Shape Controller Upgrades for the JET ITER-like Wall

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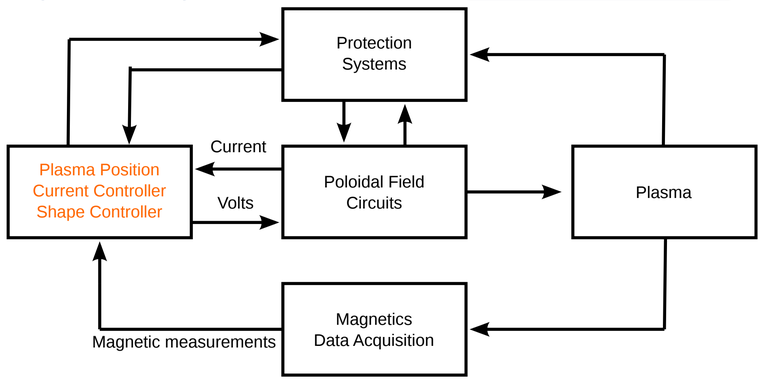
Shape Controller

Overview

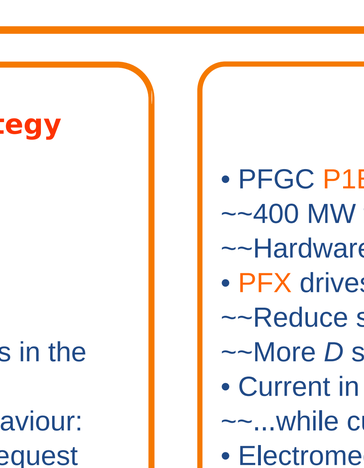
- Real-time system
  ~~MIMO controller
- Controls:
  ~~current in poloidal field circuits
  ~~plasma current
  ~~plasma shape

Architecture	VME
Processor	MVME5100 PowerPC
O.S.	VxWorks
Inputs	48 ADCs 2 Digital inputs >400 ATM signals
Outputs	24 DACs 1 Digital output >150 ATM signals
Cycle time	2 ms

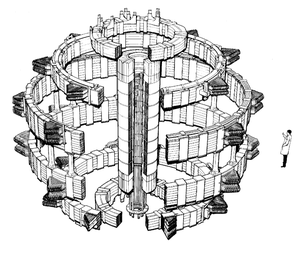


JET Circuits

- 10 Poloidal field circuits
  ~~9 controlled by shape controller
- First line of defence against faults and limits implemented in SC



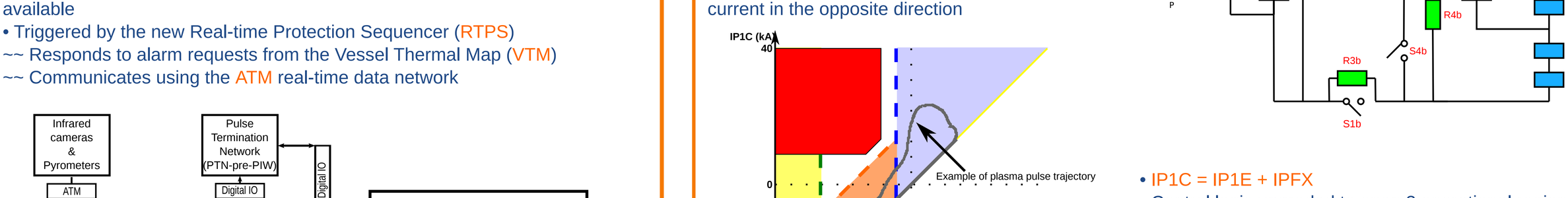
Circuit name		Coils series
Toroidal Field	(TF)	24 toroidal coils
Magnetising	(P1)	P3MU/L+P1EU/L+P1C
Vertical Field	(P4T)	P4U+P4L
Fast Radial Field	(RFA)	P2/3RU-P2/3RL
Radial Field	(IMB)	P4U-P4L
X-Point	(PFX)	P1C
Shaping	(SHA)	P2SU/L+P3SU/L
Divertors	(D1-4)	D1, D2, D3, D4



Control mode selection

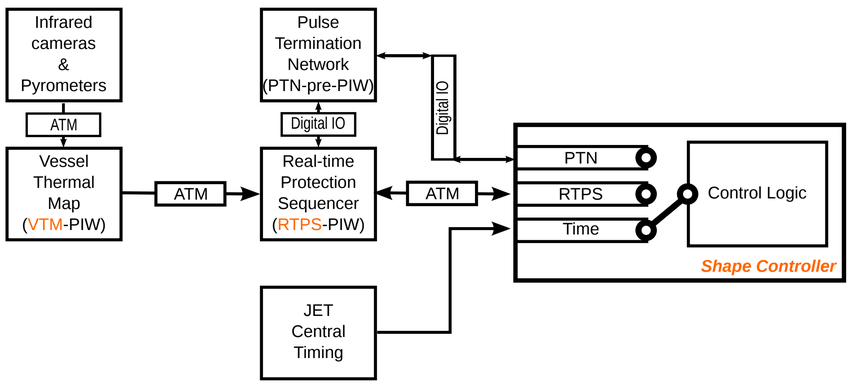
- Control modes and values dynamically assigned
  -Pre-programmed time windows
  -Stopping event

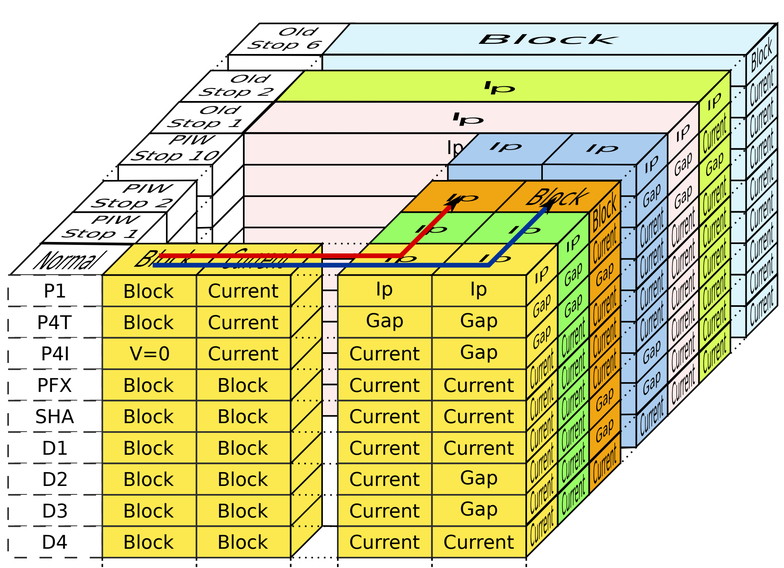
Execution sequence



Protection of the ITER Like Wall (PIW) Stopping Strategy

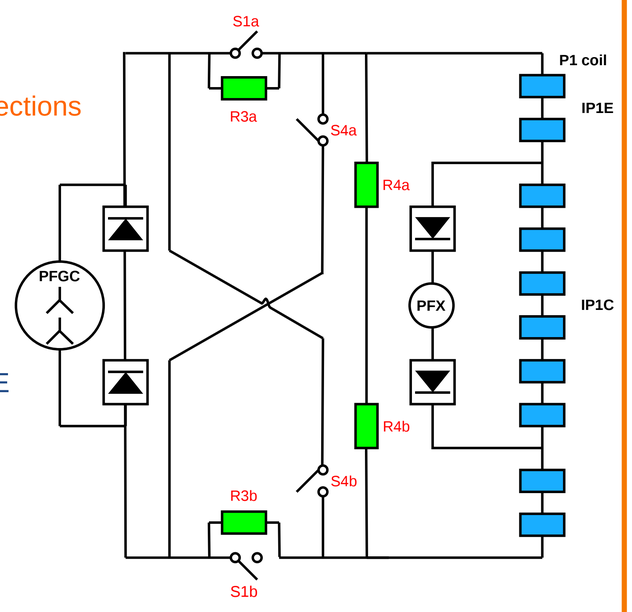
- JET upgraded to a new all metal wall
- Previously, upon the detection of a problem:
  ~~Set of global responses
  ~~~Invariant with the experimental phase
  ~~~Designed to maximise the likelihood of a safe plasma landing
  ~~ Might conflict with the requirement of avoiding localised heat fluxes in the wall components
- Upgraded system capable of dynamically adapting its response behaviour:
  ~~Accordingly to the experimental conditions at the time of the stop request
  ~~During the termination itself
- Capable of switching to alternative experiment sequence if resources not available
- Triggered by the new Real-time Protection Sequencer (RTPS)
  ~~ Responds to alarm requests from the Vessel Thermal Map (VTM)
  ~~ Communicates using the ATM real-time data network





PFX On Early Task (POET)

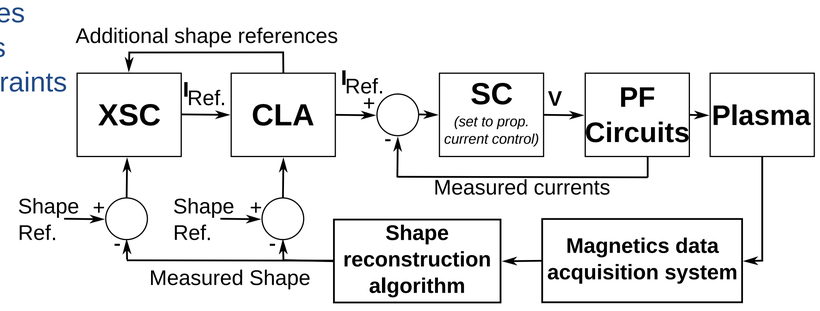
- PFGC P1E generates and controls plasma current
  ~~400 MW fly-wheel generator
  ~~Hardware swichtes (s1 and s4) enable current in both directions
- PFX drives current in central pancakes windings
  ~~Reduce stray fields
  ~~More *D* shaped plasma
- Current in PFX inhibited by shape controller...
  ~~...while current in P1E is of opposite sign
- Electromechanical modelling effort concluded that the old limits are too stringent
- POET operation space allows limited PFX current with P1E current in the opposite direction



- IP1C = IP1E + IPFX
- Control logic upgraded to open 3 operational regions
  ~~Logic protects and tracks wrong requests
- Early operation of PFX enables
  ~~Longer pulse length in the X-point plasma configuration, where the plasma last closed surface is

Current Limit Avoidance

- eXtreme Shape Controller (XSC) algorithm enables the control of the full plasma boundary
  ~~system is no longer limited to the accurate control of only a few gaps
  ~~all the circuits in shape controller are set to proportional current control
  ~~current references provided by the XSC algorithm.
  ~~algorithm is valid only around a given equilibrium
  ~~~plasma must be driven into the reference conditions using shape controller
- Current Limit Avoidance (CLA) uses the redundancy of the PF coil system
  ~automatically obtains almost the same plasma reference shape
  ~~with a different combination of currents in the PF coils
  ~~in the presence of severe disturbances
  ~~~tries to avoid the current saturations
  ~~~by relaxing the plasma shape constraints



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