LINACCALC RF ACCELERATING STRUCTURE SIMULATION SOFTWARE

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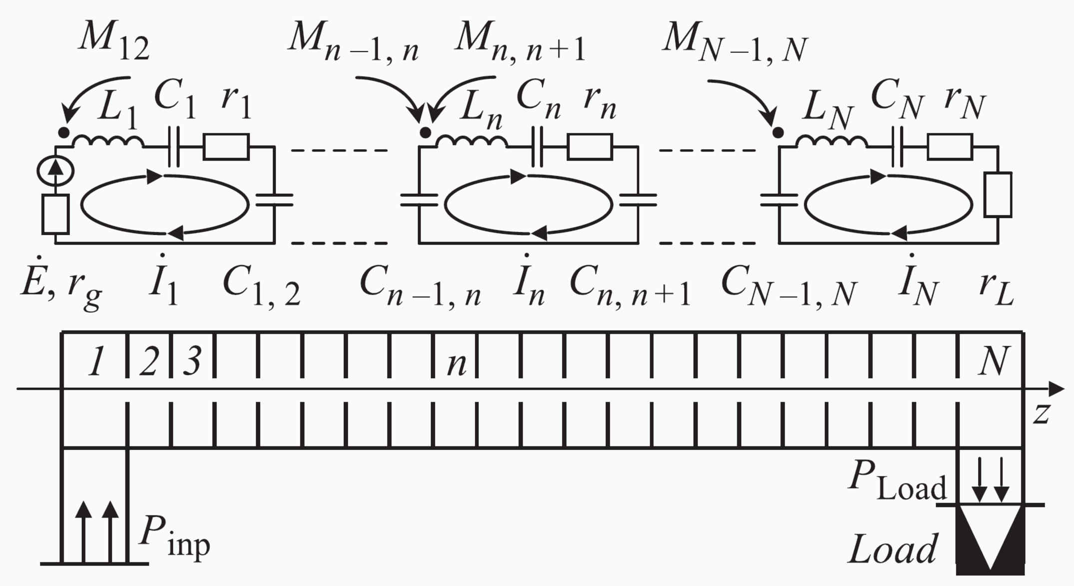
Introduction

Nowadays linac accelerating RF systems design is usually done by the finite difference method. It provides high accuracy of calculations and freedom in topology choosing, but may draw considerable amounts of computer resources with long calculation times. Alternative to this method, equivalent circuit method exists. The basic idea of this method is to build a lumped element circuit, which with certain approximation acts as an original accelerating cell. It drastically reduces the number of equations to solve. This method is long known but usually only used for the particular accelerating structures when speed of calculation is a key-factor. This paper describes an attempt to create more universal and user-friendly software application for calculating electrical field distribution in accelerating structures, provides mathematical equations this software is based on. The resulting application may be used for preliminary calculations of acceleration structures and help to determine cells electrodynamic parameters reducing overall design time.

Equivalent circuit

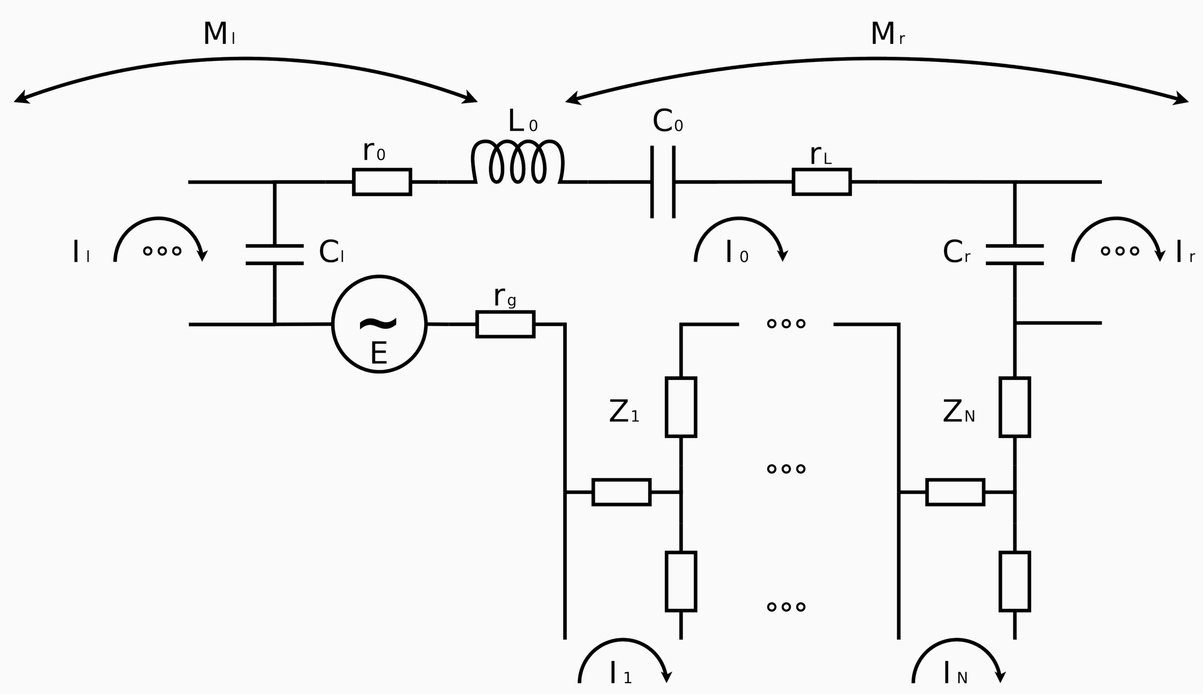


Equivalent circuit of accelerating structure

$$|A| * |X| = |B|$$

Equivalent circuit can be represented as matrix, where vector X is a vector of cell field complex amplitudes, vector B is a vector, representing input power and current load. Matrix A is a matrix characterizing the cell; line i represents cell number i.

Waveguide connected cell equations



Equivalent circuit of the waveguide connected cell

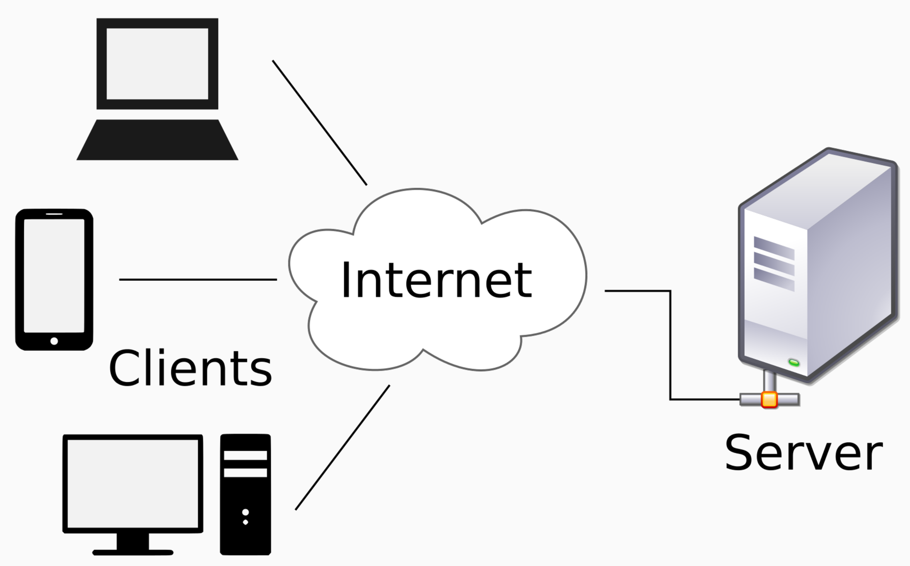
$$\left(\frac{f^2K_l^H}{2f_lf_0}-\frac{K_l^E}{2}\right)\dot{X}_l+\left(1-\frac{f^2}{f_0^2}+j\frac{f}{f_0}\frac{1+\chi_{\sum a}}{Q_0}\right)\dot{X}_0+$$
$$+\left(\frac{f^2K_r^H}{2f_rf_0}-\frac{K_r^E}{2}\right)\dot{X}_r+j\xi_{01}\dot{X}_1\sqrt{\frac{\chi_1f^2}{Q_0Q_1f_0f_1}}+\ldots+$$
$$+j\xi_{0N}\dot{X}_N\sqrt{\frac{\chi_Nf}{Q_0Q_Nf_0f_N}}=j4\sqrt{\pi\frac{f^2}{f_0}P_g\frac{\chi_g}{Q_0}}\exp j\phi$$

$$\xi_{ij}=\frac{\exp(-\gamma_{ij})+\exp(-\gamma_{ji})}{1-\exp(-\gamma_{ij})-\exp(-\gamma_{ji})}$$
$$\chi_{\sum i}=\chi_g+\chi_L+\chi_1\tau_{i1}+\ldots+\chi_N\tau_{iN}$$
$$\tau_{ij}=\frac{1+\exp(-2\gamma_{ij})}{1-\exp(-\gamma_{ij})-\exp(-\gamma_{ji})}$$

f_i is a resonant frequency of the cell, Q_i is its quality factor, K_i^e and K_i^h are coupling coefficients for the electric and magnetic fields, χ_i are coupling coefficients with waveguides, γ_i are waveguides propagation constants, P is an input power, $\dot{X}_i$ is a complex cell field amplitude.

$$\hat{Z}_{in}=\chi_g\left\{1+\chi_{\sum 0}-\chi_g+jQ_0\left[\frac{f}{f_0}+\frac{f_0}{f}+\left(\frac{f_0}{f}\frac{K_l^E}{2}-\right.\right.\right.$$
$$\left.-\frac{f}{f_l}\frac{K_l^h}{2}\right)\frac{\dot{X}_l}{\dot{X}_0}+\left(\frac{f_0}{f}\frac{K_r^E}{2}-\frac{f}{f_r}\frac{K_r^h}{2}\right)\frac{\dot{X}_r}{\dot{X}_0}-$$
$$\left.\left.-\xi_{01}\sqrt{\frac{\chi_1}{Q_0Q_1}\frac{f_0}{f_1}}\frac{\dot{X}_1}{\dot{X}_0}-\ldots-\xi_{0N}\sqrt{\frac{\chi_N}{Q_0Q_N}\frac{f_0}{f_N}}\frac{\dot{X}_N}{\dot{X}_0}\right]\right\}^{-1}$$

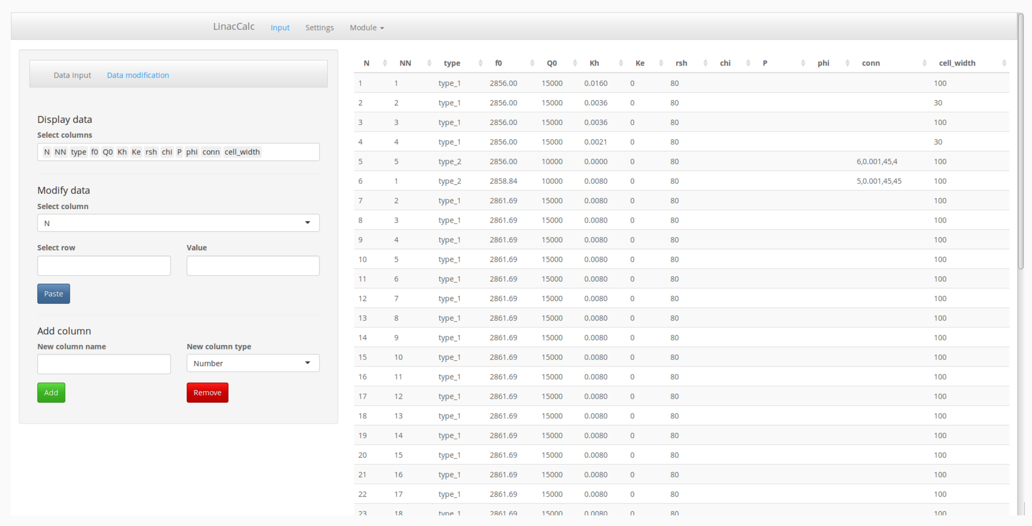
Implementation of the program



WUI diagram

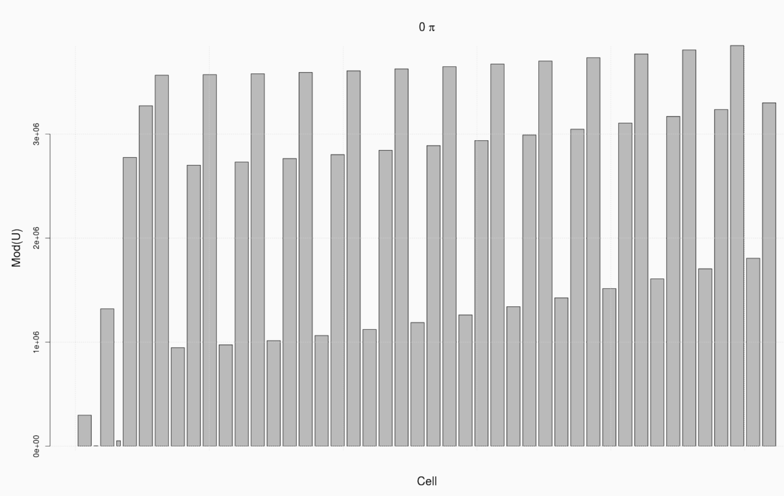
The program is written in the R programming language, WUI implemented using shiny library. WUI allows to work with the program remotely. Parallel access and session management are possible with the non-free version of the shiny server.

Program input is a table file in .csv format. Each line corresponds to a cell of the accelerating structure.

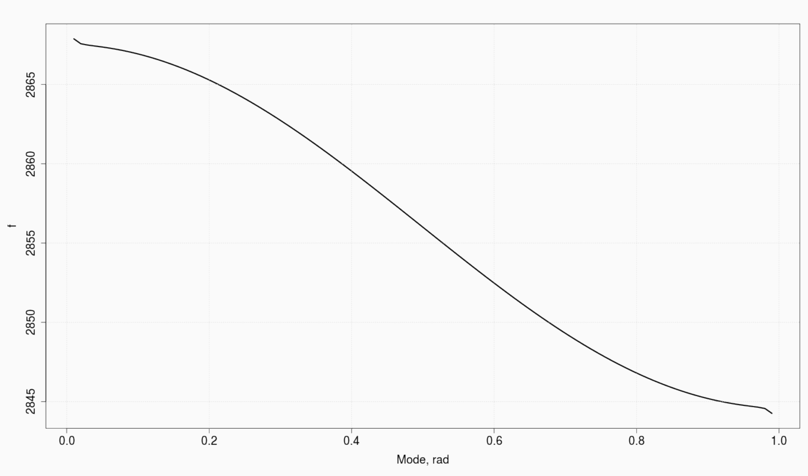


Input data tab of the LinacCalc program

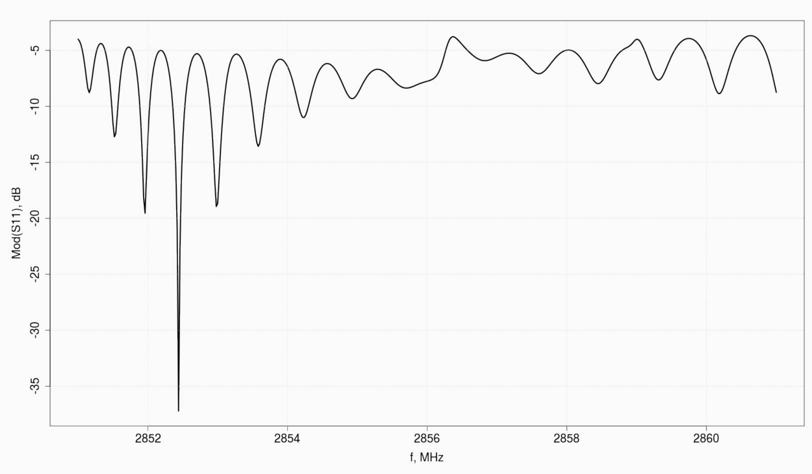
Program output



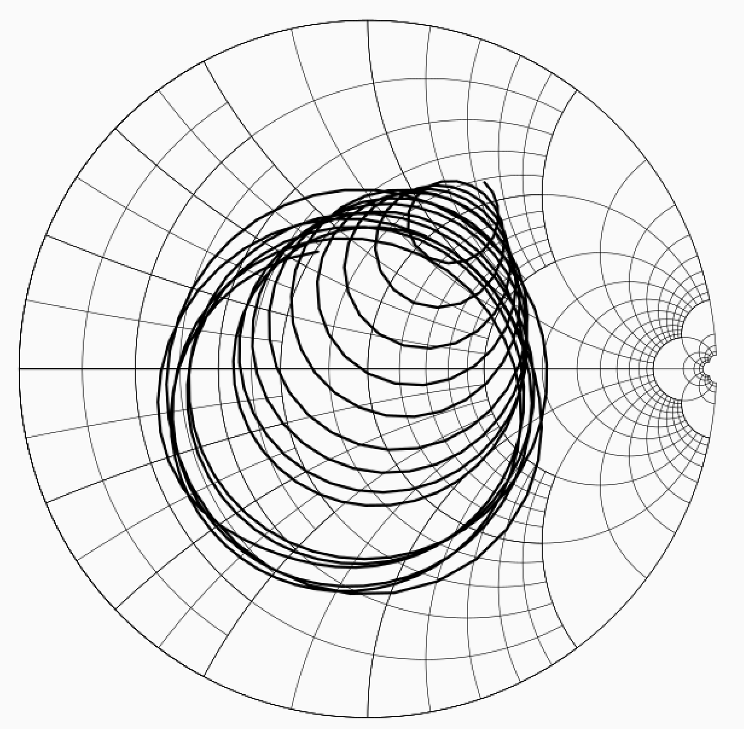
Distribution of the electric field in the accelerating section



Dispersion characteristic of the cell



Band characteristics of accelerating section



Input impedance of accelerating section

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