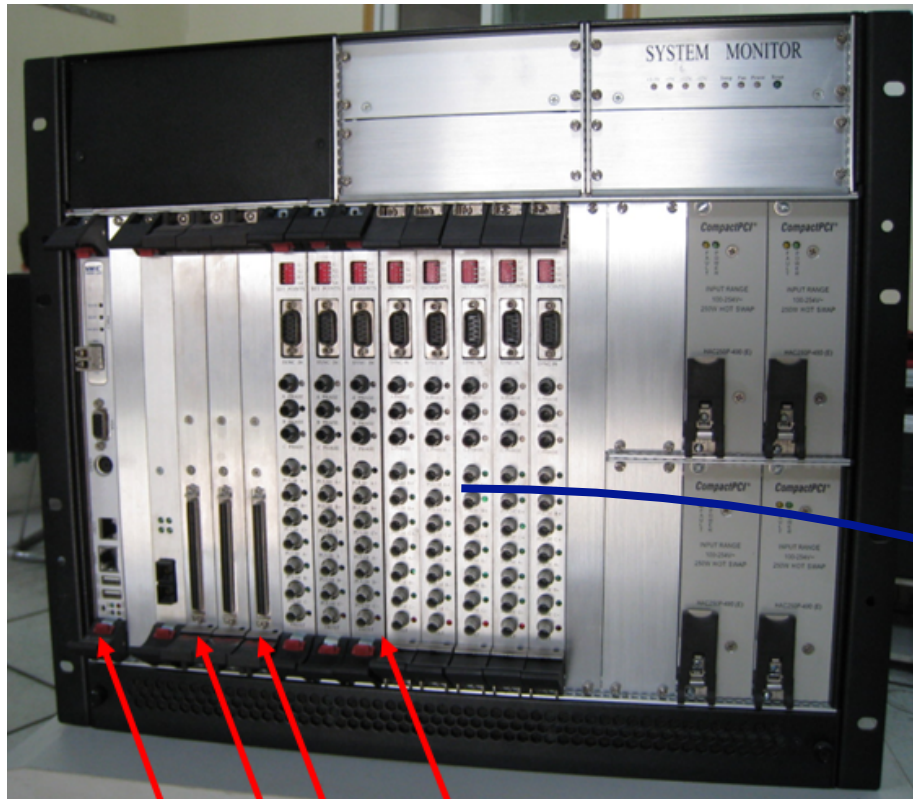Components: Fast Controller+ thyristor firing module

+PLC+interlock

Fast controller

Thyristor firing module

Diagram:

Monitor and Data Acaquirement

Master Controller

Reference voltage for Plasma control

Status of converter

System Protection

Converter Parameter

Local Controller

Current, Voltage and other digital signal of the converter

Phase Control, Circulating current control, Parallel Operation Control of converter unit

Protection

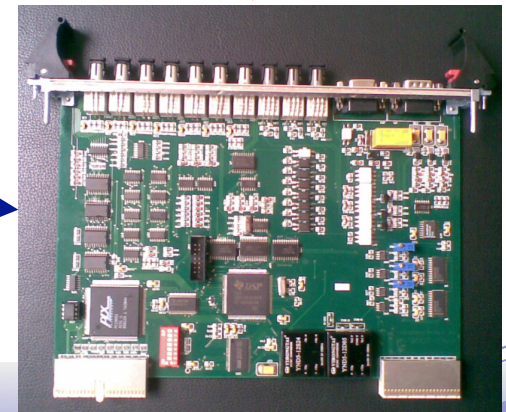Converter

Fast controller

Software(Operation system): QNX, real-time OS

Software designed by C

Hardware: cPCI local bus, A/D & DI DO interface, alpha controllers based on cPCI bus.
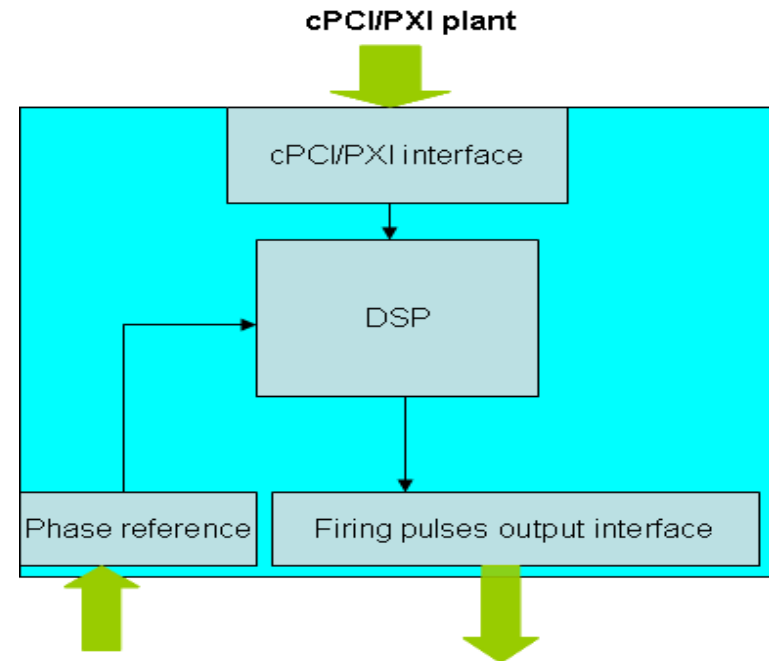
Alpha controller

Alpha controller
DI/DO
A/D
CPU

cPCI plant

ASIPP

EAST

9

Alpha controller

- **high-performance DSP**

- **Special for 6-pulse converter control**

- **Trans alpha into firing pulse**
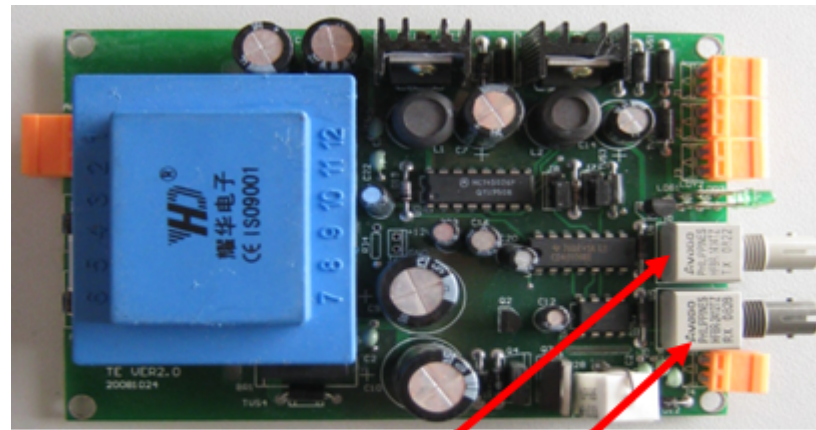
- **Optical fiber output, safe application**

cPCI/PXI plant

cPCI/PXI interface

DSP

Phase reference

Firing pulses output interface

Thyristor firing module

■ **OPTICAL FIRING:**

  ■ **High EMC immunity**
  ■ **Good shape of firing pulse**
  ■ **Safe for controller**

■ **MONITORING of:**

  ■ **Presence of firing pulse**
  ■ **Presence of TFM board power**

monitoring

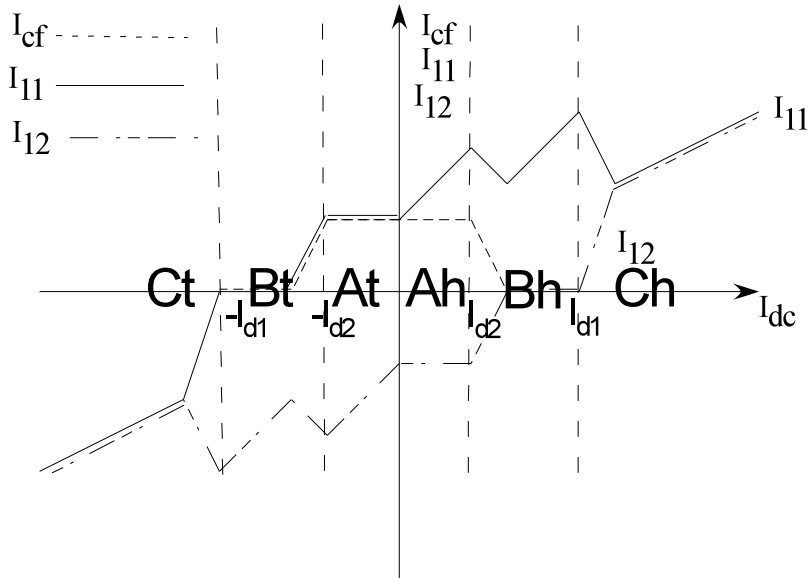firing pulse

tr<1us
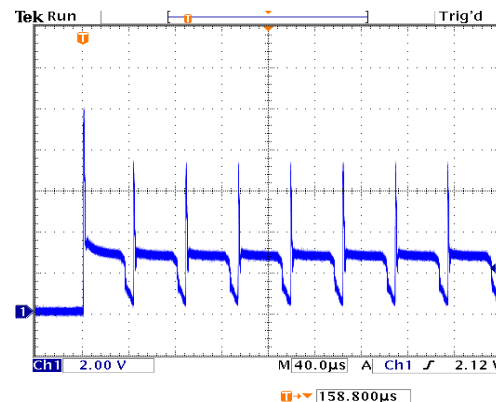
IGM≈3.0A

tp ≈35us

Simulation and analysis

- *Software:* PSCAD/EMTDC

The complete circuit contains:

- *Control scheme:* voltage regulator, circulating current regulator and the parallel branch unbalance current regulator

- *Converter sub-units*: each rated at 1.1 kV DC and 7.5 kA DC;

- *DC reactors and Load*

ASIPP

EAST

Converter Scheme

Reference circulating current (I_{Cf}) and sub-unit currents (I11, I12) versus load current Idc

Region	Sub-units	Operation mode
Ch	Head11, Head12	Parallel Connection
Bh	Head12	6-pulse
Ah,At	Head12, Tail11	Circulating-current
Bt	Tail11	6-pulse
Ct	Tail11, Tail12	Parallel Connection

Circulating current mode

To check that the switching off of one of both, head or tail sub-units,
does not occur during steady state and during transient operation.
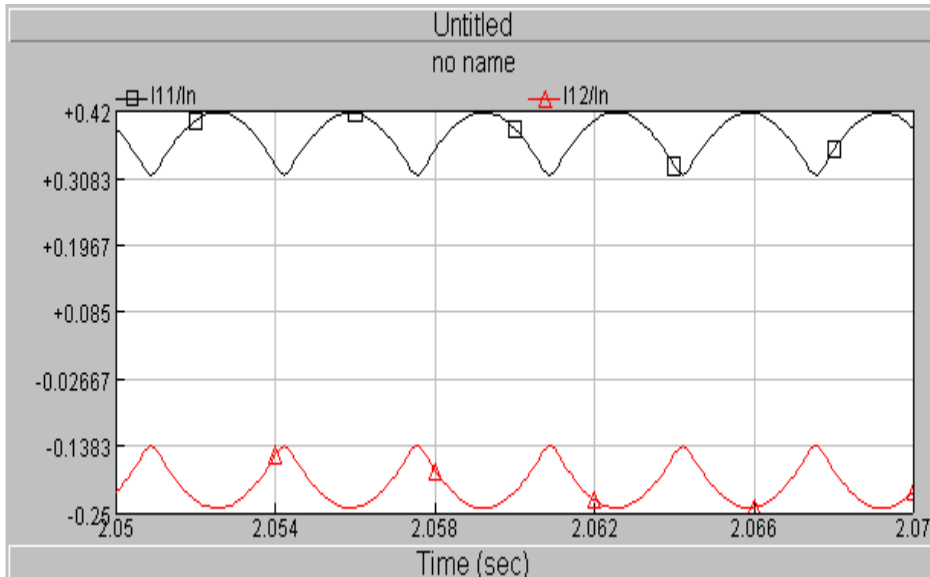
**Sub-unit currents when the triggering angle of
the head converter is 75°**
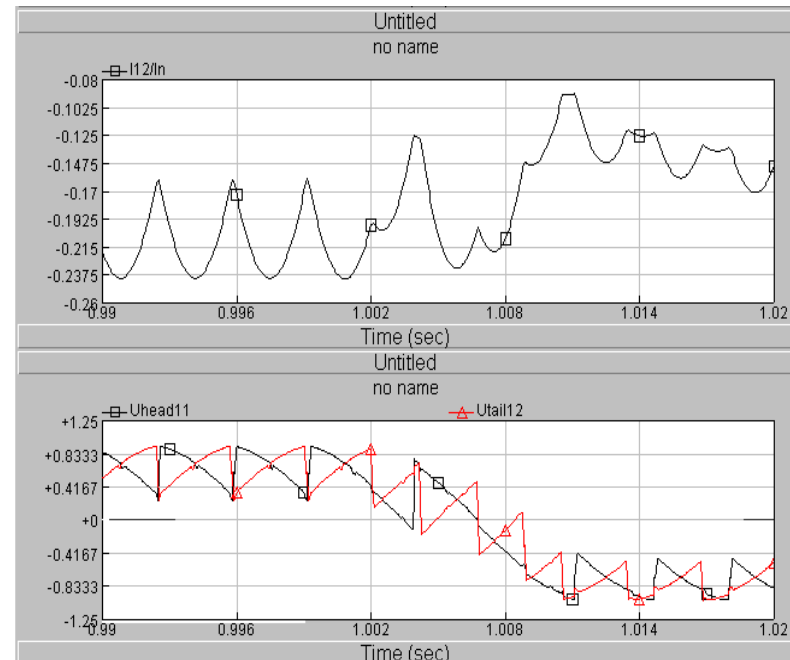

Circulating current when the output voltage changes

The mean value of the circulating current can be set as 10% of Idc0,
providing a minimum instantaneous circulating current of 4.5% of Idc0.

Parallel operation simulation

To check the peak unbalance current and duration is less than the threshold of the over-current protection to distinguish it from the fault
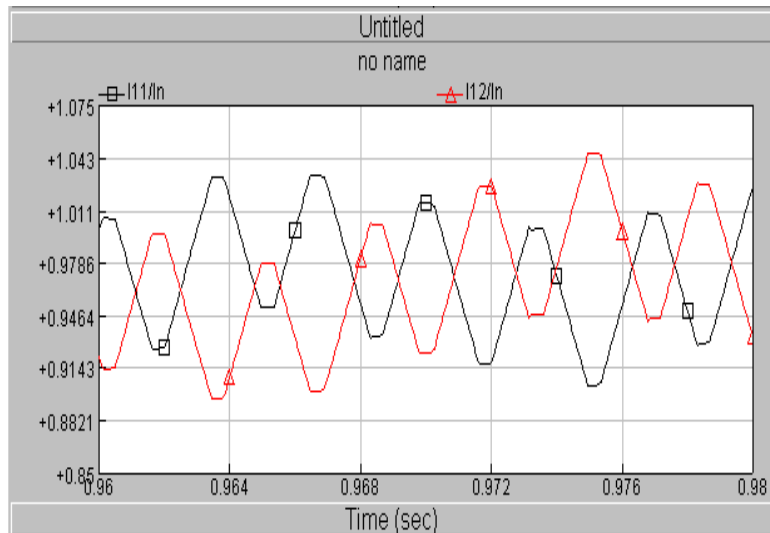
Sub-unit currents with triggering angle of 90°
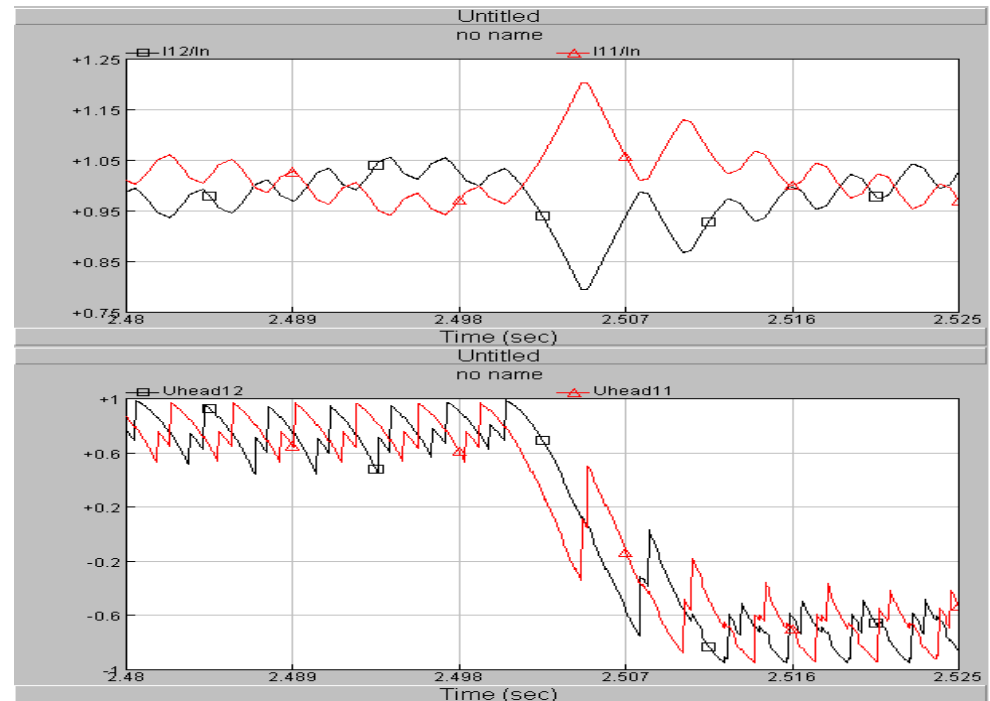
Sub-unit currents in transient case

Steady state:
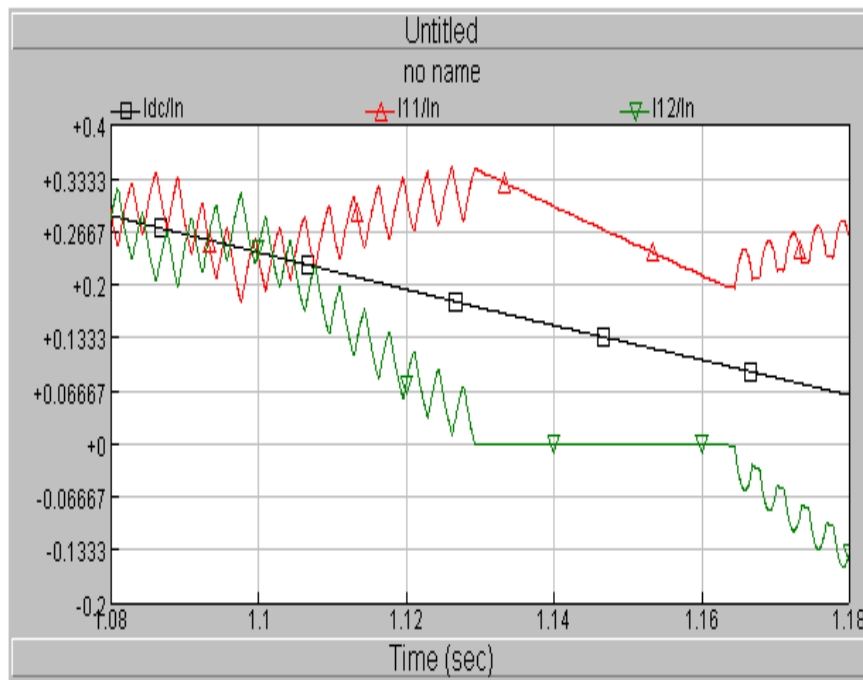➤ maximum unbalance current is 7.5% of Idc0 (15% of In)

Transient:
➤ The maximum unbalance current is 20% of Idc0 (40% of In).

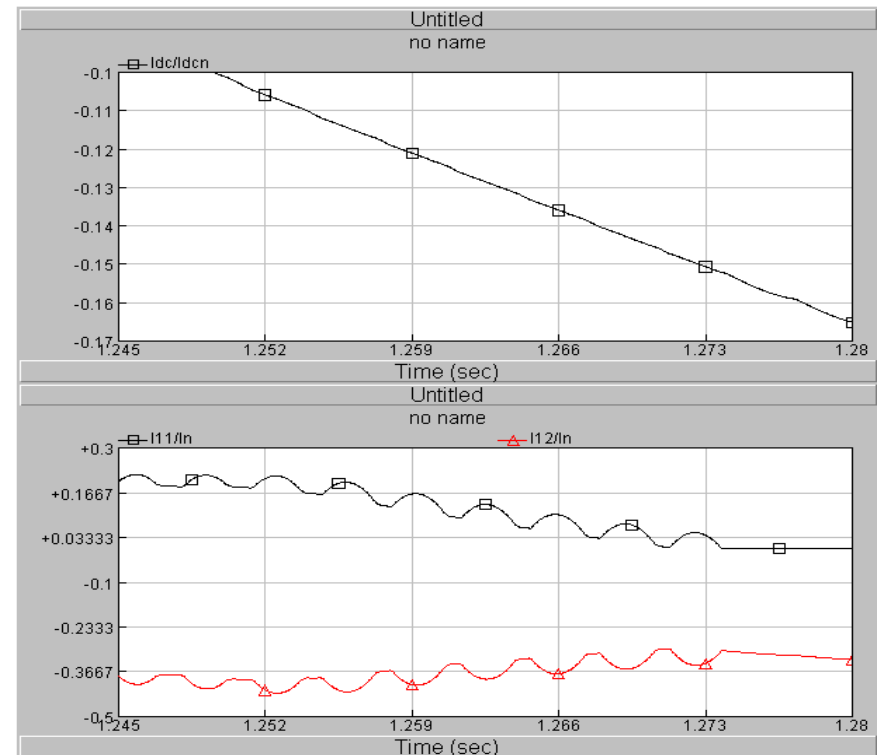ASIPP   EAST   15

Mode Transition

To check Normal operation on mode transition works properly including:
- the process of current transfer from 1 to 2 branches and vice-versa;
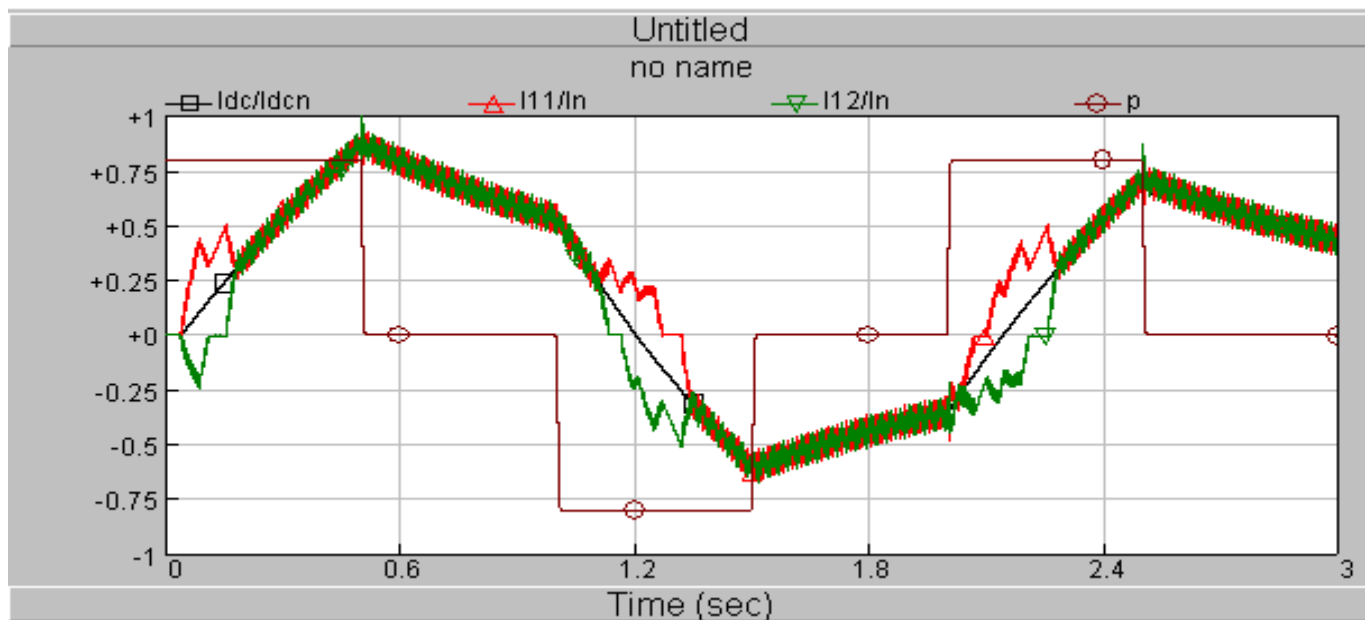- Turn-on and off the circulating current

Current transfer from two to one converter
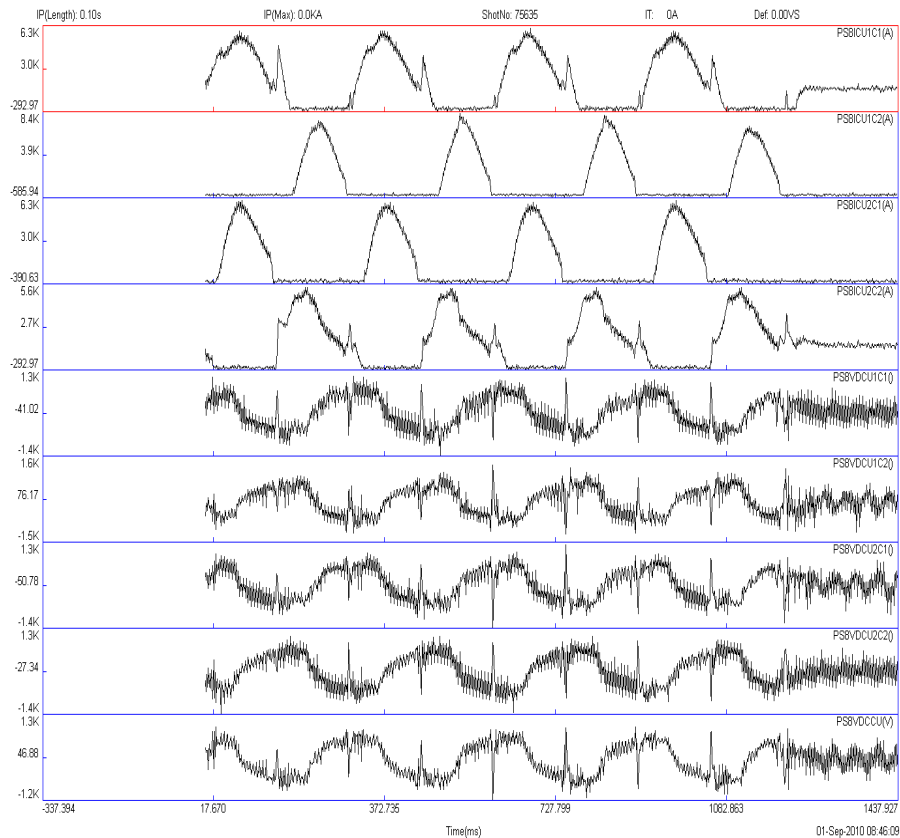

Turn-off the circulation current

Conclusion on the simulation

The results show that the process properly works.
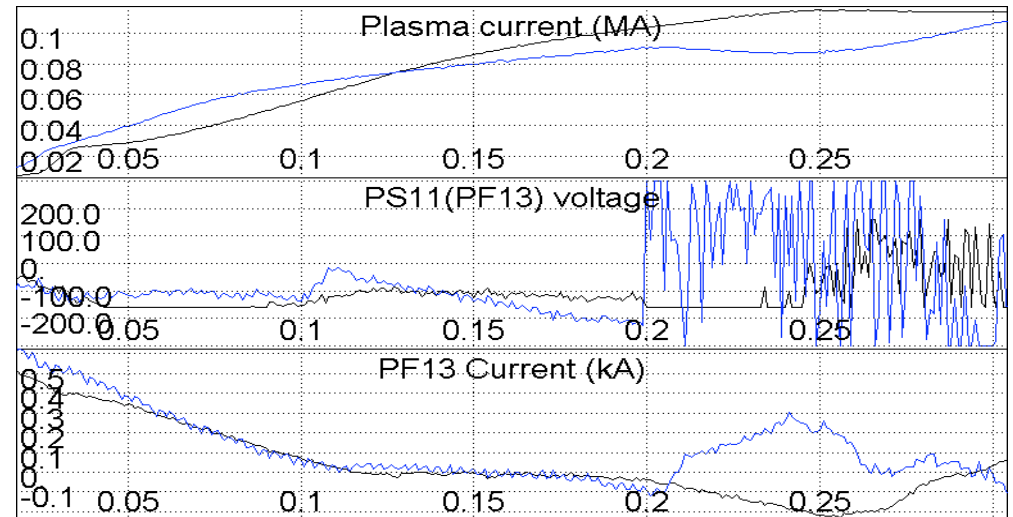

A whole cycle of the current change

Operation Result

Current, Voltage of each 6-pulse bridge

Black: 21143 (before upgrade)
Blue: 35300 (after upgrade)

Six faults (among 8548 shots) during the new converter unit's first EAST campaign, all at the beginning.

Conclusion

- Four converter units of EAST PFPS has been upgraded and operated in the autumn campaign of EAST Tokamak in 2010.

- The compact-PCI bus based converter local controller which could be used to ITER PF main converter has been tested in the new EAST PF7&PF8 Converter module.

Thank you for your attention