

FEST3D Introduction

The objective of this introduction is to explain the motivations behind FEST3D development and the target of FEST3D software, as well as the approach and basic concepts used by FEST3D.

The introduction contains the following topics:

Objective	The objective of FEST3D.
Features	Main Features in FEST3D.
Terms and Concepts	Terms and concepts widely used in FEST3D and in this documentation.

Features

FEST3D is an efficient software tool for the accurate analysis of passive components based on waveguide technology. FEST3D is the first commercial software capable to integrate high power effects in the design process.

Analysis

FEST3D is able to efficiently analyse different type of passive microwave structures in waveguide technology. Basically, FEST3D is based on an integral equation technique combined with the Method of Moments. Additionally, the Boundary Integral-Resonant Mode Expansion (BI-RME) method is employed for extracting the modal chart of waveguides with non-canonical shapes. These methods ensure a high degree of accuracy as well as reduced computational resources (in terms of CPU time and memory).

On this basis, FEST3D is capable to simulate complex microwave devices in extremely short times (of the order of seconds or few minutes) whereas general purpose software (based on segmentation techniques such as finite elements or finite differences) can spend hours for the same calculation.

Furthermore, unlike mode-matching techniques, the electromagnetic algorithms employed in FEST3D minimize the problems of relative convergence leading to more confident results. Moreover, the integral equation technique extracts part of the frequency dependent computations, allowing a faster computational time per frequency point when compared to mode-matching techniques. This benefit is more evident when many modes are required for an accurate analysis of the component.

Based on these methods, the user can analyze a wide range of passive components with FEST3D:

- Filters (dual-mode, evanescent, bandstop, interdigital, waffle-iron...)
- Multiplexers
- Dual-mode filters
- Couplers
- Polarizers
- Waffle-iron filters
- Evanescent filters
- Power Dividers
- Bandstop filters
- Infinite phased array antennas

Synthesis

FEST3D includes the possibility to automatically design several types of components from the user specifications making use of the so-called Synthesis Tools. Up to now, the user can easily design band-pass filters, low-pass filters, rectangular tapers, dual-mode filters in circular waveguide.

The synthesis stage performs full-wave simulations to consider higher waveguide modes. Thanks to this and to particular algorithms employed in each case, the synthesis process provides very good responses with respect to the user specifications. In particular, bandpass filters can be designed with up to 25-230 % of BW without the need of post-optimization, as well as dual-mode filters in circular waveguide with different order and making use of different resonant modes.

Once the synthesis process is finished, the full structure is simulated and the full-wave result is shown.

Optimization

FEST3D has an optimization tool (OPT) for the refinement of the component geometrical parameters to get the desired response. The OPT supports multiple optimisation algorithms such as:

- Downhill simplex method.
- Powell's direction set method.
- Gradient method.

The OPT also supports weighted constraints in the form of equalities or inequalities between a left and a right expression of the parameters being optimised. This allows, for instance, controlling the maximum length of a filter or to ensure that an element length is larger than a particular value.

The OPT progress can be monitored in real time, as well as stopped, reconfigured and resumed from the Graphical User Interface (GUI) at any time. Moreover, the results from the previous optimization iteration and the current one are shown, which allows identifying the source of the improvement in the response.

Tolerances

FEST3D also allows performing tolerance analysis in the components by varying their dimensions according to a gaussian deviation. The different tries are shown altogether and the user can control the whole process.

High Power

FEST3D can be easily used to analyse high-power breakdown phenomena in several type of components. In particular, multipactor and corona (arcing) modules are fully integrated into FEST3D which is capable to determine the breakdown level in complex passive components.

Export 3D geometry

FEST3D can export the 3D geometry to SAT format. This allows an easy interaction with other EM tools and using FEST3D exported file in, e. g., milling machines.

Export Project to CST MWS® 2019

FEST3D projects can be exported to a CST Microwave Studio® project.

Terms and Concepts

Several terms and concepts are used in FEST3D. Even though some of them may be well known to some users, these terms may have different meanings in FEST3D, or some users may not associate them to millimeter-wave and microwave circuits.

Circuit	The kind of circuit currently supported by FEST3D: passive, linear millimeter-wave or microwave circuit composed on cascaded discontinuities based on rectangular and circular waveguides (and perturbed variants of them). The full list of the supported waveguides and discontinuities is available in the Elements Database .
Element	The term element is very generic. In FEST3D it indicates each elementary building block of a passive, linear millimeter-wave or microwave circuit. A synonym also used in FEST3D is component. The elements, or components, supported by FEST3D are divided in two classes: waveguides and discontinuities. See also the Elements Database .
Component	A synonym for element.
Waveguide	A classic microwave waveguide, optionally open-ended (I/O port) or closed on a load, and attached to something else (one or two discontinuities). A whole section of this manual is dedicated to the various waveguides supported by FEST3D .
Discontinuity	A component connecting two or more waveguides. Discontinuities often have a non-uniform cross-section and may have non-trivial 3D geometry. In FEST3D you can only connect a waveguide to a discontinuity, and vice-versa. A whole section of this manual is dedicated to the various discontinuities supported by FEST3D .
Port	Ports are used to connect elements together. Each element has a number of ports equal to the number of elements it is connected to. Each port of an element is connected to a port of another element. The connections between elements are represented as black lines in the GUI.
GUI	Graphical User Interface. The part of a program devoted to interaction with the user. The FEST3D GUI activates the other parts of FEST3D on user demand, by launching external executables.
EMCE	ElectroMagnetic Computational Engine. The part of FEST3D that actually performs the simulation of millimeter-wave and microwave circuits.
OPT	OPTimization service. The part of FEST3D devoted to optimization. In order to optimize a circuit, the OPT repeatedly invokes the EMCE. See the Optimizer section in this manual.
Synthesis Tools	Additional programs integrated in FEST3D, capable of performing microwave circuits synthesis from user specifications. See the Synthesis Tools section in this manual.
Engineering Tools	Additional programs integrated in FEST3D, used to perform unit conversions and small computations. See the Engineering Tools section in this manual.
Convergence Study	Convergence Study is an essential technique to reasonably ensure the accuracy of EMCE results. A brief, but incomplete, summary is that the simulation must always start with low numeric accuracy parameters, continuously increasing them until the response converges. A single simulation with high numeric accuracy parameters is definitely not enough to ensure accuracy of the results. In FEST3D, numeric precision parameters include all the number of modes and also element-specific parameters. See also the tutorial section Accuracy or Speed?

MoM	Method of Moments. A mathematical model of microwave propagation physics, used in FEST3D.
Integral Equation	A mathematical model of microwave propagation physics, used in FEST3D.
BI-RME	Boundary Integral - Resonant Mode Expansion. A very efficient electromagnetic model of microwave propagation physics, used in FEST3D.
