Active field error correction at the MST poloidal gap

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Magnetic field errors at MST's poloidal gap can lead to increased plasma-wall interaction and "locking" of magnetic fluctuations to the wall, both of which can degrade MST discharges. The present pre-programmed compensation scheme can only partially correct these field errors. We are building an active correction system to suppress radial field errors at the poloidal gap. The gap radial field is monitored by 32 coils located at the poloidal gap inside MST's conducting shell. An existing analog summing circuit resolves poloidal mode signals from these coils; a similar circuit will map these mode-resolved signals for up to 38 high-power IGBT switching amplifiers. The amplifiers will drive feedback coils wound through existing holes in the poloidal flange to cancel the radial fields sensed by the internal sense coils. We show results of initial feedback tests using a single drive coil and describe the design and expected performance of the full feedback system, currently under construction.

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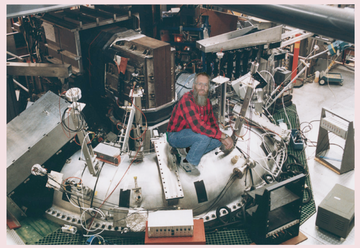


MST Reversed Field Pinch

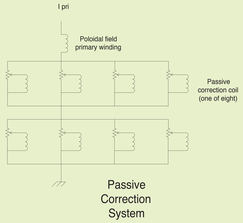
- Plasma current: 500 kA
- Discharge duration: 60 msec
- Best confinement time: ~10 msec
- Typical ne = 10^{19} m^{-3}
- Highest T_e = 800 eV
- R = 1.5 m, a= 0.52 m
- 50 mm thick aluminum wall with poloidal, toroidal gaps

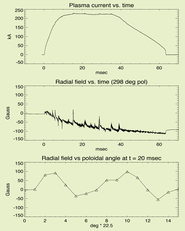
Radial field errors cause problems

- Magnetic fluctuations may lock to gap errors
- Locked mode amplitudes grow, degrade confinement
- Radial errors at gap cause increased wall interaction, impurity influx

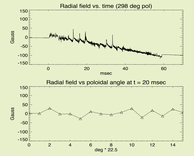
Present scheme: passive correction

- 8 single-turn correction coils are fed by portion of poloidal field drive current
- Horizontal, vertical correction coils are driven by capacitor bank
- Passive system reduces field error but has wrong waveform
- Passive system is inflexible, optimized for particular type of discharge



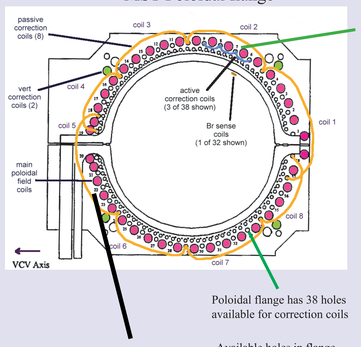


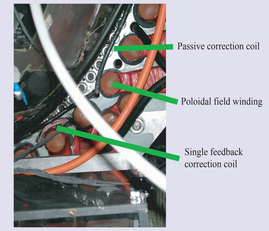
Without field correction



With passive correction

MST Poloidal flange

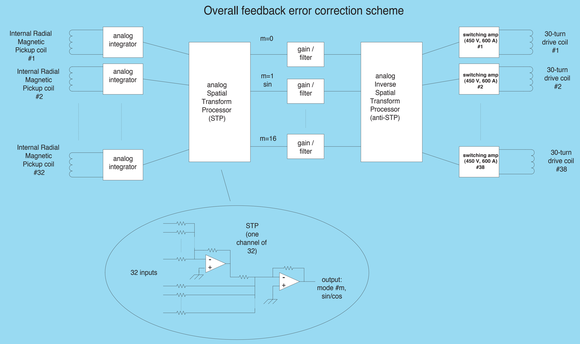




Single test feedback coil has 28 turns #14 Litz, L = 100 uH; estimated temperature rise <15 C per pulse

Feedback system will replace passive correction

- 38 coils, 30 turns each
- Switching amps (20 kHz, 600 A, 450 V)
- Coils 100 uH, so 4.5 A / usec -- may be fast enough to correct spikes at sawtooth crash
- Need robust coils; access is difficult
- Analog processor couples 32 pickup coils to 38 drive coils, allows mode selection



Acknowledgments

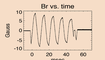
We thank Brian Nelson and the HIT group for the loan of the switching amplifier.

Thanks to the RFX group for sharing details of their feedback system

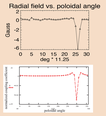
Initial tests use single coil, switching amp from HIT

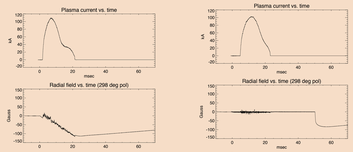
- 28-turn coil of #14 Litz wire
- HIT amp: 20 kHz, up to 900 V / 800 A
- Feedback uses single internal sense coil

Coupling test shows correction field is localized



Simple filament current model gives approximate coupling coefficients

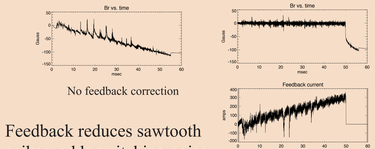




No feedback correction

Feedback forces local time-averaged field to 0

Single feedback coil correction



No feedback correction

Feedback reduces sawtooth spikes, adds switching noise
(switching amp had no output filter for test)

Single feedback coil correction

Conclusion and next steps

- Existing flange holes are adequate for feedback correction coils
- 20 kHz, 450 V, 600 A per coil is adequate
- Next: build several coils and drive amps, check for coil durability, mutual coupling
- Full system: late 2002