

# SIMULATION OF THE TRANSITIONAL PROCESS IN ACCELERATING SECTIONS BY EQUIVALENT CIRCUIT METHOD

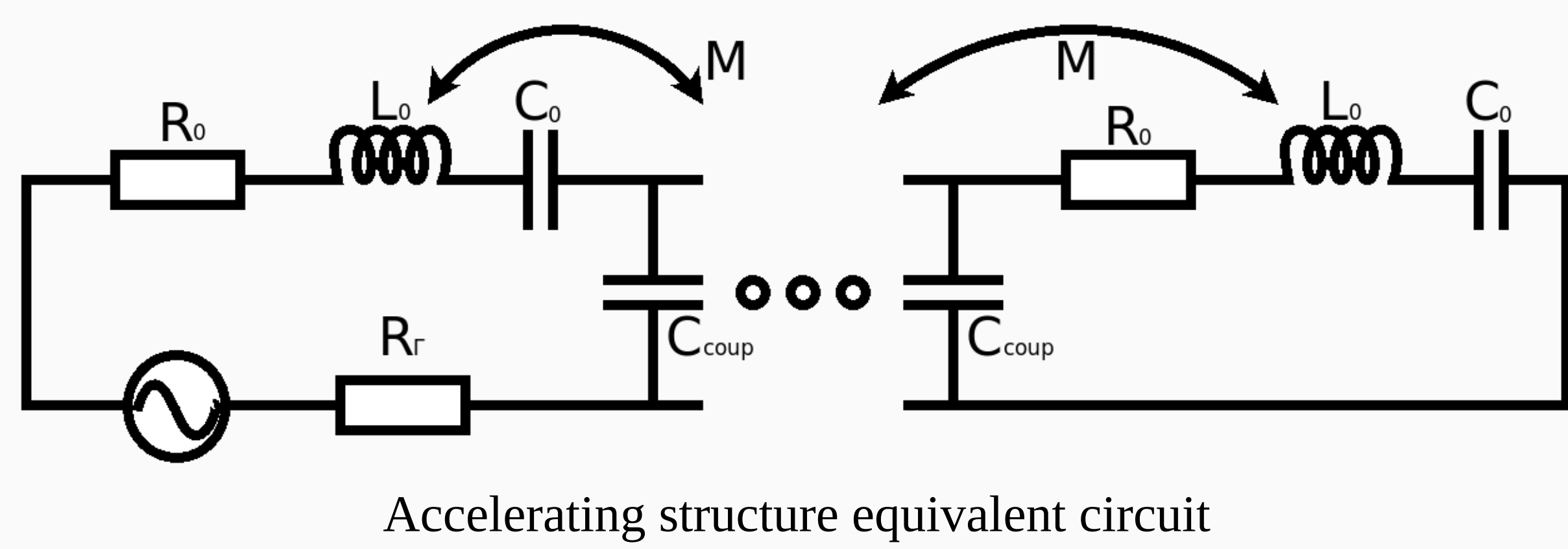
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## Introduction

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. Present paper describes a way to numerically simulate transitional processes in arbitrary coupled accelerating cells using the equivalent circuit method. This approach allows simulating transitional processes in accelerating structures significantly faster and allows doing so for structures with high quality factor and many cells – a hard task for conventional transient solvers based on the finite difference method.

## Calculation model



$$\begin{cases} \frac{dx}{dt} = \hat{x} \\ \frac{d\hat{x}}{dt} + \sum_{n=1}^N \frac{K_n^H f}{2 f_n} \frac{d\hat{x}_n}{dt} = \sum_{n=1}^N 2\pi^2 f^2 K_n^E x_n - \\ - (1 + \chi_G + \chi_L) \frac{2\pi f}{Q} \hat{x} + 4\pi f^2 x + \\ + \sqrt{\frac{4\chi_G P_g}{\pi f_G Q}} \cos(2\pi f_G t + \varphi) \end{cases}$$

$$\begin{cases} |\dot{X}| = |\hat{X}| \\ |\dot{\hat{X}}| = |K^H|^{-1} |K^E| |g(t, \hat{x}, x)| \end{cases}$$

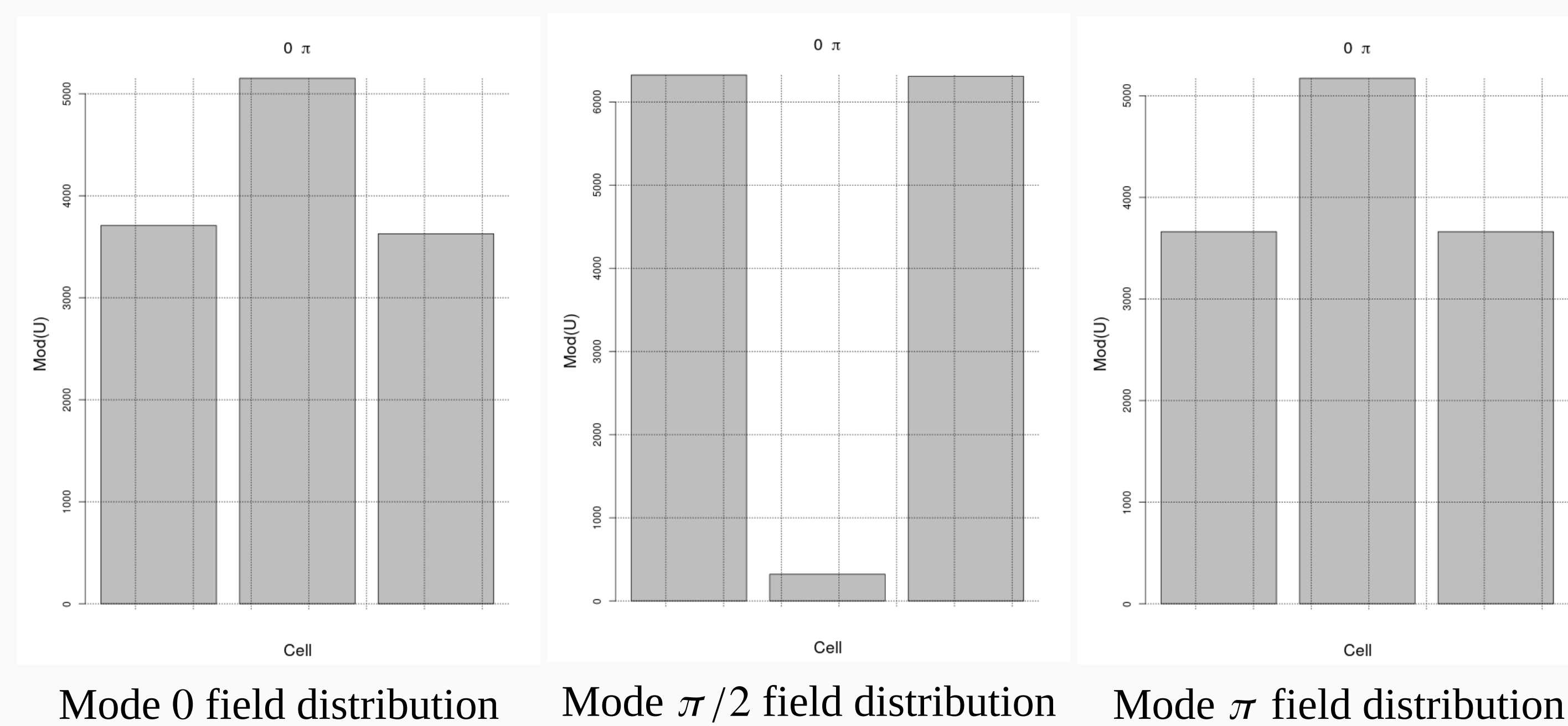
Here,  $|\dot{X}|$ ,  $|\hat{X}|$  and  $|\dot{\hat{X}}|$  are the vectors of normalised amplitudes of electric field and its derivatives.  $|g(t, \hat{x}, x)|$  is the vector of functions, independent of the adjacent cells parameters.  $|K^H|$  and  $|K^E|$  are the matrices of magnetic and electrical connection between cells respectively. Solution may be obtained by solving system of DAE numerically.

## Standing wave section



Peaks in figure correspond to mode 0,  $\pi/2$  and  $\pi$  respectively. After the 20000 periods of oscillations it appears, that amplitudes in the cells are close to those, obtained by the static solver.

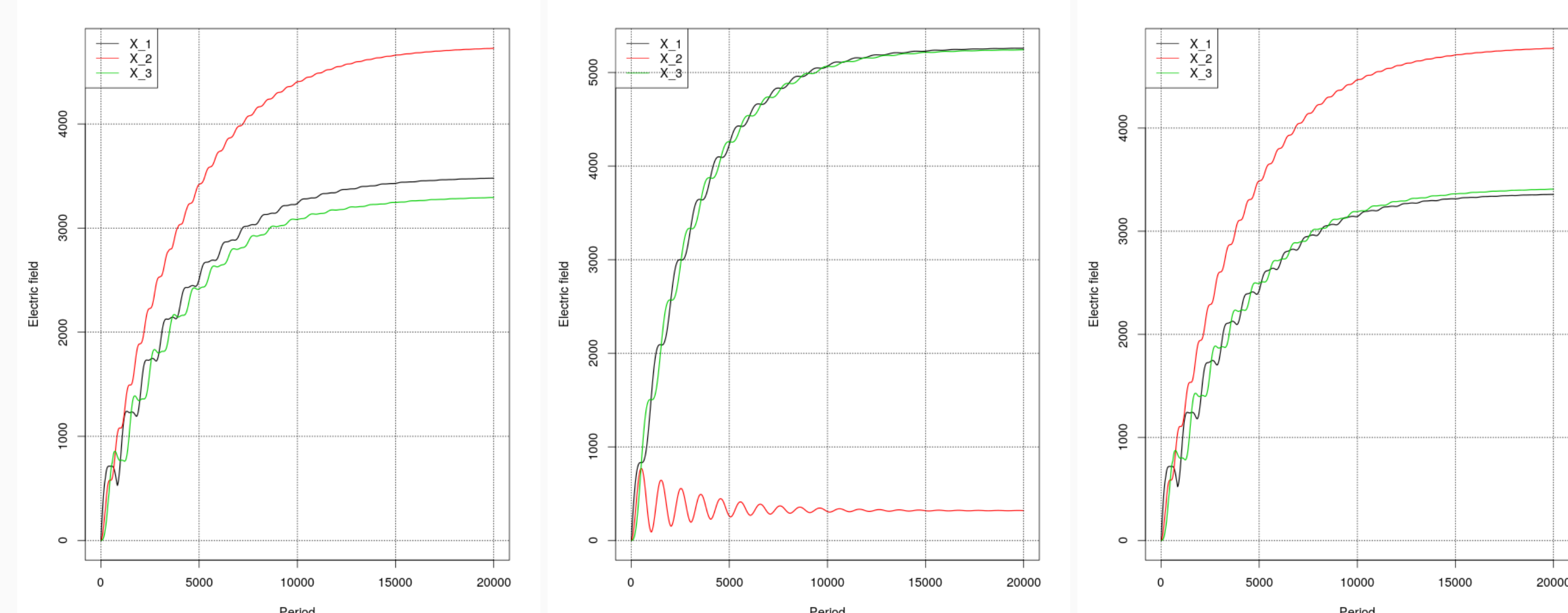
Standing wave section reflection



Mode 0 field distribution

Mode  $\pi/2$  field distribution

Mode  $\pi$  field distribution

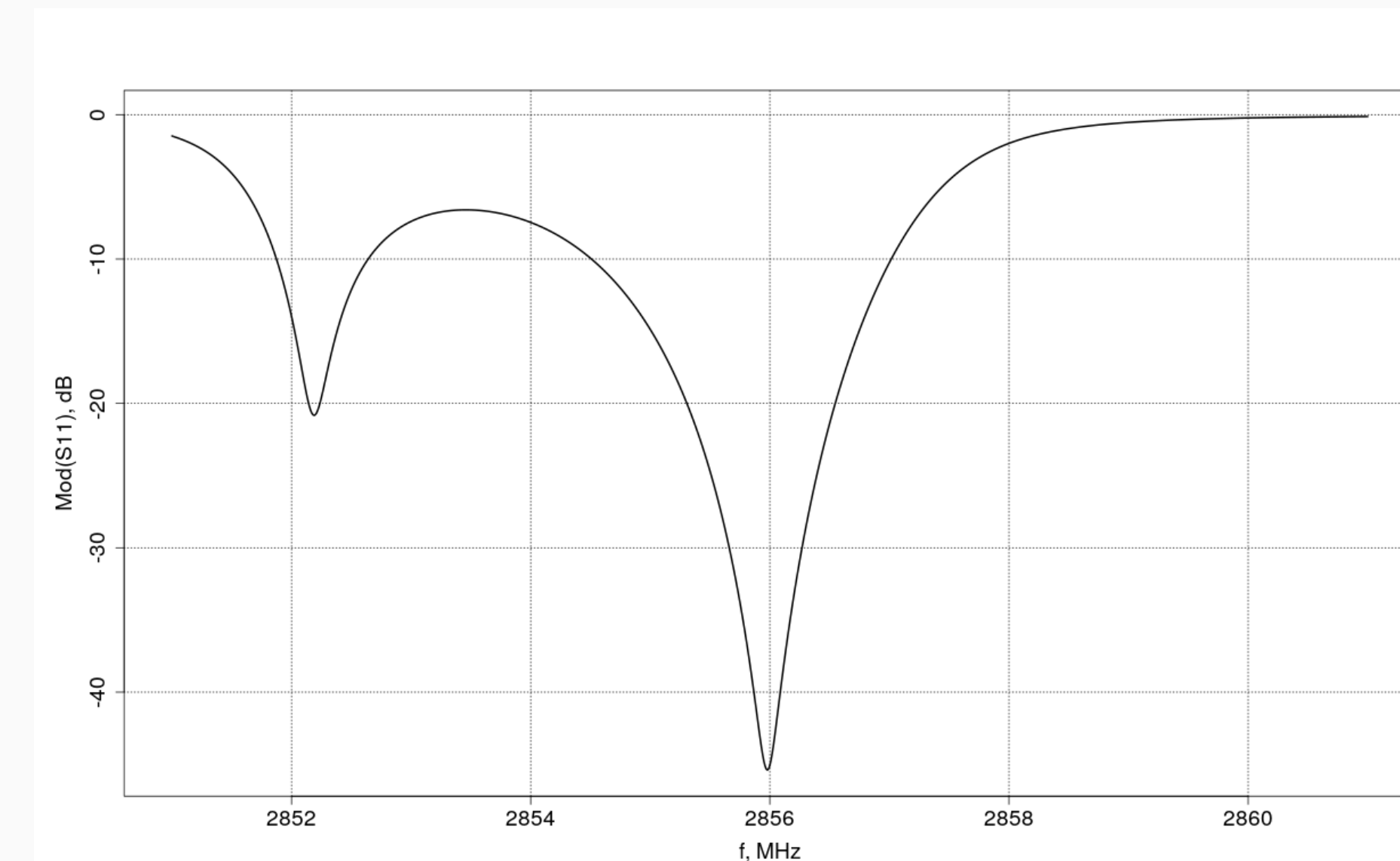


Mode 0 transitional process

Mode  $\pi/2$  transitional process

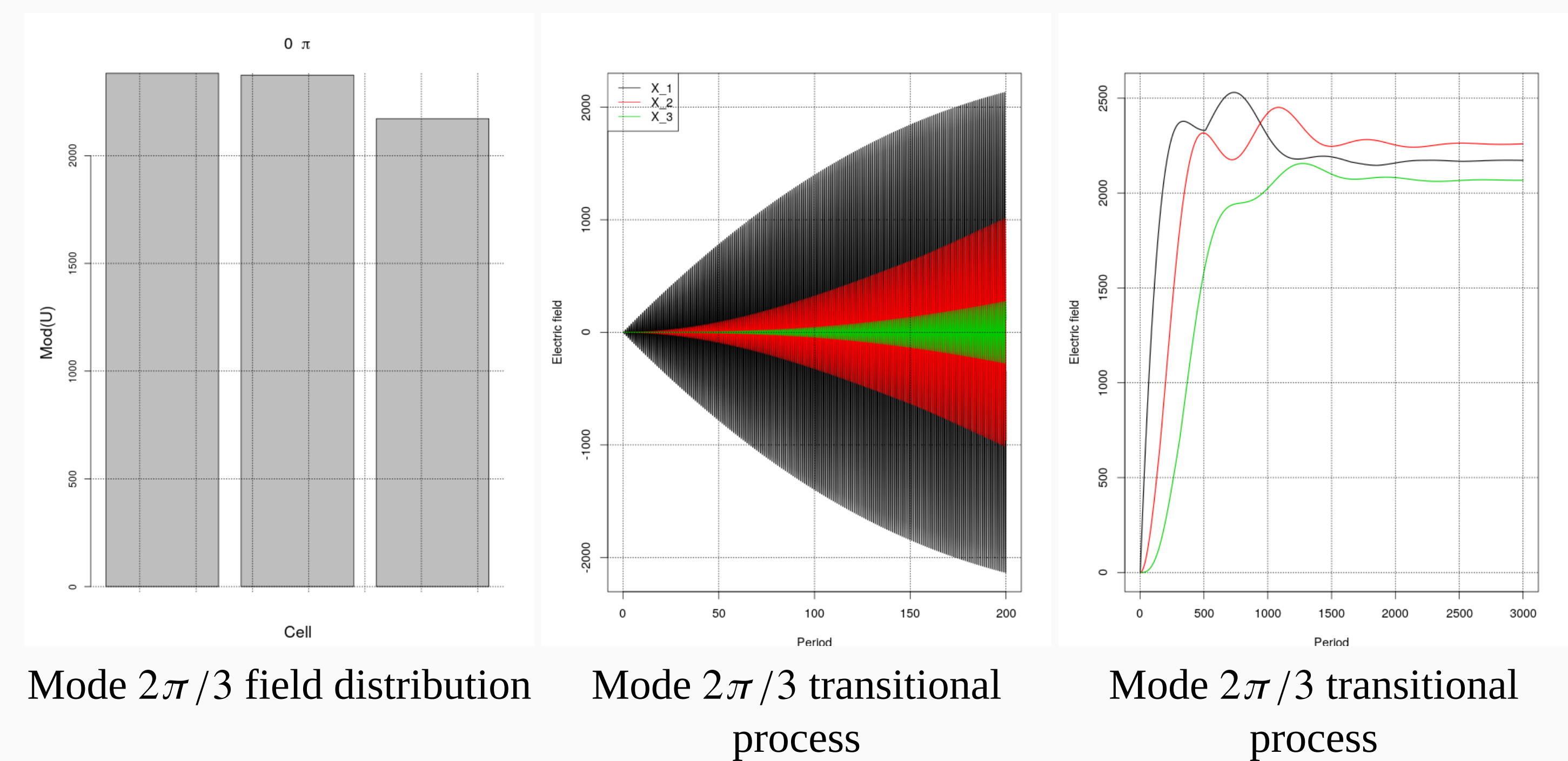
Mode  $\pi$  transitional process

## Travelling wave section



Second peak in figure corresponds to mode  $2\pi/3$ . After the 3000 periods of oscillations it appears, that amplitudes in the cells are close to those, obtained by the static solver.

Travelling wave section reflection



Mode  $2\pi/3$  field distribution

Mode  $2\pi/3$  transitional process

Mode  $2\pi/3$  transitional process

## Conclusion

### Mode Static solver Transitional solver

0	1.02/1.42/1	1.06/1.43/1
$\pi/2$	19.65/1/19.6	20.27/1/20.2
$\pi$	1/1.41/1	1/1.42/1.01
$2\pi/3$	1.1/1.09/1	1.05/1.09/1

Maximum field difference between static and transitional solvers is 4% for the standing wave section and 5% for the travelling wave section.

Relative field amplitudes in cells