

The Verasonics Essentials of Ultrasound Imaging Simulators (EoUSI Simulators) offering is a companion to *Essentials of Ultrasound Imaging*, by Szabo and Kaczkowski ([Elsevier 1st Edition](#)). This educational book offers an informative introduction to ultrasound imaging, using software simulators. In addition, ultrasound imaging knowledge can be enhanced via the use of the Course described below.

Both the book and curriculum use examples via interactive software simulators to teach key equations and concepts. These simulators enable students with minimal math background to learn the physics and concepts underlying ultrasound imaging. More advanced students, engineers, physicists, or doctors will find the simulators are powerful enough to allow in-depth exploration of the material with quantitative “virtual” experiments.

The EoUSI Simulator Package is a component of the [Verasonics Essentials of Ultrasound Imaging Course](#); a ten-module curriculum designed to be paired with a Vantage<sup>®</sup> Research Ultrasound System for a complete learning experience. The course uses hands-on simulators to facilitate a deeper understanding of the concepts. In addition, the complete curriculum includes a set of laboratory exercises and scripts for use with a Vantage system, an EoUSI Custom Phantom, an imaging-resolution phantom (available from Verasonics or you may use a similar product from your lab), a complete set of lecture slides based on the book, and a lab instructor manual.

## EoUSI Simulators - A Unique Educational Approach

Ultrasound simulators are based on a new learning paradigm. Students explore concepts with interactive, near real-time simulators via a graphical user interface (GUI). GUI controls in each simulator enable a variety of input variables. Using the simulator approach, students can benefit from the experience and efforts invested in developing these tools, representing years of programming. This allows students to focus energy on solving problems of interest in their individual research projects.

Twenty-seven interactive simulators demonstrate the physics of wave propagation, refraction, reverberation, reflection, scattering, and basic principles of imaging modes and Doppler imaging. In addition, an introduction to transducers, diffraction, acoustic fields (both continuous wave and pulsed), arrays, focusing, plane wave compounding, power law absorption, and heating are included.

The simulators are developed as MATLAB<sup>®</sup> programs with interactive Graphical User Interfaces (GUIs) and are compiled for either Windows or macOS computers. Knowledge of MATLAB scientific programming language is not required nor is a MATLAB license needed to run the EoUSI Simulators. Programs run in near real time on computers of current vintage.

The EoUSI Simulators are available for download from Verasonics free of charge separately from the Essentials of Ultrasound Imaging Course, have a one-year lifespan, and can be renewed on an annual basis. A manual for the operation of the simulators is provided. Additional understanding of the simulators can be found through the companion book and course as noted above.

## Simulator examples

The Transducer Simulator shown below is for a one way 5 MHz center frequency transducer design with no matching layers and a fifty-ohm load impedance. One way or round-trip responses can be selected. The complex transducer impedance is displayed.

The center frequency of the design, along with the number of matching layers, if any, can also be chosen. Finally, the effects of varying the series tuning inductor and load impedance can be examined. Capacitance and radiation resistance are given at the center frequency. Acoustical, electrical, transducer and insertion loss are plotted.

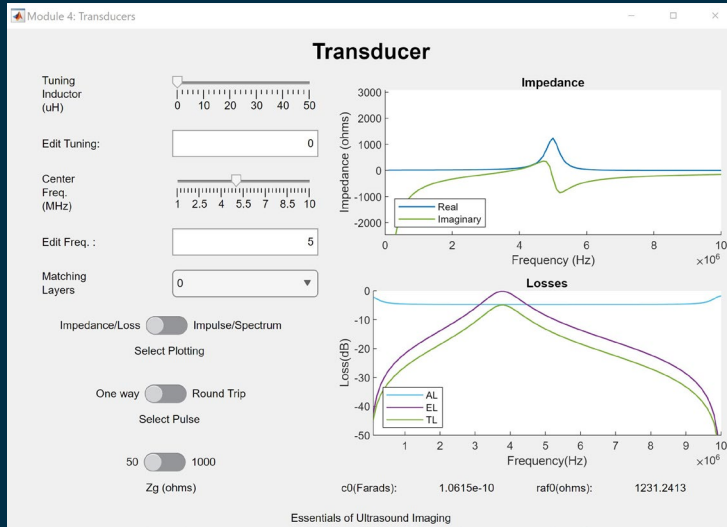


Figure 1: Transducer Simulator in one way: Impedance/Loss mode for a 5 MHz no matching layers design for 50-ohm load.

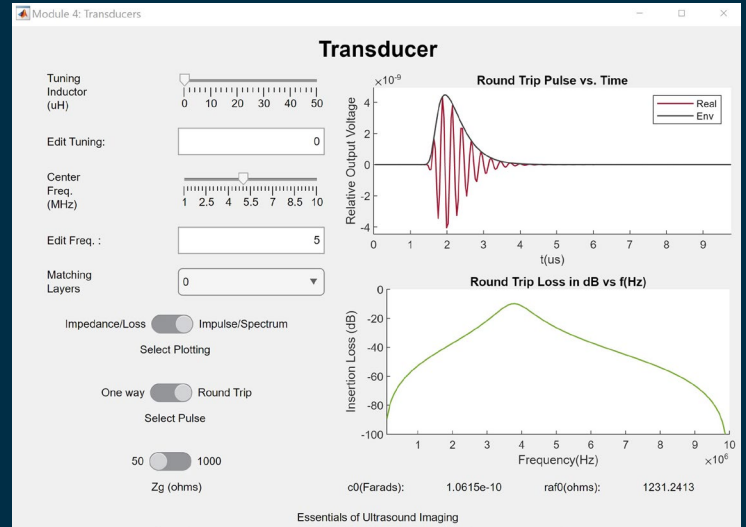


Figure 2: Transducer Simulator in round-trip - Impulse/Spectrum mode for a 5 MHz no matching layers design mode for 50-ohm load.

The Field Simulator is shown next (Figure 3). Here, the intensity plot is demonstrated. Input variable controls featured are focused or unfocused beams for a one-dimensional line aperture. Five apodization options include unapodized, as illustrated here. Aperture length and focal length in wavelengths are selectable. The display options provided are linear field (offset beamplots), linear surface, contour and intensity (shown here); extent of plot ( $Z_{max}$ ), and 2X magnification.

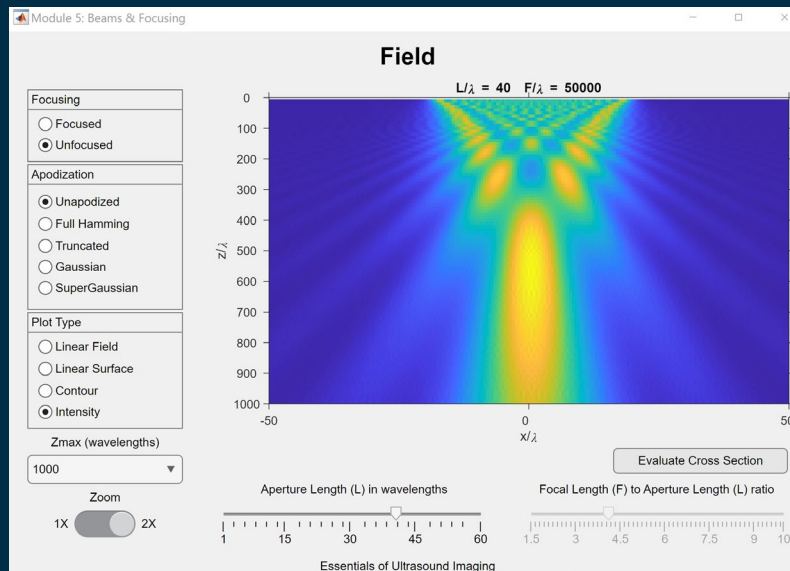


Figure 3: Field Simulator showing intensity.

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