Matrix circuit solver, equi2d module

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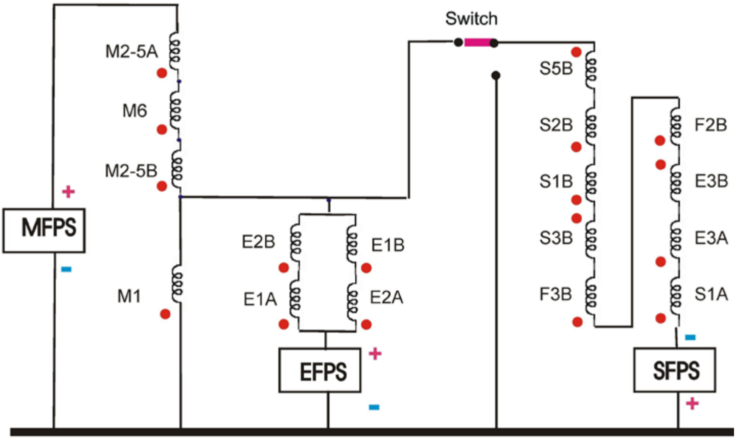
1 Matrix circuit solver
- Motivation
- Solver

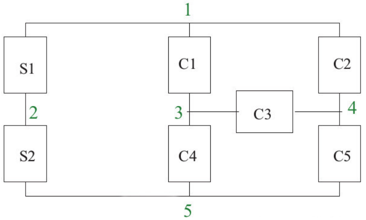
2 equi2d module
- Motivation
- Function examples

COMPASS poloidal circuits



COMPASS PF coils power supply circuits, [Havlicek,2011]

Circuit matrix



S : supply

C : coil

1-5 : circuit node

$$\begin{bmatrix} 1 & 0 & 0 & -1 \\ 1 & 0 & -1 & 0 \\ 1 & -1 & 0 & 0 \\ 0 & 1 & -1 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & -1 \end{bmatrix}$$

Potential matrix of a circuit

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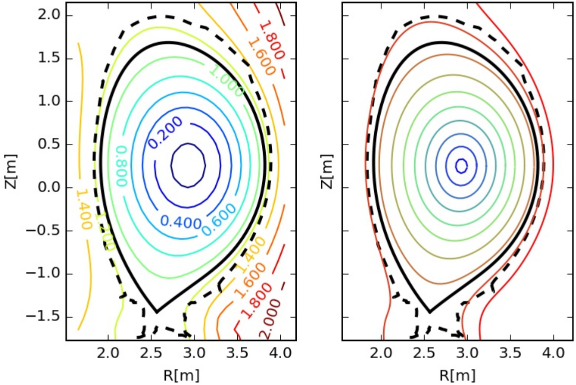
- Unification of splines, etc.
- Fast post-processing module
- Plasma volume, coordinates transformation, length of a magnetic field line, etc.

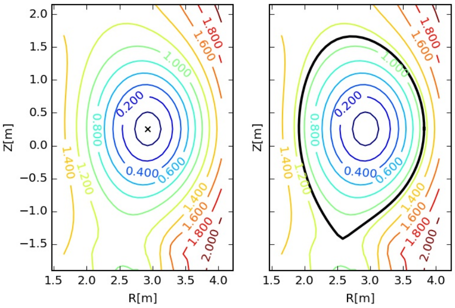
Equipotential finder



Comparison of contour plot and algorithm results

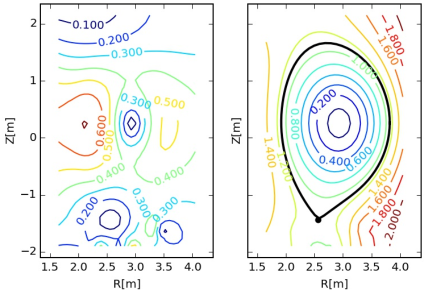
Magnetic axis and separatrix

- Iteration on the closed flux surfaces with given threshold ε_{sep}.
- Divide and conquer algorithm, exponential Newton is planned.
- Data usage for pre-calculated results.



Results of magnetic axis finder(left) and separatrix finder(right) algorithms.

- $B_{theta} = \frac{1}{2\pi R}\left(\frac{\partial\Psi}{\partial z}, 0, -\frac{\partial\Psi}{\partial R}\right)$
- Minimum of B_{theta} with initial guess (r_0, z_0) at z_{LCFS} minimum



X-point finder: B_{theta}(left) and it's minimum (right)

References

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- HAVLICEK, J., R. BEŇO a J. STÖCKEL. *A Simulation of the COMPASS Equilibrium Field Power Supply PID Controller*. Prague: Matfyzpress, 2011, s. 221-226. ISBN 978-80-7378-185-9.
- URBAN, J. and J.-F. ARTAUD. *Coupled transport and free-boundary equilibrium simulations using FREEBIE and CRONOS*. 2012.

The End

- $n_{comp} + n_{nodes} + n_{circ}$ equations grants a system of equations:

$$\mathbf{A}\vec{U} = \mathbf{B}\vec{V} + \mathbf{R}\vec{I} + \mathbf{L}\frac{d\vec{I}}{dt} \quad (1)$$

- Separating vector of variables U and pluging them into (1) yields a system

$$\begin{aligned} \mathbf{E}\vec{V} + \mathbf{F}\vec{I} + \mathbf{G}\frac{d\vec{I}}{dt} &= 0 \\ \mathbf{A}(\mathbf{A}^T\mathbf{A})^{-1}\mathbf{A}^T\mathbf{B} - \mathbf{B} &= \mathbf{E}, \end{aligned}$$

- in which the vector $\frac{d\vec{I}}{dt}$ may be separated

$$\mathbf{T}\vec{I} + \frac{d\vec{I}}{dt} = \mathbf{S}\vec{V} \quad (2)$$