GENERAL

applied electromagnetics using quickfield and matlab

Published: September 19, 2026 | Index ID: #-

Introduction

Applied electromagnetics is a cornerstone of modern engineering, enabling the design and analysis of everything from wireless communication antennas to electric motors and high speed printed circuit boards. With the advent of powerful computational tools, engineers can now simulate complex electromagnetic phenomena with unprecedented accuracy. Two of the most widely used platforms in this domain are **QuickField**, a user friendly finite element method (FEM) solver, and **MATLAB**, a versatile environment for numerical computing and data visualization. Together, they form a potent combination for tackling challenging electromagnetic problems.

This article offers a deep dive into how to harness **applied electromagnetics using QuickField and MATLAB**. We'll walk through installation, model creation, data exchange, advanced techniques, and real world case studies. Whether you're a seasoned engineer or just starting out, this guide will help you build an efficient, reproducible workflow that maximizes the strengths of both tools.

Understanding Applied Electromagnetics

What is Applied Electromagnetics?

Applied electromagnetics is the branch of physics and engineering that deals with the practical use of electromagnetic fields and waves. It encompasses the design, analysis, and optimization of devices that manipulate electric and magnetic fields, such as antennas, waveguides, transformers, and sensors. The field relies heavily on Maxwell's equations, which describe how electric and magnetic fields interact with materials and each other.

Key Applications and Industries

- Antenna Design: Optimizing radiation patterns for mobile phones, satellite communication, and radar systems.
- Power Electronics: Modeling magnetic fields in inductors, transformers, and electric motors to improve efficiency.
- High Speed Digital Design: Analyzing signal integrity and electromagnetic interference (EMI) in PCBs.
- Medical Devices: Designing MRI coils and ultrasound transducers.
- Creating sensors and actuators that rely on electromagnetic principles.

Why Use QuickField and MATLAB?

QuickField Overview

QuickField is a commercial FEM software that offers a straightforward graphical user interface for setting up and solving electromagnetic, thermal, and structural problems. Its strengths include rapid geometry creation, automatic mesh generation, and a library of material properties. For many engineers, QuickField's visual workflow reduces the learning curve associated with more complex solvers.

MATLAB Overview

MATLAB is a high level programming environment that excels in numerical analysis, algorithm development, and data visualization. With a vast ecosystem of toolboxes, including the Partial Differential Equation (PDE) Toolbox and the Simulink environment, MATLAB can handle everything from simple vector calculations to sophisticated

multiphysics simulations.

Benefits of Combining Both

- Rapid Prototyping: QuickField's GUI lets you quickly set up a model, while MATLAB's scripting capabilities enable batch processing and parameter sweeps.
- Advanced Post Processing: MATLAB's plotting functions produce publication ready figures, and its statistical tools help interpret simulation results.
- Data Exchange: Exporting field data from QuickField to MATLAB allows for custom analysis, such as machine learning or optimization routines.
- Automation: MATLAB scripts can drive QuickField, reducing manual intervention and minimizing human error.

Setting Up Your Simulation Environment

Installing QuickField

Download the latest version of QuickField from the official website. During installation, choose the "Standard" setup, which includes the 2 D and 3 D solvers, material database, and basic tutorials. After installation, launch QuickField and verify that the license is active by checking the "Help > About" menu.

Installing MATLAB and Toolboxes

MATLAB can be installed via the MathWorks website. Ensure that you have the following toolboxes: **PDE Toolbox** for solving partial differential equations, **Simulink** for system level modeling, and optionally the **Optimization Toolbox** for design optimization. These toolboxes will be essential when you automate QuickField or perform post processing in MATLAB.

Integrating QuickField with MATLAB

QuickField provides a COM interface that MATLAB can communicate with via the actxserver function. This allows MATLAB to open QuickField, create models, run simulations, and retrieve results programmatically. A typical workflow involves:

1. Starting QuickField from MATLAB: qf = actxserver("QuickField.Application");
2. Loading or creating a model: qf.Open("model.qf");
3. Running the solver: qf.Solve;
4. Exporting data: qf.Export("results.dat");
5. Closing QuickField: qf.Quit;

Once this interface is established, you can embed it within loops, functions, or scripts to perform complex simulation campaigns.

Modeling in QuickField

Geometry Creation

QuickField's geometry editor supports basic shapes (rectangles, circles, polygons) and allows for Boolean operations (union, difference, intersection). For complex PCB traces, use the "Sketch" tool to draw the copper layer, then extrude it into 3 D if needed. Always keep the geometry simple to avoid mesh complications.

Material Properties

Assign material properties from the built in database or define custom materials. For electromagnetic simulations, specify conductivity, relative permeability, and permittivity. QuickField automatically handles frequency dependent material models, which is crucial for high frequency antenna design.

Boundary Conditions

Set boundary conditions such as Dirichlet (fixed potential), Neumann (fixed flux), or mixed conditions. For electromagnetic problems, you'll often use magnetic insulation or open boundary conditions to simulate an infinite domain. QuickField provides a "Ground" option for setting a reference potential, which is essential for voltage based simulations.

Mesh Generation

QuickField offers automatic mesh generation with control over element size, refinement regions, and mesh quality metrics. For electromagnetic fields, use finer meshes near edges and in high gradient zones. The "Mesh Quality" report helps identify poorly shaped elements that could degrade solver accuracy.

Solving and Post Processing

After setting up the model, click the "Solve" button. QuickField will output field distributions, voltage and current densities, and derived quantities like magnetic flux density or inductance. Use the built in plot tools to visualize 2 D and 3 D results, and export contour maps or vector plots for later use.

Exporting Data to MATLAB

Export Formats

QuickField supports several export options: .dat for raw numerical data, .csv for spreadsheets, and .vtk for visualization tools. For MATLAB integration, CSV is often the simplest choice because it can be read directly with readtable or csvread.

Reading Data in MATLAB

Once you have exported the results, load them into MATLAB:

data = readtable("results.csv");\\nx = data.x; y = data.y; V = data.V;\\nmeshgrid(x, y); surf(x, y, V);\\n\\nFor more complex data structures, such as 3 D field vectors, consider using the load function with MAT file exports from QuickField.

Data Manipulation and Visualization

MATLAB's powerful plotting functions allow you to create high quality figures:

- contourf for filled contour maps.
- quiver for vector fields.
- Custom colormaps to highlight specific ranges.

Beyond visualization, MATLAB's integral and trapz functions enable you to compute global quantities such as total power dissipation or inductance from field data.

Advanced Techniques

Parameter Sweeps and Optimization

Use MATLAB to drive a parameter sweep in QuickField. For example, vary the trace width of a PCB and record the resulting impedance. Store the results in a table and feed them into the Optimization Toolbox to minimize return loss.

1. Define a vector of parameters.
2. Loop over each value, updating the QuickField geometry.

3. Run the solver and export results.
4. Analyze the data in MATLAB and adjust the design.

Coupled Physics Simulations

In many real world scenarios, electromagnetic fields interact with thermal or mechanical effects. QuickField supports multiphysics coupling, and MATLAB can orchestrate the workflow:

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