Antenna Toolbox provides functions for the design, analysis, and visualization of antenna elements and arrays. You can design standalone antennas and build linear and rectangular arrays of antennas using a library of predefined elements with parameterized geometry.

Antenna Toolbox uses the method of moments (MoM) to compute port properties such as impedance, surface properties such as current and charge distribution, and field properties such as radiation pattern.

The antenna geometry and the analysis results can be visualized with dedicated functions, and used for antenna-to-bits wireless system design. Antenna Toolbox provides impedance analysis that can be used to design matching networks. It also provides radiation patterns for simulating beamforming algorithms.

**Key Features**

- Antenna library including 22 elements for rapid design and visualization of metal antenna elements using parameterized geometries
- Antenna array design of linear and rectangular arrays using antenna elements
- Port analysis of impedance, return loss, and S-parameters of antennas and antenna arrays
- Field analysis of the pattern, E-H fields, and beam width of antennas and antenna arrays
- Surface analysis of current, charge, and meshing of antennas and antenna arrays
- Antenna array analysis for the embedded element pattern and the correlation coefficient of the elements of the array
- Infinite ground plane specification for analyzing balanced antennas

Design of a two-arm, wide-band Archimedean spiral antenna used for multiband communication in defense applications (left). Antenna impedance is computed from 0 to 2.8 GHz and shows multiple resonances (center). Current distribution computed at 1.9GHz confirms good matching behavior (right).

**Antenna Elements**

Antenna Toolbox provides a library of parameterized elements for rapid design and visualization of metal antennas. You can choose different antenna types and modify their geometrical properties, orientation, and feed point. The resulting antenna geometry can be visualized and inspected in 3D.

The catalog of antenna elements includes:

- Dipole
• Folded dipole
• V dipole
• Meander dipole
• Triangular bowtie
• Rounded bowtie
• Monopole
• Top-hat monopole
• Inverted F
• Inverted L
• Circular loop
• Rectangular loop
• Archimedean spiral
• Equiangular spiral
• Helix
• Yagi-Uda
• Microstrip patch
• Slot
• Planar Inverted-F (PIFA)
• Vivaldi

In addition, a cavity or a reflector plane may be added to any antenna element.

*Antenna elements that can be designed with Antenna Toolbox. Clockwise from top left: microstrip patch, PIFA, top-hat monopole, circular loop, helix, and Vivaldi elements.*
**Antenna Arrays**

With Antenna Toolbox, you can design linear and rectangular antenna arrays. You can choose the antenna element from the available catalog, define the spacing between elements, and specify the layout of the array.

Antenna array layout that can be specified with Antenna Toolbox. Linear array of microstrip patch antennas (left). Rectangular array of top-hat monopole with rectangular lattice (center), and with triangular lattice (right).

Antenna array analysis takes into account mutual coupling among elements of the array. The coupling in between elements can be used to determine correlation between multiple antennas in multiple-input multiple-output (MIMO) systems, or to study the effect of closely spaced antennas on far-field radiation patterns of phased array systems.

Design of a 4x2 array of microstrip patch antennas operating at 77 GHz for automotive radar applications. Far field radiation pattern of an individual antenna element (left). Radiation pattern of the array confirm front, back, and side lobe behaviors (center). The 2D directivity compares a patch element (red line) and an ideal cosine element (blue line), highlighting the presence of a back lobe (right).

**Antenna Analysis and Design**

Antenna Toolbox uses the method of moments to analyze antenna elements and antenna arrays. You can compute port properties such as impedance, S-parameters, and voltage standing wave ratio (VSWR) to determine the resonance frequency of the antenna, or to study impedance matching conditions. Current and charge distributions on the surface of the antenna can be computed at different frequencies and then visualized. You can also inspect and control the density of the mesh used for the analysis.
Analysis results of a nine-element array of dipoles operating at 1.8GHz. Impedance analysis of a single dipole element shows resonance at the desired frequency (left). Far-field radiation pattern of the array at 1.8GHz shows the maximum of the beam at an azimuthal angle of 90 degrees (center). Radiation patterns of individual elements of the array show the impact of mutual coupling (right).

The electromagnetic field can be computed at any point in space and at any frequency, and the far-field radiation pattern can be computed and visualized in 3D or in 2D over different planes.

Antenna Toolbox includes examples that validate its results against state-of-the-art techniques published in scientific papers.

Antenna Integration

Antenna Toolbox can be used in the design of radar systems using Phased Array System Toolbox™. The radiation pattern of antenna elements that are isolated or embedded within an array can be used for the development of beamforming and beam steering algorithms. The analysis results for antenna elements and antenna arrays can be used for end-to-end simulation of the signal processing chain from digital baseband to antenna and back, including the effects of the transmission channel.
Analysis of an 11x11 dipole antenna array geometry, taking into account mutual coupling between elements (left). Array directivity patterns are computed for the H-field (center) and E-field (right), where plots of the full wave (yellow line), isolated element (blue line), and embedded element (red line) solutions confirm the validity of the embedded element pattern approach for large arrays.

The impedance of antennas and antenna arrays computed with Antenna Toolbox can be used for the design of matching networks using RF Toolbox™. The impact of the antenna on power transfer and signal-to-noise ratio in the RF front end can be incorporated into the simulation of wireless communication systems.

Design of a matching network using RF Toolbox for a quarter-wavelength (λ/4) monopole antenna (left). The load reflection coefficient (purple line) shows a poor match to a highly capacitive antenna (center), confirmed by the plot showing where power transfer (purple line) is around -20 dB (right). With a properly designed matching network, the antenna is matched at 500MHz (blue line in center image) and the power delivered to the load is maximized (blue line in right image).