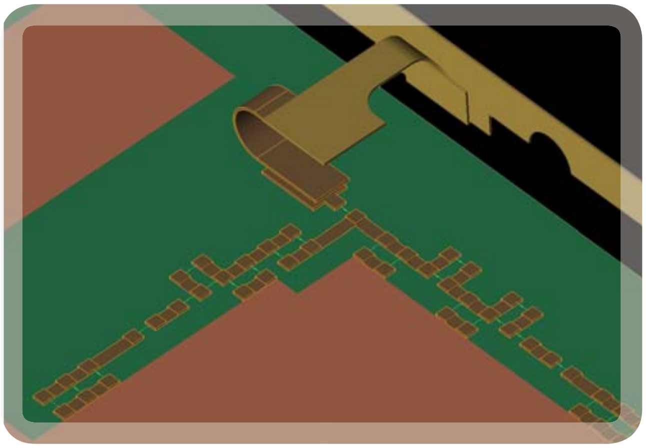
Full Wave Matching Circuit Optimization in XFdtd®



Determining the final set of component values in a matching network can be a challenging process. At higher frequencies, especially VHF and above, significant EM effects on the real circuit (inter-connection transmission line effects and coupling between the antenna being tuned, other antennas, and other parts of the structure) are difficult to quantify and account for in circuit schematic simulators alone.

Further, a single matching network may need to provide optimal antenna performance in different environments (free space, in hand, held near head) or modes of operation (transmit vs. receive). To meet requirements, RF engineers use tuners and pin diodes to augment the traditional L and C components. Often, radiated power is a more important metric than reflection coefficient so a full wave electromagnetic simulation method is required.

XFdtd Includes a Circuit Element Optimizer That Simplifies and Speeds the Process of Matching the Antenna

The Circuit Element Optimizer in XF is used for the following applications:

- Matching circuit for single antenna with single band of operation
- Matching circuit for single antenna with multiple bands (tunable antenna)
- Matching circuits for multiple antennas including MIMO
- Inter-band carrier aggregation for mobile device designers

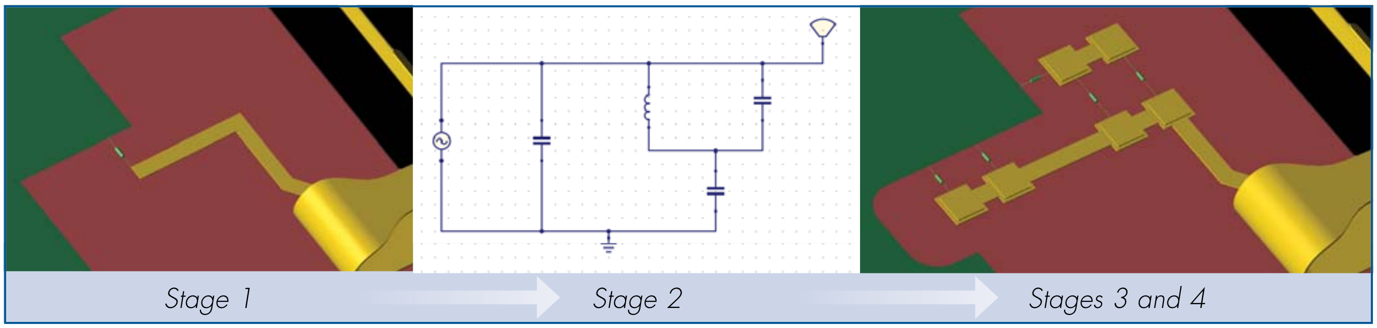
By incorporating the full wave solver, XF is able to account for:

- Interactions within the matching circuit structure
- Interactions between the antenna and matching circuit
- Cross-coupling between different antennas and their matching circuits (for diversity and other MIMO applications)
- Multiple usage modes such as mobile phone typing (in hand) and talking (held next to head)

Matching Circuit Design Process

The design of a matching circuit can be broken into four stages:

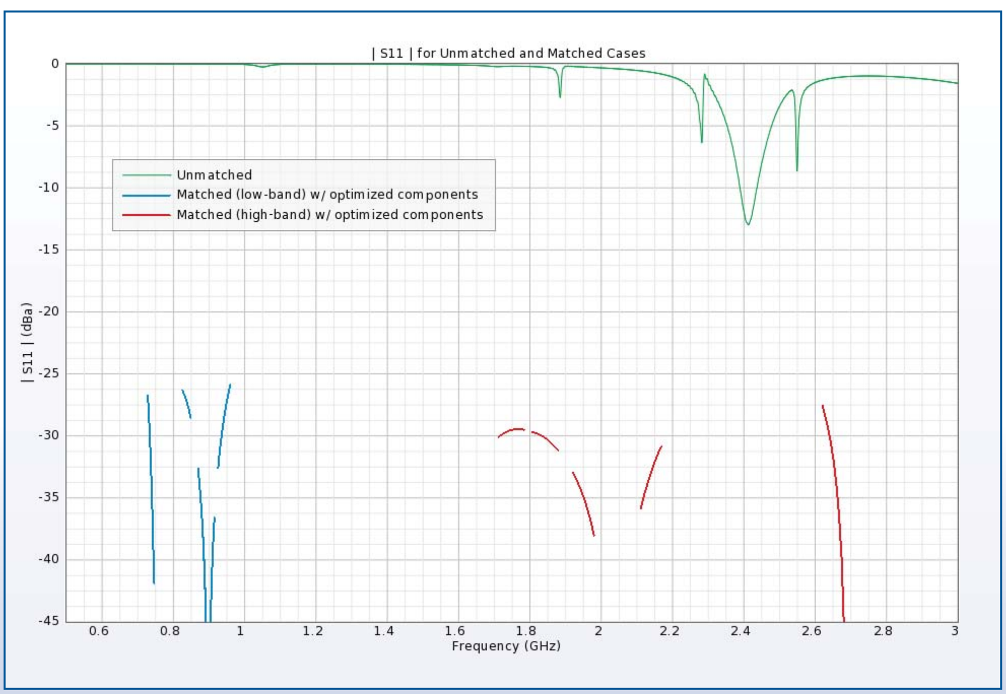
1. Determine the unmatched antenna impedance by running a full wave EM simulation in XF.
2. Find the matching circuit schematic based on the antenna impedance. A circuit solver is commonly used.
3. Layout the physical matching network on the PCB.
4. **Optimize** the components to find the final set of values **using XF's Circuit Element Optimizer**.



Summary of XF's Circuit Element Optimization Capabilities

The following aspects are taken into account:

- Optimize component values while considering parasitic and coupling effects due to circuit layout
- Common ground is not required
- Account for various physical effects (free space, in hand, near head)
- Account for multiple operating conditions and geometry configurations



- **Allowable component values can be restricted to discrete values corresponding to part families, or may be continuous ranges.**

The component types that can be optimized include:

- Fixed resistor, capacitor, inductor
- Ideal resistor, capacitor, inductor
- Realistic capacitor, inductor with user defined equivalent series resistance
- Passive tunable integrated circuits ("tuners")

The optimization determines component values based on the following goals:

- Radiation efficiency
- System efficiency
- S-parameters

Example Use Case for Mobile Handsets

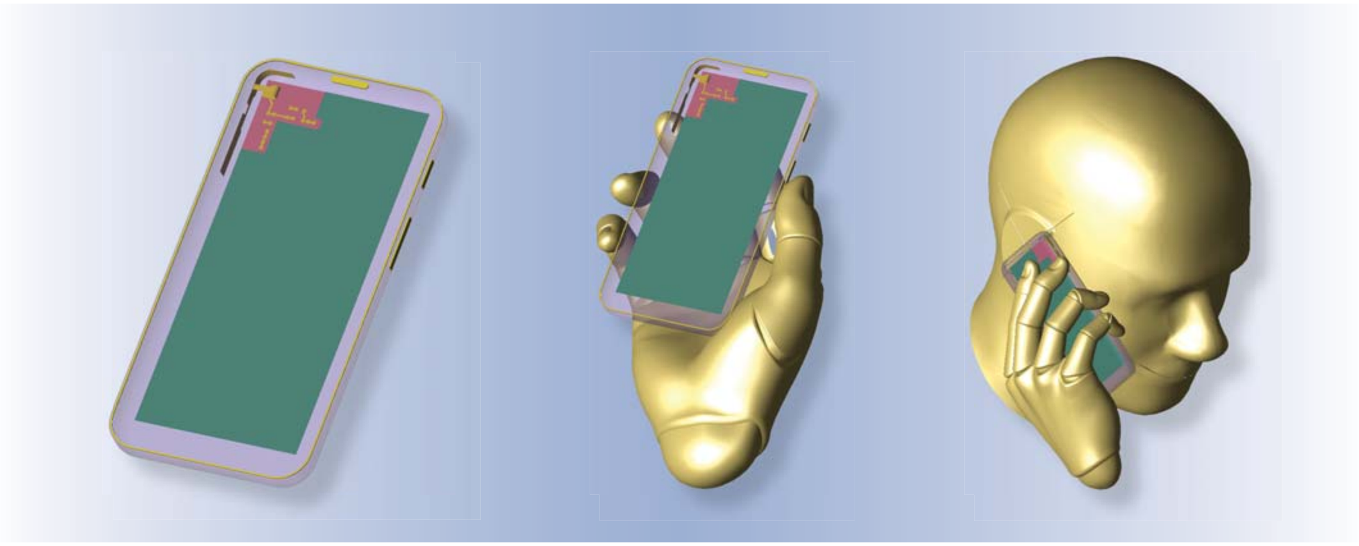
In mobile handset design there are often several antennas, each serving multiple bands, and these bands may differ depending on the carrier and region for which the phone is built. By changing only the values of the matching circuit components, a manufacturer can build a device for many different carriers and regions using the same antenna geometry, which is more efficient than having to design and build a different set of antennas for each.

The Circuit Element Optimization feature in XF addresses the following applications that matching circuits are used for:

- Multiple antennas operating in different bands: phone-related services, GPS, Bluetooth, WiFi (2.4 and 5) applications
- Multiple antennas operating in overlapping bands: diversity or MIMO applications
- Single antenna operating in multiple bands: phone-related services in several bands each, and those bands vary with carrier and region

For each of those applications, the matching circuit must deliver a specified power at or above a minimum allowable system efficiency on all bands. In addition to designing for various bands, the Circuit Element Optimizer is able to choose component values while accounting for:

- Several operating conditions of the phone, such as typing, viewing, talking
- A diversity antenna that has relatively strong coupling to other antennas



In order to meet the above requirements and complications, the Circuit Element Optimizer is able to support tuners. This increases flexibility in matching circuit design because it allows some bands to be grouped together since they can be served by the same tunable component setting.

XFdtd

Learn more about the latest release of XF at **www.remcom.com/xf7**. For additional resources on XF's Circuit Element Optimizer, including examples and whitepapers, visit **www.remcom.com/xf-circuit-element-optimizer**.

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